Development of a Preliminary Framework for the Reduction of Plastics in Packaging

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Abstract. Plastic packaging causes much waste, and its sustainability is receiving increasing attention. Companies have made efforts to mitigate the environmental impacts of packaging; however, plastic waste from packaging remains a big issue. This study builds a framework of factors that are important in helping companies reduce the amount of plastic in their packaging. The framework is based on findings from a literature review and five interviews with practitioners. The study found that to achieve a reduction of plastic in packaging, seven factors are imperative in the fuzzy-end stage of packaging design and development.

Keywords: Packaging; Plastic usage; Practitioners; Sustainable design

1   Introduction

Plastic is widely used in product packaging because of the unique benefits it offers in terms of functional properties (e.g. light-weight, strength, durability, corrosion resistance, high thermal and electrical insulation, and low cost) in addition to being simple to form into complex shapes. Because of its diversity and versatility, the use of plastic in packaging has increased twentyfold since the last century. (Thompson, 2009). According to Plastic Europe, packaging is the largest application sector in the plastics industry and represents 39.6% of total plastic demand (Europe, 2015). However, this massive usage of plastic has created a large issue for the environment as well as society as a whole. For example, to boost its functional properties, virgin plastic polymer resins are usually mixed with additives that can be toxic to the environment as well as humans (Andrady & Neal 2009; Koch & Calafat 2009; Meeker et al. 2009; Oehlmann et al. 2009; Talsness et al. 2009; Wagner & Oehlmann 2009). According to research conducted by New Plastic Economy, if we continue to consume plastic packaging at the current rate, by 2050, there will be more plastic than fish in the ocean (by weight). Most plastic packaging is used only once and 95% of its value, estimated at USD 80–120 billion annually, is lost to the economy after its initial use (New Plastic Economy, 2017).

This issue has triggered action from a broad range of stakeholders; policymakers have launched legislation to tackle this issue, which affects packaging designers, manufacturers of packaging and/or fillers, distributors and retailers. In 2002,

Bangladesh became the first country to ban plastic packaging, followed by Mauritania, Morocco, Rwanda and Kenya. France banned plastic bags less than 50 microns thick. In the United States, there are more than 130 regulations, at both city and national levels, governing plastic packaging (New York Times, 2016). Reports on social media including the documentary *Planet Earth*, produced by the BBC, and a recent article, 'The known unknown of plastic pollution', in the *Economist* have created significant social demand to address this issue. Plastic waste is increasingly been seen as a huge societal and environmental problem which needs to be addressed.

Professionals from academia and industry have tried to understand how they can work on the issue and, at the same time, handle pressure from legislation as well as the market. The impact of plastic has been studied from different perspectives along the value chain; including understanding the current barriers to reducing the usage of plastic packaging by companies' management levels and reducing plastic usage in logistic packaging by changing the design of fibreboard boxes and reusable plastic containers (Battini, 2016; Bashyal, 2011; García-Arca, 2016). A number of plastic-free grocery stores have opened across Europe. In these stores, consumers have to take their own containers, fill them with product and pay according to the product's weight. Beitzen-Heineke (2017) discussed the prospects of a new form of retail system: zero-packaging grocery stores that have renounced disposable plastic packaging for their entire product range. In many ways, these 'new' initiatives are paying homage to more traditional modes of consumption, common only a few decades ago. In addition, a small amount of research has been conducted to explore alternatives to oil-based plastics; promising materials such as polyhydroxy alkanoate (PHA), polylactic acid (PLA) and polyethylene furanoate (PEF) are frequently mentioned in these papers. However, because of some disadvantages in their properties and their cost, it is taking time to apply them widely across the packaging domain (Rabnawaz, 2017; Zhu, 2016; Scarfato, 2015; Siracusa, 2014; Miller, 2013; Colwill, 2010; Auras, 2007). Business model tools that calculate the eco-cost and/or analyse environmental pollution, clarify distribution networks and qualify economic returns and environmental impacts have been developed to help practitioners make better packaging choices. These models tend to focus on quantifying pollution and comparing different packaging concepts so that the tool users can choose the packaging concept that makes the best business sense; even though plastic usage is mentioned, the transition to using less plastic rarely discussed (Singh, 2017; Srinivasan, 2014; Accorsi, 2014; Gutta, 2013; Chen, 2006; Leadbitter, 2002). Recycling of plastic packaging is also seen as a way to reduce harmful waste. However, companies do not have primary responsibility to ensure that this happens; plastic packaging recycling relies upon policies and practices in the local area (Mwanza, 2017; Ragossnig, 2017; Hopewell, 2009).

