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PACKAGING WASTE RESEARCH RESPONDING TO THE RISE OF TRANSPORT AND LOGISTICS VOLUMES DURING THE COVID-19 PANDEMIC

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Abstract

The management of packaging material and its transport flow, including waste management, has become the focus of attention in recent decades, not least because of the emphasis on the requirements of sustainable development. Due to ever-increasing volume various types of packages, i.e. coming not only from industrial production, transport and trade, where its management is regulated, organized and controlled, but also packaging waste that is generated in households and where this waste ends at best sorted into containers according to material and in the worst case as municipal waste, or it is used as fuel in the incinerator. Author's team defined the research idea in the direction of packaging waste, coming from online shopping, logistics and shipment distribution. The research was conducted over the year 2021 in the Czech Republic, during the Covid-19 pandemic, when online shopping was on its rise and, for many people, it became as a partly substitute for regular shopping in the future. In regard to an analytical part of the research, specific empirical methods were applied. The research hypothesis is evaluated statistically using a pairwise test. The presentation of the research per se is preceded by a literature review with citations of legislative articles and scientific papers related to the topic discussed. This section is followed by a description of the paradox in terms of online trading. The next part of the article presents the research findings, their summary and related conclusions.

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1. Introduction

Packaging package is art of many structures and has evolved over millions of years in nature. For example, the need to protect the embryos of organisms from environmental influences is one of the basic assumptions of the entire evolution. In nature, we also encounter packaging for other purposes and we can even observe not only the natural process of their recycling, but also their reuse. However, with the development of the human race, there was a need to package products as well, which gave rise to the packaging industry. As for the packaging material, it comes from nature anyway, for example in the form of wood for the production of boxes or paper boxes, or plastic materials based on petroleum products. The issue of packaging in relation to environmental issues is coming to the fore mainly thanks to facts that are not often talked about. For example, that although these materials (including plastics) are from nature, they are transformed by anthropogenic activity in such a way that nature itself is not able to decompose some packaging waste effectively over time (or only to a limited extent). Some types of packaging materials can even significantly affect natural processes, both by their quantity that accumulates in a certain place, and also by the properties of the material, which in many cases can endanger organisms.

Although it is possible to observe phenomena in which organisms directly use our packaging waste, however, with regard to other aspects, this cannot be considered a relevant reason for the production of packaging. Considering the long-term trend, it is important to think carefully about packaging waste and keep in mind that different types of packaging waste, or their quantity, can bring risks to the environment. During the Covid-19 pandemic situation, there was a great need to reduce physical contact between people and therefore there was an increase in e-commerce and the related increased production of packaging waste, but as you can see, e-commerce is still increasing even though the pandemic seems to be ended. The growing trend is already starting to fill the capacities of trucks that transport millions of shipments every day. These facts motivated the collective of authors to research, using experimental approaches and questionnaire surveys. They developed several possible approaches, worthy of investigation of the issue, for instance, they evaluated the efficiency in terms of the volume of transported goods and the total volume of the shipment. These methods were subsequently applied in our own study, including hypothesis establishment and testing.

2. Literature Review

Extensive and long-term research into the management of packaging waste has already produced a large number of interesting results, methods and approaches. For example, Brinker [1] tackles this topic globally and tries to develop a scale that assesses environmental elements in retail supply chains and examines the supply chain environmental management initiatives of the world's 100 largest retailers in terms of design, methodology and approach.

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In recent years, however, there has been an increase in transactions using e-shops, especially in the retail sector. For example, [2] deals in more detail with the development of online shopping in the conditions of the Covid-19 pandemic and in the Czech Republic, but specializes in packaging waste associated with online food sales.

Klemeš [9] proposes and discusses some opportunities for energy reform accelerated by the Covid-19 pandemic and expects a strong base in the cluster of innovative technologies and mentions other aspects such as the increase of e-socialization, remote access and the popularity of the home office, e-shops including intelligent delivery. Klemeš [9] also mentions the possibilities of automated waste collection and the application of new delivery methods, such as a drone. Each of these methods has certain advantages and disadvantages related to energy requirements. The continuity of the development of e-shops is also mentioned, for example, by Mouratidis, whose study provides new evidence of changes in a number of online activities as a result of the Covid-19 coronavirus pandemic. Online activities have replaced physical participation in various activities, including shopping, and contributed to changes in urban mobility. Its findings show that both the importance and frequency of e-shops increased significantly during Covid-19 compared to the pre-Covid-19 period. The Covid-19 pandemic has further strengthened this trend as online shopping has supported the principles of the #stayhome challenge. Online shopping is growing and generates 4.8 times more packaging waste than offline shopping and could generate an additional 10% of total waste in the next decade [11].

