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"Sustainable Packaging Logistics". The link between Sustainability and Competitiveness in Supply Chains

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Abstract: Packaging is one element that can support and promote improvements and innovations in sustainable management of supply chains. This multifunctional vision has brought about the approach "sustainable packaging logistics" (SPL), which refers to the integration of packaging design, logistics management and new product development. The main aim of this paper is twofold. Firstly, to characterise the main aspects associated with SPL as a preliminary step towards constructing a conceptual model that can be validated in a quantitative way. Secondly, to carry out an exploratory study in the Spanish toy manufacturing sector in order to identify whether SPL deployment promotes changes and innovations in packaging that can lead to improved sustainability. The literature review was conducted via content analysis, and the methodology used to carry out empirical analysis was an electronic questionnaire dealing with aspects of SPL. The number of toy manufacturers participating in the study was 70. The results analysis indicates that further development of the main aspects of SPL actively contributes to better sustainable performance in almost all items considered in the study. The SPL approach is considered particularly innovative, because there is a scarcity of literature that deals jointly with packaging, logistics and sustainability from an empirical standpoint, rather than just the analysis of case studies.

Keywords: packaging; logistics; sustainability; innovation; supply chain

1. Introduction

In increasingly turbulent and volatile markets, organisations need to work twice as hard to be more competitive and to increase the competitiveness of their supply chains [1–3]. In recent years two situations have had a significant effect on the competitiveness of supply chains: on the one hand, the globalisation of supplies and sales and, on the other, the increased costs of raw materials, particularly oil.

This combination has led to an urgent need to take action to ensure maximum performance in logistical activities along the whole chain (transport, handling, storage, and production), eliminating "waste" or activities that do not add value in line with the "Kaizen" or "Lean Management" approach.

Simultaneously, different "stakeholders" (consumers, shareholders, public administrations, unions) show a growing concern for the deployment of sustainable policies in supply chain management [3–5]. The Brundtland Report formalised the concept of sustainability, based on three pillars: environmental, economic and social [6].

However, while a growing number of companies are backing the development of sustainable supply chains, many companies still limit themselves to meeting their individual legal requirements, tiptoeing around their "extended" responsibility, upstream and downstream in their supply chains. The main difficulty in extending sustainability throughout the chain is associated with a perception of

incompatibility between the search for efficiency in supply chains and the promotion of sustainable policies [3].

However, different authors show the potential impact on efficiency of adopting a sustainable supply chain in terms of environmental, economic and social development, as it saves resources, reduces waste and provides competitive advantages [5,7,8]. In this regard, the authors of this paper share the view that efficiency and sustainability are not incompatible; on the contrary, they are and should be two sides of the same coin.

In this context, packaging appears as one of the key, overarching elements that support the implementation of sustainable strategies in supply chains [9–18]. Moreover, packaging itself is a source of innovation in products, processes and materials, thereby reinforcing its strategic contribution to competitive improvement [19].

Thus, beyond packaging's traditional and essential function in product protection, it should be designed not only to differentiate the product, but also to facilitate and simplify all the logistic activities carried out along the chain, thereby reducing the overall negative impact on the environment and on society in general.

Some authors identify three main functions in packaging: a commercial one, a logistics-productive one and an environmental one [9,13,20]. Other authors have subsequently extended these three main functions to nine different sub-functions: commercial, protection, production, logistics, packaging, purchases, environmental, ergonomic and legal [14,21]. The correct integration of all of these sub-functions in the packaging design process constitutes the conceptual scope of the "Sustainable Packaging Logistics" (SPL) approach.

This paper explores the relationship between packaging design and the improvement of supply chain sustainability, both from a theoretical perspective and also applied to an exploratory study in the Spanish toy manufacturing sector.

First of all, the conceptual and applied basis of the SPL approach resulting from the literature review is developed and justified. This review will identify specific aspects of this approach which will later be analysed quantitatively in the applied study.

2. Packaging and Sustainability

As previously mentioned, the development of supply chain sustainability should be associated with the deployment of actions in the three pillars: economic, environmental and social. Therefore, adequate packaging design should contribute positively to the development of the three axes of sustainability in the supply chain, through the deployment of multiple 'dimensions' [14,22–26]. In the following section, these dimensions are briefly outlined as a preliminary step towards defining the concept of "Sustainable Packaging Logistics".

The "content analysis" technique has been used to develop this section [5,27]. The criteria for material collection involved searching for references relating to the terms "packaging", "logistics" and "sustainability" mainly in academic journals, conference papers and book chapters from 2000 to 2017. The literature review laid the foundation for the conceptual model that will later be checked empirically.

2.1. The Role of Packaging in the Deployment of Economic Sustainability

From an economic perspective, the selection of the "best packaging" is usually connected with considerations involving improved sales and reduced costs.

On the one hand, packaging should be considered as a silent or invisible "salesperson" with tangible and intangible product characteristics, promoting its degree of differentiation and subsequent sales [28]. Similarly, packaging has influence on the product's "green" image [29,30].

On the other hand, packaging should be designed to improve the efficiency of the product at a logistic and productive level. This efficiency of packaging design could be considered in terms of the impact on processes such as supplying, packing, handling, storing and transporting [11,31]. Thus, packaging would eliminate "waste" along the supply chain. Such waste could include, for example,

wasted or unused space in warehouses, transport and points of sale, use of excess materials, or product breakages [32].

Packaging design affects both direct costs (packaging purchases and waste management) and indirect costs (packing, handling, storage, transport and losses). It is precisely these indirect costs that hinder adequate understanding of the impact of certain decisions in packaging design [13].

