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# BULK PACKAGING FOR CONSUMER ELECTRONICS PRODUCTS AS A STRATEGY FOR ECO-EFFICIENT TRANSPORTATION

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## ABSTRACT

*By postponing the packing of consumer electronics (CE) products into their final consumer package, until after long-distance transportation, substantial economic savings and environmental improvements can be achieved, due to higher efficiency during transportation. In such a case, long-distance transportation is done in multiple or bulk packages. Literature presents only a limited number of examples of bulk packaging for CE goods, all with the goal of economic savings obtained through maintaining flexibility in the supply chain. The logic of environmental improvement by using bulk packaging is based on including transport efficiency as a criterion in the environmental assessment of packaging concepts. This is a new approach as until now literature and practice in eco-design of packaging have focused on resource conservation and recycling. Bulk packaging can be applied in different ways. Which way is most successful depends on the type of product, the mode of distribution, the transportation distance, the size of the production run and the prices of material and labor. This paper investigates the conditions for success of bulk packaging and works towards a methodology for comparing single-set packaging with several bulk packaging options, in order to determine when and how bulk packaging leads to an environmental improvement and a competitive advantage.*

## KEYWORDS

Packaging postponement, product distribution, eco-design, transport efficiency, decision tool, design methodology

## 1. INTRODUCTION

Production of durable consumer goods is moved to low-wage countries. This means that transportation distances are increasing, and with that, the relative importance of this phase of the life cycle of products. This increase exists 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 calls for attempts to optimize this phase of the life cycle as much as possible. This can mainly be done by keeping the number of shipments as low as possible, which means keeping the number of product per shipment as high as possible. As such, transport efficiency is an interesting area for optimization as environmental improvement coincides completely with economic savings.

As will be discussed in section 2, there are several strategies for improving the efficiency of current packages. However, it is also possible to consider a more radical change in transportation. By postponing the packing into their final consumer packages until after long-distance transportation, a more efficient stacking of products can be used during long-distance transportation. This would be done in multiple or bulk packaging. So far, little has been published on this strategy (for review see section 3). This paper aims to further research the possibilities of bulk packaging as a strategy for environmentally sound transportation. It aims to work towards a tool that will identify likely products for which bulk packaging is an improvement compared to single-set packaging, and in which way. Furthermore it will be investigated what kind of design implications such a strategy would have for the final consumer packaging.

To achieve this section 2 will discuss the relation of packaging design with the environmental impact of transportation. Section 3 will discuss bulk packaging from an economical perspective and review the existing literature. Section 4 will discuss the concept of bulk packaging in more depth, identifying the different options and subsequent consequences for the design of the final consumer packaging. Section 5 will discuss which factors determine whether bulk packaging qualifies for a certain product. Section 6 will present several calculation examples. Finally, section 7 will address the value chain acceptance.

## 2. PACKAGING AND ENVIRONMENT

Ever since the growing attention for the environmental impact of products, packaging has been one of the areas receiving a lot of attention, both from scientists, companies and environmental lobby groups. Packaging is often discarded 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. This feeling with the general public is reflected by the attention of researchers 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, is the best known.

The above shows packaging has been receiving a lot of environmental attention. However, a closer look will show that the current focus is entirely on the production and end-of-life phase of the packaging. This focus is caused strongly 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.*'

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. Yet, for packaging of CE products, where cushioning is involved, 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. As will be demonstrated in section 1.1 the packaging volume is of significant influence here. 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 production and end-of-life phase of the packaging. Second, the impact of the transportation is strongly influenced by the number of products that fit into one shipment. As will be demonstrated later on, this factor is determined solely by the volume of packages, not by their weight. Thus far this factor has been ignored in environmental assessments of packaging. As Table 1 shows, suppliers of cushioning materials do not mention volume efficiency as an environmentally important factor. Their environmental claims are mainly production and recycling related. Judging from Corporate Social Responsibility Reports from major CE manufacturers, these companies often do recognize volume as a relevant factor, but never as a major one.