By focusing on recycling as the means to plastic reduction, it places the responsibility in the hands of the consumer and not the producer of the waste. However, to make more significant progress towards zero use of plastics in packaging, the responsibility must start with the manufacturer. However, little is known about how companies can make that journey to transition away from high dependency on plastic packaging towards zero plastic usage. To address this challenge, this study aims to understand the factors that influence plastic usage in the packaging industry and is structured as follows: first, the method of this study, i.e. the literature review

and the interviews are explained. Second, results from the literature review and the interviews are discussed, and a framework for the reduction of plastic usage in packaging is developed. Third, the paper concludes with opportunities for further research in this area.

2 Approach

The framework is built from a combination of a comprehensive literature review and interviews with experts.

Scopus was used to search for the keywords 'sustainable/sustainability/green, packaging, plastics, (alternatives)' in the titles or abstracts of articles, resulting in 375 papers being identified. From this initial set of papers, duplicates were removed and abstracts screened to identify those focused on the design and development of packaging. Most of the excluded papers were related to the development of new materials and packaging techniques. This resulted in 73 papers which were selected as being relevant to reducing plastic usage through packaging design and development. Of these, 33 were accessible to the researchers, either online, in libraries or via direct requests. A snowball approach was then used to identify any additional references, adding one further paper and four reports (from New Plastic Economy, Wrap, The Industry Council For Research On Packaging And The Environment (INCPEN) and Plastic Europe).

The selected papers focused on different aspects of reducing plastic usage in packaging design and its development process. In the following section, the main findings from the literature review are summarised and combined with the findings from the interviews, which were then developed as factors that influence the reduction of plastic usage in packaging.

2.1 Expert interviews

To identify experts in the field, companies were identified in reports obtained from a grey literature search. Using professional networking platforms, individuals from packaging related areas of organisations were contacted. Five experts agreed to participate in an interview. Table 1 lists the participants and describes their areas of experience. Because the interviewees were from organisations widely dispersed geographically, a telephone interview-based approach was adopted as the most appropriate method for data collection.

All the interviews were semi-structured using a pre-determined set of questions and were recorded with the permission of the interviewees, given through verbal consent. The interview questions were developed by reviewing the literature and discussions with the professionals in the sustainable design field. The interviews adopted a conversational style to allow the discussion to flow naturally. After the interview, the audio data were transcribed and analysed. The quotes added in next section have been edited for intelligibility.

Data was analysed using an open coding approach, with support of software 'MAXQDA'. Results are presented in two sub-sections, the first focusing on responses from tool 'users' and the second from tool 'developers'.

Table 1. Interviewees involved in this study.

Company	Category	Area of expertise	Years	Country
Company A	Packaging technology	Engineering and Technology Support	10	Germany
Company B	Packaging consultancy	Packaging technician	20	Indonesia
Company C	Household goods	Marketing manager	10	UK
		Packaging development manager	4	
Company D	Toy company	Plant manager	27	China

3   Preliminary framework

The fast-moving consumer goods (FMCG) Sustainable Design Factors Framework developed by Park (2015) was used as a reference for the development framework. The FMCG Sustainable Design Factors Framework is a conceptual framework that explains the iterative relationship of eleven factors that influence the successful implementation of sustainable design at the front-end of new product development processes within the FMCG sector. These factors are classified into five categories: organisational factors, possible barriers, managerial factors, operational factors and short-term and/or long-term goals (Figure 1). It should be noted that this framework relates to sustainable design in its entirety, where packaging is one aspect. Thus, it is not tailored specifically to the issues around packaging design.
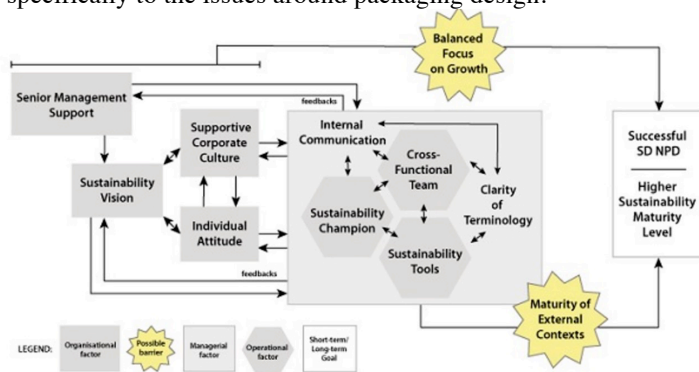

Figure 1. FMCG Sustainable Design Factors Framework.

