Thinking-about-the-Box

A Holistic Approach to Sustainable Design Engineering of Packaging for Durable Consumer Goods

Renee Wever

Propositions accompanying the thesis 'Thinking-about-the-Box' by Renee Wever:

1. Within the field of consumer electronics there are packaging engineers and packaging designers, but only very few packaging design engineers. *(this thesis)*

2. Making the marketing performance of a packaging design measurable within a business setting is a prerequisite for an effective optimization of packaging volume. *(this thesis)*

3. Selling durable consumer products without primary packaging is—although both literally and metaphorically an out-of-the-box strategy—worthy of consideration. *(this thesis)*

4. Stimulating sustainable user behavior through design is ill-addressed as an EcoDesign strategy [Wever, Van Kuijk & Boks, INTERNATIONAL JOURNAL OF SUSTAINABLE ENGINEERING 1(1) pp. 9-20, 2008]. It can be contributive in applications such as designing 'binning' behavior into often littered packaging. [Wever, Van Onselen, Silvester, Boks, accepted for publication in PACKAGING TECHNOLOGY AND SCIENCE]

5. People can easily recognize surroundings from a photo, even though details may have changed over time and with the seasons. Hence photos are an interesting presentation medium for wayfinding systems for pedestrians. [Westendorp, Wever & Mijksenaar, INFORMATION DESIGN JOURNAL + DOCUMENT DESIGN, 12(1) pp. 5-18, 2004]

6. A Cradle-to-cradle design exercise is a useful reflective activity for organizations that base their EcoDesign activities on Life Cycle Assessment and the eco-efficiency approach. Likewise, performing an Life Cycle Assessment is a useful reflective exercise for organizations that base their EcoDesign activities on the Cradle-to-cradle philosophy [based on: Bakker, Wever, Teoh & De Clercq, accepted for publication in INTERNATIONAL JOURNAL OF SUSTAINABLE ENGINEERING]

7. For some companies the potential of EcoDesign is much larger if they focus their product-design efforts on solving third-party environmental problems, instead of minimizing the (in)direct impact of their own business and products, i.e., they should develop eco-function or ameliorative products. [Wever & Boks, PROCEEDINGS SUSTAINABLE INNOVATION 2007]

8. The curriculum at Industrial Design Engineering pays too little attention to what happens to products after they leave the assembly line and before they are used in the consumers' home, and to how this phase of packaging, distribution and retailing relates to product design.

9. Due to the time-rebound effect, the question of the environmental (un)friendliness of Formula 1 racing mainly depends on the alternative activity of the hundreds of million world-wide television viewers.

10. A PhD candidate in the field of sustainability cannot afford to live in an ivory tower.

11. The truth of a proposition has nothing to do with its credibility. And vice versa. [Robert A. Heinlein, TIME ENOUGH FOR LOVE, 1973]

These propositions are considered opposable and defendable and as such have been approved by the supervisor Prof. dr. A.L.N. Stevels

Stellingen behorende bij het proefschrift 'Thinking-about-the-Box' van Renee Wever:

1. In het vakgebied van de consumentenelektronica vind je verpakkingsingenieurs en verpakkingsvormgevers, maar slechts zeer weinig integrale verpakkingsontwerpers. *(dit proefschrift)*

2. Om het verpakkingsvolume effectief te kunnen optimaliseren is het noodzakelijk om een manier te ontwikkelen om de marketingprestatie van een verpakkingsontwerp meetbaar te maken binnen de randvoorwaarden van een commerciële omgeving. *(dit proefschrift)*

3. Het verkopen van duurzame consumentengoederen zonder primaire verpakking is het overwegen waard—ook al is het letterlijk en figuurlijk een *out-of-the-box* strategie. *(dit proefschrift)*

4. Het stimuleren van duurzaam gedrag door middel van vormgeving is onderbelicht als EcoDesign strategie [Wever, Van Kuijk & Boks, INTERNATIONAL JOURNAL OF SUSTAINABLE ENGINEERING 1(1) pp. 9-20, 2008]. Het kan bijdragen aan het oplossen van problemen zoals zwerfafval, door 'correct weggooien' te integreren in het ontwerp van zwerfafvalgevoelige verpakkingen. [Wever, Van Onselen, Silvester, Boks, geaccepteerd voor publicatie in PACKAGING TECHNOLOGY AND SCIENCE]

5. Mensen zijn goed in staat om hun omgeving te herkennen van een foto, zelfs wanneer details zijn veranderd door de tijd of door seizoensverandering. Daarom zijn foto's een interessant medium voor routebeschrijvingen voor voetgangers. [Westendorp, Wever & Mijksenaar, INFORMATION DESIGN JOURNAL + DOCUMENT DESIGN, 12(1) pp. 5-18, 2004]

6. Een cradle-to-cradle ontwerpproject is een nuttige reflectieve activiteit voor organisaties die hun EcoDesign activiteiten baseren op levenscyclusanalyse en de eco-efficiëntie benadering. Op dezelfde manier, is het uitvoeren van een levenscyclusanalyse een nuttige reflectieve activiteit voor organisaties die hun EcoDesign activiteiten baseren op de cradle-to-cradle filosofie. [gebaseerd op: Bakker, Wever, Teoh & De Clercq, geaccepteerd voor publicatie in INTERNATIONAL JOURNAL OF SUSTAINABLE ENGINEERING]

7. Voor sommige bedrijven is het potentieel van EcoDesign veel groter als zij hun productontwikkeling richten op het oplossen van milieuproblemen van derden, in plaats van het verminderen van de (in)directe impact van hun eigen producten en activiteiten. Met andere woorden, zij zouden producten met een duurzame *functie* moeten ontwikkelen. [Wever & Boks, PROCEEDINGS SUSTAINABLE INNOVATION 2007]

8. Het curriculum van Industrieel Ontwerpen besteedt te weinig aandacht aan wat er met producten gebeurt nadat zij de assemblagelijn verlaten en voordat zij door consumenten worden gebruikt—en aan hoe deze fase van verpakken, distribueren en verkopen gerelateerd is aan de productontwikkeling.

9. De kwestie van de (on)duurzaamheid van Formule 1 racen, hangt vooral af van wat de honderden miljoenen wereldwijde televisiekijkers anders met hun tijd zouden doen.

10. Iemand die promoveert op een duurzaamheids onderwerp kan het zich niet veroorloven in een ivoren toren te gaan zitten.

11. De waarheid van een stelling heeft geen relatie met haar geloofwaardigheid. En visa versa. [naar Robert A. Heinlein, TIME ENOUGH FOR LOVE, 1973]

Deze stellingen worden opponeerbaar en verdedigbaar geacht en zijn als zodanig goedgekeurd door de promotor Prof. dr. ir. A.L.N. Stevels

Thinking-about-the-Box

A Holistic Approach to Sustainable Design Engineering
of Packaging for Durable Consumer Goods

Proefschrift

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Dr. Casper Boks heeft als begeleider in belangrijke mate aan de totstandkoming van het proefschrift bijgedragen.

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“Don’t be trapped by dogma,
which is living with the results of other people’s thinking”

STEVE JOBS
(commencement address, Stanford, 2005)

Contents

"Packaging is where consumers and suppliers come together and can have a real impact both on business efficiency and environmental stewardship. Even small changes to packaging have a significant ripple effect. Improved packaging means less waste, fewer materials used, and savings on transportation, manufacturing, shipping and storage."

H. LEE SCOTT, WAL-MART CEO
(New York, September 22^{nd}, 2006)

1. Introduction: Revisiting Packaging & the Environment

With packaging of consumer electronic products 'size does matter'. However, understanding as to what constitutes an optimal size differ greatly among the various professionals involved in the product and packaging life cycle. Marketing professionals, for instance, seem to live by the adage 'Big is Beautiful', as large volumes helps to grab consumers' attention. Logistics professionals, on the other hand, call for small packages—just large enough to protect the packed product. From the perspective of distribution costs, as well as from the perspective of environmental impact, small packaging is preferable, as smaller packaging typically requires less material, hence resulting in lower packaging purchasing costs. Furthermore, as will be stressed in this thesis, packaging volume strongly influences transport efficiency. Small packages mean more packages per shipment and therefore less shipments.

Whether marketing aspects or distribution aspects take priority in a packaging design depends on the type of packed product, the type of retail outlet, the intended customer and the region of the world where the product will be sold. Determining the dominant aspect is an important packaging design decision, as well as a highly relevant criterion in the evaluation of packaging designs and design proposals.

In understanding any particular packaging design, the following simple, but highly relevant question can be asked: "Why does this particular packaging have these particular dimensions?" In confronting product managers and packaging designers with this question—as was, for instance, done within Royal Philips Electronics—a lot of different answers were given, which can, however, be categorized into four groups:

a) Smaller packaging would lead to more damaged goods (i.e. distribution functionalities),
b) Smaller packaging would compromise the retail or sales performance of the packaging (i.e. sales functionalities),
c) Smaller packaging would compromise the experience performance of the packaging; i.e. the 'feel-good' of the product and brand (i.e. experience functionalities),
d) Smaller packaging may be possible, but due to project constraints there was no time or money for optimization.

The answer given is a good indication of which functionality took precedence in the packaging design (distribution functionality, sales functionality or brand-experience functionality), even though that functionality need not be what the product really requires.

Functionalities relating to sales and experience are relatively new in the Consumer Electronics (CE) industry, and have emerged as a response to ward off commoditization of CE products (which is further addressed in Intermezzo A); i.e. CE products no longer are major investments for most families. With this development, the way retailers offer CE products and the way people shop for them, has changed. In this setting the packaging has to fulfill all kinds of immaterial and emotional functionalities, besides the physical functionality of enabling distribution.

In case of answer *d*, above (no time for optimization), it can be proposed that a potential for improvement may well be present, but also in the other cases there is enough design freedom for the application of *Design for Volume Optimization*. This point will be demonstrated in this thesis. Design for volume optimization means making sure that volume, as a design variable, is used *effectively* to fulfill a required functionality, and that it is used *efficiently*, thus resulting in the minimal packaging volume that will properly fulfill that required functionality. Chapter 6 will address this further.

1.1 Justification of research scope

This thesis focuses on improving the functionality performance, including the sustainability performance, of packaging and distribution in the consumer electronics (CE) industry. In other words, by designing a package to fulfill the proper distribution-, sales-, and experience-related functionalities, in the most volume-efficient way, the package will become more sustainable.

The main approach lies in optimizing packaging dimensions and thereby improving logistical efficiency. Packaging and transportation form a life cycle phase where economical and environmental 'win-win' situations occur regularly—as is illustrated by the quote at the beginning of this chapter by H. Lee Scott, Wal-Mart CEO at the time. As there are significant amounts of money involved in packaging and transportation, it makes good business sense to pay particular attention to this phase of the product life cycle[1]. Further to this, money saved on packaging ends up directly in the pocket of the manufacturer (it is a bottom-line-contribution cost reduction), while money saved on, for instance, energy consumption, ends up in the pocket of the consumer. In addition, in *product* design, a large part of the environmental impact is determined the moment a certain technology is chosen to realize the required functionality. Therefore, in a relative sense, there is limited room for improvement in product design, at least in incremental design for sustainability. With *packaging* however, there are many design options; i.e. there is more room to maneuver—for instance in the selection of the cushioning material. This design freedom is greatest for packaging which has

[1] As an example: in a life cycle costing exercise Keijzers (2003) found that the packaging and transportation cost for a 14" CRT television set amounted to €9,65 which is significant in comparison to the total cost of the product (recommended retail price €230,-).

to fulfill marketing-related functionalities, as these package can be, and are, more varied than the corrugated board boxes of distribution packaging.

As will be demonstrated in later chapters, packaging of CE products is no longer solely about getting them from A to B. Marketing functionalities have become required—both sales and brand-experience related—and sustainability requirements have also been added to the mix. No approach currently available takes a holistic approach to packaging for consumer durables, taking into account the requirements resulting for all life cycle phases and thus including distribution, sales, as well as experience functionalities. Furthermore, no current approach to packaging for consumer durables takes a holistic sustainability approach by including the effects of packaging volume on transport efficiency.

Finally, due to relocation of production to low-wage countries in order to cut costs, paradoxically, due to longer distribution routes, the costs and impacts of transportation go up and with it the relative importance of this life cycle phase.

The old truths of packaging no longer hold, therefore the current practices need to be rethought. Hence, even though, from a total life-cycle perspective of a CE product, the environmental impact of the packaging and transportation is not the major aspect in an absolute sense (Stevels and Griese [2004] state it to be at most 10% of the total) its relative potential justifies a focus on sustainable design of the packaging within the CE industry.

1.2 Relation between packaging and environment

Ever since the growing attention for the environmental impact of products, packaging has been one of the areas receiving substantial attention, for instance from legislators, scientists, companies and environmental lobby groups. Consumers often discard packaging quickly after purchasing a product, especially packaging of durable goods, such as CE products. This quick discarding makes the environmental impact of packaging very tangible to the consumer, thus giving packaging a negative environmental image. This feeling with the general public is reflected by the attention of scientists and legislators. The attention of academia is demonstrated by the fact that in the 1970s and 1980s when Life Cycle Assessment (LCA) methodology was developed, approximately 40% of the studies published were concerned with packaging materials (Knoepfel, 1994). Attention from legislators started showing in the late 1980s. In 1991 several European countries introduced environmental packaging legislation, of which the German one, resulting in the Green Dot system[2], is best known.

Different 'shades of green' can be distinguished when analyzing these stakeholders (see, for instance, Stevels [2007], p.180):

[2] In the German green dot system (*Grüne Punkt*) all manufacturers are held responsible for take-back of every package they put on the market. As this is impossible to execute, or at least highly impractical, companies can transfer this obligation to a waste treatment organization, by paying a fee. The height of the fee is dependent on the specifics of the packaging (material, weight, volume). As proof that the fee was paid the green dot symbol (a circle consisting of two intertwined green arrows) may be printed on the packaging. Most other EU countries implemented the EU Packaging Directive by using a system similar to the German one.

- There is *consumer green*, which consists of beliefs held by the public, such as "recycling is always the best option for the environment". Such beliefs may well be incorrect from a scientific perspective, but they are usually strong, and hard to change. Or as Jacquelyn Ottman (1992, p.13) states in her book on green marketing: "In the age of environmental consumerism, the perception is the reality". Consumer green is not only a manifestation of individual citizens, but is also orchestrated through environmental NGOs such as Greenpeace and the World Wildlife Fund (WWF).
- There is *governmental green*, which is reflected in/through legislation, taxes, subsidies, and governmental procurement[3]. Governmental actions are usually based on more interests than environment alone, as they have to balance these interests with issues like employment rates, regional development, and budgets. Furthermore, legislation at least partly reflects popular concerns; i.e. consumer green. Hence governmental green may also be in conflict with a scientific perspective.
- There is *scientific green*, which aims to give a fact-based objective assessment of environmental issues, through tools such as LCA. However, even with LCA there are methodological issues (such as determining system boundaries, and attributing weights to impact categories) that make the outcome more the result of scientific consensus, than an absolute truth.
- There is *business green*, which reflects the attempt to strike the proper balance between the above three perspectives and the economic perspective.

When considering the different perspectives on green in the context of packaging for durable goods, it can be concluded that, even if all stakeholders are interested in improving the sustainability performance of packaging, their priorities may vary.

As stated above, in the past decades, packaging has been receiving substantial environmental attention. This has mainly come from a consumer green and governmental green perspective. Scientific green has, for as far as it has been applied, suffered from an issue with system boundaries, as it has so far excluded the distribution phase.

With most professionals dealing with packaging and sustainability (i.e. business green), the focus of attention has been entirely on the production and end-of-life phases of the packaging life cycle. This focus is strongly driven by the EU packaging legislation, which resulted from the many legislative initiatives by member states in the early 1990s. With the introduction of the 'Directive on Packaging and Packaging Waste' the European Union set targets for recycling (European Union, 1994). The first article of the directive clearly reflects the focus on the production and end-of-life phase of the packaging: *"… this Directive lays down measures aimed, as a first priority, at preventing the production of packaging waste and, as additional fundamental principles, at reusing packaging, at recycling and other forms of recovering packaging waste and, hence, at reducing the final disposal of such waste."*

[3] For many products governments are a major client. If a government incorporates sustainability requirements into its procurement procedure, this usually gives a strong incentive for industry to innovate.

Although, at a later point, the directive does state that the entire life cycle should be considered, in all its other guidelines it focuses on material reduction and packaging recovery. This focus is understandable as the waste issue is the life cycle phase that is most apparent to consumers (and consumer organizations) who have an influence on governments in forming legislation. Furthermore, from a governmental perspective, an example of the balancing of environmental issues with other issues can be seen. For governments in Western-European democracies, finding sites for new landfill or waste incineration plants is ‘bad politics’[4]. This gives an extra incentive to make the reduction of waste the main environmental focus for packaging.

However, by taking a LCA approach, and by placing the system boundaries to include the transportation phase, a different prioritization emerges. It then becomes apparent that, at least for packaging of CE products, the use phase of the packaging is a significant part of the environmental impact of the packaging. This use phase is the transportation of the packed product from its point of assembly, through the distribution chain, all the way to the consumer’s home. It turns out that the packaging volume is of significant influence here, as will be demonstrated later in this thesis. Due to the use of cushioning material, packaging is more voluminous than the products it contains.

		Production			use			end-of-life						
Material	Number of companies	Contains recycled content	Limited use of material	Eco-friendly production	Volume efficient in storage	Is a light weight solution	Volume efficient in use	Packaging is reuseable	Material is recyclable	Material will be recycled	Material is CFK free	Material is biodegradeble	Energy recovery	Volume efficient waste
EPS foam	6	0	5	1	0	5	0	0	6	3	3	0	0	0
EPP foam	2	0	0	1	0	1	0	1	2	1	0	0	0	0
EPE foam	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Polyether	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Polyester	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Foam in place*	2	0	1	0	0	0	0	0	2	1	1	0	1	1
Paper based	4	3	0	0	2	0	0	1	4	0	0	2	0	0
Air cushions	1	0	1	0	0	0	0	1	1	0	0	0	1	0
Korrvu**	3	1	2	0	2	0	0	2	3	0	0	0	0	0
Starch foam	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Total	**22**	**4**	**9**	**2**	**4**	**6**	**0**	**5**	**21**	**8**	**4**	**3**	**2**	**1**

Table 1.1: The number and type of environmental claims made by European protective packaging suppliers in their brochures, or on their web sites. The data was collected in October 2004. The table shows the strong focus on prevention of packaging waste and recycling. No supplier makes volume efficiency claims. *) Foam-in-place is an instant packaging solution using Polyurethane that is foamed within the space it is supposed to fill. **) Korrvu is a cushion consisting of two polyurethane films stretched on corrugated board frames, in between which a product can be suspended.

[4] Due to the population density, new landfills or incineration plants always have to be placed in areas where people are living, which tose people won’t appreciate. This is phenomenon is known as the ‘Not in my backyard’ sentiment (or NIMBY).

Thus far the significance of volume has been ill-addressed in environmental assessments of packaging. Table 1.1 shows the environmental claims of 22 suppliers of cushioning materials. None of them mention volume efficiency as an environmentally important factor. Their environmental claims are mainly production and recycling related, e.g. 21 out of 22 claim their cushioning is recyclable.

Judging from the presented metrics in Corporate Social Responsibility reports from major CE manufacturers, these companies do recognize volume as a relevant factor, but never as the most important one.

The importance of volume is based on two important facts. First, the environmental impact of transporting packed CE goods is roughly between 1 and 2 times the environmental impact of the packaging production and end-of-life phase of the packaging, as will be elaborated below. Secondly, the impact of the transportation is strongly influenced by the number of products that fit into a single shipment.[5] For CE product, this factor is virtually always determined by the volume of packages, not by their weight, as will also be elaborated below.

Elaborating the first point, that transportation is more important than packaging materials themselves, life cycle assessment (LCA) case studies done within Delft University of Technology and Royal Philips Electronics (Thijsse, 2001; Wever, 2003; Van Es, 2005) have shown for several types of products that the ratio between the environmental impact of the packaging Bill-of-Materials (BOM) and the environmental impact of transportation is approximately in the range of 1:1 to 1:3 depending on the type of packaging materials used, the mode of transportation used, and the transportation distance. Thijsse (2001) compared the environmental impact of packaging and transportation (factory to shop) of four CE products (an audio system, a portable audio, a 28" TV and a VCR). She found an average ratio of 1:2.8. A similar analysis for costs showed an average ratio of 1:1.2.

Wever (2003) looked at a molded fiber cushioning for a VCR. For this cushion its direct environmental impact related to the material and its contribution to the transport volume were evaluated. The resulting ratio between BOM and transportation found here was approximately 1:10. This high ratio is caused by the fact that just the cushion was taken into account, not the corrugated board box. Furthermore the design of the cushion was far less volume efficient than is possible with molded fiber nowadays. Compensating for these factors would bring the resulting ratio in line with findings by Thijsse.

Van Es (2005) studied several packages for electric shavers. These packages included clamshell tamperproof packaging. In this analysis only the transportation from the factory in the Netherlands to the distribution center in North America was included. Here a ratio between BOM and transportation of 1:1 was found. The relatively low impact of transportation, as compared to Thijsse, is caused here by

[5] In the distribution chain of CE products some parts are done by sea container, these usually are completely filled with a single product. In other parts—especially the leg between the warehouse of the manufacturer and the retail store—a truck usually contains a mixed load. This may be a less-than-full truckload (LFT). The link between volume and transport efficiency is most apparent in the first part of the distribution chain (i.e. sea container), which is also the longest. The distribution chain and its efficiency will be further elaborated below, as well as in Chapter 3.

the exclusion of the transport from the distribution center to the final retail outlets. If they were included, the resulting ratio would again be in line with the findings by Thijsse.

These findings are a clear indication that a strategy aiming at minimizing the transportation impact may have much more potential for environmental improvement than a strategy aiming to minimize packaging waste. The objective of this thesis is to develop an approach to do that. This potential is only increased by the fact that so far there has been little effort in the CE industry to make packaging more sustainable through improving the transport efficiency. Furthermore, by increasing the number of products per shipment—and thereby decreasing the number of shipments needed—saving costs and saving the environment may go hand in hand.

1.3 Packaging and transport efficiency

To see how packaging design influences the impact of transportation, a closer examination of used modes of transportation is required. For CE companies the most relevant modes of transportation are containerships, trucks and airplanes. Standard 40' (feet) sea containers (ISO container 1AA as described in ISO 668 and ISO 1496) have a minimum internal volume of 65.70 cubic meters with a maximum payload of approximately 28,000 kg[6]. Both values show small fluctuations as only the outside dimensions and the total weight of container and cargo are stringently determined by the standard. Therefore the specific construction of the container can influence the internal dimensions and the weight. These values result in a break-even density of 390 to 430 grams per dm^3; lower densities will be volume-critical, while higher densities will be weight-critical. If packaging has a higher density the weight limit determines the maximum container load. If the density is lower, volume is the limiting factor. The same calculation can be made for trucks. As trucks vary more in design, the break-even density also varies more, namely from 190 to 350 grams per dm^3. For air cargo the break-even point is 167 gram per dm^3. If the density is lower the carrier will calculate a fictitious dimensional weight based on this density, and charge likewise. These break-even densities can be compared to the densities of packed consumer electronics products. Figure 1.1 shows the densities of 203 CE products and the break-even densities of several modes of transport (for the origin of these data see the case study in Chapter 3).

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[6] There are two other container sizes that are in regular use. One is the 20' container, which is exactly half the size of the 40' container, the other is a 'high cube' version of the 40' container, which has the same length and width, but is slightly higher. The 20' container has a maximum weight of more than half the maximum weight of a standard 40' container, hence it is interesting for products with a higher density. The high cube container on the other hand, is more suitable for low density goods, due to its larger internal volume.

Furthermore, more stringent weight restrictions may apply for transporting containers by truck. For instance, United States highway regulations limit the gross weight of a truck with trailer and filled container to 80.000 pounds. This leads to an effective cargo limit of roughly 20.000 kg, which means a break-even density of 304 grams per dm^3.

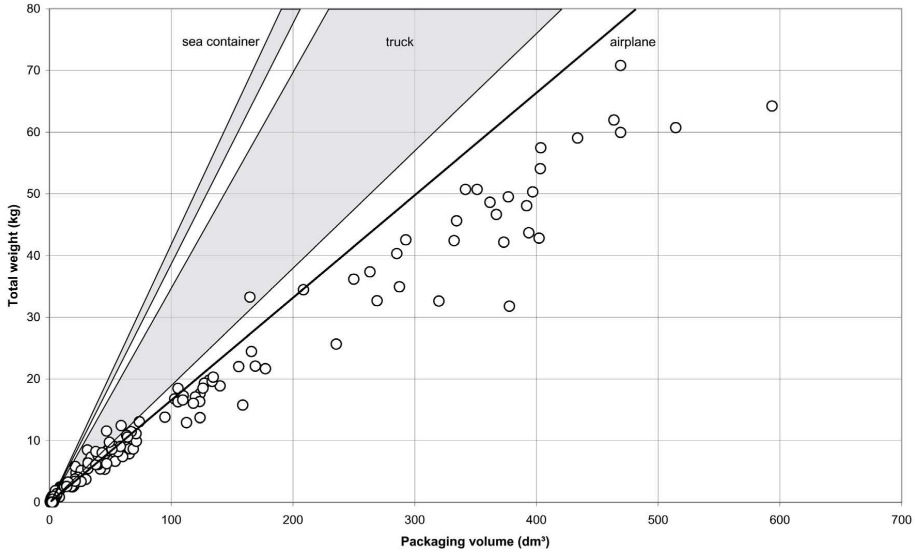

Figure 1.1: Break-even densities of the most relevant modes of transport and the 203 products from the data set (2003-2006). Most of the products have lower densities than the break-even densities of transport modes, which means that transportation will be volume-critical, and not weight-critical.

Almost all packages have densities lower than the break-even densities of the modes of transportation. Hence for all those packages, the number of products in a shipment is limited by their volume, and not by their weight. Due to the distance of the points to the break-even lines packaging volumes would have to be reduced by 5 to 50% before weight would become the limiting factor for airplanes, and by even more for trucks. As for sea containers, all packed CE products in the graph are limited by volume and most of them would still be volume-critical if their volume were half what they are now. This justifies a design for volume optimization approach.

The LCA studies and the packed product density assessment described above justify a *Design for Volume Optimization* approach to packaging design. This approach is the focus of this thesis. Simply trying to make packaging smaller will not work. There are many reasons why packaging may be the size that it is, as is illustrated by the answers of product managers and packaging professionals in the first paragraph of this chapter. Besides protection, volume may be related to sales performance and the communication of brand value. 'Purist' environmentalists may claim such marketing functions to be superfluous (e.g. Imhoff, 2005, p.12-13). However, this study is specifically aimed at the mainstream CE companies[7], which see marketing and sales as an essential part of their business. Hence, requirements set by current mainstream markets are accepted as legitimate in this thesis.

[7] Later on in the thesis data will be presented on a wider range of durable consumer goods in order to assess the extent to which findings are applicable outside the CE industry as well.

Pursuing a *Design for Volume Optimization* strategy requires insights into current packaging design methodology as well as the currently required functionalities of the packaging. Furthermore, alternative fulfillments of these functionalities need to be identified. This results in the following research questions:

1.4 Research questions

- How are the dimensions of packaging currently established; i.e. what process is followed?
- Does the present-day packaging development practice reflect present-day design theory? And can discrepancies, if any, be explained?
- What functions does present-day packaging for CE products fulfill?
- Is there a potential for improvement, and if so, how big is it; i.e. to what extent can the volume be optimized?
- How did functions, that were not relevant in the past (i.e. sales- and experience-related), when CE products were first put to the market, become relevant?
- What are the relationships between a certain packaging function and packaging volume?
- In case of multiple relevant packaging functions, how are these functions reflected in the volume of the final packaging?

Based on the findings of these first questions an additional question can be formulated regarding the generalizability of the findings:

- To what extent are the findings for packaging and distribution of CE goods identical to other durable consumer goods?

Based on the findings of the previous questions, several questions can be formulated that are more prescriptive in nature, regarding the translation of these findings to design practice:

- How can designers determine the (mix of) required functionalities of the packaging of a certain product?
- Which options for improvement can be identified and how big is their potential, both for the economic and environmental performance, and both within a specific functionality and for packages incorporating a mix of functionalities?
- How can designers fulfill the required (mix of) functionalities of the packaging in a volume efficient way?

1.5 Discussion of terminology

Before proceeding, some of the terms used throughout this thesis are defined.

Packaging

In his thesis Ten Klooster (2002, pp.18-21) discussed the many different—and in his eyes inadequate—definitions of packaging that have been proposed in literature. He concludes that the best way to define what packaging is would be to describe the functions packaging fulfills. Ultimately, he gives the following definition (p.96): *"Packaging is the fulfiller of functions that is added to a product to bridge the aspects of time and distance at acceptable cost and acceptable environmental impact, ensuring acceptable quality of the product for the end user."*

This definition is a useful start, but it has a few shortcomings. It does not define to whom it should be acceptable. In fact it does not talk at all about the different stakeholders involved in the packaging value chain and their interests. Furthermore the definition would imply that unacceptable costs preclude a candidate from being considered as packaging, whereas it might be more accurate to say that unacceptable costs would characterize a candidate as bad or poor packaging. Finally this definition does not specifically address the marketing functions of packaging; as such it is limited to the physical and economical dimension of packaging.

There are many other definitions in literature, which all have their merits too. Paine (1962, p.1) quotes two definitions as better than others:

- *“Packaging is the art, science and technology of preparing goods for transport and sale.”*
- *“Packaging may be defined as a means of ensuring the safe delivery of a product to the ultimate consumer in sound condition at the minimum overall cost.”*

The first combines the artistic design aspect with an engineering aspect, and incorporates both the physical distribution component and a marketing component. The second follows the same approach as Ten Klooster, in that it defines packaging as a function fulfiller.

The European Commission (1994) defines packaging as:

“Packaging shall mean all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer, ‘non-returnable’ items used for the same purpose shall also be considered to constitute packaging.”

This definition again takes the approach of packaging as a function fulfiller. Another useful description is that by Selke (1997, p.1):

“The basic purpose of packaging is to enable the right goods to get to the right place at the right time in an acceptable condition. Of course, the users of packaging want to do this as economically as possible; the marketers want the package to attract consumers; the environmentalists want to minimize the environmental impacts of producing and discarding the package; and other parties have other jobs for the package to perform, as well.”

One strength of this description is that it explicitly mentions the existence of different stakeholders and their different expectations from packaging.

Some of these definitions do include stakeholders, whilst others do not. Some include marketing and/or environmental aspects, whilst others do not. Combining the strong aspects of several definitions, leads to a definition that suits this thesis well. Because the focus of this thesis is on a specific sub-set of products, namely consumer durables, and in particular Consumer Electronics products, it is easier to come up with a definition that does not exclude a specific type of packaging, or includes something which is not packaging. In this thesis the following definition of packaging is used:

“Packaging is a fulfiller of functions, made of any materials of any nature, added to a product with the aim of facilitating getting the right product to the right

place at the right time in the right condition, and to present this product in the right way, as defined by the stakeholders in the value chain of the packed product."

Sustainability & EcoDesign

This thesis has been written from a sustainability perspective. Its goal is to contribute to making packaging for CE products more sustainable. The most widely used definition of sustainability is the one proposed by the Brundtland Commission in their report *Our Common Future* (Brundtland, 1987): *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* This definition is not directly applicable to product or packaging design. A common way of translating this into more tangible criteria is through the *triple bottom line*. Sustainability is concerned with three dimensions; People, Planet and Profit[8] (also see figure 1.2). Here the term 'Planet' represents the environmental component, the term 'People' represents the social component and the term 'Profit' represents the economical component. Design for Sustainability is designing products in such a way that they balance these three aspects.

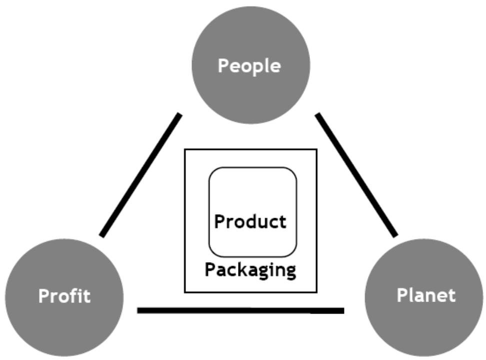

Figure 1.2: The three aspects of Design for Sustainability (People, Planet, Profit) and the place of sustainable product and packaging.

Sustainable Packaging development

Within this framework of sustainability and EcoDesign two distinctly different things can be distinguished. On the one hand there are products resulting from a process aimed at striking a sustainable balance (irrespective of whether the outcome is entirely successful), and on the other hand there are products that do strike this balance (irrespective of whether such an outcome was the objective of the followed process). Hence, 'sustainable packaging' would be packaging that strikes this balance between the people, planet and profit components, irrespective of the design process (i.e. whether it was intended or not). 'Sustainable packaging development' on the other hand, is a design process aimed at striking this balance, irrespective of whether it is successful. Hence:

[8] Both the term 'triple bottom line' and the 3Ps were coined by John Elkington in the mid-1990s.

"Sustainable Packaging Development is the development process aiming to find a balance between economic, environmental and social aspects in a packaging solution."

EcoDesign

The terms Design for Environment, (Applied) EcoDesign and Design for Sustainability are often used as if they were synonymous, but they are not. Chronologically they followed each other. The term Design for Environment was often used in the beginning of the 1990s, when design projects were aimed at improving environmental performance, irrespective of economical and social performance (i.e. only the 'planet' component). The term (Applied) EcoDesign is used as a label for a process focusing on balancing the environmental impact of products with economic performance, without taking social concerns into account (i.e. the 'planet' and 'profit' component). Finally Design for Sustainability aims at balancing all three components. As such traditional EcoDesign is a part of Design for Sustainability. In this thesis *EcoDesign is defined as the process of aiming at finding a balance between economic and environmental concerns*.[9]

Consumer electronics

Consumer electronics are products containing a printed circuit board, intended for everyday, non-commercial use by individuals. Consumer electronics include entertainment products such as televisions, radios and DVD-players, as well as communication products such as mobile phones. Other products from categories such as domestic appliances (e.g. coffeemaker), personal care (e.g. electric shaver), IT (e.g. desktop computer) and photography (e.g. digital camera) may also be included under the term consumer electronics.

The Consumer Electronics Association (2009) estimates the yearly U.S. consumer electronics market at $165 billion. If the relation between packaging & distribution cost and retail price found by Keijzers (2003, see also footnote 1) is taken as an indication, that would put the total global expenditure on packaging & distribution related to CE products in to order of several billion dollars per year.

Tables 1.2 and 1.3 give some data regarding the number of units sold per product per year or per quarter, as an indication of the size of the industry. The dominant packaging function has been assessed for each product category.

Product type	Million units per Quarter*	Dominant functionalities
Hair-care / Grooming	20	Sales and Experience
Oral care and other personal care	23	Distribution and Sales
Floor care	8	Distribution
Cooking electrics	9	Distribution

Table 1.2: U.S. quarterly sales (Q1 2009) of domestic appliances. *) source: IHA, 2009.

[9] It should be noted that in everyday language all activities that have to do with environment are now addressed as Design for Sustainability, even if in essence they are only (outdated) environmental design activities that do not take the economic interests of business and/or social issues into account.

Product type	Units sold per year (mln)	Dominant functionalities	Sources
Mobile phones	1000	Sales and experience	Cellular News, 2007; Sherwood, 2008; Charny, 2005
LCD televisions	100	Distribution	Display search, 2009; EMS Now, 2007
PCs	275	Distribution	Ogg, 2009; PCB007, 2009
Cameras	125	Distribution and sales	Shankland, 2009; Reuters, 2007

Table 1.3: Indication of order of magnitude of global shipments of CE products.

1.6 Scope of the present research

As decisions related to packaging mainly have to do with economical and environmental aspects, and not so much with social aspects, this thesis has a main focus that is on EcoDesign of packaging. The final user of the product, and therefore of the packaging, is taken into account, as subjects such as openability will be addressed, but this is not seen as (the major) part of the social aspect of sustainability (for a further discussion of the social component of sustainable packaging, see Wever & Tempelman, 2009)

Within this focus on EcoDesign of packaging an approach is taken that acknowledges business realities by accepting that there are functionalities related to marketing. The objective is to identify and utilize the potential for improvement within that business setting. The objective is *not* to argue that only the most environmentally friendly packaging design is acceptable, while disregarding business reality.

This thesis deals with packaging for consumer durables, in particular Consumer Electronics products[10]. To some extent the challenges in this field may also be applicable to packaging for Fast Moving Consumer Goods (FMCG, e.g. food, beverages)[11]. The choice for CE goods is made because of some specific characteristics of these products, and the pragmatic consideration of available industry contacts. The characteristics of the CE market that make it a logical choice for this study are first the size of the market[12] that make it of such economic and environmental relevance that improvements will actually have a substantial global impact. Secondly, the market situation has changed, with new retail formats emerging, thus leading to new packaging functionalities (as will be discussed further in Intermezzo A and Chapters 4 and 5), which are different from a lot of other consumer durables due to the size, price and purchase frequency of CE goods. Thirdly, in the current market packages can be observed that represent a

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[10] Other types of durable consumer goods will be addressed in Intermezzo B.

[11] On the one hand ,the functionalities that FMCG packaging has to fulfill are similar to that of packaging for durables, although the relative importance of each of those functionalities may differ. On the other hand, in the view of industrial design engineers, a major difference is that with durables the content of the packaging is considered the object of design, while with FMCG the packaging is the object of design.

[12] Global Electronics Industry will grow to $700 billion by 2009, CEA/GfK study finds. Press release of Consumer Electronics Association, Arlington, Virginia, July 9th, 2008.

mix of all three types of functionalities, as well as packages that are strongly dominated by one of them (i.e. a pure experience packaging, or a pure sales packaging). Together these reasons make the CE industry ideal for a descriptive study into the dynamics between the different types of functionalities, as well as for the development of a holistic design engineering approach to packaging.

1.7 Structure of this thesis

This chapter has argued that a *Design for Volume Optimization* strategy is a promising strategy to obtain more sustainable packaging. The functionalities 'causing' the volume of a package are identified as belonging to three groups, namely distribution related, sales related and brand-experience related, of which the latter two are relatively new to this industry, in the sense that they have been explicitly addressed during the design process.

Before analyzing the relationship between each of these groups and packaging volume, first a general review of packaging design methodologies is given in Chapter 2, as any proposed method of optimization will have to be incorporated in existing design methodology. In this chapter current packaging design practice will be compared to general design theory, to see if it differs, and if so, how and why.

Chapter 3 will look into the relationship between distribution-related packaging functionalities; i.e. handling enablers and protection. This is done through an empirical research using data from the environmental-benchmarking program within Philips Consumer Electronics. This work will also demonstrate the existing inconsistencies within the market place for products with similar functionalities.

Furthermore, the difference in volume characteristics between distribution-dominated and marketing-dominated packaging designs will be addressed here.

Before moving on to the relationship of retailing (i.e. sales) and pack volume (Chapter 4) and the relationship of experience and pack volume (Chapter 5), an analysis will be given on how sales and experience became relevant functionalities, based on the process of commoditization of CE goods (Intermezzo A).

As most packages will fulfill more than one type of functionality, Chapter 6 will discuss the mix of functionalities, and how to determine this mix for a given product.

The second Intermezzo will be 'variations on a theme'; analyzing data from other durable consumer goods, to assess whether the findings from the CE industry can be generalized to domestic appliances, toys, power tools and furniture.

Subsequently, Chapters 7 and 8 will describe different design optimization strategies from respectively the distribution perspective, and the sales and experience perspective, and discuss their feasibility. Chapter 9 present discussion, recommendations and conclusions.

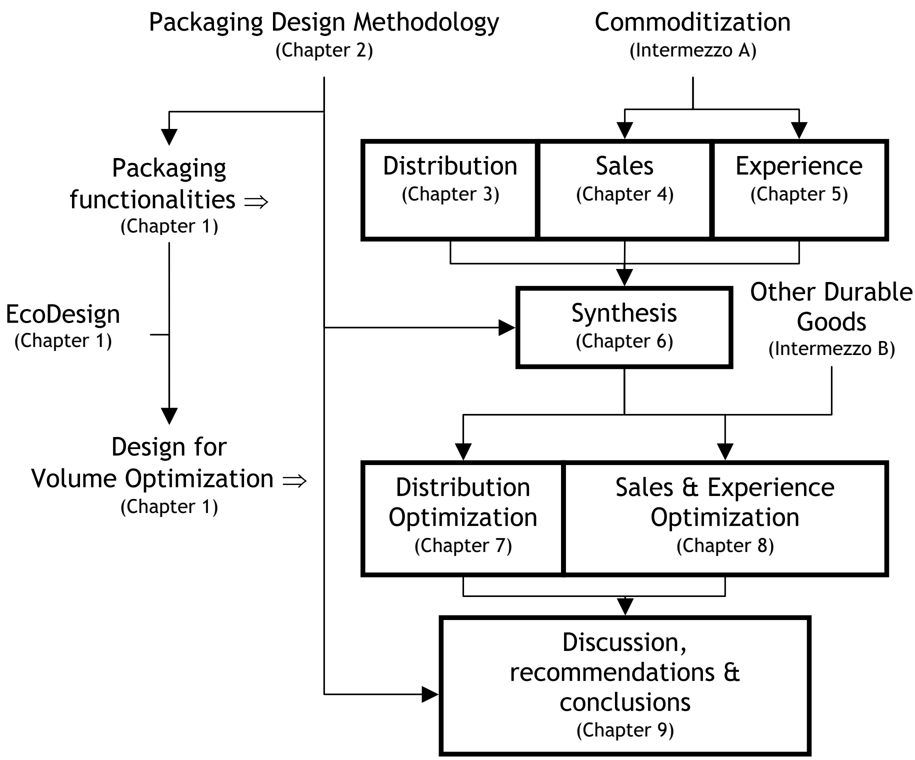

Figure 1.3: The outline of the thesis.

Summary

In summary, this thesis addresses volume optimization of packaging for consumer electronic products, with EcoDesign as a driver. The findings are distinguished from previous work in that EcoDesign regarding this type of packaging has so far been focused solely on resource conservation and material recycling. Furthermore, a holistic approach, combining both distribution-related and marketing-related functionalities into a single optimization process, is also lacking. Addressing this issue may yield savings in both an economical and a environmental sense.

"Overpackaging is the only sure way to compensate
for the amount of error and to protect
against possible damage—but it's a poor solution
from a cost viewpoint"

ALFRED H. MCKINLAY (1998, p. 52)

2. The Packaging Design Engineering Process[13]

In this chapter present-day packaging development for durable consumer goods will be studied. The goal is to answer several of the research questions posed in Chapter 1, namely:

- How are the dimensions of packaging currently established, i.e. what process is followed?
- Does the present-day packaging development practice reflect present-day design theory? And can discrepancies, if any, be explained?
- What functions does present-day packaging for CE products fulfill?

In order to answer these questions a literature research has been executed, which will be compared with observations from company visits, to packaging suppliers, Original Equipment Manufacturers (OEMs) and packaging testing labs. Furthermore, design case studies from literature are discussed. Finally, a survey among product managers and packaging developers within Royal Philips Electronics has been conducted to deepen the insight into the different functions of packaging.

Introduction

An integral approach to the design of packaging for CE goods would imply a process that takes into account all requirements, whether they are technical, financial, environmental or psychological in nature, and that also incorporates the relationship between the packed product and the packaging. In this thesis such an integral approach will be called *packaging design engineering*. This term is an adaptation of Industrial Design Engineering as it is taught at Delft University of Technology.

In everyday packaging reality though, a split between *packaging design* and *packaging engineering* can be observed[14]. Packaging engineering has to do with protection, and the fulfillment of distribution functions. Packaging engineering deals with the three-dimensional design, which is also referred to as the structural packaging design. This is the expertise typically offered by packaging suppliers.

[13] Wever, et al. (2008a) 'Packaging for Consumer Electronic Products; the Need for integrating Design and Engineering', was based on a draft version of this chapter, and presented at the 16th IAPRI World Conference on Packaging, June 8-12, 2008, in Bangkok.

[14] This observation is partly based on visits to several packaging suppliers and packaging testing facilities. These were Huhtamakhi in Drachten (NL), Smurfit Kappa in Eindhoven as well as in Hoogeveen (NL), Brødrene Hartmann in Lyngby (DK), and Pira International in Leatherhead (UK). It is also supported by a similar split between engineers and designers in packaging literature, as becomes apparent from the overview of monographs which will be presented in section 2.4.

Packaging design on the other hand, has to do with the appearance of the packaging and is related to the marketing functions (both sales and experience). Oftentimes packaging design will be limited to two-dimensional graphical aspects. It is typically the part of the total packaging concept that is supplied by external packaging design agencies. This split between packaging engineering and packaging design can also be seen in the organization of some large CE companies, as for instance within Royal Philips Electronics, there is a department called Philips Packaging Development, which assists business units in developing the packaging from a distribution point of view. Simultaneously the Philips Design department developed a harmonization program for the graphical appearance of packaging (Marzano, 2005, p. 369).

The tools and methods of packaging engineering and packaging design differ substantially. This is a result of the fact that packaging engineering deals with materials and mechanical behavior, while packaging design deals with perceptions and emotions.

This chapter will identify characteristics of successful design methodology as presented in general product design engineering theory. Subsequently the practice of both packaging engineering and packaging design will be discussed, and compared to these characteristics, in order to see if theory and practice match, and if not, whether the discrepancies can be explained. This will yield pointers as to where and how optimization of the packaging design engineering process is possible.

2.1 Theory of design methodology

The concept of *packaging design engineering* originates in the faculty of Industrial Design Engineering, the school within which this thesis is written. Industrial design engineering is focused on the integral approach of creating mass-produced products. The integration of aspects related to construction, ergonomics, aesthetics, marketing and the environment is deemed to be necessary for obtaining a successful design (Roozenburg & Eekels, 1995; Buijs, 2003; Buijs & Valkenburg, 2005, p.391).

Over the years many models of the design process and the innovation process have been proposed. Partly based on an extensive review of these previously proposed models a new model, the so-called Delft Innovation Model (see Figure 2.1), has been developed within the faculty of Industrial Design Engineering (Buijs 1979, 2003, Buijs & Valkenburg, 2005). This model represents the innovation process as circular, containing the stages of 'product use', 'strategy formulation', 'design brief formulation', 'product development', and 'product launch'.

Due to the extensive nature of their review work in the development of the Delft Innovation Model, the publications describing this work (Buijs 1979, 2003, Buijs & Valkenburg, 2005; Roozenburg & Eekels, 1995) are used as basis for identifying characteristics of successful design processes.

It should be noted that models are abstractions of reality, highlighting aspects of reality deemed important by the author of the model. Following an innovation model during a project is not necessary for success, nor is it a guarantee for success; rather, the author of a model stipulates that following a model will increase the chances of a successful outcome.