### 2.1. Importance of volume

Elaborating the first point, that transportation is important, 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 Bill-of-Materials (BOM) and the environmental impact of transportation is approximately between 1:1 and 1:2 depending on the type of packaging materials used, the mode of transportation used, and the transportation distance. Hence a strategy aiming at minimizing this impact seems more justified than aiming to min-

**Table 1** 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

| | 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 |
| **Frequency** | **22** | **4** | **9** | **2** | **4** | **6** | **0** | **5** | **21** | **8** | **4** | **3** | **2** | **1** |
| EPS foam | 6 | 0 | 5 | 1 | 0 | 5 | 0 | 0 | 6 | 3 | 3 | 0 | 0 | 0 |
| EPP foam | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 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 |
| Neopolene | 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 |

imize packaging waste. 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 container ships, 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. 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 breakeven density of 390 to 430 grams per dm$^3$. 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 breakeven density also varies more, namely from 190 to 350 grams per dm$^3$. For air cargo the breakeven point is 167 gram per dm$^3$. If the density is lower the carrier will calculate a fictitious volume-weight based on this density, and charge likewise. These breakeven densities can be compared to the densities of packed consumer electronics products. Here, and in the remainder of this paper, a data set will be used consisting of 97 CE products. In this set there a variety of CE products, there are television sets and monitors, both with CRT and LCD screens, DVD and VCR recorders and players, but also baby care and Personal Audio products. Products from a variety of brands are included. These data originate from the Philips Environmental Benchmarking procedure (see Boks and Stevels (2003) for more details). Figure 1 shows the densities of these CE products and the breakeven densities of several modes of transport. Most packages have densities lower than the breakeven densities of the modes of transportation. Hence the number of products in a shipment is limited by their volume, and not by their weight.

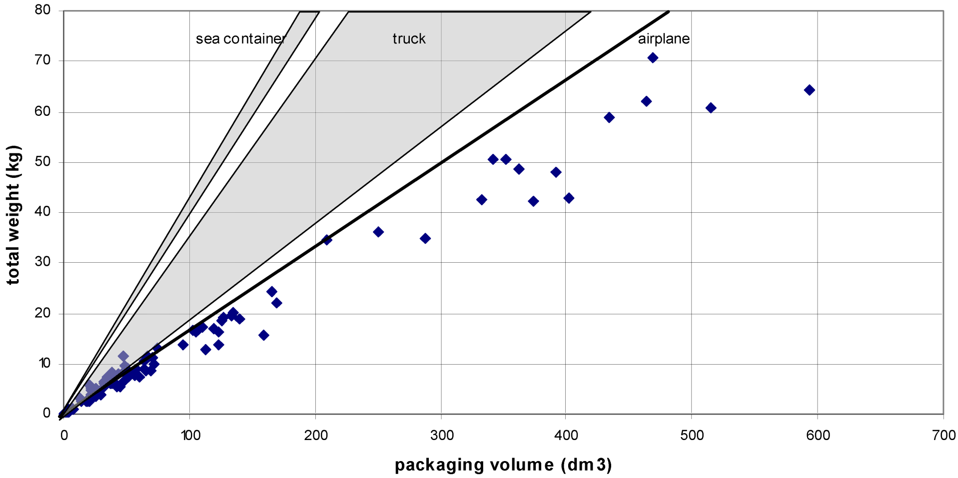


**Figure 1** Breakeven densities of the most important modes of transport and the product from the data set

This allows the conclusion that volume is the determining factor for transport efficiency of most consumer electronics products, especially where transport by sea container is concerned. Therefore it is sensible to pursue volume reduction strategies. There are several ways in which one can pursue volume reduction, one could:

- **Try to come up with better thought-out designs**. When looking at the often inefficient dimensions of existing packages for CE products, it can be concluded that transport efficiency is not always a dominant design selection criterion. Sometimes it is not even part of the design objectives at all. (Van Es, 2005, Wever et al, 2005)
- **Select more volume efficient cushioning 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 one 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 molded fiber, 2.0, EPS-foam 2.5, EPP-foam 2.7, EPE-foam 2.8, Corrugated 3.8, Air cushions 5.0 (Thijsse, 2001, Wever et al. 2004).
- **Accept a limited increase in transportation damage.** It is safe to say that within durable consumer goods industries a belief exists that all transportation damage is bad and should be prevented. Transportation damage may occur, when for instance a package is dropped during transportation or handling. As a rule of thumb changes of occurrence become smaller with increasing height of drops. Designing packaging to withstand the most unlikely drop will mean overpacking in nearly all cases. Theoretically, there must be an optimal trade-off between adding more packaging and accepting damage. Such an optimum exists both from an economic and an environmental point of view. However, these optima do not have to be the same. By researching damage reports, one could design packaging for such an optimum; however, no evidences of such practices have been reported within the consumer electronics industry.

