Implementing “Sustainable Packaging Logistics”. An analysis in liquid detergents

Implementación de la "Logística del Embalaje Sostenible". Un análisis en detergentes líquidos

Jesús García-Arca (jgarca@uvigo.es), A. Trinidad González-Portela Garrido (tgonzalez-portela@uvigo.es) y J. Carlos Prado-Prado (jcprado@uvigo.es)

Grupo de Ingeniería de Organización (GIO)
Escuela de Ingeniería Industrial. Universidad de Vigo (Spain)

Fecha de recepción: Octubre 2016

Fecha de aceptación: Diciembre 2016

Abstract: This paper presents the interest of implementing the “Sustainable Packaging Logistics” approach in order to improve efficiency and sustainability throughout the supply chain, thanks to the development of a study based on “Benchmarking” technique. After summarizing the main conceptual aspects of “Sustainable Packaging Logistics”, the paper focuses on the analysis of a sample of 17 references of liquid detergent, adopting the methodology of multi-case study.

The results of the study show an average level of unoccupied volume of 12.5% in the comparison between the liquid and the plastic bottle capacity. This unoccupied rate even reaches the 50.8% if it compares the liquid volume and the theoretical prism that fits the bottle. On the other hand, the results also show differences in the pallet efficiency up to 377 liters per pallet and 3,248 liters per truck.

These results imply that there are different logistic and sustainable effects depending on the packaging solution; that means new opportunities for competitiveness improvement.

Keywords: Packaging; logistics; supply chain; sustainability; liquid detergents

1. Introduction

Nowadays, supply chains should increase efforts to increase competitiveness and sustainability, not only by deleting activities that do not add value to customers, but also developing innovations.

In order to ease the achievement of this target, packaging could be considered as an important part of the supply chain that allows the improvement of its efficiency and sustainability (Kleivas, 2005; García-Arca et al., 2008; Sohrabpour et al., 2016). A wider perspective of packaging functions should include not only the protection and differentiation of the product (Verghese et al., 2015; Rundh, 2016), but also the search for efficiency and sustainability in production and logistics (both direct and reverse logistics).

In this context, Ciliberti et al. (2008) present the term “sustainable packaging” as “the packaging that adds real value to society by effectively containing and protecting products as they move throughout the supply chain and by supporting informed and responsible con-

sumption, is designed to use materials and energy as efficiently as possible throughout the product life cycle, is made up of materials that are cycled continuously through natural or technical systems, so minimizing material degradation and/or the use of upgrading additives, and is made up of components that do not pose any risks to human health or ecosystems”.

The environmental pillar of the sustainability associated to packaging design has promoted the development of specific environmental regulations (for instance, the European Directive 94/62 and its update, 2004/12/EC). Going beyond, packaging also plays an important role in the development of new paradigms in supply chain management, such as “Physical Internet” (Montreuil et al., 2010; Landchützer et al., 2015).

The packaging system is structured in three interconnected levels: the primary packaging (the consumer packaging), the secondary packaging (some primary packages grouped for easing handling or displaying) and the tertiary packaging (some primary or secondary packages stacked on a pallet or roll container for

easing handling, warehousing and transport) (Jönson, 2000).

Authors such as, Saghir (2002), Hellström and Saghir (2006), García-Arca and Prado-Prado (2008), Azzi et al. (2012) or Lindh et al. (2016) identify three main design requirements that packaging should accomplish:

- Commercial requirements; developing features such as, communication, attraction, branding, convenience, ergonomics, traceability or selling.
- Logistics requirements; easing tasks such as, protection, safety, handling, packing, supplying, storage or transport throughout the supply chain (including the point of sale).
- Environmental requirements; supporting the strategy of reduction of raw material consumption and waste generation.

These requirements are associated to each level of the packaging system in different ways, so we need a new, integrated and coordinated perspective in relation to packaging system, supply chain and product. In this context, authors such as Verguese and Lewis (2007) comment that environmental issues related to packaging design demand collaboration among different partners throughout supply chain in order to minimize not only environmental impact, but also global costs.