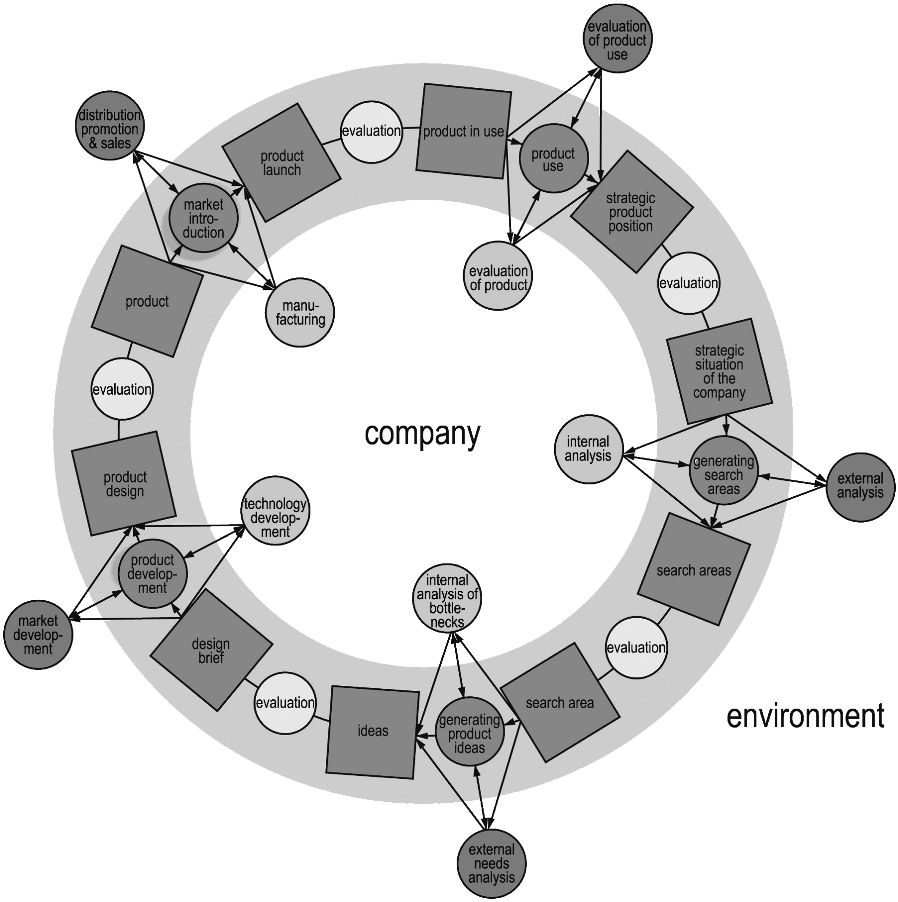

Figure 2.1: The Delft Innovation Model (Buijs & Valkenburg, 2005). Circles represent (sub-) processes, while squares represent the results if those processes. Note that the term 'environment' is used here as a term for 'competitive environment'.

Roozenburg and Eekels (1995) present a model of a basic design cycle, consisting of an analyze–synthesize–simulate–evaluate sequence (see Figure 2.2a). This cycle is present in each step in the design process (Buijs & Valkenburg, 2005). Hence it applies to the process as a whole, as well as to steps within this process, such as the detailed design of a small component. The analysis leads to the criteria the design will have to meet, the synthesis leads to a concept, which is simulated somehow in order to evaluate whether the concept meets the criteria.

Based on the evaluation a decision is taken to accept or reject the design or to iterate back to a previous phase in order to optimize the design. One aspect of the design process that is highlighted in this model is the systematic approach. Another is that there is the possibility of iterations; stepping back in the process to further optimize the solution.

This basic design cycle starts with a function to be fulfilled, which is assumed to be at least roughly known. In a second modeling of the design process (see Figure 2.2b) Roozenburg and Eekels model the new product development process from the strategic start, through product ideas, to a new business activity. This model also includes the steps that lead to the identification of the function to be fulfilled.

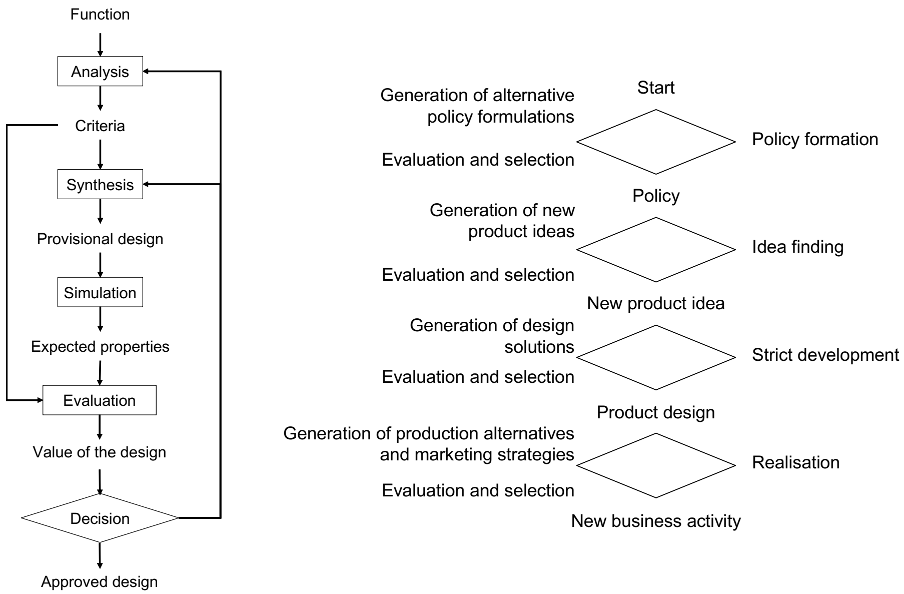

Figure 2.2a: the basic design cycle (copied from Roozenburg & Eekels, 1995, p.88), **2.2b:** Divergence and convergence in the design process (copied from Roozenburg & Eekels, 1995, p.14).

Another aspect that is highlighted in this model is the repetitive pattern of divergence followed by convergence. Alternatives are generated, after which the most viable one(s) are selected, based on which more detailed alternatives are created, etc.

The Delft Innovation Model is the culmination of the Roozenburg and Eekels models as well as other models (for an historical overview, see Buijs, 1979, 2003). Aspects that are highlighted by the Delft Innovation Model are:

- A systematic approach,
- The inclusion of a goal finding phase,
- The cyclic nature of the design process, i.e. a design is based on current use practice and will lead to new use practice, which in turn will be the basis of a new innovation cycle,
- The integration of internal and external factors, covering product, market and technology aspects.

Research into the design process is ongoing at the school of Industrial Design Engineering. However, by and large, these three models still represent how product innovation is taught within the school of Industrial Design Engineering.

In summary, the characteristics that are presented in these models as aspects of a successful design process are that it is:

- A systematic, methodological, and integral process,
- Starting with a analysis in which the required functionality is (measurably) defined,
- Followed by the generation of one or preferably more solutions,
- Which are subsequently evaluated against the defined requirements,
- Based on which a decision is taken to accept, reject or optimize the found solution, i.e. to iterate back to an earlier step.

Design for sustainability

In a discussion of the limited focus of Design for Environment, Stevels (2007, p.20, p.302) discusses the concept of functionality and stipulates that only recently have professionals working in industry on sustainability moved from a self-chosen apartheid to full integration in the value creation process. He stipulates that business is aimed at providing functionality; not only physical functionality, but economic functionality, immaterial functionality and emotional functionality as well. Only when sustainability is fully integrated in the functionality-creation process, can it be successful. Or as Stevels puts it: *"The extended paradigm for Applied EcoDesign is therefore primarily to be derived from design approaches, not from Eco-approaches"*. Hence, general models of the design engineering process are sufficient for the specific green packaging design analysis in this chapter. Therefore, there is no need for specific models of a design-for-sustainability process.

In the following sections packaging development in the CE industry will be described and the (lack of) concurrence with the Delft Innovation Model will be discussed. This comparison is aimed at evaluating both the current practice in industry as well as the Delft Innovation Model. It may yield pointers for improvement, both for industry as well as for the model.

2.2 Traditional Packaging Engineering

As stated in the introduction to this chapter, in current industry practice a distinction can be made between packaging engineering and packaging design, with packaging engineering focusing on distribution performance, and packaging design on marketing performance.

From a packaging engineering point of view the purpose of the packaging is to ensure that the packed product reaches the consumer's home in the same condition as it left the factory, i.e. to protect it from the hazards of transportation. These hazards include shocks, vibrations, humidity, extreme temperatures, etc. Dominating in this aspect is the protection from shocks, as this is the most frequent cause of product transportation damage (McKinley, 1998, p.51). Furthermore, protection from shock is the transportation hazard with the strongest link to packaging volume.

Whether a packaging provides adequate protection depends on three factors, namely:

- The fragility of the packed product,
- The distribution environment,
- The characteristics of the packaging.

Each of these three factors will be discussed in more detail in the following sections. First the theory of how each aspect should be approached from an engineering perspective will be discussed. After that, the actual day-to-day approach in the main stream consumer electronics business will be described.

2.2.1 Product fragility

Product fragility is the measure of the maximum shock a product can withstand, for instance when dropped. It is usually expressed in *G*s, i.e. a number of times the gravitational constant. Theoretically it is possible to calculate the product fragility based on material properties and a given shape, but in practice this is too complicated for most real products (Burgess, 1996). However, product fragility can be tested in a laboratory setting. There is a standardized test available for this (ASTM D3332). Basically this test comes down to fastening a product to a test apparatus that administers a shock to the product. The product is checked for damage after each shock. Starting with small shocks, the level of shock is increased until damage occurs. The last shock that did not cause damage is taken as the safe level.

Whether damage occurs from a shock actually depends on two variables, the peak acceleration and the velocity change ΔV. If the velocity change is small enough no damage will occur no matter how high the peak acceleration. Above the critical velocity change the occurrence of damage depends on the peak acceleration. These two factors can be combined in a *Damage Boundary Curve* (DBC, see Figure 2.3), a graph that has been the standard way of representing product fragility for several decades.

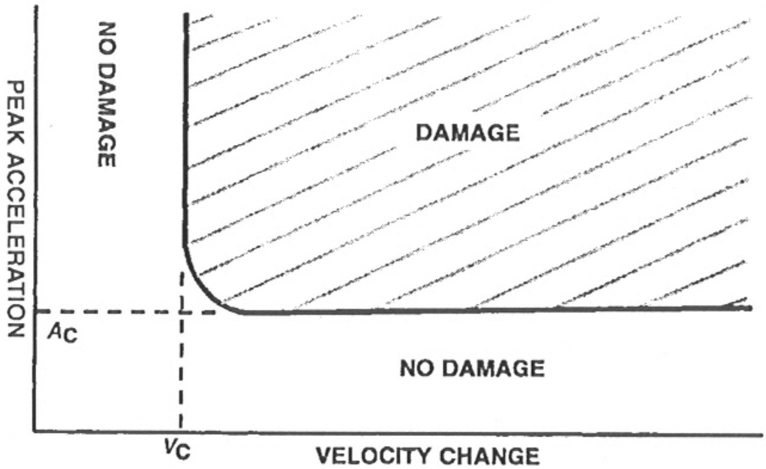

Figure 2.3: the Damage Boundary Curve shows which combinations of velocity change and peak acceleration will lead to product damage.

If the shock wave that is administered to the product has a block wave form, the damage boundary curve has a horizontal bottom line. A block wave is the most severe shock possible. The resulting damage region envelopes all other possible wave forms. The actual wave for in the real world can have several shapes, but is never a block wave. Hence in using a block wave a certain safety measure is incorporated (Kipp, 2000).

The test prescribes just one product to be tested to determine the critical acceleration. Testing just one product means a statistical sample of one, which doesn't give a very reliable figure. This can be compensated by testing more products; however that raises the costs of products and lab time.

The fragility of the product may differ for each orientation, thus requiring the product to be tested in multiple orientations (McKinley, 1998, p.53; Brandenburg & Lee, 2001, pp.112-113).

Another point of critique regarding DBCs is that, by increasing the impact time after time, fatigue may cause failure in the test product due to repeated low impacts, even though the test is based on the assumption that the final impact, by itself, causes the failure. In other words the product is assumed to fail in a brittle way, while most products behave in a ductile way (Burgess, 1996; Kipp, 2000; Daum, 2004).

CE industry practice

The process described above for determining the fragility of the product has one critical setback when applied to consumer electronics products. It assumes the product is finished before starting, or at least finalizing, the design of the packaging. Due to the dynamic nature of the market and the rapid price erosion of consumer electronics (which will be further explored in Chapter 4) this is not a viable option, as time is money. The moment the first finished products come of the production line, they need to be packed and shipped to final customers. Hence concurrent engineering of product and packaging is essential. Fragility testing can only be performed on previous product models or on mockups. This does not give very accurate data, as mockups are never made with the same production tools as mass-produced consumer electronics are. Therefore the mechanical behavior of mockups and the final product is different.

2.2.2 The distribution environment

The second factor determining the proper condition of the packed product upon arrival is the level of shock that is expected during transportation. Shocks may occur during manual and mechanical handling, but also during transportation itself. For instance, coupling of rail carriages may produce significant horizontal impacts. In truck transport shocks may be direct (e.g. driving over a pothole) or indirect, when small irregularities in the road cause vibrations that build up in stacked packages. Due to resonating effects the top package may 'jump' quite high, and impact the package below. In full-pallet shipments packages are usually tied together with bands or shrink-wrap. In less-than-full-truckload shipments (e.g. from distribution centers to retail outlets) this may not always be the case.

Data is available on the level of shock and vibration that can be expected in several different supply chains. For years a report written in the late 1970s was used as the main data source (Ostrem & Godshall, 1979). This report was actually a gathering of all previous studies, so the data in it was considerably older than the report. As both road conditions and truck suspension has since dramatically improved this data can be regarded as obsolete. Since the 1990s a serious movement has started to update the available data. Due to the fast array of different supply chains not all data has been updated yet. First focus has been on parcel shipments, e.g. UPS, DHL, Fed-Ex (e.g. Singh, et al, 2001; Singh, et al, 2004). Hence there may not always be data available on the actual supply chain a product will be going through.

The occurrence of a certain shock has a statistical likelihood. The more severe a shock the less likely it will be to occur. Figure 2.4 shows a graph (Brandenburg & Lee, 2001, p.106) demonstrating the likelihood of a certain drop height related to the package weight. This is a generalized graph from a US source. The weight is relevant because it is related to the choice for manual or mechanical handling, with related lifting heights. If the most severe shock is taken as a reference for the package design, the result will be overpackaging most of the time. Hence packaging engineers have to decide upfront against which level of impact the product should be protected. This is dependent on the value of the packed product and the cost of additional packaging.

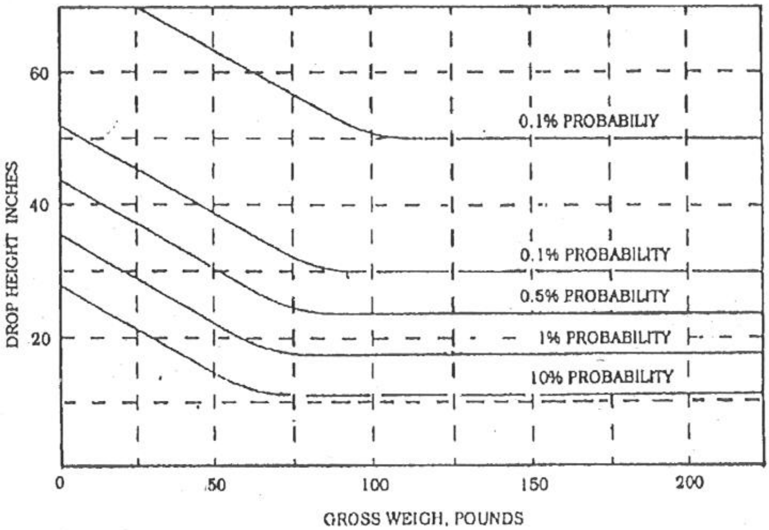

Figure 2.4: The likelihood of a drop from a certain height occurring depends on the weight of the packaging, as this determines to a large extent the way of handling. (Brandenburg & Lee, 2001, p.106)

2.2.3 Packaging characteristics

If the impact at which the product fails during testing is lower than the shocks expected during transportation two options are open, either redesigning the product or protecting it with packaging. Even though redesigning the product can yield substancial savings, as is demonstrated by Nielsen (1994) and Ten Klooster (2002)[15] this approach is seldom taken due to time restraints and the costs related to changing product-specific tools and the resulting delay of the market introduction.

To design a protective packaging in such a way that it will provide precisely the required amount of protection, requires proper knowledge of the mechanical behavior of the packaging material. For some materials, such as expanded polystyrene foam, years of design experience have led to a proper understanding of the behavior of the material. Suppliers provide packaging engineers with graphs which allow detailed design of the cushions.

Of all cushioning materials, most data is available on the behavior of plastic foams. The type and amount of material for cushioning has received a lot of

[15] Nielsen (1994) describes a redesign of a very fragile computer component. Adding some material improved the robustness of the component considerably. The design change cost $1, while the saving in packaging represented $10,80.
Ten Klooster (2002, p. 25) gives an example of a photocopier made by Océ van der Grinten. Packaging designers examined the product to see from which transportation hazards it needed protection. They found that this were mainly vibrations exiting natural frequencies of components. By redesigning the components it became possible to transport 70% of the copiers without any packaging whatsoever.

attention from environmentalists (even though it was demonstrated in Chapter 1 that volume is more essential). From this perspective a move into cushioning made of renewable materials has been evident in the packaging design for consumer electronics for years now. Especially paper-based solutions, such as molded fiber, receive a lot of attention.

Engineering in renewable, natural materials is more difficult than in plastic foams. There is less engineering experience with these materials, hence less is known of its mechanical behavior as a cushion. Furthermore natural-fiber based materials are not homogeneous, which makes their mechanical behavior less constant. Hence engineering an optimal cushion becomes more difficult. Staying with the example of molded fiber, the true understanding of the material behavior and the resulting design rules is evolving only slowly (Eagleton & Marcondes, 1994; Hoffman, 2000; Gurav, et al, 2003, Wever & Twede, 2007).

2.2.4 Traditional packaging evaluation

Once a design for a protective packaging has been made it can be tested to see whether it provides the protection required. In such a test a packed product is conditioned to a certain temperature and humidity and subsequently subjected to a series of drops and vibrations. The drop height(s) in these tests should be a representation of the actual distribution environment. However, most companies have at one time determined a test procedure, which is not revised afterwards, as long as no excessive damage occurs in the field.

Furthermore, once a packaging design passes the test, the usual approach is to accept the design[16]. There hardly ever is an iteration back, to see whether the package would still pass the test with a little less material and/or less volume. Reasons for omitting an optimization step are a lack of time and the fact that a lot of cushioning materials used for mass-produced goods require dedicated tools that cannot be easily changed. For most materials, no reliable rapid-prototyping method is available. Hence the test is more a validation than an evaluation.

[16] This observation is based on visits to several packaging suppliers and packaging testing facilities. These were Huhtamakhi in Drachten (NL), Smurfit Kappa in Eindhoven (NL), Brødrene Hartmann in Lyngby (DK), Pira International in Leatherhead (UK).

Product damage
The optimal packaging for consumer electronics products would allow for some damage. As described in Section 2.2.2 designing a package for even the most unlikely drop would mean that the product is overprotected most of the time. This overprotection has a high economical and environmental cost, both directly through materials used and indirectly through less efficient transportation (as described in Chapter 1). The cost of additional packaging should be balanced with the cost of expected damage (see also Figure 2.5).

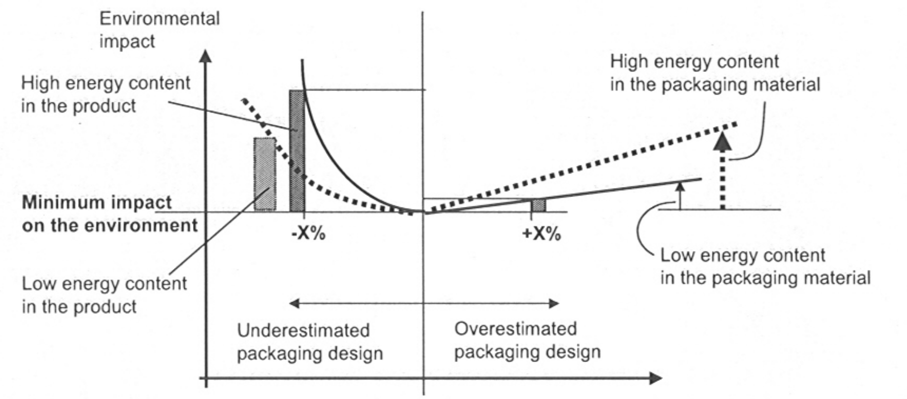

Figure 2.5: There is an optimum between the amount of packaging and the product damage percentage (Erlöv, et al, 2000). (Note that this optimum is *not* zero damage).

However, the cost of damage is not only that of a broken product, but also potential damage to brand reputation if the broken product ends up in the hands of a consumer. Because of this, OEMs (Original Equipment Manufacturers) are wary of accepting less packaging and higher damage rates. (For optimization through the damage rate see Chapter 8).

OEMs do not always collect data on distribution damage. Usually they work with reports from retailers regarding broken products, a statistic sometimes referred to as the 'Field Call Rate'. However, this number is not the same as the percentage of distribution damage, as it also includes:
– Manufacturing errors, i.e. products already broken when they go into their packaging,
– People returning products they could not get to operate, but which are functioning according to specifications (Den Ouden, 2006),
– People returning products that did not deliver the expected functionality, but which are functioning according to specifications (Den Ouden, 2006),
– Damage occurring after unpacking, that is claimed by the consumer to be caused by original distribution,
– Retailers claiming damage in order to get rid of unsold old product numbers.

Furthermore the data may exclude distribution damage for which the consumer did not take the trouble of returning to the store (although it may have caused damage to brand reputation).

To complicate things further, reported damages are not always verified; products reported as broken are often not returned to the manufacturer as costs of recollecting the product and determining the cause far exceed product value.

Finally, it should be noted that the Field Call Rate only relates to damage noticed either at the retailer or at the consumer's home, so *after* the product leaves the control of the OEM. Damage that is noticed during the part of the supply chain that is under the control of the OEM only results in financial damage related to the lost product or to the lowered outlet price. Damage making a product unsalable at full price may be related to the product itself or to the packaging as several retailers refuse packages that show too much wear and tear. Hence data available on distribution damage often is contaminated, unverified, and incomplete. True optimization between packaging costs and resulting damage does not happen in practice.

2.2.5 Conclusion regarding packaging engineering

Packaging engineering is a field of expertise reasonably well developed. It is a systematic and methodological approach. Due to constraints regarding time-to-market, forcing concurrent engineering, packaging engineers oftentimes have to work with data less precise than what they would like. Not every new product can be tested for its fragility prior to the packaging design, data on distribution environment may be outdated or related to different geographical regions, and understanding of the behavior of packaging material may be limited. Besides time constraints, the cost of tooling often prevents an optimization phase in the design after an acceptable packaging design has been found.

Optimization may be based on damage reports from the field but this information is often contaminated with other types of damage, as collecting data on true distribution damage is too expensive.

The packaging engineering approach differs strongly from the methodologies proposed by Buijs and by Roozenburg and Eekels, as the generation of multiple alternatives as the potential for multiple iterations is limited. Furthermore, as stated before, it only looks at part of the functionality of the packaging, namely the physical distribution.

2.3 Packaging design

In addition to the packaging *engineering* process looking at distribution performance, a packaging *design* process can be observed in current industry practice, which looks at marketing performance—both in the form of 'sales' and 'experience'.
From a packaging design point of view, the purpose of the packaging is to help sell the product. To do this several functions come into play, whose importance may differ from product to product. These functions can be:

- Attracting attention
- Communicating Unique Selling Points (USPs)
- Communicating brand image
- Appealing
- Proofing newness (e.g. for hygienic products such as electric toothbrushes)
- Preventing theft (e.g. making small valuable items harder to hide under a coat)

The last two functions are both part of what is also called tamperproof or tamper-evident packaging.

The last function, preventing theft, is an example of a retailer requirement. The retailing of CE goods is evolving into self-service environment, in which packed products are displayed on the shelf. Hence theft prevention has become a relevant function of the packaging. For further discussion of the changes in retailing of CE goods, see Intermezzo A and Chapter 4.

Oftentimes manufacturers will hire outside agencies for this kind of design work. The designs are produced by creative people that often have developed their own design process, as will be apparent from the case descriptions in the following section.

2.3.1 Case studies in literature

Many books are published that show examples of 'great packaging design'. Some of these books also show or discuss part of the development process that let to these designs. Below an overview is given of case studies found in such publications, in order to illustrate how the packaging design process—which is focused on the marketing aspects of the packaging—works in business reality.

Case A: Halford Cycle Computer

Cliff (1999, pp. 16-21) describes a packaging development project for Halfords' cycle computers. The project focused on the graphical aspects of the packaging. The process followed is in reasonable concurrence with the Delft Innovation Model.
External design consultants were hired. They started with an exploration of the current market, studying how competitors positioned themselves. About the design brief Cliff states (p. 17): *"The strategic importance of giving customers enough product information and the long-term need to upgrade customer perception of Halfords' own-brand cycle accessories became the core elements"*. This demonstrates the strong marketing focus of the project. From the start the designers wanted a corrugated board box instead of a blister pack or clamshell.

The designers started generating ideas in the form of very rough sketches. Many alternatives were generated, after which a selection was made of three avenues to explore further. These were detailed and presented to the customer, after which the artwork phase was started for final detailing.

Case B: Telfort Pak&Bel

Koopmans (2001, pp.234-241) describes the development process of the Pak&Bel (Grab&Call) brand for Telfort cell phones. This took place in 1998 when three new providers received licenses to operate on the Dutch market. Telfort was already active in the market for regular phones, and therefore it had an advantage over the other new entrants. Its main challenge lay in making the right marketing decisions.

At that time there were no established pack shapes or market requirements in this young market. Cell phones were perceived by the general public as complicated and something for business people. Telfort wanted to emphasize simplicity. It had to be extremely easy to start using a cell phone. Therefore they needed to position themselves as a retail brand.

Again external design agencies were hired for the design work. They started their work by a field study in the supermarket, as the quintessential place for simple, every-day-like products and packages. Here the idea came about to use the structural design of milk cartons. This design was perfect to communicate the Telfort message of Grab&Call simplicity.

Due to the dynamic nature of the market, the goal of attracting normal consumers to the cell phone market was reached in half a year. Increasingly consumers wanted more advanced phones, with additional functionality. From an advantage, the simplicity concept turned into a disadvantage, and an upgrade was needed. A metal cookie jar was introduced with a high-end Ericson phone.

Later on a second generation milk carton was introduced, now consisting of a rectangular carton within a transparent PET milk carton, which allowed a clear view of the cell phone itself.

This process shows that the structural design was fully based on marketing ideas, and not on physical distribution considerations.

Aspects of a continuous analyze-synthesize-simulate-evaluate cycle can be recognized in this project.

Case C: Boston Acoustics' car audio speaker systems

Cliff (1999, pp.86-89) describes packaging development project for Boston Acoustics' car speakers. Again this project is focusing on the graphical/ marketing aspects of the packaging, and again an external design agency is hired to do the job. Crocker, the head of the agency, describes his way of working as: *"We're hunters and gatherers. We create a scrapbook for each project, and we throw everything in there, idioms, metaphors, sometimes pictures photocopied from old books, or drawings of random thoughts."*

"Eventually the scrapbook process yielded four potential solutions, in particular an idea of a road map with a piece of music, and a 1940s photograph by Paul Rand

for the Auto Car Co. of steering wheels, taken from a book called Thoughts on Design."

"Generally, Crocker will show a client four or five directions, each one visualized as a three-quarter view of the pack."
Again aspects of the Delft Innovation Model with several consecutive diverging and converging steps can be recognized.

Case D: Nikon Compact Camera
Cliff (1999, pp.150-155) also covers two packaging design projects at Nikon, for a newly introduced low-end camera and for a range of more expensive cameras. The project was executed by an external design agency, which focused strongly on marketing issues, such as retailer demands, retail audits identifying competitor design styles and analyzing the Nikon brand identity. Although they came up with structural design for both projects, the designers were focused strongly on the marketing aspects. For instance, the selection of the type of cushioning material was based on the appearance related to the product, and not primarily on its cushioning characteristics.

Case E: Packaging for the Discovery Channel label
Fishel (2003, pp.86-89) describes a packaging project for Discovery Channel. Discovery Channel puts its name on a wide variety of products, ranging from headphones to tool sets, to popcorn dishes, to DVDs and to kids' science products (e.g. microscope, metal detector). All these products are produced and packed by third party manufacturers. Also target group-wise there is a wide spread with kids' products, adult products and products specifically aimed at either men or women. Furthermore there was the complicating factor of sub-brands such as Animal Planet. The products are sold in a variety of retail outlets ranging from high-end specialty stores to large retail outlets.

An external design agency was hired to develop a design guide for the packaging of all these products, which eventually consisted of prescribed several color palettes, typefaces and patterns. Again this project focuses exclusively at the marketing aspects of the packaging.

Case F: Remington Electric Shaver
Cliff (1999, pp.188-191) follows the development process of the new packaging for a range of electric shavers by Remington. There were three different models to be packed. An additional challenge being that Remington had no basis for claiming superiority over wet shaving or competitor brands. The external agency followed a process of mood boards leading to 3 concepts. The size of all the packs was unified because of a marketing choice to emphasize the connection between the different shavers.

Experience packaging
Cases A through F all cover examples of sales-related packaging. As mentioned previously, the marketing function of packaging for durable goods can be split into

sales-related and experience-related functions. The typical example of an experience-related packaging is the packaging of Apple products. For their product line of MP3 players, as well as their laptops, they design packaging for its unpacking experience. Products like MP3 players do not need a lot of physical protection as they are relatively robust by themselves, as compared to other CE products. Furthermore, Apple does not have to compete on the shelf with competitor brands. Their packaging only has to contribute to a brand image that creates added value compared to other brands, thus allowing Apple to charge a premium price. This topic will be further addressed in Chapter 5.

Conclusion from case studies on packaging design

These case studies demonstrate that many packaging design project have a strong focus on the marketing functions of the packaging. Projects are often executed by design agencies that have little expertise on packaging *engineering*. It is relatively common for the marketing functions to directly determine the structural design and volume of the package (e.g. Telfort Pak&Bel and the Remington Shaver).

2.3.2 Evaluation tools for packaging design

As the goal of marketing is to sell products, and many packaging designs are based on marketing functions, determining the performance of these designs becomes relevant. The effectiveness of a design cannot be *calculated*, like can be done with costs. It can however be *tested*, and to a certain extent *measured*. There are several tools available to test the marketing performance of pack designs, mainly coming from fast moving consumer goods (FMCG), and each focusing on different aspects of the performance (Wever, Boks & Stevels, 2006a, Wever, et al, 2007):

- Focus groups

  ‘Focus groups’ is a research method consisting of a group interview with carefully selected participants from the products’ target group. Focus groups have traditionally been widely used as a packaging design research methodology. It has been applied both at the start of design projects as market research and for evaluation of final designs, i.e. a form of disaster check.

  A weak point of focus groups is that it does not resemble real purchase situations very well as people do not deliberate about a product for an hour, before buying it or not, at least not with fast moving consumer goods. Hence it may be a reasonable research method for durable consumer goods, where often consumers take more time to reach a purchase decision. As stressed by Gold (2004) it is very important to at least place packaging designs next to competitor products, to improve the realism of the setting. Nevertheless, the focus groups approach does not give a numerical output; information about the packaging is generated but performance is not quantified.
- Eye-tracking

  Other methods do allow for measuring. One of these is eye-tracking. The basic idea of the test is to use equipment which is attached to a participants head to measure where (s)he is looking. When performing this test with a section of store-shelves, it can be tested how many consumers look at a certain package, how long, how often and in what order (Swope, 1981).

- Tachistoscopy (T-scope)
  Another test allowing a certain level of quantification is the Tachistoscope (T-scope). This is a method in which a participant is shown flashes of a product. Starting at for instance 1/100th of a second, exposures are incrementally increased to for instance 2 seconds. After each exposure the participants is questioned about what he saw. Hence average time scores can be obtained needed for aspects like brand recognition, product type identification and noticing special product features (Swope, 1981; Morich, 1981). Where eye-tracking determines where we look, the T-scope focuses on what we have actually seen.
  Hence T-scope is a useful tool in cases where product recognition is of the highest importance, such as medicines which may have to be used quickly in an emergency (Anon., 1993). T-scope testing has also been applied as a scientific research tool, for instance to research the effects of latency of the brain, i.e. whether placement of text and illustration on the left or right of a package made a difference (Rettie & Brewer, 2000). Major disadvantage of this method is that its setting is very different from actual shopping environments.
- Semantic differential
  This is a method in which participants are asked to score designs on scales between two extremes, i.e. modern versus old fashioned or beautiful versus ugly (Schoormans & De Bont, 1995). In comparison to eye-tracking and T-scope, Semantic differential will measure how people feel about a package.

These tools are not regularly applied in CE business practice. However, the harmonization program for Philips packaging was tested using laser eye-tracking and in-depth interviews (Marzano, p.371). As testing takes time and time-to-market is essential in the CE business, testing that was scheduled within a specific packaging project is oftentimes skipped in the end.

2.3.3 Conclusion regarding packaging design

Packaging design, as opposed to packaging engineering, is related to marketing functions, and is therefore focused on the appearance of the packaging. It is more an applied art than a science. Many different creative design processes are being applied. However, aspects such as the basic design cycle of analyze-synthesize-simulate-evaluate can often be recognized, as can repetitive divergence and convergence steps.

2.4 Overview of Pack Design books

As is evident from the quotes in the previous section a considerable body of literature is available regarding packaging design and packaging engineering. The table below gives an overview of some of the most relevant books[17]. Here again a split can be observed between books focusing on packaging *design* aspects or

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[17] The selection was written, based citations in other literature used for this thesis and was checked against the catalog of the Delft University library and through Picarta, a meta-search engine which gives an overview of most library collections in the Netherlands, including the university libraries.

packaging *engineering* aspects. This split is especially evident for books dealing with durable consumer goods.

Source	Title	Field	Perspective
Friedman (1977)	Distribution Packaging	Transport packaging	Engineering
Paine (1977)	The Packaging media	All packaging	Engineering
Paine (1985)	Fundamentals of Packaging	Transport packaging	Engineering
Sonsino (1990)	Verpackungsdesign	FMGC	Design
Paine (1991)	The packaging user's handbook	All packaging	Engineering
Stewart (1994)	Packaging design Strategy	FMGC	Design
Hine (1995)	The total package	FMCG	Design
McCaughey (1995)	Graphic design for corrugated packaging	All packaging, but only printing	Design Engineering
Stewart (1995)	Packaging as an Effective Marketing Tool	FMGC	Design
Soroka (1996)	Fundamentals of packaging technology	All packaging	Engineering
Hanlon (1998)	Handbook of package engineering	All packaging	Engineering
Cliff (1999)	50 trade secrets of great design: Packaging	All packaging	Design
Brandenburg & Lee (2001)	Fundamentals of Packaging Dynamics	Transport packaging / durable goods	Engineering
Koopmans (2001)	De kracht van verpakking [*in Dutch*]	All packaging	Design
Ten Klooster (2002)	Packaging design : a methodical development and simulation of the design process	All packaging, but mainly FMCG	Design Engineering
Ambrose & Harris (2003)	This End Up: original approaches to packaging design	All packaging	Design
Fishel (2003)	Design Secrets: packaging—50 real life projects uncovered	All packaging	Design
Calver (2004)	What is Packaging Design?	All packaging, but mainly FMCG	Design
McKinlay (2004)	Transport packaging	Transport packaging / durable goods	Engineering
Klimchuk & Krasovec (2006)	Packaging design; Successful Product Branding from Concept to Shelf	All packaging	Design
Ten Klooster, et al (2008)	Zakboek Verpakkingen [*in Dutch*]	All packaging	Design Engineering

Table 2.1: Overview of packaging monographs with their focuses on types of packaging and types of functionality. (FMCG = Fast Moving Consumer Goods)

2.5 Relative importance of functionalities

It depends on the product which type of functions will take priority in determining the final appearance of a packaging design. To illustrate this, several product managers and packaging developers within the Philips organization were contacted and asked to rank several packaging functions according to their relevance for their particular product.

For instance for shavers, the containment of accessories was deemed important by the packaging team, as a shaver comes with many small accessories. Furthermore, attracting and informing the consumer were deemed most important; which are typical marketing functions. These are functions they spend their time on. The two tamper-related functions, proofing newness and preventing theft, were also deemed important, as shavers are a high value hygiene-related product. The more distribution-related functions were deemed less relevant.

Table 2.2 shows that for a broad variety of products, such as television sets, distribution related functionalities dominate, while for others such as personal audio (e.g. MP3 players) marketing functions are by far dominant. Here experience functionalities were not identified. That may be because this analysis was done solely with Royal Philips Electronics, and their packaging, at least at the time, was more sales than experience oriented.

Packaging Functions ► / Product type ▼	Mechanical Protection	Keeping dry and clean	Containing accessories	Handling	Informing supply chain	Informing consumer	Attract consumer attention	Prevent theft	Proof of newness
TV sets	4	4	2	3	2	1	1	0	0
DVD(R)	4	3	2	1	2	2	3	0	1
Audio sets	4	3	2	1	2	2	2	0	1
Personal audio	4	2	3	0	2	4	4	4	3
Mobile phones	1	3	4	0	3	3	3	3	4
Shavers	1	2	4	1	1	4	4	3	3
Light bulbs	4	3	0	2	2	3	2	1	1

Table 2.2: Influence of potential packaging functions on the final appearance of the packaging for several types of consumer electronics products, with 0 meaning no relevance, and 1 to 4 indicating an increasing scale of relevance. (Wever, Boks, Marinelli & Stevels, 2007).

2.6 Discussion and conclusions

In this chapter present-day packaging development for durable consumer goods was analyzed, thus answering several of the research questions posed in Chapter 1, namely:

- How are the dimensions of packaging currently established, i.e. what process is followed?
- Does the present-day packaging development practice reflect present-day design theory? And can discrepancies, if any, be explained?
- What functions does present-day packaging for CE products fulfill?

As this chapter has shown the volume of a package can be a result of distribution related packaging functions, as well as the result of marketing related functionalities (both sales and experience). Often packaging has to fulfill a mix of these functions. Which type of functionality is dominant differs from product to product.[18]

Each type of functionality (mix) comes with its own design process, usually executed by different people. In most cases one of the types of functionalities seems to dominate the packaging development process.

If the emphasis is on packaging *engineering* a process is followed that matches the basic design cycle as presented by Roozenburg and Eekels (1995), with the exception that there usually is no option to iterate back and improve the design further.

Due to time-to-market restraints and limitations in the available data, the result of packaging engineering is not necessarily optimal. In the reality of the CE market, packaging professionals often have to work with estimated data regarding product fragility and the hazards of a particular distribution system. Even after shipping the feedback data is not clear enough to get a detailed picture of the pack performance. Furthermore the fact that tooling for mass-produced cushions is expensive, and there are no reliable rapid prototyping methods available for many cushioning materials, a satisfying solution often has to be accepted, instead of searching for an optimal one.

If the emphasis is on packaging *design* several processes can be distinguished that show similarities to the Delft Innovation Model; aspects such as the basic design cycle of analyze-synthesize-simulate-evaluate can often be recognized, as can repetitive divergence and convergence steps.

The same time-to-market restraints that complicate the packaging engineering process, limit the testing of the effectiveness of individual pack designs from a marketing perspective. Several tests are available, but they can be time consuming, and are therefore oftentimes skipped in the end of a development

[18] It should be noted here that the dominant factor in determining the volume of the packaging is not necessarily the same as the dominant factor determining the total design. For instance, the packaging volume for a large television set may be purely the result of distribution related functions, while marketing related functions will determine the required level of finishing, i.e. the quality and elaborateness of the printing.

process. A quick-and-dirty methodology could help here, but it is not currently available.

Packaging development literature shows a clear gap in regard to an integral approach of packaging for durable consumer goods, integrating both distribution and marketing aspects. This lack of integration is apparent in industry as well; there are *packaging designers* and *packaging engineers*, but hardly any *packaging design engineers*.

Chapter 1 has identified a potential for volume optimization. In order to achieve that potential, a integral packaging design engineering approach is needed. Chapter 2 has demonstrated that such an integral approach is currently lacking. This thesis aims to fill this gap, by taking an integral design engineering approach to the packaging development process.

"What are the facts, and to how many decimal places?
You pilot always into an unknown future;
facts are your single clue. Get the facts!"

ROBERT A. HEINLEIN (1973)

3. Distribution of Consumer Electronics Products[19]

In Chapter 1 it was demonstrated that volume is a critical design parameter for packaging of consumer electronics products. A core research question asks to what extent the volume can be optimized. In Chapter 2 it was already demonstrated that there are multiple functions for a packaging to fulfill, namely distribution-related, sales-related and experience-related functions. Furthermore, Chapter 2 clarified that the approach in practice often is one-sided, either on packaging engineering, or on packaging design.

This chapter will look more deeply into the physical distribution of packaging. The process of physical distribution will be illustrated. The main part of this chapter will be dedicated to an empirical study that focuses on two parts. Firstly, the relationship between distribution functions and the resulting volume of the packaging will be examined. Secondly, the spread in performance for both distribution-dominated packaging, as well as marketing-dominated packaging will be examined, in order to determine to what extent there is room for improvement.

3.1 Physical distribution

Due to economic reasons production of CE goods is taking place in low-wage countries; for the European market these currently are Eastern-Europe and especially the Far-East. Moving production to these countries has resulted in increased transportation distances, as well as increased organizational challenges due to increasing lead times. This re-location has only been possible due to the rise of containerization, which only got seriously underway in a standardized manner from around 1970 (Levinson, 2006, e.g. p.169, p.218).

The distribution process of CE goods can be split into three distinct phases. First the distribution from the factory to the distribution centers (see Figure 3.1a), which is characterized by full truck loads (or shipping containers), meaning that an entire shipment consists of a large quantity of one product. Then, at a certain point down the supply chain, these full truck loads are split up and re-grouped into mixed loads (which are also called less-than-full truck loads) that go to specific retailers (see Figure 3.1b). Finally there is the transportation from the retailer to the consumer's home, usually in the car of the consumer. In travelled distance, the first leg is the major part, and that is the leg that is volume-critical, as demonstrated in Chapter 1. The other two legs of the journey are neither weight-

[19] This chapter is heavily based on R. Wever, Th. Marinelli (2004) and R. Wever, C. Boks, Th. Marinelli and A. Stevels (2007).

nor volume-critical, as they are usually not full shipments. For this reason the focus of the empirical study presented in this chapter will be on the volume efficiency of the full container loads.

Figure 3.1a (left): An incoming full truck load being unloaded. (Photo: M. Keijzers, 2003)
Figure 3.1b (right): An outgoing mixed load being loaded. (Photo: M. Keijzers, 2003)

3.2 Methodology

In order to assess volume efficiency of full container loads, data is needed that contains a sufficient number of packages with data on dimensions of the packages and the products inside. For this project, data were available from Philips Consumer Electronics, collected over several years for the purpose of environmental benchmarking. These data contain a wide array of CE products, ranging from televisions and monitors to personal audio and universal remote controls. About 30% of the products in the data pool are Philips products, while the rest are made up by a wide range of competitor brands.

3.2.1 Benchmarking

The basic idea of product benchmarking is to compare a company's products with the direct competition. The goal is twofold. First, it allows the determination of a company's position in the market. On which aspects do its products score better than the competition and on which aspects do they score worse? Second, smart solutions used by competitors (that are not protected by patents) can be adopted in the next generation of the company's own product. Within Philips product benchmarking is performed with a focus on environmental aspects.

3.2.2 Environmental benchmarking at Philips

In the mid-1990s, the so-called Environmental Benchmarking Method was developed by Philips in cooperation with Delft University of Technology (Boks & Stevels, 2003). It has been in use ever since. One of the first examples where environmental benchmarking has been successful this way has been reported on in Eenhoorn and Stevels (2000).

Since the start of benchmarking at Philips CE, well over 100 benchmark studies have been performed, solely on a product level. The standard procedure involves the identification by a business group of a candidate product for benchmarking analysis, which is then carried out by the Sustainability Center (SC), a competence center working with the business groups in integrating sustainability issues with main stream business. The Philips product is then benchmarked against its best commercial competitor and one or more other direct competitors. The environmental performance of these products is compared on five focal areas, namely energy, weight, packaging and transport, potentially toxic substances and recyclability. For each focal area standardized environmental indicators have been developed by which the products are judged. Each benchmark study results in a report which concludes whether or not the Philips product under evaluation can be named a 'green flagship'. For further explanation on Philips' environmental benchmarking procedure see Boks and Stevels (2003).

3.2.3 Meta-analysis

These benchmark studies are very useful for environmental improvement in product redesigns, yet they remained on a specific product level. In recent years it was acknowledged that it may well be possible to draw more general business-performance conclusions by combining data from multiple product-level reports, which could support strategic decision making. Or as Boks and Stevels (2003) put it: *"…whereas the individual benchmark reports have contributed to product improvements, cost reductions and general environmental awareness through the organization, it is believed that from combining data from individual benchmark reports additional data and pointers for improvement can be generated…"*. First experiments in this area, based on the Philips Consumer Electronics data, were reported in Boks and Stevels (2002a, 2002b). In this chapter a more substantial case study is reported on, aiming at gaining inside in the general performance of packaging as related to distribution functionalities.

The SC has been performing benchmarks of Philips CE products for about a decade now. The way of working has continuously evolved into its current form. Since 2002[20] the data collected on each product, and relevant to packaging, is:

- Weight of product, packaging, accessories and manual;
- Dimensions of product and packaging (height, length, width, volume);
- Weight of corrugated board box;
- Material and weight of cushions;
- Material and weight of additional bags, closing strips, tape etc.

Based on these measurements several indicators are calculated in order to make the products within one study comparable. These indicators are also suitable for use in a meta-analysis across the different benchmark studies.

Originally the benchmark procedure presented a formula by which to judge packaging:

$$Packaging\ formula = \frac{weight_{packaging}}{weight_{product}} \times \frac{volume_{packaging}}{volume_{product}} \times number\ of\ materials \qquad [3.1]$$

This formula originated from the general environmental focus on material reduction and recycling discussed in Chapter 1. It has been very useful in evaluating packaging performance and identifying over-packing[21]. For one thing, it yielded the awareness that volume, due to the direct influence of packaging volume on the required number of containers, is by far the most important cost-driver in packaging design. Due to the environmental impact of long distance transportation, volume also is the major environmental driver of packaging for CE products (see also Chapter 1).

Volume has always been a part of the packaging benchmark formula, yet with weight and number of materials as equally important. In this form, the best optimization strategy for the company would be to reduce the number of materials. Hence a replacement of expanded polystyrene cushions by corrugated board cushions would yield a considerable improvement even if it leads to heavier and bigger boxes. This is not necessarily the most productive incentive to give the product managers from an environmental point of view. Hence an adaptation of the formula made sense.

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[20] Prior to 2002 only the volume of a packaging was recorded, not its dimensions. This data will prove too limited later on in this chapter; therefore only data from 2002 onwards will be used here.

[21] One of the outcomes of this work on benchmarking was the awareness that Philips always used the biggest boxes. This awareness initiated the Design for Logistics project (Philips, 2003), which aimed at reducing the box size for Philips products. This was accomplished by re-evaluating the drop height criteria to see how much the testing drop height could be lowered without resulting in increased transportation damage. Furthermore changes where made in the product development process. Now product designers have to consider container loading at the concept stage of the product development.

Furthermore, the volume aspect in this formula is only concerned with the volume efficiency of the box. However, the real cost driver is container loading; how many products go into one unit of load. For products coming from the Far East this means how many products fit into one standard 40′ sea container.

Hence the SC started incorporating the container loading in its benchmark reports. The packaging formula is still calculated, but the container loading now is the decisive basis for judging packaging performance.

In this chapter three different performance indicators will be introduced and discussed:
- Volume index
- Container loading
- Container efficiency

3.3 Results

In this section each of the three mentioned efficiency measurements will be introduced, and the resulting scores of the products and packages from the data pool. The data from the benchmark files has been collected and transferred to a spreadsheet, which was used to generate the graphs. The first data pool was generated in 2004; it was subsequently updated in a follow-up graduation project of a Delft student (Pratama, 2006).

3.3.1 Volume index

The volume index is the volume of the box divided by the volume of the product[22].

$$Volume\ index = \frac{Volume_{box}}{Volume_{product}} \quad [3.2]$$

Figure 3.2 shows the volume index of several benchmarked products against product volume itself. Less volume-efficient packages will have higher volume indices, thus producing data points higher in the graph.

[22] The volume of the product is defined as: h_{max} x w_{max} x d_{max} of the product in the orientation in which it is in the package, i.e. the smallest enclosing box shape. Hence for a CRT television which has a smaller back face than front face, the product volume includes empty space.