However, this cost reduction approach can be hazardous if not considered in an integrated manner. Although "economic" packaging would be linked to a standard format with appropriate, tried-and-tested logistic efficiency, there may be a need to sacrifice some of its possibilities to be "different" and sustainable. In practice, this means that packaging design requires an analysis of the "trade-offs" between the different functions, from a supply chain perspective.

2.2. The Role of Packaging in the Deployment of Environmental Sustainability

The efficiency of packaging design should also be considered from an environmental perspective [32]. Minimising the impact of packaging design on the environment could be guided by the following, complementary lines:

- The reduction of packaging waste and raw material consumption [14,24,26,33,34],
- The promotion of returnable packaging, recycling and/or waste recovery from packaging [24,35],
- The reinforcement of product protection, in order to avoid losses [36,37].

In practice, this has led to the introduction of specific legislation (e.g., European Directive 94/62/EC and its updated version 2004/12/EC, [38,39]). In many cases, management of the environmental impact has been simplified in economic terms by taxation, such as the green dot.

2.3. The Role of Packaging in the Deployment of Social Sustainability

The social pillar is possibly the least developed of the three, in relation to packaging. Some authors identify various needs from the social perspective: providing transparent, honest, understandable and truthful information, adapting usage and product doses to the needs of different customers (e.g., the elderly or people with disabilities), or guaranteeing safe consumption [14,40,41].

2.4. A New Approach to Integrated Packaging Design, "Sustainable Packaging Logistics"

In view of the impact of packaging on overall supply chain sustainability, this section pays particular attention to its design process. In order to put the main functions into practice, it is essential to consider packaging as a system comprising three levels [9]: primary or consumer packaging, secondary or transport packaging (usually, boxes) and tertiary packaging (several primary or secondary packages grouped together on a pallet). When considering packaging from a global perspective, the interaction between different levels and functions becomes clear, when depicting the interdependence among them.

Organisations throughout the supply chain have different requirements, perspectives and priorities with regard to packaging (the nine sub-functions previously commented). These requirements, perspectives or priorities are not distributed homogeneously in the different levels of packaging, and demand an integrated view of product, packaging and supply chain.

Furthermore, this variety of requirements, perspectives and priorities demands coordinated organisational structures in the packaging design process, both internally within each company and externally between companies in the supply chain, for example, suppliers and customers [10,13,25,42–45].

In recent years, the "packaging logistics" approach has conceptualised the integration of product design and packaging with supply chain management (direct and reverse), with a special emphasis on its strategic and sustainable repercussions. Different authors have contributed to the conceptual development of this approach [9,11,13,15,18,31], most of whom are linked to the University of Lund, Sweden.

In this context, García-Arca et al. [15] (p. 330), based on Saghir's previous definition [9], propose a broader definition, introducing the concept of "sustainable packaging logistics" (SPL): "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 maximising social and consumer value, sales, and profit from a sustainable perspective, and on a continuous adaptation basis".

In this new expanded definition, there is a specific reference to the processes involved, to the connection with sustainability, and to the dynamic vision of packaging associated design decisions. Likewise, it reinforces the idea of integrating the three systems involved: packaging, product and supply chain. Finally, it reinforces the idea of connecting packaging design with the competitive improvement of the company, i.e., obtaining better business results.

Thanks to SPL, it is possible to implement an efficient packaging design process that considers how to find and select alternatives, combining: Balance (knowledge of the different functions associated with packaging); Integration (different visions of areas, departments and companies throughout the supply chain); and Objectivity (with the majority support of quantitative indicators to compare design alternatives).

Thus, companies could search for superior packaging alternatives by combining the four main design decisions: the selection of materials, dimensions, the structure of packaging systems (relationship between primary, secondary and tertiary packaging) and the aesthetic design of the packaging (text, colours, brand, image, shape, etc.). This should generate a climate and culture of change, improvement, and packaging innovation within companies, in both quantity and quality, which would have a real impact on sustainability and on overall company and supply chain competitiveness.

In short, SPL adoption could contribute to an increase in supply chain competitiveness through the deployment of sustainability. As already mentioned, the main pillars of the SPL approach are: complete incorporation and understanding of design requirements; deployment of a suitable organisational structure for packaging design from a holistic standpoint (both internally and externally); and promotion of change and innovation in the packaging to improve its sustainable performance.

The conceptual model will aim to check whether greater development of the four pillars of SPL can actively contribute to an improvement in environmental, economic and social sustainability (see Figure 1).

The research hypotheses that we seek to validate are outlined as follows:

Hypothesis 1 (H1). The greater the role each different requirement or sub-function has in the packaging design process, the better the sustainability performance.
Hypothesis 2 (H2). The greater the coordination and internal collaboration on packaging design between departments, the better the sustainability performance.
Hypothesis 3 (H3). The greater the coordination and external collaboration between companies (packing companies with packaging suppliers, raw materials suppliers and retailers), the better the sustainability performance.
Hypothesis 4 (H4). Finally, the greater the predisposition towards change, improvement and innovation in packaging, the better the sustainability performance.