Taking the high level categorisation as a starting point (short term/long term goals, managerial factors, operational factors and possible barriers), this formed the basis of the interviews with practitioners and a focus for analysing the extant literature.

To reduce plastic usage in packaging, studies have focused on different directions: among the 33 papers reviewed, five papers were about recycling, eight papers focused

on manufacturing, 11 papers focused on materials, seven papers discussed tools and two papers discussed consumers.

A preliminary framework of the critical factors influencing the transition towards zero packaging is presented in table 2 and this will be further explained in the following sections.

Table 2. Preliminary framework of factors influencing companies' reduction of plastic usage in packaging

Category	Factor	Description
Short term/Long term goal	Strategic plastic reduction commitments	The goal of reducing plastic usage, including increase the recycle of plastic as well as the reduction of virgin plastic
Managerial factor	Internal communication	Communication between different departments relevant to packaging design and development
Operational factor	Reuse, reduce and recycle	Methods companies use in packaging design and its development phase to reduce plastic usage
	Supply chain (downstream)	This affects the shelf life of a product, which will affect the packaging design
Possible barriers	Packaging technology	Barriers in applying alternatives to plastics
	Maturity of external contexts	The attitude of suppliers, consumers, governments as well as the support from the recyclers
	Marketing	Plastic packaging allows product features to be visible to consumers

3.1 Strategic plastic reduction commitments

The companies interviewed had different goals with regard to plastic packaging. All of them showed a willingness to cut down plastic usage by a defined (often small) percentage. Company C has corporate commitments that are threefold: reduce, recycle and reuse. This includes cutting down by 50% plastic usage per consumer up until 2010, 25% of their plastic should come from recycled sources by 2025 and 100% of their packaging should be recyclable. On the other hand, other companies have goal in regards to the materials used. For example, Company D is trying to move out of using PVC (polyvinyl chloride), which is deemed unfriendly to the environment, and replace it with biodegradable or bio-based plastics or paper. These types of goals motivate companies to refine their packaging design and find alternative materials.

Thus, whilst firms may have targets to reduce plastics in packaging, they are typically modest and are based on the identification of either alternative materials or on more effective recycling on behalf of consumers or users.

3.2 Internal communication

The efficiency of communication between departments during the decision-making process determined how much plastic packaging the company could reduce. The more

tools and information the decision-makers have, the better the decisions they can make. Making sure that all departments talk to each other and think thoroughly about trade-off situations is vital to the sustainability of packaging.

Although the expertise may exist within an organisation, the transition to reduce plastic packaging usage requires that different departments communicate with each other. This could often be an internal struggle that may delay the process, as reported by Company C.

3.3   Reuse, reduce and recycle

Finding a suitable plastic-like material as an alternative to plastics can be difficult. In this circumstance, reusing, reducing and recycling is viewed by firms as the most effective means of reducing the usage of oil-based virgin plastics. This can be achieved by changing the packaging format, maximising cube utilisation in a pack, optimising the packaging to product weight ratio as well as the plastic to packaging weight ratio, and increasing the recycled and renewable content (Lewis et al. 2007; The Consumer Goods Forum Sustainability Pillar, 2018). Company C believe that maximising the use-times of plastic packaging as well as eliminating single-use plastic packaging could be an efficient way to help mitigate plastic pollution. They gave an example of a laundry bottle, which is a large and substantially engineered bottle which is typically used only once:

"why do we have this big, engineered bottle, and we use it only once. That's absurd. We should use it, I mean ten, twenty times, until it's broken and make sure that, therefore, we don't have all of this energy that is spent on recycling this bottle or burning it, it's absurd."

In order to develop their reduction strategies, companies often use tools readily available that enable them to perform their calculations. Company A reported that these tools were usually very costly and require capabilities that the organisation does not have. From the literature review, most 'tools' available to designers enable designers to calculate the environmental impact of one stage in the whole packaging life cycle, i.e. the manufacturing, logistics or recycling of packaging (Srinivasan, 2014; Gutta, 2013; Leadbitter, 2002). However, in order to reduce the plastic usage in packaging, it is crucial to consider the life cycle as a whole and think about each sector of the process.