The above strategies are all based on optimization of the present single–set packaging concept. This is the strategy where each product is put in its own packaging, with its own cushioning, as it leaves the assembly line. The saving potential of these strategies is limited as there will always be a need for volume to accomplish mechanical protection and attract attention on the shelf in the retail environment. Furthermore these strategies do not allow one to take advantage of odd shapes of products which could be more closely stacked, as each product goes into a rectangular box. Therefore it is interesting to aim for a more fundamental change by challenging this single-set concept, and thus accomplish much higher reductions of transportation volume by using bulk packaging. Bulk packaging is a concept in which products are not packed in their final consumer packages after their assembly, but placed in some sort of multiple-product cushion, which is more volume efficient than the single-set packages. These multiple-product cushions are then shipped through the distribution chain. Only when the products are geographically close to their point of sale they are repacked into their final consumer packages. This strategy has both advantages and disadvantages to the classic packaging strategy, which will be discussed in section 2.

## 3. SURVEY

Bulk packaging is a form of postponement. Postponement is the opposite strategy of speculation, on which mass production is based. (Bucklin, 1965, Zinn and 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. An alternative approach is postponement of (parts of) the production and distribution until the point that more certainty exists on actual demand. One of the 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 moment 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 and 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 your 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.

This paper focuses on one specific form of postponement, namely packaging postponement in the consumer electronics industry. This 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 are received the products are packed in their final packaging and shipped to the retailers. This requires packaging facilities in more locations, all purchasing smaller amounts of packaging, thus loosing part of the economies of scale from a scenario of packaging products at the site of production. Nevertheless advantages are obtainable. There are several reasons why this approach may be sensible. 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 and 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 adding 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) show, postponement can be a good environmental strategy as well. It does require additional packaging material, as one first needs bulk packaging and then has to repack the product 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.

## 4. CONCEPT OF BULK PACKAGING

Choosing for bulk 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:

- Bulk 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 repack 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 bulk 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 one 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 (Media Markt and Saturn shops) in Europe. These chains do not order products a piece, but per pallet or even per container.

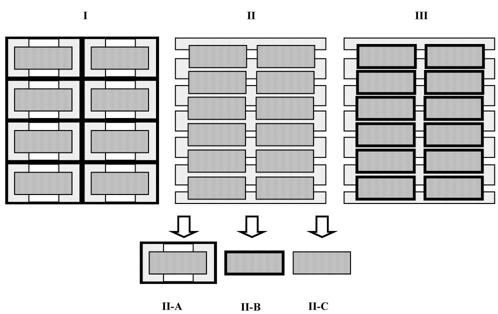


**Figure 2** Different packaging scenarios; single-set (I) or bulk packaging (II and III)

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 2. 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 bulk packaging strategy. Products are placed unpacked into bulk cushions, thus saving transport volume. In this case 12 products go into 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. Finally, scenario II-C represents the strategy of unpacked products.

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 computer related products. Here one organization may purchase hundreds of products, which will be installed by their computer support group. These people 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.

### 4.1. Example designs

From a design point of view especially scenarios II-B and III are interesting. Here a new type of packaging is introduced, solely to fulfill functions during the trip from a shop to the consumer's home. These functions would be limited to:

- Handling efficiency (carrying)
- Containing accessories
- Proof of newness (especially with mobile phones and Personal Hygiene products).
- Gift feeling
- Minimal protecting (scratches etc.)

For the manufacturer it allows the packaging to fulfill functions not directly expected by the consumer, but advantageous for consumer satisfaction and brand

promotion:
- Unpacking experience
- The bought product as a ‘walking’ advertisement

Figure 3 gives a design example of how this could look.

## 5. PRODUCT REQUIREMENTS

Bulk packaging (both strategy II and III) is not a strategy equally suitable for all products. Which products are likely candidates, is determined by several factors:
- Transportation impact and costs
- Institutional buyers
- Robust products
- Cost difference materials and labor, for assembly site and market site
- Size of the production run
- Volume saving potential

Each of these factors will be discussed below in more depth.

### 5.1. Transportation distance

Both the environmental impact and economical cost of transportation have to be high enough to make bulk packaging a feasible option. Hence, it is a strategy suited most for long distance transportation, i.e. mainly intercontinental shipments. Furthermore, if done by sea container, these are the shipments that take enough time to allow for the gain in flexibility as described in the HP case. If transport is done by plane, costs are so much higher that bulk 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 fashionable products in the field of Personal Audio.