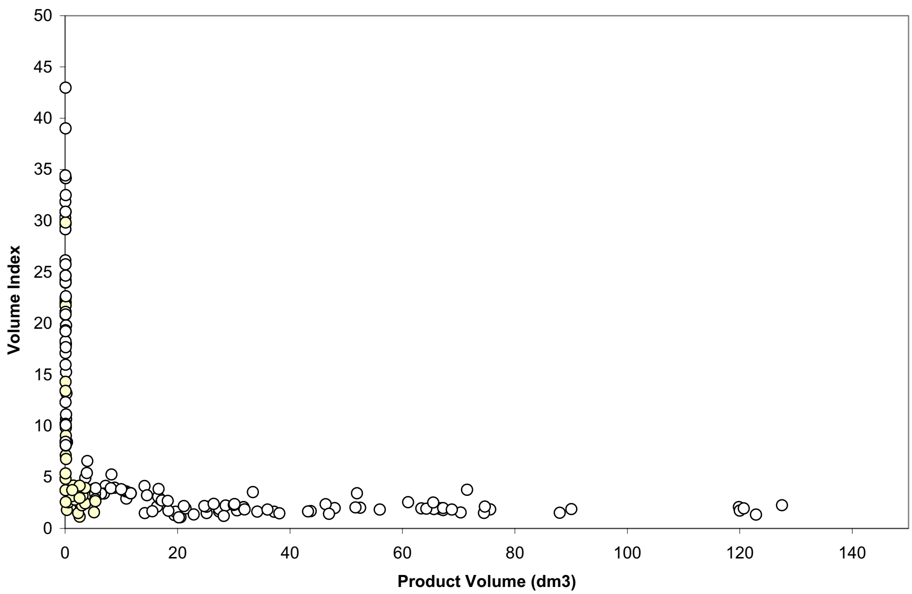

Figure 3.2: Volume index against product volume for 203 consumer electronics products from the 2003-2006 period. About one third are Philips products. Products along the horizontal axis represent distribution-dominated packages, while products along the vertical axis represent sales- and experience-dominated packages.

Figure 3.2 shows data points to be distributed along the axes of the figure. For larger products the data points show a relatively constant volume index. As product volume drops, the range for the volume index becomes increasingly larger, with some very low-volume products showing a dramatic increase. These products represent the group dominated by other functions than distribution (see also Table 2.2, they will be further discussed in the following chapters). The cut-off between the two groups lies somewhere between 10 and 20 dm^3. Here the focus will be on the constant volume index for larger products; the smaller products will be addressed in Chapters 4 and 5, and will not be part of the consideration in this chapter.

One hypothesis that can be derived from Figure 3.2 is that there is apparently a minimum volume index.

When investigating this volume index further, Figure 3.3 shows packaging volume against product volume, for the same data set. As bigger products imply bigger boxes, a positive correlation is logical. Figure 3.3 shows that correlation appears to be linear.

A trend line can be fitted through these data points. A linear least squares fit was made, which was forced through the origin, and had an R^2=0.97, meaning a good fit. The fitted line can be interpreted as the average market performance (AMP) for consumer electronics products, under the assumption that the products

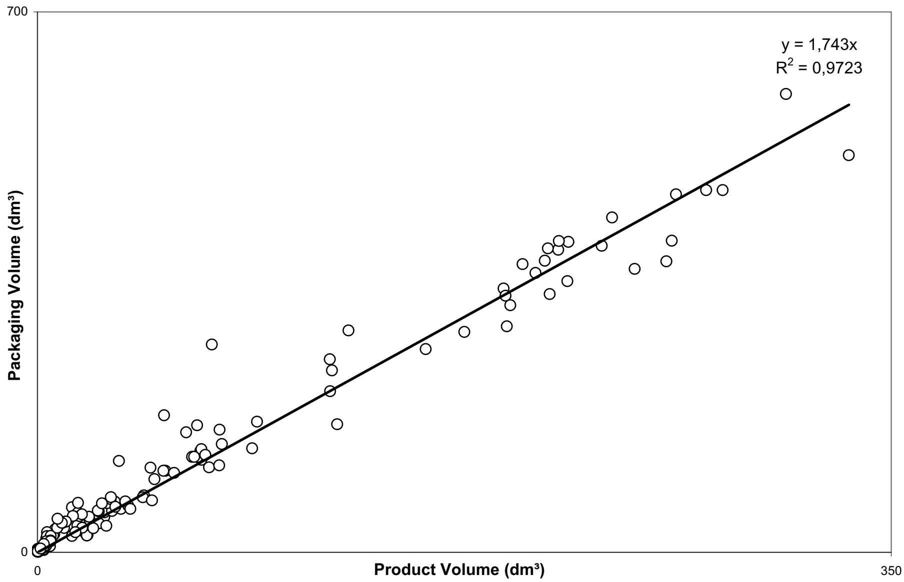

Figure 3.3: Packaging volume against product volume for 203 CE products. With Product volume in the X-axis and Packaging volume on the Y-axis. The fitted line has been forced through the origin. It has an R^2 = 0.972.

analyzed provide an average representation of consumer electronics products. It shows that the average volume index for CE goods is 1.74, meaning that the packaging volume is 1.74 the volume of the smallest enclosing box around the packed product.

This data set can be analyzed for brands and product groups, and for identification of opportunities for information gathering that go beyond single products. Such opportunities include:

- If the data set is split into a single brand and its competitors, it can be analyzed whether this particular brand is performing better or worse than the average market performance. An example is shown in Figure 3.4. As can be seen from Figure 3.4, Producer C (with the triangular data points) has products scoring both among the best and the worst. Hence, it can be concluded that, within this data set, there was no producer scoring significantly better or worse than its competition on a consistent basis.
- A company can analyze whether certain product groups are scoring consistently better or worse than others. An example of this is the product group of DVD players, which will be further discussed below.
- Outliers that are identified using this procedure will not any longer be perceived as incidental bad scores but shall receive more attention. Because the excessiveness of the volume can now be quantified.
- A savings potential can be calculated which could be reached by bringing down those packaging volumes that are above the current AMP.

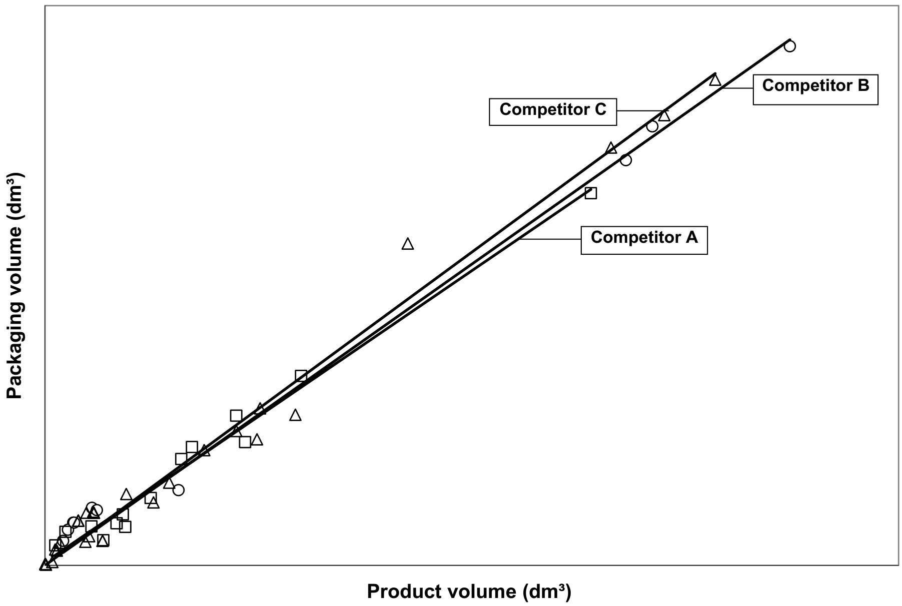

Figure 3.4: Packaging volume against product volume, split for three brands (Wever, et al, 2007).

Example: DVD players

In essence DVD players are rectangular boxes, with basic packaging designs. The main function determining packaging design for DVD-players is mechanical protection. With volume indices around 3, these were unexpectedly voluminous. It would seem that there is a significant improvement potential here. Part of this higher volume index may be due to the higher fragility of newly developed CE products, as the data used here date from a period when DVD was still relatively new. However, in 2004, a redesign by Philips Assembly Center Hungary (PACH), for a DVD player packaging using a different cushioning solution realized a volume reduction of 40%. This reduction may partly be the result of DVD players becoming more robust, but it also is a result of the better packaging characteristics of the new cushioning solution. This redesigned packaging puts DVD players within the same volume-index range as other CE products.

Economic savings potential

There may be justifiable reasons for a packaging to have a higher volume index, yet apparently there are competitors of such a product-packaging combination that deliver the same functionality (otherwise they would not have been used in a benchmark), and still have a lower volume index.

A volume index above the fitted line can be seen as a red flag, asking for re-evaluation of the package design, or even the product design. Savings can be calculated, which can be achieved per product, if the volume index is brought done to the fitted line (=average market performance).

Such calculations were carried out, based on the following assumptions:

- If a point is already on or below the fitted line, possible savings are assumed to be zero,
- Transport is done by container from Far East to Rotterdam (not all products included actually originate from the Far East),
- The relative reduction in packaging volume is assumed to correspond to an equal relative increase in container loading, resulting in an equal relative reduction of containers needed,
- Cost per container transport are assumed to be €2,500 (based on reports from business at the time of the study),
- Additional savings due to reduction of packaging material, reduced handling costs, etc are not included.

This study showed many products (26% of products included in this study) with a saving potential of €0.50 or more per product, which is quite considerable in a low margin industry. If combined with the number of products shipped per year (as was presented in Tables 1.2 and 1.3) that suggest an improvement potential for, for instance, the global LCD-television market in the order of €13 million per year. Note that this is in relation to the AMP, meaning that there are also products outperforming this score. If a best-in-class line would be used instead of the AMP, than considerably higher savings are obtainable.

3.3.2 Container loading

The container loading value used in the report is calculated, as reported values of competitors are rarely available. This calculation is based on a spreadsheet. It is assumed that the package remains upright during transport. From standard container dimensions and packaging measurements the maximum number of products in the height of the container is calculated. Based on the width and length of the box the most efficient layout on the bottom of the container is determined. By multiplying these values a calculated container loading value is reached. Comparison with reported Philips container loading data has shown good correlation[23].

Hence, in comparing the volume index with the container loading, it can be concluded that the volume index is more accurate (as it does not require assumptions regarding the use of block units, pallets or slip sheets), while the container loading correlates more closely with the actual environmental and economical impact.

Within one Philips environmental benchmark the absolute container loading is a good measure, as the products that are being compared with each other are comparable in functionality. Within this meta-analysis products with different functionality are compared, hence a relative score is used, relating the absolute container loading to the packaging volume (see Figure 3.5).

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[23] The calculated value does not account for pallets or block units, as this information is unavailable on competitor supply chains. However, as this calculation is applied to all products of all producers in the same way, it is a reliable indicator for judging best-in-class performance.

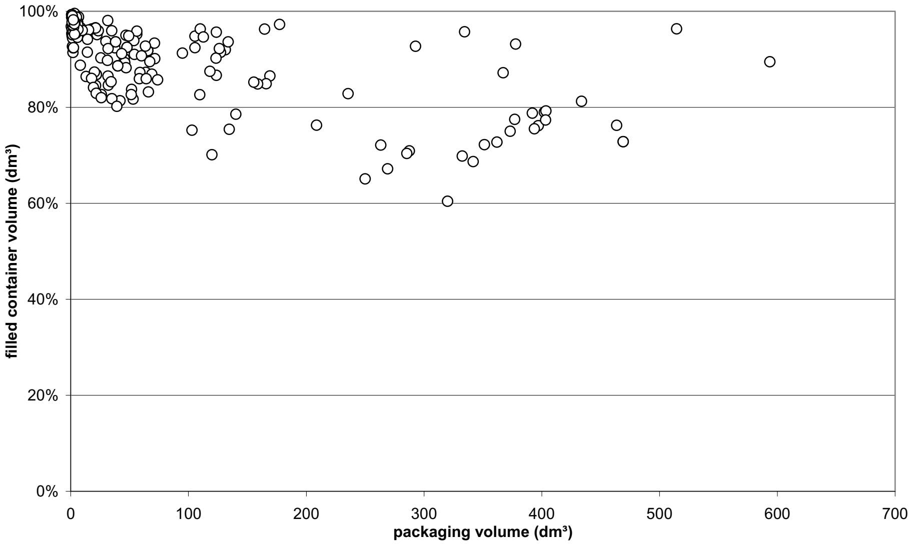


Figure 3.5: Relative container loading; percentage of container volume occupied by packaging.

In Figure 3.5 larger packages with relative container loading scores of around 65% percent can be observed. The reason for this low figure has been investigated further. It turned out that height is essential here. Many TVs have to remain upright during transportation. The height of several TV packages was found to be slightly too big to allow a third layer of products to be loaded in a container. Hence only slightly more than two thirds of the height of the container is utilized.

3.3.3 Container efficiency

The first packaging indicator discussed above dealt with the efficiency of the box volume compared to product volume. The second indicator dealt with efficiency of the box volume compared to container volume.

These two indicators can be combined into an indicator that expresses the effective volume use of a unit of load such as a sea container. It expressed the percentage of the volume of a fully packed container that is actual product, i.e. if 400 packed television sets are stacked into a 40′ container, how much of the volume of that container is actually television set:

$$\frac{\text{Product volume}}{\text{Packaging volume}} \times \frac{\text{Container loading} \times \text{Packaging volume}}{\text{Container volume}} \qquad [3.3]$$

The first part of Formula 3.3 is the inverse of the volume index. It expresses the percentage of the box that is filled with product (on average 1/1.743=57.4%). The second part is the container loading, which ranges from 65 to 100%. This indicator has been calculated for the data set and is plotted in Figure 3.6 against the product volume.

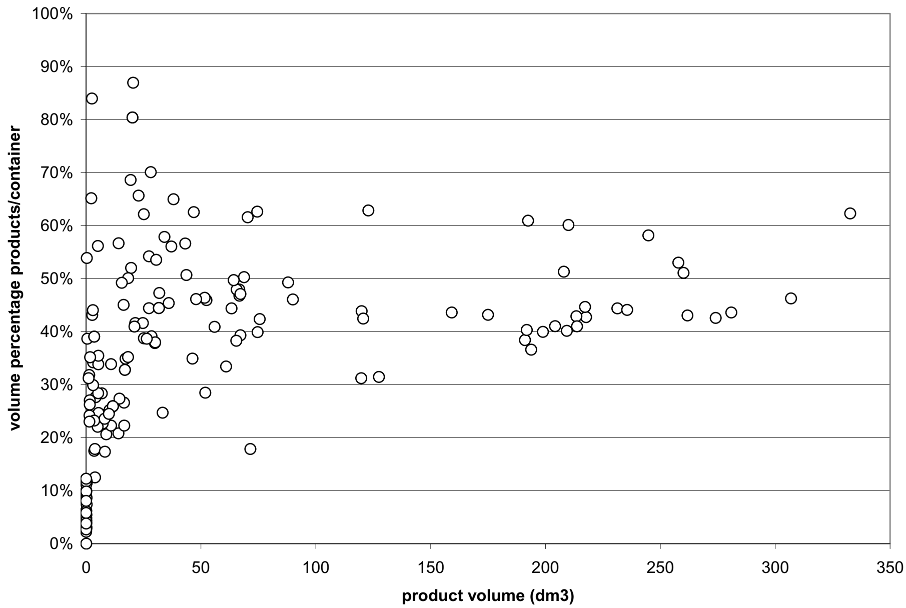


Figure 3.6: Relative container efficiency; percentage of container volume occupied by product.

This formula can create awareness for inefficient use of transport volume. There may be justifiable reasons for voluminous packages. However, what should be clear is that low scores (3 to 30%) are very costly. The spread in scores for low volume products stands out. Some score as low as 3% others as high as 87%. The majority of products are in the range of 40 – 60% container efficiency. The low scoring products are Personal Audio Players (MP3) and universal remote controls. In a separate study mobile phones were also found to be below 10%. These are all products for which the packaging has to fulfill marketing functionalities. These types of products will be further addressed in Chapters 4 and 5.

Example: LCD Monitors

There is a large efficiency spread in the product category of LCD monitors. The best product scores a relative 87.0% container efficiency, the worst 33.9%. These products have been further examined by splitting them by year, brand, screen size and presence or absence of a foldable base. None of these analyses gave a complete explanation of why the large spread in performance occurs. This suggests that currently the final container efficiency of the product is accidental. Hence, such analyses offer a strong platform for improvement actions.

3.4 Discussion and conclusions

By examining the efficiency of physical distribution, this chapter addressed the following research questions:

- What are the relationships between a certain packaging function and packaging volume?
- Is there a potential for improvement, and if so, how big is it; i.e. to what extent can the volume be optimized?

Through an empirical data-mining study it was found that, for larger CE goods—roughly over 10 dm^3 when packed—the sole functions leading to packaging volume are related to distribution. A packaging may have to fulfill sales-related or experience-related functions, but those do not lead to additional volume; the product itself is voluminous enough.

Chapter 2 already demonstrated that there are packages whose designs are dominated by distribution-related functionalities, and other packages that are dominated by marketing related functionalities. This chapter has made clear that there is an average performance for distribution-related packages that can be seen as a reference point for acceptable packaging performance. No producer or product type scores structurally better or worse. However, there are individual products that score considerably better or worse than the AMP. This suggests that there is a considerable potential for improvement, both concerning the environmental and economical performance of these products.

Within the domain of marketing-dominated packages, there are products so voluminous that less than 10% of the volume of fully packed sea containers actually consists of products (e.g. mobile phones and personal audio, like MP3 players). Furthermore the *spread* in volume-index for this type of products is much wider, even when products with identical functionalities are considered. Hence, this type of packaging seems to lend itself extremely well to volume optimization; again with considerable potential for environmental and economical savings as a result. This group is becoming more important due to the trend of miniaturization in consumer electronics, and the commoditization of consumer electronics (see Intermezzo A). At this point it is hard to distinguish between sales-related and experience-related functions within this marketing-dominated group. However, these two forms of functions will be the focus of later chapters.

Finally, a critical note deserves to be made concerning the analysis presented in this chapter. By comparing packaging performance purely on volume efficiency the differences in used materials and their related environmental issues are ignored. Even though Chapter 1 has demonstrated that volume is more important than material, a volume-only analysis is not 100% correct. However, as most packaging for CE products do not differ distinctly in material application (i.e. all have rectangular corrugated board boxes, with plastic or paper-based cushions), this is not a real issue in first approximation. However, when special packaging is considered, that does not use corrugated board boxes, material should be considered as well.

"Who would have thought that five years ago,
when DVD was introduced at $600 (a player),
that today the market share leader would be Wal-Mart?
Because a DVD player is now $39 and you can throw it in a cart."

ALAN MCCOLLOUGH, CIRCUIT CITY CEO

Intermezzo A: Commoditization and Differentiation

Consumer Electronic (CE) products have evolved greatly in the last century. They are a fruit of the industrialization of the 19th century. Some of the appliances, that we would currently call CE products, have mass-produced (manual) predecessors from the 19th century, e.g. sewing machines. The first true consumer electronics product is arguably the radio, which was introduced in the mass market in the 1920s. Since then, the number of different products has increased tremendously.

In the CE industry a trend of miniaturization can be observed. Due to the advances in technology, many products become increasingly smaller. Miniaturization may lead to relatively voluminous packaging, as products become so small, that increasing the packaging volume, in respect to what would be required from a distribution point of view, is required to fulfill sales-related functionalities; both for grabbing the consumer’s attention, as well as for reasons of theft prevention.

Simultaneously, the purchase of a CE good has evolved from a major family investment to a commonplace event, and in some cases even to an impulse purchase. Hence a process of commoditization can be observed in the CE market. Original Equipment Manufacturers (OEMs) are faced with a choice of either accepting the fact that their products have become a commodity (and market their products accordingly), or to fight this development (which requires them to find the means to differentiate and thus demand a premium price).

Within the CE industry there is a widespread belief that CE goods are being commoditized, as is demonstrated by looking at the present-day sales-oriented packaging design (Chapter 2). However, instead of simply accepting this industry belief as true, the phenomenon of commoditization will be examined in more detail in this intermezzo. Both the symptoms and potential causes of commoditization will be addressed in Section 1 and 2. Simultaneous with the changing economical situation, allowing for commoditization, the retailing of CE goods evolved, as will be described in Chapter 4.

By examining the symptoms and causes of commoditization, this Intermezzo will address the research question about how sales and experience-related functions became relevant for CE products.

A.1 Commoditization of CE goods

As mentioned above, a trend of commoditization can be observed in the CE market. Commoditization is the transformation of a non-commodity product into a commodity. Strictly speaking, a commodity is a product where consumers perceive no difference between the offerings of different suppliers or manufacturers, other than price. A typical example of a traditional commodity would be flour or sugar. Hence CE products may currently not be a true commodity; however the term commoditization can be said to describe a process in which CE goods become like daily purchases in a supermarket. The term *commoditization* is widely used in literature (e.g. De Neufville & Pirnar, 1999; Greenstein, 2004; Spector, 2005, p.65). A commoditized product is characterized by low-margins, intensive competition and low importance of brands. In order to make a certain amount of profit in commoditized markets, producers need to sell in high volumes. Non-commodity products can command higher margins, and can therefore yield a certain profit at lower sales volumes. To be a non-commodity, products need to have some characteristics that make them stand out; they have to be differentiated. This can apply to an entire product category or just specific brands. As an example, for cars as a product category, the process of commoditization may be said to have started with the introduction of the Ford model T, while for instance Ferrari has always followed a differentiation strategy.

Within CE goods a strong trend towards commoditization can be observed. The classic example in literature is IBM and the commoditization of computers (Beaty 1996, De Neufville & Pirnar, 1999). *"It* [the shift from mainframes to PCs] *has brought with it a shift in the size and volume of the products themselves – many more units of much smaller size, with much lower margins: our manufacturing value added has dropped from 40% in the 1950s to around 8% today."* (Beaty, 1996, p.217). However as Greenstein (2004, p.73) argues *"This fact* [commoditization of the computer] *fosters a myth that all high-tech product markets eventually evolve into commodities."* Greenstein argues that a commodity market is the most likely market for any product, and that only occasionally a market player succeeds at obtaining a special position in which higher margins can be maintained. He presents several strategies for fighting commoditization, one of which is through creating added value. This might be extended warranty (De Neufville & Pirnar, 1999) or by building a reputation of providing frontier, yet reliable, products (Greenstein, 2004). Real-world examples of CE brands successfully differentiating are Apple and Bang & Olufsen who obtained a special market position (partly) through exclusive product design.

As Beaty (1996, p.217) put it: *"The marketplace changes almost as fast. Every year sees a new set of companies entering the PC arena and a similar number dropping out. Competition is severe, margins are smaller, and emerging technologies are available to everyone, all of which means that the opportunities for differentiation get less and less, putting more and more emphasis on customer service and responsiveness."*

Another clear real-world example of commoditization is the Philishave. For decades Philips held the patent for three-headed electric shavers, which is a product characteristic that was perceived as added value by consumers. After the patent expired, competitors also introduced three-headed shavers, thus commoditizing that niche in the market.

By studying to what extent CE products suffer from low margins, high competition and low importance of brands it is possible to determine the importance of commoditization for CE products. For this purpose, first, phenomena that would indicate the existence of a commoditization trend will be discussed, and second, factors causing commoditization will be examined. Finally, the response of OEMs to this process, and the resulting approaches to packaging design will be discussed.

There are several developments in the CE market that may indicate that commoditization is/has taken place. These are:
- the shortening of the length of product cycles (section A.1.1),
- price erosion (section A.1.2),
- the success of retail brands (A.1.3),
- increased product knowledge of consumers and decreased product knowledge of sales assistants (A.1.4),
- reduced brand loyalty (A.1.5),
- increasing importance of impulse buying (A.1.6).

These factors will be analyzed in the remainder of this section. Of each will be explained why they are good indicators of an ongoing commoditization process.

A.1.1 Shorter product cycles

Newly introduced products possess uniqueness (especially if they are first-of-a-kind products), making them a non-commodity. Hence studying such products can give some indication of the degree of commoditization. Two aspects are of interest, first the length of time a product remains in the market (this paragraph), and second the speed with which the price of a specific product, or an entire product category drops (paragraph A.1.2).

Bayus (1994) cites several sources in the popular business press demonstrating a common belief that the length of product life cycles (PLCs) has been decreasing over the past decades. This belief has resulted in attempts to shorten the development time of new products, i.e. the time-to-market. Yet as Bayus shows the empirical evidence that PLCs are actually getting shorter is rather weak. The classic product life cycle consists of four stages; introduction, growth, maturity and decline (Figure A.1).

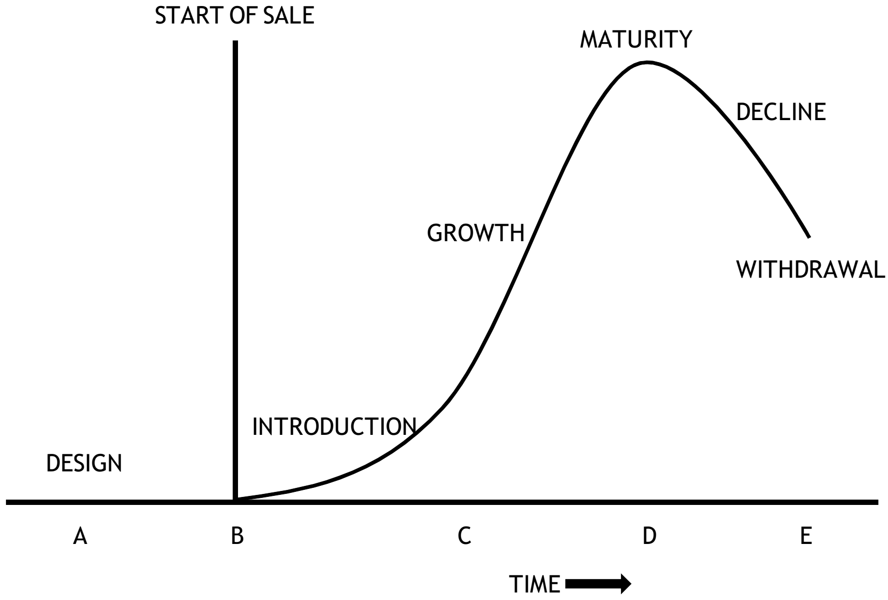


Figure A.1: the life cycle of a product design.

Most studies have focused only on the first stages of this curve, using truncated data not including the decline phase of the product. Using data from the Personal Computer industry, which is further elaborated on in a later publication (Bayus, 1998), Bayus shows that life cycles in this field are not systematically shrinking, neither at the product category level (e.g. Personal Computer), nor at the Product Technology level (e.g. 16 Bit CPU), nor at the Product Model level (e.g. IBM PS/2 model 30).
Bayus names several business aspects that are really accelerating:
- New knowledge is being applied faster (phase A-B)
- More products are being introduced (faster than withdrawn, so the total number of available products is increasing)
- The time between innovations decreases, for instance in recording media; *LP records were introduced in 1948, cassette tapes in 1965 and compact discs in 1983*. After this we saw the introduction of DAT (1988), Sony Minidisk (1991), Philips DCC (1992) and MP3 (late 1990s) together with several less successful recording media.

Other sources do claim shorter cycles; *"Instead of a 12 month planning period and a production run of 2 to 3 years for a new product, product development cycles now last 4 to 6 months and product life, at the most, 12 months."* Beaty (1996, p.218).

Hence, literature is not conclusive on this issue. However, even though the total time a product is in production *may* not be shrinking, the time during which a product can make a profit is, as Beaty (1996, p.217) states: *"On many of our products today, the window of profitability can be measured in a matter of months."*

A.1.2 Price erosion

As stated in the previous paragraph, the speed of price degradation in a product category can be an indication of the extent to which that type of product is susceptible to commoditization, as it indicates the speed with which the products loses its ability to command higher margins. Minderhoud and Fraser (2005; Den Ouden, 2006, p.11) discuss the subsequent introduction of VCR, first generation DVD and second generation DVD. They demonstrate, using street price and quantities sold, that the time-to-commodity has decreased from 30 years for the VCR to 3 years for the second generation DVD (see Figure A.2).

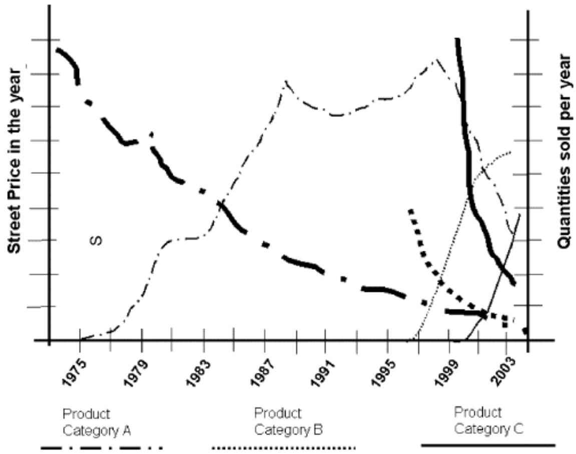


Figure A.2: Market dynamics for three kinds of consumer electronics products, illustrating the increased speed of price erosion. (Minderhoud & Fraser, 2005)

The findings of Beaty (1996) and Minderhoud and Fraser (2005) indicate increased price erosion in CE products. The characteristics that make products stand out (hence making them non-commodities) do so for only a short period of time, thus increasing the importance of packaging as the 'silent salesman'.

A.1.3 The success of retail brands

Retail brands can be seen as a good indication of a commodity market. If consumers do not believe that one specific supplier is distinctively better than another, they may be prepared to buy retail brands. Retail brands are usually cheaper than premium brands. This price advantage can make them successful. This section will discuss some of the historical attempts of retailers at establishing retail brands in chronological order.

Looking at the Dutch market (based on the analysis that will be discussed in Section A.2.4) it can be observed that in the past some retailers have attempted to launch retail brand electronics (Vendomatic in 1972 and 1981, Skala in 1981-1984, Hema in 1986-1990). These attempts have been abandoned. However, both V&D and Hema department stores recently (late 2000s) introduced a range of retailer-brand household appliances.

Today, attempts are sometimes made in a different way, as Spector (2005, p.73) discusses:

"In 2002, Best Buy, which sells almost 10 percent of all the consumer personal computers in North America, (trailing only Dell) began selling its own in-house desktop brand, VPR Matrix. It was a logical move for Best Buy, where PC sales comprised almost 10 percent of its $21 billion in sales in fiscal 2003. PCs manufactured by the likes of Hewlett-Packard and its Compaq division have become commodities, with low margins. By comparison, the VPR Matrix, designed by Porsche Design GmbH of Austria (the studio that designed the car of the same name) has a distinctive look, including a brushed metal casing, and comes with lots of cool features and high-end components, which makes it stand out. Best Buy later added a VPR Matrix laptop."

Here the retail brand is more than simple a product of reasonable quality for a reasonable price; an attempt has been made to create true added value. This added value consists of emotional value (i.e. aesthetics) and not physical functionality, as the physical functionality is deemed sufficient for all products in the eyes of most consumers.

However, as Eagle (et al, 2000) describe, retailers are constantly looking to strengthen their position, by moving into markets new to them. In markets where there are already strong brands Eagle foresees the appearance of co-branded products. This is a development that might occur in the CE market; products co-branded by a large retailer and a traditional CE brand. Spector (2005, p.71) mentions several examples such as Costco selling retail brand dishwashers built by Whirlpool. Retailers can achieve this due to the power they have over the value chain (see also Section 6.2)

From this it can be concluded that retail branding occurs, but that OEM brand names still generate added value; thus indicating a process of commoditization that is still ongoing.

A.1.4 Product knowledge of consumers and sales assistants

Due to the Internet, consumers have become more knowledgeable about CE products. At the same time, due to the quick changes in products offered, and the vast array of products on offer in large CE retail stores, the product knowledge of the sales assistants seems to have gone down. It is not uncommon for a sales assistant to answer a question of a customer by looking up the answer on the packaging or the information on the extended price tag. Or as Spector puts it (2005, p.185):

"Consumer electronics has become a low-prices commodity business, so that it is difficult even for specialty stores to make much in the way of sustained profits. A DVD player, for example, is familiar to most consumers, so discounters such as Wal-Mart and Target can pile them high and sell them cheap without having to hire knowledgeable sales and service help. Manufacturers put as much product information as possible on their Web sites (as well as the boxes the products come in), so that the customer is given enough data to make an informed decision, regardless of whether the purchase is ultimately made at Costco or Wal-Mart or Best Buy."

Consumers' independence from sales assistants is also evident from the success of Internet retailers such as Dell and Amazon.com, who sell products based on the information on their website alone.

Furthermore, there are many physical retail outlets where consumers are stimulated to choose a product without any help from sales assistants whatsoever (see Chapter 4). In such an environment, the importance of the sales-related functionalities of the packaging is paramount.

A.1.5 Brand loyalty

One of the characteristics of commoditization is the low importance of brands. A manifestation of the importance of brands in buying CE goods is brand loyalty. This can be examined through two indicators:

- the mixture of brands in a household; if people mix different brands for their TV(s), DVD player(s) and stereo(s), than brands are apparently of limited importance. And as can be observed in most households, consumers do mix CE brands.
- brand loyalty in replacement purchases. If people buy a different brand when replacing a product that again is an indication of limited importance of brands, at least when they were basically satisfied with the old product.

This second factor can be dealt with through the literature on replacement purchases. Bayus (1992) found, in studying the importance of the timing of replacement purchases, that brand loyalty for replacement purchases of refrigerators, dishwashers and color TVs was below 50% and for washing machines slightly above 50%, if the previous machine had lasted at least 10 years. Lin, et al (2000) found a brand loyalty of 55% among Taiwanese consumers for purchasing refrigerators. Finally, Prince (2008) found that brand loyalty in household PC purchases increases with product experience, however, if brand switching occurs, high levels of experience also increases the purchase of brands that are not well-known.

From these findings from literature, it can be stated that although brand loyal consumers do exist in the CE market, brand switchers constitute a significant segment of the CE market. In such a market, where a brand has to constantly fight to keep its own consumers, and steal those of competitors, the importance of sales-related functionalities in the packaging is obvious.

A.1.6 Impulse buying[24]

In a market where a significant amount of impulse purchases occur, the sales-related functionalities of the packaging are of paramount importance. If the product is purchased as a gift, experience functionalities are important as well (Vanhamme & De Bont, 2008). From a business perspective, it can be said that the occurrence of impulse purchases forms a major justification for the application of

[24] This section is based on a student bachelor research project, and was previously published in: Wever, De Vries, Boezeman, Roskam & Uythoven (2007) Sales Performance of Packaging for Consumer Electronics Products. The 23rd IAPRI World Symposium on Packaging, September 3-5, Winsor UK.

sales and experience packaging. Hence a study was performed to assess the level of impulse purchasing in the CE market.

A.1.6.1 Introduction

The term impulse buying refers to purchases that are unplanned. Literature distinguishes two types of impulse buying; reminder impulse buying (where seeing the product on display reminds the consumer of a previously identified need) and pure impulse buying (where the purchase breaks with the normal buying pattern) (Dittmar, et al, 1996). As Dittmar demonstrates not all product categories are equally likely to be bought on impulse.

A lot of research has been performed on impulse buying, though mainly focusing on fast-moving consumer goods (FMCG). Bayley and Nancarrow (1998) discovered that the differences between lifestyles people are leading, result in different impulsive behavior. Products that can contribute more to the (aspired) identity of the customer are more sensitive to being bought impulsively. For example, clothes are more likely to be impulse bought than, say, basic kitchen equipment. According to Earl and Potts (2000), the longer the consumer stays in the store, the more money he will spend, assuming he is a browsing shopper. The average influence of the retailer on the final purchase of a consumer is 30%, according to LeBlanc and Turley (1994). They also discovered that there is a significant difference between different categories of products. For example, the influence of the retailer on the purchase of electronics is 35%.

In the Netherlands, small specialized stores are often no match for big-box retailers like MediaMarkt. The only factor many customers seem to be focused on is the price. Therefore it looks like customers are much more sensitive to making an impulsive purchasing decision, based on a combination of price and selling promotions. Retailers can adapt on this trend, if the influence of this impulsive behavior is important to such a degree.

As stated above, little specific information is available in literature on impulse buying of CE goods. Hence, a more detailed study was executed to quantify the level of impulse buying currently occurring in the CE market.

A.1.6.2 Methodology used to study impulse buying

This study on impulse purchasing addresses the following (sub)research questions:

- Do impulsive purchases occur within the CE goods market?
- Is there a significant difference between the extents of impulsive purchases being made in different categories of CE goods in the Netherlands?
- Do impulsive purchases have a significant share on the total market of CE goods in the Netherlands?

Here, impulsive purchases are defined as unplanned purchases.

The total market of CE goods is defined as the total amount of purchases having been made by the respondents in our research. Since this research is about the amounts of purchases, and not the amount of money, every purchase is counted as 1.

Basically, in order to research impulsive shopping behavior, the simplest research method would be to ask people what they intend to buy before they go shopping, and then ask them what they have bought, after they went shopping. However, according to Bayley and Nancarrow (1998), asking questions at the entrance of a shop will lead to socially desirable answers. For example, when asking people before they enter the store and after they left the store, they will go shopping with a different intention. They will be more aware of their behavior while shopping, which will compromise the reliability of the results. Another method is to only ask people when they leave the store, about what they bought, and what they intended to buy. Bayley and Nancarrow (1998) mention in the same article, that this approach will lead to confusion of the respondent; most of the consumers cannot make a difference between their intention of products to buy before they go in to the store and their intention of products to buy when they are in the store.

Based on this it can be concluded executing the study at a store location will not lead to a desirable outcome. Doing a survey in a 'clean' environment is a better option. In this study an online questionnaire was used. An advantage of an online questionnaire is that people do not have to talk about their behavior face to face. Behind a computer, it is only the respondent that matters, and no one will know. Also, behind a computer, there is no influence of disturbing environmental factors, and no disturbance of time. Furthermore, an online questionnaire is a big time saver, when the group of respondents is intended to be large. The online questionnaire will be in two parts. In the first part the respondent is asked what (s)he intends to buy the next month. In the second and last questionnaire, the same respondent will be asked what (s)he has bought last month.

Of course, this includes the assumption that buying a CE product that a consumer did not consider buying a month before is an impulse purchase. This assumption is certainly believed to be true for large and expensive CE products, such as televisions and so on. The purchase is impulsive enough for the packaging to have an influence on buying such a product. For a category such as cables and batteries this might not be entirely valid.

A first questionnaire was mailed out in early November 2006. Besides seven questions that asked about the personal situation of the respondent, our next question was:

From which categories of consumer electronics do you consider buying something from the coming month? Please fill in the amount per category. If you can't find your matching category, please fill in the category that corresponds most with the product you intend to buy.

To explain the categories chosen, a few examples of products from these categories were included in the questionnaire. The categories used are:

1. Audio/visual large (such as TV, DVD player, beamer, gaming console)
2. Audio/visual small (such as mp3-player, game boy, digital camera, car radio)
3. Audio/visual accessories (such as headphones, memory card, remote control)
4. Telecommunication (such as telephone, GPS system, palmtop computer)
5. Telecommunication accessories (such as car kit, headset)
6. Computer (such as laptop, computer)
7. Computer accessories (such as printer, scanner, modem)

8. Kitchen large (such as washing machine, dishwasher, air-conditioning, built-in oven)
9. Kitchen small (such as toaster, food processor, microwave)
10. Interior (such as alarm system, fire detector, alarm clock)
11. Personal care large (such as solarium, electrical blanket)
12. Personal care small (such as lady shave, electrical toothbrush, hairdryer)
13. Cables and wires (such as plugs, audio/video switch, SCART cable)

A second questionnaire was sent out a month after the filled in first questionnaire was received. It asked which products were actually bought. This time the same categories were used, but now with a more extensive list of products belonging to this category.

To be able to analyze whether impulsive purchases are actually made, respondents were asked about their reasons that they bought the product. There are different reasons for a product being bought. Some of them could be an impulsive reason, others are not. These reasons were divided in two main groups for buying a product: for oneself or for someone else. If the product is bought for someone else, it can be an asked-for present or a spontaneous present. If it is a product bought for oneself, it can be a replacement of a product or it can be a new product. When a product is being replaced, it can be for two different reasons; the old product was broken, or the old product was not broken. If it concerns a new product, the product can be bought also for different reasons. Regarding the variables, notice was taken of the price, the spontaneous treatment, and a wanted present for oneself. To make these different reasons clear, Table A.1 shows which of these reasons were considered to be an impulsive reason for purchasing. Based on the separation in Table A.1 all answers given by consumers could be classified as being impulse purchases or not.

Reason	**Impulsive reason?**
1. Wanted present for someone else	No
2. Spontaneous present for someone else	Yes
3. Spontaneous present for oneself	Yes
4. Replacement of a broken product	No
5. Replacement of a product that still works	Yes
6. New wanted product for oneself	No
7. This price was so low, I just had to buy it	Yes

Table A.1: Decision scheme for determining impulsiveness of purchases

This way it is possible to check if an impulsive purchase was made. It is only made clear to the respondents that the research was about shopping behavior, and it was not mentioned that the research was about investigating impulsive buying behavior. Also, these reasons for buying are not confronting the respondent directly with having made an impulsive purchase.

A.1.6.3 Results on impulse buying

295 respondents filled in both questionnaires, so this is the final sample. From the data can be derived that by all the respondents, 703 products are bought in the last month (an average of 2.4 products per respondent). By our definition, 199 products have been bought impulsively, which is 28.3 percent of the total amount of purchases. In total, of the 295 respondents who filled in both questionnaires, 105 respondents had made an impulsive purchase. Out of the total amount of respondents, this is 35.6 percent. So 35.6 percent of respondents were responsible for the total amount of impulsive purchases. Table A.2 shows how many products are bought impulsively, and how many products are bought in total per category.

Total impulse per category	Total bought per category	%	Category
33	90	37	Audio/Visual large
14	57	25	Audio/Visual small
19	81	23	Audio/Visual accessories
9	39	23	Telecommunication
3	15	20	Telecommunication accessories
6	30	20	Computer
39	128	30	Computer accessories
9	34	26	Kitchen large
11	13	84	Kitchen small
23	64	36	Interior
0	2	0	Personal care large
6	28	21	Personal care small
27	104	26	Cables and wires
199	**703**	**28**	**Total**

Table A.2: products bought impulsively per category

A.1.6.4 Conclusions regarding impulse buying

Based on the data in Table A.2 it can be concluded that impulse purchases occur in the field of consumer electronics. They actually make up a substantial percentage of the total. Especially the categories of *audio/visual large* (such as TV, DVD player, beamer, gaming console), *kitchen small* (such as toaster, food processor, microwave), and *interior* (such as alarm system, fire detector, alarm clock) scored high; roughly a third of the purchases in these categories can be classified as impulse purchases.

When looked at from the other side, the largest part out of the total number of impulse purchases are in the category of *computer accessories* (such as printer, scanner, modem, 19.6% of all impulse purchases) and *audio/visual large* (16.6% of all impulse purchases). Surprisingly, impulse purchases seem to be just as likely in more expensive product categories, such as audio/visual large, as they are for cheaper, more gadget-like products.

These findings present another sturdy justification to consider the use of sales packaging, especially when realized that impulse buying is just part of the marketing function of the packaging (the other being competition of a brand with other brands in a certain category for the attention of consumer for a planned purchase).

A.1.7 Conclusions

When adding up the findings of sections A.1.1 through A.1.6 the conclusion is that a process of commoditization is indeed taking place for CE products. The window of profitability of newly introduced products has shortened to just a few months. Consequently, price erosion is exceedingly fast. Retailers are manifesting themselves as CE brands. Consumers shop without the assistance of knowledgeable sales staff. Brand loyalty is low, and a substantial percentage of CE purchases are the result of impulse decisions. All these factors increase the importance of effective sales and experience packaging. This analysis presented here yields several pointers on how to deal with sales and experience packaging which will be further detailed in the following chapters.

A.2 Factors causing commoditization of CE goods

Section A.1 has demonstrated that a process of commoditization is in fact taking place. The question remains, however, what is causing this phenomenon. In this section several phenomena will be investigated which may to some extent cause a product (category) to become commoditized. Here a deeper look will be taken into:

- the financial commitment consumers need to make; i.e. the development of price levels in comparison to consumers disposable incomes,
- the perceived quality differences in products within one product category,
- the number of brands available in the market.

Besides these factors, there probably is a mutual stimulating effect between the process of commoditization itself and the adaptation of retailing to this process (which will be described in Chapter 4). However, untangling the resulting chicken-or-egg discussion is deemed beyond the scope of this thesis.

A.2.1 Product prices versus disposable income

The data presented by Minderhoud and Fraser (2005), and discussed in section A.1.2, shows price drops of video equipment. In a more elaborate study on the measurement of prices of consumer durables over time, Gordon (1990, p.405) concludes that the prices of computers, television sets and telephone equipment have consistently dropped in the post-war period.

As at the same time disposable incomes have only risen substantially, it can be concluded that the financial commitment to purchase a CE product has gone down over time. This is also evident from the observation that many households now have more than one TV, and more than one computer, and so on.

A.2.2 Product quality and functionality[25]

If the quality and functionality of all products offered in a certain category is at least good, or is more or less equal for all products, this would make these products more into a commodity, as it eliminates such differences from the buying decision. This raises the question whether CE goods are of better quality and functionality today, than they were some decades ago, and/or whether the spread in quality and functionality has declined. Here, quality is taken to mean reliability, usability and durability, while functionality refers to the features of the product. It should be noted that interest is in the relative differences in quality and functionality among products that are on the market at a certain time, and not between the products people already have, as compared to what is on the market.
The challenge in testing to which extent quality and functionality has become less important lies in the fact that object of the study is the *perception* of quality and functionality. This perception of consumers changes over time (e.g. the battery lifetime of mobile phones, or the number of pixels in a digital camera). A product that would be perceived as very good three years ago may be mediocre in today's

[25] This section and the next section were previously published in: Wever, Boks & Stevels 2008b, 'The Commoditization of Consumer Electronics Products and its Influence on Packaging Design', Proceedings of 16th IAPRI World Conference on Packaging. June 8-12, Bangkok, Thailand.

market. Hence, to operationalize this concept an information source was selected that judges products on a consistent scale but with evolving criteria; the product tests by Dutch consumer organization: *de Consumentenbond*. Their evaluation of the quality of consumer durables is useful for this analysis, as they represent the expectations of product quality among consumers at the time of the test. The *Consumentenbond* has tested the available products in a product category, and awarded total scores ranging from bad to very good. There were also some products tested as unsafe, which for this analysis has been taken to be one step worse than bad. The tests performed on electrical and electronic consumer goods were reviewed for three periods; 1983, 1993 and 2002- March 2003 (as of April 2003 the presentation of test results was changed which makes comparison with previous results dubious). The products included audio/ video equipment, DIY tools, personal care products and domestic appliances. Figure A.3 shows the results of the analysis. The figure allows the conclusion that the spread in scores has reduced, and the average quality has increased. In 1983, 22% of the products scored less than 'reasonable', while this had dropped to 10% by 2003. At the same time, the products scoring in the range 'reasonable' to 'good' increased from 74% in 1983 to 87% in 2003.

Although Lin (et al, 2000) indicate that a reduced spread in product quality is a characteristic of a durable good that has reached its maturity stage, most of the products included in this study already reached their maturity stage by the first period sampled.

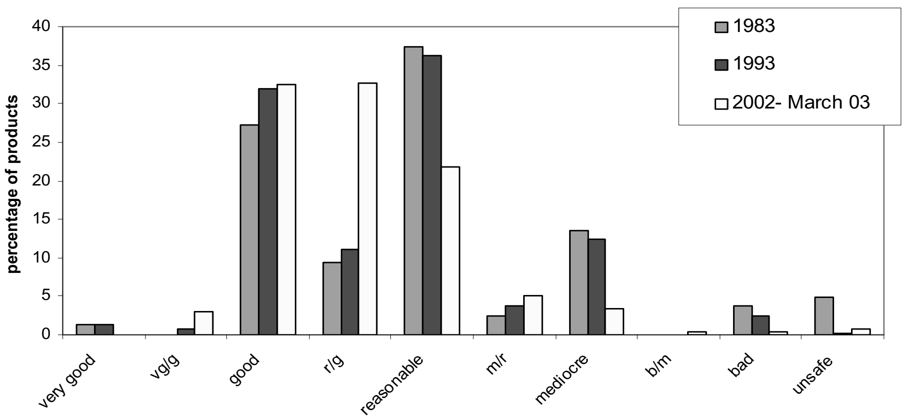


Figure A.3: the spread in test scores as given by *de Consumentenbond* for electrical and electronic products for three periods, 1983 (243 products), 1993 (539 products) and 2003 (639 products). Based on data from *de Consumentengids*.