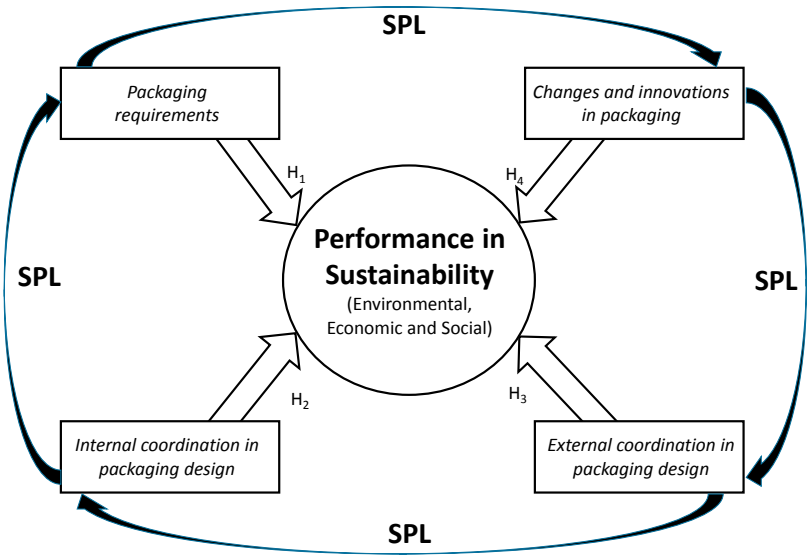

Figure 1. Conceptual model for empirical research.

3. Methodology for Empirical Research

With regard to the objectives outlined in the introduction, in this section we present an empirical analysis of companies in order to validate the extent to which implementing the previous SPL model contributes to improved sustainability.

In order to achieve the objectives described above, the authors carried out an exploratory study of the Spanish Toy Manufacturing Sector. The methodology used in this study was based on structured electronic questionnaires dealing with the four hypotheses given above. The online platform used to create the survey and gather the data was "e-encuesta" (www.e-encuesta.com).

The interviewees from each company were mostly logistics/production managers. According to the "Spanish Toy Manufacturers Association" (AEFJ: Asociación Española de Fabricantes de Juguetes; Madrid, Spain, http://www.aefj.es), there are 100 companies in this sector, with a combined turnover of 920 million Euros, directly employing more than 5700 people. Spain is the second largest toy manufacturer in the European Union.

The 100 companies were first contacted by phone in order to explain the study and invite them to take part before being sent the online survey. The AEFJ collaborated in this initial task to promote the study. Eventually, 70 of the companies participated by filling out the complete questionnaire (response rate: 70%).

The companies were invited to find out about the results of the study at a meeting organised by the AEFJ. It was also an opportunity to add detail and depth to the results and conclusions from the qualitative contributions given by the companies.

The questionnaire presented four main sections enquiring about the packaging design process. Specifically, it asked about the level of incorporation of the different requirements in packaging design, the organisational structure and the levels of internal and external coordination (with suppliers and retailers), the changes and innovations promoted in the packaging, and, finally, the results attained at a sustainability level in terms of its environmental, economic and social facets.

The items in the questionnaire were evaluated according to a level of importance/implementation. To evaluate these items, companies were asked to provide values from 1 to 5 in line with the Likert scale (where 1 is "poorly valued" or "not widely implemented" and 5 is "highly valued" or "widely implemented").

When considering the significance of the performance in sustainability, the authors used the assessments reported by companies in four aspects, related to the three pillars: economic, social and environmental.

- The increase in sales (economic sustainability).
- The reduction in costs (economic sustainability). Costs specifically mentioned were the costs of raw material/component procurement (including packaging purchases), product manufacturing costs (including packing costs) and logistic distribution costs (handling, storage and transport).
- The improvement in safety and the ease of use of products (social sustainability).
- The reduction of the environmental impact generated by the company and its supply chain (environmental sustainability). In practice, this would reduce resource consumption and the raw materials used, as well as reducing pollution and waste (including losses and product deterioration).

To carry out the analysis in companies, two groups were established based on the best or worst results achieved following the changes, improvements and innovations in their packaging (35 companies in each group).

The first group contained the companies that obtained a better sustainability performance (considering the sum of all the assessments in the previous four performance aspects). The second group contained companies with a worsened sustainability performance. The differences between the two groups are significant (p-value: 7.0255×10^{-16}).

In order to compare and justify the potential contributions of SPL implementation, a Mann–Whitney U test was applied to evaluate the companies' responses. The non-parametric Mann–Whitney test (also called the Wilcoxon test) makes it possible to statistically check whether the mean values for a variable are equal or distinct between two groups.

Like all non-parametric tests, it is not limited by restrictive hypotheses, which means it is enough for the variable to be quantitative and the sample elements to have been chosen randomly [46]. In this test, the Z statistic is used as a contrast in order to estimate the p-value. Normally, the differences between groups are considered significant when the p-value is below 0.05 (or in a more restrictive way, when the p-value is below 0.01). IBM SPSS® software was used for the statistical analysis.

The main motivation behind this paper is based on the fact that, although there is broad consensus in the literature on the important role of packaging in different fields aimed at improving competitiveness (including sustainability), it has scarcely been dealt with at an integrated level [14,18].

Such an integrated approach at an empirical level is even rarer, and mainly focuses on case-studies [15,18,19,28,31,47–51] or products comparison [33,34,40,52–59], rather than the organisational analysis of a wider sample of companies such as that included in this work. The only reference related in some way to our applied and organisational approach is that by García-Arca et al. [60] dealing with 209 manufacturers from the food sector, which analyses the adoption of meta-standards on aspects of SPL, although it does not deal directly with the impact on competitiveness and sustainability.

4. Results

In order to facilitate results analysis, this section has been divided into three sections. The first section analyses the importance of different design requirements; following that, it focuses on the internal and external organisational structure that supports the packaging design process; finally, the third part addresses the possible differences that exist in companies relating to promoting packaging changes and innovations.