This integrated perspective has promoted the appearance of the concepts "Packaging Logistics" (Saghir, 2002; Hellström and Saghir, 2006; García-Arca and Prado-Prado, 2008; Olander-Roase and Nilsson, 2009; Vernuccio et al., 2010; Svanes et al., 2010; Hellström and Nilsson, 2011; Azzi et al., 2012; Pålsson and Hellström, 2016) and more recently "Sustainable Packaging Logistics" (García-Arca et al., 2014, a; García-Arca et al., 2016).

García-Arca et al. (2014, a) propose a definition of the new term "Sustainable Packaging Logistics" as "...the process of designing, implementing, and controlling the integrated packaging, product and supply chain systems in order to prepare goods for safe, secure, efficient and effective handling, transport, distribution, storage, retailing, consumption, recovery, reuse or disposal, and related information, with a view to maximizing social and consumer value, sales, and profit from a sustainable perspective, and on a continuous adaptation basis".

For these authors, there should be three main pillars that could ease the adoption of "Sustainable Packaging Logistics": The definition of the design requirements,

the adoption of a coordinated structure for packaging design and new product development and, finally, the definition of an evaluation system both for assessing and for comparing the impact of each packaging alternative.

Unfortunately, there are no so many systems to compare quantitatively and globally the efficiency and sustainability among different packaging options (the third pillar of the approach "Sustainable Packaging Logistics") (Saghir and Jönson, 2001; Saghir, 2002; García-Arca et al., 2014, a). Likewise, this global point of view should include the last step of the supply chain, the supermarkets or the shops.

Obviously, these methods for measuring efficiency and sustainability in supply chain should consider the commercial point of view, in order not only to maintain but also to increase the sales, through the promotion of the differentiation capacity. Thus, packaging should be considered as a silent or invisible "salesman".

One of the methods for measuring the impact of a packaging design before its implementation is the adoption of comparative tests between competitors' packaging alternatives, also known as "Benchmarking" techniques (Gelici-Zeko et al, 2012; Magnusson et al., 2012; García-Arca et al., 2014, b; García-Arca et al., 2017). This paper deals with the practical adoption of these "Benchmarking" techniques in the retail sector.

2. Objectives and methodology

In this context, in order to validate the interest of adopting "Sustainable Packaging Logistics" through the implementation of "benchmarking techniques", the authors have selected and studied a sample of 17 references of liquid detergents (see Figure 1) in an exploratory way.

The main objective of this study is to identify logistic and sustainable improvements thanks to the comparison of different features of the packaging alternatives. Obviously, these improvements are potential actions that should be considered under a commercial and marketing perspective before their adoption.

The benchmarking technique is usually performed at the level of primary packaging. In this paper, the authors have developed the analysis in all levels of the packaging structure (from primary to tertiary). The comparative analysis adopted in this kind of products is totally new in the academic and business literature.

Likewise, in order to illustrate the interest of this research approach, the authors also include two exam-

ples of packaging changes in liquid detergents that have been successfully implemented. These examples have been compiled from the literature review.

The academic methodology adopted in research is based on a multi-case study (Yin, 2002). The authors compiled information, both from supermarkets (before purchase; typically, logistic information about palletization pattern and layout of products on shelves) and laboratory at university (after purchase; typically, volume, shape and weight of product and packaging).

The 17 references of liquid detergents are available in three of the main retail chains in Spain. The criteria used for selection of brands and retail chains are based on its importance according to Alimarket database (www.alimarket.es). The selection of these retail chains included one Spanish company and two international companies. In this context, products are supplied both by national and international manufacturers and the references include brands from the manufacturers and the retailers.

All the references of the sample have similar type of primary packaging (plastic bottle; HDPE: High Density Polyethylene). Simultaneously, we analyzed the logistical problems of these products in the supply chain, particularly, in the supermarkets.