The increase in packaging waste from online shopping raises not only concerns for the environment, but also an enormous and often unnecessary increase in the capacity of transported volume, given that packaging intended for logistics processes from e-shops to the customer is only weakly regulated. These consequences force expert teams to deal with the problem and look for possibilities, for example, in the use of returnable packaging for e-shops [12, 13].

Regarding food transport packaging, which was also on the rise during the Covid-19 pandemic, [9] even returnable food transport packaging is being addressed in an environmental context and new, more environmentally friendly packaging is being proposed, e.g. [4]. However, these and similar researches often do not respond to the very essence of the generation of waste, or only marginally. It can therefore be stated that there is currently a relatively broad portfolio of approaches to waste management, but the continuity can be assessed as weak, as conventional packaging methods are still widely used here. Waste management technology is being addressed and other restrictions are being prepared, but the material composition of packaging, including life cycle analysis and the possibility of separating individual packaging materials for recycling or reuse, is not being investigated [15].

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3. Material and Methods

There are many attitudes to define the term "packaging". In the legislative conditions of the European Union, this term is defined by Directive 94/62/EC of the European Parliament and of the Council [8], which considers as packaging "(…) all products made of any material of any kind presentation of goods, from raw materials to finished products, from the manufacturer to the user or consumer. "Returnable articles" used for the same purposes are also considered as packaging.". Packaging is divided into different categories according to type, purpose, material, recyclability and the like. There are a number of approaches to this. The basic function of packaging is protective, handling, sales and information. The packaging protects the products from external influences (various types of damage, pollution, etc.), while sometimes also protecting the external environment from the active or aggressive properties of the transported goods. This function affects the durability of the product, serves to preserve the taste, color, determines the shape and the like. Handling function facilitates handling and transport. In terms of sales function, packaging plays a representative role in the product (it promotes the brand, various types of activities such as competitions, charitable projects, etc.). Packaging and its appearance influence consumer behavior, color, sequence, graphics and other aspects play an important role. The information function of the packaging consists in providing important information, e. g about the product and its composition, shelf life, storage conditions or sorting of empty packaging [2, 16]. Packaging materials are of various types, and from an environmental point of view and for the purposes of this article, it is most appropriate to divide them into materials from renewable and non-renewable sources. The obligation to dispose of packaging varies worldwide. Directive 94/62/EC of the European Parliament and of the Council [6] is laid down in the European Union. with individual Member States responding to it in their legislation. For example, in the Czech Republic, this obligation is stipulated by Act No. 477/2001 Coll. [6], which sets out, inter alia, the rights and obligations of packers.

Directive 94/62/EC of the European Parliament and of the Council [8]. also specifies the types of packaging and divides them into:

- packaging or primary packaging, ie packaging intended to form a sales unit to the end user or consumer at the point of purchase;
- grouped packaging or secondary packaging, ie packaging intended to form a group of a number of sales units at the point of purchase, whether that group is sold to the end user or to a consumer, or serves only as an aid to placing on the shelves at the point of sale; they can be removed from the product without affecting its properties;
- transport packaging or tertiary packaging, ie packaging which is intended to facilitate the handling of a number of sales units or grouped packaging and to facilitate their transport in order to prevent physical damage during handling and transport. Road, rail, sea and air containers are not considered as transport packaging.

The above division of packages is schematically illustrated in Figure 1.

