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Identification and assessment of opportunities and threats for the Circular Economy arising from E-commerce

Authors:

Romagnoli V., Aigner J. F., Berlinghof T., Bey N., Rödger J.-M. and Pätz C.

Editors:

Orveillon G., Garbarino E., Saveyn H.

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Joint Research Centre

Contact information
Name: European Commission, Joint Research Centre, Growth & Innovation – Circular Economy & Industrial Leadership
Address: Edificio EXPO, Calle Inca Garcilaso 3, 41092 Seville, Spain
Email: jrc-env-research@ec.europa.eu
Tel.: +34 954 48 8318

EU Science Hub
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Foreword

The digital market, digitalisation, a sustainable and more circular economy have been priorities since the Junker Commission and remain at the top of the agenda of the European green deal[1] and the new Circular Economy Action Plan for a cleaner and more competitive Europe[2] of the new Von Der Leyen's Commission.

In 2019, the Business-to-Consumer E-commerce turnover represented in Europe EUR 621 billion, with a 13% growth[3]. With the recent COVID-19 crisis, the interest for a number of products and services has increased such as online shopping, teleconferencing or entertainment[4].

As E-commerce is gaining interest and weight in our economies, the Joint Research Centre launched a study to explore the possible impacts of E-commerce on the circular economy objectives, by identifying and assessing opportunities and threats for the circular economy arising from E-commerce.

The study was designed to be representative of the EU market. For that purpose, 5 representative EU countries and 7 relevant products were selected following a specific methodology, covering all the EU subregions and ensuring a representative basket of products covering diverse product types, market relevance, level of circularity and consumer behaviours.

The study included several stakeholders' consultations: two online surveys and a workshop. Taking into consideration both the literature research and the stakeholders inputs, opportunities and threats were defined and grouped into 7 'clusters'. Eventually, for each cluster, an assessment on the circular economy of the potential effects of E-commerce compared to the traditional 'brick-and-mortar' stores was carried out.

The study also provides the reader with a detailed description of the threats and opportunities identified, along with their current and future relevance. In addition, it provides the different actors, producers/platform providers, regulators and scientific community with a number of options for action in order to respectively mitigate or promote the effect of the threat or opportunity.

Finally, the study highlights the correlation and interlinks between a number of opportunities and threats, assesses the relevance of each of these, and provides key conclusions for each cluster.

[1] COM/2019/640 final

[2] COM/2020/98 final

[3] European Commerce Report – 2019 edition (https://www.ecommerce-europe.eu/research/ecommerce-europe-reports/)

[4] World Trade Organization – E-commerce, trade and the COVID-19 pandemic, Information note (https://www.wto.org/english/tratop_e/covid19_e/ecommerce_report_e.pdf)

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Acknowledgment[5]

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Amazon

Ambilamp

eBay

Ecolight

Ecotic

European eCommerce & Omni-Channel Trade Association (EMOTA)

Eucobat

EuroCommerce

European Recycling Platform/Landbell Group

Extended Producer Responsibility Alliance (EXPRA)

Independent Retail Europe

WEEE Forum

Zero Waste Europe (ZWE)

[5] The inclusion in the list does not imply that the organisation endorses the contents of the present report.

Authors

Valentina Romagnoli, Joachim Felix Aigner, Thomas Berlinghof, Niki Bey, Jan-Markus Rödger and Cordelia Pätz.

Abstract

The present study identifies, describes and assesses in detail opportunities and threats for the Circular Economy arising from E-commerce.

A broad literature research and direct stakeholder input led to the identification of 18 opportunities and 23 threats for the Circular Economy, allocated to 7 different clusters. Most of the identified threats refer to “Logistics and transport”, while opportunities refer mainly to the topics “Accessibility of information” and “Digitalisation”.

By means of a comparative assessment in the current situation and future optimistic and pessimistic potential developments, the direct and indirect effects of the opportunities and threats have been evaluated, with specific focus on 7 selected product categories.

In total, 11 opportunities and 16 threats have been assessed as either medium or highly relevant. The assessment revealed that most of the threats classified as highly relevant belong to the cluster “Logistics and transport”, including induced parcel transport, parcel return and inefficient transport, while most of the highly relevant opportunities are to be found in the cluster “Accessibility of information”, as in the case of second-hand commerce or product portfolio.

Executive Summary

Objective of the study and background

The study falls within the framework of the current two top priorities of the Juncker Commission: "Jobs, growth and investment" and the "Digital Single Market", and in particular the policy areas "Towards a circular economy" and "Better access for consumers and businesses to on-line goods".

In principle, the Digital Single Market offers substantial opportunities to the development of a true Circular Economy. At the same time, threats may also exist from unbridled developments that disregard the planet's resources, the environment and human health. This study aims to shed a better light on both these opportunities and possible threats.

The objective of the present study, launched by the Joint Research Centre of the European Commission and carried out by Ramboll Environment and Health in cooperation with Ramboll Management Consulting and the Technical University of Denmark (DTU) is to identify, describe and assess in detail important opportunities and threats that E-commerce constitutes for the Circular Economy, based on a selection of relevant physical products.

In order to fulfil this objective, the study envisages the following main phases:

- selection of 7 products based on a specifically developed methodology;
- identification of a set of opportunities and threats for the Circular Economy arising from E-commerce;
- in-depth assessment of the influence of the identified opportunities and threats on the Circular Economy aspects of the selected products, taking into consideration both the current and future situation in the traditional retail and E-commerce scenario; and
- grouping of opportunities and threats according to their relevance in three categories of low, medium and high relevance.

Selection of relevant products for assessment of opportunities/threats

The assessment of the opportunities and threats for the Circular Economy arising from E-commerce focused on the following **7 product categories** that are either sold online or in traditional "brick-and-mortar" stores:

1. Accessories
2. Apparel
3. Major furnishings
4. Major household appliances
5. Media and entertainment products/services
6. Non-perishable food
7. Small information and communication technology

The methodology for the selection of the above-listed product categories was based on a set of quantitative and qualitative criteria and on the results of an online stakeholder survey carried out in order to close existing data gaps and provide a direct input on relevant characteristics of specific product categories sold online.

The following criteria have been used: product category diversity, online/offline market relevance, return rates, amount of packaging required for shipping, purchase frequency and consumer preferences, with respect to online and "in shop" purchases. The criteria have been applied to an initial range of 26 product categories defined on the basis of the European integrated system of statistical activity and product classifications and after a preliminary screening of available data, based on available reports and databases.

As a starting point for the data availability check and data collection on the initial set of product categories and screening criteria, the selection of 5 main European countries was carried out with the aim of exploring possible regional differences in Europe that may affect opportunities/threats and to identify the countries that could be used as a reference in the

different stages of the study in case Europe-wide data would not be available. Considering factors such as population, share of online buyers, overall consumer spending, overall E-commerce growth rate and actual spending in the E-Commerce, the following countries were selected as representatives for each of the 5 subregions of Europe according to the Eurovoc classification:

- Central and Eastern Europe: Poland;
- Northern Europe: Sweden;
- Southern Europe: Spain; and
- Western Europe: France and Germany.

Identification and description of opportunities and threats for the Circular Economy arising from E-commerce

The study identified an overall number of **41** opportunities and threats for the Circular Economy arising from E-commerce, of which **18 opportunities** and **23 threats**.

The 4-steps methodology applied consisted in an initial broad literature research that led to the identification of a first range of opportunities and threats, followed by a systematic classification based on two orders of environmental effects (direct and indirect) and evaluation of relevance with regard to selected product categories. Subsequently, relevant stakeholders were consulted by means of an online survey and a dedicated workshop was held in order to validate the final list of opportunities and threats to be assessed in the third part of the study.

The different opportunities and threats have been allocated to **7 groups or clusters**, identified thanks to the direct input of the stakeholders, which are expected to act on the same or similar Circular Economy aspects.
The final list of identified opportunities and threats grouped by cluster is reported in the Table below.

Opportunities and threats for the Circular Economy arising from E-commerce

Cluster	O/T	Opportunities and Threats
Accessibility of information	O	Availability of information
	O	Big data/ meta data
	O	Innovation
	O	Market access to online aftermarket
	O	Product portfolio
	T	International market access
	T	Ubiquity
Consumer needs and behaviour	O	Nudging
	O	Sharing models and services
	T	Cross-selling and up-selling
	T	Ease of shopping
	T	Personalised design
	T	Shopping frenzy
Digitalisation	O	Digital goods
	O	Reduction of retail space
	O	Substitution of printed marketing material
	T	Operation of network infrastructure
End of life	O	Extended product selling cycle
	O	Product take-back
	O	ReCommerce: Second-hand E-commerce /online auctioning
	O/T	Food waste
	T	End-of-Life challenges
Legal framework	T	Difficulty to monitor
	T	Enforcement
	T	EPR free-rider effect
	T	Lack of compliance with common market regulation
Logistics and transport	O	In-House Fulfilment
	O	Collaboration between companies and partnering with waste management suppliers
	O	Optimisation of supply chain
	O	Substitution of individual shopping trips
	T	Damage on delivery
	T	Individual product delivery
	T	Induced freight traffic to remote locations
	T	Induced parcel transport
	T	Inefficient transport
	T	Inferior types of transportation
	T	Parcel return
	T	Waste from returns
Packaging	O	Development of dedicated optimised packaging solutions
	T	Excessive protective packaging
	T	Secondary Packaging

Each of the opportunities and threats identified has been further investigated and described in detail. The information provided includes a presentation and discussion of the opportunity/threat, the identification of the value chain differences between the traditional sales channel and online distribution, the current and the future relevance, the identification of factors that act as catalysts on the development of the respective opportunity or threat (supporting factors) or that slow it down (mitigating factors) and, eventually, a list of possible initiatives/solutions to mitigate the effects of the threat or further promote the opportunities, divided by Producers/Platform providers, Regulators and Scientific Community.

In-depth assessment of opportunities and threats for selected product categories

An in-depth assessment of the effects of the identified opportunities and threats on the Circular Economy has been carried out by means of a comparative analysis of the traditional retail channel and E-commerce.

In order to compare the effects of the opportunities and threats between traditional brick-and-mortar retail and E-commerce for the current state as well as future scenarios, representative Circular Economy aspects/indicators were identified for each of the selected clusters. All quantitative and qualitative effects within the respective cluster were assessed against those representative indicators relating to the functional unit "one fulfilled unit".

The Table below provides an overview of the indicators associated with the identified clusters.

Overview of effect clusters and representative indicators (Circular Economy aspects)

Cluster	Representative Indicator	Unit(s)
Accessibility of information	Qualitative assessment. Identification of specific indicators not applicable - various effects, with complex interactions.	
Consumer needs and behaviour	Qualitative assessment. Identification of specific indicators not applicable - various effects, with complex interactions.	
Digitalisation	"(Primary) Energy demand and global warming potential"	• kWh • CO_2e
End-of-Life	"Fraction that is effectively brought into a second or prolonged life cycle and product waste per fulfilled unit"	• percentage (%) • absolute (number of products wasted per fulfilled unit)
Legal framework	Qualitative assessment. Identification of specific indicators not applicable - various effects, with complex interactions.	
Logistics and transport	"Transport requirements per fulfilled unit"	• km/unit & CO_2e/unit
Packaging	"Amounts of plastic and cardboard packaging demand per fulfilled unit"	• kg plastic packaging/unit*, • kg cardboard packaging/unit **Plastic is represented by LDPE foil*

Within each cluster, the current situation, the baseline scenario as well as the future scenario (optimistic and pessimistic) have been assessed.

As regards the cluster "**Accessibility of information**", a summarised "net effect", valid for certain product categories or across all of them, could not be determined, although being a central theme when comparing E-commerce and traditional commerce. Better information can in fact be assumed to lead to less product returns and longer use phases, potentially contributing to decreasing environmental impacts. On the other hand, more devices used globally – driven by shorter innovation cycles on a device-level – can be assumed to lead to increasing environmental impact potentials, globally and at the EU-level.

The study revealed that sharing models and services evaluated within the cluster "**Consumer needs and behaviour**" support eco-conscious consumer behaviour. Nudging is assumed to have great potential for the Circular Economy by

promoting eco-conscious consumer behaviour. Yet, this opportunity is expected to be of minor significance, unless incentives or growing public pressure increase economic interests in environmental efforts. Shopping frenzy was found to be the most significant and highly relevant effect with negative impacts on the Circular Economy. This is due to its promotion of purchasing additional and not necessarily required products and the associated high return rates. Personalised design was also found to promote additional, initially unintended purchases. A rather neutral effect has been observed for the increased ease of shopping, resulting in consumers spending rather online than offline and an assumed tendency for negative impacts from impulse purchases.

The effects within the cluster "**Digitalisation**" are mainly expressed in energy demands and/or associated carbon footprints. Although energy demands and associated environmental impacts arising from network operations and advertisement in E-commerce deserve attention, a positive net effect on the Circular Economy can only be expected when traditional value chain processes (e.g. physical retail space) are substituted. In the future, several trends (e.g. increasing data traffic, changes in physical retail stores, further growth of digital goods sector, energy efficiency and renewable energy sources for network and data centre operations) will affect E-commerce and traditional value chains jointly.

As regards the cluster "**End of Life**", the assessment highlighted that E-commerce facilitates the reuse of certain goods and therefore potentially positively affects a Circular Economy. Nevertheless, future trends indicate that positive effects from reuse may be overcompensated by a disproportional increase in consumption. Indications have been found that E-commerce value chains could potentially generate more product waste due to higher return rates than traditional channels. Yet, potential negative effects from highlighted end-of-life issues or wasted products from returns in E-commerce channels have to be weighed against impacts associated with unsold products, which are considered a bigger concern in traditional supply chains. It is argued that a hypothetical switch to digital markets could reduce manufacturing waste and reduce overproduction in the future, ultimately leading to fewer unsold products.

The effects of opportunities and threats identified for the cluster "**Legal framework**" are not clear. The lack of full transparency with regard to the involved economic operators and their modes of interaction in the traditional economy (e.g. due to complex global supply chains) does not seem to be improved in the E-commerce as practiced today. No direct or indirect opportunities have been identified during the research, and no conclusive data on effects-damping factors (e.g. rising critical end-user awareness towards origins of a product, or substantial spreading of Blockchain-like technologies that would allow full traceability of products and money flows) has been identified either. Overall, it is therefore considered more likely that E-commerce would lead to more challenges for the legal framework than the current traditional commerce, resulting in rising environmental impact potentials.

The assessment of the cluster "**Logistics and Transport**" revealed that, in general, parcel deliveries to personal residences increasingly replace private shopping trips while increasing the degree of the utilisation of the means of transport, ultimately leading to less energy demand per fulfilled unit. Looking at induced parcel transport and individual shopping trips, there is a tendency towards less environmental impacts for E-commerce associated with the "last mile". Nevertheless, the increase of failures in delivery attempts might play a greater role due to the absolute increase of packages. Additionally, in urban areas the opportunity to deliver within 24 hours could also increase the probability of more delivery attempts. Eventually, the increase of faster delivery options combined with the risk of empty runs and inefficiency, is expected to be highly significant and assumed as the most relevant indirect effect.

As regards the cluster "**Packaging**", the assessment revealed that most of the suggested mitigation-oriented packaging solutions are not expected to result in actual environmental benefits for the Circular Economy compared to the traditional retail channel. Although dedicated packaging solutions for E-commerce have the potential to reduce amounts of plastics and cardboard per fulfilled unit, the positive net effect of these solutions could be diminished or (over-)compensated due to inherently higher demands of protective packaging for the shipping of products.

Relevance of opportunities and threats

Based on the findings from the in-depth assessment all opportunities and threats were grouped according to their estimated relevance for a Circular Economy in Europe in comparison to the traditional (brick-and-mortar) channel.

In total, 13 opportunities/threats have been assessed as highly relevant, 14 opportunities/threats were found to have a medium relevance and 13 were assessed as being of little relevance[6].

Most of the threats classified as highly relevant belong to the clusters "Logistics and transport". In particular, from a Circular Economy perspective secondary packaging and direct effects within this cluster deserve special attention. Moreover, certain effects relating to "consumer needs and behaviour" as well as facilitated second-hand E-commerce within the cluster "end-of-life" are of high relevance.

The cluster "Accessibility of information" includes most of the highly relevant opportunities, although related effects could not be translated into specific Circular Economy aspects or indicators, as for the cluster "Legal framework".

The opportunities and threats relating to the cluster "Digitalisation" are of medium to low relevance. This is not least due to the cascading effects from digitalisation which cannot exclusively be allocated to E-commerce.

Main conclusions and options for actions

Overall, the cluster "**Accessibility of information**" is considered to be supportive of a Circular Economy. Information flows are a core element of any commerce and, undoubtedly, they can be considered as being pivotal for E-commerce. However, it was not possible to quantify or determine the net effect of this cluster on the Circular Economy. Efforts in this context should be focused on maximising the positive impacts of the three direct effects identified in this cluster, "Availability of information", "Market access to online aftermarkets", and "Product portfolio", which should be promoted as they improve knowledge of users and other stakeholders about the product and/or its handling during the product life, and thus increase chances of well-considered product choices and preferable treatments.

Despite positive aspects of increased product utilisation in sharing systems and nudging towards products with lower environmental footprint, the interaction between the opportunities and threats identified within the cluster "**Consumer needs and behaviour**" is likely to have an overall negative impact on the Circular Economy. Nevertheless, opportunities such as nudging can be highly effective if used to promote eco-conscious product choices in support of a Circular Economy through background information and beneficial default settings. Moreover, the introduction of a clear and harmonised system to communicate the environmental footprint of products sold online could enable consumers to compare the environmental performance of products, and thus make educated choices.

As regards the cluster **"Digitalisation"**, a reliable assessment was possible but the E-commerce providers are encouraged to embrace strategies towards data sufficiency and a transition to renewable energy supplies for their operations in order to fully benefit from the manifold opportunities digitalisation technologies and applications bring about for a Circular Economy. For a Circular Economy it is essential that any of the required mechanisms and infrastructures (e.g. network infrastructures for E-commerce platforms) are operated in an energy-efficient and low-carbon manner and that attention is given to the reduction of hidden data traffic from user analytics, updates, and automatic or default downloads. Only if this is provided, enabling positive effects arising from the utilisation of digital technologies can fully materialise.

In order to maximise potential positive effects for the Circular Economy with regard to the **End-of-life** stage, focus should be given to the reuse of products. This holds true in particular for products whose environmental impacts are largely determined by the production stage. As of today, promising trends and manifestations of so-called second-hand E-commerce platforms can be observed: 2-4% of second-hand sales compared to total sales while this represents ≤0.1% for traditional offline retail[7]. It is therefore encouraged that other E-commerce platforms may also embrace such business

[6] The identified potential opportunity of "collaboration between companies and partnering with waste management suppliers", could not be ranked as it could not clearly be assigned to a single cluster or expressed in terms of a certain Circular Economy aspect. This opportunity was inherently assessed as part of the opportunities "product-take back" and "development of dedicated packaging solutions".

[7] Quantitative assessment based on data for Poland, Sweden, Spain, France and Germany. In addition, it must be noted however that these percentages are significantly influenced by the differences in products sold via the respective channels. For instance, the total turnover in the traditional retail is dominated by foodstuff. Thus, a majority of the turnover is not applicable to a potential reuse of those products.

models to supplement their existing product and service portfolio. In doing so, existing reverse logistics infrastructures for product return processes can be utilised for circular product flows (e.g. resale, product take-back). In addition, a particularly high potential for mitigating environmental effects related to unsold products may be realised in omni-channel retail structures or in collaborations between E-commerce and brick-and-mortar retail by extending product selling cycles. Products which could not be sold in stores could then be offered via online sale and stored in respective warehouses.

Practices within the current **Legal framework** are overall seen by stakeholders to be more a hampering factor to Circular Economy than a supportive one. All four threats for the Circular Economy identified within this cluster are associated with a lack of transparency. The complex network of economic actors and products being difficult to monitor pose challenges to enforcement (as not all activities would be tracked) and can foster incompliance with common market regulations – happening potentially intentionally, as in the EPR free-rider effect, or unintentionally. The EPR-free-rider effect can possibly be damped by increasing the responsibilities of facilitators of E-commerce, such as sellers, couriers and fulfilment houses, if they sell EPR-regulated products that come from economic actors outside the EU, which do not have a national representative. Other options for actions include the promotion of further cooperation/information exchange between Member State enforcement authorities on issues regarding market surveillance and E-commerce, the further development of enforcement (IT-)tools and methods which enable/support the tracing of products sold via E-commerce arrangements, and the mapping of the magnitude and forms of E-commerce sales of high-risk products from third countries.

As regards the cluster "**Logistics and transport**" it can be concluded that, although the data availability is quite limited and more studies on this topic are needed, the E-commerce has a positive impact on carbon intensity and transport requirements. The calculated carbon intensity ranged from 77 to 265 g CO_2e/fu[8] for the induced parcel transport and return, whereas it was on average 268 to 448 g CO_2e/fu for individual shopping trips. In addition, the calculated induced parcel transport distance ranged from 0.5 to 3.3 km/fu[8] for E-commerce, whereas the transport distance for individual shopping trips was calculated to be in a 2.9-7.6 km/fu range. Actions in this field should take into account the existing differences between urban and rural areas. Comparing the two scenarios, the pick-up of parcels turns out to be more carbon dioxide-intense in rural areas (in general 2.5 times) due to the higher share of transportation by car. This implies that different measures might need to be taken. For example, mainly light duty vehicles are used today e.g. for delivery packages, whereas 97% are fossil fuel and only 3% are battery-electric vehicles (BEV). BEVs might be a better choice for urban areas, and HFCV for longer distances in the upcoming years. Technological changes such as the use of drones are expected to increase in importance particularly for rural regions and should be further investigated. The optimisation of the entire supply chain is seen as one of the most relevant options for actions. Equally relevant are the promotion of improved packaging, reduced damages on delivery, and optimised parcel dimensions, all of which will help to reduce the CO_{2e}-emissions per fulfilled unit during transport.

The assessment of effects in the cluster "**Packaging**" confirms significant negative impacts on the Circular Economy arising from E-Commerce. This is particularly due to the fact that the transport to the customer creates the need for an additional layer of packaging that does not apply to brick-and-mortar. The deep assessment provides an estimate of additional demand of almost 1.5 million tonnes of cardboard and around 26 thousand tonnes of light density polyethylene foil for Europe generated by E-commerce, counting only dispatch materials and excluding inner protective materials. Mitigation-oriented packaging solutions (e.g. reusable packaging), although not eliminating the need for additional packaging, will help in reducing the demand of materials within the E-commerce value chain. In addition, opportunities such as frustration-free packaging and reusable packaging, where the packaging material itself is not owned by the customer but offered as a service, should be promoted. Moreover, the development of an optimal return infrastructure should be addressed. Another option to reduce the impact is represented by the implementation of dimensional shipping fees, where parcel size and parcel weight are factored in.

[8] Quantitative assessment based on data for Poland, Sweden, Spain, France and Germany

Disclaimer

The information and views set out in this report are those of the author(s) and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this study. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use which may be made of the information contained therein.

1 Introduction

1.1 Objective and main phases of the study

The objective of the present study, launched by the Joint Research Centre of the European Commission and carried out by Ramboll Environment and Health in cooperation with Ramboll Management Consulting and the Technical University of Denmark (DTU) is to identify, describe and assess in detail important opportunities and threats that E-commerce constitutes for the Circular Economy, based on a selection of relevant physical products.

In order to fulfil this objective, the study envisages the following main phases:

- selection of 7 products based on a specifically developed methodology;
- identification of a set of opportunities and threats for the Circular Economy arising from E-commerce;
- in-depth assessment of the influence of the identified opportunities and threats on the Circular Economy aspects of the selected products, taking into consideration both the current and future situation in the traditional retail and E-commerce scenario; and
- grouping of opportunities and threats according to their relevance in three categories of low, medium and high relevance.

The outcomes of the study are based on actual data and also on the individual expertise of stakeholders. Relevant stakeholders of all types, from big multinational companies to national businesses were identified with regard to each main stage of the study and consulted via online surveys, e-mail questionnaires and a dedicated workshop in order to guarantee the validation of the methodology used and provide essential insights along with specific data and information.

During the data collection and the stakeholder consultation processes, throughout the different stages of the study, the existing divergences between E-commerce in the EU Member States of different subregions of Europe and the influence that these exert on the definition of opportunities and threats for the Circular Economy were considered. In particular, the coverage of at least 5 EU Member States from at least 3 out of 4 subregions of Europe[9] is guaranteed throughout the study.

1.2 Background

The study falls within the framework of the current two top priorities of the Juncker Commission: “Jobs, growth and investment” and the “Digital Single Market”, and in particular the policy areas "Towards a circular economy" and "Better access for consumers and businesses to on-line goods".

In principle, the Digital Single Market offers substantial opportunities to the development of a true Circular Economy. At the same time, threats may also exist from unbridled developments that disregard the planet's resources, the environment and human health. This study aims to shed a better light on both these opportunities and possible threats.

E-commerce, with its capacity of bringing opportunities to consumers to access a wider range of goods, services and digital content as well as the possibility to compare prices and look for better deals across the Digital Single Market has grown rapidly in recent years. Today the EU is one of the largest E-commerce markets in the world: the percentage of people aged between 16 and 74 that have ordered goods or services over the internet has grown year-on-year from 30% in 2007 to 55% in 2016 (European Commission, 2017b) and online retail continues its double-digit growth, since the European E-commerce turnover increased by 12.75% to €540 billion in 2017 (ECommerce Europe, 2018a).

The rapid growth of online commerce, while seen in principle as an opportunity for fostering sustainable development under many aspects, triggers inevitable discussion on the possible opportunities and threats that it will bring along to the international trade and the environment; currently, there is no substantial data to support either position (Gori, 2016).

The effects of the growing importance of the E-commerce on the global trade system are of different types. Economic effects include change in supply chain, company decentralisation, transport modes, changes in competition and in price

[9] Eurovoc classification.

structure, whilst environmental effects comprise changes in material flows, land use, transportation, energy use and dematerialisation. Along with the economic and environmental effects also social consequences are to be expected, which can include social isolation, change of income disparities and loss of individuality (Sharma, 2005).

The Circular Economy Action Plan defined by the Commission in 2015 identifies the path to be followed in order to move towards a sustainable and competitive economy. To this day, the Circular Economy concept has been taken up, studied and developed by many organisations, and a broad range of sustainable solutions have been developed with the aim of "closing the loop", maintaining the value of materials and minimising waste generation and energy consumption along the value chain.

At European level, since 2009 the retail sector has committed to join forces and cooperate for contributing to the implementation of the EU Action Plan on Sustainable Consumption and Production and Sustainable Industrial Policy. In this context, the Retail Forum for Sustainability was launched in March 2009 by the European Commission together with EuroCommerce and the European Retail Round Table (ERRT). Concurrently, a number of progressive retailers decided to proactively contribute to the process and launched the Retailers' Environmental Action Programme (REAP) that today focuses precisely on the Circular Economy (EuroCommerce, 2018).

The commitment of the retailers on working in the direction of a Circular Economy is now facing the challenges arising from the fast growth of online-based commerce, putting the retailers in an even more difficult position when it comes to balance the market and economic needs to those of the planet. Opportunities and threats for the Circular Economy arising from E-commerce are not easy to classify and assess, since the different and often cascading aspects can have both positive and negative impacts that need therefore to be clearly identified and – if possible - measured. An example can be described with regard to the aspect of transport. A recent study estimates that E-commerce will bring a reduction of 2% in all passenger transport CO_2 emissions in 2030 compared to total emissions in 2012 (Smidfelt Rosqvist and Hiselius, 2016a). This is due to the fact that consumers use the car less, and generally tend to use alternative transport modes. On the other hand, transport-related emissions might increase due to high return rates of products. In fact, 80% of the index's retailers included in the InternetRetailing Europe (IREU) Top500 index enable shoppers to return items via post (IREU, 2017).

Another interesting example is related to the ease with which E-commerce can make products available to people all around the globe. If on the one hand this can allow for a better and easier circulation of sustainable products (in terms of sustainably sourced, manufactured and so on), it can on the other hand facilitate also the diffusion of possibly dangerous products. Today, in fact, more and more of the dangerous products[10] notified in the Rapid Alert System are sold online (European Commission, 2016a), and this inevitably creates the need for increased control measures to guarantee the safety of consumers and of the environment.

[10] Products posing a risk to consumers' health and safety.

2 Selection of relevant products for assessment of opportunities/threats

The assessment of the opportunities and threats for the Circular Economy arising from E-commerce focuses on 7 relevant physical product categories, that are either sold online or in traditional "brick-and-mortar" stores.

The final 7 product categories are identified based on a specifically developed methodology with the aim to assess the overall key elements of a product category and to select a final set that allows for a solid and representative assessment of opportunities and threats.

The study focuses on product categories (e.g. apparel, furnishings etc.) rather than specific products (e.g. cotton T-shirt, wooden desk etc.) in order to extend the applicability of the analysis of the opportunities and threats to a broader spectrum of products.

2.1 Methodology

The methodology for the selection of the 7 product categories is based on a set of quantitative and qualitative criteria that ensure the inclusion of the following key elements:

- significant diversity in the type and different impacts on various aspects of the Circular Economy;
- high relevance on the market, based on purchases' current data and future trends;
- different return rates, which can be linked to various factors such as the susceptibility to damage by transport or the need for physical/visual testing;
- impact of the packaging on different types of products for the shipping of goods sold online, depending on the number of items usually included in a single parcel;
- data availability from techno-scientific literature;
- reflection of the consumers' preferences regarding online and traditional (offline) shopping; and
- different purchase frequencies.

The identified criteria belong to two different groups, one identifying the relevance of the criterion for a specific product category, based either on quantitative or qualitative available information and data (relevance criteria), and the other identifying the differences within the product categories assessed (diversity criteria).

Table 1 provides a methodological guidance for the assessment of each criterion, including the following information:

- the set of criteria developed in relation to the specific key product categories' elements;
- the information sources used to apply the criterion; and
- the scoring system, describing how the information or available data covered by the single criteria is transferred into a score on the defined range for each criterion.

Table 1: Methodological guidance for the assessment of the criteria defined for the selection of the final seven product categories

Screening criterion	Information source	Explanation	Indicator	Scoring system
1. Product type				
1.1 Product category diversity	▪ CPA ver. 2.1 - Statistical classification of products by activity, category C – Manufactured products ▪ Expert input	To which of the following groups does the product category belong? • **Accessories and eyewear: A** • **Apparel and footwear: B** • **Cultural and recreational goods: C** • **Food, beverages and tobacco: D** • **Furnishings: E** • **Household appliances: F** • **Information and communication technology: G** • **Luxury goods: H** • **Personal and home care: I** • **Pet foods and supplies: J**	**Type of indicator:** *diversity* • **Accessories and eyewear** ○ Accessories ○ Eyewear • **Apparel and footwear** ○ Apparel ○ Footwear • **Cultural and recreational goods** ○ Musical instruments ○ Sports and leisure equipment ○ Toys and games ○ Media and entertainment products/services • **Food, beverages and tobacco** ○ Beverages ○ Fresh fruits and vegetables ○ Non-perishable foods ○ Chilled foods ○ Deep-frozen foods ○ Fresh bakery products ○ Tobacco products • **Furnishings** ○ Major furnishings ○ Small furnishings • **Household appliances** ○ Major household appliances ○ Small household appliances • **Information and communication technology** ○ Major information and communication technology ○ Small information and	A/B/C/D/E/F/G/H/I/J

Screening criterion	Information source	Explanation	Indicator	Scoring system
			communication technology • **Luxury goods** • **Personal care and home care:** ○ Cosmetics and personal care ○ Non-prescription pharmaceuticals and healthcare ○ Home and laundry care • **Pet foods and supplies**	
2. Market relevance				
2.1 Current purchases	▪ Statista ▪ Destatis ▪ Eurostat ▪ Market reports: e.g. Postnord E-commerce in Europe 2018	Which are the most relevant product categories based on the total and online market volume?	**Type of indicator:** *relevance* **Relevant product categories** Identification, for each product categories and sub-categories the revenue for the off- and online market.	Ranking from 1-26 (numbers of product categories) based on the share of the market volume – for on- and offline. **High:** >= 16 **Medium:** <7 to 16 **Low:** <=7

Screening criterion	Information source	Explanation	Indicator	Scoring system
2.2. Growth rate	▪ Statista ▪ Eurostat	Which are the product categories there are increasingly relevant on the online market?	**Type of indicator:** *relevance* **Online growth rate** For each product categories and sub-categories, the revenue for the online market is identified and compared to the data from the current purchases. Based on this, the growth rate for each product category for the online market has been identified.	Ranking from 1-26 based on the identified growth rates for the online market. **High:** >= 1.38 **Medium:** <1.38 to 1.2 **Low:** <=1.2
3. Level of circularity				
3.1 Return rates	▪ Market reports: e.g. Postnord E-commerce in Europe 2018 ▪ Expert/team input	How often do consumers return products purchased online? This criterion covers the return of online purchased goods related to the total amount of online purchased goods.	**Type of indicator:** *diversity* **Return rates** Return rate <10%: **A** Return rate >10%: **B**	A/B
3.2 Packaging	▪ Stakeholder input	During transportation to end users, several secondary or even tertiary types of packaging may be employed, containing one or several smaller items to be shipped together to the same address. How does this reflect on different product categories?	**Type of indicator:** *diversity* **Number of items contained in each parcel** 1-2 items per parcel: **A** 3-4 items per parcel: **B** 5-6 items per parcel: **C** > 6 items per parcel: **D**	A/B/C/D

4. Consumer behaviour				
4.2 Purchase frequency	▪ Statista ▪ Surveys ▪ Expert input	How often do consumers typically purchase certain products or items of a specific product category? **Slow Moving Consumer Goods (SMCG): A** **Fast Moving Consumer Goods (FMCG): B** This is a determining factor for the rotation of products, describing how fast products are sold to the customer.	Type of indicator: ***diversity*** **Slow Moving Consumer Goods (SMCG): A** This classification refers to products with a typical life time >1 year (e.g. household equipment, furniture, consumer electronics, etc.) **Fast Moving Consumer Goods (FMCG): B** This classification refers to products with a typical life time <1 year (e.g. food, beverages, personal care, cleaning and household items, apparel, shoes, tobacco, etc)	A/B
4.3 Consumer preferences	▪ Statista Consumer Market Outlook	Do consumers prefer online over traditional retail for certain product categories?	**Type of indicator:** *relevance* **Average ratio between online and traditional (offline) retail channels in EU-MS per product category.** Average ratios are determined by available statistics for EU-MS and refer to the projected reference year 2019 and are based on the share of total revenues of respective market segments.	**High:** >= 25% purchased online **Medium:** <25% to 10% purchased online **Low:** <=10% purchased online

The criteria identified and described in Table 1 have been applied to an initial range of 26 product categories selected after a preliminary analysis of information and data availability, as described in Section 2.1.3.

2.1.1 Screening criteria used for the selection of the product categories

Product category type

Product category diversity (*Diversity indicator*)

The initial range of 26 product categories has been clustered in 10 groups which aggregate the product categories with similar characteristics (see Table 1). The product categories were assigned with a letter (A to J) which identifies the respective group.

Market relevance

The goal of the analysis was to identify relevant product categories in terms of overall share. Therefore, current market data for each of the identified categories (see example in Table 2) were analysed. However, to gain a holistic view on the market the expected online growth rate per product category is also of interest. Due to limited sources on market development, data for 2021 has been chosen to indicate potential growth paths of the different product categories .

Current purchases (*Relevance indicator*)

Data on current purchases reflects the latest information between 2017 and 2019. European databases (Eurostat) and the commercial data service (Statista) were used to identify the market value and share on European level for each product category. In addition, a market report on E-commerce (Postnord, 2018) provided supplementary data. To identify the currently most relevant product categories a ranking was carried out for the total market volume.

Online purchases growth rate (*Relevance indicator*)

To determine the product categories with the highest online sales growth rates the absolute market shares of the online market for 2019 and 2021 are compared. The growth rates are classified as high, medium or low, as described in Table 1.

Table 2: Example of market relevance data on EU-28 level for the year 2019 and 2021 (Statista, 2018b, 2019d)

	2019			2021		
Product	**Total revenues [mio. €]**	**Offline revenues [in %]**	**Online revenues [mio. €]**	**Total revenues [mio. €]**	**Offline revenues [in %]**	**Online revenues [mio. €]**
Apparel	393,946	81	74,850	407,826	79	85,643
Footwear	100,196	81	19,037	105,978	79	22,255
…						

Level of circularity

In currently widely suggested and applied definitions, e.g. in (Pauliuk, 2018), the "circularity" of products is based on e.g. their weight share of recycled material content of the entire product and/or on their material recyclability. Assuming, however, that the tangible products sold via E-commerce vs. via conventional commerce are the same, i.e. remain unchanged, differences in the circularity of either type of commerce can only arise from the systems surrounding the products, i.e. from the efforts for transportation, storage, packaging, etc. For the screening of product categories, particular interest is thus set on the return rate of products and on the amounts of packaging used, since both are considered to be drivers for the circularity of the surrounding systems.

Return rates (*Diversity indicator*)

The return rate is the rate at which products that had physically arrived at an end user are returned back towards the retailer. For the product category screening, no distinction is made how far the product reaches back and thus what transport work is involved – e.g. just back to a central storage facility or even all the way back to e.g. a remanufacturing

site. Interesting is rather the diversity of return rates among the screened product categories in order to identify most relevant ones.

Main data source for the return rate is the latest PostNord report 2018 (Postnord, 2018). It provides return rates for 12 European countries. The category "apparel & footwear" has the highest average return rate, at more than 19%, and "home electronics" at some 6.5%. Lowest average return rates are below 2%, e.g. for "sports equipment".

For the screening, return rates were grouped and ranked into "up to 10%" and "above 10%".

Packaging (*Diversity indicator*)

Necessary packaging efforts vary in principle depending on the robustness of the product itself, e.g. a TV set requiring shock-proof packaging while a pair of jeans does not. Also, the type of packaging and employed material types differ since some products come with primary packaging, e.g. a printed, glossy cardboard box for a TV or a plain cardboard box for a pair of shoes, and some don't need packaging at all, e.g. books or clothes. During display in physical shops and transportation to end users, several secondary or even tertiary types of packaging may be employed, e.g. polystyrene chips inside a large corrugated cardboard box containing one or several smaller items to be shipped together to the same address.

It is indeed interesting to identify this diversity in (i) the packaging as such and (ii) the generic packaging differences between the two types of commerce. Due to the lack of available robust data, though, assessing this criterion in the screening is limited to the information received from the stakeholder survey (Section 2.2). Additionally, a stakeholder dialogue was conducted later in the detailed assessment process, providing the opportunity to identify more robust data for the selected product categories.

Consumer Behaviour

Purchase frequency (*Diversity indicator*)

The frequency with which a product is purchased by the consumer is one of the factors that influences the magnitude and type of impacts on the Circular Economy of a certain product. The distinction between products with a longer or shorter life time reflects in different ways on aspects such as transportation, packaging, end-of-life etc. In order to take this into account the identified product categories have been classified as belonging to one of the following groups, describing how fast products are sold to the customer:

- Slow Moving Consumer Goods (SMCG): this classification refers to products with a typical life time >1 year (e.g. household equipment, furniture, consumer electronics, etc.); and
- Fast Moving Consumer Goods (FMCG): this classification refers to products with a typical life time <1 year (e.g. food, beverages, personal care, cleaning and household items, apparel, shoes, tobacco, etc.).

The classification was based on available data from the commercial Statista database.

Consumer preferences (*Relevance indicator*)

The consumer preference indicator's aim is to take into account the relevance of a certain product category on the online market and therefore to identify those product categories that consumers prefer to purchase online. The indicator identifies the average ratio between online and traditional (offline) retail channels in EU Member States per product category. Average ratios are determined by available statistics for EU Member States (Statista Consumer Market Outlook), refer to the projected reference year 2019 and are based on the share of total revenues of respective market segments. Product categories have been classified as having high, medium or low relevance as described in Table 1.

2.1.2 Criteria excluded from the application of the methodology

The first concept of the methodology for the selection of the 7 products initially included two diversity criteria, "niche or common product" and "basket size", that have been subsequently excluded from the screening, due to the following reasons:

- Common or niche product (Diversity indicator): This diversity criterion aimed at including in the final selection product categories that count not only common goods but also product categories which include goods or services with features that appeal to a particular market subgroup (niche market). Nevertheless, the broad spectrum of products covered by each of the product categories identified in the initial set made the

classification into common or niche product not feasible for most of the product categories, since they could contain both common and niche products, depending on the type, brand and specific characteristics; and

- Basket size (Diversity indicator): An average basket size refers to the number of unique items purchased by a customer in one visit, online or at a traditional store, and correlates with corresponding revenues. Due the lack of available data from literature, databases and stakeholder input (see Section 2.2 for the results of the stakeholder survey), this criterion has been excluded from the final screening.

2.1.3 Selection of the initial range of product categories

The criteria identified for the selection of the final 7 product categories have been applied on an initial range defined on the basis of the European integrated system of statistical activity and product classifications. Based on the availability of statistical data on a European and country level, the category C "Manufactured products" of the Classification of Products by Activity (CPA, ver. 2.1) was selected as main reference for the identification of the initial range of product categories.

In order to obtain an initial range of product categories with a non-negligible relevance on the online market and with a sufficient data availability to allow for the implementation of the subsequent stages of the study, a preliminary screening of available data and information was done based on available reports and databases.

As a starting point for the data availability check and the actual collection of data and information on the initial set of product categories and screening criteria, the selection of 5 main European countries was carried out. The aim was to explore possible regional differences in Europe that may affect opportunities/threats and to identify the countries that could be used as a reference in the different stages of the study for data gathering in case Europe-wide data is not available. For each of the 5 subregions of Europe according to the Eurovoc classification (Central Europe, Eastern Europe, Northern Europe, Southern Europe and Western Europe), a country was selected as a representative for that specific subregion. The following factors, all weighted equally, were taken into account: share of online buyers, overall consumer spending, overall E-commerce growth rate and actual spending in the E-commerce. E.g. the population data was gathered for all countries (see second column in Table 3). Each country was ranked (1-27) and the individual rank divided by the total sum of the ranks (1+2+...27=378). The ranking calculation was conducted for each parameter separately and an overall average was formed from the results (e.g. Bulgaria with 0.039). To derive the actual overall rank of each country, the country with the lowest sum as per the calculation described above was assigned with the overall rank number 1.

Table 3: Example of factor and data considered to identify the relevant countries

Country	Population [mio. €, 2017]	Share of online buyers [in %]	Consumer spending [mio. €]	E-commerce Growth [%, 2017]	E-GDP [mio. €]	Rank
Central and Eastern Europe						
Bulgaria	7.06	11	31,251	22	359	18
Croatia	4.15	21	27,250	11	243	26
...	...	...	...	...	...	...

By this approach the following five countries were identified:

- Central and Eastern Europe: Poland;
- Northern Europe: Sweden;
- Southern Europe: Spain; and
- Western Europe: France and Germany.

The list of the 26 initial product categories selected is provided by Table 52 in Annex 1, together with an overview of the different products included in each category with respect to different sources of statistical and market data.

2.1.4 Selection of the final 7 product categories

The selection of the final 7 product categories was performed via a cascade process made up of consecutive screening rounds. The first two rounds were based on the two relevance criteria "current market relevance" and "consumer preferences", while the following ones took into consideration the diversity criteria in order of diversity degree (number of sub-categories identified by the criterion). The selection of a final number of 7 products was reached after a total of 5 screening rounds:

1. Current market relevance (relevance indicator): assessment performed on the first 10 product categories for current market relevance in terms of total (online and offline) revenues;
2. Consumer preferences (relevance indicator): assessment performed on the product categories with current (2019) high share of online purchases based on total revenue;
3. Consumer preferences (diversity indicator): assessment performed on the product categories with current (2019) medium share of online purchases based on total revenues;
4. Product diversity (diversity indicator): assessment performed on the product categories selected after the previous screening rounds; and
5. Packaging (diversity indicator): assessment performed on the product categories selected after the previous screening rounds.

In each of the first 3 screening rounds, the selection, exclusion or dragging on to the next screening round of the product categories has been based on the combined assessment of the three criteria "current market relevance", "growth rate" and "consumer preferences" and as illustrated in Table 53 in the Annex.

Eventually, the selected product categories have been screened against the two remaining diversity indicators "return rates" and "purchase frequency".

2.2 Stakeholder consultation for the selection of relevant product categories

During this first stage of the study, relevant stakeholders have been selected and consulted in order to close existing data gaps and provide a direct input on relevant characteristics of specific product categories sold online.

The stakeholder consultation was carried out via an online survey providing 5 multiple-choice core questions. The core questions focused on the online market relevance, the basket size, the packaging and the return frequency of the first gross set of product categories (see Table 52 in the Annex):

1. Do you agree with the following statement: Today, the following products are mainly sold online?
2. Do you agree with the following statement: In 2030, the following products are mainly sold online?
3. The average basket value of online purchases compared to offline (in a physical store) purchases is…
4. How many items does one parcel contain on average?
5. What is the average ratio between returned parcels and delivered parcels?

The stakeholders were requested to answer the questions only with regards to the product categories for which they had confirmed, at the beginning of the questionnaire, to have specific experience.

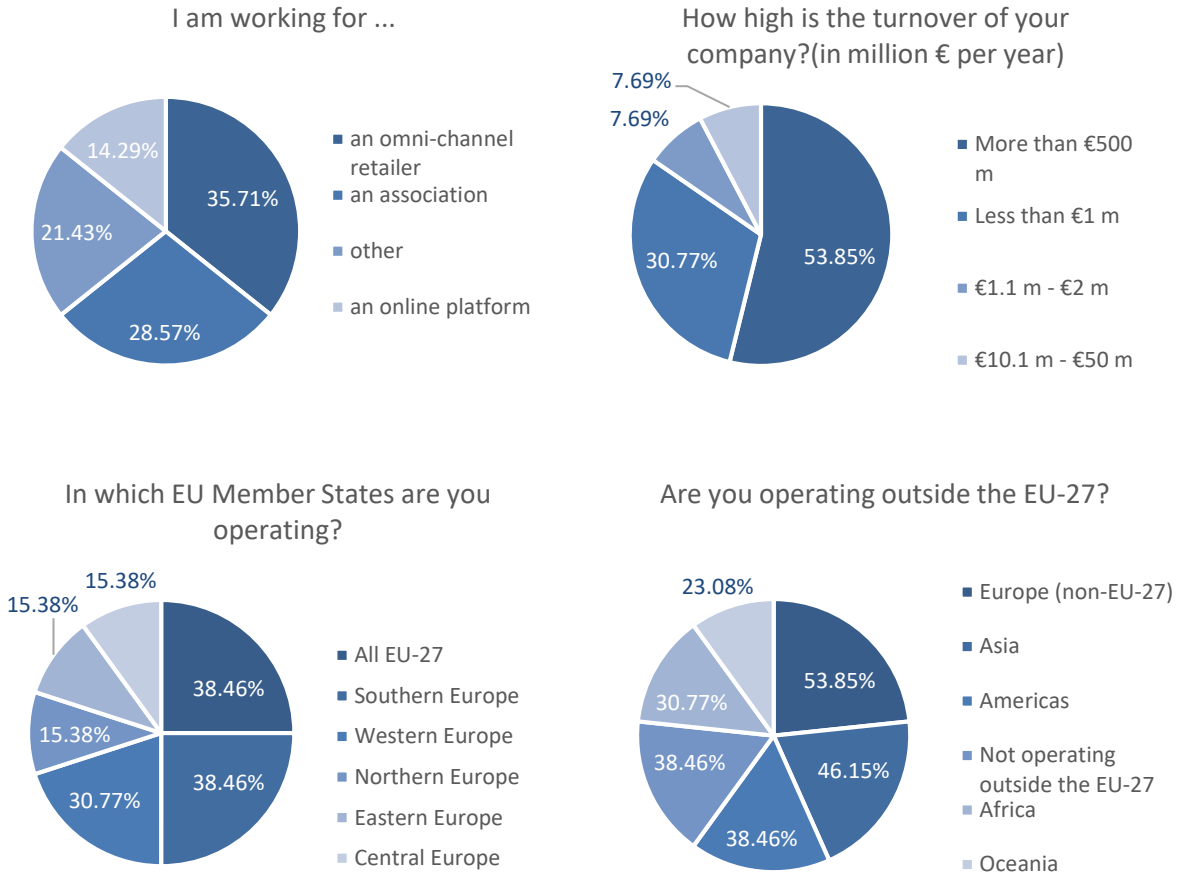
The invitation to participate in the online survey was sent out to 40 stakeholders, including:

- E-commerce platforms;
- consumers associations;
- omni-channel retailers;
- producers associations;
- retailer associations;
- trade associations;
- NGOs; and

- manufacturers.

35% of the stakeholders invited to the survey accepted to participate and filled in the questionnaire. Respondents belong to associations, omni-channel retailers, online platforms and other sectors, with experience in all the product categories included in the initial set. Most of the respondents have a turnover higher than 500 million euros and provide a comprehensive geographical coverage, operating not only in Europe but also in other continents (see Figure 1).

Figure 1: Key facts about respondents of the stakeholder online consultation



The stakeholders' answers on questions number 1 and 2 about the current and future share of products sold online were mostly in line with the information and data collected with regard to the criterion "Market relevance" (see Section 2.1.1), although some contrasting feedbacks were registered.

As regards question number 3 on the average basket size, most of the respondents were not able to provide a specific answer. Due to the lack of data, this criterion has therefore been excluded from the application of the methodology for the selection of the final 7 product categories, as already described in Section 2.1.2.

The respondents provided a good feedback on questions 4 and 5 regarding parcel composition and return ratio, allowing to close data gaps on various product categories and to use the information provided for the final selection of the product categories.

2.3 Results

The final 7 product categories selected are reported in the Table below. A more comprehensive and detailed table is provided in the Annex (Table 51).

Table 4: Overview of the selected product categories

Product categories	Current market relevance (total mio €)	Growth rate (online)	Consumer preferences (% for online purchases)	Packaging (Nr. of items per parcel)	Product type	Return rates (%)	Purchase frequency (SMCG/ FMCG)	
Accessories	53,209	1.15	22%	n/a	A	n/a	SMCG	**Value**
	medium	low	medium				A	**Score**
Apparel	393,946	1.14	19%	3-4	B	19.3%	FMCG	**Value**
	high	low	medium	B		B	B	**Score**
Major furnishings	252,140	1.25	9%	> 6	E	1.9%	SMCG	**Value**
	high	medium	low	D		A	A	**Score**
Major household appliances	32,532	1.18	37%	1-2	F	6.5%	SMCG	**Value**
	low	low	high	A		A	A	**Score**
Media and entertainment products/ services	18,870	1.55	60%	1-2	C	1.3%	FMCG	**Value**
	low	high	high	A		A	B	**Score**
Non-perishable food	247,157	1.30	3%	> 6	D	< 10%	FMCG	**Value**
	high	medium	low	D		A	B	**Score**
Small information and communication technology	120,570	1.16	36%	1-2	G	6.5%	SMCG	**Value**
	high	low	high	A		A	A	**Score**

3 Identification and description of opportunities and threats for the Circular Economy arising from E-commerce

The present section focuses on the identification and description of opportunities and threats for the Circular economy that are arising from E-commerce, with the objective to achieve the best possible balance between positive and negative aspects. A threat is defined here as an aspect that potentially negatively influences the Circular Economy, while an opportunity has a potential positive impact.

The approach used for identifying relevant opportunities and threats is described in Section 3.1.

The identified threats and opportunities are described in detail in Section 3.2.

3.1 Methodology

To identify opportunities and threats for the Circular Economy arising from E-commerce, different steps were applied:

Step 1: Literature research;

Step 2: Systematic classification of identified opportunities and threats;

Step 3: Evaluation of relevance of identified opportunities and threats with regard to selected product categories; and

Step 4: Stakeholder consultation.

3.1.1 Step 1. Literature research

As a first step, a literature research of primary and secondary sources as well as relevant market reports dealing with the topic in scope, was carried out with the aim of identifying potential threats and opportunities of E-commerce for the Circular Economy and system boundaries.

A list of literature used for the identification and description is provided at the end of each threat and opportunity in Section 3.2. A complete literature overview is included in Section 6 of this report.

The literature research further included the identification of so-called E-commerce features, which can be seen as the point of origin of potential threats and opportunities and identify certain peculiarities that distinguish E-commerce from traditional commerce. The E-commerce features can roughly be grouped into technical features and more general features. Examples of technical features are the search engine function, which enables a fast search for certain products, or the e-payment, content management, data analytics, product visualisation, but also the ubiquity of E-commerce which mainly stems from mobile connectivity and high data rates (Junglas and Watson, 2003). Some characteristics of E-commerce, however, are not directly linked to its technical implementation and are therefore referred to as general features, such as parcel delivery or return of parcels.

3.1.2 Step 2. Systematic classification of identified opportunities and threats

As a second step, a systematic 4-stage classification was carried out for each of the threats and opportunities to ensure a clear differentiation between each other. The classification included the assignment of opportunities and threats to:

1. environmental effects of E-commerce (direct and indirect effects);
2. life-cycle stages within system boundaries set;
3. E-commerce features; and
4. additionality of opportunities and threats.

Environmental effects (direct and indirect) of E-commerce

In the context of this assessment, E-commerce is primarily understood as the possibility to support, change or replace certain commercial and economic processes in the domain of sales and procurement through the application of

information and communication technologies (ICT). In essence, E-commerce encompasses many of the potential and typical ICT effects, such as virtualisation of products, dematerialisation of transport, reduction of warehouse spaces, and shortening of supply chains (Börjesson Rivera *et al.*, 2014a). Yet, it is crucial to differentiate between parallel and often not clearly separable effects arising from other applications of ICT, such as overriding digitalisation effects.

Environmental effects of ICT are commonly classified into first (direct)-, second (enabling)-, and third (systemic)-order effects (Hilty and Aebischer, 2015). This classification scheme has been evolved in academia as to facilitate holistic assessments of specific ICT applications. While this approach was adopted by several studies (Fichter, 2001, 2002; Berkhout and Hertin, 2004; Dost and Maier, 2018) to assess environmental effects of E-commerce, it can be argued that this detailed distinction is sometimes difficult and not necessarily useful (Börjesson Rivera *et al.*, 2014b). Moreover, environmental effects arising from E-commerce are not solely related to the application of ICT but may be the result of accompanying developments within other domains (e.g. transport, packaging, digitalisation of services).

Due to the potential of ICT applications, and E-commerce in particular, to exhibit cascading environmental effects – both negative and positive – this study seeks to differentiate between direct and indirect effects. This methodological approach allows for a holistic assessment and enables decision-making at different levels of society. Hence, opportunities and threats are classified following the distinctive attribution criteria in Table 5. It is evident that all effects are interdependent and interwoven which sometimes makes an unambiguous classification impossible (Börjesson Rivera *et al.*, 2014b). Nevertheless, this methodological choice is crucial in the light of subsequent in-depth assessments of those effects (see Section 4).