The first twelve references are marketed in SRP ("Shelf Ready Packaging", type "box-pallet "). One of them uses EUR pallets (1200 * 800 mm.), three of them use ¼ EUR pallet (400*600 mm.), whereas the other eight references use ½ pallets EUR (800 * 600 mm.).

The five remaining references require additional handling to place them on the shelves of points of sale so, "a priori", have a lower level of logistical efficiency. Nevertheless, this design decision could be justified from the point of view of rotation and adaptation to space available in supermarkets.

Figure 1. The sample of 17 references of liquid detergents analysed in the study

3. Identifying improvement opportunities in packaging design

In order to present the results of the analysis, this section has been structured in three parts. The first part is devoted to explain the analysis in primary packaging; the second part is devoted to explain the analysis in tertiary packaging; finally, the third part shows two examples of improvement implemented in packaging of liquid detergent.

3.1. Analysis of the primary packaging

We have started the comparison with the analysis of the primary packaging, the plastic bottle that contains the product. In this comparison, we have found some significant differences between the volume of the product and the maximum volume of the primary packaging (see figure 2). This level of unoccupied volume ranges from 3.65% to 23.80% (12.5% on average) (see table 1).

Likewise, we have found differences in the comparison between the maximum volume of the plastic bottle and the maximum volume of a theoretical prism that could content it (see figure 2). This level of unoccupied volume ranges from 21.59% to 54.79% (44% on average) (see table 1).

These levels of inefficiency are even higher if we compare the volume of the product and the maximum volume of the theoretical prism (between 30% and 65.3%; 50.8% on average) (see figure 2 and table 1).

Figure 2. Empty volume in a bottle (Left: maximum volume in a bottle versus volume of liquid detergent; Right: maximum volume in a bottle versus volume of a prism that can content it)

Ref.	A	B	C	D	E	F	G	H	I
1	2.00	2.69	23.80%	5.18	48.21%	60.53%	135	65.98	50.28
2	3.00	3.61	15.07%	7.13	49.35%	56.99%	140	45.66	38.78
3	3.60	4.69	23.24%	10.37	54.79%	65.30%	190	52.78	40.51
4	3.00	3.37	10.85%	5.58	39.70%	46.24%	115	38.33	34.18
5	3.00	3.26	7.83%	5.54	41.29%	45.89%	120	40.00	36.87
6	3.00	3.27	8.12%	5.54	41.11%	45.89%	120	40.00	36.75
7	3.30	3.43	3.65%	6.73	49.12%	50.98%	140	42.42	40.88
8	2.00	2.18	8.26%	4.34	49.77%	53.92%	90	45.00	41.28
9	2.10	2.80	23.43%	6.12	54.25%	64.97%	120	55.97	42.86
10	4.60	5.62	18.09%	7.99	29.74%	42.45%	230	50.01	40.96
11/12	3.00	3.20	6.25%	5.63	43.13%	46.68%	230	76.67	71.88
13	3.00	3.26	7.98%	5.99	45.61%	49.95%	150	50.00	46.01
14	1.50	1.68	10.45%	2.98	43.72%	49.60%	50	33.33	29.85
15	1.80	2.07	10.72%	2.64	21.59%	30.00%	60	32.47	28.99

16	3.00	3.38	11.11%	6.84	50.66%	56.14%	120	40.00	35.56
17	3.00	3.38	11.24%	5.76	41.32%	47.92%	120	40.00	35.50

Table 1. Analysis of the primary packaging (plastic bottle)

A) detergent volume (liters). B) Maximum inner volume in plastic bottle (liters). C) Percentage of unoccupied volume (detergent volume in relation to maximum capacity in bottle). D) Theoretical volume in a prism that contains the bottle (liters). E) Percentage of unoccupied volume (maximum capacity in bottle in relation to volume of the prism). F) Percentage of unoccupied volume (detergent volume in relation to volume of the prism). G) Weight of empty packaging (grams). H) Weight of empty bottle per detergent volume (grams/liter). I) Weight of empty bottle per maximum volume in bottle (grams/liter)

Obviously, some level of unoccupied volume is needed for easing the productivity in the packing process, for anticipating potential promotions in point of sales or for implementing ergonomic elements (such as the handle). However, it is surprising the difference between the references. This difference seems to recommend a major attention to the packaging design process.