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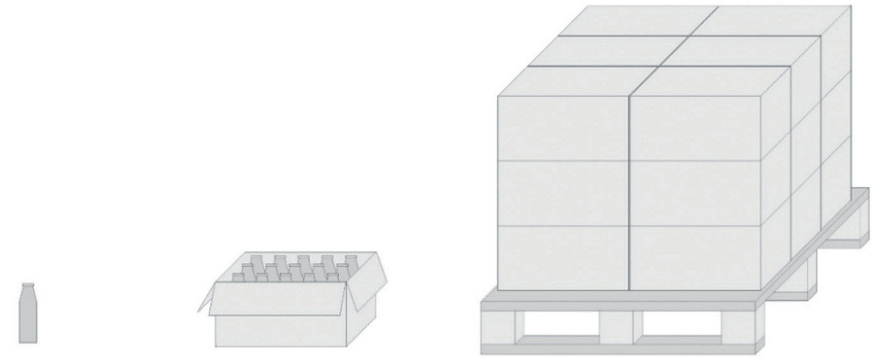

Fig. 1a primary package

Fig. 1b secondary package

Fig. 1c terciary package

Fig. 1. Distribution of packaging. Source: authors

It is also necessary to define the concept of packaging waste, where according to any packaging or packaging materials covered by the definition of waste under Directive 75/442/EEC [9] are considered as packaging waste, with the exception of production waste which also specifies the term "packaging waste management" as well as "prevention", ie reducing its amount and harmfulness to the environment, including materials and substances contained in packaging and packaging waste. For the purposes of this article, it is also necessary to define the area of trade in which packaging is used and thus responds to the situation during the Covid-19 pandemic, when there was an enormous increase in online shopping [3, 11]. This research focused on goods sold in so-called classic shops and online stores. For the purposes of this article, "classic shop" means a form of retail sale which uses premises accessible to customers for its activities, such as buildings, rented rooms, stalls or kiosks. This term is always used where the customer comes directly to the seller's premises and deals with the sellers. This also applies when the order is made online. Some online stores use classic shops as places to dispense goods.

Under the term "online store" resp. "e-shop" for the purposes of this article it is meant a website offering goods with the possibility of ordering them, as well as receiving such orders from customers, arranging and recording payments and providing additional information about products or handling complaints, while delivery of goods to the customer is carried out by means of a parcel consignment transported by a carrier, the goods in question of which must be packed in such a way that no damage occurs during transport. As described in various publications, the flow of monitored packaging waste in the above area of interest is defined by the following schemes.

Directives and legislation [5, 6] seem to presuppose the journey of goods to the customer according to the following scheme:

$$\text{terciary package} \longrightarrow \text{secondary package} \longrightarrow \text{primary package} \longrightarrow \text{consumer}$$

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The research focused on packaging resulting from online trading, where another element enters the chain – the transport package:

$$\text{terciary package} \rightarrow \text{secondary package} \rightarrow \text{primary package} \rightarrow \textit{shipping package} \rightarrow \text{consumer}$$

The assumption is that the final consumer will receive the goods, packed in the primary packaging, both when shopping in the classic shop and in the e-shop. In addition to its protective purpose, the primary packaging carries a number of information about the goods, including data on the minimum shelf life and the like. In this respect, it is not necessary to deal with the primary packaging further, it is only important to mention the assumption that the end customer must receive the goods in undamaged primary packaging. Following the situation surrounding the Covid-19 pandemic, it should be noted that disinfection of transport packaging was also considered. However, this issue is not part of this article. Of course, the "transport package" element also exists in the first schema. The goods often did not leave the classic shop only in the primary packaging. The customer often received a transport bag, sack or other packaging material for purchase, which can also be described as transport and its function was, in addition to marketing, also protective. However, EU Directive 94/62/EC [8] responded to this fact, which for various reasons (such as the reduction of packaging waste) stipulated the need to charge for such transport packaging and also defined which types of packaging fall into this category. As regards e-shops and transport packaging used to transport goods to consumers, Directive 94/62/EC [8] itself does not mention e-commerce or online shopping and therefore does not specify or regulate recycling quotas for different types of packaging materials, or aspects of packaging waste recycling within EU member states. However, it demonstrates the principle of extended producer responsibility in EU recycling programs. This means that producers and retailers who place packaging on the market are responsible for recycling their packaging, with each Member State having to enforce the EU Packaging Waste Directive in its own national laws. Member States' legislation on the management of such packaging waste responds relatively inconsistently, for example by imposing waste sorting obligations, imposing weight limits on waste production and the like. It should also be noted that the transport package for the purposes of collection from the classic shop is optional, as is the transport package for goods from the e-shop, because the quality of the primary packaging is often sufficient and it is not necessary to use another transport package.

