Sustainability, TRIZ and Packaging

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Abstract. There is a great need to increase sustainability in general and specifically of products and packaging. The paper aims at supporting efforts to improve future developments by identifying examples in the packaging industry and mapping these to existing trends.

A new general trend line to the existing TRIZ trend systematic is proposed and possible sub trends are presented. Furthermore, a classification to already existing trends are shown.

The analysis is limited to parts of the packaging industry and the found changes in this area but a transfer to other industries and the service sector seems possible without adding substantiating proof. The application of the proposed trends and sub trends could help to increase and measure product and packaging sustainability.

Keywords: Sustainability · TRIZ · Trends · Packaging · Need

1 Introduction

The need to take care of the environment and to leave future generations a place worth living in has created a trend to increased sustainability in different areas. Looking at the packaging industry the change to greater sustainability could be perceived accordingly.

The term sustainability is defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs [1, p. 41]".

Packaging is a material which "is used for the containment, protection, handling, delivery, presentation, promotion and use of products" [2, p. 44] with the possible functionality of protection, information, convenience and handling.

Trends are heuristic development directions which have been derived by analysis of past and present products and services. In [3] the notion of trends of engineering systems are described in more detail.

The paper presents examples of changes that have already been taken place in the packaging industry and proposes an addition the TRIZ trend tree.

Several sub trends are outlined, and specific guidelines are shown and explained. Furthermore, the paper tries to answer the research question if the found changes could be transferred to other industries and services.

In [4, p. 682] sustainability has three aspects (see Fig. 1). These aspects are:

Published by Springer Nature Switzerland AG 2023
D. Cavallucci et al. (Eds.): TFC 2023, IFIP AICT 682, pp. 175–186, 2023.
https://doi.org/10.1007/978-3-031-42532-5_13

- social,
- environmental and
- economic.

Important social factors are changing legislation and people's needs. The dynamics of those changes are slow but should be observed because a changing legal situation could be a threat to company objectives. Environmental factors could be divided into the areas land, sea, air and beyond earth. Economic factors are cost, e.g., for manufacturers and customers, or needed efforts like human resources.

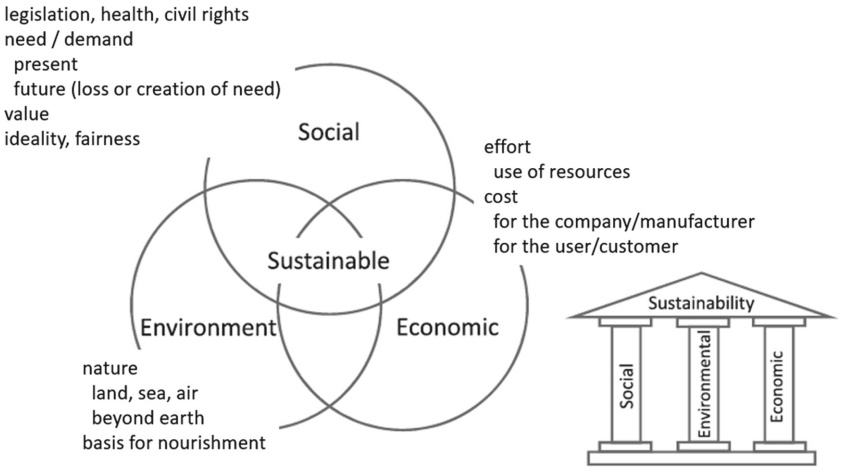

Fig. 1. Three aspects of sustainability [4, p. 682], combined with [5, p. 8] and edited by the author.

The creation and consumption of energy and material resources might be assignable either to the field of the environment or the economy. According to [5, p. 47] sustainable packaging must address the following four needs:

- effective – fulfil the required functionality (e.g., protect, limit access, ensure originality, …)
- efficient – amount of resource consumption (e.g., raw and natural materials, energy, space, …)
- cyclic – re-use, renew, recover essential material and energy
- safe – for people and the environment.

After these general outlines examples of packaging industry are presented.