Table 5: Attribution criteria of direct and indirect environmental effects arising from E-commerce

Direct Opportunities/Threats	Indirect Opportunities/Threats
Consequential and immediate effects: • intended positive effects • anticipated or existing negative effects	Hypothetical and/or long-term effects (negative or positive)
Effects can be allocated to one fulfilled unit or the purchase of a single product	Effects are rather systemic and cannot be allocated to the purchase of one single product (rather the result of cumulated purchases)
Inherent E-commerce features with high relevance for E-commerce business models	Supplementary (secondary) developments due to E-commerce features and evolving business models
Effects are mainly within the sphere of influence of E-commerce providers	Effects are mainly outside the sphere of influence of E-commerce providers and/or in the sphere of both E-commerce providers and other actors/stakeholders
Characteristic of current situation and further persistence in future scenarios	Emerging or ongoing effects with potentially high relevance in the future

Life-cycle stages within system boundaries

Typically, environmental impacts or Circular Economy aspects associated with the fulfilment of a purchased item are compared from the point of divergence (e.g. manufacturer´s outbound operation) to the point of consumption (Van Loon et al., 2015). Consequently, impacts related to the production and actual consumption or use of the products or services are excluded as those are generally not affected by the chosen fulfilment channel. The same argumentation generally applies to primary packaging which is considered an indistinguishable part of the products and thus not assessed in this study. However, the adoption by online platforms in collaboration with manufacturers of specific initiatives aimed at reducing the layers of packaging needed for the shipping (e.g. Amazon's Frustration Free Packaging Program) are taken into account within the relevant opportunities and threats as factors that may influence the impacts of secondary and tertiary packaging.

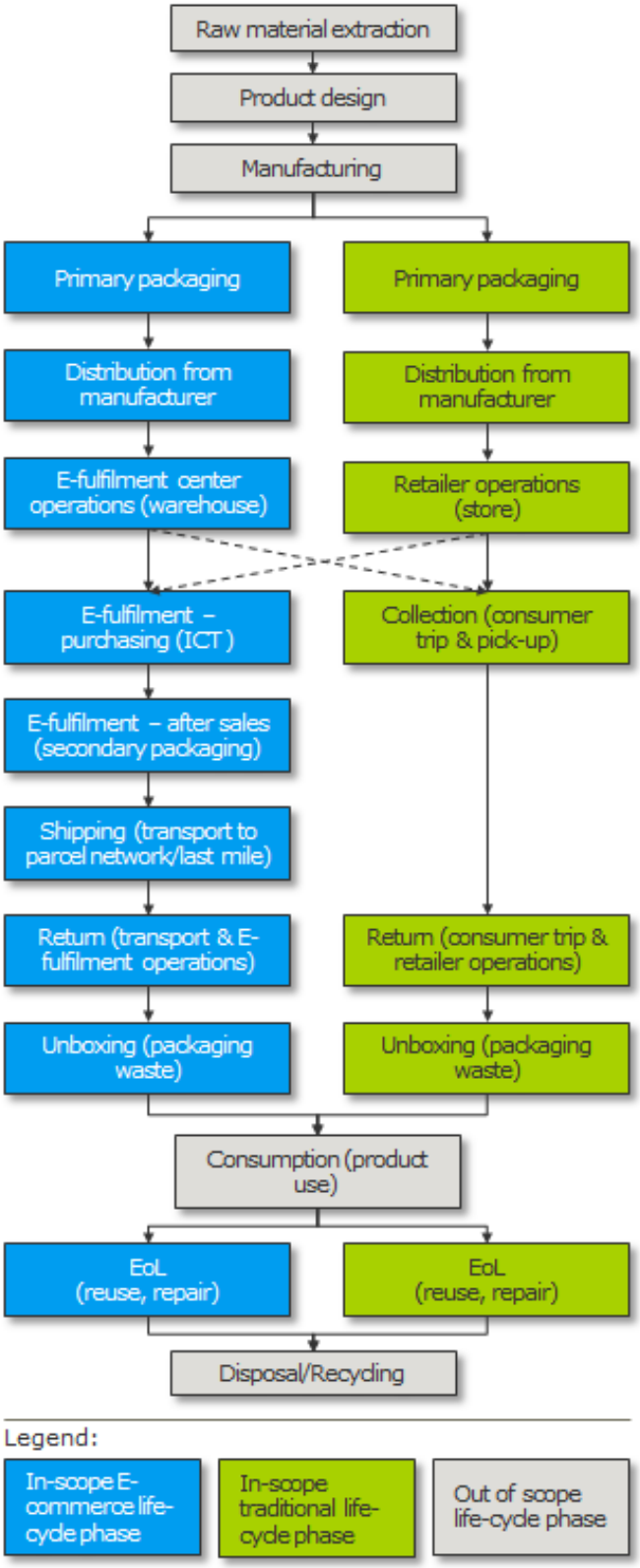
Given the circumstance that many of the changed or substituted processes are similar throughout the product categories, a universal and modular reference model was adopted (see Figure 2). A common reference model ensures a consistent

and efficient assessment of numerous E-commerce effects – both opportunities and threats – on relevant Circular Economy aspects related to the various life-cycle stages attributable to E-commerce.

Inevitably, a comparative analysis of the traditional retail channel and E-commerce necessitates to draw somewhat artificial boundaries between these often-overlapping domains (e.g. flag ship stores offering shipping services to customers). While in reality E-commerce clearly intersects with established structures and processes, the proposed reference model tries to untangle dedicated processes and attribute them to one or the other channel. For this purpose, the dominating flow of products through the value chain is assumed for both channels, as visualized in Figure 2. It is evident though, that there are numerous alternative supply chain options within both scenarios (e.g. online purchase and subsequent pick-up in a nearby store, also referred to as "click & collect") (Van Loon *et al.*, 2015a). Such deviations to the assumed flows of products may be the subject of certain opportunities and threats.

The product life-cycle stages are included in the following description of opportunities and threats in order to highlight where certain threats and opportunities potentially exert a positive or negative impact.

Figure 2: System boundaries and value chain differences for the identification of opportunities and threats and the in-depth assessment (own depiction)



E-commerce features

The identified opportunities and threats have been assigned to one or more of the E-commerce features, as described above and identified during Step 1. The list of E-commerce features identified is provided in Table 6 below.

Table 6: E-commerce features

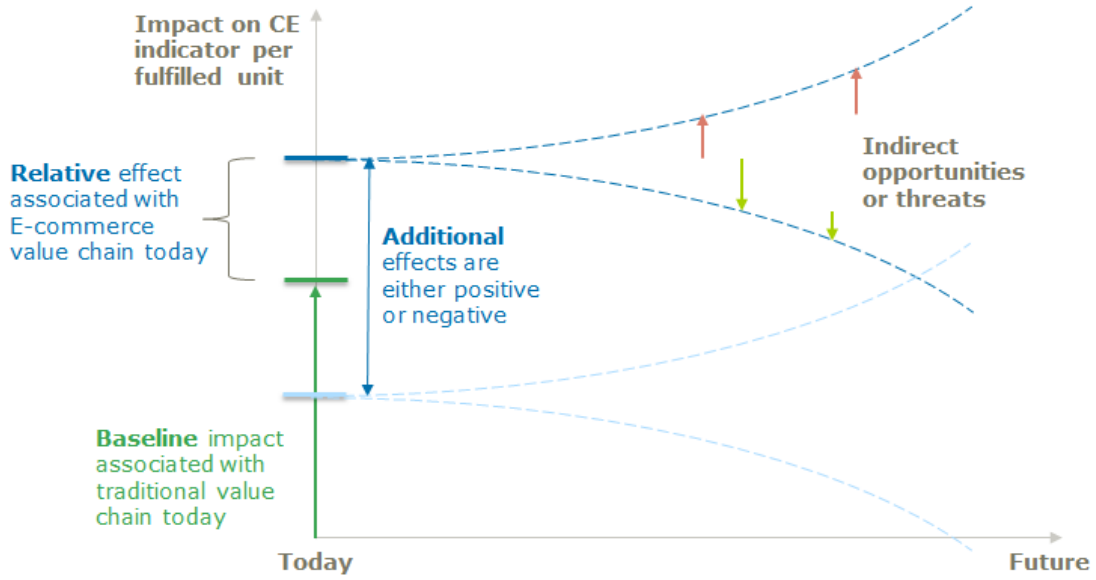
E-commerce features	Examples
Online shops and platforms	Operation of ICT infrastructure, substitution of physical shops
Automatisation of processes	Market transparency, just in time (JIT) manufacturing, additional data centre capacities
Automatisation of data analytics	Increased availability of data on purchases
Availability of information	Availability of information on specific product's features, immediate price and features comparison
Availability of products	Increased availability of products coming from distant countries, sustainable products etc.
Digital and mobile connectivity	Simplicity of user interface and ease of use
Digital purchasing and transaction process	Availability of diverse online purchasing options, preset options
Easier/broader market access	Low barrier to market entry, low transactions costs
Shipping of products	Use of packaging, induced parcel transport, return policies, take-back programmes

Additionality of opportunities and threats arising from E-commerce

By acknowledging evident intersections between E-commerce and traditional brick-and-mortar channels as well as highly dynamic developments within both value chains, a methodological choice was deemed necessary in order to make fair comparisons and draw valid conclusions. For this purpose, the traditional value chain was assumed to be static and therefore being applicable as a point of reference for identifying, describing, and assessing opportunities and threats. Consequently, all opportunities or threats are understood as additional. This means that any direct opportunity or threat arising from E-commerce results in either a reduction or an increase of a given Circular Economy indicator compared to the baseline which is generally determined by simultaneously occurring impacts associated with the traditional value chain (see Figure 3). Due to highly complex structures and uncertainties it is, however, often not possible to quantify this baseline. As a consequence, the absolute effect or extent of impact a certain direct opportunity or threat poses to the baseline may remain unclear or vague. Future developments are considered at least equally vague and are by definition highly speculative, in particular within E-commerce value chains. Such hypothetical and rather long-term effects are subsumed under the category of indirect opportunities or threats (see also Table 5). Moreover, these indirect opportunities and threats are expected to influence the future development of a given Circular Economy indicator within E-commerce value chains. Indirect opportunities and threats are often rather systemic, which in many cases prohibits comparisons to a static remaining baseline.

Figure 3 illustrates how direct opportunities and threats are generally positioned relative to the baseline (brick-and-mortar) as well as how indirect opportunities and threats may influence the future development of a given Circular Economy indicator.

Figure 3: Illustration of additionality of opportunities and threats and influencing factors on future development (indirect threats symbolised by red arrows, indirect opportunities by green arrows) (own depiction)



3.1.3 Step 3: Evaluation of relevance of identified opportunities and threats for selected product categories

Step 3 of the methodology consisted in evaluating the relevance of each threat and opportunity for the 7 product categories selected (see Section 2). It should be noted that the approach was to identify threats and opportunities in relation to a specific product category and therefore to allow for a meaningful in-depth assessment. However, a large number of opportunities and threats apply simultaneously to several product categories, sometimes with different intensity. The threat "parcel return", for example, occurs for nearly all product categories in scope (excluding digital media) but is more pronounced for e.g. the category apparel than for large household appliances (Statista, Retouren im Online-Handel, 2018).

3.1.4 Step 4: Stakeholder consultation for the definition of the final list of opportunities and threats

Second online stakeholder survey

After having defined the list of opportunities and threats followed by the evaluation of relevance described in Step 3, a second online stakeholder survey was launched with the following objectives:

- obtaining feedback on the relevance of the individual opportunities and threats identified, with particular focus on the selected 7 product categories; and
- gathering suggestions on potential additional opportunities and threats deemed relevant by the stakeholders but not yet included in the list.

The invitation to participate in the online survey was sent out to 85 stakeholders belonging to different sectors. Compared to the first survey, a higher number of stakeholders was invited, due to the broader scope of the consultation.

The stakeholders were provided with the following 4 core open questions:

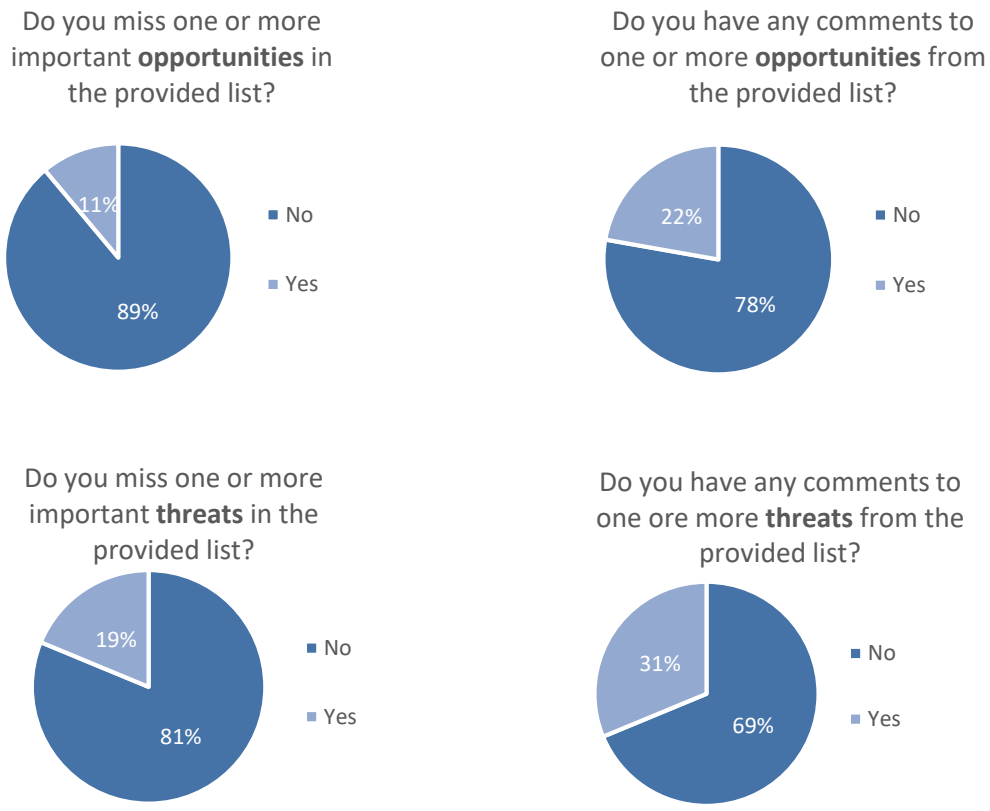
1. Do you miss one or more important opportunities in the provided list?
2. Do you have any comments to one or more opportunities from the provided list?
3. Do you miss one or more important threats in the provided list?
4. Do you have any comments to one or more threats from the provided list?

59% of the stakeholders invited participated in the survey and 68% of them provided comments to at least one of the 4 core questions, for a total of 48 comments provided. Respondents belong to associations, omni-channel retailers, online

platforms, manufacturers, NGOs and logistics service providers. Most of the respondents have a turnover higher than 500 million euros and provide a comprehensive geographical coverage, operating not only in Europe but also in other continents.

The answers to questions no. 1 and 3 about the identified opportunities and threats showed an overall agreement of the stakeholders with the proposed list, with 89% of the respondents satisfied with the provided list of opportunities, and 81% satisfied with the list of threats.

Figure 4: Overview of stakeholders' answers to the 4 core questions of the second stakeholder online consultation



The 48 comments provided aimed mostly at clarifying relevant aspects of the identified opportunities and threats, i.e. highlighting possible drawbacks of certain opportunities or providing information on the context and background of specific threats. All the comments have been screened and taken into consideration for the Stakeholder Workshop and in the final selection and description of the opportunities and threats.

In particular, two new opportunities and one new threat for the Circular Economy arising from E-commerce have been identified thanks to the survey:

- Extended product selling cycle (Opportunity);
- Optimisation of packaging (Opportunity); and
- Plastic packaging (Threat).

The newly identified opportunities and threats have been added to the initial database and have been directly discussed with the stakeholders during the Stakeholder Workshop in Seville.

Stakeholder Workshop (Seville, 20-21 May 2019)

The present study was further presented to the relevant stakeholders during a dedicated workshop which took place in Seville on 20-21 May 2019. Aim of the workshop was to provide the stakeholders with further details on the study, including the background, the methodology used for the different work steps and the set boundaries and limitations, and to gather their feedback on the proposed list of opportunities and threats.

13 stakeholders belonging to online platforms, trade and retail associations, NGOs, producer responsibility organisations, collection and recycling associations and product category associations participated in the workshop[11].

The stakeholders, which were divided into 2 groups and supported by the members of the project team, were guided through a discussion on the proposed list of opportunities and threats during 3 breakout sessions and one plenary session throughout the 2 workshop days.

On the first day the stakeholders were asked to comment and discuss each of the identified opportunities and threats, while on the second day they were invited to group the opportunities and threats by topic (cluster) and to rank them by relevance. While the clustering was done by group, the stakeholders were asked to rank the opportunities and threats individually. The results of the clustering and ranking of opportunities and threats have been taken into account for the in-depth assessment presented in Section 4.

The outcomes of the discussions showed a very high degree of interest and engagement of the stakeholders in the study. In the following, the main outcomes of the workshop are summarized by topic.

Topic: New opportunities and threats identified

Four new opportunities and three new threats were identified directly by the stakeholders during the workshop, namely:

- Big data / meta data (opportunity);
- eWOM[12] / Product reviews (opportunity);
- Innovation (opportunity);
- More services (opportunity);
- End-of-life challenges (threat);
- Difficulty to monitor (threat); and
- Enforcement (threat);

All the above-listed opportunities and threats have been taken into account in the following steps of the study. The two opportunities "eWOM / Product reviews" and "More services" have been respectively described as part of the two opportunities "Availability of information" and "Sharing models and services", while the other ones have been added in the final list as stand-alone opportunities/threats.

Topic: Proposed list of opportunities and threats

The proposed list of opportunities and threats was considered overall comprehensive, although some opportunities/threats were ranked by different stakeholders with a different level of relevance, in some cases even opposite. The most controversial opportunities/threats were the following:

- Big data / meta data (new opportunity defined by some stakeholders directly during the workshop);
- eWOM / Product reviews (new opportunity defined by some stakeholders directly during the workshop);
- more services (new opportunity defined by some stakeholders directly during the workshop);
- Damage on delivery;
- Secondary packaging; and
- Try-and-buy outlets.

[11] See Acknowledgment for the detailed list.

[12] Electronic word-of-mouth: defined here as any informal communications directed at consumers through internet-based technology related to the usage or characteristics of a particular product or company.

Topic: Clustering of opportunities and threats

The two stakeholder groups aggregated the identified opportunities and threats (including the 7 new ones identified during Day 1) into similar clusters, that were combined into the final list used for the in-depth assessment and for the presentation of the opportunities and threats in Section 3.2. The clusters proposed by the stakeholders and the final list are provided in the Table 7 below.

Table 7: Clusters proposed during the workshop and final list

Proposal Group 1	Proposal Group 2	Final clusters
Accessibility of information	Access to data	**Accessibility of information**
Consumer needs and behaviour	Consumption	**Consumer needs and behaviour**
Others	Others	**Digitalisation**
Start-up		
End of life	Increase of waste	**End of life**
	Take-back (closing the loop)	
Legal framework	Compliance	**Legal framework**
	Enforcement	
Logistics and transport	Transport	**Logistics and transport**
Returns	Supply chain	
Packaging	Resources	**Packaging**

Topic: Assessment of the effects of the identified opportunities and threats on the Circular Economy

The assessment of the effects of the identified opportunities and threats on the Circular Economy was recognised as a delicate and challenging task, due to the number of actors involved in the E-commerce value chain, the subsequent fragmentation and the lack of available data.

Combined results of second stakeholder survey and stakeholder workshop: relevance of the identified opportunities and threats

The inputs collected from the stakeholders via the second survey and the stakeholder workshop have been compared and combined in order to gather an overview of the relevance of the identified opportunities and threats from the stakeholders' perspective. The results are reported in the Table below as well as in Section 5.2 where they are compared with the outcomes of the in-depth assessment.

Table 8: Relevance of opportunities and threats based on the combined stakeholders' input from the second survey and the workshop

O/T	Name of the opportunity/threat	Cluster	Relevance from stakeholder consultation
T	**Induced parcel transport**	Logistics and transport	**high**
T	**Parcel return**	Logistics and trasnport	**high**
O	**Product take-back**	End of life	**high**
T	**Waste from returns**	End of life	**high**
T	**Lack of compliance with common market regulation**	Legal framework	**high**
T	**Difficulty to monitor**	Legal framework	**high**
T	**Enforcement**	Legal framework	**high**
T	**EPR free-rider effect**	Legal framework	**high**
T	**Excessive protective packaging**	Packaging	**high**

O/T	Name of the opportunity/threat	Cluster	Relevance from stakeholder consultation
O	Market access to online aftermarket	Accessibility of information	medium
O	Innovation	Accessibility of information	medium
O	Sharing models and services	Consumer needs and behaviour	medium
O	Second-hand E-commerce /online auctioning	End of life	medium
T	EoL challenges	End of life	medium
T	Inefficient transport	Logistics and transport	medium
T	Inferior types of transportation	Logistics and transport	medium
T	Damage on delivery	Logistics and transport	medium
T	Individual product delivery	Logistics and transport	medium
O	Optimization of supply chain	Logistics and transport	medium
O	Digital goods	Digitalisation	medium
T	Operational energy demand for the network infrastructure	Digitalisation	medium
O	Substitution of printed marketing material	Digitalisation	medium
O	Substitution of individual shopping trips	Logistics and transport	low
O	In-House fulfillment	Logistics and transport	low
T	Induced freight traffic to remote locations	Logistics and transport	low
T	Personalised design	Consumer needs and behaviour	low
T	Shopping frenzy	Consumer needs and behaviour	low
T	Ease of shopping	Consumer needs and behaviour	low
T	Cross-selling and up-selling	Consumer needs and behaviour	low
T	Secondary packaging	Packaging	low
O	Development of dedicated packaging solutions	Packaging	low
O	Extended product selling cycle	End of life	low
T	Food waste	End of life	low
T	International market access	Accessibility of information	low
T	Ubiquity	Accessibility of information	low
O	Availability of information	Accessibility of information	low
O	Reduction of retail space	Digitalisation	low
O	Collaboration between companies and partnering with waste management suppliers	No cluster	low
O	Product portfolio	Accessibility of information	contrasting inputs from stakeholders
O	Nudging	Consumer needs and behaviour	contrasting inputs from stakeholders
O	Big data/ meta data	Accessibility of information	contrasting inputs from stakeholders

3.2 Description of opportunities and threats

A total number of 41 opportunities and threats for the Circular Economy arising from E-commerce, of which 19 opportunities and 22 threats has been identified based on the methodology described in the previous section.

Based on the direct input of the stakeholders during the workshop (see Section 3.1.4), the opportunities and threats have been allocated to seven clusters, which are expected to influence the same or similar Circular Economy aspects.

Table 9 provides the final list of opportunities and threats grouped by cluster.

In the following paragraphs, each threat and opportunity is presented in a uniform format:

- Description: identification of the opportunity/threat;
- Discussion: short description of the opportunity/threat, its correlation with the E-commerce features and the Circular Economy aspect;
- Classification: classification in direct and indirect effects (see Section 3.1.2);
- Current and future relevance: data and information of expected future developments;
  Supporting factors: factors that promote the development of the opportunity/threat, in the current situation and in the future;
- Mitigating factors: factors that slow down the development of the opportunity/threat, in the current situation and in the future;
- Options for action: possible initiatives/solutions to mitigate the effects of the threat or further promote the opportunities, divided by: Producers/Platform providers, Regulators and Scientific Community; and
- Sources of information.

Table 9: Final list of 41 opportunities and threats by cluster

Cluster	O/T	Opportunities and Threats
Accessibility of information	O	Availability of information
	O	Big data/ meta data*
	O	Innovation*
	O	Market access to online aftermarket
	O	Product portfolio
	T	International market access
	T	Ubiquity
Consumer needs and behaviour	O	Nudging
	O	Sharing models and services
	T	Cross-selling and up-selling
	T	Ease of shopping
	T	Personalised design
	T	Shopping frenzy
Digitalisation	O	Digital goods
	O	Reduction of retail space
	O	Substitution of printed marketing material
	T	Operation of network infrastructure
End of life	O	Extended product selling cycle*
	O	Product take-back
	O	ReCommerce: Second-hand E-commerce /online auctioning
	O/T	Food waste
	T	End-of-Life challenges*
	T	Waste from returns
Legal framework	T	Difficulty to monitor*
	T	Enforcement*
	T	EPR free-rider effect
	T	Lack of compliance with common market regulation
Logistics and transport	O	In-House Fulfilment
	O	Collaboration between companies and partnering with waste management suppliers
	O	Optimisation of supply chain
	O	Substitution of individual shopping trips
	T	Damage on delivery
	T	Individual product delivery
	T	Induced freight traffic to remote locations
	T	Induced parcel transport
	T	Inefficient transport
	T	Inferior types of transportation
	T	Parcel return
Packaging	O	Development of dedicated optimised packaging solutions*
	T	Excessive protective packaging
	T	Secondary Packaging

* Opportunity/threat identified by the stakeholders during the second online survey and the stakeholder workshop.

3.2.1 Cluster – Accessibility of information

3.2.1.1 Opportunity – Availability of information

Description

Extensive product information can be provided on-line, including technical information, demonstration videos and customer feedback (on-line reviews, Yan *et al.*, 2016), allowing consumers to have a detailed picture of the products in terms of usefulness, reliability or durability before the purchase.

Discussion

It is undisputed that, since its beginning, the internet has increased to an immeasurable degree the availability of information to a large part of the population. This does also apply to information provided to customers of E-commerce. It should be noted here that the abundance of information can be overwhelming to the user and can even hinder decision-making if inadequately provided. It is, however, seen as an opportunity for the Circular Economy, as it enables customers to make more informed purchasing decisions.

The advice given by the salesperson in the physical shop is increasingly giving way to independent Internet research via laptop or mobile device. In addition to product information and price comparisons, it is in particular the independent evaluations of other buyers that are of interest during the research. The more trustworthy the source of the product recommendation, the more likely the product is to be purchased (Leitherer, 2017). In particular, so called user-generated content (UGC) should be mentioned here as a type of communication that gained significant importance over recent years. By giving personal recommendations to certain products, consumers support each other with product-related advice. This electronic word-of-mouth (Yan *et al.*, 2016) communication was found to be of more importance to the customer's purchasing choice than other means (e.g. recommendation from the shop) (Anastasiei and Dospinescu, 2019). It is differentiated here between online reviews on e-commerce websites and recommendations given via social media (Yan *et al.*, 2016). The latter can be attributed to digitalisation, while the focus of this study is purely on E-commerce. In practice, it is certainly difficult to clearly separate the different research channels that are used by a customer before the final purchasing decision is made (Anastasiei and Dospinescu, 2019).

The availability of information is seen here as a clear opportunity of E-commerce for a Circular Economy as the consumer is enabled to get a clear picture and understanding of a product he or she is interested in, and therefore to make an informed purchase decision.

Classification

The availability of information lies within the sphere of influence of E-commerce providers and is an inherent feature with high relevance for E-commerce business models. It is described as one of the main characteristics of online shops and has an immediate effect on shopping behaviour and thus on consumption. It is therefore considered as a direct effect of E-commerce.

Current and future relevance

The relevance of information available in online shops increased in a similar way as E-commerce developed over time (Zhang, Bin and Sun, 2015). Several studies show that especially user recommendations are used by a significant number of users of the platforms. Some of them reveal that around 90% of customers of E-commerce use some kind of UGC (such as online reviews) before purchasing a product (Yan et al., 2016). The current relevance of this aspect of E-commerce can be seen as already very high.

In the future, it seems that the decision to buy a product will be increasingly influenced by one of the many social media platforms and recommendations provided by their users (e.g. from so called 'influencers'). Additionally, social media posts that recommend a certain product or label seem to have a potentially strong influence on the purchasing decisions of users (Zhang, Bin and Sun, 2015; Leitherer, 2017).

This opportunity is of cross-product relevance and affects all product categories in focus of this study.

Supporting factors

The amount of information presented to the customer in E-commerce can be overwhelming and sometimes distractive. The availability of information is therefore only seen as opportunity for the Circular Economy, if it is presented to the customer in a user-friendly way by applying E-commerce specific techniques:

- clear structure and presentation of available information (WebAlive, 2019);
- inclusion of user product reviews and ratings (WebAlive, 2019); and
- integration of different media (text, video, pictures, interactive 3D images, etc.) (WebAlive, 2019).

Mitigating factors

- International trade, in which an information mediation adapted to the local culture is neglected, can have undesirable effects on the recipient of information (Barkai, 2008); and
- systematic problems that produce a distorted and biased image, such as:
    - Overrepresentation of extreme views; and
    - Fraudulent online reviews (Thornhill, 2019).

Options for actions

Producers/Platform providers:

- Pre-selection of most important information that supports the consumer in its purchasing decision.

Regulators:

- Develop minimum requirements for information presentation, incl. similar cross-product categories, e.g. use-features, product-service life enhancing maintenance, and end-of-life recommendation/requirement)
- Encourage – or even require - independent checks of provided information, e.g. via consumer organisations

Source of information

Anastasiei, B. and Dospinescu, N. (2019) 'Electronic word-of-mouth for online retailers: Predictors of volume and valence', *Sustainability (Switzerland)*, 11(3). doi: 10.3390/su11030814.

Barkai, J. (2008) 'What's a Cross-Cultural Mediator to Do? A Low-Context Solution for a High-Context Problem' Cardozo Journal of Conflict Resolution, Vol. 10, pp. 43-89, 2008. Available at SSRN: https://ssrn.com/abstract=1434165

Leitherer, J. (2017) *Social Commerce setzt neue Maßstäbe*. Available at: https://www.springerprofessional.de/word-of-mouth-marketing/e-commerce/konsumbarometer/15157554 (Accessed: 2 August 2019).

Thornhill, J. (2019) 'Five stars or fake? How to beat fraudulent online reviews'. Last accessed: 01.10.2019, Available at: https://www.theguardian.com/money/2019/jul/14/five-stars-or-fake-how-to-beat-fraudulent-online-reviews

Yan, Q. *et al.* (2016) 'E-WOM from e-commerce websites and social media: Which will consumers adopt?', *Electronic Commerce Research and Applications*. Elsevier B.V., 17(March), pp. 62–73. doi: 10.1016/j.elerap.2016.03.004.

Zhang, P., Bin, S. and Sun, G. (2015) 'Electronic Word-of-mouth Marketing in E-commerce based on Online Product Reviews', *International Journal of u- and e-Service, Science and Technology*, 8(8), pp. 253–262. doi: 10.14257/ijunesst.2015.8.8.26.

3.2.1.2 Opportunity – Big data / meta data

Description

As E-commerce is part of the digital realm, big data automatically becomes a topic worth to discuss with regard to developments in the Circular Economy. Big data is described as the high-speed analysis of large amounts of data from multiple sources. It is seen here as opportunity for the Circular Economy as it enables the companies to leverage the available information and to provide personalised information to the consumers, therefore increasing the potential to influence their shopping behaviour.

Discussion

Big data is a concept that was already discussed in the 90s but became widely known since 2011 (Gandomi and Haider, 2015). The ever-faster growth in data that is collected via various sources is pushing the topic into the agenda of most companies and also public authorities. At the same time, Gandomi and Haider (2015) show that there is currently no common understanding of the term. While some see big data purely as the availability of vast amounts of unstructured data, others already include forms of information processing for decision making into the concept. For this study, we follow the definition and understanding of the European Union, which was established as part of its Digital Single Market Strategy:

"Big data refers to large amounts of data produced very quickly by a high number of diverse sources. Data can either be created by people or generated by machines, such as sensors gathering climate information, satellite imagery, digital pictures and videos, purchase transaction records, GPS signals, etc. It covers many sectors, from healthcare to transport and energy." (European Commission, 2018c)

In the context of E-commerce, companies typically collect both structured (e.g. demographic data such as name, age, etc.) and unstructured data (e.g. likes, clicks, etc.) (Akter and Wamba, 2016). As the number of E-commerce customers increased significantly together with the increase in people using the Internet (around 60% of people in the EU purchased at least once in 2018 something online, (Statista, 2019a)), large amounts of data are collected by respective companies. The challenge lies in applying advanced information processing (big data analytics) that extract useful information and to get meaningful insights (Akter and Wamba, 2016).

The importance to make use of available data is not limited to a certain department, but rather of interest of most functional units of a company (e.g. marketing, production, finance).

Studies show various areas in which big data analysis can bring added value to the company, such as personalisation, dynamic pricing, customer service, supply chain visibility, predictive analytics and security and fraud detection.

From this list it becomes clear that the value of the application of big data is difficult to assess. As this study is focusing on the impact on the Circular Economy, some aspects can be highlighted.

Supply chain visibility is focusing mainly on providing in-depth information about the delivery of a product to the customer. In order to provide this service to the buyer of a product, a large amount of data from different sources (e.g. involved delivery services, warehouses, etc.) must often be evaluated in real time. At the same time, this information about the current delivery status and location of the shipment is of course also used by the companies involved in the supply chain. The possibility to obtain a detailed overview of all current deliveries enables the entire supply chain to be optimised. This in return helps to reduce waste.

Another aspect is predictive analytics, which enables firms to increase the accuracy of forecast and thus the requirements regarding inventory. It is an essential part of the Circular Economy to stop overproduction and to optimise stock levels.

Classification

Although already effectively used by some of the large players in the market, exploitation of big data is still seen as an emerging aspect with an estimated high relevance for the future. Its effects are rather systematic, and they cannot be allocated to individual products offered in the online store. It is therefore considered as an indirect effect of E-commerce.

Current and future relevance

The current relevance of big data is already very high. It is one of the top five IT trends of the year 2018 according to a survey conducted by Bitkom, which surveyed companies in Germany in 2018 (Bitkom, 2018). This can also be verified by the worldwide market size of big data, which reached around 35 billion U.S. dollars in 2017.

The future relevance of big data is expected to further increase. On the one hand, this has to do with the ever-increasing amount of data that is collected. Sensor technology, further expansion of the mobile data network, increasing number of Internet and E-commerce users are only a few of the driving factors. On the other hand, it is expected that new technologies will increase the possibilities of big data analytics. These include artificial intelligence and machine learning to evaluate the data. Some forecasts estimate an increase of the big data market by nearly 300% in the next decade (around 103 billion US dollars till 2027) (Statista, 2018a). Although it is difficult to quantify the share of big data in e-commerce exactly, it is foreseeable that the importance of big data will continue to increase here as well.

This opportunity is of cross-product relevance and affects all product categories in focus of this study.

Supporting factors

- the European Commission announced several Communications in recent years to establish a common European data space (European Commission, 2018d), which is expected to increase transparency of data security and data usage.

Mitigating factors

- still insufficient understanding of big data for companies dealing with voluminous data amounts, making it currently unfeasible for them to gain value from collected data;
- uncertainty in investing in big data and its analysis, as the market is not consolidated yet and as there are various possibilities to extract useful information from big data (uncertainties for selecting a big data technology);
- data security issues, such as leakage of sensitive information leading to loss of trust in data collection and evaluation; and
- lack of knowledge on how to convert big data into valuable insights into one's business.

Options for actions

Producers/Platform providers:

- collaboration with data analysis vendors to add value to large volumes of data and, most importantly, to comply with data security and privacy regulations. The latter is especially important to maintain customer trust.

Regulators:

- guidelines for companies should be provided to establish a common level playing-field and to ensure fair competition in use of big data. E.g. the Commission Staff Working Document 'Guidance on sharing private sector data in the European data economy' (European Commission, 2018d)
- digitisation is moving extremely fast with constant new developments and technologies (advanced algorithm analysis, machine learning, etc.). This rapid development might be in contrast with legislation, which requires comprehensive examination and factual content to be effectively developed and defined. It therefore requires a dynamic process of continuously aligning current and future developments with legislation in order to identify possible backlog requirements.

Source of information

Akter, S. and Wamba, S. F. (2016) 'Big data analytics in E-commerce: a systematic review and agenda for future research', *Electronic Markets*. Electronic Markets, 26(2), pp. 173–194. doi: 10.1007/s12525-016-0219-0.

Bitkom (2018) *Blockchain wird zu einem Top-Thema in der Digitalwirtschaft*. Available at: https://www.bitkom.org/Presse/Presseinformation/Blockchain-wird-zu-einem-Top-Thema-in-der-Digitalwirtschaft.html#item-585-close (Accessed: 2 August 2019).

European Commission (2018c) *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0232&from=EN (Accessed: 2 August 2019).

European Commission (2018d) *Communication from the Commission to the European Parliamt, the Council, the European*

Economic and Social Comittee and the Comittee of the Regions. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0232&from=EN (Accessed: 2 August 2019).

Gandomi, A. and Haider, M. (2015) 'Beyond the hype: Big data concepts, methods, and analytics', *International Journal of Information Management*. Elsevier Ltd, 35(2), pp. 137–144. doi: 10.1016/j.ijinfomgt.2014.10.007.

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3.2.1.3 Opportunity – Innovation

Description

The internet with its interconnected users across the globe offers an excellent platform to present and promote innovative ideas to a broad audience. E-commerce can play a vital role in fostering innovation in combination with concepts such as crowdfunding. These online platforms make it possible to overcome common hurdles such as high investment costs and allow the creation of an interest group. It is seen as an opportunity for a Circular Economy to enable small companies and start-ups to easily promote and put on the market their ideas, thus supporting the transition to a sustainable development.

Discussion

Crowdfunding is not a new concept but has become widely known in its "digital form" through the development of the internet and internet platforms (Gurd, 2014). It is defined by BigCommerce as "a method of raising money online through the support of many different donors. Owners of crowdfunding pages announce a specific amount of money they need to raise in order to fulfil a goal or begin an enterprise." (BigCommerce, 2019). It can be added that especially start-ups often aim at developing and pitching a new type of product or service. FinalStraw can be given here as one of many examples, which is a start-up that promotes its idea of a sustainable straw on the platform Kickstarter (Kickstarter, 2018).

Whether crowdfunding is a type of E-commerce can surely be debated. It is evident that the rise of digitalisation with interconnected networks of millions of people enabled the development of platforms on which ideas, products and services can easily be promoted to a wide audience of potential investors and supporters. Visiting one of the many crowdfunding platforms show a structure and offering of ideas similar to typical E-commerce websites.

The combination of low barriers to entry, low costs for marketing and presentation of the idea, enormous reach and the possibility to build up a loyal customer base during the application process are considered to promote innovation.

Classification

The effects of innovation emerging from E-commerce activities are hypothetical and certainly long-term. Additionally, the allocation to individual products is not possible. Innovation is therefore considered an indirect effect of E-commerce.

Current and future relevance

It is not possible to estimate the exact impact of E-commerce on innovation, especially as the field of innovation is very broad and affects many different areas at the same time. Looking at the aspect of crowdfunding allows at least to estimate an increase or decrease in importance.

The global crowdfunding market increased steadily over the past years and is predicted to reach a transaction value of nearly US$7 billion in 2019 (Statista, 2019c). The growth rate for coming years is estimated at around 15% per year. In 2019, a total of 8.72 million campaigns were financed (Statista, 2019c). BigCommerce estimated the number of crowdfunding platforms at 450 (BigCommerce, 2019).

This opportunity is of cross-product relevance and affects all product categories in focus of this study.

Supporting factors

- low barriers to be eligible (both from a legal and economic perspective) for the crowdfunding platforms, thus enabling small entrepreneurs and start-ups to present and promote their ideas.

Mitigating factors

- although there are currently low barriers to enter one of the many crowdfunding platforms, there might be a consolidation of the market with an increase in focusing on the chance of success of ideas in the future. Innovation cannot flourish if ideas are excluded at a very early stage of development.

Options for actions

Producers/Platform providers:

- the platforms should be kept open to all types of companies in order to offer a stage to a wide audience.

Source of information

BigCommerce (2019) *What is crowdfunding?* Available at: https://www.bigcommerce.com/ecommerce-answers/what-crowdfunding/ (Accessed: 2 August 2019).

Gurd, J. (2014) *Five ways crowdfunding will help retail ecommerce in 2014*. Available at: https://econsultancy.com/five-ways-crowdfunding-will-help-retail-ecommerce-in-2014/ (Accessed: 2 August 2019).

Kickstarter (2018) *FinalStraw, the world's first collapsible, reusable straw*. Available at: https://www.kickstarter.com/projects/finalstraw/finalstraw-the-worlds-first-collapsible-reusable-s (Accessed: 2 August 2018).

Mourao, P., Silveira, M. A. P. and de Melo, R. S. (2018) 'Many Are Never Too Many: An Analysis of Crowdfunding Projects in Brazil', *International Journal of Financial Studies*, 6(4), p. 95. doi: 10.3390/ijfs6040095.

Statista (2019c) *Crowdfunding-worldwide*. Available at: https://www.statista.com/outlook/335/100/crowdfunding/worldwide (Accessed: 2 August 2019).

3.2.1.4 Opportunity – Market access to online aftermarkets

Description

E-commerce can promote the possibility for consumers to extend the lifetime of a product by facilitating the access to online aftermarket where consumers can purchase spare parts to repair their product.

Discussion

Access to a physical market is strongly limited by the shops within reach of the consumer. Particularly in less densely populated areas and for special products, the probability that spare parts are available to repair items by oneself is rather low. E-commerce enables access to a large number of additional products and markets and thus also to spare parts. This is seen as an opportunity for E-commerce to increase the longevity of products.

A spare part is a duplicate part used to replace a lost or damaged part of a machine or other good. It is typically associated with the automotive industry, but there are aftermarkets for spare parts for almost all product categories in this study. The focus lies here on replacing damaged parts of machines, making this opportunity associated with small ICT and major household appliances.

Classification

Market access to online aftermarkets is seen as a direct effect as it enables the consumer to extend his product's life time. It is therefore associated with the End-of-Life stage of the product life-cycle.

Current and future relevance

It is challenging to make substantiated statements about the maturity of the existing aftermarket and how far it is used by people for the product groups in the focus of this study. There are no reliable sources for this. By searching the market, however, one will encounter a large number of suppliers of spare parts for household appliances and ICT.

The Behavioural Study on Consumers' Engagement in the Circular Economy by the European Commission (2018b) sought to evaluate, among other things, to what extent consumers are willing to repair their broken product instead of replacing it with a new one. The study shows that consumers tend to repair products (or attempt to repair them) and that the majority of them is aware of the longevity and reparability of purchased products. At the same time, the study further highlights that although consumers are typically interested in repair options, the process for doing so is often too complex or expensive.

The European Commission has announced adjustments in the eco-design regulations for a series of products. The following new requirements on the reparability and recyclability of appliances have been introduced in the eco-design measures (European Commission, 2019c):

- availability of spare parts;
- easy replaceability; and
- access to repair and maintenance information for professional repairers [...].

This indicates that the relevance of spare parts markets, which are also accessible to the end consumer, will increase in the future.

Spare parts are only relevant for those product categories where the repair of a product is an option at all. This excludes the categories non-perishable foods and media & entertainment products / services.

Supporting factors

- reparability of products (non-destructive and easy disassembly of key components);
- small and independent repair shops, repair cafés and similar. In just a few years, the Repair Café movement has grown to an impressive size in Western Europe, with a total of 1,128 local organisations (Ellen Macarthur Foundation, 2016);
- wiki-based platforms such as iFixit that teaches people how to repair various products by allowing anyone to create or edit a repair manual for a device;

- European Eco-design directive and product-specific regulations; and
- diffusion of home repair insurances (home warranties) that cover the cost to repair or replace an appliance or system.

Mitigating factors

- highly consumption-oriented society and business models, with focus on profitability rather than longevity of a product;
- limited access to repair and maintenance information as well as spare parts for consumers and independent repair shops; and
- expensiveness and excessive time needed for the repair.

Options for actions

Scientific Community:

- strengthening the application of 3D print of spare parts as innovative alternative to the current situation; and
- repair culture: promoting the "right to repair".

Regulators:

- strengthening the eco-design related regulation and initiatives with clear requirements in regard to reparability per product category.

Source of information

Anastasio, M. (2019) *Europe paves way for right to repair. European Environmental Bureau. EEB Reaction*. Available at: https://eeb.org/europe-paves-way-for-right-to-repair/.

Ellen Macarthur Foundation (2016) 'Empowering Repair', (October), p. 16. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/ce100/Empowering-Repair-Final-Public1.pdf.

European Commission (2018b) *Behavioural Study on Consumers ´ Engagement in the Circular Economy*. Available at: https://ec.europa.eu/info/sites/info/files/ec_circular_economy_final_report_0.pdf (Accessed: 2 August 2019).

European Commission (2019c) *New energy efficiency labels explained*. Available at: https://europa.eu/rapid/press-release_MEMO-19-1596_en.htm (Accessed: 2 August 2019).

3.2.1.5 Opportunity – Product portfolio

Description

A pronounced and at the same time well sorted and easily accessible selection of products enables customers to make more targeted purchases. This aspect is certainly ambiguous, since a larger selection of products does not necessarily lead to better purchasing decisions in the sense of sustainability. However, it should be emphasised here that the customer is less tied to small product portfolios and has the opportunity to select the most suitable product from a comprehensive selection.

Discussion

It might not be necessary to go online to find a large selection of specific products. Supermarkets are an excellent example, as the number of articles can reach between 2,000 and 25,000 in German supermarkets – number dependent on type of supermarket: discounter, large supermarket, etc. (Handelsforschung and V., 2018). Several studies have pointed out that such a wide choice of options does not necessarily lead to an increased sense of freedom for customers, but on the contrary can be overwhelming and frustrating (Süddeutsche Zeitung, 2014). A relatively newly initiated research area that deals with the problem of wrong decisions is the so called Regret research (Süddeutsche Zeitung, 2014).

It is seen here as a chance for E-commerce to combine a large product selection with an easy and fast search. Online shops are usually designed in a way that allows a user-friendly navigation, comparison of certain products, breadcrumb navigation, detailed product information, user reviews, product filtering and sorting. Especially the latter enables the customer to break down the seemingly infinite selection of products to a few that meet his or her requirements best. A society that is increasingly aware of the environmental impact of its behaviour and consumption demands innovative, sustainable products.

Classification

While building a product portfolio is an ongoing process, it is also one of the first key decisions of any online business. It clearly characterises the current situation and will persist in future scenarios. Although its consequential positive effects are not that obvious, it is still considered a direct effect of E-commerce.

Current and future relevance

Online retailers recognised the potential of their online shops early on. Since the products offered do not have to be physically advertised to the customer, physical retail space is saved, and a large number of additional products can be offered. Large players in the field can nowadays easily offer hundreds of thousands or even millions of products within one online shop. Especially the combination of an online retailers' own portfolio in addition to an integrated marketplace with third-party providers increases the portfolio immensely (Retail Touch Points, 2019).

Large product portfolios can be found for each of the product categories in focus. In general, cell phones and accessories, electronics, home and kitchen, and apparel are showing an extreme variation in brands and sellers. A consolidation of the market is currently not yet to be expected as globalisation continues to progress.

This opportunity is of cross-product relevance and affects all product categories in focus of this study.

Supporting factors

- modern, user-oriented and user-friendly search functions, which allow the customer to pinpoint relevant products in a seemingly unmanageable number of products; and
- customer reviews allow the buyer to quickly and easily identify proven products. However, the possibilities of fraud (see e.g. fictitious customer reviews; (Thornhill, 2019)) should also be pointed out, as well as the difficulties for new brands and products to enter the market.

Mitigating factors

- poorly organised product ranges overwhelm customers and lead to frustration.

Options for actions

Producers/Platform providers:

- the possibility should not be understood to mean that suppliers offer as wide an assortment as possible. The combination of large product selection and easy access (search, sort function, etc.) is necessary to offer added value to the customer; and
- to support the transition towards a Circular Economy, platforms providers and companies could promote products with a proven longer service life or reparability.

Source of information

Handelsforschung, I. I. für and V., im A. des H. D. – H. e. (2018) 'Fakten zum Lebensmitteleinzelhandel', *Handelsreport Lebensmittel*. Available at: https://einzelhandel.de/images/HDE-Publikationen/HDE_IFH_Handelsreport_Lebensmittel_2018.pdf.

Retail Touch Points (2019) *How Many Products Does Amazon Carry?* Available at: https://www.retailtouchpoints.com/resources/type/infographics/how-many-products-does-amazon-carry (Accessed: 2 August 2019).

Süddeutsche Zeitung (2014) *Unterschiedliche Schokoladen für morgens, vormittags, abends-Sortimente im Supermarkt*. Available at: https://www.sueddeutsche.de/geld/sortiment-in-supermaerkten-von-allem-zu-viel-1.2253540-2 (Accessed: 2 August 2019).

Thornhill, J. (2019) 'Five stars or fake? How to beat fraudulent online reviews'. The Guardian. Available at: https://www.theguardian.com/money/2019/jul/14/five-stars-or-fake-how-to-beat-fraudulent-online-reviews (Accessed: 01.10.2019)

3.2.1.6 Threat – International market access

Description

The (easy) access to markets around the world allows consumers to purchase products from everywhere. This has an impact on the international traffic of commodities and might increase the emissions due to international trade.

Discussion

Together with technological progress, digitalisation and cross-border networks, access to international markets also gained in importance. Whereas previously this was only accessible to individuals via traditional retails, E-commerce now allows direct trading with suppliers from the remotest regions (Nassrullah Mzwri and Altinkaya, 2019). A number of platforms have made it their business to bring together both domestic and international companies from different countries (Nassrullah Mzwri and Altinkaya, 2019). Thus, E-commerce has had a decisive influence on the development of new value chains, on costs, efficiency and business types.

At the same time, various new challenges arise by cross-border trade in conjunction with E-commerce, some of which are discussed in other chapters of this report, such as Difficulty to monitor (see section 3.2.5.1), Enforcement (see 3.2.5.2), EPR Free-Rider Effect (see 3.2.5.3), Lack of compliance with common market regulations (see 3.2.5.4). In this section, on the other hand, the focus will be on the aspect of distance. The large distances alone give rise to a multitude of potential problems. Even when purchasing a product abroad that is more sustainable in its production process than a domestic version, its transport distance (product kilometres) causes pollution that might outweigh other environmental effects.

This aspect is further negatively reinforced if one takes into account other common challenges of E-commerce. Delivery of damaged products, individual product delivery, inferior types of transportation, or parcel return are all aspects that decrease transportation efficiency immensely and put considerable pressure on international logistics (E-commerce Europe, 2018; PWC, 2016). It is a challenge for the transition to a Circular Economy to integrate international trade into its concept.

Classification

The international market access is inherent to E-commerce with certain environmental impacts. However, arising effects are rather systematic and hypothetical. It is estimated that the effects have a very high relevance for future scenarios.

Current and future relevance

The relevance of international market access in E-commerce is already high. Ecommerce Europe state in their 2018 report that 38% of all EU online shoppers ordered abroad in 2017, with 13% that ordered goods from outside the EU (E-commerce Europe, 2018a). The number of so called cross-border e-purchases differ significantly between the EU Members States – from 6% in Poland up to 85% in Portugal (E-commerce Europe, 2018a).

Although online commerce in general will continue to gain importance (in terms of turnover), the associated international trade must be seen in a more differentiated way for the EU. Countries such as Greece, Austria and Belgium, for example, did not experience any growth in cross-border e-purchases between 2016 and 2017. At the same time, however, Slovenia, Germany, the Netherlands, Finland and Luxembourg experienced the highest growth rates with 5-6% increase within one year (E-commerce Europe, 2018a).

This threat is of cross-product relevance and affects all product categories in focus of this study.

Supporting factors

- shopping events (see chapter 3.2.2.6) such as "Black Friday" or "Cyber Monday" encourage the focus on a low price. Where the product is coming from is often neglected.

Mitigating factors

- highlighting the environmental impact of orders delivered from abroad to customers during the purchasing process (Nudging, see Section 3.2.2.1).

Options for actions

Producers/Platform providers:

- using the concept of nudging to highlight the environmental impact that is arising from deliveries coming from abroad.

Regulators:

- implementation of rules incorporating the aspect of E-commerce and its impact on international trade as it was proposed by the EU to the World Trade Organisation in 2019 (European Commission, 2019a).

Source of information

E-commerce Europe (2018) 'European Ecommerce Report 2018 Edition'. Available at: www.haendlerbund.de/de/downloads/ecommerce-europe/european-ecommerce-report-2018.pdf.

European Commission (2019a) *EU releases proposal on new WTO rules for electronic commerce*. Available at: http://trade.ec.europa.eu/doclib/press/index.cfm?id=2016 (Accessed: 2 August 2019).

Nassrullah Mzwri, A. M., Altinkaya, Z. (2019) 'The Impact of E-Commerce on International Trade: Case of Turkey', *Internationale Journal of Contemporary Research and Review*, 10(01), pp. 21190–21209. Available at: http://ijcrr.info/index.php/ijcrr/article/view/641.

PWC (2016) *Bevölkerungsbefragung Grenzüberschreitender Online-Handel*. Available at: https://www.pwc.de/de/handel-und-konsumguter/pwc-bevoelkerungsbefragung-grenzueberschreitender-online-handel.pdf (Accessed: 2 August 2019).

3.2.1.7 Threat – Ubiquity

Description

Ubiquity describes the possibility for consumers to access E-commerce at any time and from almost anywhere (Wu and Hisa, 2004). It is an inherent peculiarity of nowadays E-commerce that clearly distinguishes it from the traditional market where customers have to physically enter a store and where they are bound to opening hours. It is relevant for all product categories in scope and is seen as a threat as it induces consumption.

Discussion

Ubiquity of E-commerce is directly linked to the technological development of recent decades. This includes in particular the progress in telecommunication technology with the expansion of and access to wireless and fast data networks and the increased use of portable devices such as tablets and smartphones. In recent years, numerous studies have dealt with the topic and its effects, thereby coining the term U-Commerce ("Ubiquitous Commerce") (Wu and Hisa, 2004; Kumar, Joshi and Saquib, 2015; Morrison, Pitt and Kietzmann, 2015; Wang *et al.*, 2017). This new concept includes E-commerce and similar forms (such as Mobile Commerce and Television Commerce).

Especially the application of online mobile shopping apps allows users to access web shops from basically anywhere. This differentiates U-Commerce significantly from web-based commerce (e.g. via a tower PC). The latter does not yet have the dimension of ubiquity (Wu and Hisa, 2004). Especially modern smartphones have become a permanent companion in daily life and combine a multitude of functionalities that have become indispensable for many people. E-commerce via these devices is therefore not only a ubiquitous possibility, but also a very simple one.

