

Packaging design for competitiveness. Contextualizing the search and adoption of changes from a sustainable supply chain perspective

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Abstract:

The “*Sustainable Packaging Logistics*” (SPL) approach seeks sustainable integration of the combined “packaging-product-supply chain” system orientated to increase competitiveness. However, characterizing which changes make it possible to guide such design in each company and supply chain is an aspect that has not been covered in the literature from different supply chain perspectives. The main goal of this paper is to identify and justify the main actions for improvement in SPL, combined with a proposal of methodology for contextualizing, selecting and implementing each of these potential actions, applying the “Action Research” approach. Likewise, this paper illustrates the interest of this methodology with its adoption in four different companies and supply chains. This paper opens up new avenues of applied research in packaging design, generating knowledge that contributes to sustainable and competitive improvement.

Key words:

Packaging, sustainability, logistics, supply chain.

1. Introduction

The rational, fair and balanced use of the planet’s scarce resources is a growing concern in today’s society, a concern that companies should reconcile with their natural and legitimate search for efficiency and profitability. Thus, the adoption in the management of business activities of a sustainable approach (in its triple perspective, economic, environmental and social) is no longer a voluntary matter but has become an unavoidable requirement of competitiveness.

Logically, in this general context, among all these business activities, productive and logistical ones stand out and a true reflection of this is that the concept of a sustainable supply chain arouses ever more interest in business and academic forums (Nilsson & Christopher, 2018).

In the promotion of this sustainability in companies and supply chains, one of the elements that cuts across the board to generate more impacts is packaging design. Thus, depending on how this design is developed, a greater or lesser impact can be generated, not only at the commercial level, but also at the level of inefficiencies or losses (“waste” in terms of *Lean Management* or *Kaizen* cultures) in the different productive and logistic processes throughout the supply chain.

This waste includes product breakages, setups and rejects in packing processes, large clearances in packaging (including load units) or excessive consumption of raw materials (and excessive generation of waste) (Hellström & Saghir, 2007; Svanes et al., 2010; Azzi et al., 2012; Sohrabpour et al., 2012, 2016; Wikström et al., 2019; García-Arca & Prado-Prado, 2020).

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To complete this strategic importance, it should also be noted that, in many cases, the packaging itself is a relevant source of innovations (García-Arca et al., 2019; Hellström & Nilsson, 2011; Lindh et al., 2016; Verghese & Lewis, 2007; Vernuccio et al., 2010).

In this context, two decades ago the term “*Packaging Logistics*” was coined in academic circles. It sought efficient integration of the combined system “packaging-product-supply chain” orientated to gain competitive advantages (Saghir, 2002; Regattieri et al., 2019); that framework was later extended to promote improved behavior in sustainability in firms and supply chains with the “*Sustainable Packaging Logistics*” approach or SPL (García-Arca et al., 2014a).

Beyond the definition of its fundamental pillars, recent literature has identified some examples of actions for improvement related to packaging design. Some of these sources illustrate these actions through the analysis of case studies (for example, Hellström & Nilsson, 2011; Pålsson et al., 2013; Kye et al., 2013; Bertoluci et al., 2014; García-Arca et al., 2014b; Molina-Besch & Pålsson, 2020) or exploratory studies (for example, Pålsson & Hellström, 2016; García-Arca et al., 2017, 2019; Coelho et al., 2020). However, in the literature there is not a methodology that allows the interest and priority of each improvement action to be contextualized in a more general and universal perspective.

Therefore, in this paper, the first goal is to identify and justify the main potential actions for improvements in the realm of SPL. To achieve this goal, a literature review is carried out, combined with a proposal of methodology for contextualizing, selecting and implementing each of these potential actions, by using the “*Action Research*” approach (Näslund et al., 2010; Coughlan et al., 2016; Prado-Prado et al., 2020). The paper also goes beyond the purely theoretical to show that potential by developing this methodology in four different companies and supply chains.

2. Systematizing the adoption of improvements in packaging design

The many faces and the impacts of the design restrictions and aspects that packaging must satisfy can be understood under a sustainable perspective (economic, environmental, and social). Those design restrictions and aspects are placed on very different

planes and have very different needs. They include, for example, marketing, protective considerations, production, logistics, purchasing, the environment, ergonomics, legal aspects, or communication (Azzi et al., 2012; Garcia-Arca et al., 2019, 2021b; Lindh et al., 2016; Molina-Besch & Pålsson, 2020; Pålsson & Sandberg, 2020, 2021; Rundh, 2016).

Nevertheless, it is not enough just to understand and internalize the many requirements that packaging must satisfy, because it is also important to know the structure of the packaging system, which is often organized in three interconnected layers: primary, secondary, and tertiary (García-Arca et al., 2020).

In this way, it is possible to distinguish a first layer (primary packaging) that is directly in contact with the product; a secondary packaging, which groups several units of primary packaging (for example, a box); and a tertiary packaging, which groups together several units of secondary packaging in order to typically facilitate handling, transport and storage operations (for example, a pallet). This structure endows the packaging with a systemic character, which means that its performance must be analyzed from an integrated point of view of the whole product-packaging-supply chain, since the design requirements are not distributed homogeneously in each one of the layers, affecting each production-logistic process, company or organization throughout the supply chain in a different way.