2 Analysis of Packaging Products and the Way of Packing

The functionality and needs stated in the previous paragraph result either in requirements a packaging must meet or in requests. To get more insight 5 questions could be asked (see Fig. 2). What is the ideal packaging for the product? For whom (client) is the packaging intended, why does the customer need it together with the question where and when is

it needed. The where and when are greatly influenced by legislation, either of a specific country or an economic area, e.g., the EU. It does not only cover the actual time of usage but includes the procurement of raw materials, the production of pre-stage parts or structures and the time after the use as well. Especially the raw material and energy consumption during the time after use have a great impact on nature and the population.

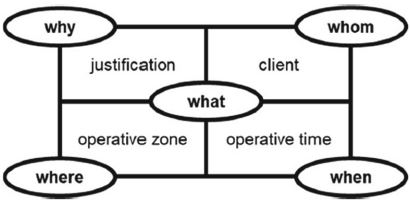

Fig. 2. 5× W to question the impact of packaging [6].

2.1 Packaging Products

Below some examples of food packaging are revealed. They depict different levels of ideality and different strategies to achieve an increased sustainability.

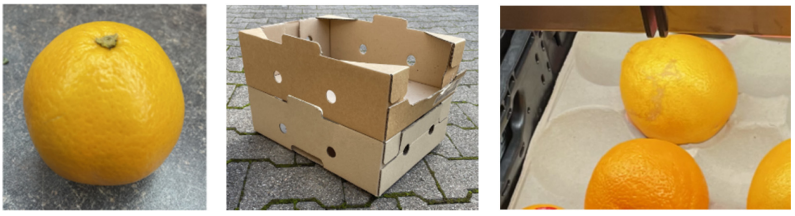

Fig. 3. Packaging in nature (left), packaging for transport (middle) and sale (right).

On the left-hand side of Fig. 3 a natural packaging of an orange is presented. For shipping and sale additional packaging like cardboard boxes and paper inserts are required (Fig 3 (middle and right). The following figures show another example of the food industry (cream cup), one example of the clothing industry (milk and shoe box) and an example of a packaging for a packaging product (clingfilm packaging).

An analysis of the different packaging reveal certain characteristics:

- reduction of plastic material, transfer of the stabilising function to a different, less harmful material, segmentation into homogeneous materials with the drawback of the gluing point (removing the glue would result in the next step to a more ideal packaging), instructions for recycling (Fig. 4)
- avoiding (refusing) of a gluing process (trimming the glue and a likely thermal process), homogeneous material, use of present processes to create the shoe box (Fig. 5)

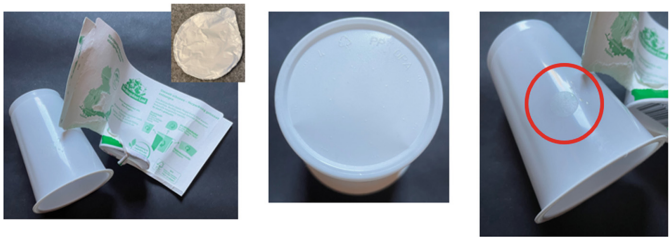

Fig. 4. Disassembled packaging of cream (cup, paper cover, aluminium lid).

Fig. 5. Transport and storage packaging for milk packs (left) and shoe packaging (middle and right).

Fig. 6. Packaging and integrated cutting aid for clingfilm.

- use of present resources to increase the customer involved functionality (integration of the cutting geometry in the paper cover, guidance of the paper cylinder holding the clingfilm with paper cover cut outs), homogeneous material (avoiding a metal cutter which was previously present) (Fig. 6)

The described changes imply that they not only increased the sustainability of the packaging but also increased the company profit assuming that the selling price remained the same. In the first example the amount of plastic material was reduced, in the second a thermal process and an additional material has been trimmed and in the last example existing resources were used to a maximum positive effect. Therefore, an increase in sustainability may also lead to positive economic effects for the manufacturer including the chance to promote the new design in advertising and improve the reputation.

2.2 Trends of Technical System Evolution and Proposal of a New General TRIZ Concerning the Respect and Care for Nature

Figure 7 presents an improved version of the TRIZ Trends of Engineering System Evolution. Together with the classical TRIZ trends and the trend of increased addressing of the senses [7, p. 21–22] the proposed new trend of increased care and respect for nature is shown.