On the one hand, it makes it much easier for consumers to search for, compare and buy products, which improves the purchase for some aspects significantly. On the other hand, however, the consumer also becomes more accessible for advertising and marketing initiatives of companies. Companies have positioned themselves much better in this mobile market in recent years. This includes mobile versions of existing websites as well as apps that are designed to specifically access some type of E-commerce, so that consumers can make numerous purchases already on their way to or from work, for example.

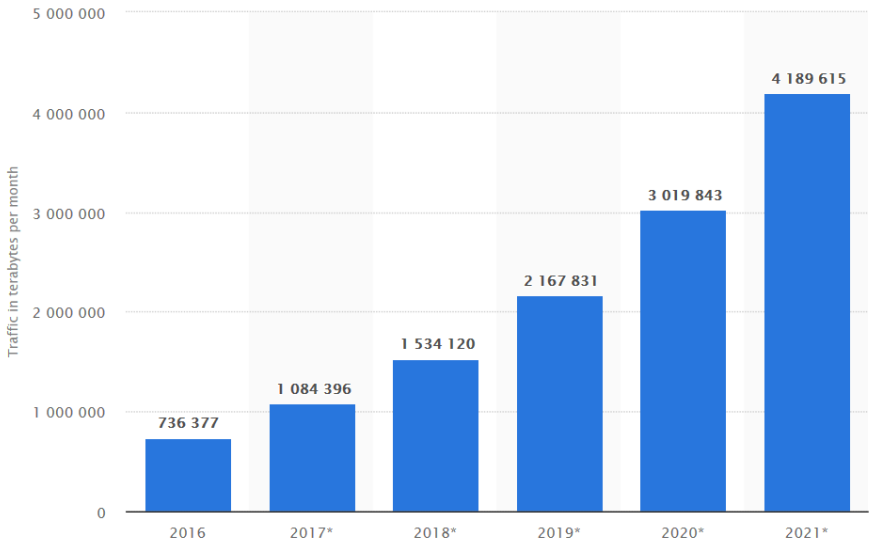
Classification

Ubiquity can be seen as an indirect effect as it has an impact on the long-term transition towards a Circular Economy. It originates from the digital and mobile connectivity of mobile devices to the Internet. The purchasing process is the phase of the product life cycle that is directly affected.

Current and future relevance

As mentioned before, ubiquity is relevant for all product categories in the scope of this study. It is linked directly to the usage of mobile devices to access the Internet and thus E-commerce. As smartphones and tablets are used by the majority of people nowadays (e.g. ~80% of people living in Germany in 2018), this aspect is already of high relevance. This is also reflected in the share of all visits to web pages coming from mobile devices – which was around 43% for Europe in 2018 (Statista, 2018c). Another indicator is the data volume of mobile Internet traffic, which more than doubled from 2014 till 2016 for Western Europe (see igure 5).

igure 5: Data volume of mobile Internet traffic in Western Europe (from Statista, 2018c; Cisco Visual Networking Index: Global Mobile Data Traffic 2017)



For the coming years, a similar development in the increase in the used data volume for mobile Internet traffic is expected (Statista, 2018c).

This threat is of cross-product relevance and affects all product categories in focus of this study.

Supporting factors

- the implementation and penetration of new cellular network technologies (e.g. 4G and 5G).

Mitigating factors

- A number of studies have already been published on the impact that the use of digital media and mobile devices can have on people. These already influence the public discussion and thus the aspect of ubiquity. Thus, users of these media are at least partially made aware of the dangers of the media described.

Options for actions

Scientific Community:

- Appropriate consideration of the ubiquity of e-commerce for a user is closely linked to the challenge of dealing with digital media in general. Approaches in mitigating this threat should therefore also be seen in the overall context of 'use of digital media and mobile devices'. Although numerous publications dealing with this topic have appeared in recent years (e.g. see 'Mobile and Ubiquitous Media: Critical and International Perspectives', by Daubs and Manzerolle, 2017), there is a lack of long-time studies.

Producers/Platform providers:

- make use of user interface design elements to draw attention to potential threats of extensive internet involvement (of which E-commerce is one part)

Regulators:

- realising and clearly formulating ubiquity of E-commerce and the internet as a substantial transformation of social practice and creating action plans to cope with that challenge at an early stage; and
- since the threat of ubiquity of E-commerce is seen here in the (assumed) increased consumption, one could address consumers' behaviour by awareness raising campaigns.

Source of information

Daubs, M. and Manzerolle, V. (2017) 'From Here to Ubiquity'.

Kumar, S., Joshi, P. and Saquib, Z. (2015) 'Ubiquitous Commerce : The New World of Technologies', *International Journal of Life Science and Engineering*, 1(2), pp. 50–55. Available at: http://www.publicscienceframework.org/journal/paperInfo/ijlse?paperId=382.

Morrison, S., Pitt, L. and Kietzmann, J. (2015) 'Technology and financial services: Marketing in times of U-commerce', *Journal of Financial Services Marketing*. Nature Publishing Group, 20(4), pp. 273–281. doi: 10.1057/fsm.2015.18.

Statista (2018c) *Mobiles Internet in Europa*. Available at: https://de.statista.com/statistik/studie/id/13136/dokument/mobiles-internet--statista-dossier/.

Wang, S.-C. *et al.* (2017) 'The Effect of Affordance on Ubiquitous Commerce Consumption'.

Wu, J. H. and Hisa, T. L. (2004) 'Analysis of E-commerce innovation and impact: A hypercube model', *Electronic Commerce Research and Applications*, 3(4), pp. 389–404. doi: 10.1016/j.elerap.2004.05.002.

3.2.2 Cluster – Consumer needs and behaviour

3.2.2.1 Opportunity – Nudging

Description

Nudging is a relatively new concept in behavioural science and economics. It is referred to as exerting a gentle "push" to alter an individual's behaviour and decision making in a preferred (e.g. environmentally sound) way. This may be achieved by designing a specific situation of choice (choice architecture) without giving direct economic incentives. There are a variety of techniques as well as different phases of the product life cycle, where nudging can be applied. This opportunity focuses on the product selection phase, which is part of the overall purchasing process.

Discussion

In its essence, nudging is similar to existing marketing techniques as it capitalises on insights in human psychology. As such it proposes an effective alternative to conventional ways of achieving compliance or sustainable behaviour (e.g. legislation, education).

There are different types of nudging techniques (Bavel *et al.*, 2013; Carmichael *et al.*, 2016; Stefansdotter *et al.*, 2016):

- information: eco-labelling, information about products' environmental footprint (e.g. carbon footprint);
- framing (prospect theory);
- pre-set (definition of a favourable default option);
- feedback and social norms: information about other people's donations, smileys and colours (e.g. traffic lights); and
- changes in the physical/virtual environment: position effects (placement or ranking of products).

E-commerce platforms act as unique interface between businesses and consumers which may be utilised in order to provide information on the circularity of products or the environmental impacts associated with intangible products such as streaming services or electronic books (Carmichael *et al.*, 2016). If possible and scientifically sound, comparisons between product or service alternatives could be displayed. Furthermore, sustainable alternatives may be presented at the time of purchase to help consumers act according to their latent preferences.

In terms of the relevance for the Circular Economy, nudging is a powerful tool to stimulate the consumption of services instead of resource-intense products or to convince people of alternatives to new products (e.g. repair options).

Classification

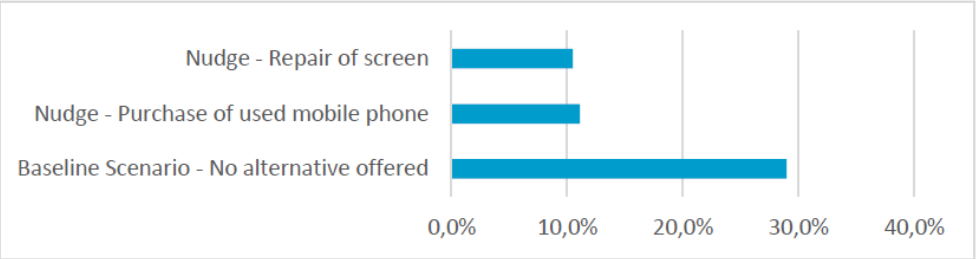
Nudging is classified as an indirect effect, depending on the applied technique and expected effect. Hence, nudging offers an opportunity to enable a behaviour in favour of Circular Economy strategies. It mainly takes place in the e-fulfilment stage during the purchasing process of a product. The underlying E-commerce feature can be seen in the seamless way nudging can be embedded in the digital process (e.g. by adding one or more questions/information that need to be read before the order can be completed).

Current and future relevance

Nudging is relevant for all product categories in scope. Currently, it is getting more attention in the Nordics as well as internationally. INudgeYou, a research network in Denmark, GreeNudge in Norway and a think tank in the UK are just a few examples of institutions or networks working on the implementation of the concept as a complementary tool in E-commerce. While consumers usually lack economical ways to access environmental information about specific product supply chains, producers or retailers are often in possession of valuable data such as carbon footprints.

A recent pilot study provides an indication that nudging has the potential to change consumption behaviour among young people. With the option for two distinct Circular Economy approaches - buying a used mobile phone or repairing the screen - respondents refused statistically significant to buy a new mobile phone compared to a baseline scenario (see Figure 6).

Figure 6: Proportions of respondents opting to buy a new mobile phone (own depiction based on data from Stefansdotter *et al.*, 2016)



Next to above findings, pushing consumers towards leasing contracts instead of single purchases has also been found to be an effective means of fostering Circular Economy models.

Another example illustrating the relevance of this opportunity refers to online video streaming. As a matter of fact, delivering contents in higher definition causes additional environmental impacts due to increased volumes of data inextricably linked to electricity demands in data transmission networks. In an experiment, the user interface has been modified to include information on carbon footprints associated with offered streaming resolutions. Furthermore, calculated carbon footprints have been expressed in metrics intelligible to users, such as light bulb days or miles driven. Disregarding the specific metric, this approach was effective in prompting participants to change to a lower-resolution stream. The most effective metric- miles driven – has resulted in a 24% reduction in the average carbon footprint associated with the conducted experiment (Carmichael *et al.*, 2016).

In general, nudging offers great potential to address all levels of a Circular Economy. It may be particularly powerful, however, to establish mechanisms as to implement what deemed to be the environmentally most effective principles of a truly Circular Economy: refuse, maintain, and reuse (Ellen Macarthur Foundation, 2017a).

This opportunity is of cross-product relevance and affects all product categories in focus of this study.

Supporting factors

- increasing willingness to shift to sustainable products and services due to political and societal discourse, often only hindered by a lack of information (e.g. information about emissions per purchase option) or awareness (Carmichael *et al.*, 2016);
- synergies between reduction of environmental impacts as well as operational costs while maintaining or improving customer satisfaction can be unlocked (e.g. individuals may think better of companies that provide such environmentally- friendly options) (Carmichael *et al.*, 2016); and
- improved supply chain management and monitoring technologies, ultimately providing relevant data and information to be included in nudging techniques.

Mitigating factors

- perception of the concept as paternalism;
- interference with the role of education and individual learning;
- adverse response to nudges due to the possible feeling to be manipulated;
- unpredictable outcomes resulting in sometimes no or adverse effects (e.g. rebound effects in which consumers feel entitled to consume more or additional products/services); and
- little research existing on long-term effects.

Options for actions

Scientific Community:

- evaluate certain nudging techniques and contexts; and
- communicate the concept as a potential tool.

Producers/Platform providers:

- capitalise on established data collection efforts for environmental reporting or internal purposes;
- expand exchange of information between producers and E-commerce platforms; and
- align nudging techniques with Circular Economy strategies.

Regulators:

- include nudging in the strategic discussions on sustainability and Circular Economy.

Source of information

Bavel, R. van et al. (2013) Applying behavioural sciences to EU policy-making, Joint Research Centre Scientific and Policy Reports. doi: 10.2788/4659.

Ellen Macarthur Foundation (2017) Circular Economy System Diagram. Available at: https://www.ellenmacarthurfoundation.org/circular-economy/infographic.

Isley, S. C. *et al.* (2016) 'Online purchasing creates opportunities to lower the life cycle carbon footprints of consumer products', in *Proceedings of the National Academy of Sciences*, pp. 9780–9785. doi: 10.1073/pnas.1522211113.

Stefansdotter, A. et al. (2016) Nudging for sustainable consumption of electronics. doi: 10.6027/ANP2016-728.

Sui, D. Z. and Rejeski, D. W. (2002) 'Environmental impacts of the emerging digital economy: The e-for-environment e-commerce?', *Environmental Management*, 29(2), pp. 155–163. doi: 10.1007/s00267-001-0027-X.

3.2.2.2 Opportunity – Sharing models and services

Description

In recent years, a series of sharing models developed that allow consumers to share specific products, such as tools or devices. Although this type of sharing is possible without any online activity, E-commerce is seen here as a promoting factor. Online sales platforms significantly increase reach and visibility, making it easier for consumers to access relevant markets.

Discussion

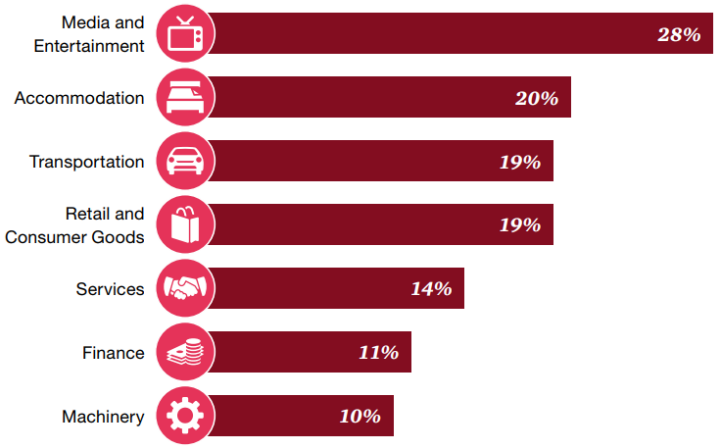
The so-called sharing economy can be defined as "the peer-to-peer-based activity of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services" (Hamari, Sjöklint and Ukkonen, 2016). Some sources include second-hand concepts such as provided by eBay or Craigslist and crowdfunding in its definition (Yaraghi and Ravi, 2011). For this study, however, these concepts are explicitly excluded, and they are discussed in separate sections (see "ReCommerce" in Section 3.2.4.1 and "Innovation" in Section 3.2.1.3).

Its current success is partially due to technological developments (e.g. mobile connectivity, ease of access and communication), but also due to changing societal values. Several initiatives and start-ups emerged over the past recent years with a variety of services and ideas. Hopes are high that the sharing economy might change the overall consumption behaviour and patterns of whole societies leading to a reduction in resource use, strengthening of regional and local communities, enabling of consumption for lower income groups, and change in the perception of property (PWC, 2018b). However, recent research shows that some developments undermine this original idea of the sharing economy. It seems that only part of society is collaborating in respective concepts and services and it is transforming from a pure peer-to-peer (P2P) approach to a professional business-to-customer (B2C) approach, where large companies dominate the market.

Another interesting aspect of sharing models is its impact on societal perception of property and the relevance of goods as status symbols. Some part of consumption, such as always buying the newest version of something, is driven by the desire to be part of a movement and to represent a certain status.

Regarding product type, the following Figure 7 shows the industry segments that currently play the most vital role in the sharing economy.

Figure 7: Share Economy usage within the different industry segments (Source: PWC, 2017; shares based on survey conducted with 4,500 consumers in 6 countries)



As seen in Figure 7, most product and service categories are not in focus of this study. The aspect media and entertainment as well as retail and consumer goods are of highest interest here. The latter is dominated by second-hand fashion, which is, as already mentioned, considered in another section of this report (see Section 3.2.4.1).

Classification

Sharing models can be successfully promoted by E-commerce and can substitute the purchase and possession of a product, thus having consequential and immediate positive effects. They are therefore considered as a direct effect of E-commerce.

Current and future relevance

The relevance of the sharing economy has rapidly increased in recent years. For Germany, around 39% of people surveyed by PWC in 2017 where using (to some extent) shared products or services (PWC, 2017). The global sharing economy market was around $14 billion in 2014 and is estimated to reach even $335 billion by the year 2025 (Yaraghi and Ravi, 2011). For Germany alone, the market for 2018 was estimated to around 24 billion € (PWC, 2017). The sharing of products and services is widespread, especially among young people (PWC, 2017).

Supporting factors

- offers that promote the building of trust are essential for the successful operation of sharing models (PWC, 2018a);
- the easy accessibility and thus usability (comfort) of the service is important for consumers to change from their previous possession-related behaviour (PwC, 2018) (PWC, 2018a);
- realistically, in the near future, only offers that guarantee cost savings compared to ownership will prevail in the broad society (PwC, 2018) (PWC, 2018a); and
- depending on the particular sharing model, there are numerous supporting factors for fostering it. For example, for car-sharing services:
    - an increase in parking fees for privately owned vehicles (Momo, 2010);
    - certain benefits, such as free parking, priority track, etc. for car-sharing vehicles (Momo, 2010); and
    - the use of public street space for car-sharing parking areas (Momo, 2010).

Mitigating factors

- relatively young market with a profoundly different understanding of ownership and use, and therefore with a current need for legal certainty to improve (PWC, 2018b);
- the quality of some of the offers (e.g. some of the foreign bike sharing providers) is currently very low, which slows down the acceptance and further spread of sharing models (PWC, 2018b);
- the market has already partially begun to consolidate, and professional providers are taking over many areas. This can possibly have a positive effect on quality, legal certainty and, above all, widespread availability (PWC, 2018b). However, since it is usually a question of profit maximisation (especially in the long term), this contradicts the original idea of the models; and
- hidden, or indirect, subsidies for private and business use of cars (Momo, 2010), making the use of shared-services less attractive.

Options for actions

Producers/Platform providers:

- since this type of market is only just developing, it is essential that customers have the possibility to give feedback. Its implementation requires an adaptability of the offered service.

Regulators:

- establishment of a clear legal framework that does not only define a common understanding of respective sharing models, but also gives incentives to promote them in a sustainable way (Momo, 2010); and
- consolidating experience made in some of the Member States with national regulations and decisions with the objective to provide recommendations and guidelines.

Source of information

Momo (2010) *The State of European Car-Sharing*. Available at: https://www.eltis.org/sites/default/files/trainingmaterials/the_state_of_carsharing_europe.pdf (Accessed: 2 August 2019).

PWC (2017) *Share Economy 2017-the new Business Modell*. Available at: https://www.pwc.de/de/digitale-transformation/share-economy-report-2017.pdf (Accessed: 2 August 2019).

PwC (2018) *European Commission Proposals for Directives regarding fair taxation of the digital economy (" Digital Tax Package ")*.

PWC (2018a) 'Consumer-Habits-Global-Consumer-Insights-Survey 2', *PwC*.

PWC (2018c) *Eigentum? Brauche ich nicht! Wie Share Economy Statussymbole ihren Reiz nimmt*. Available at: https://www.pwc.de/de/digitale-transformation/eigentum-brauche-ich-nicht-wie-die-share-economy-statussymbolen-ihren-reiz-nimmt.html (Accessed: 2 August 2019).

Smith, Z. A. (2016a) 'The Environmental Policy Paradox'. Routledge

Yaraghi, N. and Ravi, S. (2011) 'The Current and Future State of the Sharing Economy', *Ssrn*, 4(1), pp. 335–367. doi: 10.3390/wevj7040518.

3.2.2.3 Threats – Cross-selling and up-selling

Description

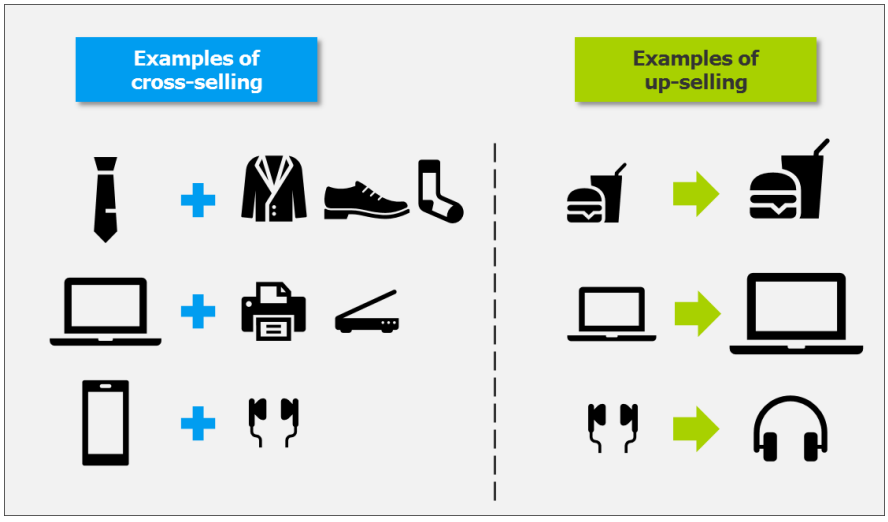
Both cross-selling and up-selling are techniques used to promote additional products during the search for a product or during and after the purchase of a product. It is seen here as threat as it directly promotes consumption.

Cross- and up-selling are two methods to generate more sales, which are used in traditional business as well as in E-commerce. In up-selling, the customer is sold a higher-value and more expensive product. Cross-selling offers the customer additional products to satisfy other related needs. The product offered through cross-selling often has complementary properties to the original desired product (Kamakura, W. *et al.*, 2003).

Discussion

Although sometimes used as synonyms by different sources, cross-selling and up-selling are two distinct concepts. Cross-selling has the objective to convince the customer to purchase complementary items from a different product category which are somehow related to the "main" item of interest. This can be earphones to a smartphone, or a printer and scanner to a laptop (see Figure 8) (BigCommerce, no date). Up-selling, on the other hand, aims at encouraging customers to purchase a "better version" of the "original" item of interest. Better version should be understood here as providing more functionalities, higher performance, or simply more of a certain good, such as increasing the menu size of a meal (see Figure 8) (BigCommerce, no date). Both concepts can be applied to basically all product categories.

Figure 8: Differences in the practices of cross-selling and up-selling



Sales has known this approach for a long time before the age of E-commerce, but it was clearly advanced by it. Digitalisation, advanced logarithms and (big) data analysis enable online retailers to automate and more accurately apply mentioned concepts (Knott, Hayes and Neslin, 2002).

The threat is seen here in the main objectives of both concepts. Both up-selling and cross-selling might increase customer satisfaction and might lead to an additional purchase that increases the usability of the original product. The main objective, however, is an increased revenue for the provider, which clearly reflects an increased consumption. These techniques have proven to be extremely effective in increasing the purchase volume of individual customers and is heavily promoted for setting up an E-commerce platform (Suresh, 2019).

Classification

Effects arising from cross- and up-selling techniques are rather systematic and supplementary development due to certain E-commerce features. Their relevance is considered to be very high in the future. This aspect is considered an indirect effect of E-commerce.

Current and future relevance

No research paper evaluating the impact of cross- and up-selling from a scientific point of view could be found. However, there are some websites that provide information on sales of so-called auxiliary goods. The private flight sector can be given here as an example. Although the sales of tickets are the core business, the top ten airlines by ancillary revenue (revenue made by the sales of additional services or products such as assigned seats, extra legroom, special meals, etc.) reached more than $28 billion in 2016 (Baskas, 2017). This surely includes aspects that are not falling in the category of cross- and up-selling but is still mainly driven by those two concepts.

The overall relevance of these concepts is considered as very high as many E-commerce players see it as a crucial factor to increase their revenue. It is challenging to estimate its relevance for the different product categories as consolidated analysis is missing.

This threat is of cross-product relevance and affects all product categories in focus of this study.

Supporting factors

- combination of cross- and up-selling of certain products with the feature of pop-up ads, as they create higher visibility and have the intend to generate additional product sales; and
- some web shop platforms use techniques (especially up-selling) to put pressure on the customer to make a purchase that is not in the customer's interest.

Mitigating factors

- customer awareness of such techniques and their impact on shopping behaviour as well as the associated impact on the environment:

Options for actions

Scientific Community:

- further research is required to understand the impact of cross- and up-selling techniques used in E-commerce on customer's purchasing behaviour; and
- a cross-industry evaluation of how much is additionally sold through the use of cross-selling and up-selling techniques would be helpful in evaluating these methods.

Producers/Platform providers:

- it should be clear to the customer throughout the whole purchasing process to which extent his decisions to buy "auxiliary goods" is impacting the price to ensure transparency.

Source of information

Baskas, H. (2017) *Airlines reap $28 billion from selling traveller 'extras' to flyers*. Available at: https://www.cnbc.com/2017/07/28/airlines-reap-28-billion-from-selling-travel-extras-to-flyers.html (Accessed: 2 August 2019).

BigCommerce (no date) *What is the difference between upselling and cross-selling*. Available at: https://www.bigcommerce.com/ecommerce-answers/what-difference-between-upselling-and-cross-selling/ (Accessed: 2 August 2019).

Kamakura, W., A.; Wedel, M.; De Rosa, F.; Mazzon, J., A. (2003) 'Cross-selling through database marketing: a mixed data factor analyzer for data augentation and prediction', *International Journal of Research Marketing*, 20, pp. 45–65. Available at: http://wak2.web.rice.edu/bio/My Reprints/Cross-selling through database marketing.pdf.

Knott, A.; Hayes, S.; Neslin, A. (2002) 'Next-Product-to-buy Models for Cross-selling Applications', *Journal for Interactive Marketing*, 16(3), pp. 59–75.

Suresh, S. (2019) *Upsell and Cross-sell: Strategies to boost eCommerce Revenue*. Available at: https://vwo.com/blog/use-upsell-cross-sell/ (Accessed: 2 August 2019).

3.2.2.4 Threat – Ease of shopping

Description

The effort required to conduct a purchase is considered to be significantly decreased with E-commerce. Especially the combination of mobile connectivity and dedicated web store solutions makes online shopping both easily accessible and intuitive for users. Since this way of shopping is so convenient for the customer, impulse or stimulus purchases can increase. Consumption is generally encouraged, which is seen as a danger to the Circular Economy.

Discussion

It should be differentiated from the aspects of "Ubiquity" (see Section 3.2.1.7) and "Digital Goods" (see Section 3.2.3.1), which are discussed in other sections of this study. This section emphasises on the general ease with which customers can purchase products online:

- no physical travel to any shop is necessary;
- mostly platform- and device-independent;
- simplified processes (such as creating profiles and saving payment types for the next purchase); and
- simplicity of user interface and ease of use.

There are countless providers offering online shop design as a service. Guidelines such as "72 Must-Have Features for Ecommerce Websites" show to which extent the whole shopping experience and purchasing process is optimised (WebAlive, 2019). Especially the creation of profiles with stored delivery address and payment data makes the purchase process considerably easier for the customer. The whole checkout process especially of large online retailers is optimised to such an extent that it takes only very little time for signed up users. Spontaneous purchases and general consumption are promoted in particular in connection with constant accessibility (e.g. mail). The necessity to create a profile enables companies to initiate special offers.

Increased convenience of shopping, attractive on-line prices and performant marketing strategies based on an individual shopper's detailed digital profile may lead to faster renewal of still functional products (e.g. mobile phones) or impulse buying of products that will not be used (e.g. clothes).

Classification

The ease of shopping is a systematic aspect with a very hypothetical and long-term effect. It can be considered a supplementary development and therefore indirect effect of E-commerce.

Current and future relevance

The relevance of this aspect can be considered as already high. Most online shops are designed to streamline the shopping and purchasing process to a high extent. Especially user profiles and a very easy checkout process enable customers to purchase products very quickly.

The development and dissemination of new technologies make it probable that his aspect will even further increase in relevance. These new developments include dash buttons, for example, which allow customers to reorder a certain product by simply pushing a button (Umweltbundesamt, 2018b). Although this concept is very controversial and corresponding providers take a step back for the time being, there are already similar developments and considerations with so-called virtual Dash Buttons (Warncke, 2019). Another example are smart speakers which are becoming increasingly popular. In Germany alone, around 13% of people has one type of smart speaker with voice assistant at home (Stern, 2018).

Although legally extremely controversial or even prohibited, such developments show the extent to which the simplification of the purchasing process can be achieved (Gassmann, 2019). There is a danger that the customer will increasingly lose touch with the associated costs and environmental impacts. The latter in particular is already a potential threat. As there is usually no direct feedback on purchases and the associated environmental impacts, it is more difficult for customers to consider these aspects when making a purchase decision.

This threat is of cross-product relevance and affects all product categories in focus of this study.

Supporting factors

- modern technologies, such as virtual dash buttons, that minimise the customers "participation" in the purchasing process (Umweltbundesamt, 2018b).

Mitigating factors

- regulations requiring online shops to highlight certain aspects of the purchasing process clearly visible and easily understandable to the customer (such as price, value-added tax, transportation costs, etc.).

Options for actions

Scientific Community:

- although there is already comprehensive literature available on how marketing affects consumer behaviour, there is currently a lack of scientific research on modern E-commerce-related technologies and their impact on purchasing behaviour. Fast developments and a highly dynamic market make it difficult for the scientific community to provide elaborate analysis.

Source of information

Gassmann, M. (2019) *Amazons Bestellknopf bekommt eine Gnadenfrist*. Available at: https://www.welt.de/wirtschaft/article186911746/Dash-Button-Amazons-Bestellknopf-bekommt-eine-Gnadenfrist.html (Accessed: 2 August 2019).

Stern (2018) *Wie unterscheiden sich die Sprachassistenten?* Available at: https://www.stern.de/kultur/amazon-alexa-und-co--wie-unterscheiden-sich-die-sprachassistenten--8345872.html (Accessed: 2 August 2019).

Umweltbundesamt (2018b) *Konsum 4.0: Wie Digitalisierung den Konsum verändert*. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/fachbroschuere_konsum_4.0_barrierefrei_190322.pdf.

Warncke, S. (2019) 'E-Commerce Trends: Amazons Dash Button in der Kritik'. Available at: https://wechseljetzt.de/nachrichten/e-commerce-trends-amazons-dash-button-in-der-kritik/ (Last accessed: 02.10.2019)

WebAlive (2019) '72 Must-Have Features for Ecommerce Website', Available at: https://www.webalive.com.au/ecommerce-website-features/ (Last accessed: 01.10.2019)

3.2.2.5 Threat – Personalised design

Description

The increased ease of ordering personalised products online might lead to decreased positive mass production effects, such as minimising waste arising during manufacturing processes, or optimisation of the product chain.

Discussion

Personalisation can describe two distinct features of E-commerce: (1) Promoting individualised offers and product recommendation and avoiding presumably irrelevant content to the customer to increase sales and (2) personalising products to some extent. The latter is discussed in this section and is based on the possibility to personalize and thus individualise, to a certain degree, numerous products traded in E-commerce. Individualisation can be as simple as changes in colour and material or to include the imprint of a desired name or logo on the final product. These operations delay completion of the product, which in turn affects the entire supply chain. In conjunction with fast delivery options, this can also increase the pressure on transport (Koch, Butz and Schlichter, 2014).

Classification

The personalisation of products is a highly debateable and hypothetical effect whose relevance is currently difficult to evaluate. Potential effects might emerge in the future, but its relevance requires further research and analysis. It is considered an indirect effect of E-commerce.

Current and future relevance

No study could be found on the topic of individualisation of products which does not purely focus on the B2B sector (Koch, Butz and Schlichter, 2014). It is estimated that there is no significant difference in the production cycle for some product groups (depending on the provider) and also no major differences between their environmental footprints. However, it should be emphasised here that the competition in the online trade as well as in the trade in general is very strong and therefore also the desire to stand out from competitors. A personalisation of products may be associated with increased costs for the customer, which he or she may be happy to pay to receive the additional service. However, the additional environmental impact might not be taken into account in this approach. Since many individual solutions have to interlock to achieve the goals of a Circular Economy, the possible disadvantage of this personalisation should be considered. One of the drawbacks of personalised products is related to their nature - they are personalised and thus tailored to a certain extent to an individual. This makes a possible resale considerably more difficult and thus reduces the benefit for a Circular Economy, where the aspect of reuse is of high importance.

Personalised design is of little to no relevance for the product categories major household appliances, media & entertainment products / services, and non-perishable foods.

Supporting factors

Due to the lack of available information, supporting factors could not be identified.

Mitigating factors

Due to the lack of available information, mitigating factors could not be identified.

Options for actions

Scientific Community:

- Scientific Community should expand their research approach on B2C offers of personalised design in E-commerce. Currently, no study focusing on this aspect have been identified.

Source of information

Koch, M., Butz, A. and Schlichter, J. (2014) 'Von der Massenware zu Individuellen Produktgestaltung', *Mensch und Computer*, pp. 29–32. Available at: https://dl.gi.de/bitstream/handle/20.500.12116/8201/Braun_Siekmann_Wallenborn_Westphal-Furuya_Wolf_2014.pdf?sequence=2&isAllowed=y.

3.2.2.6 Threat – Shopping frenzy

Description

Shopping events, mostly on a fixed date, that attract customers with special offers, promote the so-called "shopping frenzy". Such events are starting to have a significant impact on online shopping. Because of possible additional consumption, it could be seen as a threat to Circular Economy.

Discussion

From 2008 to 2018 the number of Internet users in the EU who bought or ordered goods or services online rose from less than 45% to more than 70% (Eurostat, 2018). Online retailers used this growth to launch a series of frequently returning sales events. During the time of a sales event, participating companies are promoting special offers to the customers. Extensive advertising of the events and a time restriction increase the sales figures, especially of large online retailers, enormously. According to information offered on blackfriday.com, in 2018 68% of the U.S. consumers were shopping online that day (BlackFriday.com, 2019a).

Sales events are not a special characteristic of E-commerce alone, as traditional retail used them already for a long time. There is a large number of local special sales events that can be counted in this category. Events as Black Friday, however, are on a different scale since they are now advertised worldwide by companies in traditional and online retail. Some of such events are exclusively available in E-commerce – examples are the "Free Shipping Day", a national shopping event in the U.S. or the Australian sale-event "Click Frenzy" (*Click Frenzy*, 2019).

It is seen as threat to the Circular Economy as shopping events push consumption and lead to an increase in impulse and stimulus purchases (LaRose and Eastin, M., 2010; D'innocenzio, 2017; Red Point, 2019). Online shopping is already more driven by such impulsive buying decisions than in traditional retail, but such behaviour is even more pronounced during special sales events.

Classification

Sales events are (rapidly) evolving businesses, which can be considered a supplementary development to E-commerce. Their relevance has become high in recent years, and attached effects (e.g. consumption peaks, impulse purchases, etc.) are estimated to further increase. Arising effects are rather systematic and cannot be allocated to the purchase of one single product, which is why they are considered indirect effects of E-commerce.

Current and future relevance

The relevance of sales events increased immensely in recent years. Surveys conducted by McKinsey & Co indicate that Black Friday is becoming increasingly popular around Member States of the EU (Dispatches Europe, 2018). For 2015, 19% of respondents in the UK and 9% of respondents in Germany said they had participated in Black Friday. These figures rose to more than 50% for the UK and 43% for Germany in just two years (Dispatches Europe, 2018). It is not known how much exactly this led to an increase in the online sales for those regions.

An indicator to the immense impact of sales events can be given by recent sales numbers of Amazon. In 2018, the company sold more than 100 million products during Amazon Prime Day, which surpassed the sales of Cyber Monday, Black Friday and 2017's Prime Day combined. The impact on consumption is high and this the potential impact on attached environmental burdens.

Shopping frenzy is a cross-product threat.

Supporting factors

- internet, social media and E-commerce platforms promote the dissemination of such events and increase the reach of advertising (see Sections 3.2.1.7 and 3.2.2.3);
- social pressure of inclusion into social trends;
- mobile connectivity (see Section 3.2.1.7); and
- interconnection of global markets, through which a larger number of potential customers can be addressed, which in turn allow corresponding events to become enormously outreaching (see Section 3.2.1.4).

Mitigating factors

- limited assortment of products included in the offer during shopping events.

Options for actions

Scientific Community:

- increasing the awareness of current results of shopping frenzy caused by sales events and affiliated impulse purchases among society.

Source of information

Red Points (2019). *Black Friday - are your costumers safe?* Available at: https://www.redpoints.com/pdfs/ebook-millennials-on-black-friday/ (Accessed: 2 August 2019).

Black Friday. (2018a) *Black Friday*. Available at: https://blackfriday.com/ (Accessed: 2 August 2019).

Click Frenzy (2019). Available at: https://www.clickfrenzy.com.au/.

D'innocenzio, A. (2017) *Holiday shopping: Desire for deals, but some impulse buying*, *Phys Org*. Available at: https://phys.org/news/2017-11-holiday-desire-impulse.html (Accessed: 2 August 2019).

Dispatches Europe (2018) *Black Friday 2018 (updated): Europe increasingly buys into American-style shopping frenzy*. Available at: https://dispatcheseurope.com/black-friday-2018-europe-increasingly-buys-into-american-style-shopping-frenzy/ (Accessed: 2 August 2019).

Eurostat (2018) *Internet users who bought or ordered gooss or services for private use in the previous 12 months by age group, EU-28, 2008-2018*. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/E-commerce_statistics_for_individuals (Accessed: 2 August 2019).

LaRose, R. and Eastin, M., S. (2010) *Is online buying out of control? Electronic Commerce and consumer self-regulation*. Available at: https://www.tandfonline.com/doi/abs/10.1207/s15506878jobem4604_4 (Accessed: 2 August 2019).

3.2.3 Cluster – Digitalisation

3.2.3.1 Opportunity – Digital goods

Description

Digital goods are predominantly relevant for the product category 'Media and entertainment products/services' and can be defined as goods that are stored, delivered and consumed in an electronic format. Consequently, digital goods are "shipped" electronically to the consumer through direct download from the Internet.

Discussion

Digital goods (also "e-goods") can be seen as a result of digitisation, which describes the process of transforming information available in a physical format into a digital format. In contrast to physical goods, digital goods can only be used as part of the digital realm by the use of specific devices that enable a consumer to access this digitised information (Watkins, Denegri-Knott and Molesworth, 2016). Common devices that are used for the consumption of e-goods are smartphones, tablets, computers, but also videogame consoles, TVs, MP3-players, or E-readers. In comparison to their physical counterparts, digital goods present certain characteristics: (1) They do not require any exclusive manufacturing process in the classical sense and hence do not require any immediate raw material extraction, (2) they do not require any physical warehouse space to be stored, and (3) they are provided or sent to the consumer electronically. Some examples of digital products are:

- writing: e.g. eBooks, magazines, templates, samples (e.g. cover letters, cv templates, copywriting templates), academic research papers, etc.;
- audio: songs, beats, jingles, ringtones, sound effects, audiobooks, podcasts, etc.;
- video: film, series, stock video, tutorial, documentary, etc.;
- design: wallpapers, posters, fonts, branding services, logo design, business card design, infographic design, comics, etc.;
- photography: stock photos, mock-up images;
- IT and tech: apps, games, browser plugins, software, domains, websites, online stores, hosting, etc.; and
- miscellaneous: virtual assisting, courses, nutrition plans, drawing lessons, paid newsletter, etc.

There is, however, still a physical impact of digital goods in each of the life-cycle stages. ICT infrastructures with computers, servers and networks are necessary to develop and offer digital products. Although these products do not require physical space, they still require digital space that is provided by a physical storage unit. Networks of interconnected IT devices are used to transfer the digital information to the purchaser of the product without transmitting any physical object. And finally, IT devices are, again, necessary for consuming the purchased goods.

The opportunity of digital goods lies in the described characteristics of such products. Avoiding a direct physical production reduces the amount of required raw materials as well as the demand for logistics – assuming that the digital version is replacing a physical one. This does most immediately apply to the differences in transportation modes, as no physical object has to be delivered to the consumer.

Classification

It can be argued that the delivery of digital products can be considered as an intended or anticipated effect, thus it can be classified as a direct effect arising from E-commerce. In fact, this effect is closely linked to or intersected with the operational energy demand for the network infrastructure (see Section 3.2.3.4). While the potential substitution of physical transport during the shipping stage of digital products is a consequential and immediate effect, further substitution effects relating to the production stage of physical counterparts are more speculative and, in any case, time-displaced. Consequently, this opportunity is predominantly assigned to the life-cycle stage "shipping" (the effect on raw material substitution is considered out of scope).

Current and future relevance

The market for e-goods has been growing continuously for years, for several reasons. More and more people have a suitable device (e.g. smartphone or computer) to access the Internet, while at the same time connection rates have risen

significantly. Especially the latter allowed companies to design new services and products that are easily and immediately accessible for customers, even in relatively remote locations. A number of companies have benefitted from this development and positioned themselves strongly in the market. Companies such as Netflix (video streaming), Spotify (music streaming) or Amazon (multi-channel) are only a few well-known names in the branches which are used by millions of users on a daily basis.

Europe belongs among the three largest markets for digital media worldwide with a market revenue of around US$25 billion in 2018 – US being the largest and China being the second largest market (Statista, 2019f). The digital media market can be divided into 4 main segments:

1. Video Games;
2. Video-on-Demand;
3. ePublishing; and
4. Digital Music.

The current relevance of digital goods varies between different products but is increasing considerably for most digital goods (music downloads being an example for a decreasing market due to the increasing relevance of music streaming). Revenue made from digital music in relation to total revenue of the music industry has risen from 5.8% in 2007 to 46.6% in 2017 for the market in Germany. A similar development can be seen in other digital segments, such as video games. The share of revenue made from selling downloads of video games increased from 3% in 2010 to 29% in 2017. The relevance of this opportunity can therefore be seen as already significant today (Statista, 2019f), with a trend that clearly predicts an increase in the revenue made by selling digital goods throughout all digital segments. For Europe, an increase of revenues from currently 25.3 billion US$ up to 31.5 billion US$ is estimated (Statista, 2019f).

Digital goods only concern the media and entertainment products/services and are irrelevant for the other product categories in the focus of this study.

Supporting factors

- increasing willingness to shift from physical possession to digital availability; and
- current regulation, such as the Regulation (EU) 2015/2120, which "establish[es] common rules to safeguard equal and non-discriminatory treatment of traffic in the provision of internet access services".

Mitigating factors

- cultural and societal meaning of (physically) possessing a product; perception of ownership differs between physical and digital goods;
- more distinct association of the human's self to a physical object and thus a higher value ascribed to the physical object;
- digital goods require an understanding of how to use digital media and devices in general and their use might thus not be feasible for everybody;
- forthcoming revision of current EU regulations regarding net neutrality with uncertainty on how to include the new (fifth) generation of cellular mobile communication (5G), as it provides the opportunity of "network slicing"[13]; and
- risk of losing access to purchased digital products (e.g. eBooks) in case of suspending the underlying service.

Options for actions

Producers/Platform providers:

- Strengthening the capacity to develop a social identity between consumer and digital good by personalisation and similar techniques; and

[13] The definition of "network slicing" is provided in Section 7.1.

- providing information on the difference in environmental impacts between physical and digital format of a product.

Regulators:

- Actively promoting and fostering through scientific literature and legal provisions the use of digital goods in fields that do not require a strong social bond. Studies show in fact a potential difference between the psychological ownership of physical and digital goods. In return, this could lead to physical products being preferred despite the availability of a digital version of the respective product – especially for goods that often trigger some type of social bond (such as books).

Source of information

Atasoy, O. and Morewedge, C. K. (2018) 'Digital goods are valued less than physical goods', *Journal of Consumer Research*, 44(6), pp. 1343–1357. doi: 10.1093/jcr/ucx102.

Börjesson Rivera, M. *et al.* (2014) 'Including second order effects in environmental assessments of ICT', *Environmental Modelling and Software*. Elsevier Ltd, 56, pp. 105–115. doi: 10.1016/j.envsoft.2014.02.005.

European Union (2015) *Regulation (EU) 2015/2120 Of The European Parliament And Of The Council of 25 November 2015*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R2120&from=EN

Frias, R. and Martínez, J., P. (2018) '5G networks: Will technology and policy collide?', *Telecommunications Policy*, 42(8), pp. 612–621. Available at: https://doi.org/10.1016/j.telpol.2017.06.003.

Lee, D. (2019) *Technology – Microsoft's eBook store: When this closes, your bools disappear too, BBC*. Available at: https://www.bbc.com/news/technology-47810367.

Statista (2019f) *Digital Media Report 2019 The Digital Market Outlook provides all insights for a deep understanding of the Digital Media market*.

Watkins, R. D., Denegri-Knott, J. and Molesworth, M. (2016) 'The relationship between ownership and possession: observations from the context of digital virtual goods', *Journal of Marketing Management*, 32(1–2), pp. 44–70. doi: 10.1080/0267257X.2015.1089308.

3.2.3.2 Opportunity – Reduction of retail space

Description

Retail space is a necessity in traditional retail stores, with size demands depending on the kind of products sold. In contrast, an E-commerce enterprise only needs a warehouse to fulfil orders, something a brick-and-mortar store most likely has in addition to the retail space. The reduction of retail space is therefore considered as an opportunity for the Circular Economy with regard to its potential of eliminating the impacts on the environment due to the operation of the traditional stores.

Discussion

The true potential of E-commerce to reduce retail space depends on the products sold. Evidently, small and easily storable products show less potential to reduce retail space. At the same time, the importance of physical retail space differs between product categories. While some products need to be tried on or seen in real life (e.g. clothes, shoes), others can be purchased without any (or with little) risk by only relying on the information provided either online or offline.

Classification

The reduction of retail space is a systemic effect and cannot be allocated to the purchase of one single unit. Moreover, it is considered a hypothetical effect that cannot exclusively be linked to E-commerce but also depends on other societal developments such as urbanisation etc. Potential positive environmental effects can at best be realised with a significant time lag after cumulating purchases over E-commerce platforms which eventually forces (small) shop owners to close down. Consequently, it is classified as an indirect effect arising from E-commerce.

Current and future relevance

Considering the need to reduce environmental emissions, more efficient or "eco-stores" are and will become more and more important in the future. This aspect can affect the relevance of the potential savings in terms of environmental impacts originating from the elimination of the physical shops. Moreover, the actual contribution in terms of CO_2 emissions of the retail store on the overall CO_2 emissions associated with the retail system is considered as being of minor relevance (Weber *et al.*, 2009).

Reduction of retail space is a cross-product opportunity.

Supporting factors

- cost savings that could be passed on to consumers; and
- newly founded businesses that first grow online.

Mitigating factors

- people's desire to go shopping as a pastime; and
- product's properties that require the customer to try them, especially if they are large and need significant assembly (e.g. bicycles).

Options for actions

Producers/Platform providers:

- sustainable operation of warehouses and attached logistic spaces to increase the potential environmental advantage.

Source of information

CANDRIAM (2017) *Environmental benefits of E-commerce versus brick-and-mortar retailing : reality or illusion ?*

Fichter, K. (2001) 'Environmental Effects of E-Business and Internet Economy. First Insights and Environment-political Conclusions', (August), p. 26. Available at: http://www.borderstep.de/Environmental_effects_of_e-business_and_Internet_economy.pdf.

Pålsson, H., Pettersson, F. and Winslott Hiselius, L. (2017b) 'Energy consumption in e-commerce versus conventional trade channels - Insights into packaging, the last mile, unsold products and product returns', *Journal of Cleaner Production*. Elsevier B.V., 164, pp. 765–778. doi: 10.1016/j.jclepro.2017.06.242.

Weber, C. L. *et al.* (2009) 'Life cycle comparison of traditional retail and e-commerce logistics for electronic products: A case study of buy.com', *2009 IEEE International Symposium on Sustainable Systems and Technology, ISSST '09 in Cooperation with 2009 IEEE International Symposium on Technology and Society, ISTAS*, (June). doi: 10.1109/ISSST.2009.5156681.

3.2.3.3 Opportunity – Substitution of printed marketing material

Description

Digital marketing is a natural aspect of E-commerce business models. However, it is not exclusive and, thus, not a unique feature to set this channel apart from traditional retail. It has the theoretical potential to substitute part of the printed advertising material, depending on the target audience.

Discussion

While being a large part of E-commerce, substituting printed marketing material does not necessarily result in any notable environmental benefits. This is due to the risk that evident gains from dematerialising marketing may be compensated by data-intense and numerous formats (e.g. E-mail newsletter, animated content, marketing videos) in the digital realm.

Classification

The substitution of printed marketing material cannot be allocated to the purchase of one single unit. Moreover, it is considered a long-term effect which necessitates the actual substitution of printed material. Consequently, this effect is classified as an indirect opportunity arising from E-commerce.

Current and future relevance

Online marketing is already a large factor and a substantial industry with further increasing importance in the future.

The substitution of printed marketing material is of relevance for all product categories in focus of this study.

Supporting factors

- increasing shift to digital media and online shopping.

Mitigating factors

- reluctance of certain demographic groups to adopt new technology/ability to process information (target audience of advertisements).

Options for actions

Scientific Community:

- comparative studies on specific online-marketing technologies/concepts and their impact on shopping behaviour (especially regarding the younger generation) to avoid possible drawbacks.

Source of information

Pärssinen, M. *et al.* (2018) 'Environmental impact assessment of online advertising', *Environmental Impact Assessment Review*. Elsevier, 73(September 2017), pp. 177–200. doi: 10.1016/j.eiar.2018.08.004.

3.2.3.4 Threat – Operation of network infrastructure

Description

The underlying network infrastructure, which is necessary for creating and operating E-commerce activities, requires electricity to run. Although E-commerce is merely one of many features running on a specific network infrastructure, it still contributes to an increase in energy consumption of respective network devices and thus has implications for the Circular Economy.

Discussion

From an end-user perspective, E-commerce is essentially a user interface (usually web browser or an app) that allows to browse for and to buy products online. Also, from the perspective of an E-commerce merchant, the interface between potential consumer and one's own online shop is presumably of main importance for the provider of a product. Less focus is usually given to data traffic, data processing, storage means or the interconnectivity of network devices, all of which consume electricity to function (Rahimi and Alavi Rad, 2017; Aslan *et al.*, 2018). The demand for electricity that can be ascribed to E-commerce can be seen as a threat to the Circular Economy. Aspects such as raw material extraction to establish and maintain the infrastructure as well as toxicity of end-of-life devices are, however, considered out of the scope of this study.

Classification

Arising energy demands for the network infrastructure are a direct effect of E-commerce applications and occur immediately. Although these specific demands are difficult to quantify, they can theoretically be allocated to one fulfilled unit.

Current and future relevance

The energy demand caused by the network infrastructure applies to all product categories in scope but is of higher significance for product categories that make use of high quality and data intense content. Interactive content is used across industries to promote products as vividly as possible. The possibility to use a virtual model to try on clothes before the purchase, the flexible choice of colours, the presentation of numerous product photos from different perspectives, as well as zooming in and out are just a few of the many examples. All of these increases the amount of data that has to be transmitted between provider and user.

Other factors may also play an important role in assessing the future relevance of this threat. For instance, an increase in available data transfer rates usually goes hand in hand with an increase in actual data transfer. Online shops are using more data transfer intense media such as video, audio and high-resolution photos to promote their products. Technological development in fixed broadband internet connection and mobile connection standards (e.g. from 2G in 1992 to 4.5G in 2016) facilitates high data traffic and thus also indirectly promotes E-commerce. Studies have shown that despite the increase in energy efficiency of modern technology, internet usage is estimated to have an enhancing effect on electricity consumption in the long-run. In other words, the more people are using the internet and the more intense it is used (in terms of data transfer), the more electricity is consumed (Rahimi and Alavi Rad, 2017).

This threat is relevant for all product categories, as it describes the underlying technology necessary for E-commerce, regardless of the product category.

Supporting factors

- increase in cloud services that are used to establish and provide an E-commerce platform; and
- increase in available data transfer rates.

Mitigating factors

- raising awareness on the relationship between internet usage and energy demand;
- increase in energy efficiency of devices and network infrastructure; and
- mitigation of associated environmental impacts due to adoption of renewable energy supplies for operating the network infrastructure.

Options for actions

Scientific Community:

- awareness raising on the relationship between surfing, e-shopping, data transfer, electricity consumption and impact on the environment (see Section 3.2.2.1, opportunity "Nudging").

Producers/Platform providers:

- smart use of content and media with an increased focus on data transfer (not every promotion video or photo necessarily needs to be of high resolution);
- more focus on results rather than on amount of content alone; and
- regular evaluation of how much traffic your online shop/website is generating per user and in total:
    - number of expected visitors;
    - expected page views by each visitor; and
    - average size of pages including all media.

Hosting providers:

- use of data transfer plans that include certain thresholds in agreement with the contractor; and
- coordination between hosting provider and platform operator/producer.

Source of information

Aslan, J. *et al.* (2018) 'Electricity intensity of internet data transmission untangling the estimates', *Journal of Industrial Ecology*, 22(4), pp. 785–798. doi: 10.1111/jiec.12630.

EMarketer (2017) *Number of digital buyers worldwide from 2014 to 2021 (in billions)*, *Statista*. Available at: https://www.statista.com/statistics/251666/number-of-digital-buyers-worldwide/ (Accessed: 20 March 2019).

Eurostat (2018) *Internet-Käufe durch Einzelpersonen, isoc_ec_ibuy*. Available at: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do.

Morley, J., Widdicks, K. and Hazas, M. (2018) 'Digitalisation, energy and data demand: The impact of Internet traffic on overall and peak electricity consumption', *Energy Research and Social Science*. Elsevier, 38(February), pp. 128–137. doi: 10.1016/j.erss.2018.01.018.Rahimi, M. and Alavi Rad, A. (2017) 'Internet Usage, Electricity Consumption and Economic Growth: Evidence from a Panel of Developing-8 Countries', *International Journal of Energy Economics and Policy* |, 7(3), pp. 152–156. Available at: http://www.econjournals.com.

Rahimi, M. and Alavi Rad, A. (2017) 'Internet Usage, Electricity Consumption and Economic Growth: Evidence from a Panel of Developing-8 Countries', *International Journal of Energy Economics and Policy* |, 7(3), pp. 152–156. Available at: http://www.econjournals.com.

3.2.4 Cluster – End of life

3.2.4.1 Opportunity – ReCommerce: Second-hand E-commerce / online auctioning

Description

"ReCommerce" encompasses the re-sale of used consumer goods via the internet. Fashion and electronic entertainment devices like smartphones and tablets are the primary focus for vendors (Restposten.de, 2016).

Discussion

ReCommerce, which used to be second-hand sales, is a large industry that primarily focuses on (but is not limited to) electronics and clothing. ReCommerce is essentially used by e-commerce customers in two different ways:

- the acquisition and resale of used and refurbished products; and
- platforms where people offer items that they want to give away.

This business model has grown into a multi-billion-dollar industry. It enables consumers to save money, regain some of their spending, and it prolongs a product's useful life, thus decreasing the environmental impact due to a reduced demand for new items (Janke, 2013; Umweltbundesamt, 2017a; European Valuations, 2018).