A.2.3 Number of brands

A third factor that may be relevant to commoditization is the number of brands available on the market. More brands mean that there will be more competition and that it will be harder for a specific brand to distinguish itself from the competition. Within the CE industry a belief can be observed that competition has

increased in recent years, especially through to introduction of new brands set up by owners of factories that at first were suppliers to existing brands.
To research the number of brands an analysis was done for the Dutch market by studying the tests of television sets by the Dutch Consumer organization. It was assumed that they try to give an honest review of the entire market, thus including all brands that are readily available. For the period 1968-2004 all tests for television sets (48 in total) were studied to see which brands were included. If brands were review regularly, but not in each test, it was assumed that this brand was also available between the tests in which it was included. Thus a picture was developed of the number of brands available (see Figure A.4). From this figure it is evident that the number of brands has reduced in recent years, but is still close to a dozen competitors[26]. This number is considered large enough for a level of competition where commoditization can occur, but as the number has decreased in recent years, it cannot be seen as a direct cause for commoditization. Besides the *number* of brands, it may be relevant which (type of) brands make up this number, as for instance newcomers in the market may increase the level of price competition.

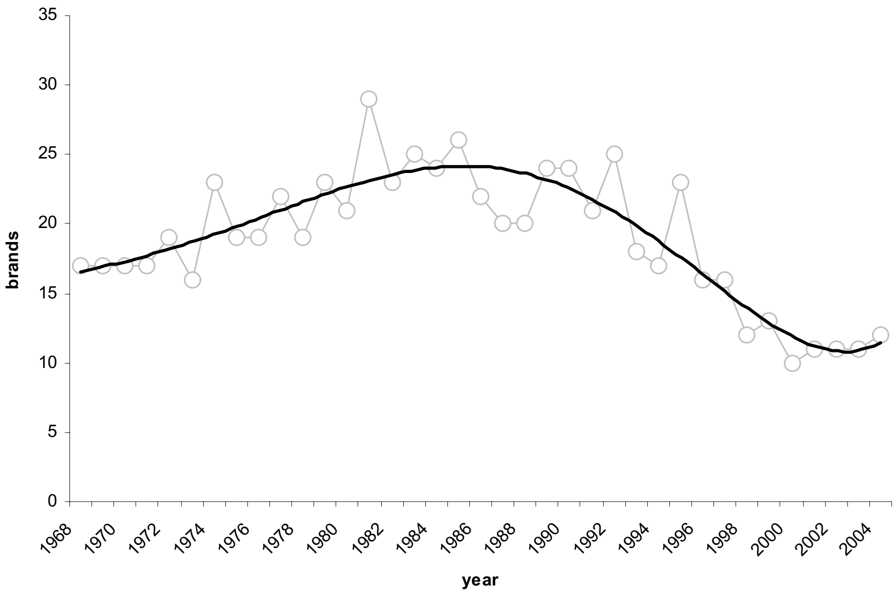


Figure A.4: Number of television brands on the Dutch market (1968-2004). Data points represent the number of brands reviewed in comparative tests by the Dutch consumer organization: *de Consumentenbond*.

[26] Note that this only refers to the brands available in the Dutch market. Many brands that used to be (readily) available in the Netherlands still exist (e.g. Telefunken, Loewe, Finlux), but are not on the Dutch market anymore. For this analysis the real range of brands consumers can choose from is relevant, not the number of brands in the world.

A.2.4 Conclusion regarding the causes of commoditization

Looking at the causes of commoditization, it is hard to give definitive answers within the scope of the studies presented here. However, some clear indications have been found. It can be concluded that the financial commitment consumers have to make to purchase CE goods has gone down relative to their disposable incomes. Furthermore, in the perception of consumer-rights organizations, the spread in quality of CE products has reduced. Finally, contrary to business belief, it seems that the number of brands available on the market has actually gone down. However, a sufficient number of brands remain to allow for a process of commoditization to occur.

Again, this analysis has yielded justification of sales and experience packaging. If the perception is that there are only very limited differences between products (section A.2.2), then sales and/or experience packaging can be a strong differentiator.

A.3 The response of OEMs

The previous sections demonstrated that commoditization is taking place in the CE market. Most CE products can only temporarily command higher margins, and brand loyalty is low.

The main driving forces behind this development were identified. Quality of CE products seems to have improved in the eyes of the consumer, in the sense that there are hardly any bad or mediocre products left in the market. Furthermore, the spread in quality between brands appears to have gotten smaller. As the financial commitment needed to purchase a CE product has gone down too, this makes a purchase decision easier to make.

As the classic differentiators used by OEMs (e.g. price, quality, reliability) have lost part of their differentiating power, the importance of the packaging as a differentiator has strongly increased. This is apparent in the designs of the packaging OEMs use to pack their products in. Two distinct approaches can be observed. On the one hand, packaging can be observed which results from an approach that accepts the fact that a product is, or quickly will be, a commodity. The design of the packaging is treated like a FMCG (Fast Moving Consumer Good); i.e. a supermarket-style packaging, which tries to capture the attention of the browsing public, communicates the product's unique selling points, and through this closes the deal. This is referred to in this thesis as sales packaging, which will be further discussed in Chapter 4.

On the other hand, packaging can be observed which results from an approach to stay out of a process of commoditization. Both the design of such products and their packaging attach uniqueness to the product in order to set it apart from the competition, thus enabling it to command a higher price. This is referred to in this thesis as experience packaging, which will be further discussed in Chapter 5.

Commoditization can happen to all CE products, irrespective of their physical volume. However, especially for small products the resulting sales and experience functionalities are more likely to increase the volume of the packaging.

By describing and researching the process of commoditization and identifying the responses of the CE industry, the research question, about how sales and experience functions became relevant for CE products, is considered to be answered.

As this intermezzo demonstrated the CE industry is in a state of rapid flux, where new products are being introduced at a high rate and the time window for turning a profit is limited. Hence the design process is under continued time pressure. For packaging design this means that there is little time for the development. In optimal cases packaging design is partly parallel to product design; i.e. concurrent engineering. However, irrespective of any concurrent engineering, there often is limited time for testing (both mechanical and consumer testing, see Chapter 2). Given these circumstances, a tool that can yield consumer insights quickly and at low cost would be highly valuable from a business perspective. Such a tool will be proposed in Chapter 8.

As stated in the introduction to this chapter, it can be said that commoditization is used to describe a process in which products become more like daily purchases in a supermarket. Looking at the retailing of CE goods, a historical development can be observed, in which the retailing is also evolving towards a more supermarket-like environment. This development will be analysis in the next chapter.

"Product designers, manufacturers, packagers, architects, merchandisers and retailers make all the big decisions about what people will buy and where and how they will buy it. But then the shoppers themselves enter the equation, and they can turn nice, neat theories and game plans into confetti."

PACO UNDERHILL (1999, p. 87)

4. Retailing of Consumer Electronic Products

This chapter will take a closer look at the developments in retailing of CE goods, and the resulting functional demands on the packaging design. In doing so, the following research question will be addressed: 'What are the relationships between a certain packaging function and packaging volume', namely for the sales-related functions of a packaging. Also a further elaboration will be given on why those sales-functions have become relevant.

This will be done through a historical analysis of the development of CE retailing, in the end identifying the specific requirements set for packaging by retail formats important in the present-day CE market. Subsequently, the ways in which packaging can fulfill these requirements will be described.

4.1 Retail formats

With the societal and economic developments described in Intermezzo A, the way consumer electronics have been sold has also evolved over time. It will not be argued here whether these developments are in part the cause of the process of commoditization, or a consequence of it, as this is deemed beyond the scope of this thesis. In the next sections the development in CE retailing will be described by analyzing the different types of retail environments. For this analysis several aspects of each retail environment will be considered. These aspects are often discussed in retail literature. Kooijman (1999) and Miellet (2001) use the following aspects: fixed prices, the number and knowledge of the sales assistants, the sales talk, the display of goods, buying on credit, and the floor space. Fixed prices were introduced with the introduction of the department store at the end of the 19th century. As this was before the appearance of mass-produced consumer electronics, fixed prices can be found at all CE retail formats in developed economies today. Therefore it will not be addressed in the description of the retail environments.

4.1.1 Specialist stores

Nowadays, CE stores sell all types of products, so-called white goods, brown goods and grey goods (household appliances, consumer electronics and IT products respectively). There are even stores like department stores and hypermarkets, where CE goods are just one segment of the total product portfolio. History shows however that there used to be more specialized outlets during the introduction years of specific CE products. Before WWII specialist shops could be observed, such as Radio shops, electricity shops (for lighting), and gas shops (for stoves and heating), as can be seen in Figures 4.1 through 4.3. Later, in the 1980s, the phenomenon re-emerged with the specialized Personal Computer stores, which can still be found today. In 1990s and 2000s specialized stores became the most common retail channel for cell phones.

These shops are characterized by highly knowledgeable, though slightly nerdy, shop assistants. They are targeting the consumer segment that Rogers (1983, p.248) classified as the innovators; the first few percent of the population that likes to experiment with new technology and is prepared to pay a premium price.

Figure 4.1: Exterior of a gas show room in Wandsworth, designed by H.W. Binns (Reprinted from Westwood & Westwood, 1937, p.92)

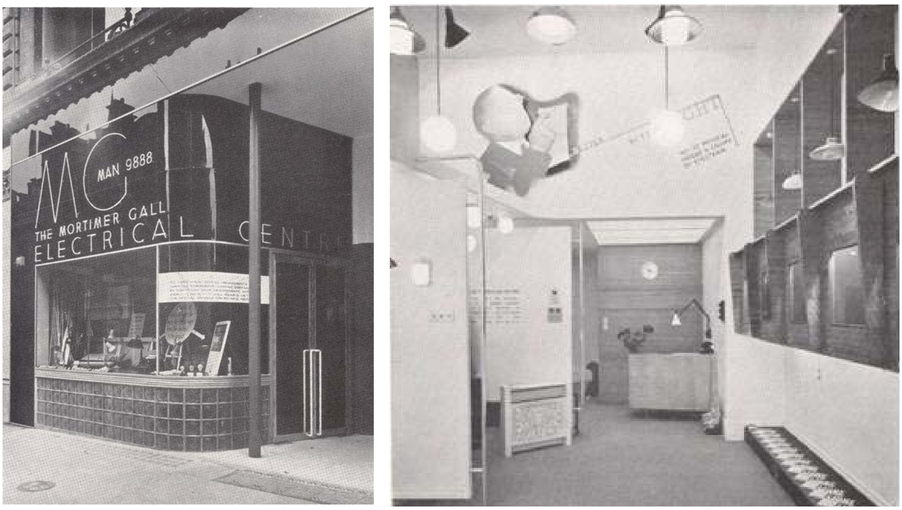


Figure 4.2: Exterior and interior of an electricity show room, designed by W. Gropius and M. Fry (Reprinted from Westwood & Westwood, 1937, p.93)

Figure 4.3: Sales assistant in a Radio shop, June 1929. (Courtesy of Mike Schultz; http://uv201.com/index.html, last viewed 28-07-09)

4.1.2 Department stores

Department stores arrived in the mid to late 19th century. They mostly started as drapery shops or shops in tailor's requisites, or something the like. When business was good they expanded by buying neighboring property and extending their merchandise. These stores were aimed at the high-end of society. Soon these new department stores sold a wide range of goods including furniture. As Figure 4.4 shows, they were also early adopters in starting to sell consumer electronics; the Dutch department store *De Bijenkorf* already had a radio department in 1925.

The department stores changed the way of retailing. Before their introduction it was common to buy on credit and to digger about the price. Through introducing cash payment, department stores were able to directly pay the manufacturers of their merchandise, which allowed for lower prices. Furthermore, the department stores introduced the principle of (fixed) low margins and high turn-over speed, resulting in acceptable, or even huge, profits. Before that, turn-over was low, so margins had to be high.

In essence, an electronics department in a department store was not extremely larger than an independent or chain store. The department could be described as a shop-in-shop (a concept formalized about a century later with separate store names and shop lay-out). The display of goods and the number of shop assistants were similar to independent shops.

Figure 4.4: An ad for the radio department of *Magazijn de Bijenkorf* from 1925, showing that department stores were early adopters in starting to sell consumer electronics. Reprinted from Miellet, 1999, p. 215.

4.1.3 Independents

As with every type of merchandise, there have been, and still are, independent retailers with just a single store. They usually are characterized by a high level of after-sales service, and knowledgeable sales personnel. Store sizes range from rather small stores in shopping centers, to larger stores on the periphery. Today independent store keepers, that are not a franchise of a chain store, usually are a member of a buying organization, to ensure enough collective buying power to demand lower prices. At first, this type of stores used to display their goods unpacked on the shelf (See Figure 4.5 through 4.7). Nowadays, due to miniaturization, there are a lot of small high-value items which are sensitive to pilferage. These products are usually displayed in locked showcases.

Figure 4.5: Audio equipment shop, USA, 1938. (Courtesy of Mike Schultz; http://uv201.com/index.html, last viewed 28-07-09)

Figure 4.6: Electronics store, USA, January 1940. (Courtesy of Mike Schultz; http://uv201.com/index.html, last viewed 28-07-09)

Figure 4.7: Bronkhorst, electronics store Deventer, the Netherlands. (around 1965-66) Source: 'Deventer in beeld', city archive Deventer.

4.1.4 Chain stores

In a response to department stores, which had been able to buy cheaper because they had introduced cash payment, independent store keepers started to organize; the birth of the chain store. As a group they were able to buy in higher quantities, thus demanding even lower prices than the department stores. Department stores were all single stores then, although they too started to open new branches in a response to the emerging chain stores. This competition with chain stores was evident in most departments that were present in department stores. As consumer electronics were just arriving, this development seems to have taken effect only after WWII. For example, Best Buy started out as an independent store in 1966, which expanded to 9 locations in 1980. In 2006, Best Buy was the largest consumer electronics retailer in the U.S. Circuit City, which was the 3rd largest retailer in the U.S. (in 2006, and has since gone bankrupt) started out in 1949 as an independent store, expanding to just four stores in 1959. RadioShack, another well-known electronics retailer in the U.S. started out as an independent in 1921, growing to a handful of shops around 1960. In the Netherlands *Van Pool tot Pool* started as an independent in 1963, later growing into the now bankrupted chain *Megapool*, and *Harense smid*, though originally starting as a blacksmith in the mid-1800s, only opened its second branch in 1978.

4.1.5 Brand store

In electronics there are a few examples of brands that are sold through brand specific outlets. For some decades this has been the case with Bang & Olufsen. In recent years the best known example has become Apple, which operates high profile Apple Centers all over the world (see Figure 4.8). Brands that operate such outlets want to distinguish themselves from mainstream products. In both the case of Bang & Olufsen and Apple this is done through design. The products are usually priced in the top-end of the market, and there are rarely products on sale in such retail environments.

Upon entering an Apple Center, or a B&O store, a store with a modern interior will be encountered, with a spacious display of products. Whereas normal electronics shops strive to optimize the use of floor space, brand stores use a more spacious display to heighten the sense of luxury. The size of these stores ranges from all the way from small to big in the major cities of the world. Assistants in these shops

Figure 4.8: The interior of the Apple Store in SoHo, New York, October 2005. Courtesy of Matt Day, flickr.com

need to be highly knowledgeable about the products, as consumers will expect to be advised on their purchases. In an Apple store the products are on display unpacked, and hooked up, so that people can try them out. Only accessories by other brands (such as speakers by Bose, specially designed to go with the design of Apple), may be displayed by showing their boxes in a showcase.

4.1.6 Category Killers

Starting in the US the retail format of several chain stores changed. Store sizes were increased, and locations were moved to outside town centers; *big-box* retailing emerged. This development started with toys (toys ‘r us). The new format was based on large stores with a very complete collection of products within a clearly defined narrow market. These new stores are called *category killers*. The idea is to sell large numbers of products at low margins (which is the same success formula of department stores around 1900).

These formats are gaining market share fast, at the cost of small- and medium-sized retail formats that traditionally dominated the CE retail landscape. In 2004, 69 new Saturn and MediaMarkt stores were opened in Europe, bringing the total to just over 500. This change-over is illustrated by the following citation from a Dutch newspaper:

“MediaMarkt entered the Dutch market five years ago. Ever since, Kijkshop, It’s, Modern, BCC and Expert shiver with fear. The rise of the German discounter was partly responsible for the bankruptcy of the ‘Horn’ chain and last month for the bankruptcy of ‘Megapool’, that is even besides the anonymous independent stores disappearing. Experts expect more bankruptcies. In just five years MediaMarkt has achieved more or less the same sales volume as the 75 It’s shops, the 54 Modern shops, or the 112 Kijkshop shops. The group of 14 MediaMarkt locations in the Netherlands is to be expanded to 40 shops in the next 4 years. By then MediaMarkt will be market leader by far.” (Baltesen, 2004, translated from Dutch)

Category Killers are typically catering to ‘price buyers’. To keep prices down, use of floor space is maximized and the number of employees is kept low, as compared to more traditional retail formats; i.e. a self-service environment is created. In the traditional CE shop products are shown unpacked on shelves or in a cabinet. In such a traditional shop, customers have to approach a sales assistant which will advise them in their purchase, and subsequently collect the chosen product from the warehouse. In category killer stores, such as MediaMarkt and Saturn, the shop floor is used as storage space (see Figure 4.9). Packed products are available on the shelves, and many consumers make their purchase choices without contact to sales assistants.

Figure 4.9: Interior of a Saturn store, where packed products are available on the shelf, allowing self-service by consumers. (source: www.saturn.de)

4.1.7 Hypermarkets

In more or less the same way in which chain stores evolved into category killers, there has been a development in which supermarkets evolved into hypermarkets. Eventually mega-stores emerged that combined an extensive assortment of fast-moving consumer goods with durable goods. The best-known example is Wal-Mart, currently the largest retailer in the world. The same format is also applied by other retailers, such as Carrefour and Auchan in France. The assortment of durable goods includes clothing, sporting goods and CE goods, among others.

This can be seen as a typical sign for commoditization of a product; ending up on the shelf of a hypermarket or supermarket. It requires that consumers are knowledgeable enough, and the prices are low enough, for consumers to be capable and willing to purchase in such a retail setting (Spector, 2005, p.185). This is illustrated by a quote of Alan McCollough, chairman and chief executive officer of Circuit City: *"Who would have thought that five years ago, when DVD was introduced at $600 (a player), that today the market share leader would be Wal-Mart? Because a DVD player is now $39 and you can throw it in a cart."* (quoted in Spector, 2005, p.66. original ref.: "Circuit City Stores Will Offer Private-label Brand Products," Wall Street Journal, 31 March 2004.)

4.1.8 Supermarkets

Discount supermarkets, like the German chains Aldi and Lidl, are developing into a more general discount store. To draw customers they introduced promotional sales of durable consumer goods in their store. This is not in the permanent product assortment, but an ever-changing mix of products believed to have the proper price/quality mix to draw a high number of consumers to the stores. Durable products that have been sold at Aldi and Lidl stores include golf clubs and art works. CE goods have often been used in this kind of sales stunts, especially computers and computer peripherals (see Figure 4.10). There is even a brand (Medion), which has emerged as a computer supplier selling its goods exclusively through this type of retail.

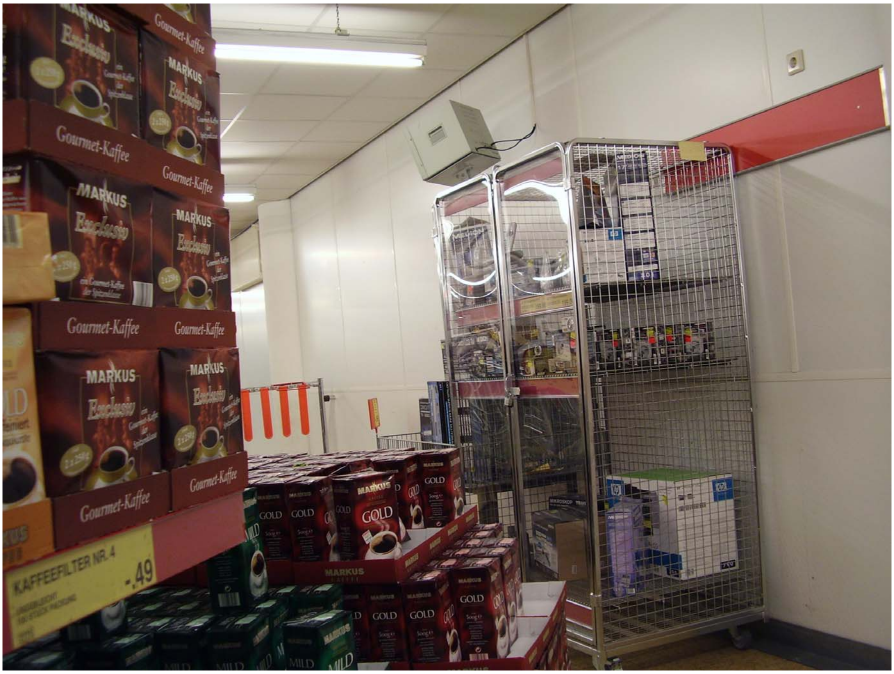


Figure 4.10: CE goods in an Aldi store in Berlin, displayed in locked roll containers.

4.1.9 Internet retailing

During the 1990s Internet retailing emerged. Currently there are two major types of Internet retailing, the first being OEMs selling their products directly through the Internet, the second is the virtual version of a normal shop.

The biggest representative of the first category is Dell, which only sells its products through their own Website. Their direct-business model is based on build-to-order. This allows for short distribution lines, which also allows them to supply the latest innovations directly to the consumers, as there are no stocks of finished goods. Building-to-order also allows for customization, meaning that the customer can get exactly what he wants, without having to buy features he is not interested in.

The companies in the second category are virtual versions of store types that can be observed in the real world. For instance, amazon.com can be considered a virtual department store, selling books, music, clothes, electronics, household products and more. Amazon.com does not originate from a brick-and-mortar retailer, but there are examples of this as well. For instance Wehkamp, originally working with mail-order catalogs, now also operates a Website, which can be seen as a virtual mail-order catalog. In essence, the merchandise offered by Wehkamp, makes it a virtual department store, just like Amazon.com.

There are also retailers on the Internet who specialize specifically in electronics, or even a sub-category. These retailers can be seen as a virtual version of an independent or chain store.

The idea of such virtual shops is to sell products without a brick-and-mortar environment, and without any contact with sales assistants.

For these retail outlets the functionality of the packaging is purely logistical; getting the product as cheaply and efficiently to the consumers' home, without damage.

4.1.10 Discussion

As was already discussed in Chapter 1, larger and fewer retailers control access to the consumer. Whereas it used to be OEMs determining what products would be introduced into the market, nowadays the large retailers, be it category killers or hypermarkets, have the most power in the value chain (see also Section 6.2). They decide which products will be available to the public. Furthermore, they can enforce their opinion on how these products should be offered. The demands retailers set on packaging are non-negotiable for most OEMs.

The retail landscape is changing fast. Hypermarkets and category killers are gaining market share (Baltesen, 2004; Lohuis, 2005). Hence, this shift in the power chain will become only more evident. The situation in the Netherlands can be illustrative here. Recently one chain of stores (Megapool) went bankrupt. Many independent retailers are in trouble or have already closed down (Lohuis, 2005). In 2005 the market was dominated by 8 players, either chain stores or category killers, with a combined market share of 55 to 60% (Lohuis, 2005). Lohuis quotes Peter Brussel, director of one of the players (BCC), as predicting that in five years time there will be room for just 4 players.

The thing category killers and hypermarkets have in common is there display of goods. They are both extreme examples of the 'open sell' philosophy. *"… the 'open sell' school of display puts almost everything out there where we can touch or smell or try it, unmediated by salesclerks. In 1960, 35 percent of the average Sears store was given over to storage. Today it's less than 15 percent. Today it's almost pointless to ask a clerk if an item you want is in the back room. In some stores there* is *no back room to speak of. Everything is either on the shelves or in the little storage cupboards above or below"* (Underhill, 1999, pp.165-166)

In conclusion, it can be stated that each of these retail environments has its own dominant packaging functionality (see also Table 4.1). In Internet-retailing that are distribution-related functions, in brand stores that are experience-related functions, and in category killers and hypermarkets that are sales-related functions.

Type of retail	Relevance of packaging functions			Power over the value chain
	Distribution	Sales	Experience	
Specialist stores	++	0	+	0
Department stores	++	+	0	0
Independents	+++	0	0	0
Chain stores	++	+	0	+
Brand stores	+	0	+++	N.A.
Category killers	+	+++	0	+++
Hypermarkets	+	+++	0	+++
Supermarkets	+	+++	0	+
Internet retailing	+++	0	+	0/+/++

Table 4.1: Assessment of the relative importance of the different types of packaging functionalities for the different types of retail outlet, as well as an assessment of the power of such retailers over the entire value chain. 0 means no relevance or power, with +, ++, +++ indication an increasing level of relevance or power.

These different functions have led to clearly observable differences in packaging. In the following section the sales-related packaging will be discussed, whereas the experience-related packaging, such as for products to be sold in brand stores, is the subject of Chapter 5.

4.2 Influence on packaging design

In Intermezzo A social and economical developments were described that increase the importance of sales-related packaging functions. Section 4.1 has discussed the related changes in the retailing of CE goods, also leading to increased importance of sales functionalities. A shift was described towards retail concepts were packed products are on the shelf for consumers to select. The packaging plays an important role in attracting consumer attention in order to ensure the specific product is noticed and considered by the consumer, to communicate the advantages of the specific product (and brand), and to close the deal. Even though shop assistants can still help consumers if required, many consumers will buy products unassisted. This puts considerable demands on the packaging, which are illustrated perfectly by the following quote from the director of Philips Design:
"At the point of sale it is necessary to communicate what the product is, what it can do for the consumer, and why it is better than any other product offering from our competitors in that specific category. In addition, it is also has to convey a general impression of the company as a whole. This is no easy task, given the cacophony of messages and choices potential buyers are faced with. Packaging plays a crucial role in persuading consumers to buy. This is particularly true in American hypermarkets, where consumers make a choice purely based on the packaging and unaided by sales personnel. Approximately 80% of all consumer electronics products in the US are sold this way - which is why packaging is also referred to as the 'silent salesman'." (Marzano, 2006, p.368)

Packaging designers faced with such challenges often choose increased packaging volumes as a means of fulfilling such sales functionalities (e.g. attracting attention, communicating unique selling points). Especially the front-facing-area is deemed important, and therefore oftentimes required to be of a certain size. As Chapter 3 demonstrated, this can lead to packaging that is 20 to 40 times as voluminous as the product contained within, and fully loaded sea containers, of which the volume percentage actually occupied by products is as low as 4%.

Next to attracting attention, self-service retail concepts put another challenge on packages, that of tampering. There can be several reasons for people to open packages, for instance to check the completeness of the content or the color of the product. These kinds of consumer actions may damage boxes, or cause accessories to go missing. In either case the product may become unsalable. Next to that, theft-prevention issues may cause a retailer to prefer voluminous and hard to open packages. Finally some products require a proof of newness, particularly those related to personal hygiene. All these issues result in a retailer demand for tamperproof packaging. The most common version of tamperproof packaging are the clamshell, which consists of two plastic shells which are sealed around a product, and the blister, which consists of a plastic shell glued to a cardboard liner.

Several retailers will put additional safety strips around packages which could otherwise be easily opened, or place packages that are deemed too valuable and small into sealed plastic cases (see Figure 4.11). In both cases, this will likely have negative effects on the pursued sales performance.

Figure 4.11: anti-tampering strips added to packaging (left), and anti-pilferage plastic containers (right). (Hettema, 2005).

4.2.1 Environmental aspects

The previous sections have demonstrated that the developments in socio-economical circumstances have let to a different way of retailing of CE goods, and subsequently to a different way of packaging these products. These developments in packaging design are negative from an environmental perspective, because of increased volume and increased and more diverse material use (which are respectively energy-, resources- and recycling-related aspects). They are however real (as was described in Intermezzo A), and their bad environmental performance as such is not sufficient ground for established businesses to change them, although environmentalists may wish differently, as is demonstrated by the following quote: *"The degree to which modern packaging serves marketing, branding, and sales interests rather than fulfilling the more essential functions of safety, efficiency, convenience, delivery, and environmental health and safety deserves to be questioned."* (Imhoff, 2005, pp. 12-13)

One of the aims of this thesis is to demonstrate that different functions can be balanced in such a way, that the environmental burden is considerably decreased with regard to current practice. The fast increase in sales and experience packaging that has resulted from the commoditization of CE products (see Intermezzo A), has led to a lack of consistent approaches. This brings a substantial improvement potential.

Although focussing on other products than CE goods, and dating from a purely material-focussed era, the following quote demonstrates that professionals in the packaging industry believe that this balance indeed exists:
"This research suggests that making a sales package [for consumer goods] *more environmentally friendly does not necessarily make it more difficult to protect or handle the product, or make the sales package less appealing to consumers. In other words, marketers do not perceive any trade-off between the marketing/ logistical demands on packaging and the environmental demands on packaging. Thus, despite environmentalism, sales packaging will remain as an important means of promoting and protecting the product."* (Prendergast & Pitt, 1996, pp. 69-70)
The objective of the current research is to actually turn such beliefs into reality.

Besides the potential of reducing the environmental impact by finding other ways of fulfilling sales-related functions, economical savings are obtained as well. If packages are smaller, more can be fitted into a shipment, thus reducing shipping cost dramatically (as was demonstrated in Chapters 1 and 3). Furthermore, smaller packaging will usually also require less material, hence also reducing raw material procurement costs.

4.3 Conclusion

In an interacting process of economical developments and changes in the retail set up of CE stores, the requirements, that packaging of CE products has to fulfill, have become much more sales-related. These functions consist of attention-grabbing and communicating, but also of protection against tampering and theft. The classic approach to fulfill these functions is to increase the volume of the packaging, and in particular to increase the frontal areas (as could also be observed in some of the case studies in Section 2.3.1). Figure 3.2 already showed this occurred regularly for products with a volume below 20 dm^3, and especially for really small items (below or around 1 dm^3). Both from an economical and environmental perspective this is a costly solution. In Chapter 8, design strategies will be presented that allow balancing of sales functionalities with logistical efficiency, and thereby with cost and environmental impact.

Through the analysis of the developments in retail concepts, in combination with the developments in Intermezzo A, the research question regarding how sales-functionalities became relevant for packaging of CE products has been addressed. Also through the discussion of the influence of these retail developments on packaging design (in combination with Section 2.3), the research question on how a certain packaging function relates to packaging volume has been addressed for sales-related packaging.

"I'll be more enthusiastic about encouraging thinking outside the box when there's evidence of any thinking going on inside it."

TERRY PRATCHETT

5. The experience of Consumer Electronic Products[27]

Intermezzo A and the previous chapter have taken a closer look at the developments in retailing of CE goods, and have described that these developments have resulted in two distinct approaches, that of commoditization and differentiation. The process of commoditization is strongly linked to sales-dominated packaging, while in the case of differentiation experience-dominated packaging is more fitting. The previous chapter elaborated on sales-dominated packaging, and now this chapter will elaborate on experience-dominated packaging. In doing so, the following research question will be addressed again: 'What are the relationships between a certain packaging function and packaging volume', now from the perspective of the experience-related functions of a packaging. Also, the research question about the potential for improvement will be addressed for experience-related packaging functions.

5.1 Introduction

When products become commoditized, as described in Intermezzo A, price becomes a dominant factor in product choice. Hence margins for the manufacturer decrease. To remain sufficiently profitable, a manufacturer either needs high sales volumes, or he needs to counter the commoditization development. In order to be able to achieve the latter a brand needs to have added value. Several brands specifically follow such a strategy of providing added value. Apple and Bang & Olufsen do this for their entire brand—even to the extent of having their own retail outlets, as described in Chapter 4. Others, like for example LG with the LG Chocolate phone and LG Prada phone, make such products as the high-end part of their product portfolio. A third category of products requiring an experience packaging, are the products that are frequently bought as gifts (e.g. special gift boxes for electric shavers).

In their book on the experience economy, Pine and Gilmore (1999, p.16) propose that companies create experiences instead of mere products: *"Manufacturers must explicitly design their goods to enhance the user's experience as well—essentially experientializing the goods—even when customers pursue less adventurous activities. Automakers do this when they focus on enhancing the driving experience. (...) What changes could an appliance manufacturer make to its white goods that would enhance the washing experience, the drying experience, and the cooking experience? (…) If you as a manufacturer start thinking in these terms—*inging *your things—you'll soon be surrounding your goods*

[27] This Chapter is based on Wever, R & Del Castillo A. (2006) Thinking out of the Box; the Unpacking Experience of Consumer Electronics Products. The 15th IAPRI World Conference on Packaging, October 2-5, 2006. Tokyo, Japan.

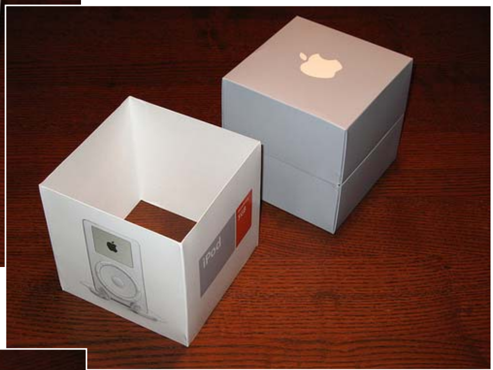
with services that add value to the activity of using them and then perhaps surrounding those services with experiences that make using them more memorable. (…) Any good can be -ing-*ed.”*

As stated above, Apple works very strongly with this strategy. Ask any big group of people—like a couple of hundred design students in a lecture hall—who owns an iPod (which will probably be the majority) and how many still have the packaging. Again this will be a considerable percentage; a fact definitively not applicable to products in distribution or sales-dominated packages.

If experience-related functionalities are important for the *product*, then the packaging should also express this. For packaging, ‘experientializing’ means creating an unpacking experience for the packed product. The importance of the unpacking experience for CE products is expressed by Marzano in his book on 80 years of Philips design (2005, p.373): *“(…), the new Philips marketing strategy involved offering experiences rather than just products. It was important to communicate the emotional dimension of what was inside the box, and this obviously had to be achieved through the packaging.”* One example of a packaging that was redesigned with the unpacking experience in mind is the package for a limited edition of the Senseo coffeemaker (see also the case study in Chapter 6).

Experience packaging that is currently on the market shows a high degree of design attention. For instance, the EPS cushions of the Apple Macbook are clearly designed to be aesthetically pleasing, as well as protective. The emergence of CE packaging designed for its unpacking experience has even led to several Internet forums dedicated to celebrating and reviewing the unpacking experience of products (although they seem to prefer the term ‘unboxing’). Figures 5.1a through to 5.1e show the quintessential example of an unpacking experience for a CE product; the original iPod. Here, the packaging was clearly designed to provide a pleasant unpacking experience. First a sleeve is removed that is around the box, which has no other function than to add a layer of material (and thereby add a step to the unpacking sequence, helping to build excitement), and to allow for a printed outer packaging as well as a clear box itself, without printing. In the second step a small seal is broken and the cubic box splits in the middle. This still does not reveal the product itself. In the third step, two flaps are folded away, thus presenting the product on the one side and the peripherals on the other side.

Three things can be observed about the interior of this and other experience-dominated packaging that sets them apart from distribution-dominated and sales-dominated packaging. First, the inside of the packaging is designed to look aesthetically pleasing; it is usually not possible to see glue lines, brown corrugated board, or other untreated materials. Secondly, a lot of thought has gone into the presentation of the product. The consumer will see it from an appealing side, in a well presented way. Thirdly, a lot of thought has also gone into the sequence in which the consumer encounters the content of the packaging (product, manual, peripherals). Of these three, especially the latter two characteristics may lead to increased volume of the outer package, as the internal organization of product, manual and peripherals is based on the presentation and the unpacking sequence, and not on efficient use of box volume.



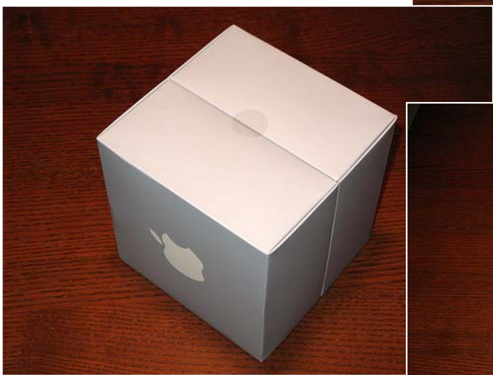


Figure 5.1 a-e: the unboxing of the original iPod by Apple. a) shows the box with the sleeve still around it. b) shows the box after removing the sleeve. c) shows the small seal holding the box together. d) shows the box split in the middle, with the product still covered. e) shows the covers folded away, revealing the product and the manual. The accessories are still hidden beneath the manual. (Courtesy of Shane O'Neill at www.flickr.com)

Pine and Gilmore (1999, Chapter 3) provide a five step plan for 'experientializing' a product (e.g. creating an unpacking experience for a package);

1. Theme the experience,
2. Harmonize positive cues,
3. Eliminate negative cues,
4. Mix in memorabilia,
5. Engage the five senses.

To get some empirical data to see how consumer perceive the unpacking of CE goods, and to see to what extent the steps by Pine and Gilmore are applicable to packaging, three separate studies were performed. First a survey was conducted asking people about unpacking CE goods. Second, several focus groups were held, studying one particular CE product (a CD/MP3 player). Third, an openability experiment was performed asking people to open a clamshell packaging for an electric shaver, and a second durable consumer good.[28]

5.2 Study 1: Internet Survey

A survey was conducted through the Internet (N=64) to get a feel what consumers think/ feel about unpacking consumer electronics. The survey asked about the most recent purchase of a CE product and about previous purchases that were memorable either in a positive or a negative way. The survey contained two separate open questions for positive and negative memories from the unpacking CE products. This question is relevant for the understanding the applicability of the five steps defined by Pine and Gilmore. Similar responses to these questions were grouped. The following positive issues were mentioned most often (the number between brackets shows how often a point was mentioned. Participants could name more than one issue):

– Simple, practical, no unnecessary extras (35),
– Good, esthetical design (29),
– Right size (compact) (26),
– Strong, offers protection, induces trust due to quality (26),
– Good interior lay out/ arrangement of parts (21).

The negative aspects mentioned most often were:

– Too much waste and separately packed parts (35),
– Package is too big (31),
– Product is difficult to get out of its package, too tightly packed or anti-theft-plastic packaging used (26),
– Package is boring or uninspiring (16).

These findings indicate that people acknowledge the need for protection and accept the resulting packaging design. This factor, combined with well thought-through design can be classified as 'positive cues' in the unpacking experience. However they dislike the sales-related functions—big packages, tamperproof packages—which present them with problems of openability and waste disposal. These two factors can be considered 'negative cues' in the unpacking experience.

[28] The first two studies were part of a bachelor student research project, while the third study was part of a Master thesis project (A. Del Castillo C, 2006).

5.3 Study 2: Focus Groups

Following the survey three focus group sessions were held, each with 4 people participating, evaluating the packaging of a portable CD/MP3 player of the AEG brand (See Figure 5.2). The product was sold in a large drugstore chain in the Netherlands, meaning it is presented as a budget product. This retail environment would make it a product with strong distribution and sales functionalities and limited unpacking experience functionalities. This limits the usefulness of this study, but budget restrictions did not allow the purchase of a CE product in a typical experience packaging.

Figure 5.2: Portable CD player used in focus group sessions on unpacking experience.

The box is reasonably volume efficient. The CD/MP3 player is on its side, in a PE film. On opening the packaging the buyer would find the folded corrugated-board inner packaging in which product and accessories both receive an equally prominent place. Participants were not told about the retail environment or the price. The product was used as a starting point for the discussion, and participants were also asked about experiences with other durable consumer goods. From these focus groups the following conclusions can be drawn:

- People expect simple packaging for cheap products. In case of the AEG box, the product is cheap; hence a simple box would be suitable. However, the package is not just simple, it actually looks “*lousy*”. The product looks (somewhat) better than the package it comes in, so that is a missed opportunity.
- People expect cushioning foam as protective material in CE packages, and they also expect accessories to be packed separately in PE bags. (This expectation does not necessarily mean they like it!) In the case of the AEG, there are separate PE bags, but the product has no additional cushioning.
- People like to be able to bring back the product; hence they prefer a package that is not destroyed in opening. Resulting from this potential product return, they also keep the package for some time after purchasing the product.
- Products people do not use often, like a compass, they like to store in the package.
- People like the product and accessories to come out of the package in a more logical and orderly fashion, than is the case with the AEG.
- People *claim* they are not influenced by the sales function of packaging of CE products.

– The different materials, which should go into different waste receptacles, annoy people.

This study again confirms that there are details that act as 'negative cues', which annoy people unpacking the product. Creating a positive experience therefore also includes eliminating all negative cues.

5.4 Study 3: Openability

Since it was suspected that openability of the packaging was a major item in positive or negative experiences, an experiment was performed. A group of participants (N=25) was asked to each unpack two products packed in clamshells. This was done during one-on-one interviews. Participants were filmed and asked to think out-loud (describing with spoken words their actions and feelings, either positive or negative) during all the given tasks. The experiment was either executed at the participant's home, or at the university in a setting resembling a home, because it is the most natural, often used setting to unpack such products.

The first part consisted of unpacking a general consumer durable packed in a plastic clamshell (e.g. earphones, children's toys, neck support pillow, a window alarm). Afterwards, the participants were asked to unpack an electrical shaver package, of which three different models were used, and finally a series of general questions about the unpacking were asked.

In the introductory part of the interview, where participants were asked to unpack a general consumer durable, it was observed and concluded that:

– Participants had a very low-price/low-quality perception of the products that were packed in clamshells.
– Right after observing the package, without any action, about half of the participants expected that it would be a hard task to get the product out of the package (8). Some of them even remembered unpleasant past experiences (3).
– Participants were intuitively looking for a corner with a clue or a hint that would lead them to unpack the product (all participants).
– Most participants were not able to find clues in most of the cases (4 persons opened the packages with their own hands, by tearing the packaging apart).
– Using a tool was seen as the next option; scissors (9) or a knife (8). Two participants used their teeth to open the packages. In some cases (2) the participants acted in a more aggressive manner which might even hurt them in a physical way.

As a general conclusion from the unpacking of this first product, people wanted to be guided and helped through the experience, by offering clear indications on what actions to take and a suggestion of an appropriate tool for the task.

In the second part, the task was to unpack the electric shaver and take out all of the contents. The responses, actions and expressions of the participants led to the following conclusions:

– The package as such was impressive enough to raise positive expectations with the participants, but the presence of the clamshell lowered the people expectations towards the unpacking.

- Participants felt irritated at some point by the fact that no clues were offered on how to open the clamshell. This provoked in them ‘wrap rage’ (an American term that describes the anger consumers feel towards packages that cannot be opened easily).
- Two participants sustained minor cuts when trying to reach for the product, while others (12) expressed in some way the discomforting feeling that they were afraid of scratching or cutting themselves on the clamshell material. This reduces people’s experience by giving them a negative feeling even before taking the product in their hands.
- During the unpacking, even though it was not expressed in comments of the interviews, most of the participants (18) had to repeat the same action in order to get to the product, for instance, having to cut the clamshell in the same place more than once. This made them feel insecure of their actions and ill-guided by the package design. It also induced to wrap rage. They desired to be fully guided and explained what type of actions to make.
- One special remark from participants concerned smell. In four cases, it was mentioned that the package emitted a bad smell during the unpacking (possibly due to some plastic components that react being enclosed in a sealed clamshell). This happened before reaching for the product, and it instantly lowered people’s perception towards the experience. These comments helped to conclude that other senses than sight can have a powerful effect. A positive influence on them (smell, touch, sound) can contribute to a good unpacking experience.
- The participants’ perception of the price of the product compared to the package is opposite. The product was perceived as a high quality object, and the package is seen generally as a cheap way to pack such product.

In general, participants in the second experiment also expected to receive more clues and help on how to open and take out the contents of the package. Furthermore, they expected to have the most important part of the package first (in this case the shaver) and not last. The relationship of this experiment with the steps proposed by Pine and Gilmore is clear; there are certain things that should be avoided. These negative aspects can be translated to positive aspects, and thus be utilized to create an unpacking experience. The more the bases are well defined and set, in aspects such as consistency of actions, openability clues and guidance for opening, the better the unpacking experience for the user will be. Thus, a better overall product perception will be obtained from the moment the consumer sees and holds the package until the final product is taken out of its package.

5.5 Conclusions

For high-margin CE products the experiential aspects have become a highly significant part of the added value of the product. For such products the unpacking experience can make a substantial contribution in enhancing these experiences. As for the research question on how experience functionality is linked to packaging volume, it has been observed that packages designed for their unpacking experience often become more bulky, due to the layering and placement of the product and its accessories. Obviously, this is at conflict with the logistical efficiency, and is therefore expensive in both economical and environmental terms. This has only gained in significance, now that production has moved to low-wage countries, resulting in increased transportation distances. However, as layering and placement of the product and its accessories is only one of the ways of designing an experience packaging, there seems to be a potential for improvement regarding the current practice of experience packaging. This improvement could be obtained through a high level of design attention, both to the outside and inside of the packaging.

Designing a positive unpacking experience is challenging, as conflicts may occur with other functional requirements of the packaging (distribution-related, sales-related). The clearest example is the conflict with the sales-related requirement that the package should be tamperproof. Non-tamperproof packages cannot be sold in a large percentage of the retail environments. However, the resulting wrap-rage compromises a positive unpacking experience. This articulates that openability deserves special attention during the packaging design engineering process.

Such trade-offs between sales- and experience-related functionalities, as well as between distribution- and experience-related functionalities, again articulate the need for a holistic approach to packaging design engineering. This will be further addressed in Chapters 6 and 8.

"The basic purpose of packaging is to enable the right goods to get to the right place at the right time in an acceptable condition. Of course, the users of packaging want to do this as economically as possible; the marketers want the package to attract consumers; the environmentalists want to minimize the environmental impacts of producing and discarding the package; and other parties have other jobs for the package to perform, as well."

SUSAN SELKE (1997, p.1)

6. The Mix of Packaging Functionalities

The previous chapters have discussed the three categories of packaging functionality that play a role in determining the volume of a package design, namely related to distribution, sales and experience. In most real-life cases the functionalities that a packaging will have to perform will not be exclusively related to one category. Instead there will be a mix of the three, with varying degrees of importance. As has been shown in previous chapters, this variance in importance depends on the packed product, the target group and the retail channels through which it is sold.

In this work, the object of study here is the relation those functionalities have with the resulting packaging *volume*, and not necessarily with the entire packaging appearance. In many cases the packaging volume *is* determined by a single type of functionality.

This chapter will discuss how the mix of functionalities can be balanced. Three case studies will be presented. Each case study deals with the balancing of different types of functionalities. Besides that, each of the studies emphasizes a particular aspect. The first study will illustrate the value-chain issues around the balancing act of mixed functionalities. The second case study will illustrate the inefficiency of working with a wrong mix of functionalities, and the third case will illustrate a design process that may lead to better balancing of the three functionalities.

In doing so, this chapter addresses the following two research questions:

- In case of multiple relevant packaging functions, how are these functions reflected in the volume of the final packaging?
- How can designers determine the (mix of) required functionalities of the packaging of a certain product?

6.1 Market segmentation

As stated the relative importance of the three types of packaging functionality will depend to a large extent on outlet channels and consumer attitudes (see Intermezzo A and Chapter 4). In studying a market, segments of consumers can be identified. Pascual and Stevels (2006) discuss a segmentation into three types of buyers:

- Price buyers, who are budget oriented, and mainly interested in obtaining a certain functionality at minimal cost,

- Feature buyers (also known as ‘technology buyers’), who are interested in the latest technology and in additional features in a product. They are willing to pay more for products with more features. These consumers may also be categorized as ‘button freaks’.
- Quality buyers (also known as ‘experience buyers’). These consumers are looking for the best product offered within certain specific functionalities. They are less concerned with the cost.