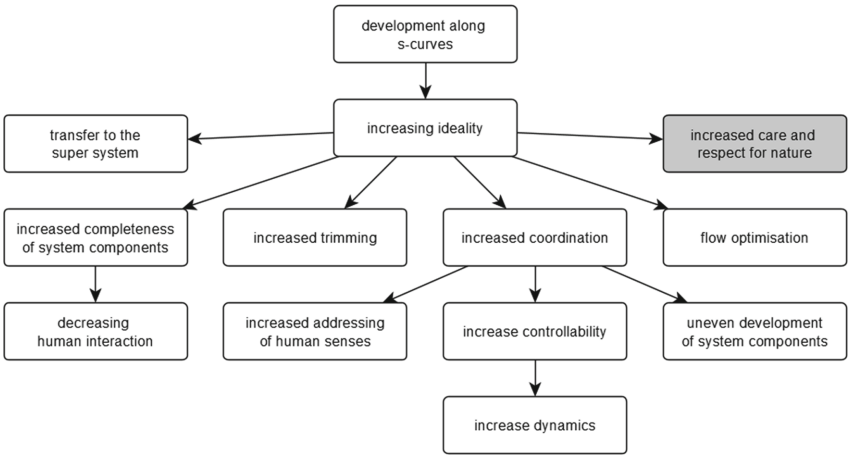

Fig. 7. Classical TRIZ tree of Trends of Engineering System Evolution [3, p.6; 8, p. 318] with the addition of the Trend of "Increased addressing of the senses" by O. Mayer and the proposed Trend of "Increased care and respect for nature".

The proposed new branch begins at the increase of ideality and adds the item "increased care and respect for nature". From there three steps are introduced:

- remove harm from the environment
- zero harm to the environment
- reduce harm to the environment.

Removing harm include developments like air carbon capturing or removing plastic waste from the sea. Zero waste aims at a cyclic process from the cradle to the grave and the reduction of harm at least limits the impact of products and processes. The order was derived from the different levels of circularity depicted in Fig. 8 [9, p. 16] and the priority is thought to be coinciding with the level of ideality.

The trend of increased sustainability is thought to be a sub-trend of reduced and zero harm to the environment (Fig. 9). Sub-trends of those are represented by the different levels of circularity (10 R's). The mapping of the 10 R's, which give exact directions of actions, to the sub-trend (see Fig. 10) create a hierarchical order that helps to implement and evaluate the level of sustainability. This schematic could support the packaging industry and its players to come up with ideas how to make required packaging more sustainable and allows for an evaluation of different actions which has been carried out.

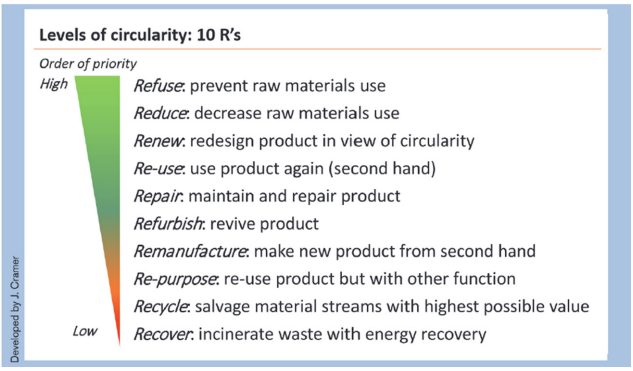

Fig. 8. Levels of circularity: 10 R's [9, p.16].

The indicated examples could be mapped to third level of increasing ideality, i.e., the reduction of harm. The sustainability is increased with measures like a decrease in plastic material consumption also having the positive effect of reducing the amount of energy needed. The possibility to dismantle items made from different materials helps to recover raw material in a pre-sorted way thus supporting a recycling process. This is further supported by making parts of the packaging from homogeneous materials and using existing production processes.

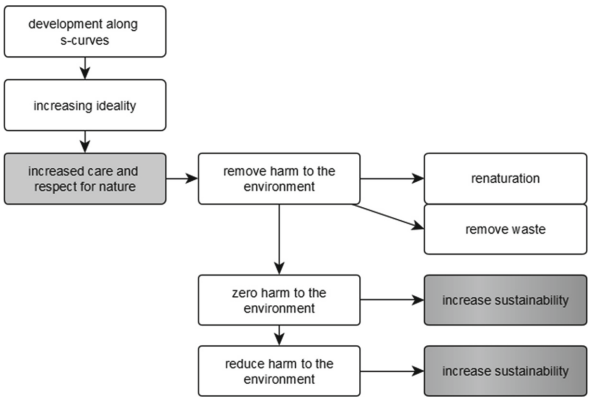

Fig. 9. Proposed new branch "increased care and respect for nature" to the TRIZ trend tree systematic.