Classification

ReCommerce is strongly facilitated through online services and applications. Some forms, however, existed before and became more accessible through the internet. In addition, the institutionalisation through dedicated companies gives the consumer security with their purchase. While the concept of reselling used items is not solely an effect of E-commerce, the improved accessibility and institutionalisation are considered direct effects of the online business model. Thus, resale of goods via dedicated online platforms is arguably an intended positive effect arising from E-commerce.

Current and future relevance

ReCommerce has grown significantly in the past ten years and with major companies entering the market the growth is expected to continue in the future (European Valuations, 2018). Therefore, ReCommerce is and will be an important cornerstone in digital market.

Apart from non-perishable food, this opportunity can be seen as relevant for all product categories in focus of this study. The second hand market offers a wide range of products.

Supporting factors

- large parts of the population are already actively buying and selling used products, which makes the ReCommerce market a relatively stable market;
- shorter product life cycles in electronics increase turnover on the second-hand market;
- ecological conscience is leading to increased interest in used items; one-time possession is regarded as "uncool";
- platforms can develop into communities that not only serve business purposes, but also people's need for social interaction; and
- online trade platforms with their rating systems have significantly improved the image of used products (Umweltbundesamt, 2017a).

Mitigating factors

- people's desire to own brand new products, especially with electronics and privacy concerns;
- limited availability and selection of used goods; and
- often lack of warranty for used goods.

Options for actions

Producers/Platform providers:

- offering of warranty; and
- proactive advertisement of environmental benefits of used products.

Regulators:

- tax incentives for resale of used goods.

Source of information

European Valuations (2018) *Market sector insights november 2018: The Recommerce Industry*. Available at: https://www.eurovals.co.uk/wp-content/uploads/Recommerce-Industry.pdf.

Janke, K. (2013) *Der Second-Hand-Boom: Alle reden über Re-Commerce, e-tailment*. Available at: https://etailment.de/news/stories/Der-second-hand-boom-alle-reden-ueber-recommerce-1580 (Accessed: 22 July 2019).

Restposten.de (2016) *Geschäftsmodell ReCommerce - warum sich der Einstieg lohnt*. Available at: https://www.restposten.de/pdf/Ratgeber-Geschaeftsmodell-ReCommerce-Warum-sich-der-Einstieg-lohnt.pdf.

Umweltbundesamt (2017) *Schaffung einer Datenbasis zur Erfassung der Mengen von in Deutschland wiederverwendeten Produkten*. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/2017-01-17_texte_04-2017_zwischenbericht_mengen-wiederverwendete-produkte_v2.pdf

3.2.4.2 Opportunity – Extended product selling cycle

Description

Online retailers have nearly unlimited amount of (digital) retail space as well as larger warehouse capabilities to offer products to consumers on their websites. This makes it easier to offer old/out of trend products (especially in the field of fashion and electronics) for a longer time, mostly with a discount. Ultimately, less products may be destroyed or sold to developing countries.

Discussion

Pålsson (2018) notes that there is a trend in E-commerce towards fewer and larger warehouses, which may be due to the desire for greater energy efficiency. Respective E-commerce vendors operate large centralized warehouses that enable them to store more products for longer periods of time. This is enabled by the spatial advantage over traditional vendors that need distributed storage which means a redundancy in stocks and the risk of accumulating unsold products. Hence, the E-commerce vendor has the opportunity to hold on to products for longer and sell them, while traditional retail has to dispose of obsolescent products to free up space (Pålsson, 2018).

Classification

The extended product selling cycle is potentially facilitated by the centralized warehouses of E-commerce retailers. However, this effect is rather hypothetical and differences to traditional value chains are uncertain. Hence, this opportunity is considered an indirect effect which may arise from E-commerce.

Current and future relevance

E-commerce's ability to keep stock longer is already very relevant due to the increased relevance of E-commerce itself. The overall growing E-commerce market volume may result in an even bigger importance in the future.

This opportunity is in general relevant for all product categories.

Supporting factors

- consumer behaviour to increasingly shop online; and
- consumer's desire to save on their purchases.

Mitigating factors

- fast paced developments in certain markets (e.g. tech, fashion); and
- desires to own the latest products in certain categories.

Options for actions

Scientific Community:

- investigations concerning the environmental implications of unsold products.

Producers/Platform providers:

- collaboration with ReCommerce platforms; and
- proactive promotion of discounted products.

Source of information

Pålsson, H. (2018) *Packaging Logistics - Understanding and managing the economic and environmental impacts of packaging in supply chains*. London: Kogan Page Limited.

3.2.4.3 Opportunity – Product take-back

Description

The development of reverse logistics allows for an efficient chain of re-use, repair and recycling possibilities. E-commerce has the potential to increase customer retention and thus also the producer's possibility to establish a profound reverse logistic.

Discussion

The take-back of products is regulated in European legislation in several Directives, such as the Packaging and Packaging Waste Directive (94/62/EC) or the WEEE Directive (2012/19/EU) and imposes the disposal of waste on the manufacturer of such products. This producer responsibility requires the manufacturer to incorporate take-back logistics to consumers and businesses. With regard to the product groups in focus of this study, this impacts especially producers of major household appliances and small ICT.

Producers must contribute their share to meeting collection quotas set in the WEEE directive. E-commerce is seen here as an opportunity to improve the producers' possibilities to take-back WEEE directly from their customers, thus improving the opportunities to comply with respective quotas. A further incentive for producers to get back their own product at its end-of-life is that producers know exactly which substances and in which quantities have been processed in their products and how exactly they can be extracted.

Classification

Product take-back is seen as an indirect effect due to its potential positive impact on a long-term transition towards a Circular Economy. It becomes relevant at the end-of-life stage of the product life-cycle.

Current and future relevance

In general, the digital market offer great potentials to automate and streamline processes at the end of their first useful life, essentially making use of already existing infrastructures for reverse logistics (Umweltbundesamt, 2018b).

The current relevance of this aspect is seen as high as the objectives set out in the WEEE Directive can be considered ambitious. This puts pressure on manufacturers, who already have a significant interest today in being able to achieve their quotas well at a reasonable expense.

Several companies are already taking advantage of the opportunities and are actively involving consumers in their products. For example, Apple or HP can be mentioned here, both of which pursue an active take-back policy.

This threat is not of relevance for the product categories non-perishable food and media and entertainment products/services. At the same time it is of particular importance for small information and communication technology and major household appliances due to existing take-back obligations for WEEE.

Supporting factors

- an existing close customer relationship increases the possibility that the customer will return the product directly to the manufacturer at the end of its life;
- take-back programmes of producers, and
- automated take-back systems, such as ecoATM's take-back programme for phones (EcoATM, 2019)

Mitigating factors

- Customer-to-customer (C2C) sales reduce the relationship between end consumer and producer of the product (e.g. in second-hand markets), which makes a return of the product at the end of its life to the producer less likely.

Options for actions

Producers/Platform providers:

- offering to the customer a return process that is as simplified as possible with clear instructions and information about the take-back programme; and
- providing incentives for returning End-of-Life products.

Source of information

Atasu, A., Van Wassenhove, L. N. and Sarvary, M. (2009) 'Efficient take-back legislation', *Production and Operations Management*, 18(3), pp. 243–258. doi: 10.1111/j.1937-5956.2009.01004.x.

ecoATM (2019) *How ecoATM works*. Avalable at: https://us.ecoatm.com/

Esenduran, G. and Kemahlioɬlu-Ziya, E. (2015) 'A comparison of product take-back compliance schemes', Production and Operations Management, 24(1), pp. 71–88. doi: 10.1111/poms.12213.

Umweltbundesamt (2018) *Konsum 4.0: Wie Digitalisierung den Konsum verändert*. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/fachbroschuere_konsum_4.0_barrierefrei_190322.pdf.

3.2.4.4 Threat – End-of-Life challenges

Description

End-of-life challenges in E-commerce mainly arise from potentially hazardous waste groups, e.g. electronic equipment. The main issue presents itself in disposal of such products that need special collection points. Deutsche Umwelthilfe criticized major online retailers for their limited compliance with their duty to enable consumers to return their old devices (DVZ, 2018a; Verbraucherzentrale, 2019).

Discussion

Generally, all retailers that offer electronic devices and that have a sales/storage space of more than 400 m^2 are obliged to take back WEEE devices, especially when the device's edge length is under 25 cm. Larger devices have to be taken back when selling a replacement unit and the retailer has to provide the logistics to do so (Weee Return, no date; Verbraucherzentrale, 2019). The difficulty arising with online retailers are the conditions under which they take back WEEE. Often, packaging requirements for the take-back schemes by vendors are difficult to meet by consumers, while larger devices have to be brought to local facilities provided/pointed out by the e-commerce retailer. Additionally, online retail often makes the return of WEEE difficult by requiring dedicated contact with customer support or hidden information (DVZ, 2018a). This means online retail effectively hinders the proper disposal of devices, leading to improper treatment and resource loss.

Classification

It remains highly speculative whether E-commerce value chains actually constitute more severe barriers and challenges at the end-of-life stage of products compared to traditional channels. Hence, this effect is hypothetical and the processes as well as potential environmental implications lie mostly outside the sphere of influence of platform providers. Therefore, this threat is considered an indirect effect.

Current and future relevance

Disposal of WEEE is already relevant but will become more important in the future with more and more devices being sold for various purposes. This threat occurs in the product categories small information and communication technology as well as major household appliances.

Supporting factors

- insufficient monitoring of legal compliance with common market regulations (see Section 3.2.5.4) (DVZ, 2018a); and
- with a rapidly increasing number of devices, the challenges of end-of-life are also likely to grow.

Mitigating factors

- implemented return logistics by producers and online retailers of respective devices and products, which is intended to be resource-saving and customer-friendly.

Options for actions

Regulators:

- complete monitoring of legal obligations and sanctions in case of breach.

Source of information

DVZ (2018) 'Onlinehandel: Deutsche Umwelthilfe bemängelt Rücknahme von Elektro-Altgeräten', 3 April. Available at: https://www.dvz.de/rubriken/logistik/detail/news/onlinehandel-deutsche-umwelthilfe-bemaengelt-ruecknahme-von-elektro-altgeraeten.html.

Verbraucherzentrale (2019) *Elektroschrott: Diese Geräte und Gegenstände gehören ins Recycling*. Available at: https://www.verbraucherzentrale.de/wissen/umwelt-haushalt/abfall/elektroschrott-diese-geraete-und-gegenstaende-gehoeren-ins-recycling-12861 (Accessed: 24 July 2019).

Weee Return (no date) *I am an online retailer. In which way does the electrical equipment law (ElektroG) affect me?* Available at: https://www.weee-return.de/services/online-retailer/?lang=en/#checkliste (Accessed: 24 July 2019).

3.2.4.5 Threat – Waste from returns

Description

Returns are commonly accepted for items sold online and constitute a necessary right of the consumer since there is no possibility to completely and realistically examine the product before delivery. The returned products might go towards different fates, one of which is the disposal as waste.

Discussion

Depending on the category between 5.9% and 21% of articles are returned in 5.5% to 45.1 % of the shipments (Asdecker, 2019a). The highest return rates are for clothing followed by entertainment products. However, in Germany, 92% of the products are sold as new or b-stock. The exact amount of destroyed returns is uncertain (Postpischil and Jacob, 2019a).

The destruction of products is the very last option especially for large retailers, but there are products that cannot be resold due to e.g. hygienic reasons (Asdecker, 2019a; Gsell, 2019a). Smaller retailers that use platforms such as Zalando often also use the platform's warehouses in exchange for a fee. Depending on how high the fee is, sometimes it can be easier to draw back a product that does not sell and destroy it because the cost is lower than the fee to be paid for the warehouse space (Postpischil and Jacob, 2019a).

Classification

The treatment and potential destruction of returned products is not an exclusive problem in E-commerce value chains. This makes a comparison with traditional channels challenging. Often this effect is also outside the sphere of control for platform providers. Consequently, it is considered an indirect effect.

Current and future relevance

Returns are a highly relevant current topic and are considered to have the potential to become even more relevant in the future, considering the growing E-commerce market.

Especially clothing is usually less susceptible to damage than, for example, IT equipment or large household appliances, which require, among other things, a higher degree of shock protection (Statista Research Department, 2014). In general, it is estimated that around 15-20% of purchases are sent back because the product arrived damaged (Statista Research Department, 2014; Gallup Institut, 2018)

This threat is of particular relevance for products that are (1) more likely to be send back and that are (2) more susceptible to damage (e.g. due to the necessity of a higher degree of shock protection), such as small information and communication technology. However, also other product categories are potentially affected.

Supporting factors

- economic factors (cheaper to destroy than to resell); and
- legal requirements (security, hygiene) (Gsell, 2019a).

Mitigating factors

- dedicated platforms for the sale of refurbished, pre-owned or open-box products at a reduced price, such as "Amazon renewed" (Amazon, 2019a);
- adequate shipping costs for purchasing products online: when customers already have to pay a certain amount for home delivery, the incentive to pay more attention to whether the product will meet their expectations increases when choosing a product. In addition, purchases are prevented for which there is a very high probability that the product will be returned when the order is placed (such as "Just give it a try"-orders).

Options for actions

Producers/Platform providers:

- introduce incentives and systems (such as the integration of different media: text, video, pictures, interactive 3D images, virtual fitting rooms (Pachoulakis, 2012)) to reduce returns.

Regulators:

- mandatory and uniform fee for returns to level the playing field between larger and smaller retailers (Postpischil and Jacob, 2019).

Source of information

Amazon (2019a). Amazon Renewed. Available at: https://www.amazon.de/gp/help/customer/display.html/ref=s9_acss_bw_h1_desfhd_md1_w?language=de_DE&nodeId=202089470&pf_rd_i=10676131031&pf_rd_m=A3JWKAKR8XB7XF&pf_rd_p=9a104d53-2b7c-4e73-bc99-d416d180fd4f&pf_rd_r=GRGCF8PC2X6TS7WMFGS3&pf_rd_s=merchandised-search-2&pf_rd_t=101 (Last accessed: 10.10.2019)

Asdecker, B. (2019) 'Herausforderungen des Onlinehandels für Umwelt- und Verbraucherschutz - Zerstörung neuwertiger, nicht verkehrsfähiger Ware', in *Herausforderungen des Onlinehandels für Umwelt- und Verbraucherschutz*. Available at: https://www.ioew.de/fileadmin/user_upload/DOKUMENTE/Veranstaltungen/WS_3_Zerstörung_Björn_Asdecker.pdf.

Gsell, M. (2019) 'Verhinderung der bewussten Zerstörung neuwertiger Retour-Ware', in *Herausforderungen des Onlinehandels für Umwelt- und Verbraucherschutz*. Available at: https://www.ioew.de/fileadmin/user_upload/DOKUMENTE/Veranstaltungen/Vortrag_3__Martin_Gsell.pdf.

Postpischil, R. and Jacob, K. (2019) *Kurzanalyse E-Commerce vs. stationärer Handel: Die Umwelt-und Ressourcenwirkungen im Vergleich*. Available at: https://refubium.fu-berlin.de/handle/fub188/24797.

Wenk-Fischer, C. (2019) 'Zerstörung neuwertiger, nicht verkehrsfähiger Ware', in *Herausforderungen des Onlinehandels für Umwelt- und Verbraucherschutz*. Available at: https://www.ioew.de/fileadmin/user_upload/DOKUMENTE/Veranstaltungen/WS_3_Retouren__Wenk-Fischer.pdf.

3.2.4.6 Threat – Food waste

Description

In terms of the biological cycle of a Circular Economy, which emphasises on the value of biological materials within the system (MacArthur, 2015), food waste is a very important issue for both consumers and the food industry. To reduce environmental impacts associated with food, avoiding food waste is paramount.

Discussion

Although still a minor segment of the E-commerce market, (fresh) food delivery is gaining more focus and more customers each year. For Germany alone, the market has grown dramatically in recent years - from 618 million € in 2014 to 1.360 billion € in 2018 (Statista, 2019l). The delivery of food is not seen as a cause of food waste but can still contribute to it (e.g. in case of damage during delivery). On the other hand, it could reduce food waste by promoting a more targeted purchase (e.g. shopping-list focused purchase, no purchases induced by the display of food in the shop). Moreover, the actual effects will certainly depend on the specific business model (e.g. home delivery, click and collect) (ATKearney, 2012; López, Gelante and Monroe, 2013).

Classification

Whether E-commerce induces additional food waste or even exhibits any potential to further reduce it, is very hypothetical and depends on systemic dynamics in the food market and the respective customer behaviour. Therefore, this is clearly an indirect effect potentially arising from E-commerce.

Current and future relevance

In the past, online grocery sales have grown much slower than the total E-commerce market (ATKearney, 2012). Moreover, the online grocery market is still in an emerging state in most European countries. For instance, the online grocery channel share in France was 4.5% in 2018. In Germany and Spain, this share was significantly lower at 0.5% and 0.7%, respectively (Ecommerce News, 2018). While there is certainly a huge growth potential, the future development of this segment seems highly speculative. In particular, substantial differences in terms of adoption by customers between countries and geographical regions can be expected.

This threat is only of relevance for the product category non-perishable foods, although it should be noted that especially perishable and fresh food is affected, which are not assessed in detail in this study.

Supporting factors

Given inconclusive manifestation (opportunity or threat) of this effect, supporting factors could not be identified.

Mitigating factors

Given inconclusive manifestation (opportunity or threat) of this effect, mitigating factors could not be identified.

Options for actions

Scientific community:

- additional research is necessary to evaluate environmental effects arising from E-commerce on food waste. Research should include different food categories (perishable and non-perishable).

Source of information

ATKearney (2012) A Fresh Look at Online Grocery. doi: 10.1080/03060497.1993.11085326.

Ecommerce News (2018) 4 European countries in top 10 online grocery markets by 2023. Available at: https://ecommercenews.eu/4-european-countries-in-top-10-online-grocery-markets-by-2023/.

López, E. G., Gelante, N. and Monroe, S. (2013) *The future of online grocery in Europe*, *McKinsey*. doi: 10.1016/S0034-3617(11)70034-0.

Statista (2019l) *Umsatz mit Lebensmitteln im Online-Handel in Deutschland von 2014 bis 2018*. Available at: https://de.statista.com/statistik/daten/studie/894997/umfrage/umsatz-mit-lebensmitteln-im-deutschen-online-handel/.

3.2.5 Cluster – Legal framework

3.2.5.1 Threat – Difficulty to monitor

Description

One of the major characteristics of E-commerce is the access to international markets which enables customers to easily purchase products from a multitude of sellers around the world. It results in an increase in complexity of international trade in comparison to traditional retail. This is also reflected by the difficulties to monitor product streams entering and leaving the EU via online trade. Such a lack of insight into the market impedes the analysis of effectiveness of current legislation as well as compliance with regulations.

Discussion

The Roadmap to the Circular Economy in Europe includes the transition towards a sustainable economy with sustainable value chains. This encompasses the regulation of products and certain substances (see e.g. Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment). The development of E-commerce poses certain challenges regarding the protection of the health and safety of consumers and other end-users from dangerous non-food products and/or products that do not comply with the requirements set out in the EU harmonisation legislation on products ('non-compliant products'). In this respect, market surveillance authorities in the Member States are confronted with multiple obstacles compared to traditional retailing. The European Commission states in its notice on the market surveillance of products sold online the following (European Commission, 2017a):

- "*difficulties with regard to tracing products offered for sale online and identifying the responsible economic operators;*
- *the increase in the number of economic operators located outside the territory of the EU offering products for sale online; this includes sales directly to EU consumers and other end-users, which renders the enforcement of product rules challenging;*
- *challenges in conducting risk assessments or safety tests due to the lack of physical access to products;*
- *difficulties in sampling products for testing, as relevant laws in certain Member States do not permit purchases to be made online or anonymous purchases (such as mystery shopping);*
- *challenges in the application of Directive 2001/95/EC of the European Parliament and of the Council on general product safety (General Product Safety Directive) as well as of Regulation (EC) No 765/2008 of the European Parliament and of the Council setting out the requirements for accreditation and market surveillance relating to the marketing of products related to the online environment; and*
- *lack of awareness among consumers and businesses about buying and selling safe and compliant products online.*"

Classification

Effects related to difficulties to monitor certain aspects of the market are clearly outside the sphere of influence of E-commerce providers. The described threat has long-term and rather systematic effects. As such, it can be defined as indirect effect of E-commerce.

Current and future relevance

E-commerce is directly linked to international trade and with rising numbers in consumers ordering from outside the EU, the relevance of monitoring is high and expected to grow. At the same time, more and more producers start to sell their products directly to end-consumer by setting up own online shops (European Commission, 2017c). Challenges with insufficient insights into the market are therefore likely to increase.

Although this risk generally exists for all product categories, it is particularly pronounced for small information and communication technology, because these types of products usually contains an increased level of potentially hazardous substances and is therefore subject to stricter regulations.

Supporting factors

- diffuse and specific nature of E-commerce, as compared to regular international trade practice; and

- economic operators of E-commerce arrangements can be located outside the jurisdiction of competent authorities.

Mitigating factors

- increasing attention of Member State enforcement authorities for the monitoring of E-commerce trade (also see section 3.2.5.2 Threat – Enforcement"); and
- increasing cooperation between Member State authorities on issues regarding monitoring of international trade and E-commerce.

Options for actions

Regulators:

- stimulate further cooperation/information exchange between Member State enforcement authorities on issues regarding market surveillance and E-commerce.

Source of information

European Commission (2018f) *Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011L0065.

European Commission (2017a). Commission notice on the market surveillance of products sold online. Text with EEA relevance. 2017/C 250/01. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52017XC0801(01)&from=EN (Last accessed: 10.10.2019)

European Commission (2017c) Available at: https://ec.europa.eu/competition/antitrust/sector_inquiry_final_report_en.pdf (Last accessed: 10.10.2019)

Iöw – Institut für Ökologische Wirtschaftsforschung (2019), Herausforderungen des Onlinehandels für Umwelt- und Verbraucherschutz – Bedeutung und Ansätze für Regelsetzung, Vollzug und Marktüberwachung, Available at: https://www.ioew.de/veranstaltung/herausforderungen_des_onlinehandels_fuer_umwelt_und_verbraucherschutz/

3.2.5.2 Threat – Enforcement

Description

Compliance of imported products with environmental and products legislation is an important factor for the current policy efforts to increase recycling and market uptake of secondary raw materials on the one hand, while ensuring safe and toxic-free product life cycles on the other. However, sources indicate that the enforcement of environmental and products legislation is made more difficult due to increased entry of products to the internal market via E-commerce arrangements.

Discussion

As described in Section 3.2.5.4 below, lack of compliance with EU chemicals and product safety regulations of products placed on the internal market contributes to the perpetuation of substances of concern in the product life-cycle if such non-compliant products are recycled upon entering the waste phase. In addition, non-compliant imported products may not meet existing and future requirements regarding "recyclability" (e.g. easy disassembly).

Currently, no direct reference exists regarding the potential negative effects of E-commerce on the enforcement of EU environmental and product regulations which affect the Circular Economy policies. However, in 2016, European Commission Reviews and assessments of the functioning of market surveillance activities in the period 2010-2013 indicate that (European Commission, 2019e):

- non-compliance with EU product law can be an issue within the context of E-commerce arrangements; and
- various Member State Authorities consider E-commerce as a challenge for their product regulations enforcement efforts.

A similar review for the period of 2014-2016 also indicates that E-commerce is receiving attention from Member State Authorities within the context of their enforcement efforts (European Commission, 2019f). From a sectoral perspective, the product group "chemicals" provides relevant indications of the potential challenges which E-commerce poses for enforcement efforts (see for example: CLEEN 2016).

Sources indicate that, in the case of E-commerce arrangements, the tracing of non-compliant products can be difficult. In addition, competent authorities seem to face challenges regarding the identification of the economic operator to be held responsible for non-compliance. In addition, there is an issue of jurisdiction, as authorities cannot act against operators who are not established in the relevant Member State.

While the challenges identified in e-commerce are currently not yet explicitly linked to compliance with the regulations relevant to circular economy, it can be assumed that these challenges are indirectly linked to such policies.

Classification

Effects related to the enforcement of E-commerce related compliance aspects are outside the sphere of influence of E-commerce providers. The described threat has long-term and rather systematic effects. As such, it can be defined as an indirect effect of E-commerce.

Current and future relevance

From the EU policy perspective, the issue of market surveillance and E-commerce is receiving explicit attention:

- in its 2015 communication on the EU single market strategy, the European Commission concluded that *"in the case of e-commerce in particular, market surveillance authorities have great difficulty tracing non-compliant products imported from non-EU countries and identifying the responsible entity within their jurisdiction"* (European Commission, 2015b);
- more recently, the 2017 Commission notice on the market surveillance of products sold online underlined that the *"development in e-commerce poses certain challenges regarding the protection of the health and safety of consumers and other end-users from dangerous non-food products and/or products that do not comply with the requirements set out in Union harmonisation legislation on products ('non-compliant products')"* (European Commission, 2017a); and
- as a most recent example, recital 19 of Regulation (EU) 2019/1020 on market surveillance and compliance of products states that *"the development of e-commerce poses certain challenges for market surveillance authorities*

with regard to the ensuring of compliance of products offered for sale online and the effective enforcement of Union harmonisation legislation. (…)" (European Commission, 2019d).

As such, it is likely that the issue of market surveillance and enforcement will remain relevant issues within the context of E-commerce.

Although this risk generally exists for all product categories, it is particularly pronounced for small information and communication technology, because these types of products usually contain an increased level of potentially hazardous substances and are therefore subject to stricter regulations where enforcement would be of especially important.

Supporting factors

- diffuse and specific nature of E-commerce, as compared to regular international trade practice;
- difficulties regarding tracing of products sold via E-commerce arrangements, as currently information about online traders cannot be requested (no information from internet service providers (European Commission, 2019d); and
- economic operators of E-commerce arrangements can be located outside the jurisdiction of competent authorities.

Mitigating factors

- increasing attention of Member State enforcement authorities for the control of E-commerce arrangements; and
- increasing cooperation between Member State enforcement authorities on issues regarding market surveillance and E-commerce.

Options for actions

Scientific Community:

- mapping the forms of E-commerce sales of products from third countries; and
- further developing of enforcement (IT-)tools and methods which enable/support the tracing of products sold via E-commerce arrangements.

Regulators:

- stimulate further cooperation/information exchange between Member State enforcement authorities on issues regarding market surveillance and E-commerce; and
- commission notice on market surveillance (2017/C 250/01) should be considered in the current examination of "options and actions for a more coherent policy framework of the different strands of work of EU product policy in their contribution to the circular economy " (European Commission, 2019f).

Source of information

European Commission (2015b) *Upgrading the Single Market: more opportunities for people and business*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52015DC0550&from=EN (Accessed: 6 August 2019).

European Commission (2017a). Commission notice on the market surveillance of products sold online. Text with EEA relevance. 2017/C 250/01. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52017XC0801(01)&from=EN (Last accessed: 10.10.2019)

European Commission (2019d). New EU rules on e-commerce. Available at: https://ec.europa.eu/digital-single-market/en/new-eu-rules-e-commerce (Accessed: 8 October 2019).

European Commission (2019e) *Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance and compliance of products and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019R1020 (Accessed: 6 August 2019).

European Commission (2019f) *The implementation of market surveillance in Europe*. Available at: https://ec.europa.eu/growth/single-market/goods/building-blocks/market-surveillance/organisation_en (Accessed: 6 August 2019).

European Commission (2019g) *Towards an EU policy framework contributing to the circular economy*. Available at: https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-2409307_en (Accessed: 6 August 2019).

Wirtschaftsforschung, I. für Ö. (2019) *Herausforderungen des Onlinehandels für Umwelt- und Verbraucherschutz - Bedeutung und Ansätze für Regelsetzung, Vollzug und Marktüberwachung*. Available at: https://www.ioew.de/veranstaltung/herausforderungen_des_onlinehandels_fuer_umwelt_und_verbraucherschutz/ (Accessed: 6 August 2019).

3.2.5.3 Threat – EPR – Free-Rider Effect

Description

The Extended producer responsibility (EPR) is an established policy instrument within the context of waste management and resource efficiency in the EU. Various sources highlight that E-commerce is leading to a free-rider effect, which means that specific producers which are subject to EPR obligations do not comply with applicable obligations or do not take part in and financially contribute to respective organisations. This effect is potentially increased due to the international market access of E-commerce.

Discussion

The extended producer responsibility is receiving increased attention as a potential driver of the Union's envisaged transition to a Circular Economy. In the EU, EPR is understood as a set of measures taken by Member States to ensure that producers bear financial responsibility or financial and organisational responsibility for the management of the waste stage of a product's life cycle.

With regard to specific product streams, EU regulations require that Member States implement the producer responsibility principle. For other product streams, Member States have chosen to lay down national EPR obligations. The focus for the description of this threat is on EPR for Waste of Electrical and Electronic Equipment (WEEE). As such, it applies to all product categories defined in the previous section, with digital goods being the only exemption.

Producers which are responsible for a specific product stream can individually fulfil financial or organisational EPR obligations. Producers can also choose or be obliged to organise themselves as one or more producer responsibility organisations (PROs) which will manage the fulfilment of EPR obligations.

Producers which are members of a PRO, are likely to be required to pay a fee for their membership, with which the PROs' activities are financed.

For various EU regulations which form the basis for EPR systems, the definition of "producer" goes beyond the traditional concept of manufacturer and also includes natural or legal persons who place EPR-covered products on the internal market via E-commerce arrangements. As such, natural and legal persons who sell products to EU consumers are required to fulfil applicable EPR obligations in the relevant Member State.

Various sources highlight that E-commerce is leading to a free-rider effect, which means that specific producers which are subject to EPR obligations do not comply with applicable obligations or do not take part in and financially contribute to a PRO (V. Monier *et al.*, 2014). As such, free riders can enjoy the benefits of existing EPR arrangements without the required contributions (Barilla, 2014; Véronique Monier *et al.*, 2014; Hilton *et al.*, 2019). This could, for example, be caused by a lack of awareness of specific E- Commerce actors (e.g. consumers or online shops that are not acting through market places and which are located outside the EU) or by limited oversight and enforcement by authorities and PROs .

The free-rider effect poses several threats to the circular economy (Véronique Monier *et al.*, 2014; Hilton *et al.*, 2019):

- free riders may not contribute financially to PROs, while electrical and electronic equipment produced by them is likely to enter the waste phase in the PROs' Member State. As a result, bigger waste streams will have to be managed by the PROs with less financial resources;
- consumers who purchase EPR-covered products via E-commerce arrangements might not be aware of existing take-back systems. Furthermore, E-commerce sellers may not fulfil their take-back obligations as demanded by relevant EPR systems; and
- purchase of EPR-covered products via E-commerce may contribute to an underestimation of the amount of arising waste from electrical and electronic equipment. This in turn might lead to over-estimation of recycling rates.

The EPR free-rider effect is seen as particularly pronounced for small information and communication technology. Nevertheless, the other product categories are also relevant because of the packaging in which the products are delivered, since free riding can also occur here.

Classification

The EPR Free-Rider Effect can be seen as an indirect effect due to its (negative) impact on the long-term transition towards a Circular Economy.

Current and future relevance

Currently, a great number of EPR systems exists in the EU, based on EU legal requirements (e.g. WEEE Directive 2012/19/EU) or Member State law or non-legislative measures. Existing literature already mentions free riding as an issue with regard to the effectiveness of EPR. In addition, the literature highlights E-commerce as a relevant cause of free riders (Véronique Monier *et al.*, 2014; OECD, 2016; Hilton *et al.*, 2019).

As mentioned above, EPR is receiving renewed attention as an effective policy tool to address some of the waste management challenges and as a potential driver of the Union's envisaged transition to a Circular Economy.

On EU level, the European Commission has expressed in its Circular Economy Action Plan the aim to improve Circular Economy schemes. This aim is pursued by the adoption of minimum conditions for EPR schemes in the amended Waste Framework Directive 2008/98/EC.

On EU Member State level, extended producer responsibility seems to be considered for the management of additional product streams. For example, the national waste management plan of the Netherlands refers to a 2016 study on the role of extended producer responsibility for the Circular Economy in the Netherlands, in which the necessity and feasibility of extension of EPR to new product streams is assessed. The national waste management plan does not draw any conclusions on future extension of EPR and indicates that a more comprehensive analysis and consultation will have to be conducted for specific waste streams, before any decisions on the matter are taken.

At the same time, products covered by EPR systems in the EU are increasingly purchased from third country markets via E-commerce arrangements. A good example is electrical and electronic equipment, such as home appliances and IT equipment. Especially small-size products, which can be bought through multi-seller market places or sent as parcel via postal service could be placed on the internal market unnoticeably. Another example is packaging, which is put on the market in combination with the shipped good.

Although no data on the extent of the free-rider problem could be found, a few general deductions can be made. The combination of strengthened or expanded EPR obligations and increased purchase of EPR-covered products via E-commerce arrangements indicates that the issue of free riders has already become visible and therefore relevant. However, it should be noted that one source indicates that for many EPR systems, the issue of free riders is considered to be limited or non-existent (Véronique Monier *et al.*, 2014). This, in return, contradicts the view of stakeholders that were consulted on this topic, as most see a high relevance in this threat. A study published by the OECD on the impact of online sales on EPR estimates regarding electrical and electronic equipment that the free-rider issue has a magnitude of 5-10% of the OECD EEE market (Hilton *et al.*, 2019). Overall, it is therefore concluded from the above points that there is relevance to this threat, although the extent cannot be accurately assessed.

Supporting factors

- increased purchase of products covered by EPR systems via E-commerce arrangements;
- difficulties in complying with legislation due to non-harmonised EPR registration process in the different EU Member States and often not enforced regulations;
- the exemption from financing obligations (de minimis) for SME might hinder the general monitoring of the system and can lead to unintended effects such as loopholes in the regulations;
- difficulty of identification of E-commerce free riders by competent authorities and PROs (also see section 3.2.5.2 Threat – Enforcement"); and
- Lack of awareness of specific E-Commerce actors (example: consumers or online shops not acting through market places and located outside EU) on EPR obligations.

Mitigating factors

- awareness raising by E-commerce sellers and buyers of relevant EPR obligations;
- identification of E-commerce sellers by PROs and competent authorities;
- enforcement by competent national authorities (also see section 3.2.5.2 Threat – Enforcement"); and
- increase responsibilities of E-commerce sellers, couriers and fulfilment houses as facilitators of products under EPR coming from producers outside the EU and with no national representative.

Options for actions

Scientific Community:

- mapping the magnitude and forms of E-commerce sales of EPR-covered products from third countries.

Producers/Platform providers:

- active compliance assessment of EPR obligations applicable in relevant markets; and
- communication and coordination with PROs' responsible for EPR-covered products.
- increase responsibilities of E-commerce sellers, couriers and fulfilment houses as facilitators of products under EPR coming from producers outside the EU and with no national representative.

Regulators:

- awareness-raising for E-commerce buyers and operators regarding EPR obligations; and
- enforcement of EPR obligations by competent authorities should take E-commerce into account.
- increase responsibilities of E-commerce sellers, couriers and fulfilment houses as facilitators of products under EPR coming from producers outside the EU and with no national representative.

Source of information

Barilla (2014) 'Dry Semolina Pasta Selezione Oro Chef: Environmental Product Declaration'.

Canadian Council of Ministers of the Environment (2007) 'Analysis of the free-rider issue in extended producer responsibility programs (Final report)'.

Ernst&Young (2016) 'Exploration of the Role of Extended Producer Responsibility for the circular economy in the Netherlands'.

Hilton, M. *et al.* (2019) *Extended producer Responsibility (EPR) and the impact of online sales - environment working paper N°142*. Organisation for Economic Co-operation and Development. Available at: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP(2019)1&docLanguage=En.

Monier, V. *et al.* (2014) *Development of Guidance on Extended Producer Responsibility (EPR) - Final Report*. European Commission. Available at: https://ec.europa.eu/environment/waste/pdf/target_review/Guidance on EPR - Final Report.pdf.

NVC Netherlands Packaging Center (2019) *NL: New National Waste Management Plan LAP3 enacted*. Available at: https://www.en.nvc.nl/news/item/nl-nieuwe-landelijk-afvalbeheerplan-lap3-vastgesteld/ (Accessed: 6 August 2019).

OECD (2016) *'20 years of EPR in France: Achievements, lessons learned and challenges ahead', in Extended Producer Responsibility: Updated Guidance for Efficient Waste Management*. Paris: OECD Publishing.

3.2.5.4 Threat – Lack of compliance with common market regulations

Description

Various EU regulations lay down requirements for products which are placed on the internal market. Often, access for these products to the internal market is contingent upon their compliance with these requirements. In various product regulations, requirements pertain to human health and environmental aspects of the product placed on the market. The international market access obtained through E-commerce increases the threat for a lack of compliance with common market regulations.

Discussion

A clear example of such common market regulations is Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

REACH contains various provisions which pertain to the placing on the market of articles (i.e. products) containing specified substances. Firstly, REACH lays down restrictions for the placing on the market of certain dangerous substances, mixtures and articles. For example, Annex XVII to REACH determines that toys which contain a concentration of benzene in the free state, greater than 5 mg/kg (0,0005 %) of the weight of the toy or part of toy, will not be placed on the internal market.

In addition, REACH requires that, under specified circumstances, producers of articles notify the European Chemicals Agency (ECHA) if a substance which is listed in Annex XIV to REACH as a substance of very high concern (SVHC) is contained in an article which is placed on the internal market.

Enforcement of provisions of EU product and chemicals law such as REACH may be challenging for competent authorities, as the more diffuse distribution of products via postal services is subject to different EU customs procedures than international trade flows. Furthermore, it might be challenging for competent authorities to effectively inspect postal consignments on compliance.

The issue of non-compliance with EU products and chemicals regulations poses two interrelated threats to the Circular Economy:

- the Circular Economy concept is based on the design and production of products which do not pose unacceptable risks for human health and the environment. As described above, placing on the market of products via E-commerce might make it difficult for competent authorities to enforce legislation which is aimed at mitigating such risks; and
- recycling waste streams containing specific substances may be forbidden by EU regulations. In addition, REACH and other regulations may prohibit or restrict the use of specific substances in the production of products, and thus also the use of recycled material containing these specific substances. As such, the placing on the market of products containing prohibited or restricted substances may create great challenges for recyclers, once these products enter the waste phase of their life-cycle. Products containing prohibited or restricted substances could get mixed with clean waste streams, which would render these waste streams unsuitable for recycling.

Classification

The aspect of emerging compliance risk can be seen as an indirect effect as it affects the long-term transition towards a Circular Economy.

Current and future relevance

In its 7th Environmental Action Programme (EAP), the EU has committed itself to the objective of a non-toxic environment. To this end, the EAP envisages a strategy which, among other things, aims to ensure "the minimisation of exposure to chemicals in products, including, inter alia, imported products, with a view to promoting non-toxic material cycles and reducing indoor exposure to harmful substances". In 2017, a study for the strategy for a non-toxic environment of the 7th EAP was conducted for the European Commission, highlighting challenges regarding non-toxic material cycles. The envisaged strategy for a non-toxic environment has not been published yet.

Within the context of a Circular Economy, the issue of substances of concern in products' cycles is highlighted in the European Commission's Circular Economy Action Plan. The action plan connects the presence of substances of concern in material cycles with the recyclability of waste streams (European Commission, 2015a)

Based on the above, it can be concluded that the issue of non-compliance with EU products law and its connection with the presence of substances of concern in material cycles is currently perceived as relevant in the EU. Based on the envisaged measures concerning this issue within the context of the Circular Economy Action Plan, future relevance could also be considered likely.

Although this risk generally exists for all product categories, it is particularly pronounced for small information and communication technology, because these types of products usually contain an increased level of potentially hazardous substances and are therefore subject to stricter regulations.

Supporting factors

- diffuse and specific nature of E-commerce, as compared to regular international trade practice.

Mitigating factors

- several national authorities have already set up specialised teams to monitor webpages and trace dangerous products that are sold online. In addition, when such products are identified, EU regulatory authorities can quickly contact the relevant online platforms to take action if needed (also see Section 3.2.5.1 Threat – Difficulty to monitor) (European Commission, 2016b).

Options for actions

Scientific Community:

- mapping the magnitude and forms of E-commerce sales of high-risk products from third countries.

Producers/Platform providers:

- active compliance assessment of EU product law obligations.

Regulators:

- enforcement of EU product law obligations during customs procedures by competent authorities should take specific characteristics of E-commerce into account, e.g.:
    - it could be assessed whether parcels could be placed under specific customs control mechanisms, which are designed to cover import of high-risk products via E-commerce arrangements.

Source of information

European Commission (2013) *Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet', OJ L 354*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013D1386.

European Commission (2015a) *Closing the loop - An EU action plan for the Circular Economy*. doi: 10.1017/CBO9781107415324.004.

European Commission (2016b) *Rapid Alert System for dangerous products - Working together to keep consumers safe - Annual Report*.

European Commission (2017) *Study for the strategy for a non-toxic environment of the 7th Environment Action Programme - Final report*.

European Commission (2018) *Communication on the implementation of the circular economy package: options to address the interface between chemical, product and waste legislation, COM(2018) 32 final*.

3.2.6 Cluster – Logistics and transport

3.2.6.1 Opportunity – In-House Fulfilment

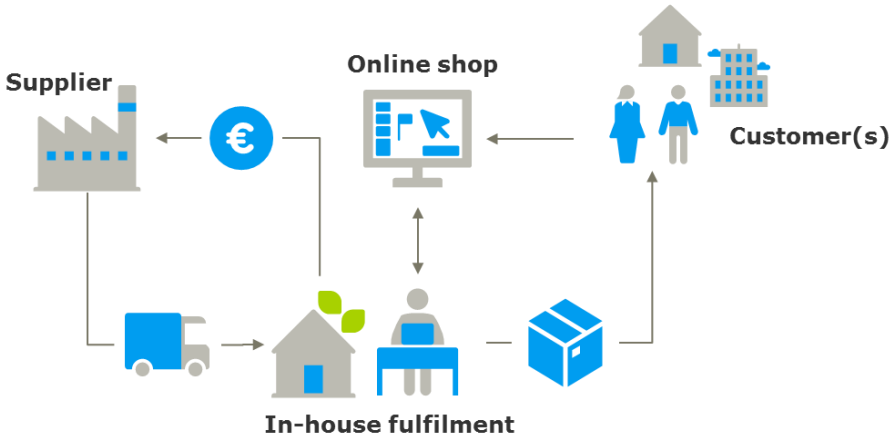
Description

This opportunity applies to small E-commerce businesses that operate from home and do not have any additional storage place. It could be seen as opportunity as it promotes competition and reduces the impacts linked to the necessity of storage space and transport.

Discussion

In-house fulfilment describes here an online enterprise that usually is launched by one or a few persons and runs the entire business from home. It is the smallest and easiest form of fulfilment of the E-commerce sector (ORDORO, 2019). Figure 9 illustrates a basic version of in-house fulfilment. It is characterised by two domains: the connection between retailer and customer via some type of online shop or marketplace, and the connection between retailer and producer/supplier of the product.

Figure 9: Illustration of a simple in-house fulfilment enterprise (based on ORDORO, 2019)



A literature research on this topic shows that in-house fulfilment is not part of the scientific discussion around E-commerce yet. There are several websites promoting this type of business and discussing several advantages and disadvantages (ORDORO, 2019; Starting-Up, 2019). Several terms can be found that describe, at least to some extent, aspects of the described business. Customer-to-customer (C2C), for example, is a common term that usually describes the selling of individual products (often second-hand products) from one to another customer. However, the regular selling of new products as a type of buy-and-sales business can be understood as a C2C business as well. The transition to a traditional business to customer (B2C) model seems seamless and difficult to differentiate exactly. For more details on C2C applications please see the point "ReCommerce" in Section 3.2.4.1.

The impact of in-house businesses on the Circular Economy is difficult to evaluate due to the lack of available information. Nevertheless, it is seen as an opportunity to highlight some aspects that are deemed relevant for a sustainable development and thus for the Circular Economy:

- setting up a simple in-house business is relatively easy and characterised by low entry thresholds. Affiliating with one of the available marketplaces allows a quick and adaptable start of one own business. It is therefore well-suited to empower a part-time self-employment and to push innovation ((Starting-Up, 2019); see also Section "Innovation" 3.2.1.3);
- E-commerce has seen a period of consolidation of the market with a few very large online businesses dominating the market. The possibility to start small businesses for basically every individual initiate a fragmentation process, which in turn increases the market's flexibility to adapt to changing market conditions and consumer demands;

- a strongly differentiated product line, which requires tailoring to the individual user, requires close contact between user and manufacturer for smaller production quantities, whereby the small company can gain an advantage over the large one; and
- niche online retailers meet the requirements of special demands, which is seen as a promoting factor for an emerging "green society" .

Even if the impact of these aspects on the environment is difficult to assess, diversification is nevertheless seen as having a generally positive effect on the Circular Economy.

Due to the poor data situation, it is difficult to assess how the relevance of in-house fulfilment differs between the product categories that are in focus of this study.

Classification

Effects arising from in-house fulfilment are allocated to evolving business models and can be seen as such as supplementary developments. The extent of the effects is hypothetical and rather long-term. They can be considered as indirect effect of E-commerce.

Current and future relevance

As already mentioned, both the data and information situation on in-house fulfilment are very scarce and do not permit any reliable statements about the current market situation. However, a few conclusions can be drawn from the marketplaces that offer microenterprises a platform for trading and which are often used by in-house businesses.

One of the most prominent examples is Amazon Marketplace which enables third parties to sell new or used products in addition to the regular Amazon offers. In 2018, around 50% of all sales come from third-party sellers on this Amazon platform (Amazon, 2019e). Approximately three-quarters of those sellers were small businesses with one to five employees. In 2018, more than 1.2 million sellers joined the different Amazon marketplaces (Amazon, 2019e), which makes this a very thriving market.

Besides this, there are many other significant players that provide, at least to some extent, one form of marketplace to third-party sellers. Among those are Walmart, eBay, Tokopedia, Google, Etsy – to name only a few. All of those players can have a considerable impact on the future markets development. Etsy, for example, increase their sales volume from $314.3 million in 2010 to nearly $4 billion in 2018 (Etsy, 2018).

Overall, the relevance of in-house fulfilment is therefore estimated to be high, although not as visible to the public or politics as the "classic" E-commerce. For the coming years, on the basis of the available data, a further increase in this market is estimated to be probable.

Supporting factors

- low barriers (especially from a legal perspective) to enter the market as in-house business, thus enabling small entrepreneurs and start-ups to develop; and
- marketplaces with easy access and fair-trading conditions.

Mitigating factors

- Complex international trade regulations make trade with non-EU countries more difficult and may have a restraining effect on the development of in-house fulfilment.

Options for actions

Producers/Platform providers:

- open marketplaces that allow the inclusion of third-party providers.

Regulators:

- legal requirements that consider the characteristics of in-house businesses; and
- guidelines for in-house businesses that help to comply with regulatory requirements.

Source of information

Amazon (2019c) *Press release – Amazon.com announces first quarter sales up 17% to $59.7 billion, retrieved from Statista, Percentage of paid units sold by third-party sellers on Amazon platform as of 1st quarter 2019*. Available at: https://www.statista.com/statistics/259782/third-party-seller-share-of-amazon-platform/.

Etsy (2018) 'Annual Report 2018, page 55, retrieved from Statista, Etsy's total annual merchandise sales volume from 2005 to 2018 (in million U.S. dollars),'.

Kreilkamp, E. (1987) *Strategisches Management und Marketing: Markt- und Wettbewerbsanalyse, Strategische Frühaufklärung, Portfolio-Management*.

MarketplacePulse (2018) *Marketplaces Year in Review 2018*. Available at: https://www.marketplacepulse.com/marketplaces-year-in-review-2018.

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Starting-Up (2019) *Gründen im E-Commerce – so klappt der Onlinehandel*. Available at: https://www.starting-up.de/gruenden/selbststaendig-machen/ecommerce-onlineshop.html.

3.2.6.2 Opportunity – Collaboration between companies and partnering with waste management suppliers

Description

E-commerce can enable successful collaboration between online or multi-channel retailers, packaging companies and waste management providers, all of which is necessary to improve the environmental impact along the whole supply chain and product life cycle.

Discussion

E-commerce is in many cases criticized for having a negative impact on our environment. Especially accruing packaging waste and the effects on road traffic are visible to the public. Together with the growing awareness of this problem among customers, the desire for more sustainable packaging and delivery solutions is also growing (Kazarian, 2018). Collaboration between online and multi-channel retailers, packaging companies, logistics providers and also waste management companies fosters synergies to be developed and can enable a more sustainable business model. Some related aspects are mentioned in the following sections: "Optimisation of the supply chain" (Section 3.2.6.3), "Development of dedicated optimised packaging solutions" (Section 3.2.7.1) or "Excessive protective packaging" (Section 3.2.7.2).

The cooperation between suppliers in E-commerce and suppliers in waste management should be emphasized here, as this aspect is seen at the end of the product life cycle and was rather neglected in the past. If the life cycle is considered in its entirety and if end-of-life aspects of packaging are already included in the design and production phase, optimisation can be achieved with regard to reusability and recyclability. These aspects are currently discussed on conferences and trade fairs such as the FachPack in Germany (trade fair for packaging, processing and technology). Companies and stakeholders along the whole value chain (including waste management) are participating to discuss new packaging solutions. With this year's key theme "Environmentally friendly packaging", it suggests that the topic is gaining more attention from the industry.

The adoption of a Circular Economy program entails that a company carries out different strategies to improve the circularity of its production system and also cooperates with other companies over the supply chain for the achievement of a more effective circular pattern.

Classification

All effects related to the collaboration between companies are rather systematic and cannot be allocated to the purchase of one single product. Potential effects are emerging and are of potentially high relevance in the future, which is why they are considered indirect effects of E-commerce.

Current and future relevance

An example is the Amazon's Packaging Support and Supplier Network (APASS) program. With this certification, packaging companies provide services directly to vendors, sellers or manufacturers related to packaging design and testing in compliance with Amazon's guidelines and certification test methods (vendor is defined here as first-party seller, selling to Amazon, while a seller is defined as third-party seller, selling directly to the end-customer; (Amazon, 2019b, 2019d) a manufacturer might be a first-party seller or third-party seller, depending on who the manufacturer is selling to). In addition, packaging manufacturers also have the opportunity to partner with regulatory agencies to set standards for recyclability through public policy (Kazarian, 2018).

This opportunity is of relevance for all product categories in focus of this study.

Supporting factors

- cross-industry conferences, congresses, symposiums and workshops that bring together companies from different parts of the value chain, such as the ISWA World Congress (ISWA, 2019), and
- cross-sector partnerships, such as the initiative for a Global Partnership on Waste Management (GPWM), which shall promote the international exchange between stakeholders with the objectives of resource conversation and resource efficiency.

Mitigating factors

- silo-thinking mentality that prevents companies from collaborating with other industries and that represents a barrier for working on cross-industry solutions.

Options for actions

Producers/Platform providers:

- associations that promote cross-industry cooperation for their members.

Source of information

Amazon (2019b). *Find the right Amazon Solution to grow your business*. Available at: https://sellercentral.amazon.de/ (Accessed: 8 October 2019)

Amazon (2019d). *Grow your business with Amazon*. Available at: https://vendorcentral.amazon.com/gp/vendor/sign-in?ie=UTF8&originatingURI=%2Fgp%2Fvendor%2Fmembers%2Fhome (Accessed: 8 October 2019)

AptarGroup (2018) *Designing for Sustainability – How to reduce E-commerce waste in the packaging design phase*. Available at: http://news.aptar.com/food-beverage/designing-for-sustainability-how-to-reduce-e-commerce-waste-in-the-packaging-design-phase/.

ISWA (2019). *International Solid Waste Association (ISWA) World Congress*. Available at: https://iswa2019.org/iswa-2019-2/ (Accessed: 8 October 2019)

Kazarian, K. (2018) *Breaking Down the Walls for E-commerce Packaging, Packaging Strategies*. Available at: https://www.packagingstrategies.com/articles/90726-breaking-down-the-walls-for-e-commerce-packaging.

3.2.6.3 Opportunity – Optimisation of supply chain

Description

Although enormous efforts have been made by manufacturers of all kinds to optimise their respective supply chains, further optimisation opportunities in the automation of the manufacturing process, the various delivery routes and the payment processes of end customers are attributed to E-commerce.

Discussion

E-commerce has significantly shaped the logistics and supply chain management sector since its emerging (Yu *et al.*, 2016). When customers place an order online, this triggers a process that is both extremely complex and (usually) fine-tuned (Yu *et al.*, 2016). The focus of optimisation efforts is mostly on an increase of material efficiency, reduction of distribution costs and time (Yu *et al.*, 2016). A characteristic of logistics in E-commerce is its relationship to the customer which is much closer than in traditional retail (Yu *et al.*, 2016). While the order itself is rather small, the complexity of its delivery to the final destination increases in comparison to transports to retail stores (Yu *et al.*, 2016). The so called last mile delivery is considered as most important both from a customer's and from an online retailer's perspective (Yu *et al.*, 2016; Ellen MacArthur Foundation, 2019).

The aspects of Internet of Things (IoT), Big Data Analytics, and Cloud Computing are not solely used by E-commerce but is specifically relevant here due to the digital environment in which the whole shopping and purchasing process takes place. The integration of these aspects into a type of digital supply chain enables companies along the chain to implement or optimise the following aspects (4flow, 2015; Kadłubek, 2015):

- limiting inventories;
- increase in flexibility to changing market situations;
- increase the information flow regarding products and customer behaviour;
- reduction of transaction costs;
- intensify the relationship between actors of the supply chain;
- adapt one of the many logistic strategies that fit the company's purpose most;
- advanced analytics of demand data to increase forecast accuracy;
- in-depth evaluation of market environment and customer characteristics; and
- implementation of digital supply chain aspects to address the adequate degree of centralisation and automation.

It should be differentiated here between two aspects: (1) efforts taken to promise customers fast delivery options (such as same- or next day delivery) that might promote the use of inefficient transport options (e.g. aircraft instead of rail transport) and thus can lead to negative environmental impacts; and (2) optimisation efforts that have a potentially positive impact on the environment (e.g. reduction of required inventory space; shortened delivery pathways; etc.). Although both might go hand in hand to some extent, the mentioned aspects have differing objectives.

Classification

Similar to the collaboration between companies, effects arising from the optimisation of E-commerce supply chains are long-term and rather systematic. They are seen as supplementary developments due to adjusting of business models. Respective effects are considered as indirect effects of E-commerce.

Current and future relevance

The relevance of optimisation of supply chains in the E-commerce sector is already extremely high. Competition and efforts taken to shorten the delivery time immensely has put pressure on all actors involved in the market. Currently, companies face several challenges such as same- or next-day delivery, smaller parcel deliveries, last mile delivery (TLI, 2016). The market of E-commerce logistics is increasing together with the growth of the E-commerce market itself. E-commerce Europe (2018) highlights the importance of logistics in the E-commerce sector and gives several examples of companies raising their revenue significantly due to their connection to the constantly growing e-commerce market. Since customers want fast delivery options, optimisation aspects will presumably continue to be of very high importance (Yu *et*

al., 2016; E-commerce Europe, 2018a). The authors recommend that companies adapt their logistics strategy to the specific requirements of their company (Yu et al., 2016) and focus on tailor-made logistics.