Simultaneously, the decisions of the packaging design process (dimensions, materials, aesthetic, etc.) are linked to the area, department or company that is especially affected by them, highlighting the importance of a suitable organizational structure based on multifunctional teams for applying an integrated vision of design.

Therefore, this organizational structure, based on multifunctional teams, should include people from different departments (commercial, productive, logistic, quality and so on) and companies (packaging suppliers, factories, retailers, 3PL or Third Party Logistics, packing machines suppliers, etc.) affected by packaging design. Likewise, the organizational structure should develop a “*dynamic*” perspective in this design process (Olander-Roese & Nilsson, 2009).

When such “*dynamic*” integration is envisaged, not only is it easier for numerous design options to appear, but also the decision-making method becomes more

objective, agile and consensual. For this reason, this coordinated and dynamic organizational approach could be considered a critical aspect that contributes actively to the implementation of a culture of continuous improvement in companies and supply chains, which undoubtedly also contributes to increasing competitiveness. This is what is proposed in the “Sustainable Packaging Logistics” approach.

Thus, [García-Arca et al. \(2014a\)](#) fit and extend the “Packaging Logistics” concept proposed by [Saghir \(2002\)](#) to the scope of sustainability, developing the term “Sustainable Packaging Logistics” (SPL) with the following definition: “*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*”.

What that means, therefore, is the integration of packaging design in the first stages of the product and supply chain design, with a “dynamic” perspective so that it can adapt at all times not only to the different perspectives of the design restrictions that each part of the supply chain appraises but also to the changes that can arise in the design restrictions themselves or in the environment (technological, legal, etc.).

The new SPL approach would radically shift how people see the way packaging-product-supply chain design is done towards a vision more in tune with “*ecodesign*” or the “*circular economy*”, in line with the UN’s Agenda 2030 aims ([De Koeijer et al., 2017a,b](#); [Wikström et al., 2019](#); [Molina-Besch & Pålsson, 2020](#)).

In order to deploy a SPL strategy with impact in the three pillars of sustainability, three aspects appear as significant ([García-Arca et al., 2017](#)):

- The identification of restrictions in the packaging design process;
- The adoption of an assessment system with a set of KPIs (Key Performance Indicators) for valuing and comparing different alternatives in packaging design;
- The implementation of an organizational structure (based on multifunctional teams) for identifying, testing and validating these alternatives.

Thanks to the adoption of these three pillars linked to SPL, an innovative and “dynamic” vision of packaging design is implemented. This area of changes, innovations or “best practices” would include the lines for improvement which have already been successfully implemented by other companies ([García-Arca & Prado-Prado, 2008](#)). In this context, the scientific literature provides these improvement lines, innovations or “best practices”.

Thus, a content analysis ([Seuring & Gold, 2012](#)) was used to carry out a bibliographic review to identify these improvements. This process involved an initial systematic search among papers in English from academic journals published from 2011 to 2021 and ranked in Scopus. The search criteria were based on different combinations of terms related with three main ideas: first, sustainable packaging design; second, sustainable logistics or supply chains; third, improvement, innovation or “best practice”.

The results of this initial search were refined through the abstract review. After selecting the papers with the greatest connection with the objective, a forward and backward snow-balling strategy was applied to prevent any relevant paper not being identified. This process led to a selection of 35 papers.

After applying this strategy, a detailed analysis of these 35 papers was developed in order to define the main improvements, changes or “best practices” related to sustainable packaging design. [Table 1](#) summarizes nine alternatives of improvement with the references extracted from literature review.

On the other hand, [Table 2](#) indicates the main potential advantages achieved with their implementation from a sustainable point of view; later, some of the most popular actions will be implemented in the four case studies and these changes are also indicated in [Table 2](#).

However, these changes, improvements, innovations or “best practices”, although they may have been successfully implemented by some companies, cannot be adopted indiscriminately without prior understanding of the constraints and requirements of the products and the supply chain (contextualization).

In this context, the authors propose a four-step methodology that adapts the proposal of [García-Arca et al. \(2021a\)](#) for selecting the best range of boxes in a company, and includes the three pillars of SPL. This methodology pursues the suitable

Table 1. Different changes/innovations for sustainable improvement in packaging design (source: authors).