Earlier certain inventive principles are hinted. These 40 inventive principles, together with separation principles for solving the physical contradiction [10, 11, p. 339–340] and already existing classical TRIZ trends [11, p. 148–183] could be combined to improve the efficiency and reliability during the process. Figures 11 and 12 give an impression on how these are connected. See [11, p. 114] for a more detailed description of the principles and their connection to separation principles.

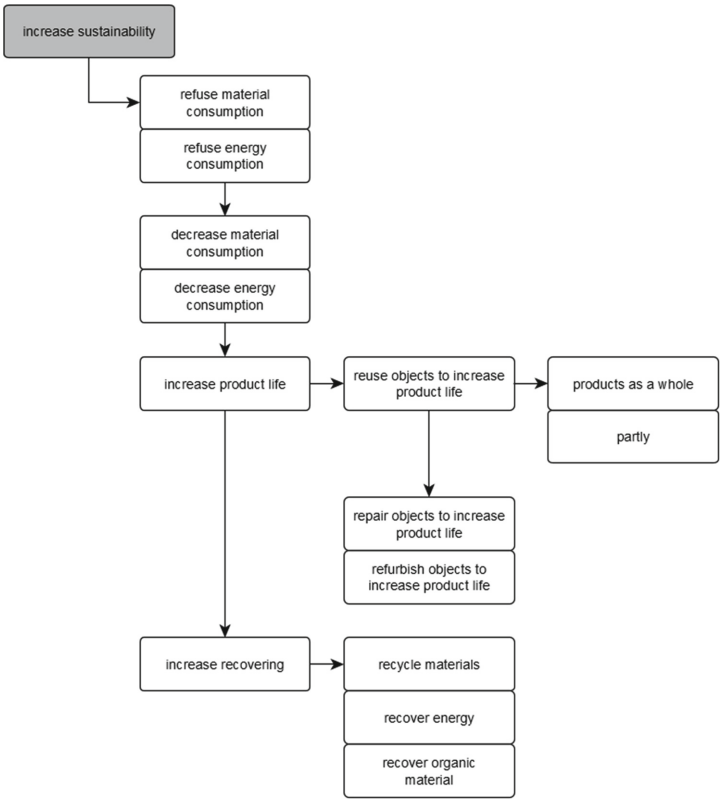

Fig. 10. More detailed schematic of the trend "increase sustainability".

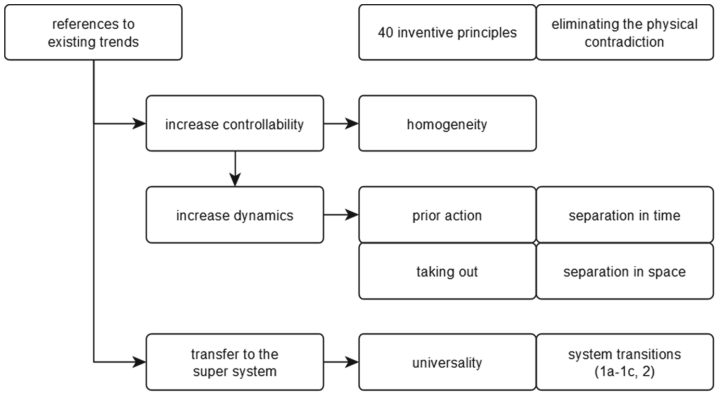

Fig. 11. References to inventive principles, separation principles and existing trends.

The author's assignment of the inventive principles is based on the analysis of examples, either the ones presented in the paper or additional ones which are not specifically