The optimisation of supply chain is of relevance for all product categories in focus of this study.

Supporting factors

- Optimised logistics chains with focus on route planning and vehicle substitution (e.g. rail instead of truck, electric transporter instead of petrol) (Postpischil and Jacob, 2019a).

Mitigating factors

- cross-border E-commerce increases complexity of logistic requirements immensely and is one of the players' key challenge (E-commerce Europe, 2018a).
- significant regional differences in the logistic infrastructure (E-commerce Europe, 2018a).

Options for actions

Scientific Community:

- further development and dissemination of indices such as the Logistics Performance Index (LPI), which help countries to identify weaknesses but also opportunities in freight transport infrastructure.

Producers/Platform providers:

- avoid multiple journeys by agreeing on delivery windows, desired neighbours, desired delivery locations (e.g. garage, parcel boxes or parcel stations) (Postpischil and Jacob, 2019a).
- cross-industry collaboration including players from all parts of the value chain (also see Section 3.2.6.2 Opportunity – Collaboration between companies and partnering with waste management suppliers").

Source of information

4flow (2015). 'E-commerce: Building an optimized digital supply chain in 5 steps'. *4flow newsletter*, 2. Available at: https://www.4flow.com/fileadmin/4flow/user_upload/newsletter/2016/2_2016/4flow_newsletter_2__2016.pdf.

E-commerce Europe (2018) 'European Ecommerce Report 2018 Edition'. Available at: www.haendlerbund.de/de/downloads/ecommerce-europe/european-ecommerce-report-2018.pdf.

Ellen MacArthur Foundation (2019) *Reuse - Rethink packaging*. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/Reuse.pdf.

Kadłubek, M. (2015) 'The Selected Areas of E-logistics in Polish E-commerce', *Procedia Computer Science*. Elsevier Masson SAS, 65(Iccmit), pp. 1059–1065. doi: 10.1016/j.procs.2015.09.052.

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TLI (2016a) 'E-Commerce Trends and Challenges'. Available at: http://www.ecwreit.com/misc/E-commerce_trends_and_challenges.pdf.

Yu, Y. *et al.* (2016) 'E-commerce Logistics in Supply Chain Management: Practice Perspective', *Procedia CIRP*. The Author(s), 52, pp. 179–185. doi: 10.1016/j.procir.2016.08.002.

3.2.6.4 Opportunity – Substitution of individual shopping trips

Description

Traditional commerce via brick-and-mortar stores requires customers to travel to the shop physically, which causes pressure on traffic and infrastructure. E-commerce turns this way of shopping around by allowing customers to order from home or on the go and have their order delivered to their front door, without any need to visit the physical store.

Although the substitution of individual shopping trips is considered here as an opportunity, it should be noted that there can be considerable differences on the environmental impact of this aspect depending on area and infrastructure (urban centre, rural area, area of high population density, etc.) and on the types of transportation used.

Discussion

Two of the main features of E-commerce - ordering products online and having them delivered to your front door - have a substantial impact on the way we shop. People no longer have to go physically to the store and no longer have to bring purchased goods home themselves. Instead, the order is conveniently received at home. The trips of the individual buyers to the shops are no longer necessary (with the exception of hybrid models) and deliveries are made to customers by parcel services, which try to optimise their routes. This has an impact on traffic and therefore on the environment. Different and sometimes oppositely results were identified in current research on the extent of the described environmental impact. However, it is certainly clear that the region (urban, rural) and the choice of transportation type play a decisive role.

The assessment of the environmental impact is challenging as the methodological approaches and applied system boundaries are manifold and as uncertainties about people's behaviour is high. Smidfelt Rosqvist and Hiselius, for example, state in their 2016 study about online shopping habits that it is unclear, whether a potential substitution of individual shopping trips might lead to trips for other purposes (rebound effect). The authors still identify a potential decrease of CO_2 emissions due to online shopping. Van Loon *et al.* (2015a) highlight the already mentioned importance of transportation method and basket size to evaluate the environmental impact. Going shopping in a physical store by bike significantly reduces the environmental impact, and the same goes for large basket sizes (both in online retail, if delivered in on parcel, and traditional retail). Further, a study from the German Federal Environment Agency states that E-commerce can have a positive effect on CO_2 emissions especially in rural areas, where people usually use their car to go to stores. The authors also point out, however, that this is opposed by fast deliveries options (e.g. same day delivery) (Umweltbundesamt, 2018b).

Overall, results from the literature research led to the conclusion that E-commerce has a potential to decrease CO_2 emissions of the transportation sector, which would be an important contribution to reach national CO_2 reduction targets. It is therefore considered worthwhile to include the substitution of individual shopping trips as opportunity in this study. Especially because the E-commerce sector with its attached logistics is increasingly focusing on alternative transportation methods. Large players, in particular, are in a position to accelerate the implementation of alternative transportation methods.

Classification

The substitution of individual shopping trips has a consequential and immediate (intended) effect. It is a characteristic of the current situation in E-commerce and further persistence in future scenarios is likely. Arising effects are considered direct effects of E-commerce.

Current and future relevance

The number of shopping trips conducted per person per day is an important indicator to evaluate the relevance of individual shopping trips. As people in different countries have different shopping behaviours also the number of trips to stores varying between the EU Member States. A study from (JRC, 2013) show that between 0.1 and 1 shopping trips are conducted per person per day in 2013. In this context, the car is by far the most frequently chosen means of transport (JRC, 2013). Rosqvist and Hiselius analyse the market for several EU Members States, for which they state that around 20% of all trips (~10% of total passenger mileage) is done for shopping purposes. The car is used in around 30% of times (Winslott-Hiselius, Schmidfelt Rosqvist and Adell, 2015).

Shown numbers indicate a high relevance for the aspect of substitution of individual shopping trips as shopping puts a considerable amount of pressure on infrastructure and traffic.

This opportunity is of relevance for all product categories in focus of this study.

Supporting factors

- As a direct effect of E-commerce the development of this opportunity is supported by all those factors that contribute to a satisfactory online-purchasing experience. a multi-faceted concept that takes into account regional particularities.

Mitigating factors

- delivery of damaged products diminishes positive effects;
- high return rates diminish positive effects; and
- faulty delivery (customer not present, wrong delivery address, etc.) diminishes positive effects.

Options for actions

Producers/Platform providers:

- highlight the environmental impact of sending multiple packages compared to one package (also see Section 3.2.2.1, "Nudging").

Source of information

Carrillo, J. E., Vakharia, A. J. and Wang, R. (2014) 'Environmental implications for online retailing', *European Journal of Operational Research*. Elsevier B.V., 239(3), pp. 744–755. doi: 10.1016/j.ejor.2014.05.038.

JRC (2013) *Analysis of National Travel Statistics in EuropeOPTIMISM WP2: Harmonisation of national travel statistics in Europe*, *Scientific and Technical Research Series*. doi: 10.2788/59474.

Smidfelt Rosqvist, L. and Hiselius, L. W. (2016) 'Online shopping habits and the potential for reductions in carbon dioxide emissions from passenger transport', *Journal of Cleaner Production*. Elsevier Ltd, 131, pp. 163–169. doi: 10.1016/j.jclepro.2016.05.054.

Umweltbundesamt (2018b) *Konsum 4.0: Wie Digitalisierung den Konsum verändert*. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/fachbroschuere_konsum_4.0_barrierefrei_190322.pdf.

Van Loon, P. *et al.* (2015) 'A comparative analysis of carbon emissions from online retailing of fast moving consumer goods', *Journal of Cleaner Production*. Elsevier Ltd, 106(2015), pp. 478–486. doi: 10.1016/j.jclepro.2014.06.060.

Winslott-Hiselius, L., Schmidfelt Rosqvist, L. and Adell, E. (2015) 'Travel Behaviour of Online Shoppers in Sweden', *Transport and Telecommunication*, 16(1), pp. 21–30. Available at: https://www.researchgate.net/publication/276429065_Travel_Behaviour_of_Online_Shoppers_in_Sweden.

3.2.6.5 Threat – Damage on delivery

Description

The delivery of products to end-consumers instead of delivery to retail shops typically increases the handling of products. This can increase the number of products that have already been delivered defective, which in return increases the impact on transport and the environment.

Discussion

Damage during transportation does occur both in logistics for E-commerce and logistics for traditional commerce. However, E-commerce supply chains have some specific features which appear to favour damage to the delivered goods. A central aspect is the (usually) higher complexity of the supply chain and the associated necessity to "handle" the product more often (Smith, 2019a). The last mile delivery is particularly noticeable as it is a major difference between traditional logistics and E-commerce related logistics and as it increases the needs for manual handling.

There are many reasons why products can be damaged during transport. Logistics companies list the following points as important causes (PackagingDigest, 2014; Teter, 2016; iGPS, 2018; Smith, 2019a):

- load shifting;
- improper packaging;
- forklift damage;
- pallet damage;
- road, weather and warehousing conditions; and
- machine or human error (e.g. dropping or throwing of parcels).

One of the counter measures to damage products is adequate protective packaging. As broken goods are a very unsustainable and costly aspect of every business that requires the transport to some kind of customer, companies usually use protective packaging solutions. As shown in Section 3.2.7.2, this is sometimes used to an excessive extent. The right balance between product protection and material efficiency is a challenge for every company.

An aspect that is not in the focus of this section but still worth mentioning is damage on return. Some products arrive unharmed at the customer but are damaged when returned to the producer. A survey conducted by Haendlerbund in Germany indicates that for the apparel sector a total of 20% of all returned products is worn, dirty or without label (Händlerbund, 2016).

Classification

The damage of products during transportation to the customer are supplementary developments due to special conditions in the E-commerce supply chain, therefore this aspect is considered as indirect effect of E-commerce.

Current and future relevance

Although data on the number of defective products delivered to the customer varies in literature, it is of significant relevance for online retailers. Products that arrive (partially) damaged at the customer are seen as least sustainable option by the industry (Hattersley, 2019). Another important aspect is customer satisfaction. It was mentioned already several times that customers of E-commerce demand a fast delivery of their purchased goods. A damaged product is obviously contradictory to the goal to satisfy the customer's demands.

It should be noted that the percentage of damaged products differs between product category. Especially clothing is usually less susceptible to damage than, for example, IT equipment or large household appliances, which require, among other things, a higher degree of shock protection (Statista Research Department, 2014). In general, it is estimated that around 15-20% of purchases are sent back because the product arrived damaged (Statista Research Department, 2014; Gallup Institut, 2018).

Supporting factors

- high rates of failed deliveries increase the need for manual handling of parcels, as the parcel has to be taken out of the delivery vehicle and returned several times by the delivery service before it finally reaches the customer; and
- fast delivery options (e.g. same- or next-day delivery) increase pressure on delivery services, which in turn increases the probability that a mistake is made during manual processing (e.g. unloading or stacking of parcels).

Mitigating factors

- collaboration with providers of E-commerce-capable packaging solutions that are designed to withstand vibrations, shock, pressure, and drops.

Options for actions

Scientific Community:

- development of dedicated packaging solutions that do not only fit the purpose of certain product characteristics, but that are also economically feasible as well as scalable (see Section 3.2.7.1 Opportunity – Development of dedicated optimised packaging solutions").

Producers/Platform providers:

- online-retailers can collaborate with providers of E-commerce-capable packaging solutions that are designed to withstand vibrations, shock, pressure, and drops.

Source of information

Gallup Institut (2018) 'Post Branchenmonitor E-commerce 2018 – Eine quantitative Untersuchung, available at':

Händlerbund (2016) *Retouren-Studie 2016 – Wie fair sind Kunden um Online-Handel?* Available at: https://www.haendlerbund.de/de/downloads/studie-retouren-2016.pdf.

Hattersley, V. (2019) *E-PACK Europe: The challenges and opportunities of e-commerce, Packaging Europe*. Available at: https://packagingeurope.com/e-pack-europe-the-challenges-and-opportunities-of-e-commerce/ (Accessed: 12 August 2019).

iGPS (2018) *How to reduce product damage during transportation*. Available at: https://igps.net/blog/2018/08/30/how-to-reduce-product-damage-during-transportation/.

PackagingDigest (2014) *Mitigating packaging damage in the supply chain*. Available at: https://www.packagingdigest.com/supply-chain/mitigating-packaging-damage-inthe-supply-chain140910.

Smith, D. (2019a) *e-Commerce Packaging Supply Chain*. Available at: https://www.dssmith.com/packaging/industries/e-commerce-e-retail/discs.

Statista Research Department (2014) *Share of online customers who experienced problems with purchases in the United Kingdom (UK) as of April 2015, by problem/issue*. Available at: https://www.statista.com/statistics/451331/online-commerce-order-delivery-problems-in-the-united-kingdom/.

Teter, B. (2016) *Shipping Guide, Eurosender*. Available at: https://www.eurosender.com/blog/en/why-a-parcel-get-damaged/.

3.2.6.6 Threat – Individual product delivery

Description

This threat describes the individual delivery of products that originates from a purchase of a basket of several products: instead of delivering all products together, sometimes each product is delivered individually. Moreover, it additionally considers the shipping policy of some online retailers that allows customers to purchase individual products without having economic drawbacks (free shipping even for single purchases).

Discussion

When a customer places an order in an online shop, a supply chain is triggered at the end of which there is usually the delivery of the order in one or more packages. The parcel is then unboxed by the receiver of the package, which leads to packaging waste (see "Secondary packaging" in Section 3.2.7.3 for more details). An unnecessary increase in packaging waste can occur when products that are purchased within one order are still sent in several different parcels.

Some reasons that might lead to and individual delivery are the following (Amazon, 2019f; Zalando, 2019b):

- different availability of the ordered products;
- products are not stored in the same warehouse and are shipped from different locations; and
- products are delivered by partners affiliated to the online-shop/retailer and thus are not stored at the same warehouse.

Products that are ordered together within one purchase process do not necessarily have to be stored in the same warehouse or fulfilment centre. If this is the case, they are typically sent to the customer from varying locations in different parcels. In case that the products would be stored in the same warehouse, but the availability is different, the aspect of fast delivery becomes of increased importance. Waiting for all components of an order is often not included as an option, as the customer usually expects the fastest possible delivery.

Classification

Individual product delivery is considered as a secondary development due to E-commerce and arising effects are considered indirect effects of E-commerce.

Current and future relevance

The current as well as the future relevance of the individual product delivery could not be assessed due to the lack of available data and information. Nevertheless, the effects on the Circular Economy are expected to be closely interconnected with those of other identified threats such as "Induced parcel transport" (Section 3.2.6.8) or opportunities, such as "Substitution of individual shopping trips" (3.2.6.4), and therefore might have a high importance if aspects are considered in a combined way. In addition, the relevance of this threat is expected to be highly dependent on the customers behaviour; an analysis of customers choices in case they are offered the option of waiting for all orders to be ready before delivery would shed a better light on this topic.

Although this threat generally exists for all product categories, it is particularly pronounced for apparel and other product categories with a tendency towards smaller and multiple products per purchase.

Supporting factors

- increasing demand for fast delivery options (same- or next-day delivery); and
- absence of financial incentives to wait for orders to be ready to be shipped within one parcel.

Mitigating factors

- nudging – highlighting the environmental impacts of individual deliveries. This is only useful if the customer is given the opportunity to choose an option such as "wait for the availability of all products before shipping them in a single package" (see Section 3.2.2.1 "Nudging" for more details).

Options for actions

Producers/Platform providers:

- clear communication and transparency about the origin of the different products included in the basket.

Source of information

Amazon (2019f) *Über das Zusammenfassen von Bestellungen in einer Lieferung*. Available at: https://www.amazon.de/gp/help/customer/display.html?nodeId=201910270.

Zalando (2019b) *Warum kommt meine Bestellung in mehreren Paketen?* Available at: https://www.zalando.de/faq/Versand-Lieferung/65776482/Warum-kommt-meine-Bestellung-in-mehreren-Paketen.htm.

3.2.6.7 Threat – Induced freight traffic to remote locations

Description

The effects of online trade on urban and rural areas can vary considerably, making a differentiated approach in analysing them necessary. Deliveries to rural areas are characterised, among other things, by particularly long delivery routes and lower efficiency in logistics. This entails the danger of increased environmental influences, especially in connection with fast delivery options and individual deliveries.

Discussion

While urban planning usually subdivides available space into three categories (urban regions, regions with partial densification and rural regions), the rough distinction between "land" (rural) and "city" (urban) is sufficient from a logistical point of view (BBSR, 2018). The delivery concepts differ only significantly between these two categories (BBSR, 2018). This Section focuses on rural areas and uses the term “remote location” to highlight the challenges of deliveries and delivery services to areas of (very) low population density.

Not all delivery concepts can be economically achieved for remote locations and large differences can be seen in the structure of passenger transport and in the availability of logistic space (BBSR, 2018). From an online retailer perspective, deliveries to remote locations are much more expensive and difficult to organize in an efficient way (Oenning, 2015). At the same time, delivery options such as same-day or next-day delivery, which are common in urban areas, are usually not economically viable in rural regions and are often not offered by the online stores. It should be noted that customers in remote locations currently emphasize less on fast delivery options, but more on the possibility to delivery to a neighbour’s place (PostEurop, 2019).

It might seem more environmentally friendly to substitute individual trips by car to the supermarket with home delivery services from online retailers in rural areas, as it is shown in a recent study by the German Environmental Protection Agency (Umweltbundesamt, 2018a). At the same time, however, delivery services operate in such regions much more energy-intensively than in urban areas and the environmental impact is highly dependent on the means of transportation (BBSR, 2018). Some concepts, such as the direct delivery without additional packaging, hybrid-models with delivery to stores or parcel stations, might only be available in urban areas (Verbraucherzentrale, 2017).

Possible savings in CO_2 emissions that could be generated by substituting passenger transport are put into perspective especially when other risks of online trading are included in the equation. Especially the aspects of “damage on delivery” (Section 3.2.6.5), “individual product delivery” (Section 3.2.6.6), and “parcel return” (Section 3.2.6.11) have a relative high impact on the environmental performance of such deliveries. A concept worth mentioning here is the so called “Große Emma”, which fosters a regional supply infrastructure to ensure the supply of the population in low density areas of Germany (BBSR, 2018). This approach tackles the problem of poor supply in sparsely populated areas and at the same time mitigates the negative effects of online trading.

In addition, the differences in customer densities bring certain advantages to urban areas over rural regions in terms of bundling of activities of the logistic sector (BBSR, 2018). At the same time, although not included in the scope of this study, it should be considered that E-commerce improves the accessibility and availability of goods and thus increases the appreciation in value of the rural area (BBSR, 2018).

Classification

Induced freight traffic to remote locations is considered as a supplementary development arising from E-commerce and evolving business models. Affiliated effects are therefore considered indirect effects of E-commerce.

Current and future relevance

Although most EU citizens live in predominantly urban and intermediate land regions (around 80% in 2016), with 20% there is still a considerable number of people living in predominantly rural areas – approximately 98 million people (Umweltbundesamt, 2018b). This can be considered an important market for E-commerce, which is also reflected by the number of packages delivered in rural regions. In 2016, nearly 300 million packages of all sizes were delivered to customers living in rural regions in Germany alone (BBSR, 2018). This number is expected to reach around 500 million deliveries till the year 2030 (BBSR, 2018). In comparison to urban areas, E-commerce revenue in rural areas grew disproportionately by 17% in Germany in 2017 (Hoffmann, 2018).

Same- or next-day delivery in remote locations are currently of less relevance than in urban areas. Flexibility in receiving the parcel is of more importance to customers in such regions. At the same time, however, this type of fast delivery is estimated to become of more relevance in rural areas as well (Joerss *et al.*, 2016). The problem of cost efficiency will remain for these regions, which is why the introduction and use of (partly) autonomous deliveries will become more important in the future (BBSR, 2018).

Additionally, the driving technology is likely to change on a large scale. By 2015, almost all delivery vehicles had still been powered by fossil fuels (BBSR, 2018), while estimates show that in particular electric drives as drive types in road freight transport will become much more widespread (BBSR, 2018).

This threat is of relevance for all product categories in focus of this study.

Supporting factors

- less dense network of automated parcel deposit and pick-up station (BBSR, 2018).

Mitigating factors

- introduction or more widespread use of new drive technologies such as electric delivery trucks (Joerss *et al.*, 2016).

Options for actions

Regulators:

- integration of concepts such as "Große Emma" (see chapter above) in less densely populated and structurally weak areas in the regional development programmes in order to promote cooperative forms of physical and digital networking in the retail trade (BBSR, 2018).

Source of information

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3.2.6.8 Threat – Induced parcel transport

Description

E-commerce implies that parcels with the purchased products are sent to the consumer, which can have a significant impact on environmental aspects related to transport and logistics. Parcel delivery in general means the movement of goods from a transportation hub to a destination. Here, we focus on the induced parcel transport represented by the last mile delivery, namely the delivery to a private consumer, typically to a personal residence (B2C) as well as other delivery options such as parcel shops or automatic parcel stations (Prümm, Kauschke and Peiseler, 2018).

Discussion

The growth and diversification of the E-commerce-market is increasing the number of parcel deliveries, carried out mainly by pickup trucks. The consequence is an increase in traffic, noise, energy demand and thus the increased production of greenhouse gases. These negative effects are further compounded by a currently inefficient parcel delivery system, due to a high delivery failure rate (missed or lost parcels) and the problem that often several delivery attempts are necessary. A low efficiency is also caused by the wide utilisation of the traditional "Hub and Spoke" delivery model. Each central location (Hub) is usually shared by several e-commerce players with differing pick-up times, which hampers the consolidation of parcels (deliveries) to end customers. Thus, parcel delivery routes are highly affected by delays in the central warehouse (Hong *et al.*, 2018; Prümm, Kauschke and Peiseler, 2018).

On the other hand, parcel delivery to personal residences may replace private shopping trips. Especially in rural areas the car would primarily be used for the shopping trip, but in urban areas these trips are primarily carried out by bicycle, by foot or by public transportation, with a lower environmental impact than the delivery by a pickup truck.

Besides the negative impact due to the growth of the traffic volume, an increase in parcel delivery can also increase the resource consumption for the parcel itself (cardboard) and the necessary packaging material for the items in the parcel.

Classification

Parcel delivery is classified as a direct effect of E-commerce.

Current and future relevance

The B2C parcel market is not just a large, but also a highly dynamic market. Since 2013 the European parcel market is growing by 12.5% on average per year, driven largely by the growth of the E-commerce market. This resulted in an annual revenue of 19 Bn. €. Further growth is expected for the next years. All together (B2C, C2X and B2B) 8.7 Bn. items were shipped in 2016; the majority of the items were delivered in Germany, UK and France. An increase of cross-border deliveries can also be identified (Dieke, 2018).

The market is strongly dependent on the consumer's needs, who asks for faster, better and cheaper parcel delivery (Hong *et al.*, 2018). In addition, the consumer demands transparency, for example through a better tracking of the parcel's location via a tracking app, or similar (Prümm, Kauschke and Peiseler, 2018). For the future this means an increase in the use of new technologies including drones and autonomous ground vehicles, but also bike couriers could play a more important role for the parcel delivery in urban areas (Joerss *et al.*, 2016).

This threat occurs in all product categories in focus of this study.

Supporting factors

- competition in the E-commerce market;
- persistent consumer preference for cheap delivery prices and fast deliveries; and
- factors of unpredictability (change of consumer demands, traffic etc.).

Mitigating factors

- shifting the delivery costs to the consumer, if the first delivery attempt was not successful (e.g. consumer was not at home); and
- automation in order and delivery processes (e.g. increase automated processing).

Options for actions

Scientific Community:

- raise awareness of the link between packages delivered and environmental impacts (see also "Nudging" in Section 3.2.2.1).

Producers/Platform providers:

- mitigation options of the negative effects of a traffic increase: optimising supply chain operations and the logistic system (efficiency standards, better connection of different transport networks; see also opportunity "Optimisation of supply chain" in Section 3.2.6.3);
- improving data management (e.g. better forecast);
- offering trainings for delivery personnel;
- offering the selection of personalised delivery times/dates for consumers in order to avoid failed-deliveries;
- providing the possibility for the consumer to track the delivery – developing new platforms;
- avoiding individual orders delivery (orders should only be shipped in full; see also threat 'Individual product delivery' in Section 3.2.6.6);
- avoid unnecessary packaging for the parcel content or use sustainable packaging materials (renewable resources, reusable; (renewable resources, reusable; see Section 3.2.7 for more details);
- make use of the smallest possible outer packaging (see Section 3.2.7 for more details); and
- offering flexible delivery options, such as specific service points, lockers, or as hybrid model with delivery directly to the respective shops.

Regulators:

- amending packaging and packaging waste legislation, e.g. creating incentives for reduction of packaging material used by producers.

Source of information

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3.2.6.9 Threat – Inefficient transport

Description

The E-commerce's promise of very short delivery times can favour less efficient utilisation of trucks and other means of transport whose loading capacities are not optimally utilised. Moreover, the increased use of faster means of transport can lead to additional negative environmental impacts due to a higher fuel consumption, threatening the realization of the EU's own targets for reducing CO_2 emissions in the transport sector.

Discussion

As shown in Section 3.2.6.3 companies active in E-commerce are already making great efforts to optimise their supply chains. At the same time, it was pointed out that this optimisation - at least partly - has the objective of promising customers the shortest possible delivery times. Among other consequences, immense pressure is put on logistics companies. Delivery time has become one of the most important factors for E-commerce and related transport. Optimal utilisation of delivery capacities and thus effects on the environment often play a secondary role (Choo *et al.*, 2016).

The factors to be considered for calculating both costs and CO_2 emissions of transportation for the shipment of parcels are described by Pålsson (2018), as follows: incurred costs, incurred CO_2 emissions, shipping distance, empty trips, load factor, and maximum loading capacity of the vehicle. In the context of the present threat, the aspect of "load factor", which indicates how efficiently the loading capacity of a transport vehicle is being used, is considered of most relevance. Decreasing the load factor has in fact a direct effect on the amount of CO_2 emitted per parcel transported (Pålsson, 2018).

A related aspect is the increase of traffic due to last-mile delivery trucks. With E-commerce expected to continuously increase its share of the overall retail market, competition between couriers, express and parcel delivery companies is very high with the expectations of a changing market due to new technologies applied (Heid *et al.*, 2018). Competing with other players increases the threat of delivering parcels in a half-empty vehicle.

Classification

Inefficient transport is considered as a supplementary development arising from E-commerce; related effects are therefore regarded as indirect effects of E-commerce.

Current and future relevance

According to a survey conducted by PricewaterhouseCoopers (PWC) for their Consumer Insight Report 2018, more than half of the surveyed persons stated that they expect their order to be delivered within two days and with more than one-third even expecting next- or same-day delivery (PWC, 2018a). When being asked, whether they would pay an additional charge for delivery within a specific time, a significant majority stated that they would pay for same- or next-day delivery (PWC, 2018a). However, in other cases the willingness to pay for this additional option appears to be very limited (Joerss *et al.*, 2016), with some surveys yielding different results. Companies may be tempted to continue offering the service with an increased price for delivery, but even if this may cover the additional costs incurred by the companies, it does not necessarily have an impact on the capacity utilisation of the delivery vehicles. On the contrary, passing on the costs to the customers does not give the companies any additional incentive to better utilise available loading capacities.

The relevance of inefficient transport is therefore very high and is estimated to continue as high for the near future. Additionally, this threat can be seen as relevant for all product categories in focus of this study.

Supporting factors

- the customer's desire and willingness to pay for fast delivery options is one of the driving factors to inefficient transport (Heid *et al.*, 2018). As long as companies play along and see short delivery times as essential factor to compete on the international E-commerce market, this will hinder the transition to more sustainable transportation.

Mitigating factors

- delivery to (automatized) parcel shops and similar for urban areas (BBSR, 2018); and
- some surveys suggest that customers would not use fast delivery in the case of a (significant) increase in costs.

Options for actions

Scientific Community:

- comparative studies to evaluate both the technical and economic feasibility of technologies that are currently developed and tested.

Producers/Platform providers:

- investing in alternative transportation modes (e.g. e-bikes for last-mile delivery, rail freight transport, light weight transport vehicle fleet).

Regulators:

- incentivising the investment in alternative transportation modes and modernisation of vehicle fleet; and
- comprehensive development programmes to promote sustainable delivery (e.g. eco-driving) technologies and the expansion of the associated infrastructure (e.g. E-Highways).

Source of information

BBSR (2018) *Verkehrlich-Städtebauliche Auswirkungen des Online-Handels, Bundesinstitut für Bau-, Stadtund Raumforschung*. Available at: https://www.bbsr.bund.de/BBSR/DE/Home/Topthemen/Downloads/online-handel-lieferverkehr.pdf?__blob=publicationFile&v=1.

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3.2.6.10 Threat – Inferior types of transportation

Description

Online shops often offer a range of fast delivery options (e.g. same day or next day delivery) that are still in high demand from customers. This, among others, has an impact on the choice of the means of transport. In particular products that are not stored in a warehouse in the immediate vicinity of the customer need to be transported by faster means of transport (e.g. by plane instead of by railway). This can increase CO_2 emissions and result in a higher environmental burden.

Discussion

Two of the most relevant characteristics of E-commerce are relatively short delivery times and international market access. The latter might often be not obvious to the customer, as he or she typically focuses on delivery time and costs. However, both aspects favour the use of means of transport that cause a higher environmental impact. Although the traditional retail trade obviously also receives goods from abroad, these are usually not tied to such narrow time windows as in online trade. Air freight is of particular importance to online retail to make the short delivery times possible at all (BDL, 2017). The Federal Association of the German Air Transport Industry, for example, reports based on data from the Federal Statistical Office in 2017 that more than 90% of all smartphones come to Germany by air. It should be noted here that freight is frequently transhipped again within Europe and redistributed to flights throughout Europe (BDL, 2017).

The efficiency of the different means of transport varies significantly. Freight transport via railways, for example, generates around half of the greenhouse gas emission generated by transport via inland waterways, and around one-fifth compared to transportation via lorry – transport via plane being the least efficient alternative (Umweltbundesamt, 2018a). Regarding air freight, it is important to consider that CO_2, but also nitrogen oxides, aerosols and water vapour are emitted in high altitudes where they are contributing more to global warming than emissions generated on the ground (Umweltbundesamt, 2018a). A recent report from the German Federal Environment Agency reports that "these various effects add up to such an extent that the greenhouse effect of flying is on average two to five times higher than the sole effect of the emitted CO_2" (Umweltbundesamt, 2018a).

Classification

Similar to inefficient transport, also inferior types of transportation can be seen as supplementary developments of E-commerce and are as such considered as indirect effect of E-commerce.

Current and future relevance

The relevance of using freight transport modes that are decreasing the transportation sector's environmental impact is very high. The EU has set several targets to reduce greenhouse emissions till 2050 by 80-95%, including transportation sector's specific targets (Öko-Institut, 2013). At the same time, forecasts announce a continued growth in freight traffic - for Germany, freight traffic is expected to double by 2050. As a result, the transport sector is under immense pressure to achieve the specified savings in climate-damaging emissions and, at the same time, to manage the growing trade in goods (Öko-Institut, 2013).

As there is currently still very strong dependence on fossil fuels, it becomes clear that a fundamental change has to be initiated (Öko-Institut, 2013). It is worth taking a more differentiated look at the sector, as there are differences between the different transportation modes (Öko-Institut, 2013):

- trucks: It is estimated that trucks can gain around 30% efficiency over the next decades by further promoting alternative propulsion technologies, such as electric driving;
- airplane: Already the least environmentally friendly option, it is currently difficult to foresee any significant increases in efficiency. In contrast to many transport options on land, there are currently few promising concepts in aviation that would suggest a comprehensive and fundamental change in propulsion technology. Investment costs and usage times of aircrafts are much higher than in other parts of the transportation sector. A renewal takes time – even with promising concepts; and
- transport on waterways: Similar to the developments on the street, there are also some promising concepts that allow to estimate an efficiency increase of around 40% till 2050 compared to 2010.

This threat is in general relevant for all product categories in focus of this study.

Supporting factors

- economic development is still seen as important factor for a nation's wealth, which in return is coupled to national and often international trade. A fast, safe, and cost-effective movement of goods is considered very important to reach this goal (Eurostat, 2018), which in turn may have an impact on the choice of means of transport. A superior mode of transport from a sustainability perspective is often not the most cost-effective and its use is therefore more infrequent. Instead, more cost-efficient means of transport and thus inferior types of transport (from a Circular Economy point of view) are used.

Mitigating factors

- introduction of more low-emission vehicles (LEV) (Bogdanski, 2019);
- implementation of an electrical high-speed rail network between main transhipment hubs and expansion of existing networks to reduce the need for short-distance freight flights (Iea, 2019);
- new concepts such as electrification of most important motorway routes with overhead lines (Öko-Institut, 2013); and
- for last mile delivery in urban areas non-motorised vehicles (e.g. cargo bikes) or pick-up stations on strategic locations of the city (e.g. railway station, central market areas) can substitute current delivery methods (BBSR, 2018).

Options for actions

Producers/Platform providers:

- highlighting the environmental impact of fast delivery option (same- or next-day delivery) to the customer (see "Nudging" in Section 3.2.2.1).

Source of information

BBSR (2018) *Verkehrlich-Städtebauliche Auswirkungen des Online-Handels, Bundesinstitut für Bau-, Stadtund Raumforschung*. Available at: https://www.bbsr.bund.de/BBSR/DE/Home/Topthemen/Downloads/online-handel-lieferverkehr.pdf?__blob=publicationFile&v=1.

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3.2.6.11 Threat – Parcel return

Description

Sending packages back (parcel return) is one of the more obvious and well-known challenges of E-commerce. It is described here as a threat because it adds additional pressure to the transport sector. The return of parcels can have different reasons, which are important to evaluate. Thus, tailored countermeasures can potentially be developed and applied.

Discussion

In order to determine whether this aspect applies to each of the product categories within the scope, it is advisable to take a look at the underlying EU legislation. Legislation within the EU clearly states that consumers have the legal right of withdrawal for purchases made online and thus the right to send back such products for any reason. The so-called cooling off period expires 14 days after a consumer has received the purchased product (EU Directive 2011/83/EU on consumer rights). To give only a few examples for exemptions:

- sealed audio, video or computer software, which the customer has already unsealed; and
- digital online content, if the purchaser already started either downloading or streaming the product.

Costs incurred by the return shipment do not have to be paid by the supplier of the product and can be passed on to the purchaser, when this was made clear before the completion of the purchase. In practice, however, the costs are often borne by the suppliers of the products. This 'free return policy' was presumably introduced with the aim of strengthening and developing E-commerce in general. One has to keep in mind that one of the major disadvantages of E-commerce compared to physical shops is that the customer only sees the products virtually and not physically in front of him. This creates a clear difference in the shopping experience, especially when it comes to apparel - changing rooms are an integral part of every physical clothing store. With the free return option, online retailers advertise that products can be tried on at home and thus promote the purchase of a selection of similar or even the same product (in different sizes). As a result, nowadays return logistics has to cope with a flood of returned parcels. Especially for 'apparel', returns often seem to be accepted as inevitable or even firmly integrated into the business model.

There are basically two different reasons for returning parcels: (1) The purchased product is defective, or (2) the purchased product does not meet the buyer's expectations. The second point can be subdivided further in: a (rather) planned return (e.g. due to multiple orders of the same T-shirt in different sizes or simply testing a product) or an unexpected return (e.g. due to an incorrect description of the product or an incorrect order). Although the difference between a planned and unexpected return seems small, there can be a significant difference in its overall transport volume and thus in its impact.

Classification

The return of parcels is an inherent feature of existing E-commerce structures as well as business models and thus classified as a direct effect on the Circular Economy. It poses a threat to a Circular Economy because it puts additional pressure on the logistics and transport of goods between merchant and customer.

Current and future relevance

Surveys on online shoppers suggest that an easy return option is one of the most important shopping criteria for selecting an online shop (Bolz, Diener and Wittmann, 2017; PWC, 2018a). This aspect reflects the consumer's side and shows that easy returns are (typically) expected nowadays. The other side is that of online merchants who, through their shipping policy, have fomented the customers' expectations and have reinforced them through partly active advertising of easy return options. The absolute majority of retailers offers customers a free return of purchased products – a total of 90% according to a study by Parcellab (2018). Besides the mere economic incentive, retailers also tend to make return as simple as possible for the customer. Around half of all retailers encloses a return label in the delivered parcel (Parcellab, 2018).

With regard to the share of returned packages and products, different values can be found in literature. Logistics companies and consulting agencies have conducted numerous surveys and studies. Overall, the following trends can be derived:

- around every eighth of online purchase is sent back (Bitkom, 2017);
- there are considerable differences between the product categories in scope in regard to the return percentage:

    - apparel has the highest return rates; and
    - large household appliance and major furnishings have significantly lower return rates.
- young consumers (14-29 years old) send back more than older generations.

This risk occurs particularly in the apparel product category, but is reduced for product categories that are large bulky products (e.g. major furnishings or major household appliances). The effort for the customer involved in sending them back is simply too high in this case.

Supporting factors

- strongly competitive market with long-established customer behaviours related to ordering a variety of products to simply try and test them at home, before returning (at least some of them) the purchased products. Customers might be conditioned to this behaviour as it is strongly promoted by some online retailers; and
- persistent promoting of free shipping and free return.

Mitigating factors

- change in consumer behaviour towards a more sustainable approach in ordering products online;
- no or limited free return options throughout the market; and
- cooperation among retailers to improve logistics (see opportunity "Optimisation of the supply chain" in Section 3.2.6.3).

Options for actions

Scientific Community:

- raise awareness of the link between packages returned and environmental impacts (see also opportunity "Nudging" in Section 3.2.2.1).

Producers/Platform providers:

- inclusion of feedback options (both in case of a return, but also to match expectations to delivered product);
- active Quality Management to identify product (groups) with potential quality issues;
- provide information about the impact of returned products (see opportunity "Nudging" in Section 3.2.2.1; and
- provide return in-store options to decrease faulty packaging of returned products.

Source of information

Bitkom (2017) 'Shopping digital – Wie die Digitalisierung den Handel tiefgreifend verändert', (November). Available at: https://www.bitkom.org/Bitkom/Publikationen/Shopping-digital-Wie-die-Digitalisierung-den-Handel-tiefgreifend-veraendert.html.

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3.2.7 Cluster – Packaging

3.2.7.1 Opportunity – Development of dedicated optimised packaging solutions

Description

In recent years, there has been a significant development in dedicated packaging solutions that focus on a more sustainable use of materials and a flexible design of packaging that fits the product's specific transportation requirements. As these optimisation strategies for packaging potentially affect the demands for plastic and cardboard, modern solutions are seen as an opportunity for the Circular Economy.

Discussion

Dedicated packaging solutions that are discussed in this study are mainly dealing with packaging-related issues of the E-commerce sector. Those aspects are dealing with problems that arise from E-commerce itself. Therefore, many distinct opportunities associated with the optimisation of packaging are not expected to result in actual environmental benefits compared to the traditional retail channel (Pålsson, 2018).

One of the requirements for the Circular Economy is to keep resources in use for as long as possible and to retrieve products and materials at the end of the materials service life (WRAP, 2019). For packaging used to ship products traded via E-commerce to the customer, this has been a challenging task.

In addition to the pure optimisation of the packaging quantity, reusable packaging can also be applied. Although this might already be done to some extent by the consumer side (e.g. reusable carrying bag for groceries), it is not common on the producer's side. A major hurdle is already posed by the question of how the parcels and packaging can be returned. RePack, for example, tackles this aspect of E-commerce disposable packaging and has introduced a business model around the idea. The company's model includes both a design for packages that makes it feasible and fairly easy to return them, as well as the implementation of a take-back system for such packages (Ellen MacArthur Foundation, 2019; Zero Waste Europe, 2019a).

Another example is the online platform LOOP, developed by the omni-channel retailer Carrefour and U.S. waste recycling company TerraCycle. This model tackles the problem arising from single-use shipping materials by introducing reusable containers for different types of products. The company "*streamlines returns for the user by offering delivery and pickup of products and empty packaging, and removes hassle for the brandowner by taking care of reverse logistics, cleaning, sanitation, and redistribution*" (Ellen MacArthur Foundation, 2019).

Classification

This emerging opportunity is considered an indirect effect of E-commerce due its rather long-term and structural implications on packaging as a result of wide-scale market developments. As long as omni-channel structures are present, dedicated packaging solutions are still a niche segment.

Current and future relevance

From an environmental perspective, reusable packaging can reduce packaging waste throughout the supply chain. However, to determine whether the environmental impact is improved or worsened compared to one-way packaging, a systemic approach is needed which includes other environmental impacts such as transport efficiency and effects on product waste. In the current literature, such a systemic approach is seldom used. Instead, studies often assume that reusable packaging is more environmentally efficient than one-way packaging simply because it is used several times. However, in some contexts, reusable packaging is more environmentally beneficial and in others, one-way packaging is better. From an ergonomic perspective, reusable packages are often more robust with better stability, but are also heavier than one-way packaging. They are also more likely to use standardized dimensions, which can provide co-loading and other efficiency benefits, but also risk a lock-in effect, where it becomes difficult to modify the packaging to cater for new types of products, new customers and changes in order sizes (Pålsson, 2018).

The relevance of dedicated packaging solutions is increasing, as is the pressure to develop more sustainable solutions along the E-commerce supply chain in general. Several models were introduced in recent years and are currently being tested or already being rolled-out to some extent. The following are only two examples of many and show that these solutions still require some time to prove their effectiveness (Ellen MacArthur Foundation, 2019):

- **RePack** – provides products in reusable containers that can be returned with a deposit reward mechanism. Around 50,000 consumers use this system worldwide. Zero Waste Europe indicates that around 20,000 RePacks were used in 2017, and around 30,000 in 2018 (Ellen MacArthur Foundation, 2019); and
- **LimeLoop** – reusable packaging that can be rented by online shops to deliver purchased products. Packaging can be returned by customers via an integrated shipping label. Currently, more than 20,000 round-trip shipments to date in the US (Ellen MacArthur Foundation, 2019).

Across the E-commerce sector, return models and other dedicated packaging solutions appear to still be relatively uncommon at present. At the same time, the usage of such solutions seems to have a steady and steep increase.

It should be highlighted here that dedicated packaging solutions are emerging along the whole supply chain and not only for end-consumer packaging. One example can be given by the Pallet Lid concept from Loadhog, which reduces material required for securing cargo significantly (Loadhog, 2019).

This opportunity will be of relevance for all product categories in the future as the transition to a Circular Economy will foster the use of sustainable packaging solutions for all types of products sold via E-commerce. However, mentioned examples of currently available dedicated packaging solutions are currently still focusing primarily on food deliveries and less on the other product categories in focus of this study.

Supporting factors

- investment in new packaging solutions and willingness to address the problem of excessive protective packaging (see Section 3.2.7.2 for more details on excessive protective packaging);
- possibility of cost savings stemming from the adoption of reusable packaging.

Mitigating factors

- low material and disposal costs for standard packaging and integrated protective material.

Options for actions

Scientific Community:

- testing new packaging solutions with regard to certain aspects, such as practicability, shock resistance, etc. and developing suggestions for innovative approaches; and
- analysing the potential benefits and trade-offs from alternatives and new packaging solutions.

Producers/Platform providers:

- cooperation with companies offering innovative packaging solutions;
- investing in concepts and infrastructure for reusable packaging systems; and
- offer the reusable packaging option in the online-store and highlighting environmental advantages to the customers.

Source of information

Ellen MacArthur Foundation (2019) *Reuse - Rethink packaging*. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/Reuse.pdf.

Loadhog (2019) *Pallet Lid - The most secure, versatile and cost effective method of securing the load on a pallet, no banding or stretch wrap required*. Available at: https://loadhog.com/product/pallet-lid/

Pålsson, H. (2018). *Packaging Logistics - Understanding and managing the economic and environmental impacts of packaging in supply chains*. London: Kogan Page Limited.

WRAP (2019) *WRAP and the circular economy*. Available at: http://www.wrap.org.uk/about-us/about/wrap-and-circular-economy.

Zero Waste Europe (2019) 'The Story of RePack'. doi: 10.1007/978-1-4899-6014-6_11.

3.2.7.2 Threat – Excessive protective packaging

Description

Products purchased via E-commerce are typically sent to consumers in packages that use different types of protective material and packaging design to ensure that the product is delivered unharmed. Adequate protection is absolute necessary to avoid damage during transportation. There are, however, various difficulties with the practical implementation of an "adequate" protection. Some products are still protected in a way that can be considered as excessive and wasteful.

Discussion

As it is discussed in the identified threat "Damage on delivery" (Section 3.2.6.5), products require adequate protection to ensure that they do not get damaged at any step of the supply chain and to ensure that they reach their destination safely. The primary packaging of the products is generally not suitable for logistic transport and rather serves marketing purposes. Protection might be required against atmospheric, magnetic, electrostatic, vibration, shock impact, or other factors. The type of protective packaging is determined primarily by the product to be protected, but also by the way in which the parcel is transported and handled. Companies that specialize in packaging protection advertise a wide range of applications and material types, such as foams, bubble wrap, cushioning pads – to name just a few.

The threat is not seen here in the protective packaging itself, but in the partially disproportionate use of it. Companies may find it challenging to offer suitable packaging and protective packaging for all the products on offer- the offered solutions are often standardized for several product groups and sizes. The use of relatively large standard boxes for small items and the use of packaging that offers a much higher shock absorption than technically needed are only two examples of many. This can lead to a negative effect on the Circular Economy as the efficiency of material and transport is low.

The challenge for companies is to provide optimal protection for each product while being efficient with protective packaging. At the same time, this solution must be integrable within the extremely synchronized and tightly timed supply chain and must be economically viable.

Classification

Excessive protective packaging is a supplementary development due to E-commerce features and is considered here as an indirect effect of E-commerce.

Current and future relevance

Currently, only very limited data is available on the overall impact of protective packaging.

Product protection appears to be of very high priority for most companies in the sector and there seems to be a general understanding that "product damage is the least sustainable option" (Hattersley, 2019). To which extent, however, excessive protective packaging is discussed by industry is difficult to evaluate. Topics at the international conferences E-PACK Europe in Berlin in 2019 were dealing with several aspects of efficient and sustainable packaging and suggest that the issue is on the industries agenda. The following points show some examples that shall highlight potential solutions and approaches to reduce excessive protective packaging:

- the packaging provider DS Smith developed a test procedure, with which different factors of influence, which can affect a package during delivery, are tested. According to their own account, this procedure does not only aim at providing an adequate protection to the product, but also explicitly focuses on using only the amount of material that is absolutely necessary to achieve the desired protection level (Smith, 2019b);
- Amazon's frustration free packaging is not only focusing on a frustration free experience for the customer, but also aims at avoiding unnecessary additional packaging, while ensuring intactness of the product (Amazon, 2019c);
- packaging distributor Kite Packaging Ltd (Kite) initiated a project with the goal to reduce the amount of space taken up by corrugated cardboard cartons in its warehouses, while at the same time ensuring the stability of the packages (WRAP, 2018); and
- Walmart developed a Sustainable Packaging Playbook in which the company is highlighting three main aspects of their packaging: source sustainability, support recycling, optimise design. The latter is incorporating the aspect of material reduction while protecting the product (Score, 2019).

The aforementioned examples shall highlight that industry is dealing with the topic of efficiency and reduction of material regarding their products' packaging and thus protective packaging. However, it is currently unclear to which extent such measures are already used by those companies as well as the whole industry.

In terms of relevance for product categories, it can be assumed that the effect seems particularly relevant in relation to shipping of small information and communication technology (ICT), and to a certain extent, to accessories (e.g. watches), but not to the other five selected product categories, as they do not comprise small, vulnerable products.

Supporting factors

- packaging and transport models with non-flexible "one-size fits all" for packaging; and
- uncertainty or lack of knowledge about the adequate protection required for the product to be supplied.

Mitigating factors

- cooperation with dedicated packaging companies (see also opportunity "Development of dedicated optimised packaging solutions" in Section 3.2.7.1).

Options for actions

Scientific Community:

- consolidate best practices that are already in place; and
- development of flexible packaging solutions that address product groups that are currently less in focus.

Producers/Platform providers:

- promote and support cross-company standards on protective packaging; and
- cooperation with providers of advanced protective packaging solutions.

Regulators:

- include an aspect of packaging minimisation that is explicitly dealing with protective packaging; and
- from a regulatory perspective, Packaging and Packaging Waste Directive 94/62/EC (and its amendments such as Directive (EU) 2018/852) should be mentioned, which requires EU Member States to take measures to prevent and reduce packaging waste with the goal to 'minimise the environmental impact of packaging'. The aspect of protective packaging is only addressed indirectly by the mentioned reduction of detrimental impacts on the environment.

Source of information

Amazon (2019c) *Frustration-free packaging*. Available at: https://www.aboutamazon.com/sustainability/packaging/frustration-free-packaging (Accessed: 12 August 2019).

'EUROPEAN PARLIAMENT AND COUNCIL DIRECTIVE 94/62/EC of 20 December 1994 on packaging and packaging waste' (2007) *Journal of Environmental Law*, 7(2), pp. 323–337. doi: 10.1093/jel/7.2.323.

Hattersley, V. (2019) *E-PACK Europe: The challenges and opportunities of e-commerce, Packaging Europe*. Available at: https://packagingeurope.com/e-pack-europe-the-challenges-and-opportunities-of-e-commerce/ (Accessed: 12 August 2019).

Kaszubowski, R. (2016) *3 ways 'The Amazon Effect' impacts protective packaging: Page 2 of 2*, *Packaging Digest*. Available at: https://www.packagingdigest.com/protective-packaging/3ways-amazoneffect-impacts-packaging1610/page/0/1 (Accessed: 12 August 2019).

Kite Packaging (2007) *Reducing corrugated cardboard weight without compromising performance*. Available at: http://www.wrap.org.uk/sites/files/wrap/15203-01 Kite Packaging report.pdf.

OECD (2019) *Unpacking E-commerce*. Available at: https://www.oecd.org/publications/unpacking-e-commerce-23561431-en.htm.

Score, I. (2019) 'Sustainable Packaging Playbook'. Available at: http://imagestore.s4rb-systems.co.uk/images/rightnow/walmartsustainability.custhelp.com/for_answers/New_wm_packagingplaybook.pdf.

Smith, D. (2017) *DS Smith shows how to reduce void fill, damage and development time at Deliver #2*. Available at: https://www.dssmith.com/packaging/about/media/news-press-releases/2017/7/ds-smith-shows-how-to-reduce-void-fill-damage-and-development-time-at-deliver-2 (Accessed: 12 August 2019).

Smith, D. (2019b) *Sustainability Report 2019*. Available at: https://www.dssmith.com/contentassets/c187988864b9404bb959135d7b92b92c/ds-smith-sustainability-report-2019.pdf.

WRAP (2018) *Reducing corrugated cardboard weight without compromising performance, Waste & Resources Action Programme*. Available at: http://www.wrap.org.uk/sites/files/wrap/15203-01 Kite Packaging report.pdf (Accessed: 12 August 2019).

3.2.7.3 Threat – Secondary packaging

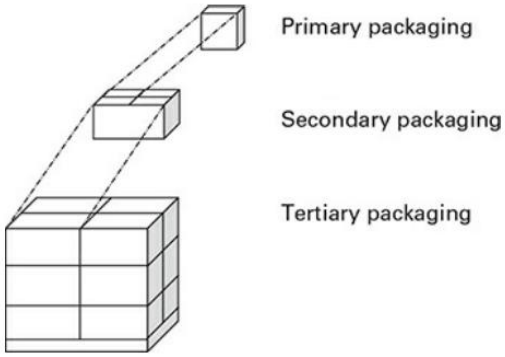
Description

Primary packaging is the type of packaging closest to the product (e.g. glass bottle, paper packaging of flour) and is sometimes referred to as retail or consumer packaging. Secondary packaging is the packaging that encompasses one or several products that are wrapped in primary packaging (Pålsson, 2018). In simple terms – it is the visible parcel that the customer receives at the door when ordering products online. Secondary packaging is seen as threat to the Circular Economy as more packaging waste is accruing.

Discussion

Secondary packaging is not only used for E-commerce applications but also for transportation of goods in traditional retail. The type of packaging as well as how companies organise their supply change can differ significantly between product groups, branches but also depending on companies involved in the logistics. In general, however, three interrelated levels of packaging are used to transport goods that are in focus of this study between point of manufacture and point of sale/end-consumer (Pålsson, 2018).

Figure 10: Three interrelated levels of a packaging system by Pålsson, 2018



Each of the packaging levels has several specific functions, such as marketing purposes, protection, containment, etc. Overall, the objective is to transport the product efficiently and without any harm to its final destination. The aspect of efficiency is seen here as important aspect that can differ considerably between traditional retail and E-commerce. Material efficiency increases with optimal use of the space in a parcel. In E-commerce, products are often shipped to consumers in smaller batch size than to retail shops (e.g. 2 shirts instead of a parcel full of shirts), which results in a decrease in material efficiency and which is seen as a direct threat arising from E-commerce (Pålsson, 2018).

Classification

Secondary packaging is inherent (at least till now) to the delivery of products to the customer. Purchasing a product online has the consequential effect of secondary packaging use and thus an anticipated negative effect. It is a characteristic of current E-commerce practices and estimated to persist in future scenarios. As such it is considered a direct effect of E-commerce.

Current and future relevance

Typically practice since the beginning of E-commerce and presumably still widely the most common practice is the take-and-dispose model, where customers receive a product at home and discard the parcel, in which it was delivered. However, various approaches are currently being developed to counter this wasteful approach.

The possibility to purchase online and pick the product up in a store is offered by more and more companies. If the product can be unpacked on site, secondary packaging waste can be directed into regulated routes. Some companies already provide reusable primary and secondary packaging (re-use systems), which are currently only offered for a few product categories (food, hygiene articles such as soap, etc.). See section 3.2.7.1 for more examples on reusable secondary packaging solutions.

Two developments can be highlighted here that are likely to have an impact on the future relevance of secondary packaging (Fisher and Lilienfeld (2017)): dimensional shipping, which incorporates the aspect of packaging size in addition to packaging weight; and Box-on-Demand, which uses customised packaging designs that fit the order's specific requirements. Both concepts directly address the problem of inefficient packaging use and have the potential to decrease this threat.

Overall, the aspect of packaging waste from secondary packaging arising from E-commerce seems to get more attention from industry and customers alike. There are currently several innovations and new models that still require some time to proof their effectiveness.

Supporting factors

- customers still prefer to receive their order at home, which makes it difficult for hybrid models to establish (Joerss *et al.*, 2016).