These buyers can be linked to outlet channels and therefore to the three types of packaging functionalities (see also Table 4.1). Price buyers do not want to pay for fancy packaging; hence simple distribution-dominated packaging is most suited for packing products for this group. Feature buyers need to be convinced of the value of additional features a product has to offer, in order to induce them to pay more. Hence feature buyers can be linked to sales-dominated packaging. Finally quality buyers want to be reassured of the quality of the product they buy; hence experience-dominated packaging fits this target group best.

The packaging requirements for different consumer groups and outlet channels may be contradictory to each other. Nonetheless, the challenge for the packaging developer is to come up with a package that corresponds optimally with the mix of outlet channels and target group of a certain product. The focus can either be on one of these target groups, or alternative products (or possibly just alternative packaging) can be provided for each of these groups.

However, the three groups do frequent different retail outlets. Price buyers are more likely to buy at price-oriented category killers and hypermarkets (see Chapter 4), while quality buyers are more likely to buy at independent retailers, retail chains and brand stores, where they expect to find a higher level of service. This gives an OEM more options for actually differentiating its offering of differently packed products.

Due to a different relative size of the three groups in different countries or regions, some brands opt for packing their products differently for different regions. An example of this is the Philishave. For the North-American market, where hypermarkets have a considerable market share, sales-oriented packaging is required. Hence, the shavers are packed in voluminous clamshell packaging. For the European market, where retail chains are still the dominant outlet for shavers, those *same* shavers are packed in smaller corrugated board boxes.

6.2 Dynamics in the value chain[29]

As discussed in Chapter 2 there are multiple stakeholders involved in a CE product that have an interest in the packaging design, or in at least one of the types of functionalities (see also Stevels, 2007, p.241). These can be both internal and external to the OEM. For instance national sales managers within the OEM will be focused strongly on the sales aspects of their products, in order to perform optimally in the specific retail situation for that country

[29] This paragraph is strongly based on: Wever, Bouvy, Hettema & Stevels (2008) A Packaging Supplier’s Contribution to Branding and Sustainability. Proceedings ICOVACS 2008, Izmir, Turkey.

Value chains are about power. A single player in the value chain—which can be either internal or external—may have the power to enforce a packaging design that is (perceived to be) optimal to his particular needs, while from a holistic view it is obviously sub-optimal. Such a value chain player, like the national sales manager, or a purchaser from a large retailer, may cause one type of functionality to become all-important.

Value chains are dynamic, and the relative importance of certain players may grow or diminish over time. Within the CE field such a historical development can be observed, as the power in the value chain has shifted towards retailers (see also Chapter 4). Besides having the advantage of direct consumer contact, this increase in power is a result of the retail concentrating in fewer but larger retail chains (see Figure 6.1).

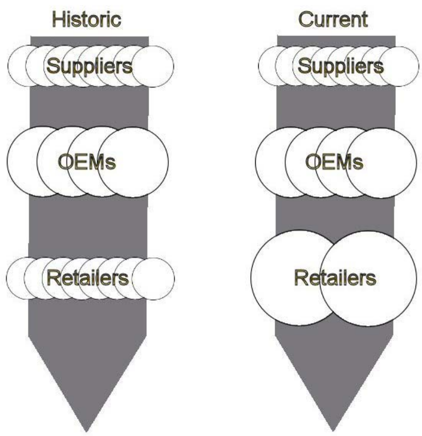


Figure 6.1: Schematic representation of size and number of players at different phases of the value chain. On the left the post WWII situation is shown, on the right the current situation. (Wever, Bouvy, Hettema & Stevels, 2008)

Retail has become the 'narrowest' part of the value chain (i.e. smallest amount of truly significant players), giving each of the remaining retailers increased power over its supply chain. This development can be seen in many different branches of retailing (for a discussion see Spector, 2005, Sampson, 2008). Due to the buying power these retailers represent, OEMs cannot afford to alienate one. The World's current largest retailer, Wal-Mart, operates in most product categories, from FMCG to consumer electronics, toys and apparel. Wal-Mart manifests its power over the value chain through all kinds of requirements it sets for its supplying OEMs, including packaging requirements.

These large retailers have started to treat manufacturers in the same way OEMs have traditionally regarded their suppliers. They set the demands, and if those are not met, one manufacturer is often easily replaced for another. The position of the packaging supplier is hereby reduced to a sub-supplier; a position that is potentially even weaker.

Retailers put a wide variety of demands on the packaging in which products are delivered. This goes for primary, as well as for secondary and tertiary packaging. Demands can cover a wide variety of subjects from dimensions of the primary pack (in order to utilize shelf space optimally), palletization (in order to fit internal distribution systems), openability of secondary packaging (in order to facilitate speedy shelf replenishment) and recently issues of identification (RFID) and sustainability (e.g. Wal-Mart sustainability scorecard). Due to the supermarket-like style of retailing, the demands set for packaging have to do with a mixture of functionalities regarding logistical efficiency, increasing sales and shopping experience. In the end these demands have a strong link to economics, either through reducing costs or through increasing turn-over.

Several retailers have published guidelines regarding packaging to which they expect their suppliers to confirm, such as Albert Heijn supermarkets in the Netherlands (Albert Heijn, 2003) which includes modular dimensions for secondary packs and Argos (Argos, 2004) which includes drop test procedures.

Wal-Mart's packaging sustainability scorecard is one of the most far-reaching examples of retailer demands, as it basically defines what sustainability is regarding packaging and simply requires its suppliers to present data on their packaging performance in relation to the Wal-Mart indicators. The score on the scorecard is subsequently a factor in the purchasing decision by Wal-Mart procurement agents (Mohan, 2008).

Some manufacturers retain some power over large retailers by having something unique to offer, something a retail outlet has to have in it assortment. This can for instance be a very strong brand that consumers simply demand to be on offer.

Such a position of essential supplier is something packaging suppliers can also strive for in relation to OEMs. But then they have to offer more than simple packaging materials.

Introduction to case studies

Several projects were executed in the form of graduation projects for Industrial Design Engineering master students. These students were all co-supervised by the author and supervisor of this thesis. Parts of these projects will be described and analyzed in the following paragraphs, thus creating insight into the balancing of packaging functionalities. In essence, these were all independent projects. However, they all started with the volume optimization objective that is proposed in this thesis. Hence, the methodology of this chapter can be seen as what has been termed design-inclusive-research (Horváth, 2007).

The first study will illustrate the issues around measuring and balancing multiple functionalities. The second case study will illustrate the inefficiency of working with a wrong mix of functionalities, and the third case will illustrate a design process that may lead to better balancing of the three functionalities.

6.3 Case Study I: Measuring and balancing functionalities (*Electric Shaver*)[30]

An analysis was made of several designs from recent years, for electric shavers from Philips (branded as Philishave or as Norelco) as well as from competitor brands. In total 18 products were included of which roughly half were by Philishave. With the exception of one earlier product all products were from the 2001-2005 period.

Following the same methodology that was used to create Figure 1.1, Figure 6.2 shows the densities of the 18 shavers studied in relation to the break-even densities of several modes of transportation. This plot allows the assessment of whether packed products will be weight-critical or volume-critical during transportation. It shows that several of the packed shavers would be weight-critical if transported by airplane, or by some of the trucks. However, all products are volume-critical if transported by sea container, which is in fact the most important mode of long-distance transport for electric shavers.

It was found that packed shavers have a volume index in the region of 1.5 to 7, which is, on average, significantly higher than volume indices of the distribution-dominated packages (see Paragraph 3.3.1). Special gift-boxes were even more voluminous. These higher volume indices were expected, as shaver packaging design is dominated by sales-dominated functions.

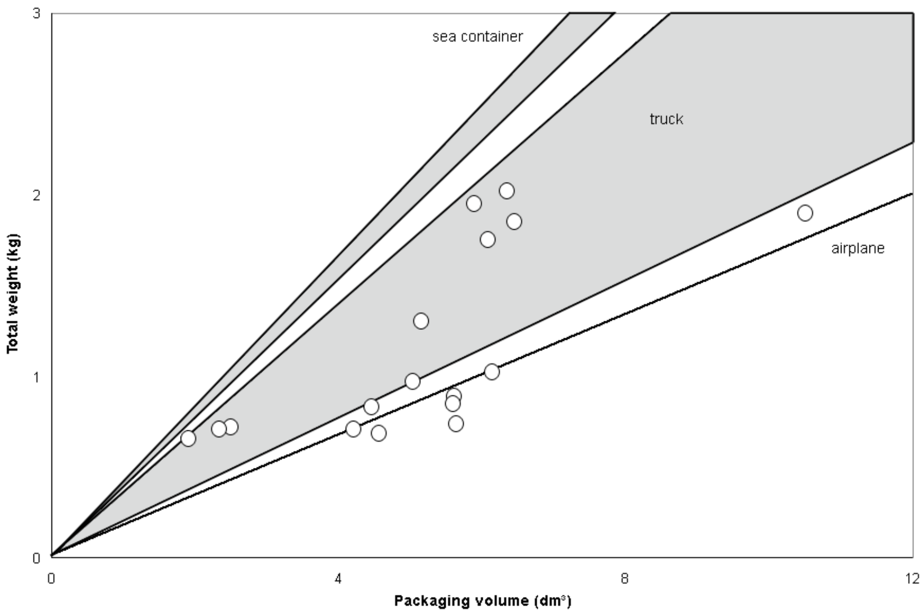


Figure 6.2: Densities for 18 packed electric shavers in relation to break-even densities of different modes of transport. (see also Figure 1.1).

[30] This case study originates from a graduation project co-supervised by the author (Van Es, 2005). It was previously published in Wever, Boks, Van Es and Stevels (2005) and Wever, Boks and Stevels (2006a).

Subsequently, using EcoScan software, calculations were made to determine for these designs what the ratio (P:T) is of the environmental impact for packaging materials on the one hand (P) and transportation (T) on the other. Here *only* the transportation from the factory in Drachten in the Netherlands, via Antwerp Harbor and Montreal Harbor, to New York City was considered. The results are shown in Figure 6.3. It shows that on average the P:T score is 3:2. Hence the finding from previous studies (see Chapter 1) is not confirmed entirely. This difference may have two causes. First, packaging design for shavers is different from the products in the data set of Chapter 1, as the basis is not a corrugated board box, but a PET clamshell. Such a clamshell has a higher environmental impact than a corrugated board box. Second, the final part of the distribution, from the distribution center to the retailer has *not* been included. This phase, consisting of truck transportation, has a high environmental (and economical) impact (due to the fact that one truck, and therefore one driver, is needed per container). Notwithstanding a potential difference in the P:T ratio, design for volume reduction still is a strategy allowing a substantial improvement potential in reducing the environmental (and economical) impact of the packaging and distribution.

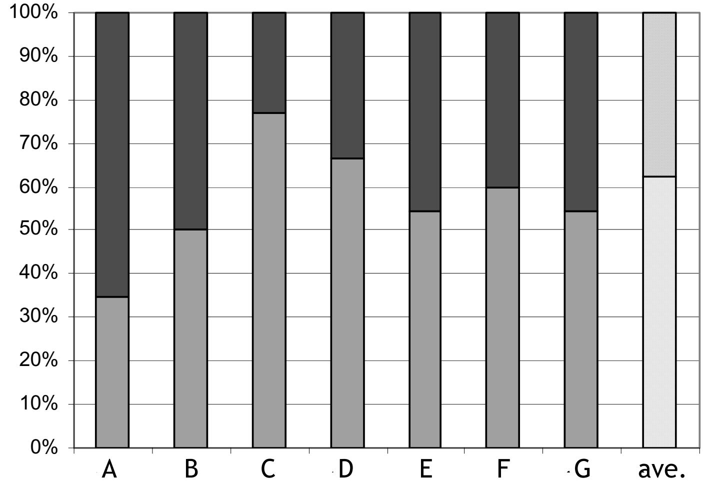


Figure 6.3: Ratio between impact of production & end-of-life of the packaging (light grey) and transportation (dark grey) for seven shaver designs. The column on the right shows the average score. Transportation only includes European factory to North American Distribution Centre.

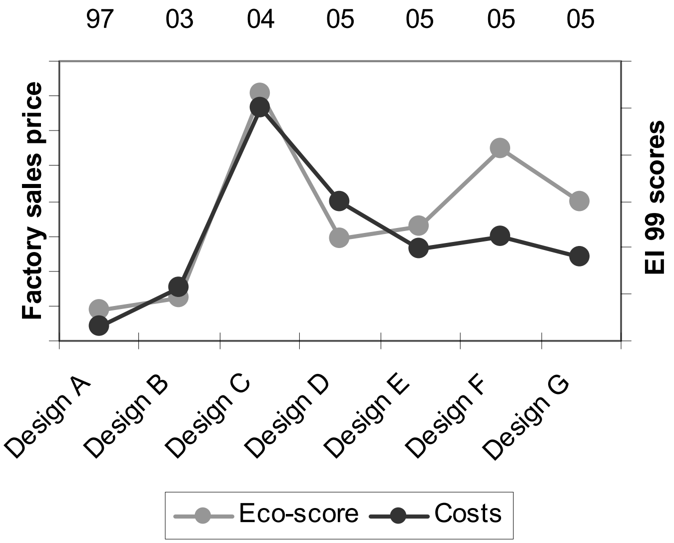


Figure 6.4: Development of costs and eco-impact over time. Above the figure is the year of introduction of the design.

For the Philips brand, a further analysis was made of the products. They were analyzed for direct cost and direct environmental impact (so packaging materials only, excluding the distribution phase). Figure 6.4 gives the results of that study, including the year the models were launched (The environmental impact was assessed with EcoScan software; the outcome is expressed in a single-score, using the Eco-Indicator 99 method). It demonstrates two things. First, that the eco-impact of the packaging is strongly related to the costs of the packaging. And second, that there has been a considerable increase in costs and eco-impact over time. This increase can partly be explained by the changes in the retail situation (requiring sales-dominated packaging, see Chapter 4), and partly by increased competition. This increased competition is the result of several brands introducing triple-headed electric shavers after the patent Philips had expired and the subsequent legal battle over the issue whether the triple headed shaver could be seen as a trademark (Dyer, 2002; European Court of justice 2002), which Philips lost. Hence, Philips lost exclusivity on its main unique selling point, and therefore needed to focus more on the sales performance of packaging more strongly.

This series of subsequent shaver models, with the described competitive developments, demonstrates a process of a shifting mix of packaging functionalities towards more and more sales-dominated packaging.

From a managerial point of view, these increases in costs and eco-impact may be justified, if these increases support an equal (or bigger) increase of sales performance. However, currently there is no methodology available to calculate the sales performance. Nor is there a test to measure it effectively and efficiently.

Available design research methods are either qualitative or, if they are quantitative, only measure part of the sales performance (as will be further discussed in Chapter 8). Hence it is difficult to figure out whether a certain design change yields enough in terms of sales performance to justify the additional costs.

This uncertainly about the exact difference in sales performance of two subsequent designs means that in practice the personal judgment of product managers and account managers is dominant in design decisions. From an environmental and cost perspective this is not desirable, as the likelihood of sub-optimal solutions is strongly increased.

From this study it can be concluded that, in order to balance packaging functionalities effectively, the performance of (several subsequent) packages needs to be measured and monitored. However, effective and efficient tools to do so are lacking so far.

6.3 Functionality mapping

As stated above, usually one of the three types of functionality dominates the design. A useful way of determining the dominant functionality of a packaging is to ask the following question (either about the packaging of the previous product generation, or a concept design for a new product): "Why isn't the packaging smaller?" In practice, there are four types of answers. The first type of answers relates to "otherwise the product gets damaged". This answer indicates a distribution-packaging. The second type of answers relate to "otherwise the in-store performance would be compromised". This answer indicates a sales-packaging. The third type of answers relates to "otherwise it wouldn't look nice". This answer indicates an experience-packaging, where feel-good is most important.

In other words, an answer related to the supply chain up to the shop indicates a distribution-dominated packaging, an answer related to in-store performance indicates a sales-dominated packaging, and an answer related to supply chain after the store (i.e. at the consumer's home), indicates an experience-dominated packaging.

The fourth and final type of answers relates to "we had no time/money, so we took a design from a related product or previous generation, and adapted it". This answer is a red-flag for sub-optimal designs, as new product generations in the CE market often are more robust and smaller than the previous product. Hence, maintaining the previous packaging tends to lead to a very unfavorable volume-index. However, this type of design re-use does happen in the CE market.

Based on such an analysis, the mix of the three types of functionalities (distribution-oriented, sales-oriented and experience-oriented) can be mapped. This mix can be visualized in a triangular graph (Wever, et al, 2007), as in Figure 6.5. How to map products will be explained below.

A design team, consisting of product managers, product designers, sales managers and packaging engineers, can map the direct commercial competitor products. The relative position to these products in the graph can be discussed, presenting arguments either why a packaging may be more voluminous, or why it should be less voluminous, than the competition.

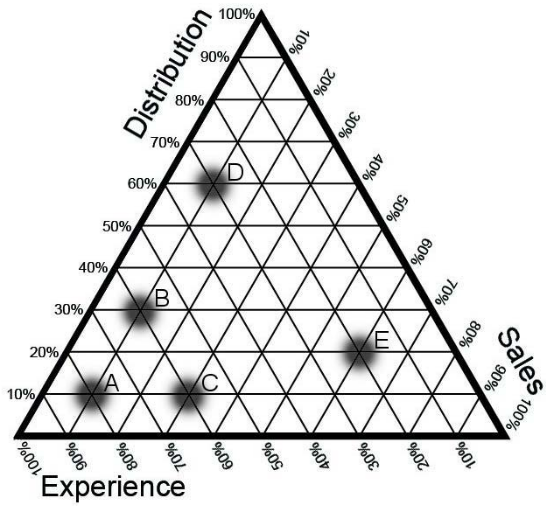


Figure 6.5: A triangular graph, representing the mix of the three types of packaging functionalities; distribution, sales and experience. With A-E representing examples of products.

For such mapping more elaborate approaches are available than only the question presented above. A first approach can be based on the relative importance of certain target groups for the product (price buyers, feature buyers and quality buyers, see section 6.1). If a product is mainly aimed at price buyers, distribution packaging will be most suitable, while feature buyers correspond to sales packaging and quality buyers correspond to experience packaging. The relative importance of each target group (e.g. 20%-50%-30%) can give a first position in the graph. It should be noted that purchase decisions are based on much more attributes than packaging alone (price, brand, etc.). Hence, the position may have to be adjusted for this.

A second approach, or a second step, to map the functionality is through an analysis of the outlet channels. In each channel the packaging plays a different role (see Chapter 4). If a product is to be sold in bulk through category killers and hypermarkets, then a mix of distribution and sales functions will be appropriate. If a product is sold through the Internet, then distribution packaging will suffice. If a product will be sold through independent retailers, the so-called 'mom-and-pop stores', packed products will be in the backroom, and can therefore be in distribution-packaging. If the product is to be sold through specialty stores or brand stores, where people pay a premium for quality, then experience-packaging would be most appropriate. The mix of channels through which the product will be sold, thus also leads to a position in the graph. In analyzing the mix of channels their relative importance can be determined based on the relative number of products that will be sold through each channel and the profit margin that will be obtained in each channel.

The triangular graph is meant as a discussion tool, aimed at visualizing the *relative* position between (competitor) products. Hence, pinpointing products precisely (e.g. 22.0% distribution, 17.4% experience and 60.6% sales) is deemed unnecessary. Also because the optimization strategies (presented in Chapters 7 and 8) cannot be linked to positions in the graph that precisely.

It should be noted that such a triangular graph can be made for an entire packaging design (i.e. the volume of the box, the materials, the graphics) or exclusively for the volume of the box. If made only for the volume, more extremes can be observed, as volume will often be determined by a single functionality. For instance in case of a large television set; the size of the product is already considerable, and therefore a pure distribution-packaging will already be of sufficient size for any sales-related functionalities. These potential sales-related functionalities can be accomplished solely with graphics.

In Figure 6.5 several products have been mapped. Here products A, B and C could form a realistic market segment, where it can be argued that differences should be minor, but that the focus of packaging C would be more on front-face area, whereas packaging A would have the strongest focus on high quality and original presentation of the product, both on the outside of the package as on the inside (the fulfillment of sales and experience functionalities will be further addressed in Chapter 8). Other positions in the triangle would justify other measures. Packaging E would be strongly focused on front face area, and would have high finishes on the outside, but a rather plain inside of the package. Packaging D would be more like the classic, efficient brown corrugated board box, but with some attention to experience (mainly printing, and not additional materials or volume).

Besides actual products the graph can also be used to plot product portfolio of one company, or different brands. An example of a product portfolio which has been analyzed is the electric shaver from Philips. Philips produces electric shavers that are virtually identical for the US and European market. Due to the different retail environment (more category killers and hypermarkets in the US displaying packed products on the shelf, and more stores in Europe displaying unpacked products in locked showcases) shavers for the US market are packed in clamshells and shavers for the European market are often packed in smaller corrugated board boxes. This is a clear consequence of a difference in sales function. Next to this Philips has special gift packages for the top-end of the market, which focus more strongly on the experience functions.

The mapping of packaging functionality of different brands can be demonstrated with three examples of computer brands: Dell, Medion and Apple, as is depicted in Figure 6.6.

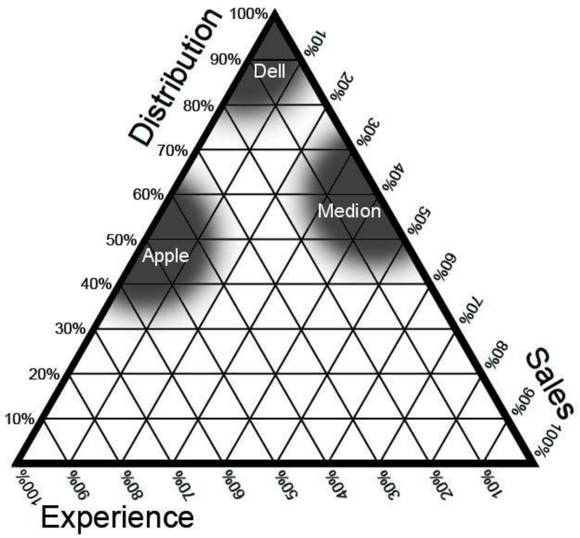


Figure 6.6: Positioning of packaging functionalities for three brands of personal computers. Here all packaging aspects are included, not merely volume. Mapping was done through a channel analysis. Dell's packaging is dominated by distribution functionalities, while Medion's Packaging is a mix of Sales and Distribution, and Apple's packaging is a mix of experience and distribution. (This graph is based on the brands in general, and might differ for specific products). (after Wever, Del Castillo C, 2006).

Dell sells its products through the Internet. In this channel, the packaging has no sales function at all, and only a very limited experience function (It need to look undamaged enough to accept when the mailman is at the door with the package). It is mainly a distribution package. Medion is a brand that builds computers for price-conscious buyers. It sells solely through low-price supermarket chains like Aldi. Hence the packaging has primarily a strong sales function. Due to the budget price it has no experience function. Finally, Apple is a brand that is strongly focused on experience. Their products are often sold in their own Apple centers. And otherwise, they still do not really compete on the shop floor with other brands, due to their loyal customer base. Hence there is hardly any sales function. The distribution function is of course still present in the Medion and Apple packages.

This observation supports the proposed model; there are companies that already apply such an approach implicitly, yet not systematically.

6.4 Unsustainable packaging

The model presented in Section 6.3 can be used both for the mapping of new packages as well as for the mapping of existing packaging. A mapping of existing packaging can be used as an analysis aimed at generating an improvement agenda. Such an agenda can aim both at the achieving more appropriate mixes of functionalities, as well as at the efficient fulfillment of those mixes.

In other words, there are two ways in which a packaging can be unsustainable, namely by providing the wrong mix of functionalities, or be fulfilling the right mix in the wrong way; a packaging can be ineffective and/or inefficient respectively.

This will be illustrated in the next case study, where, on the basis of the insights developed so far, a packaging was analyzed that turned out to suffer both from inefficiency and ineffectiveness. Based on this an improvement potential was identified, which was illustrated through a redesign. In later chapters, a more systematic description will be presented on the improvement options regarding the efficiency of distribution-dominated functionalities (Chapter 7), and of marketing-dominated functionalities (Chapter 8). The position within the functionality triangle will indicate which set of optimization strategies is most appropriate. This can be done both for new packages as well as existing ones.

6.5 Case study II: Improving effectiveness and efficiency (*Webcam*)[31]

This case study deals with a high-end webcam made by Philips (Figure 6.7, on the left). This product was selected out of a much larger group of products which has been analyzed, for being an extreme example of an existing packaging that was both ineffective and inefficient. This has been done to create maximum awareness within the company for packaging functionality analysis. Hence, this example should not be considered representative for an entire company or industry.

The current packaging of the webcam is a typical sales packaging; the volume is much bigger than would be needed from a distribution point of view, which is mainly due to a large front-facing area. The volume index is 23.6, while direct commercial competitors had volume indices of 18.8 and 7.4. Its volume is also considerably more than that of direct competitors. Furthermore, only the outside of the packaging has a high quality finish. Hence, in terms of packaging functionality analysis, it can be concluded that this packaging is clearly intended as a sales-packaging. However, Philips sells a range of webcams. This particular model is the top of the range, retailing at about 100 euros. It is aimed at quality-oriented buyers. Here, a sales-packaging is not appropriate. An experience-packaging would be better.

Regarding the performance of this packaging in the market, two things can be observed:

- The packaging functionality is mismatched. Its mix of packaging functionalities is not what the product needs. (It is ineffective)
- If it were the appropriate mix of functionalities, it would be considerably more voluminous than the average in this market segment. (It is inefficient)

Hence, a redesign was made, showing that a lower volume index can do. As a retail audit demonstrated, packaging height is a relative constant in this market, conformed to the shelf height in the store. The depth of the packaging was close to optimal in regard to the dimensions of the packed product, so the volume reduction has to come out of the width. Within this project a redesign was made which has a volume index of 11 (see Figure 6.7, in the middle). This was still a sales-dominated package design.

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[31] This case study originates from a graduation project co-supervised by the author (Pratama, 2006). It was previously published in Wever, Boks, Pratama and Stevels (2007).

Figure 6.7: On the left the original Philips Webcam package (5.3 dm^3). In the middle the student redesign (2.3 dm^3). On the right the redesigned package by the business unit that was actually launched (3.5 dm^3). (Pratama, 2006).

Interestingly, while this study was performed as a student case study within the Philips Sustainability Centre, the actual Business Unit producing this Web Cam independently launched a redesigned packaging, which has a volume index of 17.7 (see Figure 6.7 on the right), thereby validating the observation made in this student project.

To illustrate the order of savings that can be obtained through this type of volume reduction, a calculation was made for the shipping costs of these three packaging designs. The calculation is limited to the container transport from China to Rotterdam (note that this is excluding the expensive truck transport from distribution centers to retail outlets). Based on the number of products per container, and the price per container, the shipping price per product can be calculated. For the original packaging this is €0.25, for the Business Unit redesign it is €0.18, and for the student redesign it is €0.11, which is less than half the cost of the original packaging. In a low margin industry these are significant savings.

This demonstrates the improvement potential for an inefficient packaging design. However, as stated above this packaging was also deemed ineffective; the product seemed more in need of an experience package, than of a sales package. Hence also experience versions were designed, an example of which is depicted in Figure 6.8. This is a redesign of the Business Unit redesign (on the right in Figure 6.7).

This design study illustrated how large the cost difference can be between an efficient and an inefficient sales packaging. The experience redesign, on the other hand would have the same transportation cost as the Business Unit redesign, while possibly having slightly higher material costs. However those would certainly be compensated by the saving on transportation compared to the original design (Figure 6.7 on the left). Furthermore, the experience design in Figure 6.8 is deemed far more *effective*. However, that does point to a challenge as yet unsolved; that of validating design effectiveness through a quantitative evaluation method. Within this specific student design project this challenge has not been addressed. However, in Chapter 8 a proposal for measuring the design effectiveness of marketing packaging will be presented.

Figure 6.8: Example of an experience-package redesign for the webcam package. (Pratama, 2006).

6.6 Case study III: Packaging design engineering process (*Coffee maker*)[32]

The third case study is based on the development of a limited edition of a very successful coffeemaker, for which a special packaging was developed. The package was designed in a co-creation workshop between the OEM and several packaging suppliers. Furthermore, in the design attention was paid to both sales, experience and distribution optimization. As such, it is an illustration of a process that allows for truly balancing all three types of functionality.

Philips and coffee brand Douwe Egberts (a Sarah Lee company) introduced a co-branded coffee-pod system, suitable for single-serve portions. The system is called Senseo, and uses special pods of coffee that can only be used in special coffee makers. The Senseo coffee maker has been a considerable success on the Dutch market, as well as abroad.

The first series of Senseo coffee makers were made in China. Due to the high quality demands on the product, and the long lead-time for products shipped from China, production has been moved to Poland. After some time, production of the Senseo was resumed in China as well, in partial fulfillment of product demand in the US.

At this moment, the first redesign of the packaging was made, as a switch was made to European packaging suppliers (see Figure 6.9, on the left). Both the original box and the second generation consisted of a corrugated board box, with molded fiber cushions. However, in the new design the cushions were reduced in size (also see Figure 6.3), as well as the outer box. In spite of this, the box increased in complexity and material cost. This may indicate that there is/was a difference in engineering capability between European and Asian packaging suppliers. Although an interesting notion, this is deemed outside the scope of this thesis, and is therefore not further researched here.

Due to its totally different design and coffee-making concept, the Senseo became a kind of iconic product, and many stores erected walls of packed Senseo machines in their stores, which was of course a marketing success for Philips. As the packaging has a significant sales function to fulfill, the visual quality of the box

[32] This case study originates from a graduation project co-supervised by the author (Hettema, 2005).

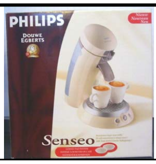
Figure 6.9: The 2nd generation product with cushions and box (left) and the sweet mandarin version in a MediaMarkt store (right). Note the safety strap here. (Hettema, 2005).

has to be excellent. Hence, during transport additional transport packaging is applied, with two Senseo packs in one secondary container.

The sales numbers for the Senseo coffee machine in the Netherlands were staggering high. In November 2007 the five millionth machine was sold in the Netherlands —a country which has about 7 million households (Berkeljon, 2008). However, this also presents a problem; how to keep on selling machines when most households have one? Part of the solution can be to continuously renew both product and packaging. One example of this is the introduction of a luxury version of the product with an aluminum finish, for which a separate packaging was developed as well. Later, yet another version was launched; the *sweet mandarin*. This limited edition was available in translucent orange or blue. The package for this model was designed in an unpacking workshop organized by Philips together with its suppliers for the corrugated board box and the molded fiber cushions. A radical new design resulted, which utilizes see-through plastic shells, allowing consumers to see the product while still packed. Hence a supplier of thermoformed plastics was also involved in the project.

This design paid much more attention to experience aspects. Hence, it can be seen as a shift in the mix of functionalities, from a packaging with purely distribution and sales functions to a packaging that balances all three types of functionalities. The strong point here is that, when the Senseo was first introduced a sales/distribution packaging was indeed sufficient, while the limited edition did indeed require more of an experience package.

Table 6.1 gives some data on the different product generations and their packaging. The interesting aspect of this project is that the new design resulted in a more elaborate unpacking experience and in improved shelf performance, through being radically different from previous packs, or even other CE packaging in general. This was achieved through allowing consumers to see the product, in combination with the method of opening. The new package also improved logistical efficiency by increasing the number of products per pallet from 40 to 42. This is not a spectacular improvement, but still good in light of the already efficient volume index of a Senseo package (roughly 1.4).

The product	**Senseo crème**	**Senseo blue**	**Senseo VIP**	**Sweet Mandarin**
				
Specifics	1st generation, 2001	2nd generation, 2003	Introduced in 2004	Introduced in 2005
Introduction price (Mossou, 2004)	~ € 70,-	~ € 60,-	~ € 170,-	N.A.
Current price **(a)**	Not applicable	€ 59.89,-	€ 149,-	€ 79.99
Product weight	2668 g	1920 g	N.A.	1920 g (assumed)
Height x width	325 x 315 mm	323 x 318 mm	N.A.	323 x 318 mm
Diameter high part	∅133 mm	∅140 mm	N.A.	∅140 mm
Diameter low part	∅213 mm	∅211 mm	N.A.	∅211 mm
Changes with the former series (Mossou, 2004)		Dimensions Top handle Cup plateau Pouring nozzle	Dimensions Metal instead of plastic	Semitransparent plastic
The primary box				
Box dimensions h x w x d, mm	400 x 385 x 255	385 x 370 x 265	400 x 395 x 265	383 x 383 x 265
Box volume	39.27 dm^3	37.75 dm^3	41.87 dm^3	38.87 dm^3
Corrugated board	E-flute ~ 550 g/m^2	E-flute 512 g/m^2 **(b)**	E-flute 560 g/m^2	F-flute **(c)** 530 g/m^2
Used board	0.84 m^2	0.96 m^2	0.99 m^2	0.76 m^2
Packed weight	3760 g	2760 g	N.A.	2830 g
F/box weight	456 g	492 g **(d)**	554.5 g	403 g
Buffer weight	640 g	225 g	N.A.	507 g
Transport position	Standing	Standing	Standing	Laying down
# products/pallet	8 x 5 layers = 40	8 x 5 layers = 40	8 x 5 layers = 40	6 x 7 layers = 42
Pallet stack height	2.0 m	2.0 m	~2.1 m	2.1 m

(a) Price at Media-markt in the Netherlands, June 2005
(b) 210 g outerliner + 120 g fluting (x1.35) + 140 innerliner
(c) Due to increased folding stress as result of the design the flute was changed
(d) measured at 502 g, which is a 2% difference with reported data

Table 6.1: The different generations of Senseo coffee makers and their packaging. (Hettema, 2005).

As the package still is of a considerable size, it becomes apparent that the biggest inefficiency from a distribution point of view derives from the shape and dimensions of the Senseo machine itself. And that factor was obviously out of the range of freedom of the packaging design team. The design of the packaging for the *sweet mandarin* model can be seen as a successful example of early supplier involvement. Another interesting conclusion is that it is possible to improve the unpacking experience without necessarily increasing the volume of the package.

There was however an issue with the retail performance of the packaging. To prevent consumers from opening packaging in the store, MediaMarkt, which is the CE chain with the largest market share in the Netherlands, applies safety strips around the box. These are red and black (the colors of MediaMarkt) which conflicts with the colors of the packaging, and worse, were applied through the middle of the window in the packaging, thus partly ruining the presentation of the product (see Figure 6.9, on the right). Hence, this issue illustrates that retailer requirements were not taken into account sufficiently during the design process. This indicates that early retailer involvement was missing.

6.7 Discussion and conclusions

The case of the electric shaver has demonstrated how the actions of competitors influence the decisions taken in a company. It has also illustrated what the lack of comparable performance indicators for all three functionalities can lead to, both in value chain issues (the importance it gives to personal opinions of product and sales managers) and to increasing cost and environmental impact.

The case study on the webcam package illustrated the differences between inefficiency and ineffectiveness that may exist in a packaging design, and has demonstrated how both may be reduced. It again made clear the need for comparable performance indicators for all three functionalities.

The case of the coffee maker finally has illustrated, although there still is room to criticize the resulting packaging design, how it is possible to combine the different functionalities, and balance their interests. It has demonstrated the potential strength of early stakeholder involvement and simultaneously (through the issue with the MediaMarkt straps) also the danger of not including all relevant stakeholders.

Both the webcam case and the coffeemaker case have illustrated that improving the unpacking experience of a packaging design does not necessarily lead to an increase of the packaging volume.

A model has been presented in the form of a triangular graph that can assist in visualizing the mix of functionalities of a product and its competitors, a product range or even brands. Once a particular product-packaging combination has been mapped on the graph, the question arises how to fulfill that particular mix most efficiently. In later chapters, several optimization strategies will be shown in more detail. Chapter 7 will focus on packaging with predominantly distribution related functionalities, while Chapter 8 will focus on both marketing related functionalities; sales and experience. Those two are combined since the optimization strategies for these functionalities are to a large extent identical.

"You should go out into the marketplace
and see exactly what is going on.
It is all too easy to think that one knows what is going on,
but the reality is sometimes different."

BILL STEWART (1996, p.17)

Intermezzo B: The Packaging of other Durable Goods[33]

The main focus of this thesis is on Consumer Electronic products. A relevant question is to what extent the findings regarding CE goods are also valid for other consumer durables. The two main pillars under the present approach for CE goods are, first, the relative importance of the transportation as compared to the bill of materials of the packaging, and second, volume being the critical factor in transportation due to the low density of packed CE goods (see Chapter 1). If a different type of consumer durable exhibits these two characteristics as well, than the approach developed for CE goods can also be applied in those other industries.

This chapter will present a quick scan of several other categories of durable consumer goods, in order to judge whether the findings related to CE goods can be generalized to these product categories as well. For each group the transportation situation will be analyzed, to see if the environmental impact of distribution will be comparable (i.e. are the distances and modes of transportation similar, which would indicate a similar ratio between packaging material and transportation as was found for CE products). The density of packed products within the category will be analyzed to determine whether volume is indeed the critical factor in distribution. Previous attempts at designing for volume efficiency will also be briefly addressed. Finally, the mix of the three main functionalities (distribution, sales and experience) will be discussed for each category, to see which is dominating. Within this study it was not possible to collect volume ratios as well. However, the data that could be collected is a good and robust indication as to the applicability of the approach presented in this thesis to the specific product categories.

The categories that will be reviewed in this chapter are domestic appliances (e.g. irons, coffee makers), power tools, toys, and furniture (specifically the IKEA brand). The data were collected within two bachelor student projects. The data related to domestic appliances and power tools result from measurements carried out in-store. The data related to toys and furniture result from Internet, as the Dutch toy retailer Bart Smit, and the furniture retailer IKEA make such data available on their website. These two Internet data sets were checked by performing an in-store check on a random sample.

As described in Chapter 4, the retailing of CE goods has become dominated by hypermarkets and category killers. This development can be seen in other product

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[33] The data presented in this Intermezzo, in combination with a large portion of Chapter 1 has been combined in a article (Wever, R. 'Design for Volume Optimization as a Strategy for Sustainable Packaging') submitted to a journal.

categories as well. Retail has become the 'narrowest' part of most value chains (i.e. only a few significant players, that can therefore exert power over other parts of the value chain), giving each of the remaining retailers increased power over its supply chain. For a discussion of the emergence of category killers aimed at different categories of products see Spector (2005) and Sampson (2008). Due to the buying power these retailers represent, Original Equipment manufacturers (OEMs) cannot afford to alienate one. As the world's largest retailer, Wal-Mart, operates in most product categories from fast moving consumer goods (FMCG) to consumer electronics, toys and apparel, hardly any industry can escape this development.

B.1 Domestic Appliances and Personal Care

Domestic appliances and personal care products tend to be seen as typical gift products (e.g. for occasions such as Mother's Day, Father's Day, birthdays and Christmas). Hence, for such products graphical quality plays an important role in packaging design. This type of product had nicely printed boxes well before the emergence of category killers and other retailer outlets where the packaging has a significant sales role (Philips House Style Manual, 1977, as cited in Marzano, 2006, p. 83). This gift value can be said to be a mix of sales and experience functionality. The packaging first has to attract and convince a gift-seeking shopper. Subsequently, the packaging needs to supply a nice gift-giving experience as well. For a discussion of the process of gift selection (specifically for electrical appliances) see Vanhamme and De Bont (2008). This mix of sales and experience functionalities are often fulfilled through graphics alone; the volume of the packaging mainly results from required distribution functionalities only.

Many producers of CE goods also produce some domestic appliances, such as irons, kitchen equipment, and/or vacuum cleaners, as well as personal care items such as electrical toothbrushes. Based on this fact it seems safe to assume that the distribution situation (regarding distances and modes of transportation) will be very similar to those of CE goods.[34]

Hence, it can be concluded that for domestic appliances the first condition applies, namely that the economic cost and environmental impact of transportation will be higher than the cost and impact of the packaging material. Regarding the second issue, whether volume is the critical factor in transportation, Figure B.1 gives the density of 145 domestic appliances (following the set-up of Figure 1.1). It can be concluded that for a large majority of these products volume will always be the critical factor, irrespective of the mode of transportation, and for all products, volume is the critical factor when using standard 40' sea containers.

Figure B.2 gives the data for personal care items. It can be concluded again, that for transport by sea container volume is always the critical factor, while for trucks and airplanes it depends on the specific product.

[34] Philips does currently produce electric shavers in the Netherlands, and produces the Senseo coffee machine in Eastern Europe. However, these products are subsequently shipped globally, thus resulting in similar transportation distances.

In general, the approach presented in this thesis can be applied to domestic appliances and personal care products. However, it should be noted that, especially with domestic appliances, the packaging often is very volume efficient compared to the contained product, as they are probably less fragile. Hence, not all optimization strategies that will be addressed in Chapters 7 and 8 will be equally applicable to this product category.

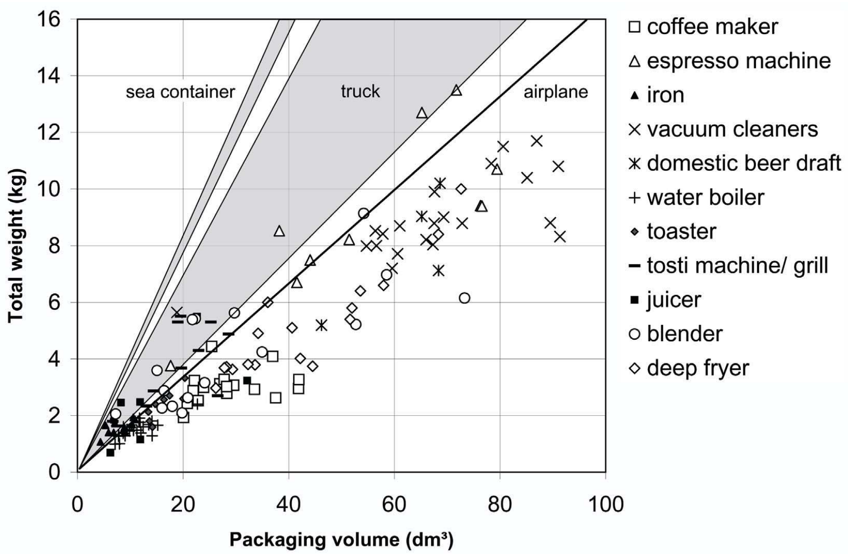

Figure B.1: The density of 145 domestic appliances in relation to breakeven densities of the most important modes of transport.

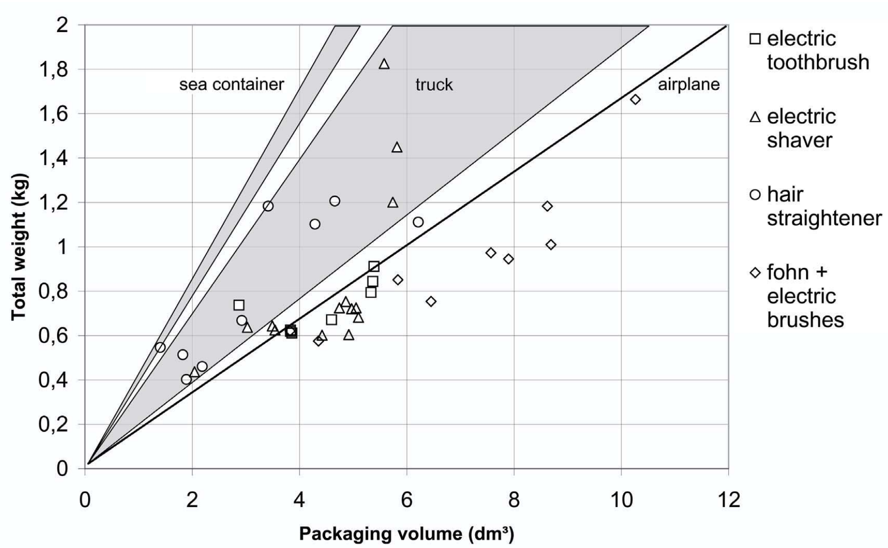

Figure B.2: The density of 40 personal care items in relation to breakeven densities of the most important modes of transport.

B.2 Power tools

The market of power tools is a global one. As Deneen and Cross (2006) report, global supply is more or less evenly divided over Asia-Pacific, North America, and Europe, with Asia-Pacific being the biggest producer. On the demand side North America takes 40%, followed by Europe and then Asia-Pacific. This suggest large international distribution, although Deneen and Cross state that international trade flow is lower than for other durable goods, as power tools are manufactured in many locations, and most of these producers dominate their respective local markets. However, brand owners from developed countries are outsourcing production to low-wage countries, thus increasing transportation distances. Hence, it can be concluded that for power tools the first condition applies, namely that the economic cost and environmental impact of transportation will be significant in relation to the cost and impact of the packaging material. Determining the exact ratio between packaging material and transportation would require an extensive LCA study.

Packaging-wise, power tools are a special category. It is common for the 'packaging' of power tools to be durable as well. Many power tools come in durable carrying cases which are meant to be used for storing and transporting the product and it accessories (e.g. bits and drills). This function of containing the accessories in an orderly fashion is in itself a mix of distribution, sales and experience functions. However, in its relation to volume, this presentation of accessories will be similar to the presentation that can be observed in an experience-dominated packaging. The materials used for such durable cases will most likely be more costly and will have a higher environmental impact that a corrugated board box would have. Even when power tools are packed in a durable case, there often is an additional corrugated board box or sleeve around it.

Figure B.3 shows the data for a mix of power tools (e.g. drills, sanders, saws). It shows that for transport by sea container volume is almost always the critical factor, while for trucks and airplanes it depends on the specific product. Hence, it can be concluded that power tools are similar to consumer electronics, and therefore the approach presented in this thesis can be applied to power tools as well, provided that the special aspect of durable packaging is given proper attention.

Again, like domestic appliances, the general impression of volume ratios for power tools is that they are relatively efficient, as compared to CE products. This is due to the fact that in this thesis product volume is defined as the smallest enclosing rectangular box around the product. Power tools have irregular shapes. Without changing the design of the product, their cases show only limited potential for improving the volume ratio. Hence, not all design strategies that will be presented in Chapters 7 and 8 will be equally applicable. However, some manufacturers of power tools have abandoned rectangular box shapes, in favor of boxes that follow the shape of the product they contain, e.g. for hedge trimmers. These boxes are then designed in such a way that two of them fit together into a rectangular space (see Figure B.4).

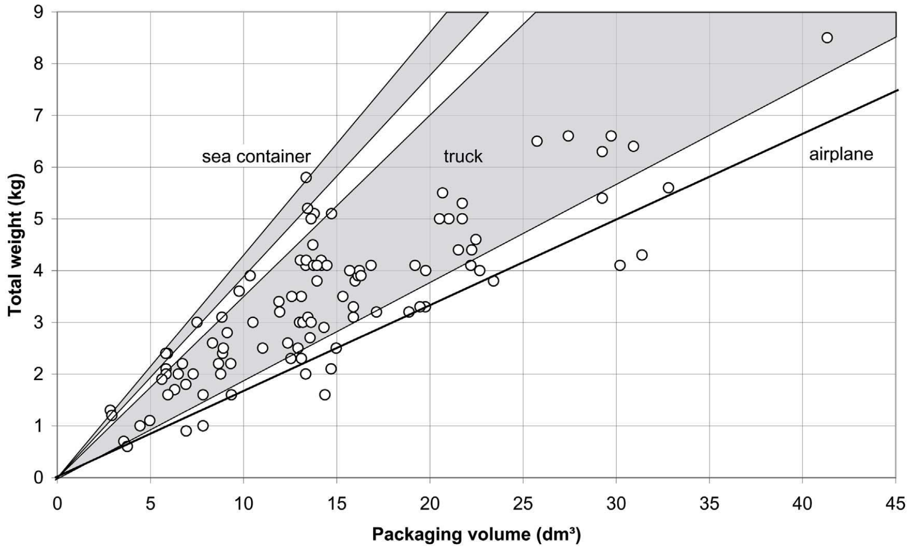

Figure B.3: The density of 107 power tools in relation to breakeven densities of the most important modes of transport.

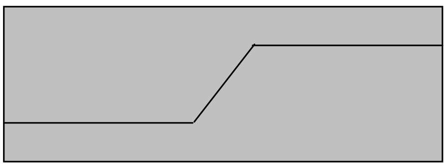

Figure B.4: Two irregular shaped containers, which together are rectangular again.