4.1. Design Requirements

The study presents some interesting results regarding the importance placed on packaging requirements in the design process (H1). From the nine types of design requirements identified in the literature, the only requirements which indicate no evidence of significant differences between both groups of companies are commercial, protective, legal and communication requirements (Table 1).

Table 1. Analysis of importance of packaging design requirements (p-value < 0.05 *; p-value < 0.01 **).

Type of Requirement	Value	Group 1 (Best)	Group 2 (Worst)	Statistical Analysis	
Commercial (differentiation capacity and product attractiveness)	Mean	4.714	4.514	Z statistic	−1.16129
	Variance	0.681	0.963	p-value	0.2455
Protective (ensuring adequate protection to avoid product loss or deterioration)	Mean	4.600	4.229	Z statistic	−1.52784
	Variance	0.365	1.005	p-value	0.1265
Productive (facilitating productivity and flexibility in packing processes)	Mean	4.029	3.343	Z statistic	−2.65289
	Variance	0.734	1.173	p-value	0.00798 **
Logistic (facilitating handling, storage and transport processes)	Mean	4.171	3.486	Z statistic	−2.70394
	Variance	0.793	1.198	p-value	0.00685 **
Packaging purchases (guaranteeing packaging purchases and supply)	Mean	4.200	3.486	Z statistic	−2.48891
	Variance	0.988	1.610	p-value	0.0128 *
Environmental (reducing raw material consumption and waste generation)	Mean	4.171	2.971	Z statistic	−3.82955
	Variance	0.852	1.734	p-value	0.00012 **
Ergonomic (facilitating product handling along the supply chain, including points of sale and consumers)	Mean	4.000	2.886	Z statistic	−3.81166
	Variance	1.000	1.339	p-value	0.00013 **
Legal (facilitating compliance with rules and regulations)	Mean	4.486	4.257	Z statistic	−0.64078
	Variance	0.669	1.314	p-value	0.5216
Communication (supplying useful and reliable information for companies and consumers)	Mean	4.171	3.886	Z statistic	−1.28871
	Variance	1.087	1.163	p-value	0.1974

The absence of differences in the legal and protection requirements could be because companies consider them to be a minimum, essential or basic design requirement that should always be fulfilled.

On the other hand, the fact that there were no significant differences in commercial and communication requirements highlights the importance that all companies place on considerations that may affect product visibility in the market. In fact, commercial requirements are the most important in both groups of companies.

4.2. The Organisational Structure for Packaging Design

This greater sensitivity to meeting the different packaging design requirements should go hand in hand with greater coordination, both at an internal, manufacturer level and at an external, supply chain level (with retailers and suppliers).

The need for this internal coordination can be illustrated by the range of departments involved in the four basic decisions associated with packaging design (materials, dimensions, number of packs per package and aesthetic design), irrespective of the group to which the companies belong.

Aesthetic design is primarily the responsibility of the Commercial/Marketing, and Research and Development (R&D) departments (see Figure 2). However, decisions relating to the type and quality of packaging material are more widely spread out, specifically, between the departments of Quality, Production, R&D and Purchasing (see Figure 3).

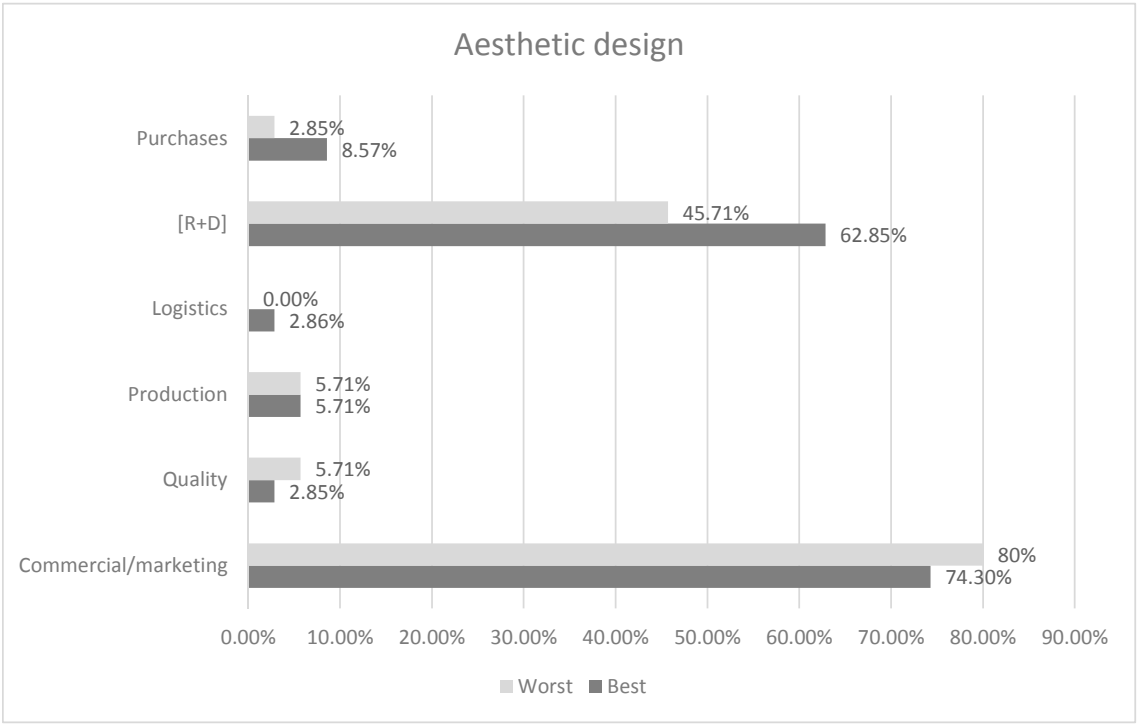

Figure 2. Departments in charge of aesthetic design in packaging.