Mitigating factors

- the use of social media in e-commerce has led to individual consumers being able to provide detailed information on e-commerce packaging to other users and potential customers (e.g. with so call "unboxing videos"; (Tagesspiegel, 2013)). Because consumers are able to be publicly critical, companies are being urged to addressed identified packaging issues (Fisher and Lilienfeld, 2017).

Options for actions

Producers/Platform providers:

- cooperation with providers of packaging optimisation solutions such as Box-on-Demand (Fisher and Lilienfeld, 2017).

Regulators:

- supporting dimensional shipping that incorporates parcel size in addition to parcel weight (Fisher and Lilienfeld, 2017).

Source of information

Digest, P. (2019) *3 challenges of ecommerce packaging*. Available at: https://www.packagingdigest.com/supply-chain/3-challenges-of-ecommerce-packaging-from-an-insider-2019-01-07 (Accessed: 12 August 2019).

Fisher, K. and Lilienfeld, B. (2017) *Optimizing Packaging for an E-commerce World*. Available at: http://c.ymcdn.com/sites/www.ameripen.org/resource/resmgr/PDFs/White-Paper-Optimizing-Packa.pdf.

Joerss, M. *et al.* (2016) 'Parcel delivery: The future of last mile', *McKinsey & Company*, (September), pp. 1–32. Available at: https://www.mckinsey.com/~/media/mckinsey/industries/travel transport and logistics/our insights/how customer demands are reshaping last mile delivery/parcel_delivery_the_future_of_last_mile.ashx.

Pålsson, H. (2018) *Packaging Logistics - Understanding and managing the economic and environmental impacts of packaging in supply chains*. London: Kogan Page Limited.

Tagesspiegel (2013). Insider packen aus. Available at: https://www.tagesspiegel.de/gesellschaft/unboxing-insider-packen-aus/8490556.html (Accessed: 10 October 2019)

4 In-depth assessment of opportunities and threats for selected product categories

As part of the identification of the opportunities and threats for the Circular Economy arising from E-commerce, the value chain differences between the traditional sales channel and online distribution were identified, as described in Section 3.1.2.

It is evident, that many value chain effects directly induced by E-commerce are broadly valid, irrespective of the product category. All identified E-commerce effects – both opportunities and threats – relate to the same system boundaries and dedicated value chain processes.

In general, the assessment and potential quantification of effects on the Circular Economy arising from E-commerce necessitates a transdisciplinary methodological approach relying upon Environmental Systems Analysis, Future Studies, Environmental Economics, and Social Sciences (Börjesson Rivera *et al.*, 2014a). However, this assessment primarily focuses on environmental aspects since those are at the core of pertinent Circular Economy promises (European Commission, 2015a; Webster, 2017; European Commission, 2018a). In line with this scope, Environmental Systems Analysis constitutes the discipline of choice in terms of literature reviewed and methods applied.

As described in Section 3.1.2, the comparative analysis of the traditional retail channel and E-commerce is based on a reference model, which tries to untangle dedicated processes and attribute them to one or the other channel (see Figure 2). In doing so, opportunities and threats are by definition additional and hence they inherently mark relative changes to the assumed baseline (traditional brick-and-mortar value chain).

4.1 Circular Economy Aspects in E-Commerce Value Chains

In general, the broad and often ambiguous concept of Circular Economy exhibits different implementation scales (Moraga *et al.*, 2019). This study aims to focus on the micro scale, thus on products or services. Moreover, the sought indicators are expected to provide relevant information for decision-making in EU policy.

The selection of appropriate indicators for the aim of this study needs to account for E-commerce-specific features, thus taking into account the identified dedicated value chain processes (see Section 3.1.2), as well as accommodate evident data availability constraints. The latter appears to be an issue when looking at some of the commonly proposed indicators which have been developed recently and are mainly used in academia thus far. Therefore, a more pragmatic approach is deemed necessary, balancing scientific state-of-the art with the scope of the study and data availability. Due to highly complex and diverse contexts associated with identified life cycle stages, Circular Economy aspects are defined as being largely independent from geographical, national, and temporal conditions.

Amongst others, the concepts of the Product Environmental Footprint Study, PEF, (Pelletier *et al.*, 2012) and, where available, the Product Environmental Footprint Category Rules, PEFCR, (e.g. T-shirt: (Pesnel and Payet, 2019) and Environmental Product Declarations, EPD, (Barilla, 2014; ISKO division, 2018) are considered as guidelines for the quantitative assessment and the choice of representative indicators. Also, it must be remembered that the identification and selection of representative indicators is a somewhat critical step, as most statistical data or indicators often used for tracking the progress of a Circular Economy mainly refer to macro-scale contexts (e.g. per-capita-numbers) and cannot be readily applied to the micro-scale or product level (e.g. per fulfilled unit).

Furthermore, the assessment of Circular Economy should be based on a set of indicators rather than on one single indicator (Moraga *et al.*, 2019) which is achieved by the selection of representative indicators per cluster, as presented and discussed below. Lastly, in some clusters, numbers of relevant effects and particularly complex interrelations between them only allowed to assess those clusters qualitatively rather than quantitatively, since robust representative indicators could not be determined.

Table 10 gives an overview of the clusters and representative indicators.

Table 10: Overview of effect clusters and representative indicators (Circular Economy aspects)

Cluster	Representative Indicator	Unit(s)	Comment(s)
Accessibility of information	(not applicable)	• (n.a.)	Various effects, with complex interactions, thus assessed qualitatively
Consumer needs and behaviour	(not applicable)	• (n.a.)	Various effects, with complex interactions, thus assessed qualitatively
Digitalisation	"(Primary) Energy demand and global warming potential"	• kWh • CO_2e	Indicators identified. Still assessed qualitatively due to complex interactions
End-of-Life	"Fraction that is effectively brought into a second or prolonged life cycle and product waste per fulfilled unit"	• percentage (%) • absolute	Reuse, remanufacturing, recycling, landfilling -subject to product category and effect
Legal framework	(not applicable)	• (n.a.)	Various effects, with complex interactions, thus assessed qualitatively
Logistics and transport	"Transport requirements per fulfilled unit"	• km/unit • CO2e/unit	Use of representative products for each product category
Packaging	"Amounts of plastic and cardboard packaging demand per fulfilled unit"	• kg plastic packaging/unit, • kg cardboard packaging/unit	Plastic is represented by LDPE foil (compare Section 4.3.8)

4.2 Methodology

Based on the preceding identification and description of relevant opportunities and threats as well as proposed clusters and corresponding Circular Economy aspects or indicators, the subsequent Sections explain how the in-depth assessment was conducted.

4.2.1 Goal & Scope of In-depth Assessment

Guided and already suggested by the overall objective of this study, the following research questions are to be answered by means of the proposed assessment framework:

- To what extent do the identified opportunities and threats currently affect relevant Circular Economy aspects?
- How do E-commerce scenarios and value chains compare to the traditional retail channels (baseline)?
- At what point(s) in the life cycle of selected products are assessed CE aspects primarily taking effect?
- What long-term/future effects do certain opportunities and threats potentially exert on relevant CE aspects? (future development)

Each assessment seeks to reflect these questions, depending on data availability and validity.

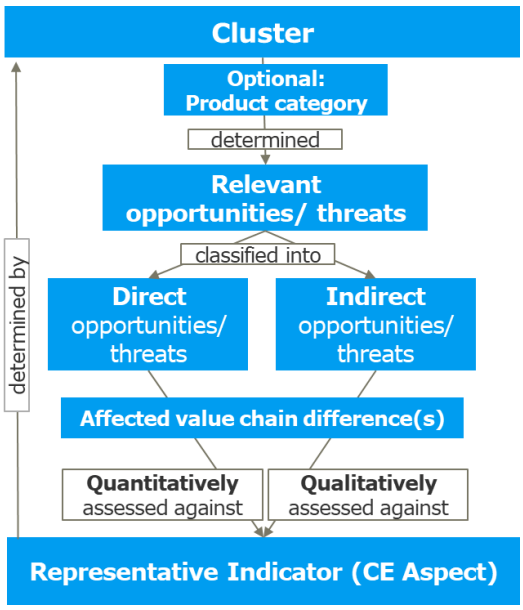
Temporal and Geographical Scope

Research and analysis were focused on Europe-wide average data. Evidently, the applicability and transferability of findings and results to certain national contexts is limited due to uncertain market conditions and obvious differences in consumer behaviour and preferences. In case EU average data was not available, data from one or more of the proposed five countries (Poland, Sweden, Spain, France and Germany; see also Section 2.1.3) was adopted as a point of reference. Moreover, if notable deviations between the results of the countries were expected or identified (depending on data availability), EU-wide data may not have provided representative information. Thus, country-specific data was also used to gauge any differences between sub-regions of Europe, or to determine, whether a certain effect could be considered more or less homogeneous across the EU.

4.2.2 Assessment Framework

Building upon the systematic classification and inherent characteristics (e.g. additionality) of identified opportunities and threats (see Section 3.1.2), a quantitative assessment is provided as far as applicable. The general procedural approach is shown in Figure 11. Due to the wide project scope and data availability constraints as well as inherent limitations, only direct effects of the three clusters “Logistics and Transport”, “Packaging”, and “End-of-Life” are suitable for a quantitative assessment. Indirect opportunities and threats of these clusters and all effects of the remaining clusters are described in a qualitative manner, stating trends and expected future developments based on available research.

Figure 11: Assessment framework and potential assessment sequences



Due to the cascading nature of environmental effects arising from E-commerce, opportunities and threats were classified as either direct or indirect (see Table 5 in Section 3.1.2). This classification is not only a methodological choice but also a prerequisite for the in-depth assessment as it provides a rationale, whether quantitative or qualitative information is deemed appropriate. This is because direct and indirect effects entail different degrees of uncertainty (due to data availability, assumptions, etc.), requiring to individually choose, whether a quantitative or qualitative evaluation of the respective opportunity or threat is feasible. The methodological possibilities to either extrapolate quantitative data from available literature or to calculate and estimate certain effects are considered rather limited due to the numerous assumptions involved. As a general rule, scientifically sound quantifications of certain effects can only be made, if the scope and unavoidable uncertainties are clearly defined and discussed (e.g. geographical and temporal conditions, population density, behavioural aspects of consumers, etc.).

Table 11 summarises available data sources and methodological possibilities referring to either direct or indirect effect pathways (opportunities or threats).

Table 11: Overview of preferred data sources and methodological possibilities for the assessment of E-commerce effects (Börjesson Rivera *et al.*, 2014b; Dost and Maier, 2018)

Effect Pathway	Preferred Data Sources	Rationale	Result Type
Direct	▪ Techno-scientific literature; ▪ Environmental Product Declarations (EPDs), LCA studies; ▪ LCI Databases (e.g. GaBi professional database, European Life Cycle Database (ELCD) of the Joint Research Centre); and ▪ Complementary LCA calculations / extrapolations and Inventory Analyses.	Consequential effects associated with ICT/E-commerce as well as immediate enabling (substitution/optimisation) effects can reliably be assessed with bottom-up quantitative systems analysis methods (e.g. (comparative) LCA) and needed assumptions are rather limited	Quantitative
Indirect	▪ Techno-scientific literature; ▪ Market reports / Grey literature (e.g. from associations); ▪ Statistics (e.g. Eurostat, Statista); and ▪ Corporate reports (e.g. annual reports and non-financial reporting).	Long-term and/or structural effects associated with ICT/E-commerce cannot reliably be assessed using quantitative systems analysis (e.g. LCA); Some hypothetical effects associated with ICT/E-commerce may be assessed with quantitative systems analysis methods (e.g. LCA) but needed assumptions are considerable and/or assessments must be combined with other methods (e.g. top-down approaches).	Qualitative

Given the wide scope of this study and the diversity of product categories being assessed, reliable quantitative assessment results are difficult to attain and, in many of the cases, quantitative assessments are not applicable to capture certain effect clusters (e.g. consumer needs and behaviour). A quantification of complex and uncertain effects (usually indirect effects) could suggest an accuracy that cannot be achieved in this study. Hence, opportunities and threats which cannot be quantified reliably are assessed qualitatively, based on techno-scientific literature and stakeholder input.

As described in Section 4.1, in order to compare the effects of the opportunities and threats between traditional brick-and-mortar retail and E-commerce for the current state as well as future developments, representative Circular Economy aspects/indicators were identified for each of the selected clusters. All quantitative and qualitative effects within the respective cluster are assessed against those representative indicators relating to a functional unit. The determination of the functional unit and of the representative indicators are explained below and in Section 4.3, respectively.

The in-depth assessment results will be discussed and summarised per cluster. As stated earlier, the following clusters entail a detailed quantitative assessment of the respective direct opportunities and threats:

- End-of-life;
- Logistics and transport; and
- Packaging.

Based on research and evidence from previous studies relating to E-commerce and Circular Economy, these clusters are considered highly relevant for this kind of assessment. Moreover, in comparison to the other clusters, more quantitative data and points of reference for the opportunities and threats contained in these clusters were found in the literature. In contrast, the other clusters contain several opportunities and threats which have been barely addressed in the literature or by any stakeholders thus far. This circumstance renders these other clusters inappropriate for a detailed quantitative assessment under the scope of this study. Nevertheless, quantitative information and data points from literature are included in the discussions and reflected in the results to the extent possible.

For the discussions and presentations of the results from the in-depth assessment, identified opportunities and threats within a given cluster are grouped according to their properties as follows (see also Section 3.1.2):

- **Relative effects associated with E-commerce as per today**: additional effects of direct opportunities and threats on respective Circular Economy aspects as well as comparison with baseline impacts as long as feasible and sufficient data available;
- **Positive influencing factors associated with E-commerce for future development:** expected effects of indirect opportunities on respective Circular Economy aspects; and
- **Negative influencing factors associated with E-commerce for future development:** expected effects of indirect threats on respective Circular Economy aspects.

In order to enable a more nuanced understanding of possible influences within the assessments, influences (i.e. opportunities and threats) were – wherever possible – ascribed:

- a "plus" (+) for positive influences;
- a "minus" (–) for negative influences; or
- a "zero" (0) where influences were inconclusive.

Furthermore, as a sign of their relevance within their respective cluster, a double sign (i.e. "++" or "- -") was ascribed for highly relevant influences.

The ascription of signs was done on the basis of circumstances such as occurrence of the influence in literature, its importance within the stakeholder consultations, and expert judgement. The below colour-coding was used to show both sign and relevance of the respective effect.

++	**Positive** effect deemed to have **high relevance** for a given CE indicator compared to traditional (brick-and-mortar) channel
+	**Positive,** effect with **low relevance**
– –	**Negative** effect with **high relevance**
–	**Negative effect** deemed to have low relevance
0	**Inconclusive effect** thus deemed to have **low relevance**
n.a.	**Not assessed/not applicable** (e.g. due to lack of data, non-applicability)

Functional Unit: "One fulfilled unit"

The functional unit for the quantitative assessment needs to be applicable for the traditional brick-and-mortar commerce as well as for the E-commerce value chain, and it shall be precise but also general enough to be used for all product categories. Consequently, "one fulfilled unit" is defined as the functional unit for the assessment. One fulfilled unit is understood as one product that is shipped to or purchased and ultimately kept by the consumer. Products returned by consumers, including all related additional resource usage and emissions, are allocated to the product that is kept.

In reality, a single item or product is often part of a larger and diverse shopping basket, thus associated environmental impacts would need to be allocated (e.g. based on the weight, volume or economic value of an item, number of orders during delivery time frame) to the single item under consideration (Van Loon *et al.*, 2015b). The determination and justification of appropriate allocation factors is, however, associated with several methodological constraints and uncertainties (e.g. limiting factors – time, volume, weight – of a truck load can be diverse and are highly dependent on individual contexts). Therefore, the assessment is conducted under the assumption that every product is packed and shipped individually. Each product category is analysed based on at least one representative product, which then serves as a reference for values such as mass or volume, where required. Representative products are determined depending on data availability.

Data Search Method

A focused literature review (= data-pull-principle) was conducted in order to support a determination of both quantitative and qualitative assessment results related to the identified opportunities and threats as well as certain product categories. Thus, all data was acquired through a secondary analysis. This method involves the utilisation of existing data (e.g. by means of extrapolation or conversion), initially collected and generated for the purposes of other studies, in order to answer above research questions and thereby support the objective of this study. In addition, a dedicated data basis for future research was compiled (see Table 12, Table 24, Table 32 and Table 41).

The secondary analysis was performed by the following steps:

Step 1: Determination of relevant data pools;

Step 2: Capturing of potentially relevant sources;

Step 3: Selection of sources and data points applicable to the respective assessment sequence (quantitative/qualitative); and

Step 4: Linkage of data points/sources to relevant opportunities/threats and calculation (of quantitative) results and estimation (of qualitative) results in terms of proposed indicators.

Assumptions & Limitations

In general, it must be differentiated between (i) assumptions and uncertainties inherent in adopted data points and (ii) assumptions that have been necessary to utilise existing data. Among the latter category of assumptions, the following were deemed a prerequisite of quantitative in-depth assessments:

- only the clusters "Logistics & Transport", "Packaging", "End-of-Life" were assessed quantitatively, and the remaining four clusters were selected for a qualitative assessment;
- focus was on environmental CE aspects and corresponding indicators;
- social and economic aspects were considered in a more general discussion, if relevant and available in the literature;
- a product-centric perspective was adopted;
- business models were not the focus of this assessment;
- representative products were identified in order to gather data and insights on certain product categories;
- comparisons between product categories were generally not possible due to different underlying assumptions, scope, etc. of data sources;
- solely single-consumer purchases were accounted for, i.e. an E-commerce purchase is placed by one individual, not by a group of individuals;
- only end-user purchases were assumed, i.e. purchases are not done with the intention to re-sell the purchased product;
- only the first life cycle of products was considered;
- transport systems and technologies in a single country were assumed similar throughout that country;
- the project scope required pragmatic decisions regarding balance of data detail and assumptions.

Further assumptions are mentioned in the respective in-depth assessment sections.

4.3 In-depth Assessment Results

4.3.1 Quantities of fulfilled and shipped units and number of packages

Data on the absolute amount of fulfilled and shipped units as well as their division into packages is relevant for all quantitative assessments and therefore described here in a superordinate form. The approach for the determination of these values for 2017, representing the situation today, and 2030, representing the future situation, is described below, assumptions and limitations are emphasised. More detailed background data used for the calculations is provided in the Annex (see Table 55: in Annex 2) and referred to in the text.

Table 12 lists the sources used and the type of relevant information they contain for the calculations of packages shipped per product category, year and country.

Table 12: List of sources for calculation of total shipped items and number of packages sent

Reference	Type of reference (Data pool)	Content
Allen *et al.* (2017)	Scientific Literature	Shares of shipped packaging size types per product category in UK (letterbox, shoebox, large box)
Statista (2019)	Statistics	Sales volume per country and product category (applicable for 3 product categories)
Postnord (2018)	Market reports / Grey literature	Shares of citizens who purchased products of the product categories online as well as return rates
Own assumptions[14]	Courier service information	Maximum dimensions for standard package
Stakeholder Survey (2019)	Statistics	Numbers of items per package
DIN EN 13724, packaging material retailers	Norms and standards	Dimensions and weight-related values for packaging material

In summary, data from secondary sources from 2017 were combined, so that absolute sales figures in pieces per product category and country could be derived. It is assumed that, in the case of generally published sales figures it is referred to the units sold, which includes returns (Annex 2, Table 55:). Therefore, in the next calculation step, the proportional number of items equivalent to the return rates (Annex 2, Table 56) is deducted.

The result corresponds to the number of fulfilled units in the respective category (Table 13) referred to below. Sales volumes are in the following named as shipped or shipped units.

[14] Own assumptions based on data from several shipping companies (e.g. DHL)

Table 13: Number of fulfilled units per product category and country in 2017

Fulfilled units in pieces 2017	Poland	Sweden (Nordics)	Spain	France	Germany	EU27
Apparel items	194,694,120	93,506,400	380,063,340	529,245,360	655,240,500	6,185,444,832
Small ICT items	16,657,344	7,907,400	25,201,260	42,929,280	48,113,568	442,144,857
Major household appliances	1,038,216	555,810	1,715,130	3,254,496	4,216,368	32,391,792
Media products	39,891,384	17,010,518	70,791,900	111,565,050	201,425,334	n.a.
Non-perishable food	30,764,160	14,874,048	72,676,800	94,962,000	95,985,120	n.a.
Major furniture	8,134,888	2,781,965	10,421,952	16,694,000	30,411,612	n.a.

In terms of the objectives of this study, a few general **limitations** are present. Firstly, no data could be found for the product category "accessories" regarding sales volume in fulfilled units or packaging size shares. Secondly, no data could be found for return rates of non-perishable food. Instead, based on expert opinion it was assumed that the rate is very low, which is why 2% were used in the calculations. Thirdly, no data could be found for absolute sold units in Europe for media products, non-perishable food and major furniture.

Within the scope of the data research, information was found on the ratio of parcel sizes sent per product category (Allen *et al.*, 2017). Although the data come from the UK, and therefore not from one of the focus countries, it is assumed that the ratio of package sizes can be regarded as generally valid. This source distinguishes between three package sizes: Letterbox, Shoebox and Larger with unspecified dimensions. To be able to calculate with the parcel types, realistic sizes were determined using the DIN EN 13724 standard, courier service information and vendor information (compare Section 4.3.8.2 and Annex 2, Table 58, Table 59). Lastly, typical numbers of items per package type were taken from the stakeholder survey results. It was then assumed that letterbox packages always contain one item, while the lower value of the average range was assigned to the shoe box and the higher value of the average range to the large box (Annex 2, Table 60). Combined with the category-specific ratio of package sizes, the absolute number of shipped packages was determined, as presented in Table 14.

Projections for the baseline scenario of 2030 were extrapolated (linear) based on data for the expected annual, relative revenue growth per product category from 2019 to 2021 (Annex 2, Table 62 and Table 63).

Table 14: Total number of packages shipped in 2017 per package type, product category and country

Packages quantity per product category in 2017		Poland	Sweden (Nordics)	Spain	France	Germany	EU27
Apparel	Letterbox	11,681,647	5,610,384	22,803,800	31,754,722	39,314,430	371,126,690
	Shoebox	22,065,334	10,597,392	43,073,845	59,981,141	74,260,590	701,017,081
	Larger	29,204,118	14,025,960	57,009,501	79,386,804	98,286,075	927,816,725
	Total quantity	62,951,099	30,233,736	122,887,147	171,122,666	211,861,095	1,999,960,496
Small ICT	Letterbox	499,720	237,222	756,038	1,287,878	1,443,407	13,264,346
	Shoebox	8,078,812	3,835,089	12,222,611	20,820,701	23,335,080	214,440,256
	Total	8,578,532	4,072,311	12,978,649	22,108,579	24,778,488	227,704,602
Major household appliance	Larger (=total)	692,144	370,540	1,143,420	2,169,664	2,810,912	21,594,528
Media and entertain. products	Letterbox	22,339,175	9,525,890	39,643,464	62,476,428	112,798,187	n.a.
	Shoebox	5,185,880	2,211,367	9,202,947	14,503,457	26,185,293	n.a.
	Larger	3,590,225	1,530,947	6,371,271	10,040,855	18,128,280	n.a.
	Total	31,115,280	13,268,204	55,217,682	87,020,739	157,111,761	-
Major furniture	Larger (=total)	8,134,888	2,781,965	10,421,952	16,694,000	30,411,612	n.a.

4.3.2 Cluster: Accessibility of information

According to the assessment framework proposed in Section 4.2.2, the following effects arising from E-commerce within the cluster "Accessibility of information" are identified:

- availability of information (opportunity);
- big data / meta data (opportunity);
- innovation (opportunity);
- market access to online aftermarkets (opportunity);
- product portfolio (opportunity);
- international market access (threat); and
- ubiquity (threat).

The following two sections describe which main effects arise from E-commerce today (4.3.2.1) and which effects may be expected under future scenarios (4.3.2.2). A third and last section (4.3.2.3) summarises the main findings.

Due to the wide project scope and data availability constraints as well as inherent limitations, all effects of this cluster are described in a qualitative manner only, stating trends and expected developments based on available research. Hence, representative indicators within this cluster depend on the respective opportunity or threat being qualitatively assessed. An overview of the cluster assessment is given below.

Table 15: Overview of direct and indirect effects of E-commerce within the cluster "Accessibility of information"

Accessibility of information		
Relative effects as per today Direct opportunities and threats	Availability of information (opportunity)	
	Market access to online aftermarkets (opportunity)	
	Product portfolio (opportunity)	
Future developments Indirect opportunities and threats	Positive influencing factors	Innovation (opportunity)
		Big data/meta data (opportunity)
	Negative influencing factors	International market access (threat)
		Ubiquity (threat)

4.3.2.1 Observations of situation today

The following three direct opportunities have been identified as relevant for today's situation in this cluster: **Availability of information**, **Market access to online aftermarkets,** and **Product portfolio**.

While all three effects can be considered to be contributors to a relatively higher traffic on the internet today including related increased environmental impacts, a general statement on overall resulting relative potential environmental impact (or "net impact") of E-commerce related to brick-and-mortar commerce cannot be made, since counteracting effects, for instance product/purchase-related effects, would need to be accounted for, but are difficult to map and quantify. For example, E-commerce sites often feature much more detailed information about the product than brick-and-mortar shops typically (can) offer. Also, the concept of dynamically changing user recommendations (User-Generated Content, UGC) for a particular product provided right next to the product description cannot be matched by traditional shops, even not, if an individual customer guidance by expert personnel could be assumed a standard in brick-and-mortar shops. However, a very well-informed purchase of a product can also be assumed to lead to fewer product returns and longer product keeping at users – especially in higher-value product categories – than may be the case, if the customer is less well-informed before the purchase. This circumstance would thus contribute to a reduction of environmental impact per fulfilled unit.

The principally wider product portfolio that online stores can present compared to traditional stores (which have a limited shelf capacity to present portfolios) also supports a potentially higher customer satisfaction and keeping of the product, since a wider portfolio provides a higher probability of a customer finding "the right product", i.e. another factor that reduces environmental impact per fulfilled unit. The access to internet-based aftermarkets with spare-parts and resulting potential extensions of product use stage periods is a similar factor, generally reducing environmental impact in E-commerce context.

4.3.2.2 Future developments

Projecting future market and technology developments based on recent historic trends, it can be assumed that all three direct effects will at least maintain their relevance or even increase it, e.g. if additional types of product information would be added. Such information could for instance be transparently presented product assessments provided by independent consumer research institutes.

- **Positive influencing factors**

Indirect effects identified as contributing to an optimistic future scenario (i.e. opportunities) are **Innovation** and **Big data/meta data**.

"Innovation" can be characterised as a generic, technology-driven phenomenon particularly relevant in the ICT sector – with obvious consequences on increasing E-commerce activities. Seen per physical device, innovation can be expected to increase technological efficiency of the device, e.g. of the employed battery technologies or energy requirements, which generally contributes to decreased environmental impact. "Big data" can be considered a result of technological development, allowing meta data analysis which gives E-commerce providers the opportunity to, for example, conduct enhanced shopping pattern analyses, develop more effective customer services, and predict future customer demands. In concert, this can be expected to lead to lowered environmental impact compared to traditional commerce.

- **Negative influencing factors**

Indirect effects identified as contributing to a pessimistic future scenario (i.e. threats) are **International market access** and **Ubiquity**. Both effects constitute complex contexts, where robust predictions of joint consequences are very hard to make – in general and for some of the product categories. What can be projected is that both effects can be expected to increase in the future: Global internet access is rising and so are internet-based market volume, geographical market spread, and market diversity, leading to increased numbers of individuals having access to E-markets. Likewise, ubiquity – understood as the omni-presence of internet-based offers – can only be expected to rise in the future, driven by for instance the increasing number of internet-capable electronic platforms (notebook, smartphone, tablet, etc.), the increasing number of devices within those platforms, and the increasing technical capabilities of the devices and of the networks, transmitting data traffic. For instance, mobile data traffic volume doubled from 2014 to 2016, and is expected to grow to 10 times the 2014-level by 2021.

4.3.2.3 Summary

Accessibility of information is a central theme when comparing E-commerce and traditional commerce. Several direct and indirect effects have been identified, but a summarised "net effect", valid for certain product categories or across all of them, cannot be determined, neither for current conditions nor for the foreseeable future. Better information can be assumed to lead to less product returns and longer keeping of products at users, contributing to decreasing environmental impact. However, more devices used globally – driven by shorter innovation cycles on device-level – can be assumed to lead to increasing environmental impact potentials, globally and on EU-level.

4.3.3 Cluster: Consumer needs and behaviour

According to the assessment framework proposed in Section 4.2.2, the following effects arising from E-commerce within the Consumer needs and behaviour cluster are identified:

- sharing models and services (opportunity) ;
- nudging (opportunity);
- ease of shopping (threat);
- personalised design (threat);
- cross-selling and up-selling (threat); and
- shopping frenzy (threat).

The following two sections describe which main effects arise from E-commerce today (4.3.3.1) and what effects may be expected under future scenarios (4.3.3.2). The last section (4.3.3.3) summarises the main findings and puts them into context.

Due to the wide project scope and data availability constraints as well as inherent limitations, all effects of this cluster are described in a qualitative manner only, stating trends and expected developments based on available research. Hence, representative indicators within this cluster depend on the respective opportunity or threat being qualitatively assessed. An overview of the cluster assessment is given below.

Table 16: Overview of direct and indirect effects of E-commerce within the cluster "Consumer needs and behaviour"

Consumer needs and behaviour		
Relative effects as per today Direct opportunities and threats	Sharing models and services (opportunity)	
Future developments Indirect opportunities and threats	Positive influencing factors	Nudging (opportunity)
	Negative influencing factors	Ease of shopping (threat)
		Personalised design (threat)
		Cross-selling and up-selling (threat)
		Shopping frenzy (threat)

With regards to the project scope, the following assessment investigates the positive and negative impact from Consumer needs and behaviour on the Circular Economy. This is carried out by following a lead question: Does this effect promote eco-conscious behaviour? (compare Table 17). Consequently, any development that leads to increased consumption of products and resources is considered a threat, while decisions that lead to reduced resource consumption are considered opportunities. Furthermore, it is emphasised, that the data basis for this cluster is extremely thin. Therefore, the trends highlighted below are derived from indications of partly individual sources, that are considered plausible, as well as logical conclusions from expert opinions.

Table 17: Qualitative indicator for the cluster "Consumer needs and behaviour"

Cluster	Qualitative Indicator(s)	Unit(s)	Comment(s)
Consumer needs and behaviour	Promotion of eco-conscious consumer behaviour	-	High or low significance and relevance compared to other effects within the same cluster.

4.3.3.1 Observations of situation today

Sharing models and services has been identified as the one direct effect arising from E-commerce. Compared to conventional systems, the sharing economy can greatly benefit from flexibility of the digital realm, which allows easy and instant communication and handling. In the sense of the Circular Economy concept, the original intention of sharing models and services can be defined as "consumers granting each other temporary access to underutilised physical assets ("idle capacity"), possibly for money" (Frenken and Schor, 2017). Sharing systems serve the consumer's needs for temporary use of products and thus offer the opportunity to promote eco-conscious consumer behaviour.

With respect to the product categories in focus for this report, one example is "Vinted", a European apparel rental and selling platform (Vinted, 2019) and another one is "Peerby", a household item rental platform founded in the Netherlands (Peerby, 2019). However, many platforms that are established in line with above definition and enable consumer-to-consumer (C2C) lending, often struggle to cover their expenses, which in the past led to the closing down of a number of platform services (Morrissey, 2015).

A more capitalised form of sharing is found in business-to-consumer (B2C) services. Those expand the access of consumers to various shared products, otherwise often underutilised products without the requirement of high investment costs from a professional perspective. Some rental systems include shifts from "disposable" to "reusable" for products such as coffee cups (ReCup, 2019), designer clothes or furniture (Emma Thomasson, 2019).

The largest and most established systems include car and house sharing (PWC, 2015). These successful sharing systems achieved profitability from their services and mediation by monetising the collaborative consumption (Bosa and Salinas, 2019). As a result, the overall global revenue from sharing models is expected to rocket from 15 billion U.S. dollars in 2014 to 335 billion U.S. dollars in 2025 (Mazareanu, 2019).

4.3.3.2 Future developments

Sharing models can have positive effects for the Circular Economy, but the future success of sharing systems is highly dependent on the financial sustainability. C2C services can be expected to stabilise but are likely to remain a niche market, particularly in the product categories in focus of this project. B2C sharing services on the other hand can be expected to see further growth and increase in diversity. However, an eco-conscious consumer behaviour and positive impact for the Circular Economy is subject to sharing essential but underutilised products. Otherwise the negative impact from excess consumption would predominate, particularly with professional providers and B2C systems, usually driven by profit maximisation.

With respect to the product categories in focus, it is arguably more applicable for apparel and accessories and media products than products potentially linked to concerns regarding data protection (small ICT), physical immobility (furniture or major household appliances) or one-time use (non-perishable food). In general, the developments in the digitalised sharing economy are relatively new, therefore the research field is growing and should continue to be monitored.

In the following, the effects are described that arise from E-commerce and affect consumer needs and behaviour indirectly.

- **Positive influencing factors**

In the optimistic scenario informational **Nudging** has been identified as an indirect effect with the potential for positive impact on the Circular Economy (Demarque *et al.*, 2015). This is a relatively new topic of interest for marketers in the E-commerce business, building on research on human behaviour. The most critical factor for its positive impact on the Circular Economy is the application.

Research focuses on marketing techniques and optimisation of user interfaces to increase revenue (e.g., Mirsch, Lehrer, & Jung, 2017, Eigenbrod & Janson, 2018, Djurica & Figl, 2017), in some cases even unethical aspects (Weinmann, Schneider and Brocke, 2016). Nudging strategies for improved sustainability and circularity are underrepresented (Kaiser, 2018). However great potential is confirmed for informational nudging aiming to reduce environmental impacts (e.g., Isley, Stern, Carmichael, Joseph, & Arent, 2016; Demarque, Charalambides, Hilton, & Waroquier, 2015; Urban, 2017). One example for nudges practiced in business is the informational nudge with the option to activating CO_2 compensation for rides with Flixbus (2018). The European intercity coach service provider reports that ten percent of customers actively choose to compensate at additional one to three percent of the ticket costs (Flixbus, 2017). This indicates a significant potential of customers susceptible for additional options and willing to pay a premium for reduced environmental impact. Default

setting of environmentally friendlier options would be an advanced step in nudging strategies and could result in an increase of participation from customers of up to approximately 30% (Kaiser, 2018). On the other hand, it can be argued, that the willingness to invest in environmentally friendly options is very sensitive to price differences of the products. A survey in Europe and the USA for instance (Miremadi, Musso and Weihe, 2012) revealed that 70% of customers generally are willing to pay 5% more for a premium product, while less than 10% choose the premium option, if the price difference is at 25%. Another study reported that by 2030, the share of consumers who are generally willing to pay extra for same-day delivery may increase to 25% (Joerss *et al.*, 2016). In this context, the attitude-behaviour gap between statements made by customers and their actual action is a well-known and discussed phenomenon (Kaiser, 2018).

Overall, it can be expected that the implementation of environmental nudges remains highly dependent on the respective retailer policies and individual sustainability commitments. Unless incentives or growing public pressure increases the industry's economic interests in environmental efforts, the impact of environmental nudging in E-commerce is likely of minor significance but entails great potential for the Circular Economy. With respect to the product categories in focus, one example for environmental nudging are financial incentives by local governments in Germany for consumers who purchase state-of-the-art energy-efficient major household appliances (SWB, 2019). Future research may provide detailed knowledge from investigating the effectiveness of environmental nudging for the different product categories.

- **Negative influencing factors**

Four indirect effects related to consumer needs and behaviour in E-commerce have been identified to affect the Circular Economy: Ease of shopping, Personalised design, Cross- and up-selling as well as Shopping frenzy.

Due to E-commerce, consumers are enabled to shop without any restrictions to time or geography, subject to internet access. This can serve consumer needs linked to the desire for immediate action. The **Ease of shopping** may contain a threat for the Circular Economy if it leads to increasing overall purchases or impulse purchases in particular. Furthermore, four aspects relate to this effect: Physical access to unlimited purchasing options, the huge variety of product variations, the ease of use with simplified processes, and personalized interface designs.

On the one hand, the nearly endless online product variety has the theoretical potential to allow the customer to find the product that is best suitable to his or her needs. It is expected that this aspect is depending on the individual willingness for time-intensive research. If eco-conscious consumers find more sustainable products online than offline, the threat can convert into an opportunity for the Circular Economy compared to brick-and-mortar. The ease of shopping is therefore linked to the accessibility of information, which generally supports eco-conscious consumer behaviour (compare Section 4.3.2).

Furthermore, many online shops have invested in the development of easy checkout-services. Simplified purchases are even more enabled through smart devices with voice assistance. The community using those new technologies is significant in Germany (Stern, 2018). It can be argued, that due to the easy access to products, the customers might increasingly lose touch with the associated costs, production conditions and environmental impacts.

Optimised customer experiences through personalised interface design is another important aspect E-retailers focus on (Mirsch, Lehrer and Jung, 2017). This is closely linked to nudging and negative impacts for the circular economy due to increased resource use (compare Section 4.3.3). On the one hand, it is a factor for customer satisfaction in E-commerce. Chances as well as challenges arising from personalisation in E-commerce are being discussed and their importance for the future is strongly emphasised (E-commerce Europe, 2018b). If the consumer is connected with the retailer on various media channels like web-based, e-mail and apps, and potentially around the clock, this approach is referred to as ubiquitous commerce (Kumar, Joshi and Saquib, 2015). The use of artificial intelligence for pattern recognition plays a major role here (EcommerceEurope, 2018).

It can be argued that in cases where a product would not have been purchased anyway, excess consumption is encouraged and translates into negative impacts from customer behaviour for the Circular Economy.

The available data indicate that purchase intentions in E-commerce are positively related to the customers' trust in the E-retailer and the satisfaction with offered services (Miremadi et al., 2012; Nisar & Prabhakar, 2017; Zhu, Mou, & Benyoucef, 2019). The line can be narrow between the advantages of personalised design and increasing amounts of customers expressing concerns about privacy protection (Kumar, Joshi and Saquib, 2015).

However, personalised product recommendations, omni-channel experiences, or push notifications by brands on availability of desired products based on wish-lists or similar are reported to result in likely conversions from 90 % of the (U.S.) customers (Scalefast, 2019). Therefore, personalised interface designs have so far been highly efficient and are likely to

have led to customer desires for immediate product access given constant, personalised and multi-channel access to E-commerce.

The topic is less relevant in brick-and-mortar, since conventional, single channel retail could not provide this high level of personalisation due to the lack of detailed customer data. However, by 2030, it is assumed that a large share of retailers likely operates omni-channel and capitalises on personalisation features. Consumer expectations may increase by then, too, leading to SMEs investing in personalised customer relations.

In conclusion, it can be argued that the sheer opportunity of access from E-commerce is unlikely to result in unlimited, excessive shopping behaviour of customers. Despite the efficiency of personalised interface designs and the resulting increased probability of impulse purchases from artificially created consumer desires, any additional, unsustainable consumption is eventually limited by the economic situation of the individual customer.

Like the previously described effects, **Cross-selling and up-selling** is closely linked to the effect of nudging. Cross-selling and up-selling strategies are based on nudges to increase sales. This is done by offering product combinations, additional purchases or premium products for reasons of higher revenue and better transport efficiency (compare Section 4.3.7). This effect does not aim towards the promotion of more environmentally friendly products. On the contrary, the practice negatively affects the Circular Economy, as more products are sold than were originally needed and/or requested by the customer.

However, in brick-and-mortar stores, too, products are places strategically next to related products and banners can be used to advertise bargains and achieve up-selling. It is therefore assumed that the impact of cross-selling and up-selling is roughly the same in both E-commerce and brick-and-mortar. On the other hand, the utilisation of collected customer behaviour data (e.g. through cookies) in E-commerce could become increasingly efficient in combination with optimised personalised advertisements (see above, personalised design) and generate additional desires with customers. This could then stimulate additional purchases and therefore increased negative impact for the Circular Economy.

Regarding **Personalised design**, negative influencing factors for the Circular Economy can be manifested in two ways: on the one hand, personalised products may result in higher customer satisfaction and extended use of products in the first life cycle. The production differences between individualised and mainstream production is estimated insignificant but if the product is not implemented as expected by the customer, the personalised product may be rejected and require a second attempt. Considering low high-quality recyclability of many materials, it generates more waste. On the other hand, as per the nature of personalised products, the products are tailored to a specific customer and any second life cycle is considerably more difficult to realise, thus reducing the benefit for a Circular Economy further. No study could be found on the topic of individualisation of products, which does not purely focus on the B2B sector (Koch, Butz and Schlichter, 2014). More research is needed to evaluate the environmental impacts based on representative data.

The last effect considered is **Shopping frenzy**, which refers to the behaviour of customers to purchase numerous consumer goods in a very short time. Real life examples are event days, where a large share of retailers (online as well as offline) offer various shopping deals, bargains or sales with potentially high discounts. Very popular examples are Black Friday and Cyber Monday in the U.S. or Single's Day in China. Additionally, outlet stores, or outlet cities advertise with large discounts throughout the year.

Historical data on U.S. holiday season (the time between end of November and early January that includes Black Friday and Christmas shopping) prove significant sales volumes. Shares of annual sales were converted during this period that ranged from 18% in conventional food and beverages stores to more than 30% for hobby, game and toys stores. In E-commerce, 22% of annual sales were generated (Manage Artworks, 2018).

The event of Black Friday and Cyber Monday was introduced in Europe relatively recently and has since been adopted by a growing number of retailers. The German Trade Association reported 1.7 billion Euros revenue from the events in 2017. With participation rates of 13-16%, the acceptance is much lower in Germany (Handelsverband Deutschland, 2017).

On the other hand, sales from Black Friday were expected to increase by 15% in 2018 (Handelsverband Deutschland (HDE), 2018). Online presence for Black Friday shopping can be found, too, with countdowns and information about participating retailers (Black Friday GmbH, 2019).

Amongst other specific thematic offers and sales in Europe are Easter Sales, Valentine's Day, Mother's or Father's Day as well as summer or winter sales and special shopping Sundays in Germany.

With respect to the shopping frenzy, guaranteed return rights by strict EU law further strengthen the consumer position by reducing the risk of mispurchases or unappreciated gifts and thus increasing potential of returns (European Commission, 2019b). In fact, analytics estimated 30% higher return rates resulting from impulse purchases from events like Amazon

Prime Day (Morris, 2019). In the UK for instance, the returns generated additional handling costs of 130 million British pounds (Davidson, 2015).

In comparison, around half of the customers preferred multi-channel, while one quarter of consumers shopped only either online or offline (Sterling, 2018). E-commerce tends to be preferred by customers for shopping frenzies due to convenience aspects. At the same time, another trend is the extension of sales days or pre-event sales aspects (BlackFriday.com, 2019b).

It can be suspected, that the circumstance of strong consumer rights compared with shopping frenzy days contributes to the intensification of E-commerce and increases the number of returns in absolute terms linear to the sector's growth rates. Consequently, in this combination, shopping frenzy has a high relevance and negative impact for the Circular Economy. On the one hand, additional, not necessarily required, products are purchased (for the benefit of the bargain) and on the other hand the increased return rates greatly affect the environmental impact per fulfilled unit.

4.3.3.3 Summary

In summary, sharing models and services, identified as the only direct effect for consumer needs and behaviour arising from E-commerce, are considered to support eco-conscious consumer behaviour and positive impact for the Circular Economy, subject to sharing essential but underutilised products. For other sharing systems of non-essential products, the negative impact from excess consumption would predominate. With respect to the product categories in focus, there are only few sharing systems applicable and those that exist are expected to remain a niche market in the future.

Regarding positive influencing factors for this cluster, environmental nudging is concluded to contain great potential for the Circular Economy through the promotion of eco-conscious consumer behaviour. However, the implementation of environmental nudges is expected to be of minor significance, unless incentives or growing public pressure increase economic interests in environmental efforts.

Regarding the negative influencing factors it is concluded that the ease of shopping through the access itself can be seen as a neutral effect, possibly resulting in customers buying online rather than offline. However, the simplification and personalised interface designs were found to promote the creation of desires of ownership and additional, initially unintended purchases. These consequently lead to unsustainable consumer behaviour. The tendency for negative impacts from impulse purchases could increase due to the spontaneity of access compared to brick-and-mortar sales. Furthermore, personalised design is an effect, where advantages and disadvantages for the Circular Economy roughly balance each other out. The negative impact is that personalised products are considerably difficult to resell. Cross-selling and up-selling effects can be argued similar in E-commerce and brick-and-mortar. In combination with ease of shopping, the effects can become very significant. Lastly, shopping frenzy is the most significant and highly relevant effect with negative impacts on the Circular Economy. This is due to its promotion of purchasing additional, not necessarily required products and the high return rates that come with it.

Table 18: Summary of the expected effects of identified opportunities and threats within the cluster "Consumer needs and behaviour"

Consumer needs and behaviour			Determined relevance of effect
Relative effects as per today Direct opportunities and threats	Sharing models and services		+
Future developments Indirect opportunities and threats	Positive influencing factors	Nudging	+
	Negative influencing factors	Ease of shopping	--
		Personalised design	0
		Cross-selling and up-selling	0
		Shopping frenzy	-

4.3.4 Cluster: Digitalisation

According to the assessment framework proposed in Section 4.2.2, the following effects arising from E-commerce within the "Digitalisation" cluster are identified:

- operational energy demand for the network infrastructure (threat);
- digital goods (opportunity);
- reduction of retail space (opportunity); and
- substitution of printed marketing material (opportunity).

The following two sections describe which main effects arise from E-commerce today (4.3.4.1) and what effects may be expected under future scenarios (4.3.4.2). The last section (4.3.4.3) summarises the main findings and puts them into context.

Due to the wide project scope, data availability constraints as well as inherent limitations, all effects of this cluster are described in a qualitative manner, stating trends and expected developments based on available research.

Table 19: Overview of the direct and indirect effects of the "Digitalisation" cluster

Digitalisation		
Relative effects as per today Direct opportunities and threats	Operational energy demand for the network infrastructure	
	Digital goods	
Future developments Indirect opportunities and threats	Positive influencing factors	Reduction of retail space
		Substitution of printed marketing material
	Negative influencing factors	*(none)*

The focus of scientific ICT-related assessments is on energy demands and often strongly correlated global warming potentials (carbon footprints). These two indicators are also highly relevant for a Circular Economy as energy-efficient and regenerative systems are considered essential building blocks of a low-carbon society.

Table 20 provides an overview of the representative indicators for the cluster "Digitalisation".

Table 20: Representative Indicators for the cluster "Digitalisation"

Cluster	Representative Indicator(s)	Unit(s)	Comment(s)
Digitalisation	"(Primary) Energy demand and global warming potential"	kWh, CO_2e	-

4.3.4.1 Observations of situation today

The direct effects identified as relevant for today's situation are **Operational energy demand from the network infrastructure** and **Digital goods**.

An indisputable pre-requisite and characteristic for E-commerce is a network infrastructure that enables data flow between parties, e.g. between store and customer or store and supplier. Some of that infrastructure exists irrespective of the E-commerce context, e.g. certain hardware including some baseline energy demand used for traditional electronic warehouse keeping and supplier dialogue. It is relevant to identify the additional **operational energy demand for the network infrastructure** from E-commerce.

Main drivers of such additional energy demand are activities of the customer and of the store. Via their additional energy demand, these activities have a direct effect on the environmental impact of the overall type of commerce. Additionally, they occur across product categories (i.e. not only for selected product categories) but not in all life cycle stages.

Evidently, it is difficult to attribute electricity consumption to one single E-commerce application (e.g. browsing and purchasing a product) as there are always many features running in parallel on a specific ICT hardware, for instance a smartphone. Furthermore, E-commerce applications are multifunctional, and unambiguous system boundaries are not present between E-commerce and traditional value chains, e.g. due to mixed ordering and delivery methods in omni-channels and showrooms. However, some general remarks can be made. Aslan et al. (2018) show in their study that an average electricity consumption can be linked to data transmission through the Internet (kWh/GB transmitted). Comprehensive recent estimates for data traffic on the world-wide web state around 0.06 kWh electricity consumption per Gigabyte (GB) traffic in 2015 (ibid.). However, when communicating via global network components, the electricity intensity of the IP core network and a fixed network access equipment that is needed for the abovementioned, is only one part in a complex system of data transmission infrastructures comprised of distinct network access points, data centres, etc. Depending on the type of the end-user device, either a mobile or fixed network access point (e.g. LTE and DSL or Wi-fi) is needed. This adds to the energy demands associated with data transmission. The storage and provision of data further necessitates the operation of data rooms or centres. Apart from the complex structure of data transmission networks, actual electricity demands are highly dependent on the geographical context (e.g. population or subscriber density, geographical distribution) (Aigner, 2018). Even if that information was known, the actual amount of data that is required to provide a certain function (e.g. display of goods online and the potential consumer buying process) is challenging to quantify. This is due not least to hidden data traffic from user analytics, updates, automatic or default downloads.

In conclusion, an EU average or representative electricity demand for the overall digital purchasing process per fulfilled unit cannot be reliably quantified under the scope of this study.

A study from the year 2009 compared the total primary energy associated with Retail and E-commerce systems by life-cycle stage (Weber *et al.*, 2009). Albeit its outdated data base and reference year, the data is deemed applicable to put this threat into perspective. Here, the additional energy demands arising from E-commerce are estimated to be 0.28-0.56 kWh (per fulfilled unit) of primary energy use from the consumer placing the order. Another 0.07 kWh (per fulfilled unit) is related to the operation of a data centre. The total energy use for the network infrastructure corresponds to about 6% of the total primary energy demand (per fulfilled unit) associated with the suggested E-commerce value chain. When comparing the total energy demand for the network infrastructure to the slightly more energy-intense traditional retail scenario, it corresponds to only 5% of the total (ibid.).

Today, energy intensities per data volume transmitted are significantly lower, therefore potentially reducing this share and overall impact. At the same time though, it can be assumed that data volumes per fulfilled unit have increased due to numerous effects (e.g. hidden data traffic for analytics, high-definition displays, animated online content, etc.) (Aslan *et al.*, 2018). Hence, it can be stated that the additional primary energy demand arising from E-commerce lies probably below 5% of the total primary energy demand associated with all other life cycle stages in the respective value chains (e.g. packaging, warehousing, transport, retail store, etc.) and is therefore of moderate relevance.

This is in line with the findings from a more recent study from 2015 on carbon emissions from online retailing of fast-moving consumer goods (FMCGs). Under the assumption that placing an online order takes between 15 and 30 min and accounting for the electricity consumption of PC's, laptops, smart phones, or tablets as well as the life cycle impacts of the respective computers, infrastructures and routers, ICT operations in total are found to have a minor impact (Van Loon *et al.*, 2015b).

Arguably, neither primary energy demand, nor electricity demand are the most suitable Circular Economy indicators. Instead, the share of renewable energy sources in the respective channels should be factored in as to give an indication about CO_2 emissions or other energy-related environmental impacts. Network infrastructure, run on renewable energies, offers a great potential to largely offset any additional impacts due to E-commerce.

In contrast to the universal operational energy or electricity demands associated with E-commerce, the opportunity of **Digital goods** is currently only applicable to one of the selected product categories ("media and entertainment products/services").

In the special case of digital goods, the processes associated with one fulfilled unit are less definite. The equivalent to the physical shipping stage would be data transmission associated with a certain type of digital content. This process is, in many instances, already part of the use stage (e.g. streaming of a video). Therefore, the proposed functional unit would account for digital contents transmitted to the end-user devices (e.g. smartphones, tablets) but not for the electricity demands and life cycle implications of those devices.

In general, the opportunity of providing digital goods through E-commerce structures represents a very important cornerstone of a Circular Economy. Evidently, virtualisation of goods affects all life cycle stages from raw material extraction until disposal. However, many of the typical implications of digital goods are referred to life cycle stages that are outside the scope of this study, and thus are not attributable to E-commerce but a larger digitalisation trend. With the provision of digital goods not only the value chain within an E-commerce scenario is streamlined and dematerialised but the whole traditional value chain may become obsolete. Whether digital goods in fact substitute their physical counterparts and corresponding value chains depends on the specific product and cultural aspects associated with it. This circumstance is often highly speculative, and at least controversial in literature (Börjesson Rivera *et al.*, 2014b). Especially e-books provide a good example to emphasise that physical goods are not simply replaced by their digital version. Printed books are not only still the more popular format, but the share of printed books and e-books is estimated to be constant for the near future (Atasoy and Morewedge, 2018). Most importantly, however, is the circumstance that many of the potential positive effects on a Circular Economy cannot be attributed to E-commerce alone. Looking at the E-commerce value chain, the only notably affected life cycle stage is the E-fulfilment process of purchasing a digital good which is assumed to be congruent with the digital shipping (data transfer) of certain goods (e.g. purchasing an e-book or streaming a video is immediately linked to the download of the content). In contrast, comparable physical goods pass through secondary packaging, distribution from manufacturer, retailer operations, collection, possible return, unboxing, and disposal in an E-commerce value chain in case physical products are purchased online.

Under consideration of in-scope life cycle stages, the positive enabling effect of E-commerce is particularly high for products where impacts due to data transmission of contents are rather low. This is the case for digital goods comprised of little data volumes. Here, induced electricity demands remain low (Aslan *et al.*, 2018). Therefore, products that fall into the segment of e-publishing could be taken as a point of reference. Within this segment, e-books make up the biggest share of the market volume in terms of revenue in Europe (statista, 2019a). An indication of the importance of books or e-books related to E-commerce lies in the observation that books are the most frequently assessed product in quantitative assessments in the available literature on E-commerce effects (Pålsson, Pettersson and Winslott Hiselius, 2017). Compared to other e-publishing products (e.g. e-magazines or e-papers), e-books are associated with a small amount of data (2-3 MB) being transferred through E-commerce platforms to the user (Moberg, Borggren and Finnveden, 2011; Aigner, 2018). Assuming a correlation between electricity demands of internet infrastructures (e.g. data centres, transmission and access networks) and data volumes (Malmodin *et al.*, 2014), the impact of purchasing an e-book is considered negligible. Essential processes with notable implications for a Circular Economy (e.g. upstream effects of devices needed to read e-books, electricity demands for operation of devices) are not solely attributable to E-commerce and generally not within the area of influence of providers. In some cases it is, however, observed that E-commerce platform providers expand their area of influence by e.g. offering dedicated devices to consumers (e.g. Amazon Kindle e-reader devices). On the other hand, processes needed to provide consumers with physical books in the traditional value chain scenario may be substantial and versatile.