3.4   Supply chain

The delivery system and supply chain are believed to have a large impact on the reduction of plastic packaging. Firms noted that if the time from production to consumption can be reduced, then the need for plastic packaging might also be reduced as a core function of packaging is often to increase the 'life' of products which might otherwise degrade. By enabling quicker consumption, this might enable companies to move away from plastics as the preferred mode of packaging.

With developments in e-commerce, it is possible that this will enable greater choice on behalf of consumers to specify the types of packaging which they prefer.

Consumers may decide to eliminate the amount of plastic packaging used in their delivery when purchasing online. Company D thinks e-commerce will change the nature of packaging delivered to their end consumers:

"Now with progress and increase of e-commerce, we don't have to do [it, and] that means we can have closed boxes which are just – you put the toy in the box; but on the website or on the shelves, you have [a] couple of pieces, which are displayed. You really don't have to have a package because at the end of the day the customers throw the package [away]."

3.5   Packaging technology

Current developments in packaging technology are beginning to influence the reduction of plastic in packaging. However, plastics remain the primary choice of packaging in many instances, where specific technical requirements may be difficult to achieve using alternative materials. Coffee, for example, contains high levels of oxygen and water vapour, and the packaging must provide a barrier to light, be sealed against moisture and prevent contamination by strong odours. Thus, the focus for the company is on how to ensure the packaging provides the most effective level of protection and thus, environmental concerns are secondary. A common solution is to provide an aluminium layer between the plastic packaging and the contents. However, this combination of different materials makes the packaging impossible to recycle. Whilst this technology was developed for specific applications, it is also used for other applications, even though the technical demands might not be so high. Outsourcing of packaging can result in companies reusing technologies created for other applications. Alternatively, having invested in capital equipment on one production line, this may be reused across different products to ensure return on investment.

The development of new materials was emphasised, to a great extent, in both the literature review and the interviews. To apply new materials, companies have to overcome two barriers: the functional properties and the material supplier's structure. Polymer packaging is very frequently applied because of its functional properties; for example, flow-pack type packaging that wraps products with a plastic film depends on the properties of the plastic to keep the product inside dry. Company A stated:

Many of the food companies, especially the bigger the companies get, [sic] the more they are focused on having very stable and not changing [the] quality of their product. Also, over the whole shelf life, they want long shelf life. They want high barrier requirements, and this guarantees high product quality over a long period of time, and for this, plastics-based packaging [is the] standard material.

For bio-based and biodegradable plastic, the major issues are perceived to be the cost, technical performance and ability to achieve desired production volumes. One interviewee saw paper-based packaging as a promising alternative to plastics if only they could improve the 'barrier' properties.

Compared to the value of the product, the packaging is relatively cheap. If companies want to make the recycling process economically feasible, it is a matter of the volume of recycled packaging. For example, if companies have standardised types of plastic for water bottles, it makes business sense to recycle them. The recyclers

could use the same infrastructure to clean the bottle and return it to the companies for reuse.

3.6   Maturity of external contexts

This includes suppliers, consumers, retailers, recyclers and governments. Company C thinks that the packaging suppliers have a lot of power with regard to plastic usage. One company represents only a small market share for the suppliers. If suppliers do not feel the urge to change plastic usage, there is not much a company can do.

Changing demands of consumers provide one of the most significant drivers for companies to change the design of their packaging. If the consumers do not demand changes in packaging to reduce the amount of plastic, then companies will not prioritise this change. However, consumers are a large and varied group and whilst some may value sustainability, others may be demanding low purchase prices with little direct concern over the materials used. However, the interviewees acknowledged that regardless of consumer priorities, packaging should look sustainable from the consumers' perspectives. This may be based on their experience, their understanding, or the look and texture of the packaging. When discussing consumers, the focus is often on 'end-users', but for many manufacturers, the consumer of concern to them is the buyer in major retailers (e.g. Walmart, Marks & Spencer and Tesco). These retailers normally have tools including sustainability scorecards and metrics, which assess the sustainability of the companies' products. Company A stated:

"This is from one article that I have read; 'You don't have to explain [to] the consumer the sustainability of an egg carton. He just gets it. He just understands an egg carton is a packaging solution that is environmentally friendly.'"

The retailers' requirements can have a major influence on their suppliers' strategies for packaging. Big retailers like Walmart set their targets to be environmentally friendly and reduce plastic usage in packaging. They ask companies to help them achieve the targets by, for instance, reducing the percentage of plastic in their packaging materials.