A detailed analysis of the first level of efficiency (see Table 1, column C) identifies that the most efficient products (unoccupied rate <10%) are the references 5, 6, 7 (the most efficient), 8, 11-12 and 13. Moreover, this analysis also identifies that the worst products (unoccupied rate >15%) are the references 1, 2, 3, 9 and 10.

The other products (references 4, 14, 15, 16 and 17) are at a medium level of inefficiency (with an unoccupied rate between 10 and 15%). However, the rank of these references changes depending on the type of efficiency adopted (see table 1; Columns, C, E and F). These levels of waste in packaging volume, obviously, also produce a lesser efficiency in pallets and, therefore, in handling, storage and transport throughout the supply chain. We shall comment this logistic impact later.

Furthermore, these levels of unoccupied volume have a potential impact on the purchases and environmental efficiency of plastic, as the weight of the bottle is related to its volume (if there is unoccupied volume, it should imply extra plastic consumption and waste). However, since the thickness of plastic is not distributed homogeneously throughout the body of the bottle, it is not easy to calculate exactly the potential of this weight reduction.

In fact, due to the high density of the product, it could be necessary to reinforce the structure of the package as the detergent amount increases. For example, the reference 11-12 with 3 liters of product (the second reference in the rank of volume occupation), has a weight per volume larger than other references with lower volume (for example, the references 14 and 15).

Anyway, we have found differences up to a 57% in the relative weight of the bottle (weight of empty bottle per detergent volume) between the most unefficient bottle and the least unefficient bottle (reference 11/12 and reference 15).

3.2. Analysis of the tertiary packaging

Moving on to the analysis in tertiary packaging, we have studied the environmental and logistic efficiency of the first twelve references marketed in three different "box-pallet" types (EUR pallet, ½ EUR pallet or 1/4 EUR pallet). In this context, it would be reasonable, from a logistic point of view, that these different types of pallets contained the maximum amount of detergent as possible.

As a reference of an "efficient" pallet, the RAL standard ("Recommendations AECOC for Logistics", chapter "Efficient Unit Load", 2012) has been used. Therein, it is stated that the maximum height of an EUR pallet load should not exceed 2.6 meters (maximum internal height in truck; 1.3 meters if pallets are stacked) and the maximum weight should not exceed 1,000 kilos. In the case of a half EUR pallet load, RAL proposes as the maximum height, 1.3 meters.

Likewise, the RAL standards cover the SRPs units ("Shelf Ready Packaging"; 2007) proposing as the maximum height for a "box pallet" 1.3 meters (including the height of wood base of pallet), although it allows to overpass this height in some type of shops and for some type of products (for example, liquid detergent).

In order to ease the comparison among the different bases of pallets, we have applied the theoretical concept "Equivalent Pallet". This concept allows to transform a 1/2 pallet and a 1/4 pallet into one EUR pallet, after multiplying by 2 or 4, respectively. The main results of this analysis are shown in table 2.

In table 2 (column H), four groups of unit loads are presented from an efficient point of view ("EUR equivalent pallet"). The first group includes the reference 10 with more than 1,000 kilos per pallet. The second group includes references 2, 3, 11 and 12 with a weight between 690 and 800 kilos. In the third group, we can find five references (4, 5, 6, 7 and 8) with an individual weight that varies from 400 to 500 kilos. Finally, in the fourth group (the least efficient one) we could identify the references 1 and 9 with a weight less than 400 kilos.

Most of the pallets could be considered as heavy, especially, in the first group. In this aspect of weight is important a global perspective of the supply chain. Thus, from a handling and storage point of view it would be interesting to implement a heavy pallet (without exceeding 1,000 kilos according to RAL standard). In this context, for example, the reference 10 would be above this maximum weight, although its composition is theoretical.