4. Results

The following hypothesis was established for the research:

In terms of their function, transport packaging for goods from online stores is often more demanding on the amount of material consumed than transport packaging designed for the simple transport of goods from the classic shop to the end customer's household.

For the purposes of this hypothesis, it was important to quantify the amount and materials of packaging. The research team therefore decided to create a comparative study when purchasing the same goods in the e-shop and in the classic shop. The research methodology

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consisted of a questionnaire survey, consultations with representatives of both types of stores, observations during business transactions and laboratory analysis of individual packages. Qualified interpretation and statistical processing of the obtained results created a basis for testing the hypothesis. The range of goods that is distributed through e-shops to the customer is growing enormously and includes clothing, food and similar commodities. Electronic products – such as headphones, speakers, computer components and the like – were selected as typical goods for research purposes, whose sales through e-shops grew up during the Covid-19 pandemicy, i.e., goods that must be protected against external influences during transport in order to avoid damage. At the same time, it is a product that is usually completely covered by the primary packaging, and in the event of any damage, the goods can also be assumed.

For illustration purposes, weights are given in grams (not kilograms as SI units)

The main part of this work is the analysis of shipments, respectively shipping packages. These were assessed in terms of volume and material used, including linings. First, however, it was necessary to identify "typical" shipments, i.e., the most common, most used - those that move in the transport chains hundreds of thousands a day [10]. This was preceded by a general analysis, where methods of empirical research, discussions with forwarding staff and the like were used. Only on the basis of these investigations was it possible to select 25 so-called typical consignments, which were later subjected to a thorough analysis and transport tests. These consignments had a total weight of 100 grams to 2960 grams, including the primary packaging, which is considered an integral part of the product for the purposes of the above reasons. Shipments were assessed in terms of volume, weight and type of packaging material. The goods packed in the primary packaging were considered as a unit of goods and the whole package, including the unit of goods, shipping package and possible linings, according to the formula (1).

$$\text{product in primary package} + \text{shipping package} = \text{packet}$$

Laboratory measurements were performed in normal conditions. The research team decided only to dry all samples in climatic chamber (3 hours in 343,15 K) before analyse. Due to the diversity of packaging materials, material weights and composition, the research needed to be generalized. First, the chemical composition of the plastic components of the packaging was omitted. Only in Table 2 there is noted the type of material and if used plastic is biodegradable. The individual types of material were separated and subsequently analyzed. Due to the fact that cardboard residues, which could distort the measurement results, adhered to their adhesive surface during the separation of the adhesive tapes, their weight was determined by recalculation according to the weight of a 20 meter long roll of the same type of tape. This procedure – that is, that only the length is sufficient to calculate the weight of the tape used - proved to be progressive, as there is no need to separate the individual layers with its use. If this research is repeated, it is also possible to use a less accurate weight using this method, the error of which, however, can be at least partially eliminated using statistical methods.

The obtained values are summarized in Table 1, where:
packaging capacity (A) is volume of whole consignment, counted as volume of geometric shape,

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as closely as possible described shape of the whole consignment (usually a block) in [dm^3];
primary packaging capacity (B) is the volume of the primary packaging (usually also a block) in [dm^3];
packaging oversize capacity (C) is the difference between the volume of the secondary packaging and the primary packaging in [dm^3], according to the formula:

$$C_i = A_i - B_i \tag{1}$$

- efficiency coefficient (D) is the ratio of packaging capacity, from which the volume of the primary packaging was deducted, to the volume of packaging capacity in [dm^3], according to formula:

$$D_i = \frac{C_i}{A_i} \tag{2}$$

Tab. 1. Overview of packagings. Source: authors

	A		B	C	D
i	Packaging capacity [dm^3]	Main material of secondary packaging	Primary packaging capacity [dm^3]	Packaging over-capacity [dm^3]	Efficiency coefficient [–]
1	4.25	singlewall cardboard	0.66	3.58	0.84
2	3.78	doublewall cardboard	0.66	3.12	0.82
3	10.50	bubble wrapper	0.66	9.84	0.94
4	3.00	singlewall cardboard	0.66	2.34	0.78
5	10.50	bubble wrapper	0.66	9.84	0.94
6	27.20	singlewall cardboard	4.00	23.20	0.85
7	9.57	stretch foil	8.23	1.33	0.13
8	22.95	doublewall cardboard	18.75	4.20	0.18
9	9.24	singlewall cardboard	5.40	3.84	0.42
10	3.30	singlewall cardboard	0.44	2.86	0.87
11	0.82	singlewall cardboard	0.24	0.58	0.71
12	29.76	singlewall cardboard	10.44	19.32	0.65
13	1.90	singlewall cardboard	1.15	0.74	0.39
14	0.71	stretch foil	0.57	0.14	0.20
15	3.99	doublewall cardboard	0.77	3.22	0.81
16	5.4	singlewall cardboard	0.70	4.69	0.87
17	3.96	singlewall cardboard	1.17	2.79	0.71
18	8.05	singlewall cardboard	3.71	4.34	0.54
19	4.91	singlewall cardboard	1.79	3.12	0.63
20	2.94	singlewall cardboard	1.38	1.56	0.53
21	0.83	singlewall cardboard	0.24	0.59	0.71
22	2.52	doublewall cardboard	1.13	1.39	0.55
23	9.30	stretch foil	8.85	0.44	0.05
24	7.54	singlewall cardboard	3.91	3.63	0.48
25	1.78	doublewall cardboard	0.90	0.88	0.49
$\sum$	188.75	–	77.07	111.68	Average=0.60

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As seen in Table 1, the most used material as box is cardboard. The sum of the measured volumes also shows, that half of the volume is a shipping package and average value of the volume share of the shipping package on the whole consignment is about 60%

Shipments from e-shops were also examined in terms of volume – in particular, what kind of shipping package is transported with its own shipment. The results and mutual ratios of these values are shown in the Figure 2, where the total volume of packaging is considered as 100% volume and the volume of the transported consignment is expressed as a percentage, noting that the volume of some consignments is up to four times the volume of transported goods. Another interesting fact is that in terms of total volume, shipments were evaluated as the most efficient, when the primary packaging was repackaged for the purpose of transport by several layers of stretch film. The negative phenomenon of this style of packaging is the greater susceptibility of the goods to damage and also recyclability – the degradability of the material is time consuming and its secondary use complicates gluing with paper labels.

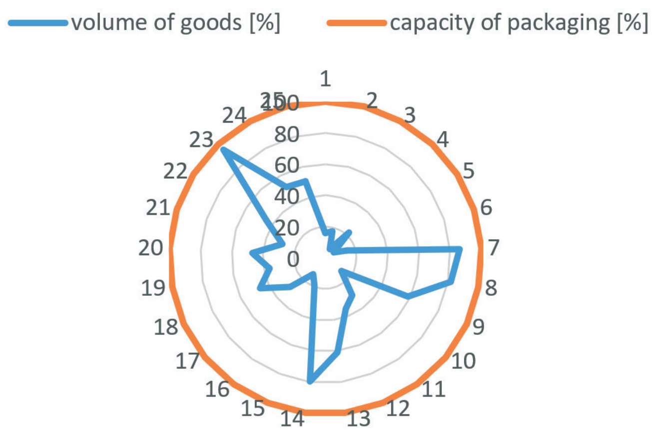

Fig. 2. Volume share of goods in the consignment. Source: authors

The types of materials used for the shipping package of the examined reference shipments, including the weight, are listed in the following Table 2. The weight of the identification paper labels was neglected and the measured values were rounded to whole grams.

As marked in Table 2, the most weight of material and at the same time the biggest mass of packaging is cardboard, which is a partly biodegradable material. Figure 3 shows the weight fraction of cardboard weight and weight of plastics in shipping package from e-shop.