B.3 Toys

Most of the world's toys are produced in the Far East and transported over long distances.

The Pearl River Delta region in mainland China (Dongguan) is the largest producer of toys, and Hong Kong is still a major exporter (Law & Shan, 2003, Luk, et al, 2004). Hence it can be concluded that distribution distances for toys will be similar to CE goods.

Retailing of toys is usually done in shops displaying the packed products on the shelf. Hardly any toys are packed in pure distribution packages. Sales functionalities are most important. Contrary to domestic appliances, these sales functions are not solely fulfilled through graphics, but through volume as well, as can for instance be observed in packaging for dolls and their accessories. With such packaging, volume ratios will also be high enough to allow for application of the optimization strategies that will be presented in later chapters.

It should be noted here as well that the buyer of toys is usually not the person who will play with them. The same remark as was made with domestic appliances applies here; toys are typically gifts, therefore the buyer wants the packaging to look nice.

Figures B.5 and B.6 give the densities of 295 toys, including such categories as construction (e.g. LEGO), model cars, dolls and board games. Again most packages are volume-critical, especially for sea container transport. Some even have extremely low densities. These are products like a toy shopping cart and a Disney furniture set. Both are toy versions (so light-weight) of voluminous products.

Based on the distribution situation and the density of packed products, it can be concluded that the approach of this thesis is applicable to toys as well.

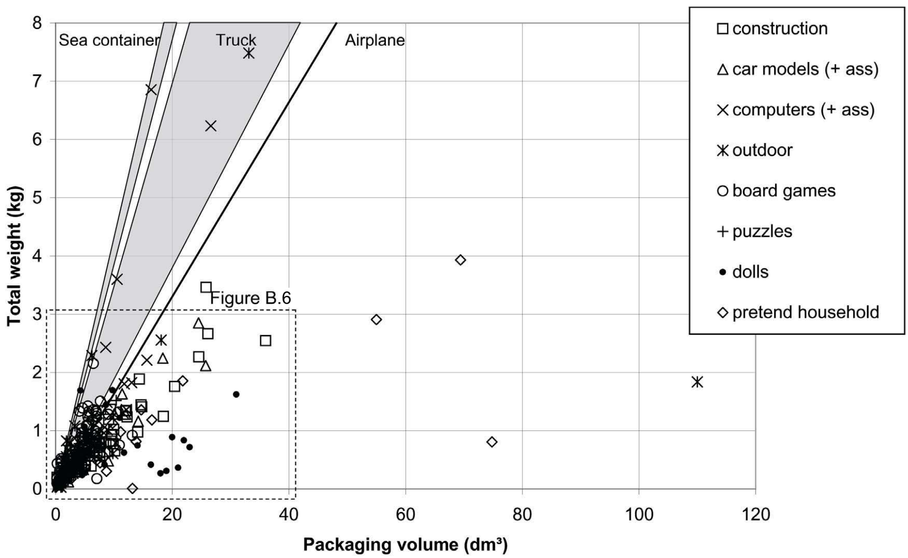

Figure B.4: The density of 295 toys in relation to breakeven densities of the most important modes of transport.

B.4 Furniture (IKEA)

In studying furniture, IKEA is an interesting case for two reasons. First, IKEA has a tradition in designing for volume efficiency; most products are sold unassembled, allowing them to pack the products more efficiently (the so called flat-pack concept). Hence, if studying the density of packed IKEA products shows volume to be the critical characteristic, than volume would certainly be the critical factor for almost all other furniture products, which are not flat-packed. Second, data for all IKEA packages are made available on the Internet, hence facilitating easy data gathering.

IKEA boxes are very simple brown corrugated board boxes with minimal printing. There are several reasons for this:

- Products are displayed in concept interior. Hence people see the packaging only after the purchase decision has been taken,

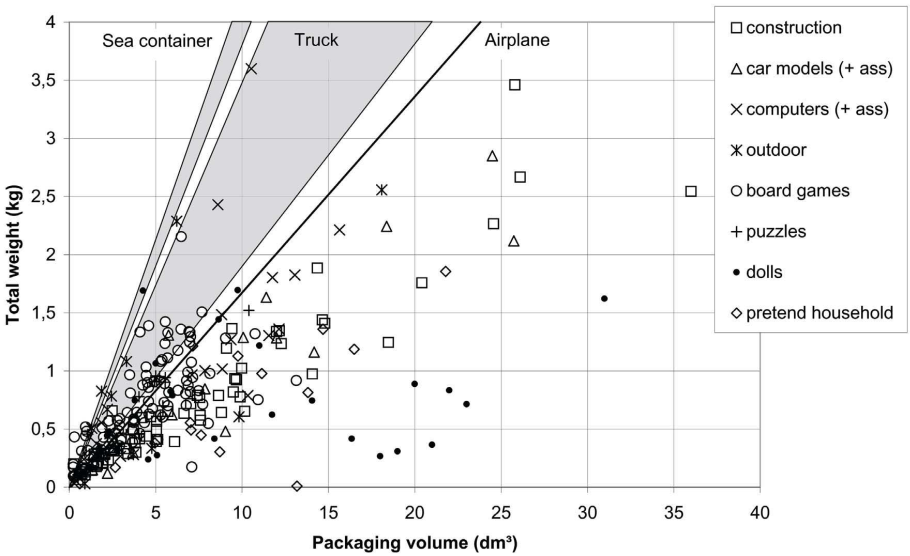

Figure B.6: Detail of Figure B.5

- IKEA is a vertically integrated company, controlling design, production, distribution and retailing of their product. Hence in the retail setting there is no competition between brands, and therefore no sales packaging is required,
- IKEA targets price buyers. They can advertise with its flat-pack system as cost-saving. IKEA wants a price-conscious image; the brown corrugated board fits into this brand image perfectly.

Hence it can be stated that IKEA packaging is purely distribution oriented. Other furniture companies also mainly use distribution-dominated packaging. There are also examples of furniture where there is no or hardly any packaging (e.g. just a plastic foil). Sales-related functions may be present, but they will be fulfilled through graphics only, and not through additional volume.

IKEA procures its products from over 50 countries, with China being the largest at 14%, and selling them globally (Baraldi, 2003). IKEA uses third party logistics, with trucks for shorter distances and ships and trains for longer distances (Baraldi, 2003).

Figure B.7 gives the densities of 254 pieces of IKEA furniture. It shows that IKEA, who has been working towards volume efficient packaging for decades, has actually reached weight limitation for some of their products, even in sea containers. However, the reason may well be that IKEA has opted for using 20' sea containers, instead of the standard 40' container. 20' have more than half the weight allowance of a 40' container; hence the maximum density of the cargo which is still acceptable is about a factor 1.6 higher than in a 40' container.

'Normal' furniture (i.e. non-flat pack) may be assumed to be clearly on the volume side, as most other manufacturers deliver their products assembled to shops and consumers. As a consequence, the volume optimization is relevant to furniture packaging as well. However, volume ratios for many furniture packaging may already be very low, as little or no cushioning is used. In that respect, the same applies as with power tools, namely that not all optimization strategies presented in later chapters will be applicable to furniture packaging.

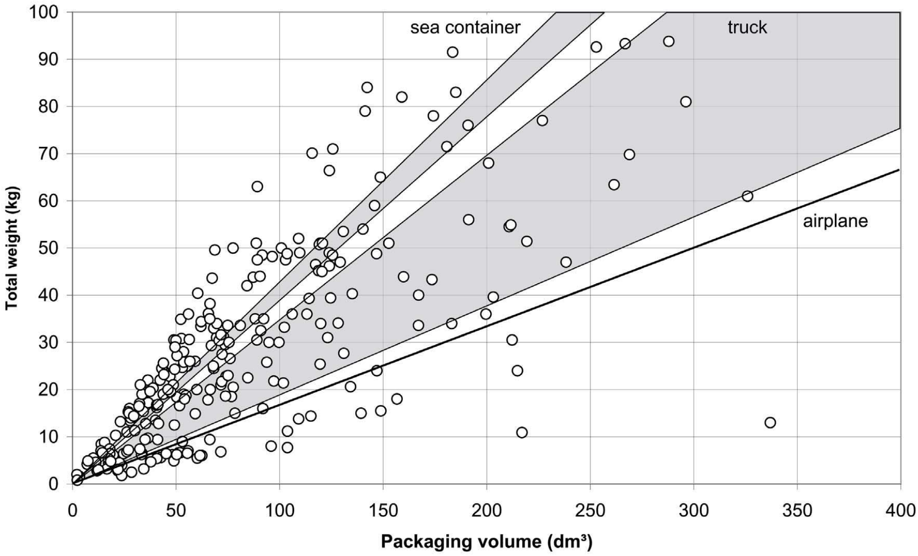

Figure B.7: The density of 254 pieces of IKEA furniture in relation to breakeven densities of the most important modes of transport.

B.5 Conclusions

Based on the findings of these quick scans, it can be concluded that the specific findings for the CE industry can be generalized to other durable goods; the cost and impact of transportation is bigger than the cost and impact of the packaging materials and volume is the critical factor in transport efficiency.

The IKEA study shows what is obtainable if a radical volume efficiency strategy is followed, with products / retail concepts that allow for distribution-dominated packages.

For the other product groups it is concluded that there is no tradition of specifically designing volume efficient packaging. Hence the optimization strategies that will be presented in Chapters 7 and 8 can be considered appropriate for CE goods as well as for other durable goods. However, due to special characteristics (e.g. durable packaging for power tools) not all optimization strategies that will be presented for CE goods will be equally applicable to other durable goods.

*"We found that when items are boxed, people have the tendency
to throw them around or run into them with forklifts.
Boxes actually invite damage.
So we eventually decided instead to ship products without one."*

KEVIN HOWARD, HEWLETT PACKARD
(in: D. IMHOFF, 2005, p.58)

7. Design Strategies for Distribution-dominated Packaging

Production of durable consumer goods has largely been moved to low-wage countries. This has resulted in increased transportation distances, and with those, an increase in the relative importance of packaging and transportation within the total life cycle of products. This increased importance can be observed both from an economical perspective and an environmental perspective. Combined with the fact that the market of consumer electronics is a highly competitive one, this makes it imperative to pay much more attention to optimize this phase of the life cycle. As was demonstrated in Chapter 1, this can mainly be done by following a volume optimization approach, aimed at keeping the number of product per shipment as high as possible, and thereby keeping the number of shipments as low as possible. As such, transport efficiency is an interesting area for optimization as environmental improvement coincides completely with economic savings.

As has been clarified in Chapter 3, for a substantial part of the CE goods distribution-related criteria determine the volume of the packaging. For these products transport efficiency can be a leading issue in their packaging design process.

In judging the performance of current packaging, Chapter 3 introduced several performance indicators, namely the volume index and the container loading. Both these indicators can be used in a packaging volume optimization approach, namely as:

- an identification of packages suitable for a redesign,
- an evaluation criterion of a proposed packaging design,
- an incentive for optimization by including target scores on such indicators early in the new product development process.

The first two sections will describe in more detail how this could be done (Section 7.1 will discuss the volume index; Section 7.2 will discuss the container loading).

The remaining sections will discuss several design approaches that can be followed in order to actually decrease the volume of a packaging design, either related to the packaging, or to the product contained within. This will first address optimization of the design of the packed product itself (Section 7.3), than the optimization of the design of the packaging (Section 7.4), followed by the optimization of the distribution (Section 7.5), and finally the evaluation of the testing procedure (Section 7.6). Section 7.7 will discuss the prioritization of these different strategies.

An additional optimization strategy that may sometimes be relevant to distribution-dominated packaging, namely that of multiple packaging, is discussed in Chapter 8, as it is mainly relevant to marketing-dominated packaging.

7.1 Average Market Performance guideline[35]

Chapter 3 has examined the volume ratio of 203 CE products. A trend line was fitted through these data points. A linear least squares fit was made, which was forced through the origin, and had an R^2=0.97, suggesting a good fit. The fitted line can be interpreted as the average market performance (AMP) for consumer electronics products, under the assumption that the products analyzed provide an average representation of consumer electronics products.

As said, the fit can be perceived as the average market performance (AMP). There are products performing better as well as products performing worse than the AMP. For the products in the group with a distribution-dominated packaging there is neither a product type scoring consistently better than AMP, nor a single brand that is consistently better than the AMP. Had a particular brand scored consistently better, this might have been caused by using different design criteria, for instance lower drop test requirements. Such lower requirements in turn might have been based on a less hazardous supply chain, or the acceptance of more transportation damage. As this is not the case, it can be concluded that the spread in volume indices results from specific design choices that were made during the design of either the packed product or the packaging. Hence, from a volume optimization point of view, it can be said that the AMP should always be attainable for each distribution-dominated packaging. Therefore, a guideline for the design phase of the packaging can be developed: if a packaging concept scores above the AMP, the cause should be identified and a redesign considered, either of the product or the packaging.

If this performance indicator is re-applied in a different study, and the brand under review scores systematically worse than its competitors, this can mean several things:

- The products of this company are systematically more fragile than the competitor's products.
- The testing standard (e.g. drop heights, vibration testing) of the company are tougher than the competitors, which in turn can mean two things, either the competitor excepts a higher damage percentage, or the company under review systematically overpacks its products.

An example of the latter, namely excessive packaging due to excessively tough drop testing, is described by Howard (2009) as happening with Hewlett Packard some 20 years ago. HP required packed products to be drop-tested with 26 drops (all faces, edges and corners), even though no packed product actually would experience 26 drops during actual shipping.

[35] This section is based on: Wever, Boks, Marinelli & Stevels (2007) Increasing the benefits of product-level benchmarking for strategic eco-efficient decision-making. *Benchmarking; an International Journal*, 14(6) 711-727.

In both cases a review of occurring transportation damage should yield insight into this situation. For this purpose, it is however essential to get real damage data, and not rely on reported data from retailer (as is discussed in Chapter 2).

Bringing down the volume index to the AMP will result in smaller packaging, which in turn results in more products per shipment (= higher container load). Due to discontinuities, not every reduction in volume results in a proportional increase of container loading, but in essence there is an inverse linear correlation. If it is assumed that this correlation and the cost per shipment of the transportation mode used is known, the savings per product can be calculated. These data can then be combined with sales data or sales projection to set priorities for packaging redesigns. Within this study such a calculation was performed for transportation by standard ISO sea container (ISO container 1AA as described in ISO 668 and ISO 1496) from Shanghai to Rotterdam Harbor. At the time of this study (2004), costs for such a shipment were approximately €2500,- per container. Based on the internal volume of the sea containers ($65m^3$) and the possible volume reduction, it can be calculated how many more products would go into one shipment. The cost of the shipment can then be allocated a higher number of products, which results in savings. In this study numerous products were identified with a savings potential between €0,50 and €1,00 per product. In a market with low profit margins, these are significant savings, and they are only the savings from costs for sea transport, not including savings on other parts of the transportation, nor savings on packaging material. Such savings in transportation and material also constitute substantial environmental savings.

7.2 Container loading

As already acknowledged in the previous section the volume ratio is only concerned with the volume efficiency of the box, while the real cost-driver is container loading; how many products fit into a unit of load. For products coming from the Far East this means optimizing the number of products that fit into one 40′ sea container.

Because of the significance of the number of products per container, Philips adapted the packaging performance indicator within their environmental benchmarking procedure (as introduced in Chapter 3) to container loading.

The container loading figure used in the Philips benchmarking procedure is calculated (instead of measured for each case), because reported values of competitors are rarely available. This calculation is based on a spreadsheet. It is assumed that the package remains upright during transport. From standard container dimensions and packaging dimensions the maximum number of products in the height of the container is calculated. Based on the width and length of the box the most efficient layout on the bottom of the container is determined. By multiplying these values a calculated container loading value is reached. Comparison of calculated container loading with actual Philips container loading data has shown good correlation. Therefore the calculation is a good representation of reality.

Besides incorporating the container loading within the environmental benchmarking procedure, Philips also incorporated this parameter directly into their product development process. Product designers have to consider the container loading they are expecting to achieve, already during at the concept stage of the product development.

The volume index and the container loading are performance indicators which help to select packaging that has a potential for improvement. However, they do not show how this improvement can be obtained in practice. Sections 7.3 through to 7.5 will discuss several of these design avenues.

7.3 Product-related optimization strategies

Sometimes packaging volume is inefficient due to the design of the packed product, which can be unnecessarily fragile, or of inconvenient dimensions. In Chapter 2 two examples were already mentioned of redesigns limiting the fragility of the product. Nielsen (1994) describes a redesign of a very fragile computer component. Adding some material improved the robustness of the component considerably. The design change cost $1, while the saving in packaging represented $10,80.

Ten Klooster (2002, p.25) gives an example of a photocopier made by Océ van der Grinten. Packaging designers examined the product to see from which transportation hazards it needed protection. They found that these were mainly vibrations exiting natural frequencies of components. By redesigning the components it became possible to transport 70% of the copiers without any packaging whatsoever.

Another example of this type is given by Imhoff (2005, p.58) quoting Kevin Howard from Hewlett-Packard as saying: *“For example, the addition of a few reinforcing ribs on the printer itself created a stronger product that in turn reduced the materials needed to protect it during distribution”*.

Hence, fragility of the packed product is an essential aspect, and an important option for improvement of the total product-packaging combination. However, as already stated in Chapter 2, the fragility of products is all but impossible to calculate, and measuring it requires finished products, which are usually not available during the development process. Therefore, optimizing the fragility is challenging and expensive.

Here, it should be noted, that Hewlett Packard has opted an approach of optimizing fragility for its printers (Clugston, 2009). Test runs of products are produced, which are evaluated using packaging testing procedures. The aim is *not* to develop packaging that will protect the product, but to help product engineers come up with more robust products. Potential redesigns are evaluated based on the estimated cost of changing the design and the estimated cost of allowing for the damage to occur (based on the value of the product and the likelihood of the damage occurring). Such a procedure can only be applied in companies that have (very) high production runs of relatively low value products. It requires both considerable development time, as well as R&D capacity. Hence, it may not be applicable to CE companies that have wider product portfolios.

An anecdotal example of the second cause for inefficiency (that of inconvenient dimensions of the packed product) is the design of a solarium, where packaging was only considered after the tooling for the molds of the product had already commenced. It was found that the product was about an inch to wide to be able to fit two on a pallet. There was no principal reason why the product could not have been an inch smaller, but now that tooling had started, the product design couldn't be changed anymore, resulting in disproportional distribution costs.

7.3.1 Postponed assembly

A classical example of efficient distribution packaging is the flat-pack concept used by IKEA for its furniture (also see Intermezzo B). This is a case of postponed assembly (for more on the theory of postponement strategies see Section 8.5 on packaging postponement). The consumer has to assemble his or her own product, thereby allowing extremely efficient distribution. Furthermore, IKEA products are designed so that they can be fit efficiently into packs of minimal dimensions.

Although this strategy is successfully applied to some CE goods, it may not be applicable in most cases. One example where it is applied, is the pedestals of LCD and plasma screens. By having the consumer mount the pedestal to the screen, a more efficient arrangement of components within a box can be achieved than if the pedestal was already attached.

More or less the same applies to some computer monitors were the pedestal is in a folded position during distribution.

Another example, which combines a product-redesign with partially postponed assembly, can be found in the coffee pod machines by Inventum, a Dutch producer of household appliances. Their product engineer, during a presentation at the faculty of Industrial Design Engineering in January 2009, explained that Inventum developed a coffee pod machine in response to the success of the Philips Senseo. The design team succeeded in creating a high-end product, which was distinctly different from the other coffee pod machines in the market (see Figure 7.1a). When a second generation of the Inventum product was introduced, a cheaper alternative was also developed (see Figure 7.1b). Due to the basic shape on the one hand, and the detachable drip tray on the other, the packaging volume of the cheaper alternative was far more efficient than the original Inventum machine. It raised the container loading from 1440 to 2600 products.

INVENTUM

Figure 7.1a: The Inventum HK10M (container loading 1440). **Figure 7.1b**: The Inventum HK5R with detachable drip plate (container loading 2600)

7.3.2 Transport orientation

Another interesting solution here is making sure that the product can be transported in any orientation. The first generations of LCD-TVs, for instance, had to be transported upright, which often results in an inefficient use of the height of sea containers, as there is just too little room for an extra layer of products (Wever, 2007). Whether or not a product can be transported in multiple orientations depends strongly on the design of the packed products. "This side up" signs on packages—when actually observed by logistics personnel—limit the flexibility of stowing, and thereby transportation efficiency.

An example of how packages can be designed to utilize the container volume is demonstrated by Figure 7.2, which shows a container full of Panasonic LCD televisions (note that these do not suffer from a 'this side up' limitation).

Together, these strategies sum up the product-related optimization strategies: increased robustness, optimized product dimensions, postponed product assembly and transport orientation. Next to product-related optimization strategies, there are packaging-related optimization strategies. These will be discussed in the next section.

Figure 7.2: Efficient container loading of Panasonic LCD televisions (Eco Style Fair, Tokyo 2007).

7.4 Packaging-related optimization strategy[36]

Packaging adds volume to the packed product. Most of this added volume is ‘created’ by the cushioning, while the outside package (usually the corrugated board box) adds relative little volume. One of the design factors influencing the final volume of a packaging design is the selection of a cushioning material. There are many different solutions available that can be used to cushion a product. Perhaps best known is expanded polystyrene (EPS), which is also known as Styrofoam. Other solutions that are widely used are based on:

- Expanded polyethylene (EPE), which is a soft foam,
- Expanded polypropylene (EPP), which is a hard foam like EPS,
- Polypropylene shells,
- Folded corrugated board,
- Multi-layer corrugated board,
- Beeboard, which is cardboard with a honeycomb structure,
- Molded fiber,
- Several types of air cushions.

The choice for one solution or the other is not only based on the level of protection needed, but (among others) also by, for instance, the predicted production run. EPS and EPP require design specific molds, while EPE is cut and assembled form sheet material. Hence, EPS and EPP are more suitable for large productions runs of tens of thousands of products, while EPE, because of its low tooling costs and labor intensiveness, is more suitable for smaller production runs. The same comparison can be made for paper-based solutions, where molded fiber requires the design specific molds and corrugated board and Beeboard are assembled from sheet material.

Another difference between EPS on the one hand and EPE and EPP on the other hand is that EPS is not suitable for multiple impacts, while EPE and EPP are. Hence, in the example of HP addressed in Section 7.1, with the 26 drop drop-test, HP was forced to utilize EPE, which was far more expensive than an EPS solution. When it was realized that the testing procedure was too severe, a shift to EPS could be made. However, up to that point, an engineering tradition in the company focused on EPE. A transition to a different material always carries risks.

Of all these materials, EPS is most widely used for cushioning CE goods. This is partly due to the size of the production run, and partly due to the engineering experience that has been built for this material. However, due to environmental concerns, and due to the fact that many consumers dislike large blocks of EPS as a waste material (because of the resulting loose pellets when breaking the blocks into smaller pieces), alternative solutions have been gaining ground.

Regarding cushioning characteristics, there are differences between the materials. Every cushioning material requires a different thickness to meet the criteria set for the packaging. The efficiency of cushioning materials can be expressed in the C-value of the material. In essence this is a value expressing the inefficiency of the material. Hence, an ideal cushion would have a C-value of 1

[36] This section is based on: Wever, Boks & Stevels (2006) Bulk Packaging For Consumer Electronics Products As A Strategy For Eco-Efficient Transportation. Proceedings of TMCE 2006, April 18–22, 2006, Ljubljana, Slovenia

and a higher C-value expresses a more volume-inefficient the material. Though dependent on several case-specific criteria, a rough indication of C-values is: Beeboard 1.8, Molded fiber 2.0, EPS-foam 2.5, EPP-foam 2.7, EPE-foam 2.8, layers of corrugated 4.0 to 4.5, and air cushions 5.0 (based on Philips experience, and reported in Thijsse, 2001). Next to this *physical* difference between materials, there can also be *design* differences within a certain material; not all designs are equally efficient (see Figure 7.3 for an illustrative example).

Figure 7.3: Design variety within a particular cushioning solution. The cushioning of two subsequent generations of the Philips Senseo coffee maker. On the left the first generation, which consisted of side cushions, on the right the second generation, which consisted of top and bottom cushions. Both are molded fiber cushions. The resulting outer box dimensions were nearly identical.

Thus far this factor has been ignored in environmental assessments of packaging. As Table 1.1 already showed, suppliers of cushioning materials do not mention volume efficiency as an environmentally important factor. Their environmental claims are mainly production- and recycling-related.

From this, it can be concluded that there is a lot to be gained as far as optimized packaging volume is concerned, by choosing volume efficient cushioning materials. Even within certain business restrictions, such as the size of the production run, there usually are multiple material solutions to choose from. However, alternative material solutions still face an uphill battle, as EPS retains its dominant market share. This is further illustrated by the case of molded fiber in the next section.

7.4.1 Molded-fiber packaging[37]

A specifically interesting case is that of molded-fiber packaging, which is also referred to as molded-pulp or paper-pulp packaging. It has been around now for a little over a hundred years. After being restricted to niche markets such as egg trays and boxes for a long time, its market share has increased as it is perceived as environmentally friendly material (for a more extensive history see Wever & Twede, 2007). This perception is resulting from the recycled nature of the used material. However, also the cushioning characteristics of molded fiber are very good. Several sources have indicated that, if properly designed molded fiber can be more volume efficient than EPS, thus allowing for smaller pack sizes (De Bever, et al, 1996, Eagleton & Marcondes 1994, Lambourne, 1990).

The challenge, however, lies in the fact that engineering experience for EPS covers more than half a century, while engineering experience for molded fiber, as a cushioning for durable goods, is still very limited. Furthermore, EPS is a more or less homogeneous material, while molded fiber is based on recycled organic fibers, which are more heterogeneous, and also may vary over time. Reliable and constant-quality sourcing of fiber material is an issue, especially in Asia, where they would be required for application in CE packaging. These factors have so far complicated the widespread market penetration of molded fiber.

7.5 Distribution-related optimization strategy[38]

The goal of distributing CE goods is to get a CE product in good order to a consumer. The final optimization strategy for distribution-dominated packaging that will be discussed in this chapter will address the optimization of the distribution process aimed at fulfilling that goal; that of optimizing the percentage of products that arrive at the consumer in good order, or in other words, optimization of the damage percentage.

It is safe to say that within the consumer-durables industry a belief exists that all transportation damage is bad and should be prevented. This is especially related to the potential of a malfunctioning product ending up in a consumer's home, with its resulting damage to brand image. Furthermore, the organizational costs involved in warrantee issues are substantial.

If the indirect costs of damage to the brand image are left out for a moment, the direct costs related to damage present a basic (though not easy to solve) optimization problem.

Transportation damage may occur, when for instance a package is dropped during transportation or handling. As a rule of thumb, chances of occurrence become smaller with increasing height of drops (also see Figure 2.3). Designing packaging to withstand the most severe, but also most unlikely drop will mean

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[37] This section is based on: Wever & Twede (2007) The History of Molded Fiber Packaging; a 20th Century Pulp Story. Proceedings 23rd IAPRI World Symposium. September 3-5, Winsor, UK.

[38] This section is partly based on:

- Wever (2003) Environmental aspects of moulded pulp as a packaging material for durable consumer goods. MSc thesis, Delft University of Technology
- Wever, Boks & Stevels (2004) Influence of Product Failure on Comparative Life Cycle Assessments of Protective Packaging. Proceedings EGG2004+, Berlin, pp. 1081-1082

overpacking in nearly all cases. Therefore, there must be an optimal trade-off between adding more packaging (or taking some away) and accepting damage. Such an optimum exists both from an economic and an environmental point of view. However, these optima do not necessarily coincide. By researching damage reports, packaging could be designed for such an optimum. From an economical point of view, this is what Hewlett Packard does (Clugston, 2009). From an environmental point of view, a discussion is presented in the next paragraph, but no industry application has been found in literature.

As was already discussed in Chapter 2, the data available within business that are related to damage usually consists of reports coming back from retailers, which is not examined to determine which product damages really resulted from insufficient packaging. Hence in practice, this type of optimization may be difficult. However, it can be stated that no damage at all is a clear sign of overpacking.

A special case of accepting damage is related to box damage. One of the purposes of the packaging is to protect its content. Hence from a purely engineering perspective it may very well be acceptable that the package gets slightly damaged performing this function (e.g. a scratch or a dent). However, several retail chains and a lot of consumers will not accept such a package, as they feel it will compromise the sales performance of the package on the shop floor, or may have compromised the packed product. Making sure that the package does not show any damage would require one or more of the following actions:

- Increasing the quality standards of the packaging,
- Redesign the box, or switch to different material,
- Introducing a certain amount of secondary packaging to protect the primary packaging,
- Including a few unfolded boxes in container shipment, to allow for repacking of damaged boxes (combined with a performance check of the repacked product).

7.5.1 Product damage percentage and the environmental impact of packaging

The difference in the level of protection is also something that should be taken into account when comparing two potential cushioning solutions on their environmental performance (Wever, 2003; Wever, Boks & Stevels, 2004).

Most CE companies set requirements for the design of packaging based on drop tests (or more elaborate testing programs including vibration, compression and climatic testing). A packed product has to go through a series of predefined drops without the packed product getting damaged. Experience has shown that passing these tests means they will only cause a limited number of rejects. This does not mean that all packaging solutions passing the test perform exactly equal.

The importance of incorporating the content of packaging in environmental studies, such as LCA, has been acknowledged long before. See for a discussion on the subject Kooijman (1993) and Heijungs and Guinnée (1995). However, those LCA studies on protective packaging, which are available in the literature, use functional units excluding the distribution phase. (See for example IK, 1996).

A theoretically proper comparison has to incorporate differences in reject percentages when judging two packaging solutions. This could be expressed by the formulation of the functional unit on which the LCA is based. This could be something like '*the delivery of a certain number of undamaged products to a point of sale*'.

In theory it is simple to incorporate the damaged products into the LCA of protective packaging. Of a certain product-packaging combination, the number of rejects is taken and multiplied with the environmental impact of the failed product. Subsequently, this is divided by the number of packages (Formula 7.1). This will give the relative increase of the LCA score caused by rejects.

$$\Delta E_{pack} = \frac{N_r \times E_{fp}}{P_{pack}} \quad [7.1]$$

With:
E_{pack}: *environmental impact of the packaging*
E_{fp}: *environmental impact of a failed product*
N_r: *number of rejects in distribution of this specific product-packaging combination*
P_{pack}: *production run (number of packages made)*

As a failed product will not be used, E_{fp} should exclude the use phase. The remaining phases of the life cycle can be added up. It can be assumed that there are no significant rebound effects caused by a failed product. If a damaged product is sold, a disappointed consumer may switch brands, but that does not result in an environmental rebound effect, although it may have several economical effects.

Formula 7.1 gives the exact increase of a specific product-packaging combination. In practice E_{fp} and N_r may not be known. However, Formula 7.1 does allow making a general estimation based on average figures from multiple products. This will give an idea of the magnitude of the influence. An estimate based on available data relating to damage rates (anonymously reported from several CE brands), environmental impacts of CE products (using Philips CE environmental benchmark data) and number of products made, showed this influence to be less than 2% (Wever, 2003, p.170). In a case with two packaging solutions that both passed the transport simulation test, the *difference* in protective performance would be even smaller, and therefore negligible (Wever, Boks & Stevels, 2004). This is especially true in case of large production runs, as the relative influence of a single additional failed product decreases with the size of the production run. The implication of this is, that there is a potential for optimizing the balance between less packaging and slightly increased damage.

7.6 Evaluation of test procedures

In order to be able to optimize for damage, it is required that the packaging evaluation is an adequate representation of the distribution environment. Many companies test their packed products with drop tests only, or with a combination of drop test and vibration (e.g. the ISTA 1 series test procedure)[39]. Even though this may result in workable results, this does not constitute a simulation of the actual distribution environment. Other tests, such as ISTA 3 (general simulation) and ISTA 5 (focused simulation) give general and tailored representations of the actual distribution hazards. This encompasses climatic conditioning, compression, impact and vibration.

As already described in Section 7.1, Hewlett Packard had been using test procedures that were non-representative for years, resulting in overpacking. A similar case was observed within Philips in their evaluation of their test procedure, where drop heights were found to be unnecessarily high.

Using test procedures that ill-represent the distribution hazards will either lead to unintended overpacking, or to unintended increased damage. Hence, a more sophisticated test has the potential to lead to a better optimized packaging. The level of sophistication that is affordable for a specific product will depend on the value of the product and the size of the production run.

7.7 Prioritization of strategies

The strategies presented in this chapter are not mutually exclusive; they can be applied simultaneously. Which of these strategies is best to follow will depend mainly on the size of the production run. Some strategies can always be applied, while others are only realistic in case of a considerable production volume.

It is always possible to incorporate distribution efficiency into the product development process, through early prediction of container loading and through optimizing product dimensions. Selection of cushioning materials, in itself, is already determined largely by the size of the production run, as it determines whether or not dedicated tooling is economically sound.

More sophisticated test procedures are more expensive. These costs need to be justified by the optimization potential of the packaging, which is easiest in case of high production volume. Hence, the higher the production volume, the more sophisticated the simulation of the distribution hazards can be done. Optimization of the damage rate requires a high level of data accuracy, and is therefore only applicable in cases where there is sophisticated testing.

Finally, distribution-oriented design as practiced by Hewlett Packard (producing test-runs of products, in order to optimize their robustness and thereby their distribution efficiency) requires very high production volumes, and relatively low value products.

Time-wise, some strategies require a major shift in the way a company operates (e.g. producing test runs) and/or a diversion of certain company traditions (e.g. shift to different cushioning material). Such strategies would require more time to implement. Others, such as making sure that a target for the container loading is set early in the product development process, can be implemented quicker.

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[39] See www.ista.org for details on these test procedures. ISTA is the International Safe Transit Association. (last retrieved on 28-05-2009)

7.8 Conclusion

Even though the field of protective packaging engineering has been developed for decades, there is still a considerable improvement potential. By collecting facts on current performance and analyzing those through performance indicators such as the volume index and container loading (and comparing scores against competitors), candidate-packages for redesign can be selected, and concept designs for new packaging can be evaluated. In this study numerous products were identified with a savings potential between €0,50 and €1,00 per product, which would result in millions of savings for an entire OEM. The positive correlation between cost-savings and environmental improvement should be a strong driver in achieving these improvements.

In order to achieve these savings, several strategies are open to product and packaging developers. Some are specifically product-related (increased robustness, optimized product dimensions, postponed product assembly and transport orientation), some are packaging-related (selection of cushioning material) and some are distribution-related (optimization of damage percentage, calibration of testing procedure). The prioritization of these strategies is mainly based on the size of the production run.

"Good things come in small packages"

ENGLISH PROVERB

8. Design Strategies for Sales- & Experience-dominated Packaging

Intermezzo A and Chapter 4 and 5 have shown evidence that marketing functions (i.e. sales and experience) can be strong determinants of the final packaging design. Both sales and experience functionalities often lead to increased volume[40]. This chapter will show how these functions can be fulfilled while keeping volume at a minimum, given the requirements. Doing so will address the research question on *'how designers can fulfill the required (mix of) functionalities of the packaging in a volume efficient way'*.

This chapter will discuss different strategies for keeping the volume of a packaging to its minimum. Some of these will be more managerial in nature; others will be more focused on design. These strategies include strong brand identities (section 8.2), optimization in the third dimension (section 8.3), imitating jewel boxes (section 8.4), and improved unpacking experiences (section 8.5).

The following sections will be devoted to optimization of the sales performance (Sections 8.2 and 8.3) and experience performance (Sections 8.4 and 8.5). But first these strategies will be linked to sales and experience functionalities in section 8.1.

From the perspective of distribution efficiency, as well as environmental impact, a basis prioritization can be presented: first try to achieve the required sales or experience with graphics. If that is insufficient apply different and/or more material, and only as a last resort increase the volume. This basic prioritization is reflected in the different strategies presented.

A requirement for the effective optimization of packaging volume is to be able to quantify the effectiveness with which the marketing functionalities are fulfilled, in order to enable the balancing of marketing functionalities with the efficiency with which distribution functionalities are fulfilled. Thereby, as a result, environmental impact will be reduced as well. This issue of quantification will be discussed in section 8.6. Here a method of measuring marketing performance or effectiveness (i.e. how well are the sales and experience functionalities fulfilled) within a business setting will be described and tested. Subsequently, in section 8.7 the balancing of marketing performance against costs and environmental impact will be discussed in more detail.

In some cases it will turn out that in spite of all efforts the requirements of consumer packaging and distribution efficiency cannot be sufficiently reconciled. In such a case, the solution suggested is to cut the distribution into two parts: a transportation part and a sales part. This strategy of packaging postponement is described in section 8.8.

[40] Furthermore, these functions lead to the application of more material, as well as material with a higher cost and environmental impact.

8.1 Linking design strategies to packaging functionalities

The sales and experience functionalities of a packaging can be divided into several aspects. First a packaging need to draw the attention of the consumer; it need to be noticed. Secondly, a packaging needs to communicate about the product. Thirdly, it needs to appeal emotionally to the consumer; it has to be positively appreciated. Finally, especially for experience packaging, the packaging has to be special. Depending on several variables, such as the type of product, the price, the brand, the retail outlet and competitor actions, the relative importance of these four functionalities may vary. Also, the design strategies presented in sections 8.2 through 8.5 are focused on some of these four functionalities. Table 8.1 gives the correlation between the design strategies and the sales and experience functionalities.

	Strategy→	§ 8.2 Graphic unity	§ 8.3 Third dimension	§ 8.4 Designing a jewel box	§ 8.5 Designing an unpacking experience
Functionality ↓	Level → Sales / Experience↓	Product portfolio	Single product	Single product	Single product
Eye-catching	S	+++	++	+	0
Communication	S	+	++	0	0
Appealing	S/E	0	0	++	+
Being special	E	-	0	++	+++

Table 8.1: Correlation between design strategies and sales and experience functionalities.

The strategies presented here, can be combined to some extent, and in practice they are. Graphic unity combines well with optimization of the third dimension. Designing a 'jewel box' combines well with designing an unpacking experience. The other combinations can be combined as well.

8.2 Unity of graphics for entire brand

One way of achieving brand recognition, and thereby increasing the chances of being noticed by a consumer, is through consistency in the graphical appearance of all packaging. Graphics are the preferred way of achieving marketing functions, as the costs and environmental impact related to more fancy printing are lower than those of more material and more volume. A brand, of which the consumer is at least latently aware, can make sure it is being noticed by applying easily recognizable graphics.

This strategy is more a design-management strategy than a pure design strategy. Discipline of the designers, in staying within the boundaries of the brand style, is a condition for success.

Currently, only few of the major brands in consumer electronics goods follow such a strategy consistently. When Philips started to standardize its packaging range around the turn of the millennium, it was the first program of its kind in the CE industry (Marzano, 2005, p.369). The current Philips harmonization program prescribes in great detail how to design the graphics on a package, including for instance how a product should be photographed (see Figure 8.1 for some example packages within the Philips style).

Figure 8.1: Several clamshell packages designed within the Philips harmonization program for packaging (Marzano, 2005)

It should be noted that this strategy is highly suited for products where sales functionalities are important. However, it may be counterproductive for experience packaging, as all elements of surprise are eliminated.

This brand unity strategy is mainly expressed through graphics. Potentially it could also be extended to materials and details such as gloss and texture, which can also be included in a harmonization program. As stated above, if graphics alone will not yield enough in terms of required sales performance, a next step can be to alter the packaging dimensions. However, this does not necessarily mean that the volume has to be increased, as it may be limited to a change in the basic shape of the packaging, while retaining the volume (i.e. more flat than cubical).

8.3 Optimization of the third dimension

With packaging that is dominated by sales-related functionalities, the front-facing area of a package is most relevant to the fulfillment of marketing requirements. Hence, the front-facing area often is enlarged from what would be required from a purely distribution point of view. A minimal front-facing area may be required to attract attention or to communicate the unique selling points. A minimal area may even be prescribed by the retailer to match shelf dimensions. In order to have an enlarged front-facing area and still keep volume to a minimum, the third dimension of the packaging needs to be reduced as much as possible. Packaging designers can work on an optimal arrangement of product and accessories to minimize the depth of the package.

The issue of front-facing area already was apparent in Case II in Chapter 6 on the web-cam packaging (Figure 8.2 gives another picture of the unpacked product, showing that the contents do not require this size of box). Here the original packaging was relatively flat and the front-facing area had been enlarged considerably, without a need, given the dimension of the product. In that particular case this enlargement was judged as excessive, but it is a good illustration of how a large front-facing area works in packaging design.

Figure 8.2: Unpacked web-cam. The contents (bottom right do not require this size of box. The size is purely a result of shelf performance considerations. (Pratama, 2006)

An example where the third dimension could be optimized, without compromising the front-facing area is a package for a Philips MP3-player that was studied. Its packaging was more or less cubical, splitting in the middle (apparently trying to copy the original iPod packaging, but with far less attention to detail, and hence not entirely successful in creating a nice unpacking experience).

Judging by the contents of the packaging, the box could easily be reduced to half its current volume. By rearranging the contents of the box the third dimension could roughly be cut in half (Figure 8.3). Hence the front-facing area could be maintained, and the money saved on material and transportation volume could be invested in higher quality of material and finishing.

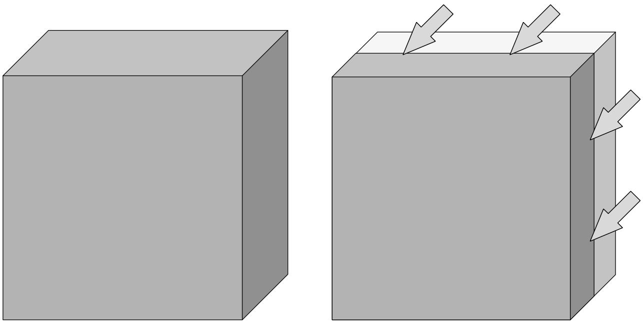

Figure 8.3: Reduction of packaging volume without compromising the front-facing area, which is important for the sales performance of the packaging.

8.4 Designing a 'jewel box'

In design of marketing packaging, the aim should be achieving the required functionalities with a minimal volume; hence marketing functionalities should preferably be fulfilled through upgrading finishes (i.e. printing). If this is deemed insufficient more and/or higher quality materials may be utilized, and only as a last resort should the volume be increased. This goes for both sales packaging and experience packaging.

Experience packaging may thus be optimized by mimicking a small 'jewel box', instead of a big bulky package. This is in essence the strategy followed by Apple for its iPod packages (certainly in comparison to its rivals, which were found to be twice as voluminous), by using relatively small boxes, luxurious materials and high quality printing and especially finishing. The extraordinary attention to details makes iPod packages so nice to unpack (also see the picture series in Figure 5.1).

Figures 8.4 through 8.6 give examples of experience-dominated packages. The iRiver MP3 player in Figure 8.4 uses a product presentation like a 'necklace'.

Figure 8.4: The packaging of the iRiver N10 512 Mb utilizes like a necklace in a jewel box. Extra layers of material are applied to increase the experience. (Pratama, 2006).

The packaging of mobile phones in Figures 8.5 and 8.6 utilizes high quality finishes, high quality and/or more material. The package in Figure 8.5 is first removed from its sleeve. Subsequently two slides can be pushed out. The movement of these slides is connected. Hence, when one slide is pushed out, the other will slide out as well.

In all three cases, the presentation of the product has resulted in an increase in volume. However the designers primarily used the finishing and the material to the extreme to create high quality boxes. Thereby they kept the increase of volume to a minimum.

Figure 8.5: The packaging of the Motorola V3 RAZR utilizes high quality finishing, additional material (the sleeve) and original presentation of the product (which does increase the volume). (Pratama, 2006).

Figure 8.6: The packaging of the Nokia 7380 phone utilizes high quality finishing, additional materials (sleeve), high quality materials (metal box) and layered presentation of product and accessories (which also requires additional material). (Pratama, 2006)

One step further still, would be the co-branded LG-Prada phone. It comes in a relatively volume-efficient, cubical box that truly mimics a jewel box by style and used materials. (see Figure 8.7)

Figure 8.7: The packaging of the LG Prada phone truly mimics a jewel box.

8.5 Designing an unpacking experience[41]

As discussed in Chapter 5, Pine and Gilmore (1999, Chapter 3) provide a five step plan for 'experientializing' a product:

1. Theme the experience,
2. Harmonize positive cues,
3. Eliminate negative cues,
4. Mix in memorabilia,
5. Engage the five senses.

These steps can to some extent also be applied to create a great unpacking experience for durable goods. Elaborating on the first point, 'theming' the experience may be as simple as mimicking an existing experience. Looking outside the world of packaging there are several real-life examples of great 'unpacking' experiences. There is a scale of options here:

- Presenting (like a waiter presents a wine bottle, or the stereotypical silver platter)
- Unveiling (like the unveiling of a statue, the opening of a stage curtain, or unwrapping a gift)
- Revealing (unveiling followed by presenting, like a diamond ring box)
- Teasing (showing just part of the object, like a car at a motor show, covered by a cloth, and just showing one of the head lights)

[41] This paragraph is strongly based on Wever and Del Castillo C. (2006)

At this point, it is important to realize that the unpacking experience is but a single act in the total brand experience. Still, it is the first act that will draw the consumer closer to the actual product. The theme chosen for the unpacking experience has to be in harmony with the brand experience. This means for instance that the unpacking experience of Philips should be in harmony with *Sense and Simplicity*, and the unpacking experience of a Panasonic product should match with *Ideas for Life*.

The second point, the harmonization of positive cues, is a call for consistency in the unpacking experience. In connection to this, the third point, the elimination of negative cues, means taking away anything that does not add to a positive experience. For a package this implies that it is easily opened—something which is rare in a world filled with tamperproof clamshells. It also implies avoiding other negative cues, such as too big packages for their content and too much waste left over.

The fourth point, mixing in memorabilia, is part of the larger brand experience. Therefore memorabilia need not necessarily be part of the unpacking experience itself, although the packaging may contain brand memorabilia. An example here is Apple adding Apple stickers to the packaging of the iPod.

Finally as the fifth step, multi-sensory stimulation is something that is not applied very often in packaging for CE products. Usually packages are only designed to work well visually. Scents, sounds and texture are rarely applied to enhance the experience of the unpacker. Study 3, as described in Chapter 5, gave an example of smell as a negative cue in the unpacking of an electric shaver. However, it should be possible to utilize smell as a positive cue here, especially as Philips already produces a co-branded shaver with Nivea.

Based on this, a model was made for building a great unpacking experience (see Figure 8.8). Some aspects are a consistent part of this strategy, these are:

- openability (elimination of negative cues),
- the multi-sensory approach (the triggering of other senses than sight alone),
- the consistency (harmonization of positive cues).

From this there are basically two avenues that can be followed to theme the experience. The first is a logic approach, presenting the product and accessories in the most favorable way, at the logical moment in the logical sequence (this would be most fitting for a brand experience such as *Sense and Simplicity*). The other approach is that of surprise. As Van Hamme and Snelders stated (2001) theoretical arguments and empirical findings strongly suggest that a positive surprise may play an important role in consumer satisfaction. This can be done by applying the principal of unveiling, revealing or teasing.

Looking back at the unpacking examples in Figures 5.1 and 8.4 through 8.7, these steps can be recognized. All are easily openable. Tactility and audio have received limited attention, but they are involved in opening a metal case (Figure 8.6), and the LG Prada box (Figure 8.7) utilizes texture in its material. The different steps match (for instance through color schemes), hence providing consistency. Especially the V3 Razr (Figure 8.5) follows a surprise approach with the two slides coming out simultaneously, but in opposite directions. The iPod

(Figure 5.1) and the LG Prada phone follow the revealing strategy (like the diamond ring case).

Based on these examples, and the studies in Chapter 5, it can be concluded that the general theory on creating experience by Pine and Gilmore can be translated successfully into an unpacking experience using the approach in Figure 8.8.

However, it was found, that details in a package design can act as negative cues—as happened with the unpleasant smell in study 3 mentioned in Chapter 5. Hence testing new package designs in an unpacking experiment (for instance using a focus group) remains advisable.