Change or innovation	Main mentions in references according to literature review
1.- Dimensions	Wever (2011); Grönman et al. (2013); Wever & Vogtländer (2013); Accorsi et al. (2014); Bertoluci et al. (2014); García-Arca et al. (2014, a, b); Gámez-Albán et al. (2015); Pålsson & Hellström (2016); García-Arca et al. (2017); Zhao et al. (2017); Mumani & Stone (2018); García-Arca et al. (2019); Lu et al. (2020); Coelho et al. (2020); Molina-Besch & Pålsson (2020); García-Arca et al. (2020); García-Arca et al. (2021, a, b)
2.- Amount of product per packaging	Grönman et al. (2013); Pålsson & Hellström (2016); García-Arca et al. (2017); Krishna et al. (2017); Mumani & Stone (2018); García-Arca et al. (2019)
3.- Packaging materials	Hellström & Nilsson (2011); Sohrabpour et al. (2012); Albrecht et al. (2013); Pålsson et al. (2013); Wever & Vogtländer (2013); Accorsi et al. (2014); Bertoluci et al. (2014); García-Arca et al. (2014, a, b); Regattieri et al. (2014); Pålsson & Hellström (2016); García-Arca et al. (2017); Licciardello (2017); Pålsson et al. (2017); García-Arca et al. (2019); Lu et al. (2020); Coelho et al. (2020); Molina-Besch & Pålsson (2020); García-Arca et al. (2020)
4.- Change in the way of packing	Hellström & Nilsson (2011); Pålsson et al. (2013); Wever & Vogtländer (2013); Bertoluci et al. (2014); Faccio et al. (2015); García-Arca et al. (2017); Mumani & Stone (2018); García-Arca et al. (2019)
5.- Number of primary units per secondary or tertiary packaging	Hellström & Nilsson (2011); Sohrabpour et al. (2012); Grönman et al. (2013); Kye et al. (2013); Pålsson et al. (2013); García-Arca et al. (2014, a, b); Gámez-Albán et al. (2015); McDonald (2016); Pålsson & Hellström (2016); García-Arca et al. (2017); Pålsson et al. (2017); García-Arca et al. (2019); Lu et al. (2020); Molina-Besch & Pålsson (2020); García-Arca et al. (2020); García-Arca et al. (2021, b); Sternberg & Denizel (2021)
6.- Standardization (dimensions, formats, qualities)	Grönman et al. (2013); Kye et al. (2013); García-Arca et al. (2014, a, b); Regattieri et al. (2014); Faccio et al. (2015); McDonald (2016); García-Arca et al. (2017); Zhao et al. (2017); García-Arca et al. (2019); García-Arca et al. (2020); García-Arca et al. (2021, a, b); Sternberg & Denizel (2021)
7.- Elimination of “overpackaging” (excessive materials, size and/or protection)	Hellström & Nilsson (2011); García-Arca et al. (2014, a, b); Regattieri et al. (2014); Krishna et al. (2017); Licciardello (2017); Pålsson et al. (2017); García-Arca et al. (2019)
8.- Returnable packaging	Levi et al. (2011); Albrecht et al. (2013); Kye et al. (2013); Pålsson et al. (2013); Accorsi et al. (2014); García-Arca et al. (2017); Bortolini et al. (2018); Accorsi et al. (2019); García-Arca et al. (2019); Accorsi et al. (2020); Coelho et al. (2020)
9.- New graphic design	Gelici-Zeco et al. (2012); Sohrabpour et al. (2012); Grönman et al. (2013); Pålsson & Hellström (2016); García-Arca et al. (2017); Krishna et al. (2017); Mumani & Stone (2018); García-Arca et al. (2019)

contextualization of the needs, restrictions and requirements of each company and supply chain in order to value the interest and priority of each potential implementation.

In this process of analysis and implementation the researchers participate directly under an “Action Research” approach, coordinating the adoption of the actions through multifunctional work teams.

Through this direct involvement, researchers can not only know first-hand the problem to be solved, but are also in a better position to provide an external, clean and different vision of the needs and possibilities of each potential improvement. Along these lines, the role of these researchers is also to generate reflection and knowledge that can be extrapolated or adapted

to other problems and environments. Thus, the four steps of the methodology are:

Step 1. Structuring the process of packaging design. This step includes the definition of a multifunctional work team for contextualizing needs and priorities and identifying design requirements. This team is coordinated by the researchers following the “Action Research” approach.

This team is also responsible for proposing an assessment system for evaluating design alternatives from a sustainable perspective (particularly, economic and environmental; for example, costs, filling rate in packaging and load units, environmental impact, waste reduction).

Table 2. Impact of changes/innovations regarding packaging design in sustainability (source: authors).

Change or innovation	Main impact on the economic axis of sustainability	Main impact on the environmental axis of sustainability	Main impact on the social axis of sustainability	Implementation in case studies
1.	Packaging purchase cost. Logistics costs.	Consumption of raw materials and waste generation. Energy consumption and contamination (transport)	Help in use, ergonomics, and dosage for the needs of different final customers	A, B, C
2.	Packaging waste management costs	Recyclability. Valorization.		D
3.	Packaging purchase cost. Packaging waste management costs	Consumption of raw materials, energy, and waste generation. Energy consumption and contamination (transport)	Help in use. Perception of product quality	A, B, C
4.	Packing cost. Cost of deteriorated products or rejections. Waste management costs	Waste generation (in production). Energy consumption in packing activities	Help in use and lengthening useful life of product. Perception of product quality	A, B
5.	Packaging purchase cost. Logistics costs. Packaging waste management costs. Consumption point handling cost.	Consumption of raw materials and waste generation. Energy consumption and contamination (transport)	Help in use, ergonomics, and dosage of product for the needs of different customers on the supply chain	A, B
6.	Packaging purchase cost. Production cost. Waste management costs		Communication (“visibility”). Perception of product quality	B, C, D
7.	Packaging purchase and logistics costs. Packaging waste management costs. Handling cost.	Energy use (production). Consumption of raw materials and waste generation. Energy consumption and contamination (transport)	Help in use. Perception of product quality	A, B, C, D
8.	Packaging purchase cost. Logistics costs. Packaging waste management costs		Help in use. Perception of product quality	D
9.	Packaging purchase cost	Consumption of raw materials and waste generation	Help in use. Communication (“visibility”). Perception of quality	A, B

Step 2. Searching for potential changes and improvements in packaging design. The team explores new packaging alternatives and these alternatives are selected from the general list of actions mentioned previously (see Table 1).