Likewise, from a transport point of view it would be interesting to define a pallet that maximizes the volume or weight available on trucks (both, long distance and delivery truck). If we consider the maximum capacity of a "trailer" truck (33 EUR pallets without stacking and 24.4 tonnes of load), the "ideal" weight in pallet for filling completely the truck would be around 739 kilos, related to the second group considered in analysis.

In the groups 3 and 4, the lower weight of the unit loads will force to stack pallets in order to harness weight capacity of the truck. In this last case, it would be necessary that the height of the pallet does not overpass the 1.3 meters (for example, references 1 and 2), but also, that the maximum weight does not overpass 369.5 kilos (739/2). Thus, we found problems with the height in some references (for example, references 4, 5, 6, 7 and 8)

In summary, the difference between the best and the worst "equivalent pallet" according to the number of liters per unit load, is about 377 liters per pallet (see table

2, column G). The pallets of the references 11 and 12 have the maximum height allowed in RAL standards. In fact, this height is only permitted in some type of supermarkets. In this context, the references 11, 12, 2, 3 and 10 are the unit loads with better design from a handling and storage point of view.

Additionally, the highest density of product in each pallet would ease to maintain the search for logistic efficiency in the final step of distribution (typically, transportation to supermarkets), combining with pallets of products with lower density.

However, the efficiency in a long distance transport (trucks) depends on the maximum number of full original pallets that can fit to the maximum truck capacity. In this sense, the most efficient solutions would be the references 7 and 5 (see table 2; columns J and K); these results show differences in the transport filling rate up to 3,248 liters per truck (difference between reference 7 and 1).

The comparison among the most efficient unit loads and the others could imply a significant reduction in the number of pallets throughout the supply chain. Thanks to the primary and tertiary packaging design, companies could achieve an important reduction in their logistic costs (handling, storage and transport throughout the supply chain, including supermarkets).

From a sustainable point of view, a better palletization (number or liters per pallet) also contributes to reduce the environmental impact of transport, thanks to the reduction of the number of trucks throughout the supply chain.

Additionally, we have found extra benefits in terms of the density of material consumption (comparatively, less cardboard could be needed in the "box-pallet") and environmental impact (comparatively, less waste of cardboard could be generated). The range of density of cardboard varies from 650 grams/m² to 1,100 grams/m² (922 grams/m² on average; see table 2, column I).

Ref.	Original pallet	A	B	C	D	E	F	G	H	I	J	K
1	½ EUR	1,135	3	24	72	144	176	294	352	790	132	19.008
2	¼ EUR	1,345	3	18	54	166	196	664	784	890	124	20.584
3	¼ EUR	1,390	3	15	45	162	187	648	748	890	130	21.060
4	½ EUR	1,090	3	24	72	216	247	432	494	650	98	21.168

5	½ EUR	1,135	3	24	72	216	238	432	476	959	102	22.032
6	½ EUR	1,120	3	24	72	216	240	432	480	100	101	21.816
7	½ EUR	1,237	3	21	63	208	227	416	454	1,100	107	22.256
8	½ EUR	1,075	3	32	96	192	212	384	424	950	115	22.080
9	½ EUR	1,150	3	24	72	152	182	308	364	1,400	132	20.064
10	¼ EUR	1,270	3	18	54	248	288	992	1,152	850	84	20.832
11	½ EUR	1,533	4	28	112	336	378	672	756	790	64	21.504
12	EUR	1,573	4	52	208	624	691	624	691	790	33	20.592

Table 2. Analysis of the tertiary packaging (pallet)

A) Pallet height (mm. including wood base). B) Layers per pallet. C) Bottles per layer. D) Bottles per original pallet. E) Liters of detergent per original pallet. F) Weight of the original pallet (Kilos; including wood base and packaging). G) Liters of detergent in "EUR equivalent pallet". H) Weight of the "EUR equivalent pallet" (Kilos; including wood base and packaging). I) Cardboard density (grams/m²). J) Maximum number of full original pallets per truck (considering the constraint of volume or weight; considering stacked pallets if were possible). K) Liters of detergent per truck (according to 24.4 tonnes per truck and considering the maximum number of full original pallets)

3.3. Examples of packaging improvement

From an aesthetic and commercial point of view, the negative impact of changing some packaging solutions should not be important. Nevertheless, depending on the bottle design, it could be necessary to manufacture a new injection die for the bottle. A big amount of products sold yearly could ease to overpass the trade-offs between new investment (die) and savings (reduction of cost of materials, waste, transport, handling and storage). Many times, the cost of a new injection die hinders the visibility of the overall costs and savings.