	the 40 ip	separation	classical trends
reduce harm to the environment			
├ increase sustainability			
├ refuse/avoid material consumption –	6, 9, 17, 20, 31, 33	space, (time)	trimming of materials and/or processes, (flow optimisation)
├ refuse/avoid energy consumption –	10, 11	time	trimming of processes, flow optimisation
├ decrease material consumption –	30, 31	space	trimming of materials and/or processes
├ decrease energy consumption –	8, 12, 18, 19, 20, 21, 25	time, (system transition)	trimming of processes, flow optimisation, (transition to the super system)
├ increase product life			
├ reuse objects			
├ products as a whole –	5, 22, 34	time, system transition	increased coordination, trimming of materials and/or processes, transition to the super system
├ partly –	2, 4, 5, 13, 22, 34	space, time, system transition	increased coordination, trimming of materials and/or processes, transition to the super system
├ repair objects –	1, 2, 22	space, time, system transition	increased coordination, trimming of materials and/or processes, transition to the super system
├ refurbish objects –	1, 2, 5, 22, 34	space, time, system transition	increased coordination, trimming of materials and/or processes, transition to the super system
├ increase recycling of materials –	1, 3, 5, 10, 15, 33	space, time, system transition	increased coordination, trimming of materials and/or processes, transition to the super system

Fig. 12. Proposed trend and reference to inventive or separation principles and existing trends.

mentioned. The Figs. 11 and 12 show a first proposal which the author thinks is easy to work with.

3 Results

The focus of the present work is to create a general characteristic or guideline to help increasing the sustainability of packaging products by proposing a new trendline and additional sub-trends to the classical TRIZ trends of engineering system evolution. The goal was to provide a tool to systematically develop and evaluate current and future products by comparing them to a sustainability trendline for determining a reference position. The process starts with the definition of the development goal. This is either the future packaging, the product to be developed or the improvement of the current product which is to be evaluated. The objective of the comparison is to identify the development direction and the points or areas of improvement. Difficulties and problems which might arise are a fitting and suitable definition of the object which should be evaluated together with correct statement of constraints, i.e., what is allowed to be changed and what must remain untouched. Finding a common understanding and the limits of possible change together with the system border are needed because without them the level of uncertainty of the outcome concerning the implementation increases. The involvement of third parties creates additional problems which must be addressed. The analysis of the current situation should be done as objectively as possible. If information of processes and products are required, they have to be acquired. The comparison might include the analysis of potential competitors as well.

The trendlines and the connection with inventive and separation principles allow a good overview and act as a working aid: These support tools are derived from a limited number of samples from the packaging industry. The conclusion seems to be consistent since certain changes could be mapped to already existing trend lines. The fact that products and services could be mapped to the proposed trend lines as well imply a general applicability

Figure 13 gives some examples for services and parts, e.g., the evolution of a map for spare time activities in a certain holiday region. The size of the map was reduced significantly from the year 2022 to 2023 (reduced amount of needed material) and it could be used for winter and summertime spare activities (increased universality, manufacture with greater batch size). The inventive principle of universality is also used for the improvement of timetables. Displays always show the most recent information, increase the user interaction, allow for giving the information in different languages and unite multiple types of information in one area. Thus, the amount of available information is increased, and the large paper timetable can be removed leaving space for the people. Ball pen designs made of paper or wood would be another example (see Fig. 14). The presented T-shirt is made from recovered ocean plastics which is considered a further step to increased sustainability.

The implementation and work with the process is supposed to be straightforward, but the current level of practicability/usability should be improved by further work. This includes the search and integration of more examples to the diagram presented in Fig. 12. Computer and AI support could be gained by setting up a database with possible examples and associated images for the different boxes of the trend hierarchy with special reference to care and respect for nature (sustainability).

This database could be browsed, or an AI could provide proposals based on a user interaction, e.g., questions raised by the AI application and answers of the user. Herrig proposed this kind of expert system for evaluating results of an examination and determining a suitable treatment [12, p. 34; 13, p. 84; 14, p. 6–61].

Entering images of designs, problem sketches or part lists followed by automated, AI supported image processing and providing suggestions based on development trends for increased sustainability could also help to improve products, processes and services.