Logically, the interest and priority of each action is based on the fulfillment of the packaging design requirements and the understanding of the supply chain and market needs (contextualization).

Step 3. Proofs, selection and adoption. To ensure a correct selection and development of design options, the following four phases are followed:

- An evaluation of the different alternatives thanks to the KPIs system adopted.

- “Artisanal” proofs for new design options (with internal “artisanal” packaging samples) including new ways of product placement inside them. “Industrial” proofs with packaging samples; these samples are supplied by packaging suppliers;
- After these two phases of proofs, the work team decides the best changes in packaging design to implement.

Step 4. Monitoring and improvement; Due to potential changes in initial design requirements (for commercial, technological, social, logistic or legal reasons, for example), it would be recommendable to establish a monitoring system to improve the initial packaging design for adapting it to the new needs. This step supports the “dynamic” perspective

commented previously, closing a PDCA cycle. In this final step should participate again the initial work team, including the researchers.

In the next four sections, the most relevant aspects of the implementation of the proposed methodology in four companies are presented. In order to obtain a broad view of the applicability of the methodology, the authors have selected companies from different sectors and supply chains, including two in the retail sector (case A, a pizza maker and case B, a fishery product manufacturer) and two in the industrial sector (case C, a street furniture supplier and case D, an automotive supplier).

In these teams, at least one of the authors participated directly, although with different involvement and duration depending on the company and the target of each project.

3. Case A. Pizza maker

This food company is devoted to producing frozen products. Its workforce is around 100 people and its yearly turnover is around 50 million euros. Its main activity is frozen pizza production.

The work team included two of the authors, the production manager, the logistics manager and a purchasing technician. The intervention process was divided into three different periods of six months each, spread over 6 years.

The contextualization of the problem can be summarized in that the pizza has little added value and little density (a full pallet can weigh less than 200 kilos), which means logistics costs can be up to 25% of overall costs. Likewise, a better pallet efficiency implies a reduction in environmental impact of transport.

Improvement of the pallet efficiency is thus a key factor for competitiveness. For this reason, the basic KPI adopted to evaluate the improvement is the number of kg per pallet.

Initially, the packaging system at the firm was based on an individual cardboard box (35 mm. height; primary packaging), grouped 12 by 12 in corrugated cardboard boxes (secondary packaging); these boxes were palletized on EUR pallets (49 boxes per pallet; 176.4 kg. per pallet; tertiary packaging).

In order to improve this pallet efficiency some conceptual changes could be adopted, such as dimensions (1), packaging materials (3), packing system (4), number of primary packaging per each secondary packaging (5), elimination of “overpackaging” (7). Additionally, any change in primary packaging could support changes in image and graphic design (9).

However, other conceptual changes were discarded: the amount of product per primary packaging (2), as it affects the needs identified by the customers; the standardization (6), as the initial level was good and a greater level of standardization could affect the improvement of pallet efficiency; the adoption of a returnable secondary packaging (8), as the high number of collecting points in the retail supply chain of the firm makes it difficult to implement without increasing the reverse logistics costs.

In the first period of intervention, after an analysis of product positioning in the primary packaging and some preliminary tests, it was concluded that its height could be lowered from 35 mm. to 31. This modification meant the secondary box dimensions could be adjusted to add another layer on the pallet (from 7 to 8 layers; see Figure 1) without exceeding the height restrictions set by the supply chain.

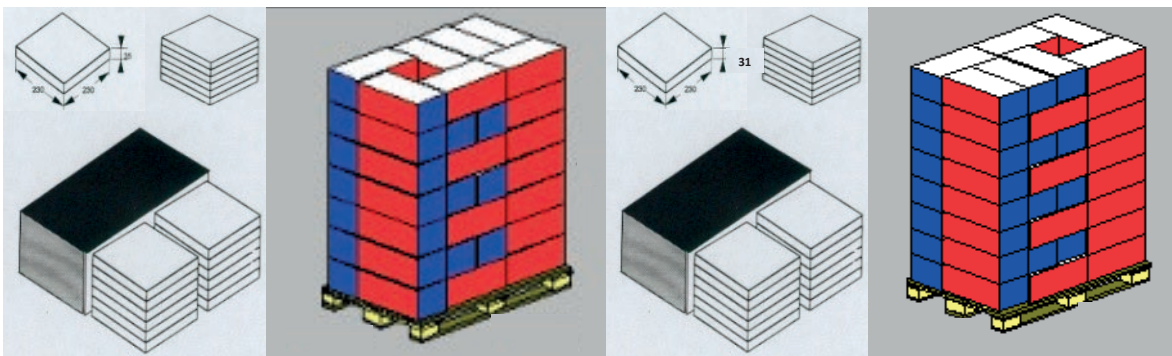


Figure 1. Initial situation (left) and improvement (right) in the pizza packaging system (source: authors).

Curiously, this height reduction demanded a change in some of the pizza topping ingredients; for example, whole olives were swapped for sliced olives.