Recyclers also play an important role. However, compared to rest of the value chain, plastic recycling companies have a minority voice. Perversely, they also have an interest retaining some plastics for business growth. Many of the recycling firms are small and operate locally rather than nationally. As a result, they have comparatively little 'power' in influencing what original manufacturers may do. The recycling infrastructure is also very different across different nations or regions, such as Germany, Eastern Europe and Southern Europe. This makes it more complicated for companies that ship their products to different countries to adopt design practices that work in all areas. In addition, the neglected status of recycling companies hinders the development of relevant technology, which affects the improvement of material recyclability in the long run.

Governments potentially have the biggest impact on changing practices through legislation. These changes have begun, with growing emphasis in the UK on reusing plastic bottles, banning the sale of some plastic items (e.g. straws) and charging for the use of plastic bags. However, practices vary and are highly dependent on the

values of the governing parties in different nations. As a result, there is no certainty that legislative pressure will have the desired effect in the long run.

3.7 Marketing

For manufacturers, one of the most important functions of packaging is to promote the goods inside and ensure the product is attractive to the end user. For the toy manufacturer, the display of the doll through a transparent display window in their packaging is viewed as essential to both protect the doll but also to allow the doll to be seen. Although they have replaced all of their PVC windows with a more environmental friendly plastic, polyethylene (PET), a better alternative is still to be explored. Company D stated:

"[A] Major barrier is marketing and how you appeal [to] customer[s] and sale[s]. When the packages are bigger, they have visibility . . . We used to have timely functions where the customers . . . [could] physically play [with] them. I think then it became – it's really appealing to the customer to market it and also be the shelf presence trying to be present on the shelf."

Currently, there are no specific design tools or expertise available to aid with the reduction of plastic packaging with an emphasis on satisfying marketing rather than environmental issues. Company C stated:

"They didn't [have] enough expertise on the topic. It has changed in the last, as I said, two years. I guess it's the same [for] all of the companies. I think, maybe, it's the consciousness, like strong consciousness around the problem, and now, there is more expertise, and then you have pockets of expertise."

4   Conclusion

This study has developed a preliminary framework of factors influencing companies' reduction of plastic usage in packaging. This is just a first approach based on insights from literature and five exploratory interviews and as a result, the framework needs further validation. However, some interesting issues have emerged.

Reducing plastic usage in packaging is not a priority for many companies. The advantages of the functional properties of plastic make it hard for companies to find alternatives. But, growing environmental pressure and public awareness of the damage created by plastics is pushing the need to change up the agenda. In this study, the analysis of the literature on plastic packaging and the interviews confirmed that knowledge of the subject of plastic packaging is still fragmented, and there is a need to tackle reduced plastic usage in packaging in a more structured way.

Many companies are beginning to understand the need to reduce the amount of plastic used in packaging and are explicit about this in their company strategies. However, packaging fulfils a number of different purposes and thus, making changes is not straightforward. Two factors are dominant in the argument for retaining plastics: the importance of marketing/promotion and the need for packaging which offers sufficient protection of the contents. For example, the toy company tries hard to

reduce the amount of plastic used in their packaging by reducing the size of the display window for a doll. However, they believe it would be impossible for them to completely cut out the usage of plastic in their packaging, as the plastic needs to fulfil a display function.

Evidence from industry also demonstrates how this is a complex systemic issue, with a range of different stakeholders from end-users, customers, supply chain, sub-contract producers, original designers, recycling agencies, pressure groups and government agencies. There is a danger that each of these is relying upon other stakeholders to take change their behaviour and as a result, no one wishes to make the first move. Currently, there is over-reliance on the end-users of packaging changing their behaviour to ensure more is recycled or reused. As a result, there is arguably, insufficient pressure on the originators of waste plastic to change methods of production. This will not change without significant legislation or without substantial changes in consumption behaviour. There is hope on the horizon, with new materials possibly offering some potential but there is a risk that these will not be sufficient without complementary changes in consumption behaviour.

This paper presents a preliminary framework of the factors that influence the reduction of plastic usage in packaging for companies. Future work is required to involve more decision-making practitioners and test the proposed framework. Related to this, it is evident that in different companies there are complex trade-offs to be made between different elements through packaging design. Due to the complicated nature of packaging, how firms handle the trade-offs during sustainable packaging design might provide fruitful opportunities for research.

Finally, assessing the influencing factors is only part of the story. To be effective, long-term changes to design processes and practices need to be more formally institutionalised. There is, therefore, work to be done to better understand how such changes could be implemented and good practices anchored as part of a company's design activity.

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