### 5.2. Institutional buyers

As described in section 3, for some types of products a considerable amount ends up for professional use in large companies, universities or governmental institutions. This specifically applies to computer related products. Here single-set packages are a nuance, presenting local computer-support groups with storage problems and problems in disposing of the cushioning materials, especially if this is a type of non-compressible foam.

### 5.3. Robust products

Cushioning is added to products to protect them from shocks and vibrations during transportation. However, some products exist that do not need very much protection, as they need to be 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 exercising, regardless of the shocks and vibrations they receive. These products lend themselves especially for bulk packaging with the minimum required cushioning only.

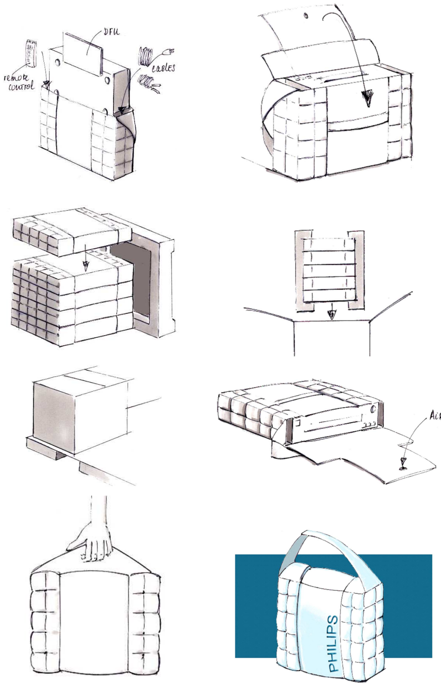


**Figure 3** Design example for a scenario III distribution. The product is packed at the assembly session in a un-inflated, but inflatable handbag. The packed products are put in stacks (in this case of 5 products) protected by multiple cushions. These multiple packs are ships normally. Bags are inflated at the retailer, and carried home by consumers. (Boks, et al. 2003)

### 5.4. 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. Thirdly packaging materials themselves are more expensive in western countries and due to the smaller badges ordered one can profit less from economies of scale. 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 bulk packaging strategy.

### 5.5. Size of the production run

Naturally 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 cost, 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 relatively low, bulk packaging may become too expensive. Hence, especially main stream products with high production runs are likely candidates for bulk packaging. This also complies with the idea that large retailers may order one or more full-container loads of the product.

### 5.6. Volume saving potential

Perhaps most essential is the potential of saving transport volume. This means that products should not already be over the breakeven densities as shown in figure 1. If they are, transport efficiency cannot be increased by using bulk packaging and neither economic savings nor environmental improvements can be obtained. If weight is already the limiting factor, there is no use in minimizing volume further. 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 the more likely a candidate it is for bulk packaging. To show to what extent the distance to the breakeven lines is caused by the added packaging, figure 4 shows the density of the bare products from the data set, again compared to the breakeven densities of the different modes of transportation. The figure makes clear that even unpacked a lot of products are still below the breakeven density of sea containers.

Two types of products are particularly interesting, namely those products with odd shapes, and those products with extremely large packages, relative to product volume. 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.

The other option, considering relatively high package volumes, will be demonstrated with a study of the same data set as used in figure 1. Of these products the relative volume efficiency was calculated (the volume index). This is the volume of the packaging divided by the volume of the product. Here, the volume of the packaging is self evident, as it is a rectangular box. The volume of the product is defined as the smallest enclosing rectangular box in the position in which the product is to be transported, i.e. the product of maximum height, width and depth in that orientation. Looking at the volume index for the products in the data set, volume indexes range from just above 1 to almost 40. Figure 5 shows a graph of volume index against product volume. It shows that products with high volume indices, which make them very suitable for bulk packaging, are the relatively small ones. A closer study of these products reveals that these are products such as MP3-players and other Personal Audio products and universal remote controls (See also Wever et al, 2005 for a further discussion on volume indices).