The combination of all these changes led to a better pallet capacity of 14.28% (from 176.4 kg. per pallet to 201.6 kg.), achieving an important logistics saving (including savings in the cost of both box types as they were smaller, as well as waste reduction from the boxes).

Some years after, in a second period of intervention, the work team focused on eliminating the initial cardboard box (secondary packaging) and substituting it for a shrink-wrap plastic pack. The alternative was to use the shrink-wrap pack as a grouping agent to substitute the secondary box, using a stronger individual box (primary packaging) of heavier cardboard (more expensive).

At the same time, eliminating the initial cardboard box brought added economic benefits, not only because of the better use of pallets but also because the costs associated with it were eliminated (savings that were greater than the cost of the shrink-wrap pack, amortization of the shrink-wrapping equipment and even the increased environmental costs of the plastic used).

At first, a study of the plastic pack was carried out with the individual boxes placed horizontally in the palletization pattern (the initial distribution; boxes stacked in the plastic pack, see [Figure 1](#)). However, improvements in pallet efficiency were not found.

Later, the potential of vertical palletization of these individual boxes was studied. This study enabled improvement in not only the efficiency of pallet (13.67%) and strength in the individual box compression (which allows changes in the type of raw material in the primary packaging and its cost), but also the stability of the pallet.

However, this last proposal presented, a priori, two major drawbacks: the pizzas could bend if the temperature in any step of the supply chain dropped too much and the topping could fall off because of the movement and handling during transport. Both incidents could lead to deterioration in the image of the product on the market.

After tests with individual boxes placed vertically, it was seen that the new layout was possible as long as the cold chain was maintained throughout the whole

distribution process and the tension in the shrink-wrap plastic was also maintained in the packing process. Once these two key factors were ensured, it was feasible to implement the newly proposed format with an overall saving in materials and logistics costs (with respect to the initial packaging system) of 45%.

A third period of intervention took place some years after with the approval of the commercial department. For some products with high rotation, the number of individual boxes (primary packaging) in each shrink-wrap pack was increased (depending on the product, it was increased from 6 to 8 boxes per pack or from 8 to 10 boxes per pack). Simultaneously, in the individual box, the height was adjusted, by which pallet capacity was increased by up to 14% (on the improvements already obtained in the two previous stages).

In addition, the company took advantage of each period of intervention to update the image and graphic design that appeared on the primary packaging. The evolution of the packaging system for this product family is a good example of how the design process must be tackled dynamically to adapt to the needs and opportunities that arise in the environment and in the market.

4. Case B. Fishery product manufacturer

The second case focuses on a food firm, specialized in production of pre-cooked products derived from fish and cephalopods. This firm processes around 30 000 tons a year.

The work team included two of the authors, the firm director, the industrial manager, the purchasing manager and a production technician. The intervention process was divided into three periods of six months each, spread over five years. Initially, the packaging system was based on two types of boxes: an individual one (primary packaging) and a cardboard box (secondary packaging). The logistics systems used is based on EUR pallets (800×1200 mm, tertiary packaging).

The contextualization of the problem can be summed up as the general need to reduce production and logistics costs in order to be more competitive. This double target implies working simultaneously in two directions: higher packing process efficiency and

higher pallet efficiency. Likewise, both directions lead to a reduction in environmental impact of production and transport (energy consumption and pollution generation). For this reason, the basic KPIs adopted to evaluate the improvement were the number of kg. per pallet and the reduction of hours in setups.

In order to move in these two directions some conceptual changes could be adopted. From a pallet efficiency perspective, most of these changes were related to dimensions (1), number or primary packaging per each secondary packaging (5) or elimination of “overpackaging” (7).

On the other hand, from a productive perspective, most changes could be related to the packing system (4), with or without changes in materials (3) and, particularly, standardization (6), as a reduction of packaging formats implies a reduction of setups in packing machines or lines. Likewise, any change and update in primary packaging could support changes in image and graphic design (9).

Again, two conceptual changes were discarded by the work team for similar reasons as case A: the amount of product per primary packaging (2), and the adoption of a returnable secondary packaging (8).

In the first period of intervention, the firm focused on improving pallet efficiency, substituting the cardboard boxes that grouped the primary boxes with shrink-wrapped plastic packs and, for some products, increasing the number of primary packaging per each secondary packaging. Thanks to these actions, an average improvement in the quantity of kg per pallet of 22% was achieved. As a whole, this generated logistics savings (handling, storage, and transport) and materials savings (cardboard), which far exceeded the cost of the new wrapper (including the plastic material themselves and a stronger quality of individual boxes).

Some years after, in the second period of intervention, the work team proposed going forward in packing process efficiency with the standardization of the dimensions of the primary packaging bases (individual boxes) because, by doing so, they could reduce the number of tools (“*dies*”) used for conforming and closing in the packing process, in order to optimize the number of line setups. Therefore, this standardization meant improvements in production performance as it reduced the

number of stops on the manufacturing line (which had previously caused a bottleneck there) without decreasing, but rather increasing, the flexibility of the lines.

Initially, the firm had two production lines (A and B) devoted to producing six different products (two products in line A, and four products in line B) with six different dies (a different die base for each product).