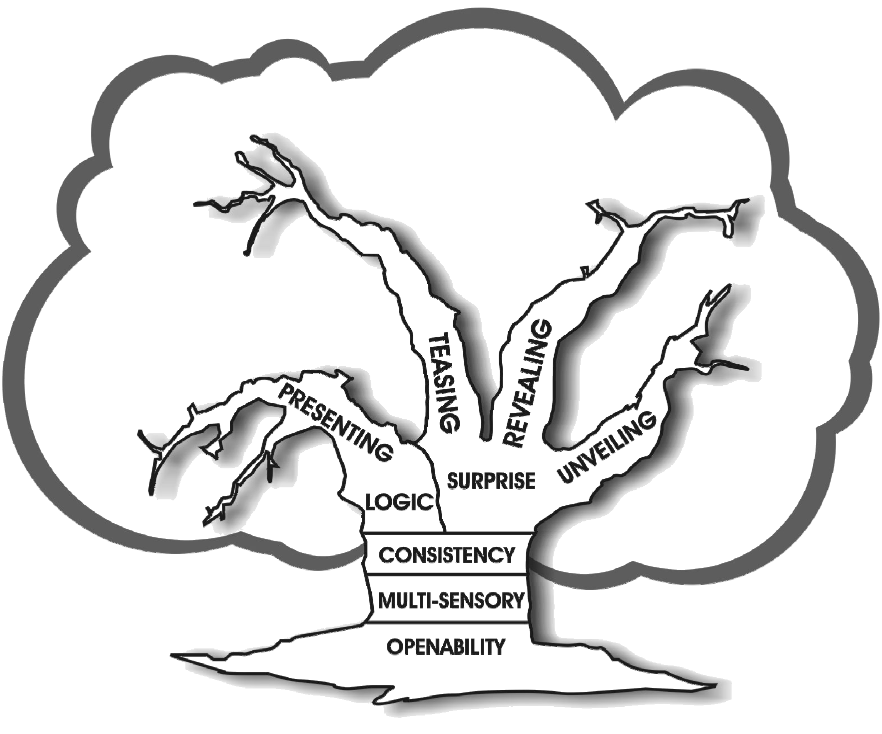

Figure 8.8: An approach for building the unpacking experience, based on the theory of Pine and Gilmore (1999). The experience is based on openability, a multi-sensory approach and consistency. On top of this basis there are several possible scenarios (branches). Their applicability depends on the brand experience, of which the unpacking experience is just one part. (Wever & Del Castillo, 2006).

8.5.1 Improving openability[42]

In Figure 8.8 openability is mentioned as one of the essential elements of any good unpacking experience. This indicates the importance of this aspect. Consumer electronics, like other durable goods, mostly come in two types of packaging: corrugated board boxes and blisters/clamshells. The boxes usually do not present an openability problem, where the clamshells do. Many consumers complain about openability of clamshells. This problem is so frequent that the irritation aroused in consumers by un-openable packaging has a name: 'wrap rage'.

Simply eliminating such packaging is not possible because the un-openability is actually required by major retailers for the in-store environment. These retailers want to prevent theft and tampering on the shop floor, while still maintaining a self-service environment. And, since the dominant power in the value chain lies with the retailers, as addressed in Chapter 6, clamshell packaging is here to stay.

There are several research and development programs underway to make it possible for a package to maintain tamperproofness in-store, while being easily openable after purchase. The first one is Natralock®, a plastic blister enclosed in tear-resistant cardboard. Due to the tear-resistancy it is nearly impossible to open with bare hands (in-store) but easy with a pair of scissors (at home).

A second development is offered by the company Stora Enso, which works with a special glue that loses its stickiness when a small electrical current is applied (Sandberg, 2006). Originally developed to quickly change the signs on military aircraft, Stora Enso is exploring packaging applications. One of them would be a clamshell packaging that is pulled through a machine at the cash register, which applies a small current, thereby unlocking the clamshell. The machine would be something like a credit-card reader. Such a solution would require the cooperation of the retailer. As this is comparable to the removal of anti-theft measure in clothing that have to be removed at the cash register, this cooperation seems likely.

A third option was developed during a graduation project at Philips Domestic Appliances in Drachten (Del Castillo C., 2006). Here the plastic of the clamshell would be perforated (see Figure 8.9). To prevent people from opening the packaging in-store, the perforation does not go all the way to the edge of the package. The consumer first has to cut away a small strip of material to gain access to the perforated part of the clamshell. Preliminary tests that could be executed with the limited means of a university workshop already gave promising results as to the workability of such a solution. It turned out that such an opening sequence can be designed in such a way that clear cues are presented to the consumer as to which actions are required from him/her in order to open the package. A limited evaluation experiment (N=6) confirmed that both the cues and the technical openability were improved compared to existing clamshells used by Philips Domestic Appliances.

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[42] This section is based on a graduation project (Del Castillo C, A., 2006) co-supervised by the author and previously published in: Del Castillo C, Wever, Buijs & Stevels (2007) Openability of Tamperproof Packaging. The 23rd IAPRI World Symposium on Packaging, September 3-5, Winsor, UK.

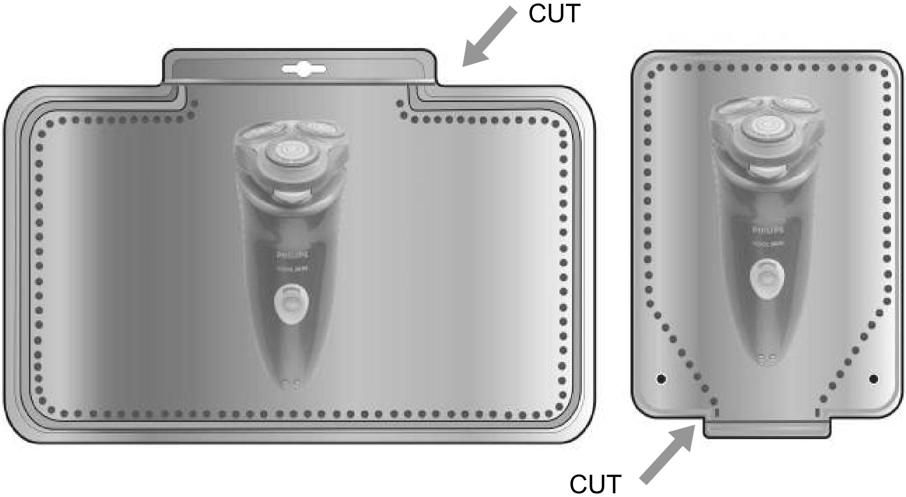

Figure 8.9: Designs of a clamshell with combined perforation and cutting (Del Castillo C., 2006). Both these specific clamshells where intended to be placed in a corrugated board box with a cut-out window in the front facing area.

In conclusion it can be said that the requirement set by powerful retailers, that products should be packed tamperproof, need not mean that the packaging becomes difficult to open. Design strategies are available for packaging developers, that are tamperproof in-store, yet easy to open at home.

8.6 Quantifying sales performance[43]

Sections 8.2 through 8.5 have presented design strategies that can be applied in order to fulfill sales and experience functionalities, while keeping the volume of the packaging under control. Hence, these strategies allow for a balancing between sales and experience functionalities on the one hand, and distribution efficiency on the other. In order to do this balancing, and to facilitate design decisions, quantification of the sales (and experience) performance is needed. Currently sales performance is not quantified in practice. Nevertheless, (alleged) sales performance is deemed more important than distribution efficiency in the packaging-design for a lot of CE goods (see Intermezzo I and Chapter 4). Distribution efficiency (and resulting from that also environmental performance) is of lesser concern. Even though consumers name too much packaging waste as their number-one annoyance when it comes to unpacking CE goods (Muller & Vroom, 2005), boxes are not getting smaller.

As demonstrated before, sales functions need not necessarily be performed by increasing the volume. Also material (both type and amount) and especially graphics can be utilized. Graphics have the potential of creating a substantial increase in sales-performance at a minimal cost and impact. Volume may also

[43] This section is based on: Wever, De Vries, Boezeman, Roskam & Uythoven (2007) Sales Performance of Packaging for Consumer Electronics Products. The 23rd IAPRI World Symposium on Packaging, September 3-5, Winsor, UK. This paper is in turn partly based on a student research project.

create a substantial increase in sales-performance, but usually at a higher cost and impact.

The more detailed the information about performance is, the better the optimization can be performed. Prior to the launch of a product, (direct) cost and environmental impact can be *calculated* to a single score figure (see also Case Study I in Chapter 6 for an example), while sales performance cannot be *calculated*. However, there are some tools available to *test* the sales performance of pack designs, mainly coming from Fast Moving Consumer Goods (FMCG), which were already introduced in Section 2.3.2 (see also Wever, Boks & Stevels, 2006a). These tests have their pros and cons, and may not all be immediately applicable in a business setting in the CE industry. Nevertheless, these testing tools can serve as a starting point for a further exploration of what could be achieved in this respect. These tools are:

- Focus groups

  A focus group is a research method consisting of a group interview with carefully selected participants from the products' target group. Focus groups have traditionally been widely used as a packaging design research methodology. It has been applied both at the start of design projects as market research and for evaluation of final designs, i.e. a form of disaster check.

  The focus groups approach allows the gathering of information about the packaging, but performance is not quantified. It is more about *learning* than about *measuring*.

  A point of critique regarding focus groups in FMCG is that it does not resemble real purchase situations very well, as people do not deliberate about a product for an hour before buying it or not. However, that means it may be a reasonable research method for durable consumer goods, where consumers often take more time to reach a purchase decision. However, as also became evident in the study described in section 5.2, this artificialness is a complication. In the end, sales functionalities of a packaging are largely aimed at the impulsiveness of the shopper.

  As stressed by Gold (2004) it is very important to at least position packaging designs next to competitor products, to improve the realism of the setting.
- Eye-tracking

  Other methods do allow measuring. One of these is eye-tracking. The basic idea of the test is to use equipment which is attached to a participant's head to measure where (s)he is looking. When performing this test with a section of store-shelves, it can be tested how many consumers look at a certain package, for how long, how often and in what order (Swope, 1981). Eye-tracking was one of the tools used by Philips during their packaging harmonization program, to evaluate the template they had designed (Marzano, 2005, p.371).
- Tachistoscopy (T-scope)

  Another test allowing a certain level of quantification is the tachistoscope (t-scope). This is a method in which a participant is shown flashes of a product. Starting at for instance 1/100th of a second, exposures are incrementally increased to for instance 2 seconds. After each exposure a participant is questioned about what (s)he saw. Hence average time scores can be obtained needed for aspects like brand recognition, product type identification and noticing special product features (Swope, 1981; Morich, 1981).

Where eye-tracking determines where we *look*, the T-scope focuses on what we have actually *seen*. Hence T-scope is a useful tool in cases where product recognition is of the highest importance, such as medicines which may have to be used quickly in an emergency (Anon., 1993). T-scope testing has also been applied as a scientific research tool, for instance to research the effects of latency of the brain, i.e. whether placement of text and illustration on the left or right of a package made a difference (Rettie & Brewer, 2000). Major disadvantage of this method is that its setting is very different from actual shopping environments.

– Semantic differential

  This is a method in which participants are asked to score designs on scales between two extremes, i.e. modern versus old fashioned or beautiful versus ugly (Schoormans & De Bont, 1995). In comparison to eye-tracking and T-scope, semantic differential will measure how people *feel* about a package.

Table 8.2 relates these strategies to the sales and experience functionalities that have to be fulfilled.

Method → ↓ Functionalities	Focus groups	Eye-tracking	Tachistoscopy	Semantic Differential
Eye-catching	0	+++	+	0
Communication	0	+	+++	0
Appealing	++	0	0	++
Being special	++	0	0	++

Table 8.2: Correlation between design evaluation methods and sales and experience functionalities.

A tool combining these last three measurements would be ideal. It would give quantitative data as to what extent a package is noted among its competitors, what is actually seen, and how it is perceived emotionally. This would yield the data required to make well funded design choices. A scoring-system could even be designed to bring the three aspects into a single score, somewhat like it is often done with environmental impact. However, execution of such a set of experiments in a controlled laboratory setting is (too) time-consuming and expensive. In most business cases is there is a limited budget, and even more important, there is only limited time available. Therefore practicality is of the utmost importance.

8.6.1 Towards a tool for quantifying sales performance

Looking from a business perspective, it is important that a tool:

- gives meaningful answers, as regards discrimination of alternatives;
- can be applied fast and easy;
- preferably allows the testing of design concepts against existing (competitor) packs.

Regarding the first point of meaningful answers, scoring the marketing effectiveness is a process aimed at design-management decision making. On the one hand, this means that it must be possible to translate the outcome into design or management actions. On the other hand, the reliability and accuracy should be good enough to base decisions on, but need not deliver 100% proof.
Based on these criteria an Internet-based tool seems most suitable; it allows for a set-up testing graphical representations of pack designs (photographs of existing packs, or computer generated images of new designs) with a pool of respondents. As people will not have to come in to a laboratory, it can be executed rather quickly. Furthermore, respondents from all over the world can be reached. And most importantly, as will be explored below, it has the potential of supplying meaningful answers.

Looking at the available research methods, focus groups and eye-tracking are not executable via an Internet connection to people's homes. Hence a combination of semantic differential and t-scope seems more realistic. Below, an experiment will be discussed that utilizes these two. It should be perceived as an exploratory attempt to see whether such a quick quantifying tool can deliver results which are sufficiently significant to for design decisions.

By executing the t-scope with pictures of a retail shelf with several products, rather than single packs (as is the default method of application of this tool), some of the aspects that could otherwise only be measured with eye-tracking are incorporated as well (i.e. where people are looking).

The goal of the t-scope is to define which product (packaging) catches the most attention on a shelf. For the test five flash movies were used (for an example see Figure 8.10, right), each with the same content, but with increasing duration; from 250ms till 1500ms (as advised by Swope, 1981). Five different versions of flash animations were used to provide for the fact that preferences for a certain corner of the screen/shelf may influence the results. For example; a packaging in the upper left corner has (in Latin-alphabet regions) more chance to be seen than the same packaging in the lower right corner (Swope, 1981).

This test will use participants working on their own PCs in their own homes. The tool shows several pictures and asks questions to adapt it to screen resolutions of the user. Of course, different screen resolutions and other aspects of the used PC and monitor make that the execution of a t-scope will not be totally identical for each participant. However, in a business setting this is acceptable, as the tested design is in the same picture as the competitor products, and the objective is relative scoring. Hence, with a single participant all designs stand an equal change of being spotted.

The semantic differential will show people single images and ask them to score these designs on a scale with two extremes (robust vs. fragile, simple vs. complex, flashy vs. modest). This type of questions allows a brand to test for attributes that are important to that specific brand, i.e. *Ideas for Life* for Panasonic, or *Sense and Simplicity* for Philips.

Figure 8.10: on the left a real retail shelf, on the right a computer generated shelf image as used in the Internet t-scope test.

Basically the t-scope will yield two types of quantitative data: the percentage of people that recognized a specific brand, and the average speed with which they did so. In practice this may be more complicated then it seems, with participants recognizing part of a brand name, or product feature. The semantic differential will yield an average score on each question asked (with a standard deviation). As long as the different scores are kept separately, these data are reasonably objective. However, within a business setting, combining these different scores into a single score may be more workable, even though that would reduce objectivity. As long as it is executed consistently through time (and checked for correlation with resulting sales data or an occasional focus group), that should work fine.

As stated before, a combination of semantic differential and t-scope will be utilized, thus testing what people have *seen*, and how they *feel* about the designs. Added to this, participants will be asked to score all packages on two scales; one for 'remarkability' and one for attractiveness. The 'remarkability' score is expected to match the t-scope result and the attractiveness is expected to match the semantic differential result. Thus an internal check is built-in. It should be understood that this is mainly an attempt to see whether these research methods will work when applied in such a way, it is not intended to claim that this is the right final tool.

Testing set-up

To test this preliminary tool it has been evaluated with actual packages. As a test-product earphones were selected (see again Figure 8.10). This type of product has several advantages:

- it is a well-known, unisex product;
- design of the product it pretty similar across brands;

- the packaging plays a major role in the sales of the product;
- the price category allows for grab-and-go shopping.

The test was hosted at *www.netquestionaires.nl* which allows free testing up to 100 participants. In the settings of the questionnaire it was made impossible for the respondents to redo the test, and also to stop and restart it. In total, 62 usable responses were collected. Participants were between 16 and 66 years of age, and were invited to participate by e-mail. As the invitees were in the social network of the students executing this research, the population was skewed towards younger participants. Furthermore, the response rate may have increased due to this factor.

Testing results

The t-scope showed 6 products at a time, so not all products were shown the same number of times in total. Table 8.3 shows the brand recognition from the t-scope (N=62). All products included are listed. It should be noted that two Sony products and two Philips products were included. However, there were never two products by the same brand in one shelf picture.

A first interesting result is that the Sennheiser earphones (top left in right picture of Figure 8.10, also see the cover of this thesis), which is bright orange and yellow, scores very low nonetheless.

A second conclusion is that there are substantial differences between the different brands.

A third interesting result is that several times brands were named that were not in the picture the participant had just seen (e.g. Apple, Samsung, JVC).

	Sennheiser	Sony Bass Boost	Philips Extra Bass	Sony Orange	Hema Round	Bandridge	Philips Easy Wear	Lenco	Packard Bell	Hema Ear
spotted	6/62	9/11	24/30	22/24	3/11	0/54	4/7	18/43	52/62	5/51
%	9,7	82	80	92	27	0,0	57	42	84	9,8
ranking	**9**	**3**	**4**	**1**	**7**	**10**	**5**	**6**	**2**	**8**

Table 8.3: Result on brand recognition from the t-scope, with rank 1 being best.

Table 8.4 shows the results of the ranking made by the participants of all 10 pack designs. The ranking for 'remarkability' was expected to be similar to the ranking of the t-scope. It clearly is not. Especially the difference regarding the Sennheiser seems relevant. When ranked by participants it scores very high, probably due to its bright yellow and orange colors (see Figure 8.3, right picture, top left). In the t-scope however it scores very low on brand recognition. This may be due to the relatively small printing of the brand name, as compare to competitors.

This test is also used to sort out the unreliable answers. Some participants randomly filled in the test. By comparing two almost identical packages (Hema) it was estimated which participants had randomly filled in the test (for example in case they rated the one Hema package with a 1, 2 or 3 and the other Hema with an 8, 9 or 10, while they were very similar). These respondents were omitted from the results.

		Sennheiser	Sony Bass Boost	Philips Extra Bass	Sony Orange	Hema Round	Bandridge	Philips Easy Wear	Lenco	Packard Bell	Hema Ear
remarkability	mean score	*7,6*	*6,1*	*7,0*	*5,2*	*3,7*	*5,4*	*6,0*	*5,4*	*5,0*	*4,3*
	ranking	**1**	**3**	**2**	**7**	**10**	**5**	**4**	**5**	**8**	**9**
attractiveness	mean score	*6,0*	*6,0*	*5,7*	*5,1*	*5,1*	*6,5*	*5,3*	*5,4*	*5,1*	*4,5*
	ranking	**2**	**2**	**4**	**8**	**8**	**1**	**6**	**5**	**7**	**10**

Table 8.4: The results of the ranking question

What makes a good score on a semantic differential scale depends on the intended message. Hence it turned out to be hard to translate these results into a ranking.

Discussion and conclusions regarding quantification of sales performance

The t-scope was successful in discriminating between different packaging designs, even under the wide variety of settings of PCs used by the participants. (Only a few of the respondents had to stop testing because the size of the images could not be matched to their screen resolution.) As a measurement for brand recognition it is a good way to get a quantitative score. Next to that it gives qualitative information on which aspects of pack designs are also noticed (and how quickly). The use of a shelf picture instead of a single pack design seems a useful adaptation of normal t-scopes. The t-scope measures the effectiveness of the communication, which is different from the 'remarkability', as was demonstrated by the comparison with the ranking by participants on 'remarkability'. The effectiveness of communication is deemed to be a better indicator of sales performance, than 'remarkability', i.e. the t-scope is deemed more relevant than the ranking on 'remarkability'. However, both could be incorporated in a final tool. How to weigh the 'remarkability', the percentage of participants recognizing a brand name, and the speed with which they do that, can be calibrated over time with actual sales data, or eye-tracking data of physical packages.

The experience with the semantic differential shows that it is hard to turn into a ranking as a high score on a certain scale may be positive for one brand and negative for the other. It all depends on which connotations and emotions a brand wants to communicate; one brand could be striving for a more masculine, high-tech image, while another could be striving for a more feminine, user-friendlier image. For testing design alternatives however, it is highly suitable. Such a test would require a predefined target score on certain semantic differential scales. In other words, it should be clear what profile of connotations and emotions the packaging is meant to communicate. The ranking in attractiveness, which was used as a built-in check in this preliminary tool, can be used as a check on the semantic differential.

The overall conclusion is that the combination of t-scope (with multiple packages) plus semantic differential plus direct ranking seems suitable to obtain a quantification of sales performance. This first experimental study already gave a clear indication in that respect. However, more work will be needed to improve the tool, for instance regarding the level of inaccuracy introduced by running it on subject's home PCs.

It seems appropriate to keep the scores for seeing (i.e. 'remarkability') and feeling (i.e. attractiveness) separate instead of combining them in a single score, as these aspects are clearly very different from one another.

This section has focused on measuring the sales performance of a packaging. The second part of the test, the semantic differential, would also be suited for testing and scoring the experience performance of the packaging (i.e. the unpacking experience). However, as the unpacking experience usually consists of a sequence of actions, it may be harder to effectively test this via the Internet, because aspects such as three-dimensionality, texture and gloss may be important, and these aspects are hard to capture effectively in 2-D.

8.7 Managing packaging design proposals

Packaging design is all about optimization and compromise between different functionalities. There are plenty of opportunities to optimizing pack designs for CE products by balancing marketing functions on the one hand (sales performance, tamperproof, unpacking experience) and economic and environmental functions on the other hand (distribution efficiency, material usage). However, to do this properly, quantitative information is required about how well the marketing functionalities are fulfilled: to what extent do packaging features (volume, material, color) that are intended to communicate certain messages, actually communicate those messages?

When working on such an optimization process, there are several possible effects that can result from proposed design *changes* (see Figures 8.11 a and b). Costs and environmental impact can go up or down and the (expected) sales performance can go up or down. If the sales performance goes up, while costs and environmental impact go down a real improvement has been achieved (upper right-hand corner in both graphs). Likewise a design proposal with higher costs and lower sales performance is clearly deterioration (lower left-hand corner in both graphs). The difficulty occurs when design proposals achieve higher sales performance at the cost of higher environmental impact, or lower environmental impact at the cost of lower sales performance (see Figure 8.11). To make these situations manageable it is necessary to know how much sales performance is sacrificed for a certain saving in costs and environmental impact, or how much a certain improvement in sales performance is going to cost financially and environmentally. Calculating SP/€ or €/SP scores and SP/EI or EI/SP scores for different design options helps to make such design decisions.

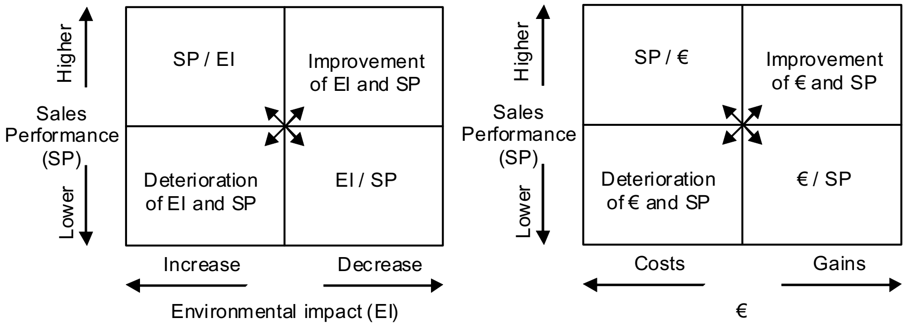

Figure 8.11a and b: The four directions of design changes, with 8.1a depicting sales performance (SP) related to environmental impact (EI), and 8.1b depicting sales performance (SP) related to costs (€). (Based on the eco-efficiency directions [Huisman, 2003, p. 262-263], and previously published in Wever, Boks & Stevels, 2006).

8.8 Packaging postponement[44]

Sections 8.2 through 8.5 aimed at providing ways of fulfilling marketing functionalities in ways that do not increase the volume of the packaging. Notwithstanding the effectiveness of these strategies, in the end it may be the case that a sales packaging is required with a relatively large volume compared to the packed product. In such cases, splitting the distribution into two phases may be considered: long-distance transportation and the retail phase, with dedicated packaging for both of these phases. This strategy is called 'packaging postponement'.

By postponing the packing into their final consumer packages until after long-distance transportation, a more volume-efficient stacking of products can be used during long-distance transportation. This would be done in multiple or bulk packaging. Hence, optimal distribution packaging would be used during the transportation phase and marketing packaging would be used during the sales and unpacking phase. Such a strategy can even enable differentiation of the final consumer packaging by outlet channel.

Multiple packaging is a specific form of postponement. Postponement is the opposite strategy of speculation, on which mass production is based (Bucklin, 1965, Zinn & Bowersox, 1988) Speculation allows for economies of scale. The location and magnitude of demand for a certain product are predicted upfront. Products are manufactured and distributed according to these forecasts in the assumption that they will be sold. Errors in such forecasts will result either in products being in short supply or in unsold stocks. Yet if the costs of errors in the prediction of sales are lower than the savings achieved through the economies of scale, speculation is a sound business principle.

The alternative approach is postponement of (parts of) the production and distribution until the point that more certainty exists on actual demand. One of the

[44] This section is based on: Wever, Boks & Stevels (2006b) Bulk Packaging for Consumer Electronics Products as a Strategy for Eco-Efficient Transportation. Proceedings of TMCE 2006, April 18–22, 2006, Ljubljana, Slovenia.

best-known examples of this strategy is Dell's direct business model, building computers to order from components kept in storage, thus allowing for customization. Short lead times allow Dell to bring new developments to the market quickly, thus creating a competitive advantage (Magretta, 1998). Dell's example is however not the only possible form of postponement. The extent to which manufacturing is postponed can differ. The point in the supply chain where the manufacturing of subassemblies based on speculation connects to the postponed actions is called the decoupling point (for a discussion see Yang & Burns, 2003). As Yang and Burns show, the 'decoupling point' can be any place between full speculation and full postponement. What is the right point for a certain industry depends on the maximum acceptable waiting time for customers and the uncertainty of market forecasts. Fisher (1997) states that more innovative products, which have more uncertain demands and quickly lose value in storage, benefit more from postponement, as it creates a more flexible supply chain, that is more capable of responding to actual demand.

(Sales) packaging postponement in the consumer electronics industry is a concept in which products are not packed in their final consumer packaging at their place of manufacturing. Instead they are shipped in bulk cushions to the different distribution centers. Only when orders have been received are the products packed in their final individual packaging and shipped to the retailers. This requires packaging facilities in more locations. Each location will purchase its own packaging separately, thus losing part of the economies of scale from a 100% speculation scenario. Nevertheless substantial savings can be obtained, for instance through more efficient transportation.

There are several drivers for a packaging postponement approach. Hewlett Packard uses such a system for its printers because it allows them to localize a product only at the last moment (Lee, et al, 1993; Feitzinger & Lee, 1997; Twede, et al, 2000). Because power supplies and the language of the directions-for-use (DfU) and packaging can be different for each country, a packed printer can only be sold in a limited geographical area. Postponing connection of the power supply and addition of DfU and packaging allows HP to change the destination of products as late as possible. Even though this strategy requires the local distribution centers to be equipped with staff and machinery to perform these tasks, thus creating additional costs, HP claims serious economical benefits from this strategy (Twede, et al, 2000). The HP example shows that financial motivations can be a good reason for applying a postponement strategy.

Another reason can be environmental. As Boks (et al, 2003) shows, postponement can be a good environmental strategy as well. It does require additional packaging material, as multiple packaging is needed for the first leg of the trip and subsequently the product has to be repacked into normal consumer packaging. Yet savings made by the more efficient long-distance shipments, because of the higher number of products in a unit of load, clearly outweigh the environmental impact of the additional packaging material. For several products an important part of the possible savings is caused by the fact that they are bought in substantial amount by institutional or industrial buyers who have no need for single set packaging.

HP claims to have saved $3 million/month through implementation of multiple packaging for its inkjet printers (Twede, et al, 2000), which *"(…) is the largest reported cost savings in history attributable to a packaging change!"* (idem, p.105). Other examples of implementations in main stream business have not been documented in literature, though some experimental projects are known to be in progress; Philips has for instance started selling light bulbs per 2, using the shape of the bulbs to pack them more volume efficiently.

Also, there have been a number of studies showing the potential of multiple packaging in theory. Keijzers (2003) worked on a project for cost-saving distribution for a 14" Philips television set. He demonstrated through various calculations that, by implementing multiple packaging, savings could be obtained in the order of 1 euro per set. If not all products need repacking (something depending on the sales channel), much higher savings are obtainable. In the example given by Keijzers the number of television sets per pallet was raised from 24 to 42, which results in a (theoretical) reduction of long-distance shipments of 43%.

As stated, not only economical costs can be minimized by implementing a multiple-packaging strategy, but the environmental impact as well. Thijsse (2001) made a life cycle assessment of a multiple-packaging scenario. She demonstrated a (theoretical) environmental saving of 53% for a multiple packaging strategy applied to VCRs.

8.8.1 Strategies based on multiple packaging

Opting for multiple packaging does not fix the exact lay-out of the distribution chain. There are still several options. Firstly there is the positioning of the decoupling point, as discussed in the previous section. Here there are several options:

- Multiple packaging can be applied in that part of the distribution chain that is common for all products. For example, looking at an audio set produced in China, there will be only a few streams of products leaving China, probably one to Europe and one to North America. Repacking could occur in the main European and North American distribution centers, before the stream is split and designated for national or regional distribution centers. Thus only two repacking facilities would be required.
- Repacking may also occur in the regional or national distribution centers. If it is placed further down the chain, the environmental advantage of the multiple packaging is maximized, but more repacking locations will be necessary. More repacking locations raise the economic costs, and possibly the number of packaging suppliers with whom OEM has to deal.
- The decoupling point may also be placed as far down the chain as the retailer. Especially with the rise of large retail chains such as Wal-Mart in North-America and Carrefour and Metro (MediaMarkt and Saturn shops) in Europe. These chains do not order products a piece, but per pallet or even per container.

Secondly the way the products are repacked can differ considerably, ranging from a normal single set packaging to little or no packaging. Little or no packaging may become an option if the decoupling point is placed as far down the chain as the retailer, thus only leaving the transportation phase to the consumer's home. During this transportation the requirements the packaging has to fulfill are not the same as during the transportation from the factory to the retailer, thus allowing for alternative packaging designs. The different options for repacking are depicted in Figure 8.12.

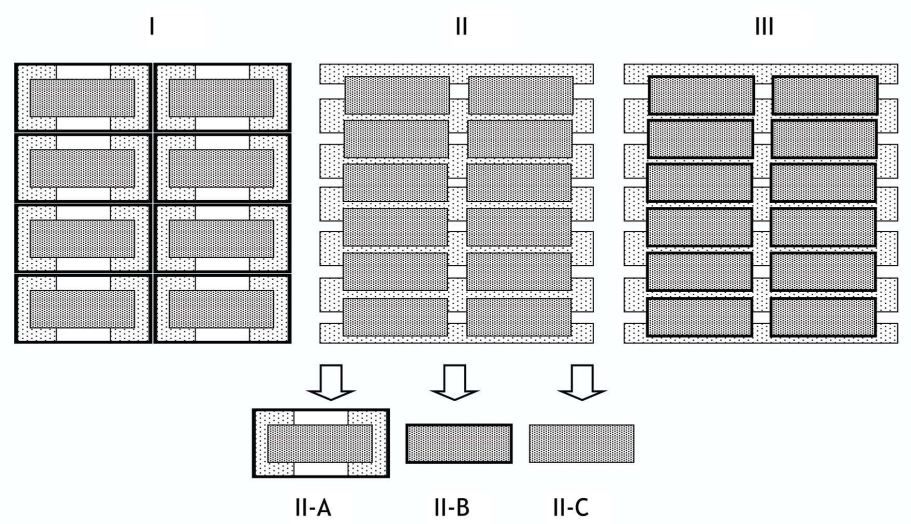

Figure 8.12: Different packaging scenarios; single-set (I) with 8 product per pallet, multiple packaging of unpacked products (with 12 products per pallet) with different repacking options (II-A through II-C) and multiple packaging of minimally-packed products (III) with 12 products per pallet. The thick lines indicate corrugated board boxes. The light grey areas are cushioning, the dark grey areas are products.

Here, scenario I represents classical single set packages. Each product has its own cushions and eight products fit together on a pallet. Scenario II represents the multiple-packaging strategy. Products are placed unpacked into bulk cushions, thus saving transport volume. In this case 12 products go onto a pallet. At the decoupling point the products are repacked. Here there are three options. In scenario II-A the products are repacked in a classical single-set package, like the ones in scenario I. In Scenario II-B the products are repacked in a minimized package that only fulfills the conditions required in the final stage of the distribution chain; the trip home from the shop. This packaging could of course also be applied at the original manufacturing location, resulting in strategy III. This strategy might also suit a retail-ready packaging concept, where the bulk package is placed on the shop floor as a whole, and secondary packaging is used for marketing purposes.

Finally, scenario II-C represents the strategy of selling unpacked products (which will be further discussed in section 8.6.2). For certain products this may be acceptable as no specific packaging requirements are to be fulfilled for the consumer leaving the shop. Another option is to apply this strategy for only part of the products, namely for those sold to institutional buyers. This is mainly relevant for B2B products, such as desktop computers and monitors. A single organization may purchase hundreds of such products simultaneously, e.g. a university renewing computer facilities for students. These organizations do not need hundreds of boxes, with their cushions, manuals and installation discs. Here a bulk packed pallet would be highly appreciated by the buyer.

8.8.2 Drivers for multiple packaging

In further discussing the potential of a multiple packaging strategy, first drivers for considering such a packaging postponement strategy will be addressed. The first would be a substantial difference in the volume between the required sales packaging and what would be required from a distribution perspective. This difference can be caused by very voluminous sales packaging and/or very robust products which would need little cushioning. The second reason for considering packaging postponement could be gaining flexibility in the supply chain (time-to-market).

Volume saving potential

Perhaps most essential is the potential of saving transport volume. This means that products should not already be weight-critical in transportation (see Chapter 1). If they are, transport efficiency cannot be increased by using multiple packaging and neither economic savings nor environmental improvements can be obtained. This also applies to products that are just barely limited by volume. The further a product is away from the breakeven density of its mode of transportation (see Figure 1.1), the more likely a candidate it is for multiple packaging.

Two types of products are particularly interesting, namely those products with odd shapes, and those products with extremely large packages, relative to product volume (i.e. high volume indices, also see Section 3.3.1). Products with odd shapes may be placed in more efficient grids if they are unpacked, as for instance with inkjet printers. Due to their T–shape they can be placed in bulk cushions more efficiently then when they are first packed in rectangular boxes.

High level of robustness

Cushioning is added to products to protect them from shocks and vibrations during transportation. However, some products exist that do not need a lot of protection, as they are robust themselves, due to their expected way of use. Mobile phones for instance are expected to survive when dropped during use. The same goes to some extent for electric shavers. MP3-players and other Personal Audio products are expected to work while users exercise, regardless of the shocks and vibrations they receive. These products lend themselves especially for multiple packaging with the minimum required cushioning only. In other word, they could simply be stacked tightly together in a corrugated board box. This approach results in huge volume savings compared to individually packed products.

Long-distance transportation
Both the environmental impact and economical cost of transportation have to be high enough to make multiple packaging a feasible option. Hence, it is a strategy suited most for long distance transportation, i.e. mainly intercontinental shipments. Furthermore, if transported by sea container, these are the shipments that take so much time, that they allow for the gain in flexibility as described in the HP case (i.e. packages with different languages for different geographical areas). If transport is done by plane, costs are so much higher that multiple packaging also becomes an interesting option quickly. Transport by plane may be necessary for products with high rates of depreciation, as is the case with fashion products in the field of Personal Audio.

8.8.3 Economic savings potential of multiple packaging

A packaging postponement strategy is mainly interesting if the total costs are lower than in a speculation scenario. Whether this will be the case is dependent on several factors. These include size of the production run, and the cost difference regarding labor and materials between the location of the product assembly and the potential decoupling point. Due to the 1:1 correlation that was found between economic costs and environmental impact regarding packaging, an economic saving will likely also result in an environmental improvement.

High production runs
Obviously, the design and manufacturing of packaging costs money. If both a bulk cushion and a final consumer package have to be designed, tested and manufactured, this means additional costs, both in labor and in manufacturing tools, such as molds. These costs have to be spread over the total number of products sold. If this number is low, multiple packaging may become too expensive. Hence, especially mainstream products with high production runs are likely candidates for multiple packaging. This also complies with the idea that large retailers may order one or more full-container loads of the product.

Cost difference packaging
If products are repacked close to the retail point, both packaging materials and labor have to be purchased in that country. This may be considerably more expensive than costs at the assembly site. Firstly this is caused by the number of packing locations. The closer to the retail point repacking occurs, the more repacking locations are necessary. They all need equipment, warehouse space etc. Hence fixed costs are higher. Furthermore in western countries (which are the most likely markets) the labor costs are much higher than in the countries where assembly took place (note here that in the HP case the final packing was moved from the US to Europe, hence there was little difference in cost of labor between the two geographical locations). Thirdly, the cost of packaging materials themselves may differ. Due to the smaller batches ordered, less benefit from economies of scale can be obtained. These additional costs need to be smaller than the savings in long distance transport. Hence, the smaller the difference in costs

between the country of assembly and the country of retailing, the more feasible is a multiple packaging strategy.

8.8.4 Acceptance of multiple packaging in the value chain

Even if the product-packaging combination warrants a packaging postponement strategy, and the economical result would be positive, implementation of such a strategy is heavily dependent on the acceptance in other parts of the value chain.

The OEM producing and selling the product is not the only stakeholder in the value chain affected by packaging design decisions. If the decoupling point is placed in a spot of distribution chain still under the control of the manufacturer, the question of acceptance has to do with the internal value chain as well. These internal stakeholders may be influenced by external factors, such as legislation, suppliers, or insurance. Stakeholders within the internal value chain probably have built up longstanding relationships with packaging suppliers in the vicinity of the assembly plant. If the final consumer packaging is only added to the product in a later stage, these relationships will be affected. Current suppliers will only be able to supply the bulk cushions, and new suppliers must be selected near the market. Possibly multiple suppliers will be needed; one for each repacking location. Another concern of this type may be the insurance of shipments. As the value per shipment is dramatically increased, through the higher number of products per shipment, the insurance against theft of shipments may not be covered under a standard agreement.

Another, more down-to-earth issue with the internal value chain may be the issue of which part of the business has to pay for what. The business unit paying for the long distance transport would be in favor of volume efficiency through multiple packaging, while the business unit that has to pay for the local repacking may be opposed to the concept of multiple packaging.

If the decoupling point is placed outside the direct control of the manufacturer, other stakeholders have to agree, to allow for implementation. If the decoupling point were to be placed in the shop, the retailers would have to repack in case of scenario II-A and would also have to get rid of the bulk cushions in both scenarios II and III (Figure 8.12).

The willingness of retailers to cooperate with such a system may be influenced by at least two factors. First a system of multiple packaging may allow for lower overall costs, which means lower retail prices. From a competitive point of view a single retailer may not be in the position to block implementation of multiple packaging. Furthermore, a relatively new phenomenon is occurring in the CE market. Large retailers are starting to customize packages to sell products under their own name, only adding 'made by X' to it. As they are repacking the products anyway, there is no need for a single-set package during the first part of the distribution chain.

In case of scenarios II-B, II-C and III (see Figure 8.12) the consumer leaves the store with a differently packed product than he is traditionally accustomed to. Before such a scenario could be implemented, it would be essential for the manufacturer to assure himself of consumer acceptance (or even preference) of such a packaging solution. Though far from a final answer, a first study into this matter is reported by Boks (et al, 2004). Here it is found that consumers do expect the packaging to fulfill other functions than solely mechanical protection during distribution. What these functions are depends on the kind of product. For instance, with mobile phones people see the presence of the unopened package as a guarantee that the product is new. If the package is minimized, because of distribution reasons, they still want the package to keep this function.

8.8.5 Selling unpacked products[45]

The benefits of multiple packaging are partly offset by the necessity to repack products individually for protecting them in the last stage of the distribution chain. Increasingly this last stage involves only the stage of transportation from the retailer to the consumer's home, since sale of consumer electronics increasingly takes place in large retail stores which purchase directly from original equipment manufacturers (OEMs) in large quantities reducing the need to repack in the OEM's national or regional distribution centers. Calculations show that at a level of 60% of the products needing repacking, multiple packaging still shows significant overall benefits. Additional efforts to reduce the need for repacking would clearly contribute to even larger economical and environmental gains.

In this context, a project was carried out at the Design for Sustainability group of Delft University of Technology, titled "The customer perception of buying new—but unpacked—consumer electronics". This project ultimately addressed the following research questions:

- Will customers consider purchasing consumer electronics when these are offered unpacked?
- What are the main concerns for customers when considering buying an unpacked consumer electronics product?
- How can an unpacked consumer electronics product best be offered to the customer, taking into account his main concerns?

Results show that more than 50% of a large research population is positive towards buying unpacked products, whereas less than 25% are absolutely negative. Putting aside for a while various objections to be overcome such as handling problems of retailers and reduced marketing opportunities, this shows the potential of the concept. It has been found that the main concerns that customers have about buying unpacked products are focusing on 'doubts about newness' (in case of mobile phones), damage to products (in case of TV sets) and loss of parts and accessories (coffee makers). People expect unpacked products to result in lower prices.

From this it can be concluded that selling CE products unpacked, or at least without cushioning is a strategy that could be appropriate to some products and outlet channels. In combination with multiple packaging for the long-distance transportation, this can yield considerable savings compared to individually packed products.

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[45] This section is based on: Boks, Galjaard, Huisman & Wever (2004) Customer Perception of Buying New but Unpacked Electronics Products. Proceedings IEEE Phoenix, USA. The paper is based on a student research project, that was supervised by Boks, and based on a research question by Wever.

8.8.6 Conclusions regarding packaging postponement

So far, discussions in literature about the feasibility of multiple packaging only take place with the goal of obtaining a flexible supply chain (and thereby obtaining economic savings), which is the classic objective of a postponement strategy. However, the work presented in this chapter has demonstrated that the reduction of the environmental impact of packaging and transportation can be a good driver for multiple packaging as well, as packaging volume is the critical factor in transportation. Furthermore it has been demonstrated that there are more options than simply repacking into the 'normal' consumer package that would have been used in a speculation strategy.

Conditions for success are:

- The saving potential, which is determined by volume efficiency of the single-set package, robustness of the product, but also by the size of the production run and the transportation distance,
- The acceptance by the internal and external value chain,
- The cost difference in materials and labor between the location of assembly and the potential location of repacking.

Hence, a multiple packaging strategy is not suitable for all CE products. However, in business practice far more products meet these criteria than are bulk-packed today. Hence a considerable potential for improvement exists. Implementation appears to be mainly obstructed by non-acceptance of the value chain (either real or perceived) or by lack of thinking 'out-of-the-box'.

8.9 Conclusions

Chapter 6 has demonstrated how packaging designers can deal with the analysis of the force field between the three types of functionalities for packaging of CE goods: distribution-related, sales-related and experience-related. Chapter 7 has presented the different approaches for packaging where the volume is predominantly determined by distribution-related functionalities. This chapter has now done the same for packaging where the volume is predominantly determined by marketing-related functionalities.

This chapter addressed the research question on *"how designers can fulfill the required (mix of) functionalities of the packaging in a volume efficient way"*, for as far as marketing functionalities are involved (both sales and experience). This chapter has shown how these functions can be fulfilled while keeping the volume of the packaging under control.

Several strategies were presented, some on a design management level, some on a packaging design level. Regarding approaches that are more managerial in nature, Section 8.2 discussed the potential sales performance that may be achieved through harmonizing the appearance of all packaging within a company. Currently, still many CE companies use different graphical presentations for each product, or for each product category.

Regarding approaches that are more design related, this chapter has described approaches through which sales performance can be maintained and simultaneously volume can be kept to a minimum (Section 8.3 on the third dimension). Also approaches regarding experience performance have been described through the application of high quality materials and finishes (Section 8.4 on Jewel Boxes). Subsequently, the challenge of designing positive unpacking experiences has been elaborated on (Section 8.5), thereby successfully translating general theory of Design-for-Experience into an approach applicable for packaging of durable goods.

A major reason why packaging volume optimization is not already consistently applied in practice is the lack of a quantification of marketing performance of a packaging (i.e. its sales or experience performance). A first version of an Internet-based tool for this purpose was presented and tested. Although further optimization would be required, it has been demonstrated that a tool can be developed that would produce workable information with a speed and cost that would be acceptable in a business setting, such as a Consumer Electronics OEM.

Situations may occur where the strategies presented in this chapter do not lead to an acceptable, balanced compromise between voluminous consumer packaging and distribution efficiency. In such cases, a strategy of multiple packaging may be applied (Section 8.8). In this approach the transportation from the factory to the consumer is split in a first phase where distribution functionalities are dominant, and a packaging can be utilized that is strongly optimized for that, and for the second phase, where marketing functionalities are dominant, the product is repacked into its final consumer packaging. This chapter has discussed the potential of such a strategy both in reducing cost and environmental impact, and has identified the conditions for success of such an approach.

"To doubt is the blessing and the curse of the intellectual"

J. VERSTEGEN (1969, p.101)

9. Conclusions, Discussion and Recommendations

In this chapter, conclusions will be drawn regarding the research questions presented in Chapter 1. Subsequently, the scope and limitations will be discussed, in order to access the applicability of the findings beyond the field of CE packaging, and the position of this work in the research field of design for sustainability and the research field of packaging. Finally, recommendations will be presented for the stakeholders involved in the subject of this thesis.

9.1 Findings

This thesis addressed sustainable packaging for durable consumer goods. Within the wider setting of sustainability, the main focus has been on EcoDesign (i.e. on economical and environmental aspects, excluding social aspects).

Currently, both within industry and academia, the attention regarding sustainability and packaging is strongly on material recycling and resource conservation. This is mainly due to the focus taken in European legislation. However, as has been demonstrated in Chapter 1, transportation has a higher environmental impact (and economical cost) than the materials used for packaging. This is particularly true in the case of intercontinental transport, which has become the default situation since most production of CE products has been moved to Asia, and in particular China. As volume is the critical factor in transport efficiency for packed consumer electronic products (and many other durable consumer goods, as has been demonstrated in Intermezzo B), volume optimization is currently the most rewarding strategy for improving the environmental and economical performance of packaging. This basic finding has meant that this thesis focuses on volume optimization within the packaging development process.

From this perspective eleven research questions were formulated in Chapter 1. In the subsequent chapters these questions have been addressed. In this section the findings will be summarized for each of the research questions. The basic finding that volume optimization will yield both economical and environmental improvement is reflected throughout the answers to these questions.

9.1.1 How are the dimensions of packaging currently established, i.e. what process is followed?

As was demonstrated in Chapter 2, the volume of a package can be a result of distribution-related packaging functionalities, as well as the result of marketing-related functionalities (i.e. sales and/or experience). Most packaging has to fulfill a mix of all functionalities. Which type of functionality is dominant differs from packaging to packaging. It should be noted here that the dominant factor in determining the volume of the packaging is not necessarily the same as the dominant factor determining the total design. For instance, the packaging volume for a large television set may be purely the result of distribution related functions, while marketing-related functionalities will determine the required level of finishing, i.e. the quality and elaborateness of the printing.

Usually either distribution-related functionalities or marketing-related functionalities are given priority. Distribution-related functionalities are the area of expertise of packaging *engineers*, while marketing-related functionalities are the expertise of packaging *designers*. In practice there is little interaction between these two groups of professionals. Depending on which functionality is given priority, either designers or engineers will determine the volume, following their own development process.

Regarding distribution-related functionalities, the dimensions of a packaging are determined through an engineering process that aims to meet the required level of protection. Ideally, this should be based on fragility measurements of the finished product, combined with specific data on the roughness of the distribution environment.