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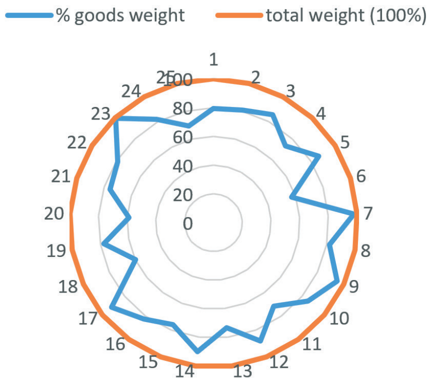

Fig. 3. Weight quote of goods. Source: authors

Tab. 2: Material analysis of selected packagings

i	Packaging weight total [g]	Cardboard weight [g]	Packaging weight (e-shop) [g]	Plastic material (classic shop) [g]	Filling material (only e-shop)
1	110	108	2	3	polystyrene flakes
2	99	98	1	5	–
3	72	68	4	5	polystyrene flakes
4	155	150	5	4	corrugated cardboard
5	63	59	4	2	bubble foil
6	526	500	26	1	bubble foil
7	30	0	30	5	–
8	370	335	35	3	–
9	130	125	5	5	–
10	60	56	4	3	–
11	40	32	8	4	–
12	260	245	15	4	bubble foil biodegradable
13	160	148	12	2	mirelon
14	10	0	10	3	–
15	124	123	1	4	paper
16	150	141	9	2	bubble foil
17	133	126	7	5	PVC foil
18	114	108	6	5	–
19	136	131	5	2	bubble foil
20	103	94	9	3	–
21	64	62	2	2	paper
22	82	76	6	3	PVC foil
23	21	0	21	2	–
24	160	160	0	4	paper
25	97	95	2	2	–

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Subsequently, shipping / transport packages from classic stores and e-shops were compared. In classic shop, there was requested the common packaging which is offered for customers, they don´t have their own bag. The mass results are shown in Figure 4.

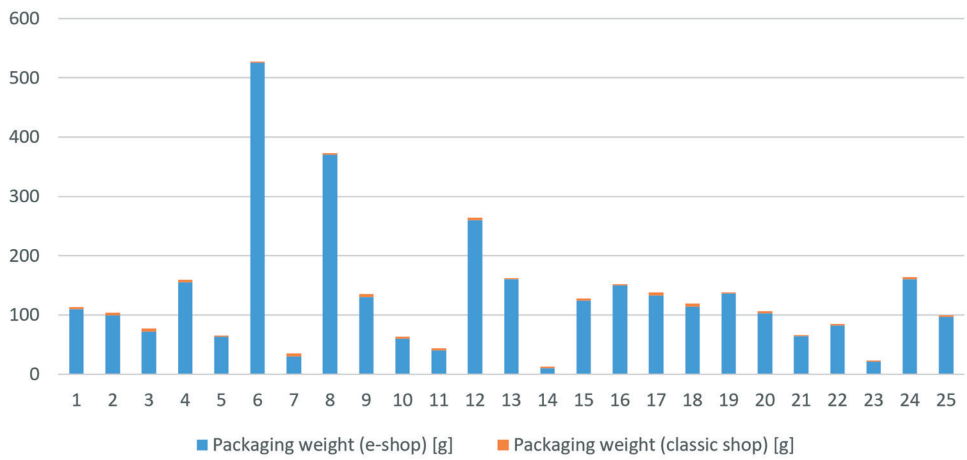

Fig. 4. Analysis of packagings. Source: authors

The above comparison of packages by weight in the Table 2 was chosen only for simplicity. The results can also be compared according to the type of material, the possibility of their recycling and the like. The research team expected the classic shops to be more creative about packaging offered (min. such as paper bags), but only plastic bags were received from them. Therefore, the Figure 5, which shows the mass proportion of plastic components of shipping package from e-shops and plastic bags from classic shops.

Fig. 5. Weight share of plastic material in consignments from e-shops and classic shops. Source: authors

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The exact values for the Figure 4 are shown in Table 2. These values are used as a basis for statistics pairwise test, which is presented in the following chapter.