After the trials, standardizing the bases of the individual boxes (primary packaging) was seen to be viable. In order to carry out the standardization proposed, the possibility of rapidly adjusting the height of the box closure without changing the die was taken advantage of.

However, the dimensional changes in primary packaging that allow a higher level of standardisation (with greater production efficiency by reducing the number of setups required), could also be associated with losses in the overall efficiency of palletisation (given that standard primary packaging may not adapt as well volumetrically to the product as a more specific one). Logically, these dimensional design decisions also condition the total amount of cardboard consumed (and its associated waste) in each primary packaging.

Therefore, in this analysis, different dimensional alternatives arise with their pros and cons in terms of production and palletising efficiency. To illustrate this complexity, [Table 3](#) shows two of the alternatives contemplated by the work team in which the level of standardisation achieved (with its reduction in annual setup hours compared to the initial situation), the range of improvement in palletisation (compared to the initial situation) and the total savings achieved (productive and logistical) can be seen.

After evaluating the different alternatives and carrying out the tests described in the methodology, the work team decided in favour of the second of the options described in [Table 3](#), which not only allows a higher level of overall savings, but also a higher level of production flexibility, as only one type of die base is needed to be able to package any of the six products involved, regardless of the line on which it is produced.

In some cases, redimensioning the primary packaging could also involve changes in the placement of the product. [Figure 2](#) shows an example with hake slices

Table 3. Comparison of annual savings according to the number of dies.

	Productive Line	Different dimensional bases in dies	Range of improvement in pallet efficiency (different products involved)	Annual reduction in hours of setups	Annual savings
Proposal 1	Line A	1	10%-19%	300	73,000 euros
	Line B	1	9%-21%	300	
Proposal 2 (final implementation)	Line A	1	4%-15%	900	85,000 euros (only one dimensional base in dies on both lines)
	Line B		5%-17%		

in which, thanks to the new positioning, logistics savings were achieved (improved pallet occupation by 12%) with additional savings in materials consumption (less cardboard was used and less waste generated).

Some years after the implementation of the standardization program, in the third period of intervention, the firm once again re-thought its packaging system to return to the corrugated cardboard box, adjusting primary packaging to avoid losses in pallet efficiency, but without affecting die standardization.

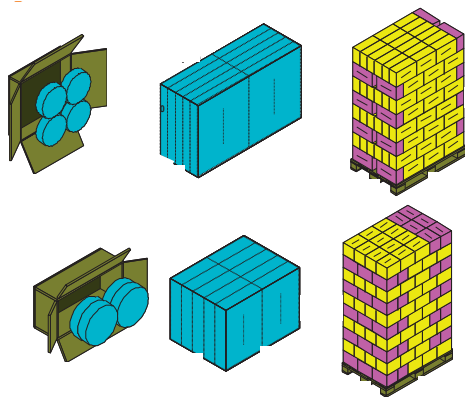


Figure 2. Improvement in hake slice. Initial situation (top) and improvement (bottom) (source: authors).

This new approach responded to several considerations: on the one hand, to increased production line automation that allowed adjustment of slack in the boxes; and on the other hand, to increase automation in internal and external storage (the shrink-wrap pack presented more rejections when handled automatically); finally, it responded to increased pressure from the firm's main customers to reduce plastic use for environmental reasons.

As for the previous case, the company took advantage of each period of intervention to update

the image and the graphic design that was visible on the primary packaging.

The changes of the packaging system for these products illustrates again how the design process must be tackled dynamically.

5. Case C. Street furniture supplier

The third case is developed in a firm that manufactures street furniture and games for children and adults with a wide diversity of components and sets, both standard and tailored. It presents a yearly turnover of around 12 million euros with a growing importance in international sales.

The work team included one of the authors, the operations director, and a purchasing technician. The intervention process lasted four months.

The initial packaging system included 10 formats of cardboard box and different types of large wooden crates used for exporting equipment and sets (see Figure 3). The selection of packaging in each shipment depended on the type and number of products, as well as the final destination. Inside these wooden crates, cardboard sheets were used to protect and separate the different components. Transport used EUR pallets (800×1200 mm.) and intermodal containers for export.

The contextualization of the problem can be summed up as the general need to reduce packaging costs and logistics costs (improving space occupation) in order to be more competitive in an international context, but ensuring product protection.

Likewise, both costs strategies lead to a reduction in the environmental impact of each shipment (energy consumption and pollution generation). For all these reasons, the basic KPIs adopted to evaluate the

improvement were the packaging material cost per shipment and the filling rate in boxes, pallets and containers.

In order to go forward in these two directions some conceptual changes could be adopted: from dimensions (1) and materials (3) to standardization (6) and elimination of “overpackaging” (7).

However, due to the different products involved in each shipment (type and number), no special analysis was needed to put a value on changes in the amount of product per packaging (2) or the number of primary packaging per each secondary packaging (5). Likewise, due to the low number of shipments and the high diversity of products, no alternative for easy and efficient automation in the packing process was developed, although some new methods or criteria in manual packing could be considered (4).

On the other hand, due to the various international destinations of shipments, the implementation of a returnable system for secondary packaging was discarded (8).

Finally, as the company operates in the industrial sector, image and graphic design are not so critical from a commercial perspective (9).