In order to illustrate that some of these potential changes could be implemented successfully from a commercial point of view, the authors have searched for some examples of improvement through a literature review.

Thus, Pro-Europe (2012) presents a change in the packaging system (primary packaging: plastic bottle; secondary packaging: box; tertiary packaging: EUR pallet). Thanks to the change in the shape of the bottle and to the reduction in the number of bottles per box (from 12 to 10) a 25% improvement in the number of

bottles per pallet has been achieved (from 576 to 720; that means an annual reduction of 100 trucks in the supply chain).

Simultaneously, the bottle weight has been reduced a 19% (annual savings of 115 tonnes of plastic) and the box weight has been reduced a 25%. Equivalent reduction in waste generation is achieved.

On the other hand, another company (Alcaraz, 2014) has applied the finite elements technology to identify zones in the surface of the bottle that should be reinforced from a resistance point of view. Likewise, this technique also identifies zones of the bottle that could be lighten up. Thanks to this reengineering process, a 10 grams reduction per bottle has been achieved (annual savings of 10 tonnes of plastic).

The change in the primary packaging improves the overall resistance of the system and the number of layers per pallet (EUR) increases from 3 to 4. In summary, a 30% improvement in the number of bottles per pallet has been implemented (from 160 to 208). Going beyond, in a ½ pallet, the improvement in the number of bottles reaches a 56% (from 72 to 112).

The two previous examples have been successfully implemented, so the packaging changes promoted from a logistic and sustainable perspective can and should be aligned with the commercial requirements.

4. Discussion and conclusions

The approach "Sustainable Packaging Logistics" can be applied to any category of product, whatever their commercial or logistical features, providing opportunities to increase competitiveness in an integrated context of differentiation improvement, cost reduction and environmental sensitivity. The "Benchmarking" analysis of the liquid detergent packaging confirm and illustrate the above statement.

In the study of the 17 references of detergent, we have found an average 12.5% level of unoccupied volume in the comparison between the liquid and the bottle capacity. On the other hand, the rate of unoccupied volume even reaches the 50.8% (on average) if we compare the liquid volume and the prism that fits the bottle. Likewise, we have found differences up to a 57% in the relative weight of the bottle (weight of empty bottle per detergent volume).

Likewise, we have found differences in the pallet efficiency up to 377 liters per pallet and 3,248 liters per truck, if we compare the best and the worst design decision.

In order to illustrate the potential interest of these global results, we are going to use the figures of a Company that sells 30 millions of liquid detergent per year (Hortal, 2014).

Thus, If we consider, the most common size of liquid detergent (3 liters), the comparison between the worst and the best packaging alternative shows potential savings of 350 tonnes of plastic per year. That means the reduction, not only in the costs of plastic purchases, but also in the waste the Company generates.

On the other hand, if we compare the efficiency between the best and the worst equivalent pallet, the Company could achieve a reduction of 71,800 equivalent pallets per year in handling, storage and transport throughout the supply chain.

In fact, depending on the capacity of transport, one of the alternatives supports the reduction of up to 230 trucks per year. Obviously, this reduction in the number of trucks implies a reduction in the transports costs, but additionally, also implies a reduction in the CO₂ emissions. According to the EERE (The Office of En-

ergy Efficiency and Renewable Energy in USA), this emissions could be estimated around the 332 tonnes of CO₂ per year (considering a return trip of a truck of 1,200 kilometres).