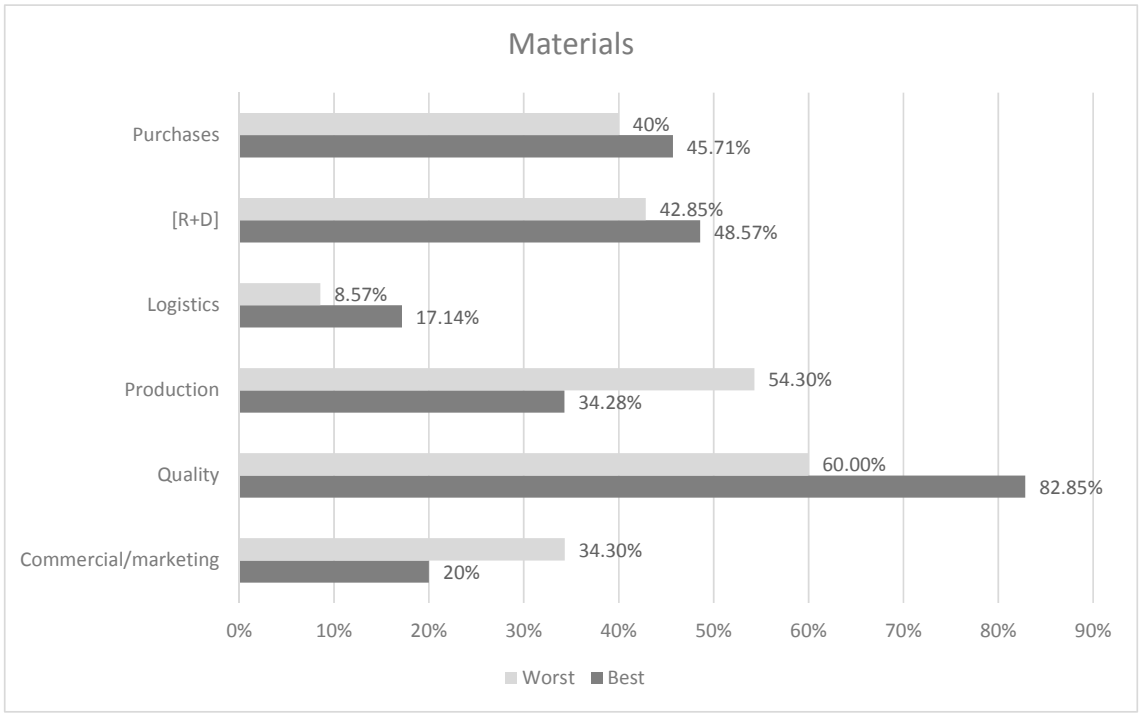

Figure 3. Departments in charge of materials selection in packaging design.

A similar spread of responsibilities appears in the design decisions linked to packaging's hierarchical structure (number of primary packages per secondary packaging). These design responsibilities are shared between the commercial/marketing, production, and logistics departments (see Figure 4).

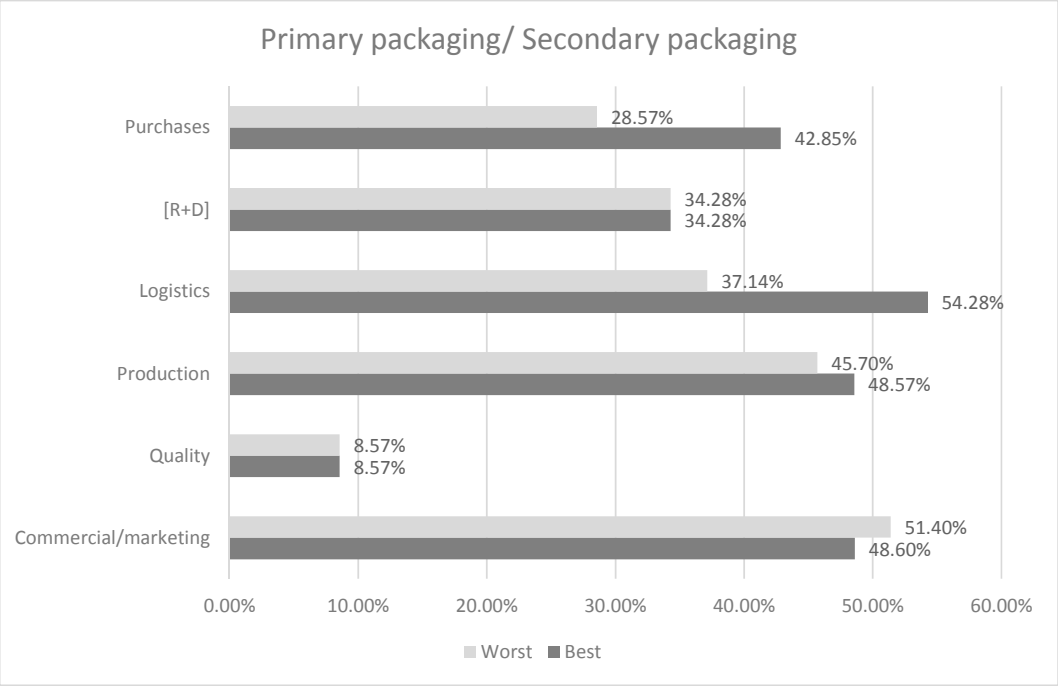

Figure 4. Departments in charge of hierarchical structure in packaging design.