Due to the very complex and potential systemic implications of digital goods offered through E-commerce, disentangling of certain impacts and attributing them to generic value chains is considered impossible under the scope of this study. Also it must be remembered that the environmental impacts induced by digital goods are predominantly determined by the use stage, hence allocated to upstream impacts of devices and electricity for operating end-user devices (Moberg, Borggren and Finnveden, 2011).

4.3.4.2 Future developments (all qualitative)

When delimiting the operational energy demands for the network infrastructure to the E-fulfilment purchasing process as the most distinct process (compared to the traditional value chain), it must be remembered that this potentially offsets an individual consumer trip. Hence, any additional impacts may be weighed against impacts associated with consumer trip scenarios. However, online purchases often not necessarily replace but complement a consumer trip (Van Loon *et al.*, 2015b). Therefore, it is worthwhile to look at trends and forecasts associated with respective ICT use. Energy demand and the associated global warming potentials are the main focus of current ICT-related assessments. Several indications point to a shift from overall electricity consumption dominated by (increasingly more energy-efficient) end-user devices towards an increasing relative significance of networks and data centres (Prakash *et al.*, 2014; Andrae and Edler, 2015; Cook, 2017; Pärssinen *et al.*, 2018). Assuming that this trend also holds true for E-commerce applications, it can reasonably be expected that efficiency gains related to the use of networks and data centres are overcompensated by increasing data volumes per fulfilled unit. Consequently, E-commerce providers should embrace strategies towards data sufficiency and a transition to renewable energy supplies. Moreover, virtualisation and cloud computing can increase the utilisation of existing hardware and are therefore expected to further mitigate this threat in the future (Umweltbundesamt, 2018b).

Energy demands associated with the network infrastructures are inextricably linked to the provision and subsequent use of digital goods. This opportunity, however, entails immediate as well as long-term systemic implications for the Circular Economy. In any case, these predominantly positive effects deserve attention in the future as the European market of e-publishing is expected to grow on average by 7% per year in terms of turnover over the years 2017 until 2023 (Statista, 2019). The corresponding average growth rates for video-on-demand and digital music are both around 5% (Statista, 2019).

- **Positive influencing factors**

The full potential relating to the **reduction of retail space** may unfold if E-commerce actually replaces existing brick-and-mortar distribution systems. There are indications that E-commerce value chains could become more environmentally friendly if energy and resource demands of physical retail stores are offset and taken into account when estimating the overall performance of E-commerce (Umweltbundesamt, 2018b). However, these beneficial effects differ from product category to product category. For instance, physical display space may be less important for media and entertainment products like books, while for apparel the display space may facilitate trying on clothes and thus could reduce product returns.

As a general rule it can be stated that the carbon footprint of running an E-commerce website is significantly lower than its physical counterpart comprising allocated impacts from Heating Value and Air Conditioning systems and the life cycle of buildings (CANDRIAM, 2017). This assumption is supported by the circumstance that energy consumption in stores is usually higher than in warehouses (Fichter, 2001; Pålsson, Pettersson and Winslott Hiselius, 2017). In addition, there is a tendency towards fewer, larger and more energy-efficient warehouses in E-commerce value chains (Pålsson, Pettersson and Winslott Hiselius, 2017). In the case of products with low space requirements like books, it was found that the life cycle energy consumption related to buildings is 5-6% lower in E-commerce value chains compared to traditional distribution systems (Pålsson, Pettersson and Winslott Hiselius, 2017). Regarding the entire life cycles of analysed media products, however, buildings have only a minor effect on the total energy consumption differences. These were instead found to predominantly be influenced by packaging, transport, and the amount of unsold products or product returns (Pålsson, Pettersson and Winslott Hiselius, 2017). Similarly, for a representative product from the small information and communication technology product category (one fulfilled unit of a flash drive) the total primary energy demand associated with the physical retail store had a minor impact, too (Weber *et al.*, 2009). Overall, this factor is considered to be of medium relevance to the Circular Economy.

Comparable to the opportunity of digital goods, traditional processes associated with paper-based content production may become obsolete due to **substitution of printed marketing material** with digital equivalents. This specific opportunity is neither well-described in the literature, nor linked to the specific E-commerce applications, nor compared with traditional marketing means. In comparison with other effects within this cluster, this opportunity is expected to be of minor importance per fulfilled unit of any product category. Nevertheless, from a top-down perspective online advertising is an essential factor regarding the energy demand: On a global scale it was found that online advertising makes up 25 to 75% of the total data traffic associated with web, e-mail and data applications, which arguably includes E-commerce (Pärssinen *et al.*, 2018). Although digitalisation of text-based content is in most cases beneficial for the environment (Aigner, 2018), the possibilities introduced by digital marketing (e.g. more quantity, animated content, personalised content and analytics) have at least a large potential to overcompensate these environmental gains and must therefore carefully be looked at in the future.

- **Negative influencing factors**

Not applicable, as no indirect threats have been identified within this cluster.

4.3.4.3 Summary

In summary, the effects within this cluster are mainly expressed in energy demands and/or associated carbon footprints. ICT assessments in the literature focus on these parameters. On the one hand, energy demands and associated environmental impacts arising from operations and advertisement in E-commerce due to operations and advertisement deserve attention. On the other hand, a positive net effect on the Circular Economy can only be expected when traditional value chain processes (e.g. physical retail space) are substituted. This holds also true for the specific opportunity related to digital goods. Under current conditions with multi-channel value chains, the net effect of mentioned opportunities and threats remains unclear (Dost and Maier, 2018). In the future, several trends (e.g. increasing data traffic, changes in physical retail stores, further growth of digital goods sector, energy efficiency and renewable energy sources for network and data centre operations) will affect E-commerce and traditional value chains jointly.

Table 21 summarises the expected effects of identified opportunities and threats within the cluster "Digitalisation".

Table 21: Summary of the expected effects of identified opportunities and threats within the cluster "Digitalisation"

Digitalisation			**(Primary) Energy demand (per fulfilled unit)**	**Global Warming Potential (per fulfilled unit)**
Relative effects as per today Direct opportunities and threats	Operational energy demand for the network infrastructure		–	*n.a.*
	Digital goods		0	0
Future developments Indirect opportunities and threats	Positive influencing factors	Reduction of retail space	+	+
		Substitution of printed marketing material	0	0
	Negative influencing factors	-		

4.3.5 Cluster: End-of-Life

According to the assessment framework proposed in Section 4.2.2, the following effects arising from E-commerce within the End-of-Life cluster are identified:

- second-hand E-commerce / online auctioning (opportunity);
- extended product selling cycle (opportunity);
- product take-back (opportunity);
- end-of-Life challenges (threat);
- waste from returns (threat); and
- food waste (threat).

The following two sections describe which main effects arise from E-commerce today (Sections 4.3.5.1 and 4.3.5.2) and what effects may be expected under future scenarios (4.3.5.3). The last section (4.3.5.4) summarises the main findings and puts them into context.

Table 22: Overview of the direct and indirect effects of the "End-of-Life" cluster

End-of-Life		
Relative effects as per today Direct opportunities and threats	Second-hand E-commerce / online auctioning (opportunity)	
Future developments Indirect opportunities and threats	Positive influencing factors	Extended product selling cycle (opportunity)
		Product take-back (opportunity)
	Negative influencing factors	End-of-Life challenges (threat)
		Waste from returns (threat)
		Food waste (threat)

The above direct and indirect effects mainly refer to the reuse, remanufacturing, refurbishing, or recycling of a product at the end of its first life cycle. With regard to the EPDs of different specific products, exemplary from the product category apparel (ISKO division, 2018), End-of-Life indicators used are "components for reuse", "material for recycling" or "energy recovery" and accounted in kg. Another EPD in the Non-perishable food product category refers to percentages of "recycling", "energy recovery" and "landfill" (Barilla, 2014).

From a wider Circular Economy perspective, the relative importance of upstream, production-based impacts generally makes a strong case for reuse. In addition, there is a ubiquitous trend that energy requirements of many powered products are decreasing in the use phase and thus shifting the majority of life cycle impacts to the production phase (Cooper and Gutowski, 2017). This is particularly relevant for products from the selected categories of small information and communication technology and major household appliances. Consequently, it is argued that potential environmental gains from reuse are particularly high for products whose average life cycle impacts are largely determined by the production stage. This is likely to hold true for many product categories. Although reuse scenarios in general are understood to positively contribute to a Circular Economy, environmental benefits are not always guaranteed (Cooper and Gutowski, 2017). For instance, this may be the case if the use phase of energetically inferior products is prolonged although newer and more energy-efficient products would be available (e.g. refrigerators).

Despite aforementioned limitations and uncertainties, it is assumed that reuse rates are a valid indicator for measuring the positive and negative contributions to a Circular Economy arising from E-commerce. Moreover, reuse is commonly prioritised over other End-of-Life options (recycling, recovery, disposal) and should therefore receive the most attention (European Commission, 2016c; Ellen Macarthur Foundation, 2017b). In contrast to other potential indicators (e.g. recycling rates, repair rates, etc.), reuse rates can potentially be captured at the point where product ownership is transferred between customers, often facilitated by E-commerce platforms for other resale activities. In addition, most EoL pathways cannot be attributed to either one of the distinct retail channels, thus making a comparative in-depth assessment

impossible. However, a differentiation between reuse, remanufacturing and recycling will be included to the extent possible, depending on data availability and the specific effect under consideration.

Due to evident time lags between purchase and potential reuse or alternative EoL scenarios as well as unclear origins of products, respective rates cannot always be expressed per fulfilled unit.

Table 23 provides an overview of the representative indicators for the cluster "End-of-Life".

Table 23: Representative Indicators for the cluster "End-of-Life"

Cluster	Representative Indicator(s)	Unit(s)	Comment(s)
End-of-Life	"Fraction that is effectively brought into a second or prolonged life cycle and product waste per fulfilled unit"	%, absolute	Reuse, remanufacturing, recycling, landfilling - subject to product category and effect

4.3.5.1 Observations of situation today

The direct effect identified as relevant for today's situation is **Second-hand E-commerce / online auctioning**.

In recent years, there have been noticeable effects on reuse possibilities due to the increasing proliferation and acceptance of online platforms (Umweltbundesamt, 2017b). According to a survey in Germany, E-commerce platforms are the dominant channel for purchasing used products (Statista, 2017). Next to established customer-to-customer (C2C) platforms (e.g. eBay, Shpock), professional intermediaries (e.g. AmazonWarehouse, reBuy) are entering this segment.

Evidently, marketplaces and channels for resale of used products are versatile and fragmented. Consequently, data sources and quantitative information relating to product-specific reuse rates and/or E-commerce specific circumstances are rare and highly uncertain. Apart from identified data points (see Table 24), most sources do only reveal qualitative data or survey results with limited validity for a European policy context.

Taking the position that respective online platforms which facilitate the reuse of products are attributable to E-commerce, reuse becomes an inherent feature of E-commerce. Thus, this opportunity is understood as a direct effect arising from E-commerce. Therefore, a quantitative assessment sequence was deemed appropriate in line with Step 3 of the assessment framework.

The selection of sources and data points needed for this quantitative assessment sequence is presented in Table 24.

Table 24: Overview of sources and data points applicable to the assessment of second-hand E-commerce (opportunity)

Reference	Type of reference (Data pool)	Content
Statista (2019e)	Statistics	Industry revenues of online and offline retail sales of second-hand goods in different countries
Statista (2019b)	Statistics	Total revenues and future projections in E-commerce in different countries
Statista (2019a)	Statistics	Total revenue in traditional retail per country in Europe
Statistisches Bundesamt (n.d.)	Statistics	Industry revenues of offline retails sales of second-hand goods in Germany
eBay (2016)	Survey	Preferred channel for sale of second-hand goods

With regards to the weak database, this opportunity may be approached by looking at the overall industry revenues from online and offline retail sales of second-hand goods, as presented in Table 25. European aggregates or averages were not found in identified data sources. Thus, this assessment focuses on the identified relevant countries.

Table 25: Industry revenues of online and offline retail sales of second-hand goods in selected countries for the year 2017 in Million EUR (Statista, 2019g)

Poland	Sweden	Spain	France	Germany
301.22	164.7	354.33	1,894.33	2,881.48

4.3.5.2 Findings from quantitative assessment for situation today

No revenue shares of online and offline retail are disclosed or readily available. The literature or respective statistics does not provide any indications or shares concerning the respective products or product categories that constitute the overall revenue. Therefore, further assumptions and approximations were made.

According to the survey by eBay (2016), 89% of the respondents refer to online channels as their first choice to purchase second-hand goods. In the case of 82% of the respondents, online platforms are the preferred channel to sell their products (eBay, 2016). Available data supports these tendencies for the German market of second-hand goods: Taking 2016 as a reference year, the industry revenue of second-hand goods in offline channels amounted to 617 Million Euro (Sueddeutsche Zeitung, 2018). Comparing this value to the respective turnover from both channels together (Statista, 2019e), sales through offline channels correspond to about 22%. For subsequent calculations and estimates it was therefore assumed that 80% of revenues were generated by E-commerce (and online platforms in general) and 20% by traditional retail. Applying this ratio, the following revenues can be attributed to the respective retail channels (see Table 26). In addition, total revenues in respective retail channels are given as reference and the relevance of the second-hand market is calculated as the percentage of total sales in both channels.

Table 26: Allocated industry revenues of retail sale of second-hand goods through E-commerce and traditional channels in relation to respective total revenues for the year 2017 in Million EUR (own calculations based on Statista (2019b, 2019a))

	Poland	Sweden	Spain	France	Germany
E-commerce (online) retail:					
Industry revenue of retail sale of second-hand goods through E-commerce	240.98	131.76	283.46	1,515.46	2,305.18
Total revenue in E-commerce (B2C)	6,889	8,729	13,986	38,109	59,111
Percentage of second-hand sales compared to total sales in E-commerce	3%	2%	2%	4%	4%
Traditional (offline) retail:					
Industry revenue of retail sale of second-hand goods through traditional retail	60.24	32.94	70.87	378.87	576.30
Total revenue in traditional retail (B2C)	119,376.8	78,046.2	227,640.7	469,185.7	560,228.6
Percentage of second-hand sales compared total sales in traditional retail	0.05%	0.04%	0.03%	0.08%	0.10%

Both absolute revenues from second-hand goods as well as noticeable fractions with respect to total sales in E-commerce range from 2 to 4% in the different countries. This demonstrates a positive contribution from E-commerce for the Circular Economy. Arguably, these fractions are expected to be significantly higher if revenues from second-hand goods were to be

compared to the total revenues associated with products that can potentially be reused. Yet, there was no possibility to gather data without accounting for foodstuff, personal care products, household products, etc.

Furthermore, the assumed ratio between both channels indicates that the absolute revenue from second-hand retail is significantly lower in the traditional retail channel. However, the presented percentages for traditional retail must not be compared to the percentages in E-commerce. In fact, they only serve as a point of reference for the traditional retail channel. This is because of the noteworthy deviations in products sold via the respective channels. For instance, the total turnover in the traditional retail is dominated by foodstuff, while this category is currently negligible in E-commerce. Therefore, a majority of products generating the revenue in the traditional retail channel are not applicable for a potential reuse scenario. This has a weakening effect on the percentages of second-hand sales in comparison with the total values.

The assessment results and industry revenues cannot be derived per product category due to a lack of data. However, surveys in Germany, Spain, and France commonly indicate that the product categories "media and entertainment products and services", "apparel", and "small information and communication technology" are dominating this segment in both E-commerce and traditional channels (Statista, 2019i, 2019k, 2019j). Taking eBay as an example for online second-hand trade with high market share, it was found that commonly sold products vary significantly between E-commerce and traditional channels (e.g. reuse centres) (Umweltbundesamt, 2017b). While E-commerce platforms seem to be the primary choice to sell and purchase used electronic devices in Germany, traditional channels are still more relevant for apparel and furnishings (Umweltbundesamt, 2017b).

Although the relative shares of second-hand sales cannot be compared between the distinct channels, it is evident that second-hand sales are an outstanding feature of dedicated E-commerce platforms. Thus, it is argued that the positive effects from this opportunity are of high relevance for the Circular Economy.

4.3.5.3 Future developments (all qualitative)

Due to the incommensurability of traditional and E-commerce channels regarding second-hand retail revenues and percentages, a future scenario is only proposed for expected developments in E-commerce. This approach is deemed appropriate to gauge the importance of second-hand retail in E-commerce.

For the calculation of respective revenues average annual growth rates between 2017 and 2023 (Statista, 2019e, 2019g) have been applied and revenues from Table 26 were extrapolated to the year 2030. The revenue share of second-hand retail generated by E-commerce was assumed to remain at 80%.

Table 27: Average annual growth rates and extrapolated revenues in E-commerce for the year 2030 in million EUR (own calculations based on Statista (2019b, 2019e))

	Poland	Sweden	Spain	France	Germany
Annual growth rates:					
Annual growth rate (2017-2023) of revenue of retail sale of second-hand goods	3%	-1%	5%	-1%	1%
Annual growth rate (2017-2023) of total revenue in E-commerce (B2C)	12%	7%	11%	8%	6%
Estimated industry revenues in 2030:					
Industry revenue of retail sale of second-hand goods through E-commerce	344.83	123.26	564.15	1306.90	2534.00
Total revenue in E-commerce (B2C)	30,186	20,874	56,363	100,295	130,921
Percentage of second-hand sales compared to total sales in E-commerce	1.1%	0.6%	1.0%	1.3%	1.9%

Considering the market developments in E-commerce, it becomes evident that the whole sector is strongly growing in terms of revenue. In contrast, the revenues from second-hand sales show lower growth rates and are even expected to decrease in Sweden and France. Consequently, the percentages of second-hand sales compared to the overall market volume in E-commerce are expected to be lower in 2030 than what they were in 2017. This trend may be an indication that beneficial effects on a Circular Economy (by facilitating reuse) are potentially overcompensated by increased consumption in the future. Yet it must be remembered that revenue figures do not allow for conclusions concerning the actual numbers of fulfilled units. This is due to the fact that new and second-hand goods differ significantly in economic values per unit. Furthermore, it should be highlighted that growth rates of second-hand resale differ between product categories. For instance, the global market for refurbished and used mobile phones is expected to grow by 8.9% per year between 2017 and 2025 (Digital Day News, 2019). During the period of 2017 to 2023, the global second-hand apparel market is expected to grow on average by 17% per year (ThredUp Resale Report, 2019). Moreover, several market actors are promoting and experimenting with digital business models in the second-hand apparel market. German fashion store Zalando for instance broadened its portfolio recently with its purchase program "Zalando Wardrobe" (Zalando, 2019a), while thredUP in the U.S. focuses on second hand-only (thredUP, 2019). In both cases, issues of reliability and transparency concerning peer-to-peer transactions do not apply anymore. Instead, consumers close a contract with a business entity whereby customer rights and a guarantee of at least one year apply as per the law (European Commission, 2019b). Such business models may provide significant opportunities for the Circular Economy.

- **Positive influencing factors**

In comparison to traditional brick-and-mortar distribution channels, E-commerce channels are expected to avoid environmental impacts and negative effects on a Circular Economy associated with unsold products due to **extended product selling cycles** (Pålsson, Pettersson and Winslott Hiselius, 2017). For products whose life cycle impacts are mainly determined by the production stage, every product that is not brought into a service-providing use stage has far reaching and significant negative impacts on a Circular Economy. In the case of some (here unspecified) product categories, the number of unsold products can be up to 35% of all products in traditional brick-and-mortar stores (Mangiaracina *et al.*, 2015). Consequently, any environmental impacts accumulated due to production and distribution to retail stores would need to be allocated to eventually fulfilled items. An investigation of Borggren, Moberg and Finnveden (2011) found that 14% of the books in traditional bookstores were not sold, whereas only 0.5% could not be sold via online bookstores. This circumstance would result in a 13.5% higher upstream impact for books distributed via traditional supply chains, ultimately leading to a higher share of product waste per fulfilled unit. Depending on the magnitude of environmental impacts associated with production stages for certain products, the number of unsold products can be a decisive factor for the overall environmental performance (e.g. energy efficiency) of different sales channels (Pålsson, Pettersson and Winslott Hiselius, 2017). For instance, the environmental impacts from books produced and not sold were found to exceed impacts associated with transport for product returns (Borggren, Moberg and Finnveden, 2011). Given significantly lower shares of unsold products reported for E-commerce distribution channels, this opportunity is of high relevance for a Circular Economy which seeks to increase and optimise the utilisation of single products.

From a strategic Circular Economy perspective, there are **product take-back** programs for products facilitated by retailers or manufacturers. This is most relevant for (technical) products which can be repaired, remanufactured or recycled at the end of their useful life. Currently, this seems especially applicable to valuable products from the categories "small information and communication technology" and "major household appliances". In the future this opportunity could certainly be relevant for all products apart from food products. Whether this approach is environmentally beneficial must by analysed for each individual case (Umweltbundesamt, 2018b). If deemed applicable and in favour of the environmental performance, it would require manufacturers and retailers to fully embrace eco-design approaches and circular business models. In parallel to largely digitalised and automated distribution and E-fulfilment processes, reverse logistic processes could be implemented into the existing E-commerce systems which already facilitate smooth reverse logistics (Umweltbundesamt, 2018b). In this respect, E-commerce may exhibit substantial advantages over decentralised and less automated processes in traditional supply chains. Moreover, E-commerce platform providers usually gather more data about their customers which could be used to stimulate effective tack-back programs. Apart from take-back programs where manufacturers collect products directly from the consumers, retailers can play an important role in collecting products from their customers and give or sell them back to the manufacturers (Kumar and Putnam, 2008). In this case, E-commerce value chains are expected to facilitate product take-back schemes of a larger scale than traditional channels. Next to likely bigger geographical reach and efficient logistics processes in place, this circumstance is based on the assumption that E-commerce consumers are already familiar with returning goods (The Supply Chain Consulting Group, 2019). In summary, there are reasonable indications of a positive effect on a Circular Economy arising from this opportunity. Yet, these indications remain rather speculative and unspecific. Thus, this effect is considered to be of medium relevance.

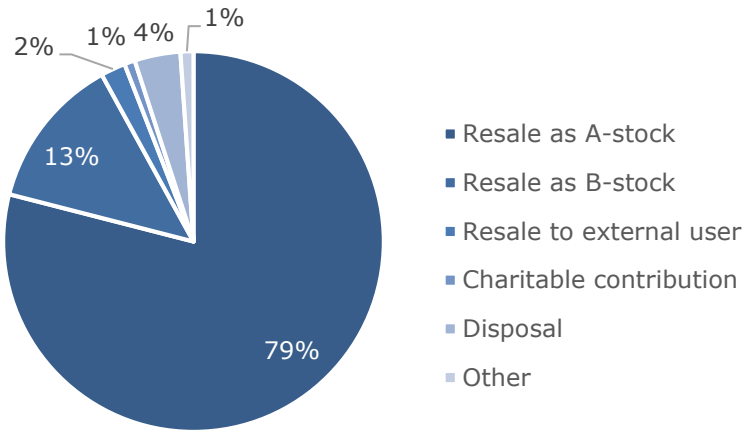
- **Negative influencing factors**

Apart from the manifold opportunities concerning resale through E-commerce channels, **End-of-Life challenges** may arise. This is due to the circumstance that disposal opportunities are less prevalent in pure E-commerce markets the lower the revenue generation is. Yet, those cost-incurring end-of-life treatments (e.g. waste collection and recycling) still constitute the dominating fate of many products. This is particularly relevant for products with low economic value which are often found in the product categories of "apparel", "accessories", and "major furnishings". Also, many products from the categories "small information and communication technology" as well as "major household appliances" lose economic value very quickly or exhibit generally short lifespans.

Due to well-established collection and disposal systems for most of the product categories considered, the greatest attention should be paid to hazardous wastes, which are mainly found in electrical appliances. Currently, there are indications that many E-commerce platforms do not sufficiently adhere to information and take-back obligations stipulated in the European Waste Electrical and Electronic Equipment Directive (WEEE Directive) (DVZ, 2018b). It was furthermore found that certain E-commerce operators hamper the return of waste electrical equipment through strategies like hiding information, high demands on packaging for returns and complicated customer service (DVZ, 2018b). On the contrary, stationary retailers are fulfilling their obligations by offering and financing well-functioning reverse logistic systems (DVZ, 2018b). Despite these indications and potential differences between E-commerce and traditional channels concerning the treatment of waste products, a conclusive assessment cannot be provided. While potential negative effects on a Circular Economy may occur, they are not attributable to either one of the distinctive value chains nor can they be expressed per fulfilled unit.

Environmental impacts and negative effects on a Circular Economy depend on the product-specific return rates (see Section 4.3.1). Additionally, there is concern related to product returns in E-commerce. Substantial damages to the products due to handling during E-fulfilment or shipping can ultimately lead to **waste from returns** caused by E-commerce. Even more alarming are indications that E-commerce actors are suspected to systematically destroy functioning products upon return from customers. This suspicion is based on the circumstance that costs for processes associated with returns (e.g. checking, storing, repacking) may exceed the profit margin achievable from the product's resale in some cases. Such practices and their potential negative effects on a Circular Economy cannot reliably be quantified nor conclusively evaluated (Postpischil and Jacob, 2019b). An exemplary ratio of destroyed products after return of 0.5% of all received items is disclosed by the German retailer Zalando (WirtschaftsWoche, 2018). Zalando, however, claims to only destroy products in exceptional cases, e.g. due to contamination. Given the platform's product portfolio this ratio applies to the product categories "accessories" and "apparel". From the perspective of overall reprocessing options for returned products in the German E-commerce market, disposal makes up for approximately 4% (see Figure 12). Extrapolating this number for the German market in 2019, 7 million items (approx. 2.3 million textile articles and 750,000 electronic goods) are expected to be disposed of upon return from customers (Gsell, 2019b). Another interesting observation is that the disposal rate depends on the company size. Large companies seem to achieve significantly lower disposal rates (2.7%) for returned goods than medium (6.5%) and small companies (14.7%) (Asdecker, 2019b). Other reprocessing options and percentages are shown in Figure 12.

Figure 12: Reprocessing options for returned products in Germany (Asdecker, 2019b)



The treatment and potential destruction of returned products is not an exclusive problem in E-commerce value chains. Therefore, a comparison with traditional channels is challenging. Due to more fragmented and decentralised structures in the traditional brick-and-mortar distribution channels, data on wasted products from returns are not available. However, the theoretical risk for disposal of products is significantly higher in E-commerce due to the higher return rates (Postpischil and Jacob, 2019b). This potential is further amplified when factoring in steady growth of market volumes in E-commerce. Consequently, this threat is assumed to be more relevant for E-commerce value chains with a potential for negative impacts on the fraction of untimely product waste per fulfilled unit. Thus, this threat is of medium relevance to a Circular Economy.

Based on the selection of relevant product categories, **food waste** may only be relevant for non-perishable food in this assessment. On the one hand, food waste could be generated due to damage during delivery or resulting from grocery products returns by customers. However, such data is unavailable, and it remains unclear to what extent E-commerce of groceries contributes to or mitigates food wastage.

On the other hand, experimental research indicates that food waste is more likely if products (e.g. non-perishable crackers) were bought online rather than offline (Ilyuk, 2018a). This assumption is based on experiments which have shown that online purchases are associated with lower perceptions of purchase effort and thereby reduce experiences of psychological ownership. This could increase consumers' intentions of eventually discarding those groceries (Ilyuk, 2018b). Arguably, this threat is highly speculative and clearly outside the area of influence of E-commerce platform providers. Therefore, the potential negative effects to a Circular Economy are of medium relevance.

4.3.5.4 Summary

There is clear evidence that E-commerce facilitates the reuse of certain goods and therefore potentially positively affects a Circular Economy. From a broader sustainability perspective the trading of used goods is considered mostly positive (Clausen *et al.*, 2010). For instance, the Schibsted Media Group as a provider of ten online marketplace platforms like Leboncoin (France), Vibbo (Spain), Blocket (Sweden), estimated the overall savings from secondhand products at 21.5 million tons CO_2 equivalents (Schibsted, 2019). Nevertheless, it remains unclear whether there has only been a shift from traditional channels to E-commerce channels in second-hand trade.

Moreover, a positive net effect on environmental impacts depends on an actual and beneficial substitution of new products through reuse (Cooper and Gutowski, 2017). It can even be argued that the net effect may be negative due to overconsumption through purchasing unnecessary items. Reasons are low prices and abundant possibilities (Parguela, Lunardob and Benoit-Moreau, 2016). Additionally, rebound effects are potentially caused by savings from second-hand purchases (Parguela, Lunardob and Benoit-Moreau, 2016). In conclusion, future trends indicate that positive effects from reuse may be overcompensated by a disproportional increase in consumption.

Whether E-commerce induces additional or more severe challenges at the end-of-life stage of products cannot reliably be documented. Current research usually does not separate product waste stemming from unsold products or returns from

unsatisfied customers (Pålsson, Pettersson and Winslott Hiselius, 2017). Nevertheless, there are indications that E-commerce value chains could potentially generate more product waste due to higher return rates than traditional channels. Yet, potential negative effects from highlighted end-of-life issues or wasted products from returns in E-commerce channels have to be weighed against impacts associated with unsold products. Those are considered a predominantly bigger concern in traditional supply chains. It is argued that a hypothetical switch to a digital market could reduce manufacturing waste and reduce overproduction in the future, ultimately leading to fewer unsold products (Pålsson, Pettersson and Winslott Hiselius, 2017). Lastly, it is assumed that E-commerce channels and structures facilitate more effective and efficient tack-back schemes for products, hence allowing for an individual producer responsibility.

Table 28 summarises the expected effects of identified opportunities and threats within the cluster "End-of-life".

Table 28: Summary of the expected effects of identified opportunities and threats within the cluster "End-of-life"

End-of-Life			**Fraction that is effectively brought into a second or prolonged life cycle (per fulfilled unit)**	**Product waste (per fulfilled unit)**
Relative effects as per today Direct opportunities and threats	Second-hand E-commerce / online auctioning		++	*n.a.*
Future developments Indirect opportunities and threats	Positive influencing factors	Extended product selling cycle	*n.a.*	++
		Product take-back	+	*n.a.*
	Negative influencing factors	End-of-Life challenges	0	0
		Waste from returns	*n.a.*	–
		Food waste	*n.a.*	–

4.3.6 Cluster: Legal framework

According to the assessment framework proposed in section 4.2.2, the following effects arising from E-commerce within the cluster "Legal framework" are identified - all four effects are threats for the Circular Economy:

- difficulty to monitor (threat);
- enforcement (threat);
- EPR – Free-Rider Effect (threat); and
- lack of compliance with common market regulations (threat).

The following two sections describe which main effects arise from E-commerce today (4.3.6.1) and which effects may be expected under future scenarios (4.3.6.2). A third and last section (4.3.6.3) summarises the main findings.

Due to the wide project scope and data availability constraints as well as inherent limitations, all effects of this cluster are described in a qualitative manner only, stating trends and expected developments based on available research. Hence, representative indicators within this cluster depend on the respective threat being qualitatively assessed. An overview of the cluster assessment is given below.

Table 29: Overview of direct and indirect effects of E-commerce within the cluster Legal Framework

Legal Framework		
Relative effects as per today Direct opportunities and threats	Lack of compliance with common market regulations	
Future developments Indirect opportunities and threats	Positive influencing factors	*(none)*
	Negative influencing factors	Difficulty to monitor
		Enforcement
		EPR - Free-Rider Effect

4.3.6.1 Observations of situation today

The only direct effect in this cluster – and thus only effect relevant for today's situation – is "Lack of compliance with common market regulations". One example for this is REACH regulation, to which products placed on the internal market may not comply due to their contents of regulated chemicals but for which at the same time the situation may be diffuse concerning responsibility for the placement on the EU market. This is especially valid in E-commerce, where a particularly large number of economic operators may be involved, which may be located both inside and outside the EU.

4.3.6.2 Future developments (all qualitative)

Projecting future market and technology developments based on recent historic trends, it can be assumed that the identified direct effect will stay relevant or even become more relevant. For instance, an expectable increasing number of economic operators selling products within or exporting products to the EU internal market, can be assumed to lead to a corresponding increase in non-compliance cases. With REACH regulation as one example, an increasing relevance can be assumed for all seven selected product categories. Within the potentially increasing number of non-compliance cases, the share of detected and enforced cases may increase, stay at the current share or decrease. The effect cannot be allocated to one main player or economic operator which could be said to have main responsibility for it or main influence to mitigate it.

- **Positive influencing factors**

No optimistic scenario is applicable, as no indirect opportunities have been identified within this cluster.

- **Negative influencing factors**

Indirect effects identified as contributing to a pessimistic future scenario are "Difficulty to monitor" non-/compliance, "Enforcement" of non-/compliance, and "EPR – Free-rider effect". The three effects can be seen as mutually amplifying: Difficulties in monitoring non-/compliance entail generic difficulties in enforcing compliance requirements (what is not known, cannot be assessed in terms of its compliance, and thus nor be enforced) and enforcement in non-EU countries can be difficult, creating a situation which entails higher potentials for free-riding (deliberate or undeliberate), and a resulting increased number of cases, in turn, makes monitoring more difficult.

4.3.6.3 Summary

The legal framework around an economic system is core for such a system's functioning as it regulates the way economic operators (or: "players") interact within the system. This requires, however, that involved players and their modes of interaction are known. Both is not necessarily fully transparent in traditional economy due to, for instance, complex global supply chains. And E-commerce as practiced today seems not to improve such transparency – although it in principle could do so – due to several constraints, e.g. that an economic operator on the internet can exist for only a very short time with a web shop and that products for potential testing cannot be bought by an anonymous person (e.g. a governmental agent not presenting their name), which is possible in traditional commerce.

No direct or indirect opportunities have been identified during the research, and no data on effects-damping factors has been identified either. Such data could have been a clearly rising critical end-user awareness towards origins of a product, or substantial spreading of Blockchain-like technologies that would allow full traceability of products and money flows.

Overall it is therefore considered more likely, that E-commerce would lead to more challenges for the legal framework than the current traditional commerce does, resulting in rising environmental impact potentials.

4.3.7 Cluster: Logistics and transport

According to the assessment framework proposed in Section 4.2.20 the following effects arising from E-commerce within the "Logistics and transport" cluster are identified:

- substitution of individual shopping trips (opportunity);
- induced parcel transport (threat);
- parcel return (threat);
- in-House Fulfilment (opportunity);
- optimisation of supply chain (opportunity);
- collaboration between companies and partnering with waste management suppliers (opportunity);
- induced freight traffic to remote locations (threat);
- damage on delivery (threat);
- inefficient transport (threat);
- individual product delivery (threat); and
- inferior types of transportation (threat).

The following three sections describe which direct and indirect effects arise from E-commerce today (see Section 4.3.7.1), summarize findings, and display what effects may be expected under future scenarios (see Section 4.3.7.2). The last section (Section 4.3.7.3) summarises the main findings and puts them into context.

Table 30: Overview of the direct and indirect effects of the logistics and transport cluster

Logistics and transport		
Relative effects as per today Direct opportunities and threats	Substitution of individual shopping trips	
	Induced parcel transport	
	Parcel return	
Future developments Indirect opportunities and threats	Positive influencing factors	In-House Fulfilment
		Optimisation of supply chain
		Collaboration between companies and partnering with waste management suppliers
	Negative influencing factors	Induced freight traffic to remote locations
		Damage on delivery
		Inefficient transport
		Individual product delivery
		Inferior types of transportation

All three direct effects mainly refer to resource efficiency from a Circular Economy perspective. "Logistics and transport" is an often-mentioned topic in the public discourse about environmental impact of E-commerce. The additional driven distance by the delivery vans as well as the return rate of some products indicate an additional environmental burden. This discourse will be even stronger in the next decade as an increasing number of packages in shorter time will be shipped (BIEK, 2018; Statista, 2018b; BMVdI, 2019). To assess the current status, the following indicators were identified which allow to compare the impact on the last mile, the substitution of shopping trips as well as parcel return (Table 31).

Table 31: Indicator for the logistics and transport cluster

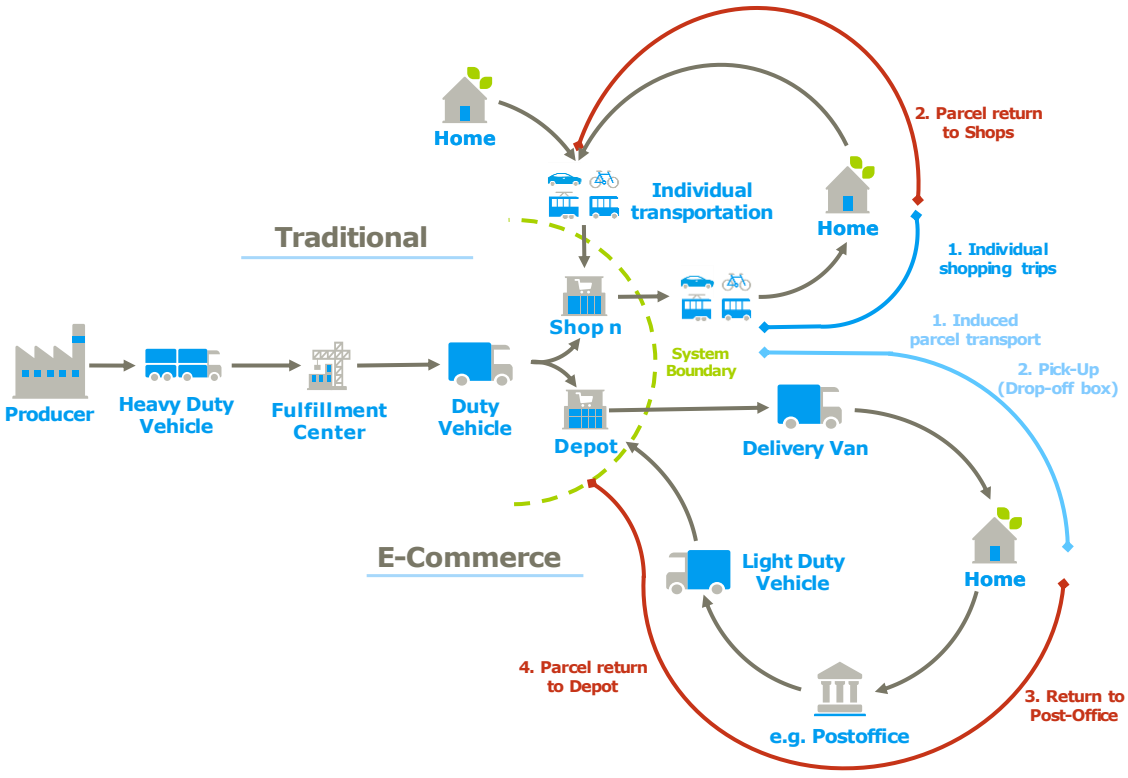
Cluster	Representative Indicator	Unit(s)	Comment(s)
Logistics and Transport	"Transport requirements per fulfilled unit"	km/fulfilled unit & CO_2e/fulfilled unit	Use of representative products for each product category

The first indicator (unit: km per fulfilled unit) represents the distance covered due to the induced parcel transport or shopping trip. The second indicator reflects the "Environmental impact" by using the impact category global warming (unit: CO_{2e} per fulfilled unit, i.e. Carbon Dioxide equivalents). One fulfilled unit is defined as one product that is shipped to or purchased and ultimately kept by the customer. Products returned by customers, including all related additional resource usage and emissions, are allocated to the product that is kept.

4.3.7.1 Observations of situation today

To evaluate the direct effect in the transport and logistics sector, the following scope was chosen (see Figure 13). This figure shows that in the traditional retail sector the transport from the home to the different shops (n) by various means of transportation is considered as well as the way back home. For the E-commerce calculation, the "Last-mile" delivery from the last depot to the customer is taken into consideration. Both traditional and E-commerce are also differentiated into urban and rural scenarios to reflect the diverse transport distances and customer behaviours in the selected countries.

Figure 13: Schematic representation of the scope of the assessment of the two retail sectors. The numbers indicate the different steps which are calculated individually for urban and rural areas



Along the assessment of the two different scenarios some assumptions were made and due to some data constraints, some limitation needs to be considered as well. Most of the data used is available in Germany, England and Sweden (see Table 32). The applicability of these data points to the other selected countries might be limited, though. In general, limited data was available, and it needs country- or even product-specific studies to get specific insight to the supply chain. Also, only delivery to home and to a Pick-Up Station were considered although several other options exist. There are different means of transportation with individual emission factors in the respective countries, but average factors were

chosen in this study. Additionally, choosing one fulfilled unit as the functional unit has its limitations as it makes no distinction between the types of consumer item, the weight or volume of the product (Van Loon *et al.*, 2015b).

Table 32: Overview of sources and data points applicable to the assessment of logistics and transport cluster

Reference	Type of reference (Data pool)	Content
Biek (2017)	Report	Sustainability Report of urban courier express parcel service in three German cities, Methodological approach
Statista (2019)	Statistics	Sales volume per country and product category (applicable for 3 product categories)
Postnord (2018)	Market reports / Grey literature	▪ Shares of citizens who purchased products of the product categories online ▪ Return rates
Biek (2019)	Report	Current situation and development of the transport market
Statista (2018)	Report	Shares of engine types (Battery Electric Vehicle (BEV), Intern Combustion Engine (ICE)) of the Light-Duty vehicles (LDVs)
Smidfelt, Rosqviat and Hiselius (2016)	Scientific Paper	Share of means of transportation for the Pick-Up of packages
BBSR (2019)	Report	Customer behaviour in urban and rural areas for several product categories
Knörr *et al.*, (2016)	Report	Transport-related emission factors

4.3.7.2 Findings from quantitative assessment for situation today

Induced parcel transport on the last mile through E-commerce is an often-discussed effect, which is only applicable to physical goods. This effect can be clearly seen, as the European parcel market has grown since 2012 between 8 and 14 % until 2018, driven largely by the growth of the E-commerce market (Statista, 2019m) and is mainly due to the B2C market (Mohr, 2017).

The delivery opportunities of purchased goods are getting more diverse due to the growth of the E-commerce market: instead of picking them up at a physical store, the goods can be delivered directly to the consumer, to the neighbour, to a parcel shop, to the working address or to an automatic parcel station. It is therefore of high importance to understand the general environmental impact. Looking in general at the delivery of the goods ordered online, today they are mainly delivered by light-duty vehicles (LDVs) with a transport capacity between 2.8 t and 7.5 t (BIEK, 2017). Germany is by far the largest E-commerce market in Europe and within the selected five countries (Statista, 2018b). However, the markets in the five selected countries show different peculiarities. For example, the number of people buying online varies significantly and the behaviour between urban and rural areas as well. This leads to different shares of potential customers and thus to different average transport distances. In Poland, only 33 % of the population is buying online, whereas Sweden has the highest rate of 67 % (see Annex, Table 63). In order to determine the transport performance and the related CO_{2e} emissions, the most important parameters are the fulfilled units in the countries, as well as the share between urban and rural areas. Those figures are presented in Table 33 and give an indication where the highest transport demand can be expected. The indicator delivered packages per capita shows that the lowest package per capita ratio can be expected in rural areas of Poland whereas urban region delivery in Germany has the highest with 7.9.

Table 33: Fulfilled units and delivered packages in urban and rural areas for the selected countries and product categories

	Fulfilled Units			Delivered packages			Delivered packages		
Country	**Total [mio. pieces]**	**Urban [mio. pieces]**	**Rural [mio. pieces]**	**Total [mio. pieces]**	**Urban [mio. pieces]**	**Rural [mio. pieces]**	**Total [pieces / capita]**	**Urban [pieces / capita]**	**Rural [pieces / capita]**
Poland	292	191	101	139	91	48	3.7	3.9	3.2
Sweden (Nordics)	137	121	15	72	64	8	7.1	7.3	5.8
Spain	561	467	94	273	227	46	5.9	6.1	5.0
France	797	661	136	406	337	69	6.3	6.5	5.3
Germany	1,031	816	215	623	493	130	7.5	7.9	6.5

For the actual calculation of the transport distances, more parameters must be considered in order to get a reasonably conclusive statement. Therefore, the number of packages delivered per tour in the three identified LDVs, the first delivery ratio, the effective distance, the actual distance and the distance to the Pick-Up Station must be also included. The effective average distance describes the distance from the first to the last delivery stop while the actual average distance also covers the distance from/to the depot. Distance to Pick-Up shows the average distance (Round-trip) to a Pick-up station. Table 34 shows the average figures, and more detailed numbers can be found in the Annex (Table 64).

Table 34: Parameters to calculate the impact of Induced parcel transport (BIEK, 2017)

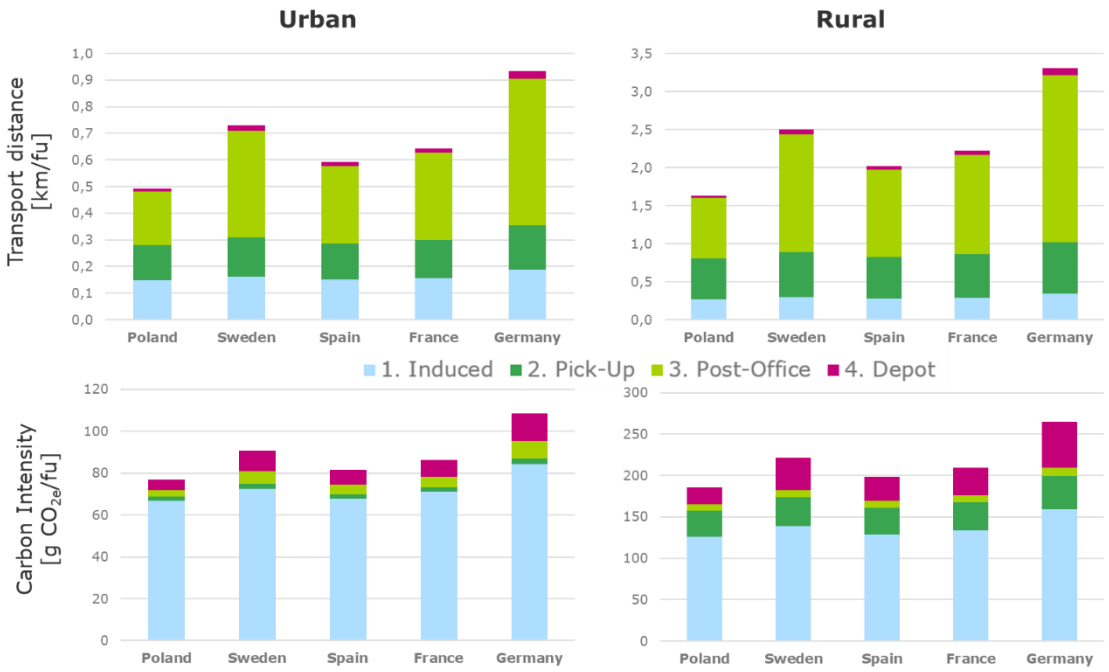
Area	Number of packages per Delivery Van (Average)	First Delivery Ratio (Average)	Effective average distance per tour [km]	Actual average distance per tour [km]	Distance to Pick-Up [km]
Urban	157	94	19	53	5.0
Rural			39	94	20.0

Parcel returns are one of the more obvious and well-known challenges of E-commerce and are considered here as a direct effect as they add additional pressure to the transport sector. The return of parcels can have different reasons, especially for 'apparel', returns often seem to be accepted as inevitable or even firmly integrated into the business model. There are basically two different reasons for returning parcels: (1) The purchased product is defective, or (2) the purchased product does not meet the buyer's expectations. It is important to determine the return rate per product category as it effects the transport demand and thus both indicators (km/unit and CO_{2e}/unit). The return rate for apparel varies between 13 % and 28 % in the selected countries for the online purchased goods (Mohr, 2017). In the brick-and-mortar context, a return rate of 8 percent can be expected (Inwesp, 2019). The impact of this direct effect is included in the "induced parcel transport" effect as well as in the "substitution of individual shopping trips" effect, as shown in Figure 13.

Results for the direct effects (Induced parcel transport and returns) of today

Based on the limited data, following results (Figure 14) could be derived. It can be clearly seen that Germany has the highest transport demand per fulfilled unit in the urban as well as rural area (0.9 km and 3.3 km, respectively). Looking more into the different steps along the process, the first step of the induced parcel transport and the pick-up distance only vary slightly. However, the return of the parcel indicates a considerable difference. The main factor is the return rate, which varies substantially between the countries, in addition to the varying consumer behaviour. Overall, the transport demand per fulfilled unit differs on average roughly by a factor three between urban and rural areas. These results can only be an indication, as more country-specific data may lead to other conclusions.

Figure 14: Results for the induced parcel transport and Carbon Dioxide Intensity per fulfilled unit (fu)



In terms of carbon intensity per fulfilled unit a similar pattern across the countries can be observed. However, the induced parcel transport plays are more crucial role for the overall results. It is responsible for up to 80 % of carbon intensity in the urban areas and up to 70 % in the rural areas. The carbon intensity of the means of transportation is crucial for this calculation and the differences between the urban and rural transportation patterns can be clearly seen (data can be found in Annex 2, Table 65 and Table 66). Comparing the urban and rural scenario, the pick-up of parcels is more carbon dioxide intense in rural areas due to the higher share of transportation by car. In Germany for example the whole induced parcel transport including return might emit between 120 g CO_{2e} and 260 g CO_{2e}, whereas it in Poland with the lowest return rates has the smallest impact. Overall, the carbon intensity between urban and rural areas varies in general by a factor 2.5.

Substitution of individual shopping trips means that due to E-commerce a physical journey to a shop is called off. To understand the importance, first the actual impact of the shopping trips must be determined. However, no study was found which indicates comprehensively the impact of individual shopping trips. To identify the annual shopping trips per selected country, the number of fulfilled units based on annual sales subtracted the returns have been identified (see Table 35) for the urban and rural areas. The return rate in general is smaller in traditional commerce compared to E-commerce (Inwesp, 2019). The number of trips was determined by using three different basket sizes per product category (e.g. 1, 3 or 5 apparel items bought per trip) and how likely those sizes are. By this, the total numbers of trips and per-capita trips have been identified. A recent study shows that 0.6 shopping trips per person and day can be expected for shopping. This would result in about 220 trips per year, which seems quite high (Smidfelt Rosqvist and Hiselius, 2016b). In this study the selected products represent 30 % of the total market volume of the products which indicates a slightly higher number (e.g. 46.7 trips in Sweden compared to 60 trips based on the economic value). It can be seen, that due to the limited distances in urban areas more trips are made in comparison to rural areas where more combined trips (30 %) can be expected in order to lower the time effort.

Table 35: Fulfilled units, number of trips and per-capita trips for the selected product categories per year

	Fulfilled Units			Number of trips			Trips per capita		
Country	**Total [mio. pieces]**	**Urban [mio. pieces]**	**Rural [mio. pieces]**	**Total [mio.]**	**Urban [mio.]**	**Rural [mio.]**	**Total [trips / capita]**	**Urban [trips / capita]**	**Rural [trips / capita]**
Poland	2,115	1,281	834	826	607	218	21.7	26.4	14.6
Sweden (Nordics)	1,069	920	148	472	434	39	46.7	49.8	27.4
Spain	4,604	3,684	920	1,979	1,739	239	42.7	46.9	25.9
France	6,263	5,009	1,254	2,698	2,369	328	41.6	45.7	25.3
Germany	7,539	5,708	1,830	3,197	2,714	483	38.6	43.3	24.0

Several assumptions were needed in order to determine the distance and the carbon dioxide intensity per fulfilled unit (see Table 36 and Table 37) due to limited data. The average travel distance is based on data from Smidfelt, Rosqvist and Hiselius (2016a) and adjusted according to the different basket sizes which also reflects additional stops during one trip for several items. The study shows an average distance in urban areas of 4.6 km while no accurate data for rural areas is available. Therefore a best estimate based on data from BIEK (2017) was chosen and aligned to the distances of parcel transport in rural areas.

Table 36: Average distance per basket size

		Smallest basket	Medium basket	Large basket
Urban	km / trip	5	**6**	**7**
Rural		20	**25**	**30**

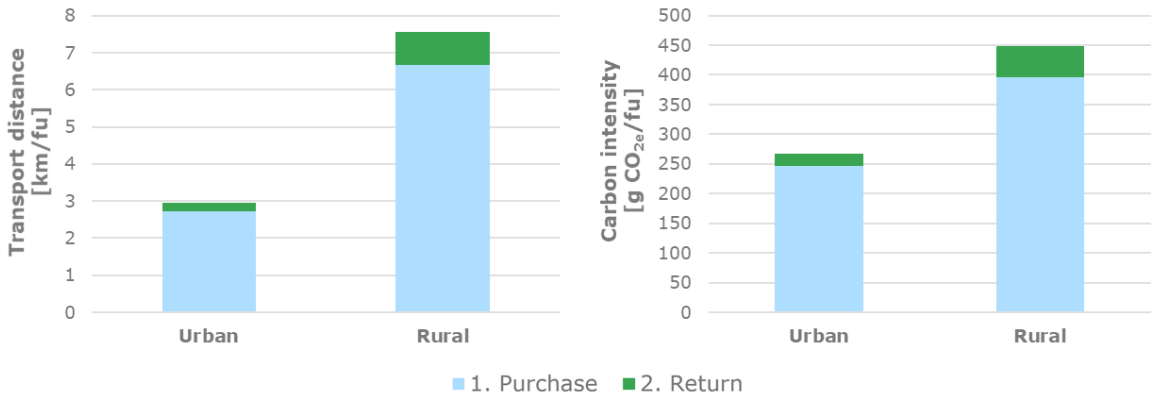
Another important factor contributing to the impact of shopping trips is the selection of the means of transportation. In urban areas, a lot of shopping trips are done by foot, bike or public transport while the car is less important (see Table 37).

Table 37: Share of means of transportation in urban and rural areas for shopping trips

	Pedestrian	Bike	Bus	Metro	Car
Urban	0.25	0.20	0.15	0.10	0.30
Rural	0.05	0.25	0.05	-	0.65

By combining these data, following results were derived (see Figure 15), which indicate a higher transport distance, and hence a higher carbon intensity, per fulfilled unit in rural areas compared to urban areas. In urban areas, an average transport distance per fulfilled unit of about 2.8 km can be expected compared to 6.8 km in rural areas. A significant characteristic of the individual shopping trips is the low return rate, which leads to a minor impact.

Figure 15: Transport distance and carbon intensity per fulfilled unit for individual shopping trips



It can be concluded, although the data availability is quite limited, that the individual shopping trips tend to have a higher impact on average than the delivery in E-commerce. The most significant parameters are the combination of the trips (larger basket size with more products) and the selection of the means of transportation (Cheris *et al.*, 2017). Some studies indicate that the travel habits already are changing due to E-commerce with less shopping trips and less car travel, especially in urban areas (National Travel Survey, 2010; Smidfelt Rosqvist and Hiselius, 2016b).