Obviously, not only logistics and sustainable requirements should be applied to packaging design, for example, commercial requirements (in some times the most important one, especially in retail supply chains). However, all the requirement could and should be valued from an overall perspective and the methodology adopted reinforces the interest of implementing the "Benchmarking" technique for comparing different packaging alternatives in order to identify some improvement actions.

Likewise, the results of this analysis underlines the need to consider and understand all the requirements and costs as a whole, from a sustainable supply chain perspective but without forgetting the needs and trends of the market (for example, communication, attraction, branding, convenience, ergonomics, traceability or selling). This last statement implies to combine quantitative and qualitative analysis in the selection of the best alternative.

This paper may be of interest both for researchers and professionals, mainly because the adoption of the "benchmarking" technique can aid companies to identify alternatives of improvement in packaging design, not only from a logistic and environmental perspective, but also from a commercial point of view. Thus, for professionals who wish to gain a competitive advantage, this paper explains in detail how it is possible to implement an easy and quantitative analysis of different packaging alternatives (with pros and cons).

The paper's basic limitations arise from its reduced empiric base due to its sole focus on a limited number of references, brands and retail channels. As it is commented previously in the methodology section, the selection of the sample is considered reasonably representative, although, future studies could require a wider empiric base (even with a wider geographical base) in order to validate the technique from an overall point of view.

Likewise, this paper provides a new vision for researchers in relation to the implementation of the "Sustainable Packaging Logistics" concept. Anyway, the search must continue for new or improved measuring methods which would simplify the selection process for efficient and sustainable alternatives of packaging.

References

- AECOC (2007), "RAL. Recomendaciones AECOC para la Logística. Embalaje Listo para Vender. SRP – Shelf Ready Packaging". Edited by AECOC (Barcelona), Spain.
- AECOC (2012), "RAL. Recomendaciones AECOC para la Logística. Unidades de Carga Eficientes". Edited by AECOC (Barcelona), Spain.
- Alcaraz, J. (2014). "Optimización del envase y embalaje: del diseño al final de línea". Conference Empack 2014 (Madrid).
- Azzi, A., Battini, D., Persona, A. and Sgarbossa, F. (2012), "Packaging Design: General Framework and Research Agenda", *Packaging Technology and Science*, No. 25, pp. 435–456.
- Ciliberti, F., Pontrandolfo, P., and Scozzi, B. (2008). "Logistics social responsibility: Standard adoption and practices in Italian companies". *International Journal of Production Economics*, 113(1), pp. 88-106.
- European Commission (1994), Directive 94/62/EC on packaging and packaging waste, Brussels.
- European Commission (2004), Directive 04/12/EC on packaging and packaging waste, Brussels.
- García-Arca, J. and Prado-Prado, J.C. (2008). "Packaging design model from a supply chain approach". *Supply Chain Management: An International Journal*, 13(5), pp. 375-380.
- García-Arca, J., Prado-Prado, J.C. and González-Portela Garrido, A.T., (2014, a) "'Packaging logistics': promoting sustainable efficiency in supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 44 Iss: 4, pp.325 – 346.
- García-Arca, J., González-Portela Garrido, A.T. and Prado-Prado, J.C. (2014, b). "Packaging as source of efficient and sustainable advantages in supply chain management. An analysis of milk cartons". *International Journal of Production Management and Engineering* Vol 2 (1), 15-22.
- García-Arca, J., González-Portela Garrido, A. T. and Prado-Prado, J. C. (2016). "'Packaging Logistics' for improving performance in supply chains: the role of meta-standards implementation". *Production*, 26 (2), pp.261-272.
- García-Arca, J., González-Portela Garrido, A. T. and Prado-Prado, J. C. (2017). "Deploying "Packaging Logistics" in paper napkins". Chapter in the book "Engineering Systems and Networks", edited by Springer (London).
- Gelici-Zeko, M. M., Lutters, D., Klooster, T. R. and Weijzen, P. L. G. (2012). "Studying the influence of packaging design on consumer perceptions (of dairy products) using categorizing and perceptual mapping". *Packaging Technology and Science*, 26(4), 215-228.
- Hellström, D. and Saghir, M. (2006). "Packaging and logistics interactions in retail supply chain". *Packaging Technology and Science*, 20, pp. 197-216.
- Hellström, D. and Nilsson, F. (2011). "Logistics-driven packaging innovation: a case study at IKEA", *International Journal of Retail & Distribution Management*, 39 (9), pp.638 - 657
- Hortal, M. (2014). "Sostenibilidad en envases y su impacto en la cuenta de resultados de la empresa". Conference Empack 2014 (Madrid).
- Jönson, G. (2000). "Packaging Technology for the Logistician", 2nd ed., Department of Design Sciences, Division of Packaging Logistics, Lund University (Sweden).
- Kleivas, J. (2005). "Organization of packaging resources at a product-developing company". *International Journal of Physical Distribution & Logistics Management*. 35 (2), pp. 116-131.
- Landschützer, C., Ehrentraut, F. and Jodin, D. (2015). "Containers for the Physical Internet: requirements and engineering design related to FMCG logistics". *Logistics Research*, 8(8), pp. 1-22.
- Lindh, H., Williams, H., Olsson, A. and Wikström, F. (2016). "Elucidating the Indirect Contributions of Packaging to Sustainable Development: A Terminology of Packaging Functions and Features". *Packaging Technology and Science*, 29, pp 225–246.
- Magnusson, A., Olander, M. and Olsson, A. (2012). "Finding Methods for Innovative Packaging Development: The Card Approach". Edited by University of Lund (Sweden).
- Montreuil, B., Meller, R. D. and Ballot, E. (2010). "Towards a Physical Internet: the impact on logistics facilities and material handling systems design and innovation". *Progress in material handling research*, 305-327.