5. Pairwise Test of the Dependence of the Weight of Plastic Packaging on the Method of Purchase of Goods

The paired test method was chosen to test the hypothesis. The dependence of the weight of plastic packaging on the method of purchasing goods will be tested using a pairwise test at a 5% level of significance. The test will be performed using R Commander statistical analysis software. For testing purposes, a sample statistical set of 25 statistical units was created, see Figure 6. Statistical units represent a specific type of goods that were purchased in the e-shop and in the classic shop in order to perform the test. The statistics file contains two statistical characters. The first statistic determines the weight of the plastic packaging when buying goods in a classic shop. The second statistic determines the weight of the plastic packaging in the case of purchasing goods in the e-shop. Statistical characters will be used as two selections in a paired test.

	plastic_e.shop	plastic_store
1	2	3
2	1	5
3	4	5
4	5	4
5	4	2
6	26	1
7	30	5
8	35	3
9	5	5
10	4	3
11	8	4
12	15	4
13	12	2
14	10	3
15	1	4
16	9	2
17	7	5
18	6	5
19	5	2
20	9	3
21	2	2
22	6	3
23	21	2
24	0	4
25	2	2

Fig. 6. Analysis. Source: authors

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Before performing a pairwise test, it is necessary to verify that the values of both samples come from the normal probability distribution. We verify the normality for both selections separately at the 5% level of significance using the Shapiro-Wilk data normality test [7]. To perform the test, we establish a null and alternative hypothesis: H0: The selection values come from the normal probability distribution. H1: Selection values do not come from a normal probability distribution. The results of the Shapiro-Wilk test performed in R Commander for both selections are shown in Figure 7.

```
> shapiro.test(Dataset$plastic_e.shop)

        Shapiro-Wilk normality test

data:  Dataset$plastic_e.shop
W = 0.795, p-value = 0.0001875


> shapiro.test(Dataset$plastic_store)

        Shapiro-Wilk normality test

data:  Dataset$plastic_store
W = 0.889, p-value = 0.01065
```

Fig. 7. Shapiro test. Source: authors

The P-value obtained by the Shapiro-Wilk test is lower than the selected level of significance in both selections. Based on this, at the 5% level of significance, we accept the alternative hypothesis H1 for both selections. Thus, the values of both selections do not come from a normal probability distribution. Because the values of both selections do not come from a normal distribution, a nonparametric test must be used to perform a paired test. We use the nonparametric paired Wilcoxon test. For the test, we choose the following null and alternative hypothesis: H0: The weight of plastic packaging when buying goods in the e-shop is on average the same as when buying goods in the classic shop. H1: The weight of plastic packaging is on average higher when buying goods in the e-shop than when buying goods in a classic shop. The results of the Wilcoxon paired test performed in R Commander are shown in Figure 8.

```
> wilcox.test(Dataset$plastic_e.shop, Dataset$plastic_store,
+   alternative='greater', paired=TRUE)

        Wilcoxon signed rank test with continuity correction

data:  Dataset$plastic_e.shop and Dataset$plastic_store
V = 214, p-value = 0.002325
alternative hypothesis: true location shift is greater than 0
```

Fig. 8. Wilcox test. Source: authors

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The P-value obtained by the Wilcoxon paired test is lower than the selected level of significance. Based on this, we accept the alternative hypothesis H1 at the 5% level of significance. It can therefore be argued that the weight of plastic packaging is on average higher when ordering goods through the e-shop.

6. Discussion and Recommendation for Further Research

Based on the available professional literature and valid legislation, the presented research summarizes the current state of the solved packaging waste from e-commerce, the volume of which has increased dramatically due to the Covid-19 pandemic. The research methods used have been verified and allow the research to be repeated. The analysis of the measured data revealed the types of packaging materials used, their weight fractions and possible volumes. Testing the research hypothesis confirmed that transport packaging of goods from online stores is often more demanding in terms of their function of the amount of material consumed than transport packaging designed for simple transport of goods from the classic shop to the end customer's household [14].

However, the findings are almost negligible in terms of unit scale. It is necessary to consider tens of thousands of similar shipments per day and multiply the amount of packaging material by them, and also to consider that the trend of e-commerce is increasing even after Covid-19 pandemic. The total amount can then be expressed, for example, in tons of packaging material per day. The recyclability or reuse of material was also mentioned in passing in the article. There is currently no biological way to decompose or reuse certain types of materials. However, this remains the subject of further research, as in addition to feasibility, motivation must probably be addressed, which will probably have to be enforced by legislation. Nevertheless, the research team, based on its findings, would like to suggest several options for rationalizing this situation:

- Change the primary packaging so that it can also serve as a transport package. As mentioned above, in this case a lot depends on the quality of the primary packaging, especially with regard to its resistance to mechanical or climatic influences. Furthermore, it is necessary to define the areas for gluing on the packaging with transport labels with data about the shipment so that important product data is not pasted over. It is also necessary to ensure that the readability of the data is not lost or reduced due to transport – for example by printing the most important data inside.