Regarding marketing-related functionalities, the design of the packaging is determined through a design process that includes activities such as making mood boards, generation of multiple ideas through sketches and retail audits. The dimensions follow from factors such as unity throughout the portfolio, shelf presence and conceptual ideas (e.g. if it is decided to pack something in a milk carton, because milk cartons communicate cheapness, then the dimensions of a milk carton need to be used).

9.1.2 Does the present-day packaging development practice reflect present-day design theory? And can discrepancies, if any, be explained?

As stated above, in the development of packaging solutions in present-day practice in the CE industry, a split can be observed between packaging engineers and packaging designers—there is a clear lack of a packaging design engineer approach (Chapter 2). On that level, a discrepancy with the design engineering theory can already be observed: the approach usually is not an integral one. Better coordination between design and engineering would result in better balancing between distribution and marketing functionalities, and thereby in fewer obviously faulty packaging solutions. This lack of a holistic approach, integrating both distribution and marketing aspects, can also be observed in packaging development literature, especially in regard to packaging for durable consumer goods. This thesis has filled that gap, by taking an integral design engineering approach to the packaging development process.

If the emphasis is on packaging *engineering*, a process is followed that matches the basic design cycle as presented by Roozenburg and Eekels (1995), with the exception that there usually is no option to iterate back and improve the design further.

Due to time-to-market restrains and limitations in the available data, the result of packaging engineering is not necessarily optimal. In the reality of the CE market, estimated data regarding product fragility and the hazards of a particular distribution system have to often be used. Generally, even feedback data from the transportation chain is not clear enough to get a detailed picture of the packaging performance. Furthermore the fact that tooling for mass-produced cushions is expensive, and there are no reliable rapid prototyping methods available for cushioning materials that require dedicated tooling, often a satisfactory solution has to be accepted, instead of searching for an optimal one.

If the emphasis is on packaging *design* several processes can be distinguished that show some similarities to the Delft Innovation Model; aspects such as the basic design cycle of analyze-synthesize-simulate-evaluate can often be recognized, as can repetitive divergence and convergence steps.

The same time-to-market constrains that limit the possibilities of engineering process, also limit the design process. Usually this results in limited or no testing of the effectiveness of individual pack designs from a marketing perspective. Several tests are available, but they can be time consuming, and are therefore oftentimes skipped in the final stage of a development process. A quick-and-dirty methodology could help here. A first version of such a tool, executed through the Internet was developed, and tested with promising results (Chapter 8).

As this thesis demonstrated the CE industry is an industry of 'change', where new products are introduced at a high rate and the time window for making a profit is limited. Hence the design process is under continued time pressure. For packaging this means that there is little time for the development. In optimal cases packaging design is partly parallel to product design, i.e. concurrent engineering. However, irrespective of any concurrent engineering, there often is limited time for testing (both mechanical and consumer testing) and optimization.

9.1.3 What functions does present-day packaging for CE products fulfill?

By asking packaging developers and product managers, it became apparent that there are four general reasons for packaging to have the volume it has. Three are related to required functionalities, they are distribution-related, sales-related and experience-related functionalities. The fourth is a result of insufficient time and money for development, upon which a previous packaging design is reused.

Distribution-related functionalities include protection from distribution hazard such as impacts, vibrations and climatic conditions. Also stackability (both in shape and strength) is a distribution-related functionality. Hence, in case distribution is the dominant driver in the packaging development, volume is determined based on mechanical properties.

Sales-related functionalities include communication to the consumer, through attracting attention, communicating unique selling points, and appealing. Furthermore, sales-related functionalities include retailer requirements regarding issues as tampering and pilferage, and compatibility with shelf dimensions. Especially for small products this leads to increased packaging volume. Hence, in case sales is the dominant driver in the packaging development, volume is determined based on communication properties.

Experience-related functionalities form the packaging component of wider brand and product experiences. This implies an unpacking or unboxing experience. Such an experience can be embodied through the organization/presentation of product and accessories, the type and quality of material and finishes. Through more layers of material and the visually attractive positioning of product and accessories, experience functionalities often lead to increased packaging volume. In case experience is the dominant driver in the packaging development, volume is determined based on emotional properties.

9.1.4 Is there a potential for improvement, and if so, how big is it; i.e. to what extent can the volume be optimized?

Through an empirical data-mining study (Chapter 3) it was found that, for larger CE goods—roughly over 10 liters when packed—the functions determining packaging volume are solely related to distribution. A packaging may have to fulfill sales-related or experience-related functions as well, but those do not lead to additional volume; the product itself is voluminous enough.

Chapter 2 already demonstrated that there are packages whose designs are dominated by distribution-related functionalities, and other packages that are dominated by marketing-related functionalities. This data-mining study in Chapter 3 has made clear that there is an average market performance for distribution-related packages that can be seen as a benchmark for acceptable packaging performance (AMP). No brand or product type scores structurally better or worse. However, there are individual products that score considerably better or worse than the AMP. This suggests that there is a considerable potential for improvement, both concerning the environmental and economical performance of these products.

Within the domain of marketing-dominated packages, there are products so voluminous that less than 10% of the volume of fully packed sea containers actually consists of products (e.g. mobile phones and personal audio, like MP3 players). Furthermore the *spread* in volume-index for this type of products is much wider. Hence, this type of packaging seems to lend itself extremely well to volume optimization; again with considerable potential for environmental and economical savings.

9.1.5 How did functions, that were not relevant in the past (i.e. sales- and experience-related), when CE products were first put to the market, become relevant?

CE goods have become commoditized (Intermezzo A). Most CE products can only temporarily command higher margins, and brand loyalty is generally very low. Some of the driving forces behind this development were identified. Quality of CE products seems to have improved in the eyes of the consumer, in the sense that there are hardly any bad or mediocre products left in the market. Furthermore, the spread in quality between brands appears to have become smaller. Therefore quality has become less important differentiator in the market. As the financial commitment needed to purchase a CE product has gone down, this makes a purchase decision easier to make, even to the extent that impulse purchases have become commonplace in this field.

Simultaneous to the commoditization of CE products, the retail landscape has evolved (Chapter 4). CE goods historically were sold by specialty stores, either independent or part of a chain. Over time different retail formats have gained importance. These are mainly so-called big-box retailers, which fall into two categories. First there are hypermarkets like Wal-Mart. These are basically supersized supermarkets that also sell many durable goods. Secondly, there are so-called category killers, large stores with a wide offering within a particular product type, such as Best Buy and MediaMarkt for consumer electronics. The thing category killers and hypermarkets have in common is their display of goods; products are presented in their packaging on the shelf in a self-service environment. These retail formats fit the commoditization development.

There are also retail formats that fit with an attempt to counter the commoditization trend. The quintessential example within consumer electronics would be the Apple centers.

Each of these retail environments has its own dominant packaging functionality. In Internet-retailing these are distribution-related functionalities, in brand stores these are experience-related functionalities, and in category killers and hypermarkets these are sales-related functionalities.

The response of OEMs (Original Equipment Manufacturers) to these developments is apparent in the designs of the packaging they pack their products in: it has yielded the marketing-function of CE packaging. Two distinct approaches can be observed. On the one hand, packaging can be observed which results from an approach that accepts the fact that a product is, or quickly will be, commoditized. The design of the packaging is treated like a Fast Moving Consumer Goods (FMCG) product; i.e. a supermarket-style packaging, which tries to capture the attention of the browsing public, communicates the product's unique selling points, and hopefully closes the deal. This is referred to in this thesis as sales packaging.

On the other hand, there is packaging which results from an approach to fight the process of commoditization. Both the design of the product and the packaging try to attach uniqueness to the product in order to set it apart from the competition, thus enabling it to command a higher price (Chapter 5). This is referred to in this thesis as experience packaging.

9.1.6 What are the relationships between a certain packaging function and packaging volume?

In regard to distribution-related functions, volume is added to the basic product for two reasons; to make stackable rectangular shapes, and to add protection (i.e. cushioning).

In regard to sales-related functions, it has been found that the main functionalities are attention-grabbing and communicating, but also of protection against tampering and pilferage. The classic approach to fulfilling these functions is increased volume, and in particular increased front-facing areas. Finding other ways to fulfill these functions, such as through graphics or materials, will lead to substantial savings (both economical and environmental), through reduced shipping.

In regard to experience-related functions, it is observed that packages designed for their unpacking experience may become more bulky, due to the layering and placement of the product and its accessories. However, as layering and placement of the product and its accessories is only one of the ways of designing an experience packaging, there seems to be a potential for improvement, namely through a high level of design attention both to the outside and inside of the packaging. For some CE products the experience aspects have become a highly significant part of the added value of the product. For such products the unpacking experience can make a substantial contribution in staging these experiences.

Designing an unpacking experience is challenging, as conflicts may occur with other functional requirements of the packaging (distribution-related, sales-related). The clearest example is the conflict with the sales-related requirement that the package should be tamperproof. A large percentage of the retail environments require tamperproof packaging, but the resulting wrap-rage of such packaging makes a positive unpacking experience impossible. In regard to potential for optimization it should be clear that, unless the issue of openability is sufficiently addressed, any material and/or volume added to improve the unpacking experience is in vain.

9.1.7 In case of multiple relevant packaging functions, how are these functions reflected in the volume of the final packaging?

In Chapter 6 three design projects were described in order to study how the translation of required functionalities to packaging volume works in practice. The first case, on a electric shaver, demonstrated how the actions of competitors influence the prioritization of the three types of functionalities. It has also illustrated what the lack of comparable performance indicators for all three functionalities can lead to, both in value chain issues and to increasing cost and environmental impact.

The second case study, on a webcam package, illustrated the differences between ineffectiveness and inefficiency that may exist in a packaging design (i.e. making sure that a package has the right mix of functionalities, and fulfills these efficiently), and has demonstrated how both may be reduced. It again identified the need for comparable performance indicators for all three functionalities.

Finally, the third case, on a packaging for a coffee maker, illustrated that it is possible to combine the different functionalities, and balance their specific requirements. It has demonstrated the potential strength of early stakeholder involvement as well. Simultaneously, the danger of not including all relevant stakeholders was identified.

Both the webcam case and the coffeemaker case have illustrated that improving the unpacking experience of a packaging design does not necessarily lead to increased volume.

In Chapter 6, a model has been presented in the form of a triangular graph that can assist in visualizing the mix of functionalities of a product and its competitors, a product range or even brands. Mapping products onto such a graph can be done through an assessment of the relative importance of target groups, i.e. price buyers, feature buyers, and quality buyers. An assessment of the relative importance of different types of retail outlets can also be used to map product onto the graph.

Once the specific mix of distribution, sales and experience functionalities has been established for a particular product-packaging combination on the graph, the question arises how to fulfill that particular mix most efficiently.
An important conclusion is that, although most packaging designs need to fulfill multiple functionalities, the volume usually is a result of just one functionality; if the volume of a pure distribution packaging already is voluminous, than marketing functions will be fulfilled through materials and finishing only, and if the volume of a packaging is determined by marketing-related functionalities, than there easily is enough volume to provide the required protection.

9.1.8 How can designers determine the (mix of) required functionalities of the packaging of a certain product?

A design team, consisting of product managers, product designers, sales managers and packaging engineers, can map the direct commercial competitor products, using the triangular graph presented in Chapter 6. The relative position with respect to these products in the graph can be discussed, presenting arguments either why a packaging may be more voluminous, or why it should be less voluminous, than the competition.

For such mapping several approaches are available. A first approach can be based on the relative importance of certain target groups for the product (price buyers, feature buyers and quality buyers). If a product is mainly aimed at price buyers, distribution packaging will be most suitable, while feature buyers correspond to sales packaging and quality buyers correspond to experience packaging. The relative importance of each target group (e.g. 20%-50%-30%) can give a first position in the graph. It should be noted that purchase decisions are based on much more attributes than packaging alone (price, brand, etc.). Hence, the position may have to be adjusted for this.

A second approach, or a second step, to map the functionality is through analyzing the outlet channels. In each channel the packaging plays a different role (see Chapter 4). If a product is to be sold in bulk through category killers and hypermarkets, than a mix of distribution and sales functions will be appropriate. If a product is sold through the Internet, then distribution packaging will suffice. If a product will be sold through independent retailers, the so-called mom-and-pop stores, packed products will be in the backroom, and can therefore be in distribution-packaging. If the product is to be sold through specialty stores or brand stores, where people pay a premium for quality, than experience-packaging would be most appropriate. The mix of channels through which the product will be sold, thus also leads to a position in the graph. In analyzing the mix of channels their relative importance can be determined based on the relative number of products that will be sold through each channel and the profit margin that will be obtained in each channel.

Finally, in mapping existing packages, the finishing quality of the packaging can be assessed. Distribution packaging is basic both on the outside and the inside. Sales packaging has high quality finishing on the outside, but basic quality on the inside. Experience packaging will have high quality finishing both on the outside and the inside.

The triangular graph is meant as a discussion tool, aimed at visualizing the *relative* position between (competitor) products. Hence, pinpointing products with a high level of precision is deemed unnecessary, also because the design optimization strategies presented in Chapters 7 and 8 cannot be linked to positions in the graph that precisely.

9.1.9 To what extent are the findings for packaging and distribution of CE goods identical to other durable consumer goods?

Based on the findings of the quick scans of the domestic appliances, toys, power tools and furniture (Intermezzo B), it can be concluded that the specific findings for the CE industry can be generalized to other durable goods; the cost and impact of transportation is bigger than the cost and impact of the packaging materials, and volume is the critical factor in transport efficiency.

The IKEA study shows what is obtainable if a radical volume efficiency strategy is followed, with products / retail concepts that allow for distribution-dominated packages. For the other product groups it is concluded that there is no tradition of specifically designing volume-efficient packaging. Hence the optimization strategies that were presented in Chapters 7 and 8 can be considered appropriate for CE goods as well as other durable goods. However, due to special characteristics (e.g. durable packaging for power tools) not all optimization strategies that were presented for CE goods will be equally applicable to other durable goods.

9.1.10 Which options for improvement can be identified and how big is their potential, both for the economic and environmental performance, and both within a specific functionality and for packages incorporating a mix of functionalities?

Answering this question will be split into the potential for optimization of distribution-related packaging and marketing-related packaging. Looking at distribution packaging, it can be observed that, even though the field of protective packaging engineering has been developed for decades, there is still a considerable improvement potential (Chapter 7). By collecting facts on current performance and analyzing those through performance indicators such as the volume index and container loading (and comparing scores against competitors), candidate-packages for redesign can be selected, and concept designs for new packaging can be evaluated. In this study numerous products were identified with a savings potential between €0,50 and €1,00 per product, which would result in millions of savings for an entire OEM. The positive correlation between cost-savings and environmental improvement should be a strong driver in achieving these improvements.

Within the marketing-dominated packages there are some so voluminous that less than 10% of the volume of fully packed sea containers actually consists of products. Furthermore the spread in volume-index for this type of products is much wider. Hence, this type of packaging seems to lend itself extremely well to volume optimization. This potential for improvement was again illustrated by the second case study in Chapter 6.

Previously, two types of packaging were identified that have an inherent potential for improvement. The first being packaging that was copied from another product or previous product generation due to lack of development time or budget. The second being packaging that fulfills the wrong mix of functionalities. The Web-cam case illustrated how such a packaging can be optimized.

9.1.11 How can designers fulfill the required (mix of) functionalities of the packaging in a volume efficient way?

A first requirement is to ensure that the mix of functionalities is the right one (Chapter 6). Subsequently, the objective becomes fulfilling that mix in the most efficient way.

Most packaging designs need to fulfill multiple functionalities, however, the volume usually is a result of just one functionality.

In cases where the volume is determined by distribution-related functionalities, several strategies are open to product and packaging developers (Chapter 7). Some are specifically product-related (increased robustness, optimized product dimensions, postponed product assembly and transport orientation) some are packaging-related (selection of cushioning material) and some are distribution-related (optimization of damage percentage).

In cases where the volume is determined by marketing-related functionalities, optimization approaches can be split into managerial and design approaches (Chapter 8). Regarding approaches that are more managerial in nature, Section 8.2 discussed the potential sales performance that may be achieved through harmonizing the appearance of all packaging within a company. Currently, still many CE companies use different graphical presentations for each product, or each product category.

Regarding approaches that are more design related, Chapter 8 has described approaches through which sales performance can be maintained and simultaneously volume can be kept to a minimum (Section 8.3 on the third dimension). Also approaches regarding experience performance have been described through the application of high quality materials and finishes (Section 8.4 on Jewel Boxes). Subsequently, the challenge of designing great unpacking experiences has been elaborated on (Section 8.5), thereby successfully translating general Design for Experience theory into an approach applicable for packaging of durable goods.

A major reason why packaging volume optimization is not already consistently applied in practice is the lack of a quantification of marketing performance of a packaging (i.e. its sales or experience performance). A first version of an Internet-based tool to quantify this performance was presented and tested. Although further optimization would be required, it can be concluded that a tool can be developed that would produce workable information with a speed and cost that would be acceptable in a business setting, such as a Consumer Electronics OEM.

Situations may occur where the strategies presented in Chapter 8 do not lead to an acceptable, balanced compromise between voluminous consumer packaging and distribution efficiency. In such cases, a strategy of multiple packaging may be applied (Section 8.8). In this approach the transportation from the factory to the consumer is split in a first phase where distribution functionalities are dominant, and a packaging can be utilized that is strongly optimized for that, and for the second phase, where marketing functionalities are dominant, the product is repacked into its final consumer packaging.

9.2 Management of volume optimization

Within any business setting sustainability-related activities need to somehow have a positive influence on the business. This means they either have to result in reduced costs, or in increased value. The volume optimization approach developed in this thesis does both. Activities regarding packaging optimization for distribution fall mainly into the cost reduction approach, while packaging optimization for marketing falls into the value creation approach. However, this difference in sustainable objective between cost reduction and value creation adds to the challenge in holistic optimization of packaging.

From the cost perspective, a rough priority in actions can be identified, as the physical distribution part is more expensive than the materials and the printing. From an environmental perspective a similar prioritization exists: Volume has the highest impact, followed by the materials and finally by the finishing/printing. Hence, from a cost and impact perspective it is preferred if marketing functionalities can be fulfilled with high quality printing/finishing. If this is not enough, adding and/or upgrading the material would be the next step, and only as a last resort should the volume be increased.

The data needed for such a volume optimization approach are to a large extent already available within companies, although these may be rather scattered. Structural collection of these data needs to be organized.

The main focus of this thesis has been on *how* to do Design for Volume Optimization. Simply knowing how will not make it happen, though. In order to make it happen two things are required; people with the right skills (the *who*) and the right incentives to ensure it happens (the *why*). Regarding the right people, this thesis has demonstrated that there is a need for packaging *design engineers*. However, multidisciplinary teams of people with relevant mono-disciplinary skills can tackle the issue as well. The other issue is that of the incentives. A major incentive is the potential for cost savings. Another—one of the most powerful incentives regarding packaging and sustainability—has been the Wal-Mart sustainability scorecard. This is an example of the most powerful player in the demanding action on the issue of packaging and sustainability. Wal-Mart has wisely included several volume-related items in its scorecard, such as cube utilization and packaging/product ratio. Due to the importance as an outlet channel for many OEM, Wal-Mart's requirements have generated a lot of packaging innovation.

An organization that is not faced with a powerful link in the external value chain that is pushing Design for Volume Optimization can still implement it. It could incorporate such measures as compulsory quantification of marketing performance in its packaging development process, or as Philips has done, at the start of every *product* development project, the development team already has to set a target on how many products they will be able to fit in a standard sea container. This way the issue is top-of-mind with the design team.

Most of the approaches in this thesis are related to design, and some are more managerial. Decisions on higher organizational levels also have their influence, such as the selected business model. The economic cost and environmental impact of packaging in Dell's business model will differ strongly from an organization that operates in a market that requires effective sales packaging. However, these types of choices will never be made from a drive to reduce the environmental impact of packaging and distribution and have therefore not been addressed in this thesis.

9.3 Scope and limitations

This thesis is based on certain observations on the *current* practice in packaging and distribution of durable consumer goods. This paragraph will assess the durability of those practices, i.e. the 'shelf life' of the thesis, to use a packaging term.

Furthermore, this thesis has taken a focus on CE goods, with Intermezzo B also looking at other consumer durables. In this paragraph it will be reflected on to what extent the findings can be generalized to other fields of packaging as well.

9.3.1 Volume vs. material and material recycling

It was observed that, mainly due to environmental legislation related to packaging, the focus of professionals working on packaging and the environment is strongly on resource reduction and material recycling. As was demonstrated in this thesis, packaging for durable consumer goods has a considerable impact on transport efficiency, because of its low density. The impact of this transportation is roughly twice the impact of the materials used for the packaging. Therefore, this thesis has focused strongly on volume reduction of packaging, while leaving the resource reduction and material recycling for what they were. Obviously, on average there will be a positive correlation between smaller packaging and using less material. Hence resource conservation and volume reduction are closely related strategies. The focus of this thesis on volume does not mean that material recycling is unimportant, or that it can be ignored. Nonetheless, packaging recycling is already receiving significant attention from industry, academia and governments, therefore less potential for improvement regarding material reduction and recycling remains. Hence, a strong focus on volume reductions was deemed appropriate for this thesis.

9.3.2 Density

As demonstrated in Intermezzo B, the density for a wide range of consumer durables is so low that volume is the critical factor in transportation—especially where transport by sea containers is concerned. The 'shelf life' of the findings of this thesis depend in part on whether volume will remain the critical factor, even after following volume-reduction strategies for a period of time. There are two reasons to assume volume will remain critical. First, a study of the density of the packed product has shown that for consumer electronics, the products themselves already would be volume-critical. Hence even a packaging without cushioning would still be volume-critical; product-packaging combinations of CE goods will not quickly fall into the weight-critical category. Second, the 'distance' of the densities of many of these products to the break-even densities of common transport modes (where a product-packaging combination would change from being volume-critical to weight-critical) are on average quite large. Many products would have to be twice as compact (with the same weight) to become weight-critical.

9.3.3 Impact of transportation

The observation that the impact of transportation is roughly twice as impacting for the environment as the impact of the materials of the packaging is a result of current practices in transportation. If, for instance through the wide-spread introduction of 'green energy', the environmental impact of container ships and truck were to drop dramatically, the ratio between the packaging materials and the transportation may change. However, such a development would probably also reduce the impact of the packaging materials. Furthermore, such a development, in a wide spread form, is most likely decades away.

9.3.4 Efficiency vs. effectiveness

This thesis is focused on the potential contribution of design within the current business setting to lower the environmental load. This matches very well with the mission of the Faculty of IDE and with my personal ambition. It does not address changing existing business models, or current consumer behavior, and is certainly not about 'saving the world'.

This thesis is a clear example of an eco-efficiency approach; doing more with less. Eco-efficiency has been the most common approach to design for sustainability among industry and academia for the last decade. Recently, several critical thinkers have questioned the underlying assumption that this 'reduction of un-sustainability' will automatically lead to sustainability (e.g. Ehrenfeld, 2008, p.7, Braungart & McDonough, 2002, e.g. p.76, Newcorn, 2003).

More significant changes than the ones proposed in this thesis *can* be made, and there are obvious signs that more significant changes *need* to be made. It is by no means the intention of this thesis to stipulate that the type of optimization effort advocated in this thesis will be sufficient to reach a sustainable society. However, the steps advocated in this thesis are mostly win-win in the current business setting, and can therefore be implemented almost immediately.

9.3.5 Packaging of other products

In this thesis the focus has been on durable consumer goods, in particular CE goods. To assess the applicability of the approach to other fields of packaging, two of those fields—Fast Moving Consumer Goods (FMCG) and pharmaceuticals—will be discussed below.

One of the main starting points of this thesis is that packed CE goods have such low density, that volume is the critical factor in distribution. When assessing the applicability of the findings to other fields of packaging this would be the first factor to evaluate. With food packaging, as well as other FMCG, a mix of weight-critical and volume-critical packaging can be observed. Pharmaceutical packaging will often be on the volume-critical side, with just a few pills in a carton. However, a designer can simply check whether a certain packed product is volume or weight-critical.

A second factor in judging the applicability of the findings to other fields of packaging is whether that packaging is also required to fulfill a mix of functionalities consisting of distribution, sales and experience. For FMCG, distribution and sales functionalities are obvious. The case of CE goods described in this thesis is based on the observation that CE goods retailing is becoming more and more like FMCG retailing. Experience packaging can also be observed in FMCG; for instance in the packaging of chocolates.

As for pharmaceutical packaging, distribution functionalities apply. Sales functionalities are only relevant for over-the-counter drugs. In the case of prescription drugs there is no marketing-based choice by a consumer, and therefore no sales function. As for experience, there may not be a lot in present-day pharmaceutical packaging, but there certainly is a potential. A major issue with drugs is making sure that patient actually take them, and do so in the right amount and frequency. Proper design-for-interaction can help achieve this goal; this could be categorized as an experience functionality.

Although the three categories of packaging functionalities identified in this thesis can also be found in FMCG and pharmaceutical packaging, this does not mean that the approach presented in this thesis can be applied without any adaptation. Additional functions may apply to those fields of packaging that do not apply to durable consumer goods. One example being that for those kinds of packaging, the contained product is consumed in smaller portions over time, and therefore the packaging also fulfills a storage function.

In conclusion, the approach may present useful pointers to other fields of packaging; however, it should not be applied blindly.

9.4 Recommendations

This thesis has identified a substantial potential for environmental and economical improvement of packaging for CE products, through volume optimization. Many different stakeholders, that are involved in the value chain of a packaging design, such as OEMs, suppliers, and retailers will be involved in grasping this opportunity. Furthermore, environmental NGOs show their interest in the subject. This paragraph will give recommendations to each of these parties, as well as to researchers in this field, and to the school in which this thesis is defended.

9.4.1 OEMs

Original Equipment Manufacturers—the companies that are putting the packed product on the market—tend to consider themselves a company making CE goods, and not a company making packaging. Hence, packaging and distribution related issues are not considered the core business of the company. To some extent this may be correct, as packaging and distribution is not the biggest part of their cost, or of their value creation. However, with the emergence of global supply chains, packaging and distribution are gaining in relative importance. Furthermore, money saved in packaging and distribution ends up directly on the bottom line of the OEM, thus making optimization attempts worth the effort.

OEMs are advised to retain at least a minimum expertise in-house relating these issues. Also, by striving to combine the strength of their marketing department and their engineering department substantial improvements may be obtained, as in current practice with separate departments, the internal communication leaves room for improvement.

To optimize their packaging decision process, OEMs are advised to strive, first, to clarify the required functionality of packaging more clearly. By gathering factual information the potential for improvement in their particular case can be determined. This way they can ensure that the resulting packaging design actually does the job it is supposed to do, in respect to distribution, sales and experience. Second, they are advised to implement a design process that is focused on fulfilling those requirements in the most efficient way, both from an economical as well as from an environmental perspective. Third, they are advised to involve external stakeholders in their packaging development process, such as packaging suppliers and retailers.

9.4.2 Pack suppliers

Packaging suppliers are subject to the dynamics of the value chain they are in. For more and more products—both consumer durables and FMCG—the power over the value chain is shifting form brand owners to retailers. The position of packaging suppliers is thereby demoted from supplier to sub-supplier, and their client (the OEM) is no longer to sole party setting requirements for the packaging.

Those packaging suppliers that understand these dynamics, and proactively try to understand the wishes of retailers, will have a considerable competitive advantage over other packaging suppliers. While packaging suppliers that simply want to continue selling corrugated board by the (kilo)meter might find themselves in trouble.

Packaging suppliers that specialize in cushioning materials are well advised to explore the volume aspects of their cushioning, in order to see whether it is a threat or an opportunity to their business. Currently, cushioning suppliers do not make any claims about the volume efficiency of their product, but such claims may be seen in the near future.

9.4.3 Retailers

Retailers can be divided into two groups: those that are so large that they have considerable power over OEMs, and those who are too small for such power. The small ones are well-advised to monitor the major retailers, in order to know what they will be facing. While the large retailers—currently the Wal-Marts and the MediaMarkts—can utilize their power to get value chains to innovate in a direction which fits them most.

Wal-Mart's packaging sustainability scorecard is one of the most far-reaching examples of retailer demands, as it basically defines what sustainability is regarding packaging and simply requires its suppliers to present data on their packaging performance in relation to this definition. The score on the scorecard is subsequently a factor in the purchasing decision by Wal-Mart procurement agents. Although the weights of the evaluation criteria in the scorecard will not be exactly right for any specific packaging, it will be roughly the right direction, and at least it will force all supplying OEMs to innovate. Hence, Wal-Mart is accomplishing something that no legislative body or NGO could accomplish this easily. As the scorecard is a mix of material and volume related indicators, *can be* combined with a design for volume optimization.

At least part of the drivers for Wal-Mart to act on this issue are to reduce its own cost, and to improve its own image. Nevertheless, the Wal-Mart Packaging Sustainability Scorecard is an example of a retailer using its power in the value chain for a purpose that is in harmony with societal goals. Other retailers could follow this example.

9.4.4 Environmental lobbyists and NGOs

One cannot 'save the world' by changing the face of business instantly. Working within the real economic world, with its limited resources of time, money and R&D capacity, priorities need to be set. Of all the measures that can be taken, the ones with a positive correlation between money and environment will take preference, followed by the ones that yield the largest environmental improvements per unit of investment. Design for packaging volume optimization may not 'save the world', but it is a step in the good direction and due to its positive correlation with economical issues, it will encounter little opposition. Hence, those fighting for more corporate commitment to sustainability should celebrate these win-win efforts by OEMs, because these efforts present a promising avenue towards more far-reaching commitments.

9.4.5 Researchers

This thesis has identified more interesting gaps in the literature than it could fill. Several interesting research questions remain that could be the basis for further enhancement of the volume optimization design avenue. The most promising ones seem to be:

- How to deal with lack of data on the final product design (especially in relation to fragility), when doing concurrent engineering of product and packaging, as is the practice in the present-day consumer electronics industry?
- How to quickly quantify the marketing performance of packaging design concepts within a business setting? (Chapter 8 did present some preliminary work)

In regard to the research related to modeling the industrial design engineering process (such as the Delft Innovation Model, see Chapter 2), an additional issue can be observed, namely:

- How to adapt the model to real-world circumstances that limit the ability of the designer to follow the model entirely (e.g. tooling cost preventing iterations)?

9.4.6 Faculty of IDE

Both the curriculum and research portfolio at Industrial Design Engineering could be improved by paying more attention to what happens to products after they leave the assembly line and before they are used in the consumers' home. This phase of packaging, distribution and retailing relates to product design through issues like product robustness and logistical efficiency. The way a product is packed and presented will strongly influence how consumers and other value chain stakeholder perceive it.

Worldwide there are only very few higher education programs aimed at packaging. The ones that do exist are either art schools, with little or no understanding of engineering, or they are engineering schools with little or no understanding of esthetics or marketing. As the IDE faculty does have a lot of experience with integral product design, incorporating such aspects as esthetics, engineering, ergonomics, business and environment, the school could bring a useful contribution to this industry. This could either be done through training more of its own graduates in the field of packaging, or by starting cooperation with existing packaging programs, in order to jointly strive for combining art and engineering.

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Summary

Ever since the growing attention for the environmental impact of products, packaging has been one of the areas receiving substantial attention, for instance from scientists, companies and environmental lobby groups. Consumers often discard packaging quickly after purchasing a product, especially packaging of durable goods, such as consumer electronics (CE) products. This quick discarding makes the environmental impact of packaging very tangible to the consumer, thus giving packaging a negative environmental image.

The current sustainability focus on packaging is strongly linked to the waste minimization aspect. To be more specific, the focus is on resource conservation and material recycling. In academic circles, it has been acknowledged that the environmental impact of packaging should be seen in a wider perspective, including its relation to the impact of the packed product. However, for the packaging of consumer durables, where cushioning is involved, attention for environmental impact does so far not include damage rates of packed products and influence on distribution efficiency. The starting point of this thesis has been to improve the sustainability of packaging for consumer durables, from a holistic perspective.

A holistic perspective was taken, covering the entire packaging lifecycle including the influence of packaging on transportation efficiency. It was demonstrated, based on LCA studies, that for typical cases the transportation of packed consumer durables has a higher impact than the packaging material used. Analysis of a substantial set of packed consumer durables has demonstrated that transportation efficiency is determined by packaging based on volume.

The main aim of this thesis has been to identify why packaging for consumer durables has a specific volume, and how that volume can be optimized. Several research methodologies have been employed to this end. First, the packaging development process was studied, through literature review, company visits, and interviews with product managers and packaging developers within Royal Philips Electronics. This has resulted in two important findings. First, three types of packaging functionalities can be distinguished; distribution-, sales- and experience-related. Each type of functionality has its own relationship to the final packaging volume. Second, two types of packaging professionals can be distinguished; packaging *engineers* and packaging *designers*. Packaging engineers are concerned with the distribution-related functionalities, like cushioning. Packaging designers are concerned with the marketing aspects of sales and experience. Packaging *design engineers*, who would be capable of integrating both aspects are very rare.

Subsequently, a data mining exercise was carried out on a data set from Royal Philips Electronics, consisting of environmental benchmarking data. Together, these studies gave insight into the current state of the field of packaging for consumer durables.

Before exploring the marketing functionalities of packaging further, the process of commoditization, through which these functionalities became relevant, is

explored. Through a survey the level of impulse buying of consumer electronic products was studied, which showed impulse purchases to be a significant percentage of total purchases, even for large products like flat-screen TVs. Through desk research both product quality was studied more in-depth, which showed that the spread in perceived quality has reduced, thus allowing for a process of commoditization to take place. The number of brands on the Dutch TV market was also studied through desk research. This study showed that the number of brands that are regularly available has reduced slightly.

In studying the development of sales-functionalities, a historical overview of the different types of retail formats is given. This was studied through literature and through collecting historical photographs of consumer electronics shops from several archives. This study has given insight into the developing role packaging plays in selling consumer electronic products. Packages designed for their sales performance often become more bulky, especially if the products they contain are smaller than roughly 20 liters. The increase in volume is mainly caused by an increase in the front-facing area of the packaging.

The experience functionalities of packaging where studied through an Internet survey, several focus group sessions and an unpacking experiment. Packages designed for their unpacking experience often become more bulky, due to the layering and placement of the product and its accessories.

In reality, most packages will have to perform a mix of all three functionalities. In order to optimize the volume for such packages it is required to determine the proper mix of all three for the product to be packed. What is the proper mix depends on the type of product, the brand, the target group, the competitive environment and the planned retail outlet. A model has been presented in the form of a triangular graph that can assist in visualizing the mix of functionalities of a product and its competitors, a product range or even brands. Once a particular product-packaging combination has been mapped on the graph, the question arises how to fulfill that particular mix most efficiently. This is addressed in the descriptive part of the thesis.

However, before moving to the descriptive part of this theses, the extent to which the findings of the analytical part of the thesis are also applicable to other types of consumer durables was studied. This was done by following the methodology also applied on the data mining study on Royal Philips Electronics data. For domestic appliances, power tools, toys and furniture an assessment was made whether these products have similar style packaging, whether they travel similar distances with similar modes of transportation, and whether they are volume-critical during transportation. This turned out to be the case. The only product group found that is weight-critical for some products is IKEA furniture, which is known for their extreme volume-efficient packages.

In the prescriptive part of this thesis several volume optimization strategies are presented, split into distribution-related and marketing-related functionalities. The design strategies for distribution-dominated packaging cover: postponed assembly, transport orientation, efficient cushioning, optimization of the damage rate, and a re-evaluation of the packaging testing procedures.

The design strategies for marketing-dominated packaging cover: unity of graphics for the entire brand, optimization of the third dimension, designing a ‘jewel box’, optimization of the unpacking experience and improving openability, quantifying the sales performance and balancing it with costs and/or environmental impact, and packaging postponement.

This thesis has presented a holistic approach to packaging development for consumer electronic products; an design engineering approach. By following such an approach, the volume of the packaging can be optimized, in the sense that a packaging will have the *right mix* of functionalities, and will fulfill those functionalities in the *most efficient* way. Hence, it will be no larger than necessary to fulfill its requirements. Through optimizing the volume both costs and environmental impact will be reduced.

Samenvatting

Vanaf het moment dat er aandacht kwam voor de milieu-impact van producten, zijn verpakkingen één van de productgroepen die bovengemiddeld veel aandacht hebben gekregen, bijvoorbeeld van wetenschappers, bedrijven en pressiegroepen. Consumenten gooien de verpakking van een product vaak snel na de aankoop weg, zeker ook de verpakking van duurzame goederen, zoals consumentenelektronica. Dit snelle weggooien maakt de milieu-impact van verpakkingen erg tastbaar voor de consument; iets wat verpakkingen een negatief milieu-imago geeft.

De huidige aandacht voor duurzame verpakkingen richt zich sterk op het aspect van afvalvermindering; meer specifiek op grondstofconservering en materiaal-recycling. In de academische wereld wordt onderkend dat de milieu-impact van verpakkingen in een wijder perspectief gezien moet worden; een perspectief dat ook de relatie tussen verpakking en verpakt product omvat. Bij de verpakking van duurzame consumentengoederen, waarbij sprake is van buffering, is het huidige perspectief niet zo breed dat ook de relatie met productschade en de invloed op transportefficiëntie wordt meegenomen in de milieuoverwegingen. Het uitgangspunt van dit proefschrift is geweest om de milieuvriendelijkheid van verpakkingen van duurzame consumentengoederen te verbeteren, vanuit een wijder perspectief.

Dat wijdere perspectief omvatte de invloed van de verpakking op de transport efficiëntie. Er is aangetoond, gebaseerd op LCA studies, dat voor representatieve gevallen het transport van verpakte duurzame goederen een hogere milieu-impact heeft dan het materiaal gebruikt voor de verpakking. Een analyse van een uitgebreide dataset aangaande verpakte consumentenelektronica heeft vervolgens aangetoond dat de verpakking invloed heeft op de transportefficiëntie doormiddel van volume.

Het hoofddoel van dit proefschrift was om te bepalen waarom een verpakking een bepaald volume heeft, en hoe dit volume kan worden geoptimaliseerd. Verscheidene onderzoeksmethodes zijn voor dit doel gebruikt. Allereerst is het verpakkingsontwikkelingsproces bestudeerd, door middel van literatuuronderzoek, bedrijfsbezoeken en interviews met productmanagers en verpakkingsontwikkelaars binnen Royal Philips Electronics. Dit heeft geresulteerd in twee belangrijke bevindingen. Ten eerste, dat drie types van verpakkingsfuncties kunnen worden onderscheiden, namelijk distributie-, verkoop- en belevingsgerelateerde functies. Elk van deze type functie heeft zijn eigen relatie tot verpakkingsvolume. Daarnaast is vastgesteld dat er twee type verpakkingsontwikkelaars zijn: *verpakkings-ingenieurs* en *verpakkingsvormgevers*. Verpakkingsingenieurs houden zich bezig met de distributiegerelateerde functies van de verpakking, zoals buffering. Verpakkingsvormgevers houden zich bezig met de marketing aspecten van verkoop en beleving. *Verpakkingsontwerpers*, die in staat zijn om beide aspecten te integreren zijn zeldzaam.

Vervolgens is een *data mining* studie uitgevoerd, op basis van een dataset van Royal Philips Electronics, bestaande uit milieugerelateerde *benchmarking* data.

Samen met voorgaande studies heeft dit inzicht opgeleverd in de huidige stand van het verpakkingsvakgebied aangaande duurzame consumentengoederen.

Alvorens de marketing functies van verpakkingen verder te onderzoeken is het proces van *commoditization* bestudeerd. Dit proces, waardoor in steeds hogere mate alleen de prijs van producten bepalend is in de keus van de consument, ligt ten grondslag aan het relevant worden van verkoop- en belevingsfuncties van verpakkingen. Middels een enquête is de hoeveelheid impulsaankopen van consumentenelektronica onderzocht. Hieruit kwam naar voren dat impulsaankopen een significant aandeel vormen van het totaal aantal aankopen, zelfs voor grote producten, zoals *flatscreen* TVs. Vervolgens is de evolutie van de kwaliteitsbeleving onderzocht door middel van de beoordelingen in de Consumentengids. Dit laat zien dat de spreiding in beoordelingen over de tijd kleiner is geworden. Iets waardoor een proces van *commoditization* mogelijk wordt. Ook het aantal merken op de Nederlandse TV markt is op deze wijze onderzocht. Dit onderzoek laat een lichte daling zien in het aantal aanbieders op de markt.

Ter bestudering van de verkoopfunctie van verpakkingen is een historisch overzicht gemaakt van de verschillende types van winkels. Deze zijn bestudeerd door middel van literatuuronderzoek en een analyse van beeldmateriaal uit verschillende archieven. Deze studie heeft inzicht gegeven in de ontwikkeling van de rol die verpakking speelt in het verkoopproces van consumentenelektronica. Verpakkingen met een belangrijke verkoopfunctie zijn vaak meer volumineus, vooral als de verpakte producten kleiner zijn dan ongeveer 20 liter. De toename in volume is vooral een gevolg van het vergroten van die zijde van de verpakking die op het winkelschap zichtbaar is.

De belevingsfuncties van de verpakking zijn onderzocht middels een internetenquête, enkele focusgroepen en een uitpakexperiment. Deze functies leiden vaak tot meer volume door de ordening en presentatie van het product en accessoires.

In de praktijk zullen de meeste verpakkingen een mix van alle drie de type functies moeten vervullen. Om dan het volume te kunnen optimaliseren is het noodzakelijk om de juiste mix vast te stellen. Wat de juiste mix is hangt af van het type product, het merk, de doelgroep, de concurrenten en de beoogde winkelomgeving. Er is een model ontwikkeld in de vorm van een driehoeksdiagram dat kan helpen om de mix van functies van een product en de producten van concurrenten te visualiseren. Naast een enkel product kunnen ook productportfolio's of zelfs merken worden geplot. Als een bepaalde product-verpakkingscombinatie eenmaal is geplot ontstaat de vraag hoe die specifieke mix van functies het meest efficiënt vervuld kan worden. Dit wordt behandeld in het descriptieve deel van dit proefschrift.

Voor er echter naar het descriptieve deel van het proefschrift overgegaan wordt, is eerst nog onderzocht in hoeverre de bevindingen uit het analytische deel van het proefschrift ook gelden voor andere duurzame consumentengoederen. Hierbij is dezelfde methodologie gebruikt als bij de *benchmark* studie op basis van de data van Royal Philips Electronics. Voor huishoudelijke apparaten, elektrisch gereedschap, speelgoed en meubelen is onderzocht of zij dezelfde soort verpakkingen hebben, dezelfde afstanden afleggen in dezelfde transportmiddelen en of hun verpakkingen ook volume-gelimiteerd zijn. Dit bleek het geval. De enige productgroep die gedeeltelijk gewichtsgelimiteerd is, zijn IKEA meubelen, die ook bekend zijn om hun volume-efficiënte verpakking.

In het prescriptieve gedeelte van dit proefschrift worden verschillende volume-optimalisatie strategieën gepresenteerd, opgesplitst naar distributiegedomineerde en marketinggedomineerde verpakkingen. De ontwerpstrategieën voor distributie-gedomineerde verpakkingen omvatten: uitgestelde assemblage, de oriëntatie van de verpakking tijdens transport, efficiënte bufferingsmaterialen, optimalisatie van het schadepercentage, en her-evaluatie van de verpakkingstestnormen.

De ontwerpstrategieën voor marketinggedomineerde verpakkingen omvatten: het eenduidig toepassen van grafiek voor het hele merk, optimalisatie van de derde dimensie, het ontwerpen van een 'juwelendoosje', optimalisatie van de uitpakbeleving en het gemakkelijk openen van de verpakking, het kwantificeren van de verkoopprestatie van de verpakking en het in balans brengen daarvan met de kosten en/of milieu-impact, en uitgestelde verpakking.

Dit proefschrift presenteert een holistische benadering van de verpakkings-ontwikkeling voor consumentenelektronica; een integrale ontwerp benadering. Door een dergelijke benadering te volgen kan het verpakkingsvolume worden geoptimaliseerd, in die zin dat het leidt tot een verpakking die de *juiste mix* van functies *zo efficiënt mogelijk* vervult. Daardoor zal de verpakking niet groter zijn dan strikt noodzakelijk. Door het optimaliseren van het volume worden zowel de kosten als de milieu-impact verlaagd.

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Thank you all!

Curriculum Vitae

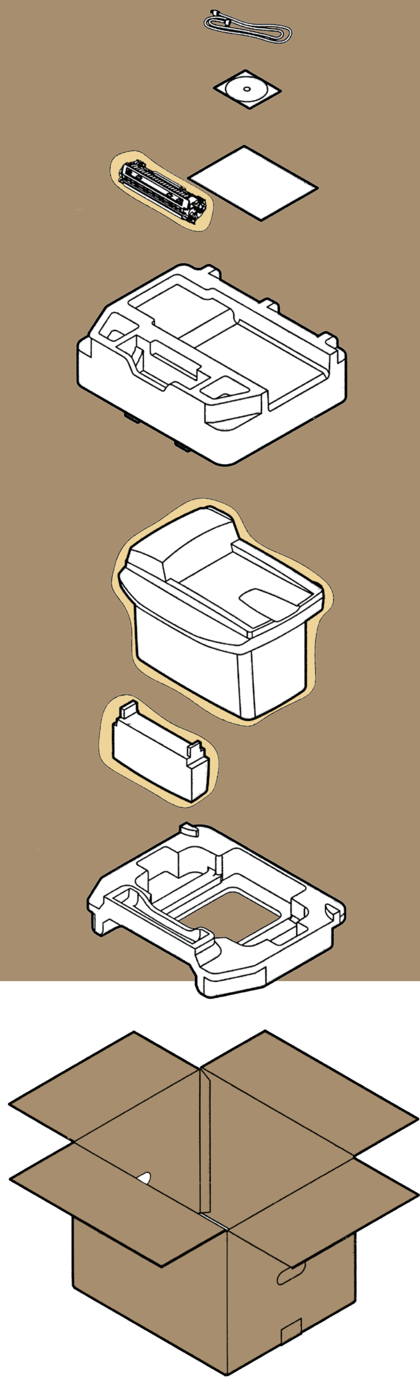
Renee Wever was born in Deventer on 2 April, 1978. After finishing his atheneum studies at the Florens Radewijns College in Raalte in 1996, he started the Industrial Design Engineering program at Delft University of Technology. He obtained his Master's degree cum laude in 2003, while also obtaining the 'Technology in Sustainable Development' annotation. During his Master's program he put a special focus on packaging and sustainability. His graduation project was entitled: 'Environmental aspects of moulded pulp as a packaging material for durable consumer goods'.
Renee interrupted his studies for one year, to be a full-time board member of the Delft Union of Students; the *Vereniging voor Studie- en Studentenbelangen te Delft* (VSSD).

In May 2004 he started a PhD project at Delft University of Technology, of which the first 8 months were funded by the Sustainability Center of the Consumer Electronics division of Royal Philips Electronics. Since February 2007 he has been spending half his time teaching several sustainable design subjects in both the Industrial Design Engineering program and the Industrial Ecology program.

Renee has published several journal papers and conference contributions. Both on subjects related to his PhD, as well as related to other subjects, such as presentation media for wayfinding systems for pedestrians, design for sustainable behavior, sustainability in the fuzzy front end, and sustainable design education. He won a best paper award at the 2008 ICOVACS conference in Izmir, Turkey.

Besides his PhD project, he is/was involved in other packaging related projects, one that concerns the environmental impact of retail-ready packaging and another that concerns the prevention of litter through packaging design. He has acted as a reviewer for several journals. For several years he has been part of the jury for the EISA Green Award.

After the completion of his thesis, Renee will continue working at Delft University of Technology, as an assistant professor.



Delft University of Technology
Design for Sustainability program

So far, the sustainability focus on packaging has been strongly on resource conservation and material recycling. However, as this thesis demonstrates based on LCA studies, for typical cases of packed consumer durables, the transportation of the packed product has a higher environmental impact than the packaging material used. Analysis of a substantial set of packed consumer durables demonstrates that transportation efficiency is determined by packaging based on volume. Hence, a design-for-volume-optimization approach is proposed.
The packaging development process is studied, identifying a need to integrate packaging design and packaging engineering.
Three types of packaging functionalities are identified, namely distribution-related, sales-related and experience-related. Each type of functionalities has its own relationship to packaging volume.
An approach to analyze the required mix of functionalities for a specific package is proposed. For each type of functionalities different volume optimization strategies are presented.

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