- Olander-Roase, M. and Nilsson, F. (2009), "Competitive advantages through packaging design- prepositions for supply chain effectiveness and efficiency", International Conference on Engineering Design, ICED 2009 (Stanford University, USA), pp. 279-290.
- Pålsson, H. and Hellström, D. (2016). "Packaging logistics in supply chain practice – current state, trade-offs and improvement potential". *International Journal of Logistics Research and Applications*, 19 (5), pp. 1-18.
- ProEurope, (2012). "Effective packaging—effective prevention". Edited by ProEurope (Brussels).
- Rundh, B. (2016). "The role of packaging within marketing and value creation". *British Food Journal*, 118 (10), pp. 2491 – 2511.
- Saghir, M. and Jönson, G. (2001), "Packaging handling evaluation methods in the grocery retail industry". *Packaging Technology and Science*, 14, pp. 21–29.
- Saghir, M. (2002). "Packaging Logistics Evaluation in the Swedish Retail Supply Chain", Edited by University of Lund (Sweden).
- Sohrabpour, V., Oghazi, P. and Olsson, A. (2016). "An Improved Supplier Driven Packaging Design and Development Method for Supply Chain Efficiency". *Packaging Technology and Science*, 29, pp. 161–173.
- Svanes, E., Vold, M., Møller, H., Pettersen, M. K., Larsen, H. and Hanssen, O. J. (2010), "Sustainable packaging design: a holistic methodology for packaging design", *Packaging Technology and Science*, Vol. 23, pp. 161–175.
- Verghese, K. and Lewis, H. (2007). "Environmental innovation in industrial packaging: a supply chain approach". *International Journal of Production Research*, 45(18-19), pp. 4381-4401.
- Verghese, K., Lewis, H., Lockrey, S. and Williams, H. (2015). "Packaging's Role in Minimizing Food Loss and Waste Across the Supply Chain". *Packaging Technology and Science*, 28, pp. 603-620.
- Vernuccio M., Cozzolino A. and Michelini L. (2010), "An exploratory study of marketing, logistics, and ethics in packaging innovation", *European Journal of Innovation Management*, 13(3), pp. 333–354.
- Yin, R.K. (2002). "Applications of Case Study Research", Thousands Oaks: Ed. Sage Publications.