- Optimize shipment storage – Use filling material from biodegradable materials. This proposal, however ideal, has many pitfalls. First of all, it must be considered that such material (such as hay) may cause invasive plants to be introduced into endangered areas. It can also cause allergic reactions. However, the advantage of such materials is that they are available almost everywhere, are light and 100% biodegradable.

- It is not necessary to oversize the packaging. As part of the research, reference shipments with very thin packaging were also sent out, and yet these shipments arrived in perfect

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condition. The vast majority of carriers do not specify the load to which consignments are subjected during transport. At the same time, shipments are insured against damage that may be obvious at first glance upon receipt. If it is not a unique product, it can be replaced within the complaint.

- Promote the sortability of packaging waste. This recommendation is based on the principle of recyclability or reuse of individual types of material – it is therefore recommended not to stick paper labels on plastic packaging due to the difficult separability [7, 11].

7. Conclusions

The research presents knowledge about the current state of the specified group of packaging waste. The topic of the article is current due to the expansion of e-shops and contributes to solve the problem, because it has both environmental, economic and social overlap and mentions legislative shortcomings. Packaging waste can be marked as a subject for continuous improvement in terms of material, but also in terms of unnecessary acquisition of shipments.

The economic subtext of this problem is that the transported consignments will take up a larger volume in vans, wagons and the like, and at the same time a larger amount of used material also means an increase in the price of the consignment. The social aspect of the ever-increasing volume of packaging material coming from e-shops is that it ends up in the hands of the public and ordinary people have to sort it properly in order to reuse these materials.

The environmental view of packaging waste then extends into ecological relationships in nature and forces philosophical ideas. Not all types of waste are necessarily harmful, as they all come from nature. However, some materials are so transformed by anthropogenic interventions that nature is not able to decompose them in the foreseeable future. Given the current situation of the management of fossil raw materials and renewable resources, it is necessary to appeal to smarter use of materials, with special emphasis on those materials that are used only for a short time and will eventually become waste. In this article, the research team outlined several research methods that can be used to perform shipment analysis on a wide range of goods.

One of the interesting values found is the so-called packaging over-capacity, which tends to be several times higher due to the volume of transported goods. Another interesting fact is that some packages weigh more than the weight of the goods being transported. It can be stated that if this research is repeated by another team, similar results will be achieved, of course, with different values. However, the wish of the entire research team is that the researched values are more favorable in the spirit of sustainable development, i.e., that the volume of packaging waste is much smaller and their material composition is as environmentally friendly as possible.

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The established hypothesis was confirmed on the basis of analysed shipments, which the research team considers as a reference after many partial analyses. It can be stated that shipments from e-shops are more demanding in terms of the amount of packaging materials used. This finding contributes to previously published conclusions. Although the research only covered the narrow profile of goods, it can be assumed that a similar situation can be observed in other industries, or online orders of goods. Of course, this controversy can also be disputed, for example because of the number of consignments that are damaged during transport. An analysis of the ways in which the damage occurred and the extent to which it is affected by the shipping package can also contribute to the joint discussion. This is also in terms of whether the transported goods are substitutable or not. The results are a contribution to the study of issues and knowledge in the field and show exemplary options in the event of its recurrence.

Further steps in such research may lead to legislative changes at both national and supranational levels. They can also serve as a basis for the design of unconventional types of packaging, packaging and filling materials with an interdisciplinary approach in the diction of the principles of sustainable development. Last but not least, it is possible to exclude only a part of this research and use it, for example, for alternative teaching of children at school.

In addition to being able to test the research on their own, their results will also be able to contribute to the solution, either in the form of measured values or through their own inventions to improve this situation. The young person is not burdened with general problems and is able to think only in the solved direction. Sometimes these proposed solutions bring new light to the issue. After all, it is the children who will live in this world after us, and it is our duty to give it to them in good condition.

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