Likewise, there is a broad distribution of design responsibilities relating to dimensions, which are divided between the Logistics, Production, Commercial/Marketing and R&D departments (see Figure 5).

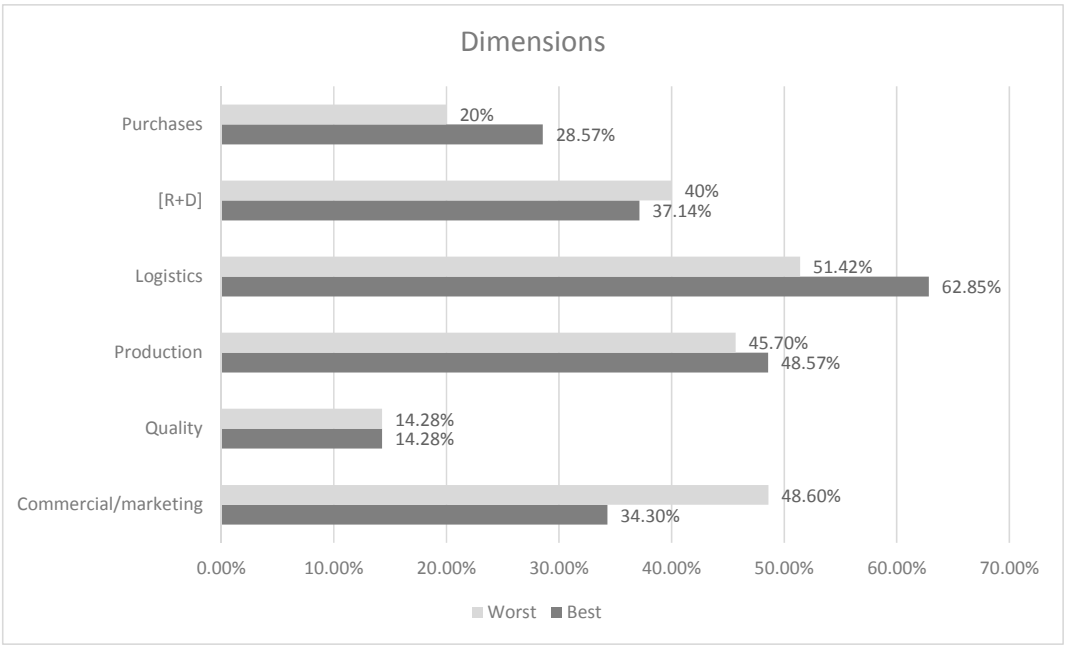

Figure 5. Departments in charge of dimensions selection in packaging design decisions.

In this context, significant differences have been found in the level of internal coordination implemented by companies in order to produce an integrated packaging design, with greater differences in those companies with better results (see Table 2).

Table 2. Analysis of development of an organisational structure for packaging design (p-value < 0.05 *; p-value < 0.01 **).

Type of Coordination in Packaging Design	Value	Group 1 (Best)	Group 2 (Worst)	Statistical Analysis	
Internal coordination in packaging design	Mean Variance	4.200 0.871	3.543 1.432	Z statistic p-value	−2.35692 0.0184 *
Coordination with packaging suppliers	Mean Variance	3.343 0.820	2.629 1.652	Z statistic p-value	−2.43807 0.0147 *
Coordination with other suppliers for promoting packaging improvements	Mean Variance	3.419 0.985	2.179 1.115	Z statistic p-value	−3.96039 0,00007 **
Coordination with retailers	Mean Variance	3.029 1.205	2.286 1.563	Z statistic p-value	−2.66866 0.00761 **

Therefore, it could be concluded that the companies which have implemented internal coordination mechanisms between departments for packaging design achieve better results in sustainability (H2).

Furthermore, significant differences have also been found in design organisation at the level of external coordination between companies and their packaging and raw material/component suppliers (see Table 2). In fact, this collaborative approach with suppliers is consistent with the importance, as outlined, of purchase-based design requirements.

This collaborative approach, used by the best performing companies, also appears in retailers, downstream in the supply chain (see Table 2).

In this context, it could be concluded that the companies which have implemented external coordination mechanisms throughout the supply chain in packaging design achieve better results in sustainability (H3).

4.3. Packaging Changes, Improvements and Innovations

In accordance with the synthesis provided by some authors [13,19,32,49] and additional contributions from different packaging, environment, and logistics related institutions (such as, ECOEMBES (www.ecoembes.com), AENOR (www.aenor.es), ECR-EUROPE (www.http://ecr-all.org/about-ecr-europe) or EUROPEN (http://www.europen-packaging.eu)) one could consider the following lines of improvement in packaging design:

- Dimensional changes. Resizing the packaging can contribute to reducing the material used and, consequently, the quantity of waste generated. On the other hand, it also facilitates the improvement of the product's volumetric and subsequent logistical efficiency, making the packaging and packing processes more productive, as well as reducing deterioration and ensuring the packaging sufficiently protects the product.
- Material changes. These changes can contribute to simplifying the number of materials used (allowing for economies of scale), cheaper materials, or the use of more easily recyclable or recoverable materials.
- Change in the amount of product per packaging. The changes in the quantity of product per packaging can help reduce the consumption of materials and the generation of packaging waste. In this respect, family or economy size formats generally present a better logistical and environmental option.
- Change in packing process. Switching from a manual to an automatic process (or vice versa) can contribute to lowering production costs, as well as decreasing product rejection/deterioration, and resource consumption. Obviously, the introduction of new materials can also mean changes in the production process with associated costs and rejections.
- Change in the number of primary packaging per secondary packaging (and/or tertiary packaging). Redesigning the relationship between primary, secondary and tertiary packaging can contribute

to improving logistic performance (handling, storage and transport), by rationalising the consumption of materials and waste generation.