Figure 3. Example of initial wooden crate (source: authors).

An analysis made by the work team highlighted generalized poor use of volumetric space in the cardboard boxes (depending on the product being packaged, this wasted space could vary between 20 and 60 per cent; see an example in Figure 4).

Simultaneously, it was noted that the wooden crates were too heavy and strong for the function and use the firm needed from them. Finally, it was identified that organizationally there were no clear criteria for selecting the packaging and placing the components

in it, which did not facilitate good use of the packaging resources.



Figure 4. Examples of the poor use of volumetric space in boxes (source: authors).

In this context, the firm has redimensioned the cardboard boxes and also reduced the number of formats (from 10 types to 5). This format standardization meant a 50% reduction. This two-fold change allowed the firm to reduce the cost of purchasing boxes (increased buying volume and more efficient boxes). Likewise, it has improved the criteria for selecting and for placing the components and sets, both in the cardboard boxes and in the wooden crates.

The wooden boxes have been structurally redesigned to “lighten” both their weight and cost (adjusting the board type and number). In parallel, the size of the cardboard sheets has been adjusted to the size of the crate. Logically, all these changes have been applied without affecting the performance of the packaging in terms of protection and logistics.

With the implementation of all these actions, savings of 33% have been achieved in cardboard box purchases, 30% in wooden crates, and 12% in the cardboard sheets in each shipment. At the same time, the improved use of the space within the boxes and crates (15% in average) has also led to major savings in terms of handling and, particularly, transport.

6. Case D. Automotive supplier

The last case was developed in a firm making components for the automotive sector, specialized in the manufacture and integration of specific plastic and metal parts that together form the framework for a vehicle seat or some of its components. The

Spanish factory, where the project is developed, has a workforce of more than 500 and supplies components to 10 car assembly factories in Spain.

The work team included one of the authors, the production director, the quality director and a logistics technician. The intervention process was developed over a period of six months.

The initial packaging system included returnable “box-pallets” (type unit, measuring 1000×1200 mm. the base and 980 mm. the height), plastic boxes and cardboard boxes (modular system 600×400 mm. in bases of boxes). The aim of rationalizing the packaging system was to improve the efficiency and sustainability of the operations undertaken during handling (wrapping and unwrapping), storage and transport. Transport was based on the American pallet (1000×1200 mm.). Likewise, any change in the packaging system should ensure product protection and quality. The basic KPI adopted to evaluate the improvement was the filling rate in boxes and pallets.

In order to go forward in this aim, the company wanted to maintain the packaging system adopted previously (both returnable (8) and cardboard) without changing dimensions (1), materials (3) and packing process (4), as this initial packaging system was also used by other factories outside Spain. So, in all factories of the company, a standardization program of the packaging system had been developed previously (6).

In this context, other conceptual changes could be adopted: amount of product per packaging (2) and elimination of “overpackaging” (7) in terms of over protection. As there was no primary packaging in the system, the alternative 5 (increasing the number of primary packaging per secondary packaging) was not feasible.

Finally, as the company operates in the industrial sector, image and graphic design are not so critical from a commercial perspective (9).

After the analysis and trials, in the packaging system for small pieces, improvements of between 20 and 50% of pieces per box were implemented, depending on the product. The main line of improvement work was to rethink how parts were placed in the box (from flat piles to vertically on edge; see an example in Figure 5). This was done, furthermore, without questioning the dimensions of the parts or of the returnable plastics boxes (for local or regional

customers) or the cardboard box (for international customers) with a base size of 600×400 mm.



Figure 5. Improvement in placement of small component inside the box. Initial situation (left) and improved situation (right) (source: authors).

At the same time, in the more voluminous components (the main seat framework structure) there was also an increase in the quantity of components for each palletized unit (“box-pallet”). This improvement varied between 9% and 20%, depending on the product. Again, it was only necessary to redesign how the products were placed within the “box-pallet” (improving the way the parts fitted together; see Figure 6).

These two examples were developed without altering the main dimensions of the products while at the same time, of course, ensuring product protection and quality.



Figure 6. Improvement in placement of main structures inside the “box pallet”. Initial situation (left) and improved situation (right) (source: authors).

7. Discussion

Deploying the Sustainable Packaging Logistics (SPL) approach can actively contribute to competitive improvement in supply chains and, by extension, each and every company comprising them, regardless of whether they are located in the industrial or the consumer field. This deployment should be done from a sustainable and dynamic standpoint.

When any supply chain (industrial or retail) is analyzed in detail, highly diverse initial situations

in the packaging system can appear. Thus, in some companies the changes are produced in a conscious and structured way, founded on prior experience and knowledge of the repercussions of certain decisions when designing the packaging, motivated by changes in commercial, protection, productive and/or logistics requirements.

In this way, companies and supply chains adapt their packaging design process for deploying efficiency and sustainability, behaving like “*learning organizations*”. This learning process is the focus of the proposed methodology, i.e., to understand and contextualise the interest of adopting certain changes or innovations that do not always adapt to the needs of each company and supply chain.

However, in many other companies, the relationship between packaging, product and supply chain may have been created in an anarchic, random, or unconscious fashion. Logically, in such cases, it is difficult for all the proposed alternatives to contemplate a complete, multifunctional, and objective vision of the design requirements, or an overall evaluation of the effect of some resolutions on the sustainability (and efficiency) of the supply chain they form a part of.