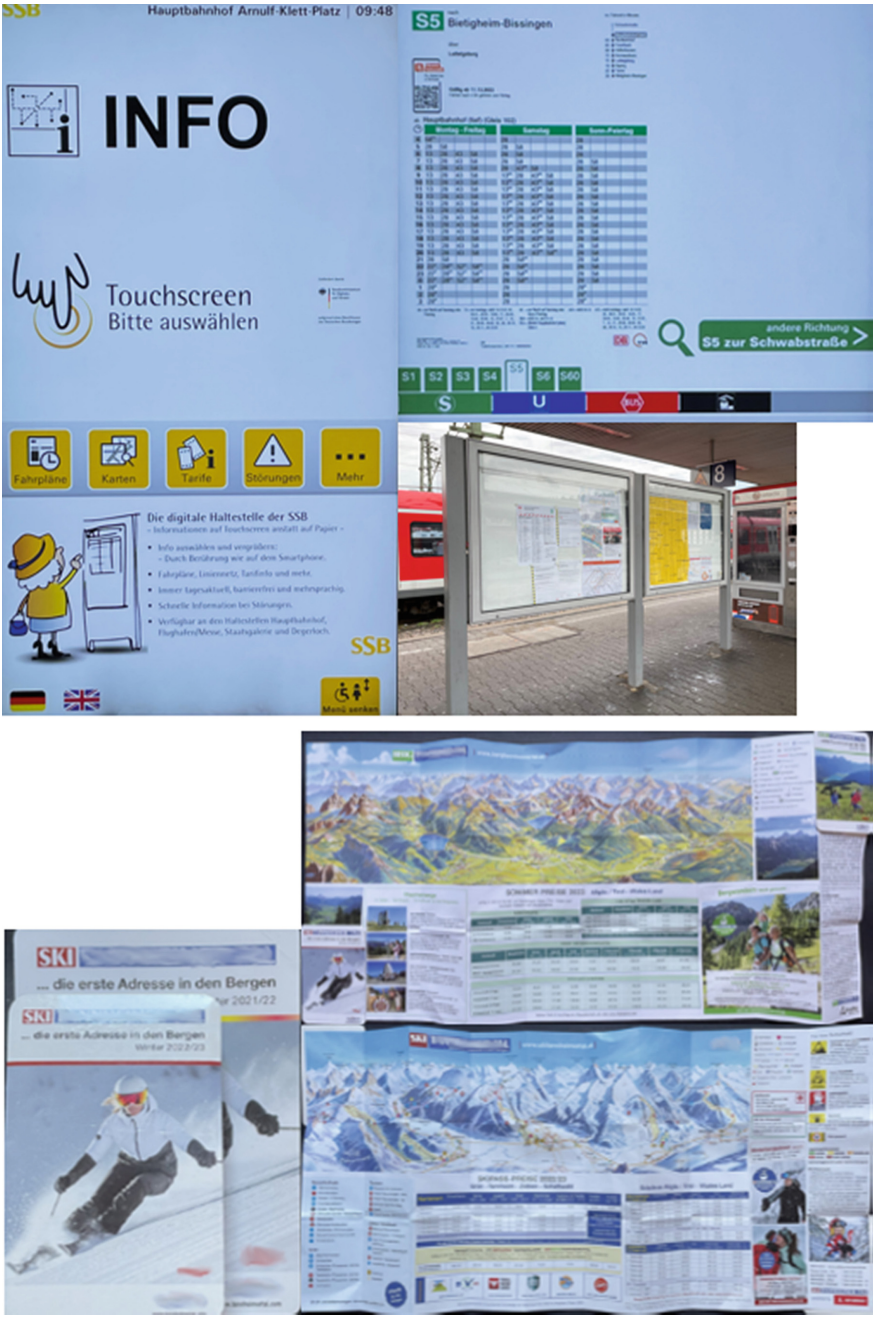

Fig. 13. Examples of services (timetables, top) and parts (tourist information, below)

Fig. 14. products made of recovered plastic waste (T-shirt) and recycled (paper and plastic, left ball pen) or sustainable material (wood, right ball pen)

4 Summary and Conclusions

The analysis of packaging example led to the proposal of an additional trendline to the TRIZ trends hierarchy of Technical Engineering System Evolution. The proposal must be further validated with more examples and with different industries. Nevertheless, the systematic structure seems to be logic, sensible, useful, and fitting common sense because it was derived from the analysis of changes which already have taken place for packaging products. The drivers of these changes could not be identified with one hundred percent certainty since some super effects like getting rid of thermal process (drying glues) and additional materials (the glue) are present as well. These super effects reduce cost and increases profit therefore helping the producer in two ways (more sustainable and cost reduction). The increased sustainability is used for marketing and improving the company reputation as well. The inventive principles used to increase the sustainability of packaging are present in other products and services as well. Therefore, it could be assumed that the transfer of the found trendlines and the associated action directions with them is possible and feasible in other areas as well.

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