- Materials Standardisation. Standardising the material types and characteristics in the packaging, facilitates procurement and supplying tasks for the packaging manufacturer, and contributes to obtaining economies of scale.
- Dimensional Standardisation. Complementary to the previous measure, dimensional standardisation in packaging formats contributes to simplifying the procurement process for packing companies, providing economies of scale when purchasing. It also benefits productivity by reducing set-up times in packing equipment.
- Aesthetic changes. A suitable design in terms of text, colour, iconography, material or shape can simplify the purchasing and recycling costs of packaging. It can also promote sales and consumption by communicating the attributes, and the product's tangible and intangible features.
- Returnable packaging. The use of returnable packaging instead of single-use packaging can facilitate the reduction of overall logistics costs, including the reduction of purchase costs, resources consumption and waste generation.
- SRP (Shelf Ready Packaging). SRP consists of a group of primary packages in secondary or tertiary packaging that is ready for exhibition at the point of sale, facilitating consumer purchasing. It also facilitates the reduction of material costs, waste generation and logistical costs, particularly those associated with handling and product location at the point of sale.

Of course, the previously mentioned changes, improvements or innovations should not be implemented indiscriminately. On the contrary, it would require a multifunctional vision of the packaging design process, as proposed in the SPL approach.

With regard to the selection of these last 10 changes, improvements or innovations in packaging design, the authors identified significant differences in the level of development in nine of these (see Table 3). The exception in this analysis is associated with aesthetic changes, typically coming from commercial requirements, although it is consistent with the fact that there are no significant differences in commercial design requirements.

Table 3. Analysis of frequency of changes and innovations related to packaging (p-value < 0.05 *; p-value < 0.01 **).

Type of Change/Innovation	Value	Group 1 (Best)	Group 2 (Worst)	Statistical Analysis	
Dimensional changes	Mean	3.886 (2)	2.914 (2)	Z statistic	−2.887873
	Variance	1.339	2.022	p-value	0.00387 **
Material changes	Mean	3.314	2.500	Z statistic	−2.278312
	Variance	2.163	2.015	p-value	0.0227 *
The amount of product per packaging	Mean	3.400	2.706	Z statistic	−2.110407
	Variance	2.071	1.790	p-value	0.0348 *
Change in packing process	Mean	3.229	2.063	Z statistic	−3.313054
	Variance	2.005	1.544	p-value	0.00092 **
Number of primary packaging per secondary/tertiary packaging	Mean	3.429	2.618	Z statistic	−2.397032
	Variance	1.723	1.819	p-value	0.0165 *
Materials Standardisation	Mean	4.000 (1)	2.788 (3)	Z statistic	−3.245103
	Variance	1.455	2.297	p-value	0.00117 **
Dimensional Standardisation	Mean	3.853 (3)	2.758 (4)	Z statistic	−3.122268
	Variance	1.644	2.002	p-value	0.00179 **
Aesthetic changes	Mean	3.800 (4)	3.559 (1)	Z statistic	−0.871027
	Variance	1.929	1.890	p-value	0.3837
Returnable packaging	Mean	2.471	1.727	Z statistic	−2.673548
	Variance	1.590	1.392	p-value	0.0075 **
SRP (Shelf Ready Packaging)	Mean	3.138	1.760	Z statistic	−3.192769
	Variance	2.623	1.273	p-value	0.0014 **

According to the analysis, this situation implies that the promotion of almost all types of changes or innovations is greater in the group of companies with better results (H4), despite the fact that the most frequent changes implemented by both groups of companies are essentially similar (materials standardisation, materials and dimensional changes, aesthetic changes). Table 3 shows the order of the first four types of changes in each group of companies, in parentheses.

5. Discussion

In the context of sustainable supply chain management, why pay attention to packaging? The reason is that packaging reproduces all the complex relationships, perspectives, and needs arising in each company and between companies, but on a smaller scale. Packaging is an overarching element which connects the flow of materials and information along the sustainable supply chain, playing an ever more strategic role.

However, because of its multifunctional nature, each supply chain company has traditionally adapted its design decisions based on their perception of the impact it could have on the processes that it knows and/or manages. The situation is more striking when this partial, disintegrated vision occurs in areas or departments within the same company.

From a conceptual point of view, when any packaging design decisions are considered, it should not be done in isolation; on the contrary, it would be reasonable to make these decisions following on from internal and external coordination, and with objective data regarding their impact. Obviously, the benefits of coordination and collaboration between companies on the supply chain is not limited merely to packaging design, but it does constitute yet another argument for fostering their development.

If all companies on the supply chain (suppliers, manufacturers, retailers, third party logistics, and so on) do not understand the overall impact of packaging design decisions, or do not implement a method of comparing packaging alternatives from a holistic perspective, they are losing potential sources of competitiveness improvement through sustainability deployment.