Some of these changes, supposedly designed as improvements, may, depending on the case, be counterproductive; in fact, many of the potential changes are interrelated, in some cases fostering the emergence of synergies and, in other cases, the emergence of negative impacts.

In order to promote the deployment of the SPL approach in companies, it would be necessary for one of the parts in the supply chain to act as its leader. That is the role of the researchers, integrated in the work teams to act as agents of change (“*Action Research*”). As a result of this evolution in the perception and interpretation of SPL, a working framework has been obtained in which solutions combining product, packaging and supply chain are identified and evaluated with a double perspective of efficiency and sustainability.

Logically, the diffusion of best practices or innovations (Tables 1 and 2) that have already been implemented with good results in other firms or in other sectors will help to enlighten, incentivize, and motivate other companies and chains, which means swifter organizational learning.

As commented previously, however, the diffusion of successful best practices, even though this may motivate the search for new alternatives in other organizations, is not, in itself, necessarily associated with their being implemented in a sure way. This claim is based on the fact that not all companies or chains are equal and, therefore, neither the design requirements nor the costs are equally important. In this context, it is critical to adopt a good system for measuring and evaluating the alternatives.

Nevertheless, one of the main difficulties when structuring and implementing a method for measuring and evaluating is associated with the problem of weighting the design requirements in an objective way and on the same scale (for example, costs, environmental impact through techniques such as Life Cycle Assessment (LCA), the customer’s perception of quality).

In practice, the above problem implies a need to combine different methods simultaneously (qualitative and/or quantitative). This process of measurement and evaluation is another key responsibility of the work team in the proposed methodology. In this field, in the four cases described here, a measurement system based mainly on the objective measurement of costs has been used. However, this is in turn enriched indirectly by the results from other scales or metrics that are connected to the costs, particularly from an environmental perspective.

For example, if the amount of material is reduced in the packaging system, (and, therefore, the quantity of waste is also reduced), the purchase cost of the material is improved; on the other hand, if palletizing efficiency is improved (with more product per pallet), there is an improvement in the firm’s environmental behavior as well as in the costs of transport, handling and storage, because fewer vehicles are used for distribution (less fuel is needed), and the contamination associated with those vehicles is also reduced.

The challenge facing organizations and chains is to shift from a passive approach in their packaging system design (a packaging alternative is launched without contemplating all its potential impacts) to a more proactive approach, that is, a launch that is, from the outset, as efficient and sustainable as possible, at least as far as the baseline restrictions at the time are concerned.

To make that shift, it would be recommendable to join packaging design into the product design itself (including its supply chain design), as in the approach proposed by SPL and the methodology. To illustrate this integrated design, it can be recalled that in three of the cases analyzed (A, B and D), the implemented improvements included changes in the arrangement of the products or even the components (for example, the type of pizza topping in case A).

In addition, this vision that integrates the design process should also be complemented by a vision that is dynamic, flexible, or capable of adapting to new conditioning or restricting factors in the commercial, logistics, legal or technological environment. This dynamic and continuous monitoring is again one of the roles of the work team.

For example, the sphere of materials and equipment suppliers is a continual source of technical solutions and novelties that can and should be considered when it comes to seeking alternatives. Examples of this continual adaptability can be found in cases A and B.

At the same time, this dynamic vision takes on more relevance when the packaging system configuration to be used with the product varies according to the makeup of the order itself (case C). Thus, this example exposes the need to search for the best combination of packages in each order, which can be selected from a previously designed range of alternatives.

This final question is related to a technical issue faced today by many companies operating in e-commerce: what is the most ideal range of packaging options and what dimensions and features are associated with it? The solution to this issue is a future challenge facing the retail market from a perspective of logistics efficiency and sustainability.

From among all the potential changes described in [Tables 1](#) and [2](#), a special mention should be made

of the impact of standardization on the packaging systems of some companies (cases B, C and D), which presented opportunities for improvement that are not only in production (such as those given in the packaging process in case B) but also in purchasing (case B again, but also with the packaging rationalization in case C). Additionally, this rationalization is key for the proposal of other alternatives that have, a priori, less environmental impact, such as the returnable packaging in case D.

8. Conclusions

This paper has presented different changes or innovations related to packaging design that can contribute to improving the efficient and sustainable management of supply chains and, in short, improve their overall competitiveness. Going beyond that, this paper has proposed a methodology for contextualizing, selecting and implementing each of these potential changes or innovations, applying the “Action Research” approach. In order to illustrate its applicability, this methodology has been applied in four different case studies. These case studies present different perspectives of the retail and industrial sectors from a “dynamic” point of view.

From a scientific point of view, this article is interesting because it opens up new avenues of research in the design (and management) of packaging. On the other hand, from an applied point of view, this article may be useful for companies and supply chains to understand and to apply actions related to packaging that promote sustainable and competitive improvement.

Likewise, the “Action Research” approach proposed in the methodology to develop, in a collaborative way, the packaging redesign in the four companies can also be mentioned as new and innovative. Thanks to this collaboration, researchers and practitioners can generate useful knowledge in the context of packaging design.

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