## 6. EXAMPLE CALCULATIONS

HP claims to have saved $3 million through implementation of bulk packaging for its inkjet printers (Twede et al., 2000). Other examples of implementations in main stream business have not been documented in literature, though some experimental projects are known to be in progress. There have also been a number of projects showing the potential of bulk 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 bulk packaging, savings per set could be obtained in the order of 1 euro. If assumed that not all products need repacking 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%. With the impact of transportation

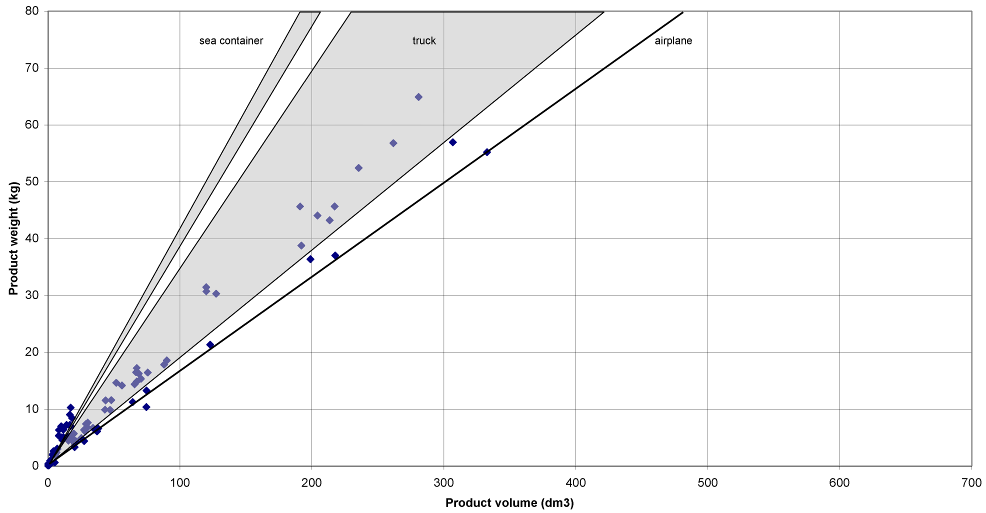


**Figure 4** Density of unpacked CE products, as compared to breakeven density of different modes of transportation

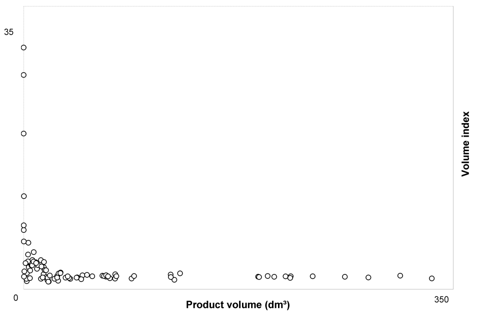


**Figure 5** Volume index against product volume for the products in the data set

being at least as important as the packaging materials (as repeatedly shown by Thijsse 2001, Wever 2003 and Van Es 2005) this means a significant saving.

This paper argues that not only economical costs can be minimized by implementing a bulk-packaging strategy, but the environmental impact as well. Thijsse (2001) made a life cycle assessment of a bulk-packaging scenario (wich was a scenario of type II-B, see figure 2). She demonstrated a (theoretical) environmental saving of 53%.

## 7. VALUE CHAIN ACCEPTANCE

The company producing and selling the product is of course 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 is mainly to do with the internal value chain. These internal stakeholders may be influenced by external factors, such as legislation, suppliers, or insurance. An example of such legislation may be the environmental packaging legislation which calls for a minimization of the use of packaging material, while bulk packaging may increase the total amount of packaging material used. 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.

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 to get rid of the bulk cushions in both scenarios II and III.

The willingness of retailers to cooperate with such a system may be influenced by at least two factors. First a system of bulk packaging may allow for lower 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 bulk 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 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 fulfill this other function.

## 8. DISCUSSION & CONCLUSIONS

So far, discussions in scientific literature about the feasibility of bulk packaging are only done with the goal of obtaining a flexible supply chain, which is the classic objective of a postponement strategy. However, this paper has demonstrated that reducing environmental impact of packaging and transportation can also be a good argument for bulk packaging, as packaging volume is the limiting 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.

A bulk packaging strategy is not suitable for all CE products. 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.

In business practice far more products meet these criteria than are bulk-packed today. Hence a considerable potential for improvement exists. In the view of the authors implementation is mainly obstructed by non-acceptance of the value chain (either real or expected).

This paper is meant as a first step towards a calculation tool for determining the feasibility of bulk packaging for a specific product. As indicated in this paper there are numerous factors to be incorporated in determining to most efficient set-up of the distribution chain. Therefore a tool is needed to make quick calculations possible. Results of these calculations can than show whether a large enough part of a company's product-portfolio would benefit from a shift to bulk packaging. This would than help in convincing both the internal and external value chain.

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