When an integrated approach such as SPL is considered, a greater number of alternatives become available along with the criteria for their selection. This can become a real driving force for change and improved competitiveness. To illustrate this diversity of alternatives that are in keeping with design requirements, the following needs can be stated:

- The commercial department would request packaging with size differentiation adapted to the Market, ensuring, moreover, a reduction in deterioration and breakages.
- The production department would want packaging that is standardised to a degree that enables a reduction in tool changes or set-ups on the manufacturing line in order to improve its speed and performance.
- At the same time, the purchasing department would request packaging that enables a reliable supply that meets needs at the most economical cost.
- The logistics department would require that packaging makes the most of volumes and weights in freight loads, which would ease storage, handling and transport.
- The quality and environmental department would need packaging that rationalised the consumption of resources and minimised waste generation.
- Furthermore, all the above departments would require that the packaging itself acted as the means for conveying both commercial and logistics information.
- Finally, to complicate the situation even further, in addition to the above needs, there are those coming from other companies on the chain, for example, the packaging manufacturers themselves, the packing and wrapping equipment suppliers, the suppliers of raw materials and components, third-party logistics companies, the retailers and the points of sale.

On the other hand, the decisions that affect the different levels of the packaging system (primary, secondary and tertiary) are also related to the part of the supply chain that exerts the most influence or leadership. For example, if retailers "dominate" over packing companies, the final decisions to do

with packaging could be dependent upon what the retailer considers to be a priority. Logically, such an approach will not necessarily lead to the best solution from the all-encompassing viewpoint of a sustainable chain.

Moreover, this overarching design approach in the supply chain should also be considered dynamically and adaptively, i.e., subject to the changing needs and perceptions of the market and the environment with a proactive approach to continuous improvement.

Based on an understanding of how the packaging system works and how it is integrated, it is possible to conduct a structured and systematic search for packaging alternatives and innovations that leads to achieving better performance in terms of sustainability. In this sense, the results of the study presented in this paper highlight the potential of adopting SPL from a sustainable perspective.

As seen in the analysis of the toy manufacturing sector, different companies in the same sector perceive and structure their packaging design process differently. Accordingly, the results suggest that a more multi-faceted and global view of design requirements, combined with a suitable organisational structure that integrates them internally and externally, would not only promote a greater number of changes, improvements and innovations, but these changes improvements and innovations would have a greater impact on the sustainability of supply chains.

In this context, the analysis of the results in the toy sector study shows evidence that partially supports the hypotheses that were originally raised.

1. The greater the role each different requirement has in the packaging design process, the better the sustainability performance.
   Thus, companies with better results have greater consideration in five of the nine packaging design requirements related to sustainable supply chain management. This appears to indicate a greater sensitivity in these companies towards a multifunctional view of packaging as a way to improve sustainability.
2. The greater the coordination and internal collaboration on packaging design between departments, the better the sustainability performance.
   We have found positive differences between two groups. Companies with better results have promoted greater internal coordination in packaging design, in an organisational setting in the firms where the responsibilities for packaging design are shared out widely among the different departments.
3. The greater the coordination and external collaboration between companies, the better the sustainability performance.
   We found this positive impact in the coordination and collaboration with packaging manufacturers, with raw materials suppliers and with retailers. Again, this situation could support the statement that companies that previously had better results have achieved a greater knowledge of the impact of certain packaging design decisions, searching for collaboration throughout the supply chain (upstream and downstream).
4. Finally, the greater the predisposition towards change, improvement and innovation in packaging, the better the sustainability performance.
   Therefore, if companies understand the impact of certain packaging decisions internally and externally, it is possible to promote efficient and sustainable changes, improvements, and innovations based on packaging design. The only exceptions to this are the changes, improvements and innovations from a commercial point of view ("aesthetic changes"), given that we have not found significant differences between the two groups of companies.

Ultimately, scientific evidence has shown that deploying the main pillars of SPL contributes to better results, in terms of environmental, economic and social sustainability. Clearly, even within the companies with better results, different levels of deployment for each of the pillars of SPL could be found.

Therefore, rolling out SPL could be considered as an evolutionary process that is conditioned by how each of the departments or companies on the chain transforms over time to interpret and assess the different functions of the packaging. However, the preliminary results from this work do not look in depth into how and why organisations evolve from basic, inefficient models to the more advanced SPL models within a broad empirical context. This evolutionary vision of organisational structure for design is a pointer towards future lines of research work.

In this context, the main limitations of the paper are related to the subjectivity of the companies' assessments in each of the items of research, and to the low number of companies in the study belonging to a specific sector (toys). Admittedly, the evidence gathered regarding the impact of implementing SPL on sustainability is based solely on the analysis of a group of companies within the supply chain.

Similarly, in order to simplify the analysis, we considered the group of companies that performed better in sustainability terms, and whose sum of performance-linked variables were higher, rather than each company independently.

In this regard, each of the variables associated with the deployment of the SPL approach was analysed individually, without considering possible cross-correlation between them. All these limitations will be taken into consideration by the authors in future research.

6. Conclusions

The SPL approach is considered particularly innovative because there is a scarcity of literature that deals jointly with packaging, logistics, product design and sustainability, from an applied approach. This paper may be of interest to both academia and industry because the results identified can aid researchers and companies in improving their global vision of product/packaging design in order to increase sustainability throughout the supply chain.

The work reinforces packaging's important role in improving the sustainability of the chain as a whole, which has been pointed out in other works from the literature although generally in only a partial way. Nevertheless, the main contribution of this paper stems from the proposal of a basic SPL model and its empirical validation in a broad range of companies (in the toy sector), which provides the quantitative grounds for the generalisation of results and discussion in different sector contexts.

Likewise, this paper supplies a fresh perspective for researchers in the structuring and implementation of SPL. Clearly, some of the limitations mentioned earlier should be borne in mind for future research, so as to enrich and qualify the preliminary results presented here.

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