Comparing both scenarios – parcel transport and individual shopping trip – there is a tendency towards less environmental impact for E-commerce on the "last mile". In urban areas, the factor might be even bigger compared to rural areas from relative perspective (e.g. some 3 times higher related Carbon Dioxide emissions). However, it must be mentioned, that the parameter selection of the means of transportation has a great impact. Therefore, for people who only move around by bicycle to shop in the cities, it's more environmentally friendly, but for such an evaluation, a separate study would be needed.

4.3.7.3 Future developments (all qualitative)

Based on the analysis above, the following parameters play a crucial role for the scenario 2030 in order to determine the transport distance and carbon intensity per fulfilled unit:

1. number of fulfilled units incl. return rate;
2. degree of Urbanisation;
3. technology progress of delivery and individual shopping trips; and
4. number of items per package or shopping trip.

Assuming that expected annual revenue growth rates between 2019 and 2021 can be applied for the linear increase of fulfilled units and that those further continue until 2030, an increase of 5 % for the packages per year can be expected. Parts of it are likely to result from a strong increase of foreign packages from outside the European Union that is observed (from 60 million in 2016 to 164 million in 2018) (Statista, 2018d). Additionally the trend of urbanisation might play a role as well, as it reduces the average transport distance, thus leading to less impact in rural areas (Rösch, 2015). Regarding the means of transport, mainly light duty vehicles (<3,5 t) are used today e.g. for delivery packages in Germany, whereas 97 % are fossil fuel and only 3 % are battery-electric vehicles (BEV) (Statista, 2018d). More electric vehicles (BEV) and Hydrogen Fuel Cell vehicles (HFCV) can be expected in the upcoming years for the delivery services (Buthe, Modes and Richter, 2018). This might lead to less direct emissions even though over the life cycle no final statement for 2030 is possible. The number of individual shopping trips will most likely decrease according to National Travel Survey (2010) and thus a positive impact per fulfilled unit can be expected. However, on an absolute scale more items will be sold which might counteract the effect of reduction of individual shopping trips, especially if the number of items per trip will remain low.

- **Positive influencing factors**

To improve the parcel transport, the following two opportunities have been identified. The effect of **in-house fulfilment** refers to small enterprises as well as C2C systems, whereby production, storage and packaging take place at the retailer's

home rather than requiring extra space outside. This is relevant, because in the whole supply chain of E-commerce more and more SMEs are active (PostEurop, 2019). Therefore, due to in-house fulfilment, transport distances might be reduced by cutting one or several process steps (e.g. to the fulfilment centre or to an additional depot). This effect is confirmed by Amazon (2019), who reported that three-quarters of the marketplace sellers can already be assigned to the C2C-group. Based on the revenue growth in the C2C business between 2010 and 2018 and it is expected to continue moving into the digital space until 2030 (Etsy, 2018), the segment is likely to see linear increase without disruptive changes. There is also a tendency of increasing delivery services provided for the specific needs of SMEs, including package pick-up services, that can further increase transport efficiency and reduce the CO_{2e}- emissions per fulfilled unit (PostEurop, 2019).

However, no definite picture can be drawn to assess the impact on Circular Economy aspects, due to limited data basis. Overall, positive effects from in-house warehousing may be outweighed by the high risk for inefficient delivery logistics if the seller drops the parcel at the post office with a half-utilised vehicle.

An additional lever for less environmental impact is the **optimisation of supply chain**, which goes hand in hand with financial savings and environmental impact reduction. Until 2030 it is likely, that optimisation efforts in the supply chain focus on same-day delivery, smaller parcel deliveries and last mile delivery in general (TLI, 2016). While these aspects are likely to lead to inefficient transport and therefore include strong, negative impacts on the Circular Economy, retailers and delivery service operators continuously try to optimise their supply chains out of economic interest. Aspects of implementing dedicated packaging solutions, described in Section 4.3.8.3, also play a role here, since improved packaging and optimised parcel dimensions help to reduce the CO_{2e} emissions per fulfilled unit in transport (compare Kite Packaging, 2007).

In conclusion, the optimisation of the supply chain is and will continue to be highly relevant (ECommerce Europe, 2018b). However, it is expected that any measure could only soften the negative effects that come with the increase of faster delivery options, assuming that slower and thus more utilised delivery options will remain to be more transport efficient and environmentally-friendlier.

Collaboration between companies and partnering with waste management suppliers can be understood as an optimisation of supply chain as well as dedicated packaging solutions. This has been already described in detail above in this section, in the packaging as well as End-of-Life section. Therefore, this opportunity is an overarching topic which cannot be assessed individually.

- **Negative influencing factors**

Several threats have been identified for the transport and logistics as well for the upcoming years. One of them is the **Induced freight traffic to remote locations**. In rural areas, population density is significantly lower than in urban areas, and distances are greater, resulting in negative impacts in transport, due to higher transport costs and carbon footprints overall and therefore per fulfilled unit. However, in rural regions in Europe, too, it is important to secure the basic supply which includes postal and delivery services. It can be assumed that the governments across Europe will maintain their responsibility to provide basic services in the future, through for instance national operators (PostEurop, 2019). Consequently, it can be assumed, that same-day deliveries will not play a role in rural regions (see also the effect of inefficient transport described below).

On average, 87 % of households in the EU had an internet connection in 2018. In purely technical terms, there is further growth potential for E-commerce here (Statista, 2019h). It is likely that the largest share of households without internet access can be seen in rural areas and that a higher volume of freight transport can be expected here in the future as a result (PostEurop, 2019; Moriset, 2018).

However, research did not provide any indication for extreme increase in freight traffic in remote locations. On the contrary, studies have indicated that a customer's social environment and income situation have a greater impact on purchasing behaviour than its geographical location (Moriset, 2018).

On the other hand, technological changes, such as the use of drones are expected to increase in importance for rural regions in particular (Joerss *et al.*, 2016). In mountainous, rural China, e.g. operator JD.com has already implemented a drone delivery system with capacities of 15 kg per drone, planning for capacities of one ton (Moriset, 2018).

In conclusion, the impact of induced freight traffic to remote locations is assumed to be less significant but negative due to higher CO_{2e} emissions per fulfilled unit. However, the freight traffic from E-commerce is not expected to drastically increase by 2030, if basic supplies remain locally available.

A second identified threat is the **Damage on delivery**. The delivery of products to customers instead of retail shops typically increases handling steps of the products. This may increase the number of defective products. Damaged products delivered to the customer require exchange and result in at least doubled transport and package kilometres. Some literature describes 15-20% damaged products (Gallup Institut, 2018; Statista Research Department, 2014), which appears too extreme. More differentiated data is provided by the Research Group "Retourenmanagement" (Forschungsgrupe Retourenmanagement, 2019). They found that the share of returns, neither appropriate for direct resale (e.g. originally packed) nor B-ware (minor faults or scratches), amounts to a maximum of 8% across all product categories. The data does not provide further distinction between defects from production, which are expected equal in share for both traditional retail and E-commerce, or from E-commerce-specific handling in distribution phase. Considering average return rates across product categories of 7%, this means than 0.6 % of all shipments in Europe or 19.7 million of expected 3.5 billion packages in 2020 in Germany are defective and disposed (Bundesverband Paket&Express Logistik BIEK, 2018). In conclusion, the impact of damages from deliveries has minor significance for the logistics and transport cluster. In particular, product protection has been a thematic focus in previous years and is expected to remain priority, due to the impact of low customer satisfaction on the businesses (OSM, 2016, Billerudkorsnäs, no date). This is expected to further decrease damages caused specifically by the E-commerce value chain.

The third threat is the so-called **inefficient transport**, which describes same-day or express deliveries as an additional selling point for growing expectations from customers (Allen *et al.*, 2017) and as a means of competition with advantages against traditional retail. The amount of online retailers offering same-day delivery could increase to 65 % in the next couple of years (Saleh, no date). Other surveys found, that in 2016 around 25% of customers from China, USA and Germany were willing to pay extra for express deliveries which is likely to increase even further (PWC, 2018a), subject to price developments for faster delivery (Joerss et al., 2016).

In the case of efficiently loaded delivery vehicles, many challenges have been experienced in the literature. Regarding assessments of general load factors of vehicles, values likely contain uncertainties and biases due to the complexity of the system (Santén and Rogerson, 2018). Consequently, attempts on determining the impact of same-day deliveries on vehicle load factors would be highly speculative and inappropriate for this study. However, the German Environmental Agency states, that CO_{2e} emissions of same-day deliveries are high compared to standard delivery (Umweltbundesamt, 2018b).

It is reported, however, that logistic processes currently do not enable same-day deliveries on large, nationwide scales (Hausmann *et al.*, 2014). It can be expected, that the systemic limitations will remain until 2030. Accordingly, the impact from same-day deliveries can be estimated as follows: The proportion of the urban population in Europe is expected to rise to just below 80 % by 2030, with for instance Sweden reaching even 90 % (UN DESA, 2018). Based on 520 million inhabitants projected for the EU (Eurostats, 2019), this would mean that around 416 million people will live in urban regions of Europe in 2030. Of those 416 million citizens, 25 % or 104 million may prefer to choose same-day delivery over standard delivery. Considering that there are multiple orders per person and year (four orders per person and year on average in Europe in 2017 in apparel product category alone), there is large environmental impact to be expected from same-day delivery. Under the assumption that there is a greater risk of empty runs and inefficiency with this delivery option, inefficient transport is expected to be highly significant and assumed as the most relevant indirect effect.

The fourth threat is **individual product delivery** although the data basis appears to be very weak. Zhang *et al.* (2019) described the threat but no actual numbers of last-mile split shipments are given. Cheris *et al.* (2017) report that rising expectations from consumers towards fast delivery are likely to lead to an increase of split orders and higher carbon footprints of the purchased items. Additionally, developments like Amazon prime membership promote guaranteed free, single shipments of small and low-value items. On the other hand it is stated that, if E-commerce purchases are sent together rather than split, a doubling of items per package can reduce the carbon emission by 30% and costs by 50% (Cheris *et al.*, 2017).

Overall, this is expected to be an effect with limited impact for the logistics and transport cluster. The significance of the effect of individual product delivery depends on the scale of this logistic practice but the development is likely restricted by economic feasibility.

The last considered threat are the **inferior types of travel** in E-commerce. Like the inefficient transport, it stems from the aim to achieve a high customer satisfaction, short-term availability and fast dispatch. As part of a study, shipping options were already named as the third-most important purchase criterion in 2017 (KPMG, 2017b, Cherrett and Allen, 2019). Faster delivery processes ultimately also shift long distance freight shipping towards air travel (Cheris *et al.*, 2017). Referring to expectations and assumptions stated for the effect of inefficient transport, inferior types of travel are expected to further increase in importance as customer expectations rise towards same-day deliveries. Due to the larger environmental impact from air travel compared to ship, the use of inferior types of transport on long distances causes a significant and immediate deterioration in the environmental impact (Jofred and Öster, 2011).

4.3.7.4 Summary

In summary, there is clear evidence that logistics and transport is a manifold cluster with impacts depending on the selected country and/or product, but also on the various assumptions which are necessary for the assessment and the existing data limitations. Therefore, it is recommended to carry out country- and product-specific related studies to gain a clearer picture.

In general, it can be expected that parcel deliveries to personal residences increasingly replace private shopping trips, while increasing the degree of the utilisation of the means of transport, leading to less energy demand per fulfilled unit. The use of more alternative means of transportation (Battery electric, Plug-In and Fuel Cell) in the delivery sector will most likely lower the direct emissions. It can be seen that the means of transportation is typically better utilised in urban areas than in rural areas. In urban areas, individual shopping trips are currently primarily carried out by bicycle, by foot or by public transportation (see Table 37), and this share will rise, meaning individual shopping trips with even less environmental impact. The increase of failures in delivery attempts might play a greater role due to the total increase of packages. Additionally, in urban areas the opportunity to deliver within 24 hours could also increase the probability of more delivery attempts.

To conclude, a reliable quantification of outlined impacts on Circular Economy aspects is considered unfeasible under the scope of this assessment, and concrete scenarios must be defined. Only indications can be given. Looking at induced parcel transport and individual shopping trips, there is a tendency towards less environmental impact for E-commerce on the "last mile". In urban areas, the effect might be even bigger compared to rural areas from a relative perspective. The total amount however will increase with the total number of fulfilled units both in urban and rural areas.

Table 38: Summary of the expected effects of identified opportunities and threats within the cluster "Logistics and transport"

Logistics and transport			km / fulfilled unit	g CO_{2e} / fulfilled unit
Relative effects as per today Direct opportunities and threats	Substitution of individual shopping trips		+	+
	Induced parcel transport		0	+
	Parcel return		–	–
Future developments Indirect opportunities and threats	Positive influencing factors	In-House Fulfilment	0	0
		Optimisation of supply chain	+	0
		Collaboration between companies and partnering with waste management suppliers	*n.a.*	*n.a.*
	Negative influencing factors	Induced freight traffic to remote locations	–	–
		Damage on delivery	0	0
		Inefficient transport	–	0
		Individual product delivery	–	0
		Inferior types of transportation	0	–

4.3.8 Cluster: Packaging

According to the assessment framework proposed in Section 4.2.2, the following effects arising from E-commerce within the "Packaging" cluster are identified:

- secondary Packaging (Threat);
- development of dedicated optimised packaging solutions (Opportunity); and
- excessive protective packaging (Threat).

The following two sections describe which main effects arise from E-commerce today (Section 4.3.8.1 and 4.3.8.2) and what effects may be expected under future scenarios (Section 4.3.8.3). The last section 4.3.8.4 summarises the main findings and puts them into context.

Table 39: Overview of direct and indirect effects of E-commerce within the cluster "Packaging"

Packaging		
Relative effects as per today **Direct opportunities and threats**	Secondary Packaging	
Future developments **Indirect opportunities and threats**	Positive influencing factors	Development of dedicated optimised packaging solutions
	Negative influencing factors	Excessive protective packaging

All three effects (direct and indirect) refer to material efficiency regarding the packaging and its waste. The material weight in kg is as such the most significant unit in which to express the effects of this cluster, but it is sought differentiated into material types, in particular cardboard and plastics, as they vary between the product categories. While cardboard is used for appr. 75 % of E-commerce shipments, the market share of flexible plastic packaging materials is growing fast (All4Pack, 2018). In combination with the increased relevance of plastic pollution in the political context (European Commission, 2018e), plastic packaging is included in the quantitative assessment.

A weak basis of available data, as well as the scope of the study require adaptations within the assessment of this cluster. In favour of achieving reasonable comparability of the packaging material demands, it was therefore decided that only the actual dispatch box material is assessed. Inner protective material is excluded here but qualitatively discussed in the pessimistic scenario.

In this context, Low-Density Polyethylene foil (in the following referred to as LDPE foil or just LDPE) is the main material for secondary packaging at this value chain stage (PlasticsEurope, 2018; New InnoNet, 2016), representing the plastic packaging. The importance of LDPE in E-Commerce is, moreover, implicitly emphasised by the circumstance that reusable packaging solutions (e.g. RePack) aim to reduce both disposable LDPE and cardboard (RePack, 2018). It is also the second-most demanded plastic material in Europe with a share of 17.5%, while Polypropylene (PP) ranks first. However, PP is insignificant for the secondary packaging that is assessed below (PlasticsEurope, 2018). Furthermore, the packaging sector is ranked as the largest consumer LDPE foil and responsible for 40% of the overall plastics demand in Europe (ibid.). Consequently, the quantitative assessment is conducted in consideration of values for LDPE foil and cardboard.

Table 40 provides an overview of the representative indicators for the cluster "Packaging".

Table 40: Representative Indicators for the cluster "Packaging"

Cluster	Representative Indicator	Unit(s)	Comment(s)
Packaging	"Amounts of plastic and cardboard packaging demand per fulfilled unit"	• kg plastic packaging/unit, • kg cardboard packaging/unit	Plastic is represented by LDPE foil

4.3.8.1 Observations of situation today

The only direct effect identified as relevant for today's situation is "Secondary packaging" in the stage of distribution to consumer.

Unless a separate packaging solution is specifically developed for the E-commerce channel (see opportunity "Development of dedicated optimised packaging solutions" above), a direct threat arising from E-commerce is the additional packaging demand for final shipping to the customer (Pålsson, 2018). This type of secondary packaging at this value chain stage does not exist in the traditional retail value chain. Therefore, a quantitative assessment sequence was deemed appropriate in line with Step 3 of the assessment framework.

The selection of sources and data points applicable to the assessment sequence is presented in Table 41.

Table 41: Overview of sources and data points applicable to the assessment of secondary packaging (threat)

Reference	Type of reference (Data pool)	Content
DHL (2019)	Business service	Maximum dimensions for standard package
Stakeholder Survey (2019)	Statistics	Numbers of items per package
DIN EN 13724 (2013), packaging material retailers	Norms	Dimensions and weight-related values for packaging material
Hestin *et al.* (2017); Reiner (2019)	Market report/grey literature	Plastic demand, packaging material share and waste
Packaging today (2018)	Grey literature	Cardboard packaging demand Germany, likely overestimated
Kinsella *et al.* (2018)	Market report/ Grey literature	Cardboard packaging demand Europe

In summary, all quantities of shipped packages are differentiated per country, product category, the ratio of the packaging material and package dimension (Section 4.3.1). They are multiplied with the respective packaging weight, which was determined by standardised densities of LDPE foil and corrugated cardboard, respectively (Annex 2, Table 58 and Table 59). In a next step, the total weight is brought in context with the absolute number of fulfilled units of the product category packed in cardboard or LDPE foil in order to determine a unit-specific weight.

Accordingly, a number of **assumptions** had to be made for the quantitative assessment in addition to those mentioned in Section 4.3.1. Firstly, in comparison with traditional retail, all secondary packaging from distribution to consumer is additional in E-commerce. The baseline of a brick-and-mortar scenario would be zero packaging material in this case. Secondly, packaging material dimensions are the same for LDPE and cardboard, respectively, within the respective

category (letterbox, shoebox, large box) but the weights are determined by the different packaging material weights. Additionally, the ratio of plastic and cardboard packaging for product categories is estimated from expert opinions due to an information gap in available literature within this research field Reasons for the choice of LDPE and exclusion of inner protective material are explained earlier in this Section.

4.3.8.2 Findings from quantitative assessment for situation today

The ratio of packaging size and resulting material demands is presented in Table 42. There are large variations between the product categories. While 75 % of media and entertainment products are shipped in shoebox-sized packages or smaller, apparel is often packed in large boxes. Smaller packaging sizes and major furniture as well as household appliances are mutually exclusive. Similarly, large packaging does not apply for small ICT devices, but small letterbox-sized-packaging is hardly ever used either (Allen *et al.*, 2017).

Table 42: Share in quantity of packaging size and packaging material per product category in [%]

Product	Letterbox		Shoebox		Larger		Total quantity
	Plastic	Cardboard	Plastic	Cardboard	Plastic	Cardboard	
Media and entertainment products	28%	28%	0%	26%	0%	18%	100%
Apparel	6%	0%	34%	0%	6%	54%	100%
Major household appliances	0%	0%	0%	0%	80%	20%	100%
Small information technology	0%	3%	0%	97%	0%	0%	100%
Major furniture	0%	0%	0%	0%	60%	40%	100%

In Table 43, the average weights per fulfilled unit of cardboard and LDPE foil packaging are displayed, differentiated by product category and country. European values are calculated as average from all focus countries. Considering that the weight per package ranges from 10 to 35 grams for LDPE foil material and 71 to 1,176 grams for cardboard (see Annex 2, Table 59), there are a number of interesting results. It can be seen that the weight per fulfilled unit apparel with cardboard packaging is on average 368 g, while Poland is lowest with 339 g and Germany highest by far with 406 g. This reflects the impact of the apparel return rates in Germany on the values for the fulfilled unit. Similarly, the cardboard packaging weight of major furniture is significantly increased due to the high return rates common in the online retailing of major furniture. The values for LDPE foil in apparel on the other hand, are lower than the average packaging weight for the smallest parcel type. This can be explained by the fact that if shoebox-sized LDPE foil parcels contain three items, the packaging share per item is reduced from around 15 g to 4 g.

Table 43: Secondary packaging material demand for cardboard and LDPE foil per fulfilled unit, product category and country as per 2017

E-commerce: Secondary packaging per fulfilled unit per product category in [kg]		Poland	Sweden (Nordics)	Spain	France	Germany	EU27
Apparel	Plastic (LDPE)	0.007	0.008	0.007	0.008	0.008	0.008
	Cardboard	0.339	0.377	0.355	0.362	0.406	0.368
Small information technology	Plastic (LDPE)	0.011	0.011	0.012	0.011	0.011	0.011
	Cardboard	0.148	0.148	0.160	0.152	0.152	0.152
Major household appliances	Plastic (LDPE)	0.025	0.025	0.026	0.025	0.025	0.025
	Cardboard	0.820	0.821	0.886	0.845	0.841	0.843
Media and entertainment products	Plastic (LDPE)	0.010	0.011	0.011	0.011	0.011	n.a.
	Cardboard	0.227	0.230	0.229	0.231	0.233	0.230
Major furniture	Plastic (LDPE)	0.036	0.036	0.035	0.036	0.036	n.a.
	Cardboard	1.198	1.195	1.185	1.198	1.217	1.199

Table 44 provides an overview of the total quantity in tonnes from secondary packaging of the "last mile" for all fulfilled units including returns in 2017. Compared to the values per fulfilled unit, the absolute impact and market demand for packaging is visible. Apparel occupies by far the front position regarding total material demand for secondary packaging for the distribution to the customer in E-commerce and for both packaging material types. Almost 1.5 million tons of additional cardboard packaging and around 26 thousand tons of LDPE foil are consumed by E-commerce compared to brick-and-mortar businesses. The second-highest impact originates from major furniture, followed by media and entertainment products. In the low range, results indicate minor significance of LDPE foil from secondary packaging in small information and communication technology, as cumulative values remain below 20 tons in Europe. This reflects the fact that small electronic articles are more sensitive to transport damage from shocks than is the case for apparel and that cardboard meets these requirements better.

Table 44: Total secondary packaging material demand for cardboard and LDPE foil per product category and country in 2017

E-commerce current state 2017: Secondary packaging per product category in [t]		Poland	Sweden (Nordics)	Spain	France	Germany	Europe
Apparel	Plastic (LDPE)	631	336	1,287	1,829	2,536	21,632
	Cardboard	35,692	19,032	72,785	103,477	143,484	1,223,830
Small information technology	Plastic (LDPE)	<2	<2	<2	<2	<2	<20
	Cardboard	2,458	1,168	4,016	6,525	7,281	66,968
Major household appliances	Plastic (LDPE)	20	11	36	66	85	652
	Cardboard	170	91	304	550	709	5,454
Media and entertainment products	Plastic (LDPE)	117	50	210	333	607	n.a.
	Cardboard	6,533	2,811	11,676	18,551	33,804	n.a.
Major furniture	Plastic (LDPE)	175	60	222	359	664	n.a.
	Cardboard	3,897	1,330	4,942	7,997	14,809	n.a.

Reviewing literature, the comparison of packaging demand with total plastic packaging demand could be conducted for only 5 out of the 7 product categories.

Table 45 provides an overview of the impacts of the product categories on the total packaging demand regarding LDPE foil. Secondary packaging from distribution to consumer indicates the highest relevance in apparel, which leads back to the size of the market and the extreme return rates. Runner's up are media and entertainment products and major furniture with just below 0.2‰.

Table 45: European plastic packaging material demands and share of secondary plastic packaging from distribution to consumer per product category in 2017

Country	Market share [%]	Plastic packaging demand for packaging purposes per country [t]	Share of secondary packaging LDPE foil from distribution to consumer per product category in [‰]				
			Share Apparel	Small ICT	Major household appliances	Media and entertainment products	Major furniture
EU27	100.00%	19,551,000	1.1‰	<0.1‰	<0.1‰	n.a.	n.a.
Germany	24.60%	4,809,546	0.53‰	<0.1‰	<0.1‰	0.13‰	0.14‰
France	9.60%	1,876,896	0.97‰	<0.1‰	<0.1‰	0.18‰	0.19‰
Spain	7.70%	1,505,427	0.85‰	<0.1‰	<0.1‰	0.14‰	0.15‰

With regards to cardboard, the data basis is even weaker than for plastics. Data was searched for using combinations of "cardboard", "packaging", "demand" "consumption" with Europe or focus countries but only two data points were relevant and included in Table 46. Furthermore, the websites of the following cardboard and packaging related associations were included in the search for data, but no actual values could be identified:

- European Federation of Corrugated Board Manufacturers;

- Packaging Europe Ltd.;
- European Association of Carton and Cartonboard manufacturers (Pro Carton); and
- The Confederation of European Paper Industries (CEPI).

The two identified datapoints indicate the significance of packaging in apparel with a 2.4% share of the total paper packaging demand in Europe. The second datapoint from non-scientific literature reports a market share of Germany of 40%. In this case, the share of apparel decreases to 0.7%. However, a market share of 40% is expected to be too high. Consequently, these data points are to be handled with restraint.

Table 46: European paper packaging material demand and share of secondary cardboard packaging from distribution to consumer per product category in 2017

Country	Tonnages of paper packaging [t]	Share of secondary packaging cardboard from distribution to consumer per product category in [%]				
		Share Apparel	Small information technology	Major household appliances	media and entertainment products	Major furniture
EU27	50,600,000	2.4%	<0.05%	<0.01%	n.a.	n.a.
Germany	20,500,000	0.7%	<0.05%	<0.01%	0.16%	0.07%

Overall, it can be expected that the outer packaging material as the secondary packaging for distribution to the consumer in E-commerce already accumulates to a relevant threat for the Circular Economy. This significance increases when considering the results extrapolated to all product categories and with the inclusion of protective inner packaging filler material like polystyrene (PS). With regards to (Hestin *et al.*, 2017) and (Reiner, 2019), plastic packaging waste accounted for 60 % of the total plastic waste. The majority (70%) of this plastic packaging waste is partially or entirely lost for circularity as about a quarter (23% points) of it is landfilled and about half (47% points) is incinerated.. This shows the importance of demand reduction and the successful implementation of circularity aspects for increased recycling of plastic packaging.

4.3.8.3 Future developments

Table 47 provides the baseline scenario data for 2030, if expected annual revenue growth rates between 2019 and 2021 can be applied for the linear increase of fulfilled units and further continue until 2030. Under these conditions, packaging materials without any other technological or regulatory innovations, can be expected to roughly double in total for cardboard and LDPE foil.

Table 47: Total secondary packaging material demand for cardboard and LDPE foil per product category and country in BAU scenario 2030

E-commerce BAU Scenario 2030: Secondary Packaging per product category in [t]		Poland	Sweden (Nordics)	Spain	France	Germany	EU27
Apparel	Plastic (LDPE)	1,058	508	2,066	2,877	3,562	33,628
	Cardboard	59,882	28,760	116,896	162,781	201,533	1,902,464
Small information technology	Plastic (LDPE)	<5	<5	<5	<5	<5	<50
	Cardboard	6,951	3,300	10,517	17,915	20,078	184,509
Major household appliances	Plastic (LDPE)	42	22	69	132	170	1,309
	Cardboard	351	188	580	1,100	1,425	10,950
media and entertainment products	Plastic (LDPE)	533	227	946	1,490	2,690	n.a.
	Cardboard	29,686	12,659	52,680	83,022	149,892	n.a.
Major furniture	Plastic (LDPE)	450	154	577	924	1,684	n.a.
	Cardboard	10,047	3,436	12,871	20,617	37,559	n.a.

- **Positive influencing factors**

Evidently, optimisation strategies for packaging potentially affect the demands for plastic and cardboard. Yet, most packaging solutions have been implemented in order to optimise the demand of materials in response to packaging-related issues of the E-commerce value chain. Therefore, many distinct opportunities associated with the optimisation of packaging are not expected to result in actual environmental CE benefits compared to the traditional retail channel (Pålsson, 2018). Rather, they constitute relative changes and optimisations to alternative E-commerce channels.

For instance, reusable packaging systems (e.g. RePack) are a response to the waste issues associated with secondary packaging (last-mile shipping) but do not necessarily result in actual benefits compared to the traditional value chain. In fact, such measures only mitigate amounts of plastic and cardboard packaging demand per fulfilled unit in different E-commerce scenarios. Material-related aspects of so-called "frustration-free packaging" solutions (e.g. appropriate dimensions of shipping box, replacement of additional shipping box, recyclable material use) are likewise mainly addressing E-commerce-specific challenges, at best counteracting additional impacts from E-commerce scenarios. After 20 uses of a specific reusable packaging solution, demands for disposable plastic (LDPE) and cardboard are assumed to be almost entirely offset (relative savings of 92% of LDPE and 96% of cardboard) (RePack, 2018; Zero Waste Europe, 2019b). However, it needs to be remembered that the reusable packing material will also turn into waste after about 20 uses (RePack, 2018). Further research is required for comparison of benefits from reusable packaging on the one hand and the efforts and resources required for the collection, transport and provision of reusable packaging.

In contrast to mere elimination or mitigation opportunities, the convergence of primary and secondary packaging or "e-channel-enabled packaging" may offer actual improvements in terms of amounts of plastics and cardboard per fulfilled unit compared to traditional packaging suitable for brick-and-mortar or omni-channel retail. The life cycle stages affected by those changes are secondary packaging and e-fulfilment (after sales). In this respect, it is noteworthy that those life cycle stages are typically influenced by different actors, thus collaboration along the value chain is paramount in order to capitalise on this opportunity.

The emerging opportunity lying in value chain collaboration is considered an indirect effect of E-commerce due its rather long-term and structural implications on packaging because of wide-scale market developments. Hence, a qualitative assessment sequence was deemed appropriate in line with Step 3 of the assessment framework. In this context, it can be

argued that E-commerce will alter the current role of primary and secondary packaging with respect to attracting consumer interest in retail stores (Feber, 2019). Assuming a continuing shift from traditional brick-and-mortar channels towards digital single-markets for certain product categories – i.e. respective products are potentially only distributed via E-commerce – packaging would no longer need to fulfil any marketing, "on-the-shelf" display and/or product information purposes. A potential shift to utilitarian and minimalistic protective packaging could result in packaging dimensions that are notably smaller than current packaging which is often designed for omni-channel distribution (Pålsson, 2018). Consequently, product manufacturers may be developing dedicated packaging solutions for online distribution. For example, a detergent producer in the USA has innovated packaging to reduce its overall weight during transport as part of the launch of a novel laundry detergent specifically designed for E-commerce (Feber, 2019). Thus, dedicated packaging solutions for E-commerce channels have the potential to reduce amounts of plastics and cardboard per fulfilled unit. However, minimising the demand of packaging materials in response to altered requirements from a marketing perspective needs to be weighed against remaining protection requirements. As protection demands are generally higher in E-commerce value chains, the positive net effect of dedicated packaging solutions could be diminished or even (over-) compensated.

In a worst-case scenario, material-efficient packaging solutions could even result in increased damages to the products, and thereby negatively affect a Circular Economy.

Looking at the selected product categories, it is assumed that accessories, non-perishable food products, media and entertainment products as well as small information and communication technologies offer opportunities related to dedicated packaging for E-commerce. This is because those products are generally smaller than products from the other categories. However, certain products within those categories (e.g. watches, smartphones, crisps, books) are more vulnerable and thus need protection which may inhibit any optimisation possibilities. For apparel products, no noteworthy opportunities are expected in this regard as those items are usually sold in plastic bags in E-commerce or even without packaging in traditional stores (Pålsson, 2018), resulting in low optimisation potential. Hence, relative possibilities for improvement are very limited in the digital market.

- **Negative influencing factors**

The direct effect of over-sized as well as over-protective packaging (and combinations of the two) represent a threat for the CE. Examples are the use of relatively large standard boxes for small items and the use of packaging (incl. inner packaging) that offers a much higher shock absorption than technically needed. The former type can generally be characterised as having a negative effect on Circular Economy, due to low material efficiency (more material used than needed for the fulfilled unit; both cardboard and plastic material) and low transport efficiency (transportation of air instead of goods). The latter type, though, represents an optimisation challenge between, on the one hand, ensuring that the packaged product reaches its destination in perfect condition and, on the other hand, material efficiency related to the expectable shock impacts during transportation.

Excessive protective packaging is found as not well-described in the analysed data pools. Neither earlier studies, e.g. Kite Packaging (2007) nor recent studies, e.g. OECD (2019), – although dedicated and broad – touch upon this effect. In the entire pool of reviewed sources, neither qualitative nor quantitative data points could be retrieved for this threat. Thus, the present qualitative assessment was done.

In terms of relevance for product categories, it can be assumed that the effect seems particularly relevant in relation to shipping of small information and communication technology (ICT), and to a certain extent, to accessories (e.g. watches), but not to the other five selected product categories, as they don't comprise small, shock-vulnerable products.

While both product categories deemed relevant show relatively low growth rates (see Section 2.1.1), particularly small ICT equipment has high market relevance today and in the foreseeable future, and the same goes for its consumer relevance, purchase frequency, and return rates. Thus, excessive protective packaging is a threat to be solved particularly related to small ICT equipment.

4.3.8.4 Summary

The total current secondary packaging material demand from E-commerce was identified taking into account two packaging materials (cardboard and LDPE foil) and three packaging sizes per product category and country. The highest EU-wide demand in cardboard packaging in kg per fulfilled unit across the 7 selected product categories is found for major furniture (1.2 kg/unit with cardboard packaging) and major household appliances (0.84 kg/unit) with apparel ranking third (0.37 kg/unit). The LDPE foil packaging demand is highest in major furniture (0.036 kg/unit) and major furniture

(0.025 kg/unit). However, by normalisation of the values over market share of total plastic packaging demand, apparel is significantly highest (1.1 ‰), followed by media products and major furniture in the range of just below 0.2 ‰. In cardboard packaging, subject to the reliability of the data point, secondary packaging for apparel may be responsible for up to 2.9% of the cardboard packaging demand.

The majority of suggested mitigation-oriented packaging solutions (e.g. reusable packaging) optimise the demand of materials within the E-commerce value chain but is not expected to result in actual environmental CE benefits compared to the traditional retail channel.

Dedicated packaging solutions for E-commerce channels have the potential to reduce amounts of plastics and cardboard per fulfilled unit. However, the positive net effect of dedicated packaging solutions could be diminished or (over-)compensated due to inherently higher protection demands in E-commerce value chains.

Table 48: Summary of the expected effects of identified opportunities and threats within the cluster Packaging

Packaging			**Packaging demand (per fulfilled unit)**
Relative effects as per today Direct opportunities and threats	Secondary Packaging		– –
Future developments Indirect opportunities and threats	Positive influencing factors	Development of dedicated optimised packaging solutions	0
	Negative influencing factors	Excessive protective packaging	–

5 Conclusions

5.1 Correlations between identified opportunities and threats

As part of the systemic identification, classification and description process as outlined in Section 3.1.2 as well as the conducted in-depth assessment, all opportunities and threats have been clustered and attributed to distinct characteristics or properties (see attribution matrix in Annex 2, Section 10.2). Therefore, the following properties were used to examine potential interrelations between the identified opportunities and threats:

- E-commerce feature;
- life-cycle stage;
- effect order; and
- cluster.

Eventually each of the opportunities and threats is clearly described by one E-commerce feature that primarily facilitates a certain effect and by one life-cycle stage from where the effect is expected to originate. And, as already elaborated on, every single opportunity or threat is unambiguously attributed to a cluster and an effect pathway (direct or indirect).

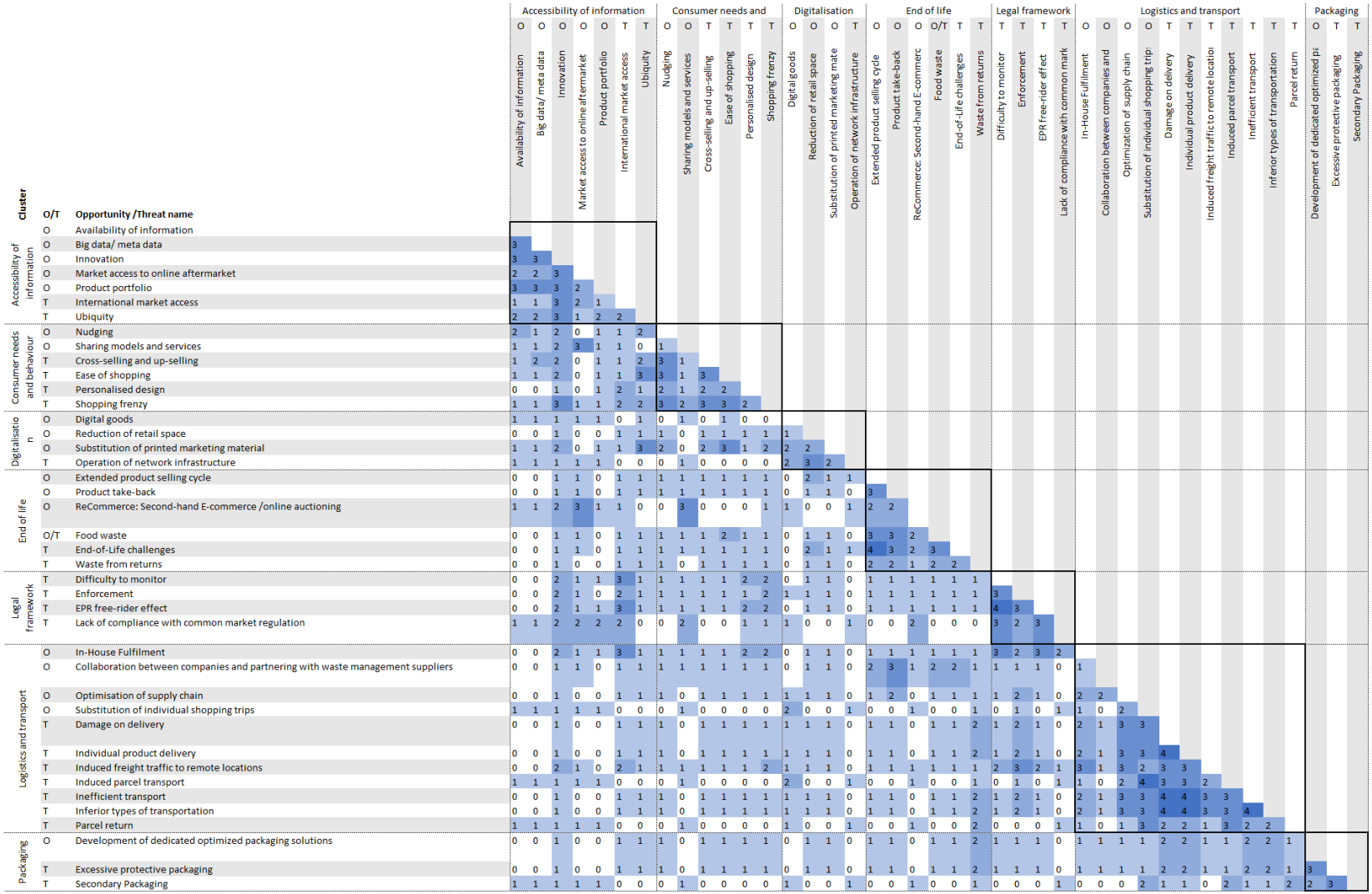
With these specific properties at hand, valid assumptions can be made whether a certain opportunity or threat is closely or less closely linked to another. For instance, it can be argued that opportunities and threats that originate from the same E-commerce features are potentially stronger linked than others. Moreover, a closer link can be assumed when opportunities and threats affect the same life-cycle stages of a given product. Naturally, stronger interrelations are assumed when two opportunities or threats are both classified as direct or indirect, thus coming into effect either today or in the future. An attribution to the same cluster certainly constitutes a close link as specific opportunities and threats are suspected to affect the same Circular Economy indicators.

To establish an objective assessment of correlations within a highly complex and uncertain web of effects, it is assumed that the more properties a pair of opportunities or threats has in common, the closer the link. Adopting this approach, the following nuances resulted from this assessment:

- 0: very low probability of a strong link;
- 1: low probability of a strong link;
- 2-3: moderate probability of a strong link;
- 4: high probability of a close link; and
- 5: very high probability of a close link.

In Figure 16, the probability of a strong link is shown for all identified opportunities and threats.

Figure 16: Mapping and visualisation of the probabilities of strong link between identified opportunities and threats (own depiction)



Based on the above assessment, a ranking of all opportunities and threats is facilitated by adding up the number of overlaps a given opportunity or threat has in common with others (see Table 49). Hence, those opportunities or threats sharing many properties with others should be given priority in analysing their actual implications on other effects. Based on this ranking the opportunities and threats have been further allocated to three groups identifying a high, medium or low number of correlations with other opportunities/threats. The results are reported in Table 50.

Table 49. Ranking of opportunities and threats based on the sum of overlapping properties with other effects

Rank	Opportunity/Threat	Sum
1	Innovation	66
2	Induced freight traffic to remote locations	56
3	Damage on delivery	55
4	Individual product delivery	55
5	Inefficient transport	55
6	Inferior types of transportation	55
7	In-House Fulfilment	53
8	Shopping frenzy	52
9	Enforcement	50
10	International market access	49
11	Difficulty to monitor	47
12	EPR free-rider effect	47
13	Optimisation of supply chain	47
14	Ubiquity	45
15	Ease of shopping	45
16	Substitution of printed marketing material	43
17	Waste from returns	43
18	Nudging	42
19	Cross-selling and up-selling	42
20	Extended product selling cycle	42
21	End-of-Life challenges	42
22	Product take-back	41
23	Substitution of individual shopping trips	41
24	Induced parcel transport	41
25	Food waste	40
26	Excessive protective packaging	40
27	Development of dedicated optimized packaging solutions	39
28	Personalised design	38
29	Market access to online aftermarket	37
30	Sharing models and services	36
31	ReCommerce: Second-hand E-commerce /online auctioning	36
32	Collaboration between companies and partnering with waste management suppliers	36
33	Reduction of retail space	34
34	Lack of compliance with common market regulation	33
35	Parcel return	33
36	Availability of information	29

Rank	Opportunity/Threat	Sum
37	Big data/ meta data	29
38	Product portfolio	29
39	Digital goods	28
40	Secondary Packaging	26
41	Operation of network infrastructure	21

5.2 Relevance of opportunities and threats

Based on the findings from the in-depth assessment (see Section 4) all opportunities and threats were grouped according to their estimated relevance for a Circular Economy in Europe. Therefore, opportunities and threats arising from E-commerce are either of

- high,
- medium, or
- low

relevance for a Circular Economy in comparison to the traditional (brick-and-mortar) channel.

The differentiation between the three groups is subject to the assumptions and limitations of the in-depth assessment, as indicated in Section 4. Therefore, this ranking describes the relevance of certain opportunities and threats in terms of their expected influence on identified environmental Circular Economy aspects (e.g. packaging demand, product waste, global warming potential, etc.). Moreover, the respective relevance and influence on a Circular Economy of a given opportunity or threat is not understood as an absolute influence. In fact, it describes a relative difference to the traditional value chain. Hence, compared to the traditional value chain, a certain opportunity/threat is of high/medium/low relevance for a Circular Economy.

It must be remembered that the actual impacts of certain opportunities and threats may depend on the product category. Yet, as described, many of the affected value chain stages and thus identified effects are largely independent from the most critical life-cycle stages of a product value chain (see also Figure 2 in Section 3.1.2).

The presented ranking does not make value judgements between the assessed Circular Economy aspects (indicators) or clusters. This means, none of the Circular Economy aspects or indicators is assumed to be of higher relevance than another, i.e. they are considered equally important.

In summary, the proposed ranking primarily takes into account:

- the described effect pathway, with direct effects being generally more relevant as per definition;
- the degree of evidence from the assessment and the reviewed literature; and
- the measurability of a given opportunity or threat in terms of a Circular Economy aspect or indicator.

Table 50 summarises and groups all 41 opportunities and threats in descending order based on the in-depth assessment results. The grouping of relevance according to the stakeholder inputs is also presented as point of reference.

Table 50: Grouping of opportunities and threats according to their relevance based on the in-depth assessment, the stakeholder input and the number of correlations with other opportunities/threats

			Relevance (from in-depth assessment results)		
	Name of the opportunity/threat	**Clusters**	**In-depth assessment results**	**Stakeholder consultation**	**Number of correlations with other O/Ts**
Opportunity	Availability of information	Accessibility of information	high*	low	high
	Market access to online aftermarket	Accessibility of information	high*	medium	medium
	Product portfolio	Accessibility of information	high*	contrasting	low
	Sharing models and services	Consumer needs and behaviour	high	medium	medium
	Second-hand E-commerce /online auctioning	End of life	high	medium	medium
	Substitution of individual shopping trips	Logistics and trasport	high	low	medium
Threat	Inefficient transport	Logistics and trasport	high	medium	high
	Induced parcel transport	Logistics and trasport	high	high	medium
	Parcel return	Logistics and trasport	high	high	low
	Lack of compliance with common market regulation	Legal framework	high*	high	low
	Shopping frenzy	Consumer needs and behaviour	high	low	high
	Secondary Packaging	Packaging	high	low	low
Opportunity	Extended product selling cycle	End of life	high	low	medium
	Nudging	Consumer needs and behaviour	medium	contrasting	medium
	Digital goods	Digitalisation	medium	medium	low
	Product take-back	End of life	medium	high	medium
	Optimization of supply chain	Logistics and trasport	medium	medium	medium
Threat	Inferior types of transportation	Logistics and trasport	medium	medium	high
	International market access	Accessibility of information	medium*	low	medium
	Ubiquity	Accessibility of information	medium*	low	medium
	Personalised design	Consumer needs and behaviour	medium	low	medium
	Operational energy demand for the network infrastructure	Digitalisation	medium	medium	low
	Waste from returns	End of life	medium	high	medium
	Difficulty to monitor	Legal framework	medium*	high	medium
	Enforcement	Legal framework	medium*	high	medium
	EPR free-rider effect	Legal framework	medium*	high	medium
	Excessive protective packaging	Packaging	medium*	high	medium

	Name of the opportunity/threat	Clusters	Relevance (from in-depth assessment results)		Number of correlations with other O/Ts
			In-depth assessment results	Stakeholder consultation	
Opportunity	Innovation	Accessibility of information	low*	medium	high
	Big data/ meta data	Accessibility of information	low*	contrasting	low
	Reduction of retail space	Digitalisation	low	low	low
	Substitution of printed marketing material	Digitalisation	low*	medium	medium
	Development of dedicated packaging solutions	Packaging	low	low	medium
	Collaboration between companies and partnering with waste management suppliers	No cluster	-	low	medium
	In-House Fulfillment	Logistics and transport	low*	low	high
Threat	Induced freight traffic to remote locations	Logistics and transport	low	low	high
	Damage on delivery	Logistics and transport	low	medium	high
	Individual product delivery	Logistics and transport	low*	medium	high
	Ease of shopping	Consumer needs and behaviour	low*	low	medium
	Cross-selling and up-selling	Consumer needs and behaviour	low*	low	medium
	EoL challenges	End of life	low*	medium	medium
	Food waste	End of life	low*	low	medium

*** little evidence / limited data basis**

From a Circular Economy perspective, secondary packaging and direct effects within the cluster "logistics and transport" deserve special attention. Moreover, certain effects relating to "consumer needs and behaviour" as well as facilitated second-hand E-commerce within the cluster "end-of-life" are of high relevance.

The effects from the clusters "accessibility of information" and "legal framework" could not be translated into specific Circular Economy aspects or indicators. Nevertheless, direct effects from these clusters are potentially of high relevance despite the fact that there is little evidence or only a limited data basis. One of the main reasons for this conclusion is that the reviewed literature does not clearly differentiate between E-commerce and traditional channels when it comes to legal issues or the accessibility of information.

The opportunities and threats relating to the cluster "Digitalisation" are of medium to low relevance. This is not least due to the cascading effects from digitalisation which cannot exclusively be allocated to E-commerce.

The potential opportunity of "collaboration between companies and partnering with waste management suppliers" , as already mentioned in Section 4.3.7.3, could not be ranked as it could not clearly be assigned to a single cluster or expressed in terms of a certain Circular Economy aspect. This opportunity was inherently assessed as part of the opportunities "product-take back" and "development of dedicated packaging solutions".

5.3 Conclusions and options for actions

The relevance of the identified opportunities and threats cannot be univocally defined due to the extremely broad scope of the topic and the different aspects that come into play while analysing the impacts on the Circular Economy of a potential positive or negative future development. Nevertheless, the outcomes of the assessment of relevance performed under different perspectives (in depth-assessment, stakeholder consultation and correlations) and reported in Table 50 can be

compared with the aim of highlighting those opportunities or threats that can be considered relevant under a combination of the perspectives considered.

The opportunities and threats where a more in-depth analysis of the potential effects on the Circular Economy is deemed particularly relevant, based on what is reported above, are the following:

- **Induced parcel transport** (threat), **Parcel return** (threat), **Lack of compliance with common market regulation** (threat): these threats turned out to have a high relevance based both on the in-depth assessment performed in this study and the stakeholders' feedback. A further and more extensive analysis, also considering the current limited availability of data, is considered therefore relevant;
- **Inefficient transport** (threat), **shopping frenzy** (threat) and **availability of information** (opportunity): these threats / opportunities show a high relevance for the Circular Economy based on the in-depth assessment and a high number of overlapping properties with other opportunities and threats. Therefore, further studies and potential actions aimed at supporting or mitigating their effects could indirectly affect also a significant number of other opportunities and threats.

In the following, key conclusions are provided within each cluster.

5.3.1 Cluster – Accessibility of information

Overall, the cluster Accessibility of information is considered to be supportive of a Circular Economy. Information flows are a core element of any commerce and, undoubtedly, they can be considered as being pivotal for E-commerce. Consequently, the assessment determined the relatively high number of seven direct and indirect opportunities and threats arising from E-commerce compared to traditional commerce.
A summarised "net effect", valid for certain product categories or across all of them, could not be determined – neither for current conditions nor for the foreseeable future.
However, the assessment determined that there are three direct effects in this cluster – i.e. effects relevant for today's situation – being: "Availability of information", "Market access to online aftermarkets", and "Product portfolio". All of them are assessed to be opportunities, as they generally improve knowledge of users (and other stakeholders) about the product and/or its handling during the product life, and thus increase chances of well-considered product choices and preferable treatments.

5.3.2 Cluster – Consumer needs and behaviour

Despite positive aspects of increased product utilisation in sharing systems and nudging towards products with lower environmental footprint, the interaction between the opportunities and threats identified within this cluster is likely to have an overall negative impact on the Circular Economy. This is for instance due to easier accessibility of E-commerce services, available in an instant and around the clock, that can promote consumption and impulse purchases. Challenges may also arise from professional providers of sharing models and systems if profit maximisation is prioritised over sustainable product portfolios with longer lifetime and higher recyclability. On the other hand, nudging can be highly effective if used to promote eco-conscious product choices in support of a Circular Economy through background information and beneficial default settings. Moreover, the introduction of a clear and harmonised system to communicate the environmental footprint of products sold online could be seen as an opportunity to enable consumers not only to compare price and user ratings, but also the environmental performance of products and thus make educated choices.

5.3.3 Cluster - Digitalisation

It is implicitly indicated in relevant studies assessing the environmental implications of digitalisation and ICT that induced energy demands and associated global warming potentials are a major concern in this context. Consequently, any related effects arising from E-commerce should at least be measured against those two indicators. For a Circular Economy it is essential that any of the required mechanisms and infrastructures (e.g. vital network infrastructures for E-commerce platforms) are operated in an energy-efficient and low-carbon manner. Only if this is provided, enabling positive effects arising from the utilisation of digital technologies (e.g. digital goods, reduction of retail space, substitution of printed marketing material) can fully materialise. Particular attention should also be given to reduce hidden data traffic from user analytics, updates, automatic or default downloads, all of which are directly associated with energy demands and potential emissions. From an environmental and Circular Economy perspective it is, moreover, important to factor in the

geographical context of where the data transmission and processing of data occurs. Depending on the electricity mix (e.g. share of renewable energy supplies), climatic conditions or other factors (e.g. population or subscriber density, geographical distribution) in a specific geography, the environmental implications and effects on the Circular Economy can vary significantly.

Next to relative indicators such as energy intensities per data volume or per fulfilled unit, cumulative energy demands of the E-commerce sector deserve further attention. This is deemed necessary as to keep track of the net effects of observed trends. On the one hand, relative energy demands per data volume are constantly decreasing due to efficiency gains in ICT and data transmission. On the other hand, absolute data volumes are expected to increase due to various reasons.

With regards to the digitalisation or virtualisation of entire products or services, E-commerce certainly acts as a facilitator and catalyst. Although beneficial effects on the Circular Economy cannot solely be attributed to E-commerce, it is acknowledged that E-commerce platforms exhibit substantial potentials in this area.

In order to fully benefit from the manifold opportunities digitalisation technologies and applications bring about for a Circular Economy, E-commerce providers are encouraged to embrace strategies towards data sufficiency and a transition to renewable energy supplies for their operations.

5.3.4 Cluster – End-of-Life

In order to maximise potential positive effects for the Circular Economy, focus should be given to the reuse of products. This holds true in particular for products whose environmental impacts are largely determined by the production stage. As of today, promising trends and manifestations of so-called second-hand E-commerce can be observed. Their business models are explicitly in favour of the Circular Economy. It is therefore encouraged that other E-commerce platforms may also embrace such business models to supplement their existing product and service portfolio. In doing so, existing reverse logistics infrastructures for product return processes can be utilised for circular product flows (e.g. resale, product take-back).

It has been demonstrated that E-commerce can mitigate environmental effects related to unsold products and thereby contribute to a Circular Economy. A particularly high potential in this regard may be realised in omni-channel retail structures or in collaborations between E-commerce and brick-and-mortar retail by extending product selling cycles. Products which could not be sold in stores could then be offered via online sale and stored in respective warehouses.

An almost unavoidable but nevertheless negative effect on the Circular Economy is rooted in product waste due to damages during shipping. Therefore, effective measures (e.g. protective and reusable packaging) and mitigation strategies (e.g. nudging) need to be developed and embraced by the respective actors in E-commerce.

5.3.5 Cluster – Legal framework

Practices within the current legal framework are overall seen to be more a hampering factor to the Circular Economy than a supportive one. All four threats for the Circular Economy identified within this cluster are associated with a lack of transparency regarding two issues: firstly, who/which product type exactly is involved (an economic actor/product under regulation or one not under regulation?), and secondly, from which location exactly does each economic actor operate (within or outside the EU?). One consequence of this lack of transparency is the EPR-free-rider effect, i.e. the circumstance that certain producers, while being subject to EPR obligations, do not comply with applicable obligations or do not take part in nor financially contribute to respective organisations. This effect can possibly be damped by increasing the responsibilities of facilitators of E-commerce, such as sellers, couriers and fulfilment houses, if they sell EPR-regulated products that come from economic actors outside the EU, which do not have a national representative.

Among the four identified threats, "Lack of compliance with common market regulation" is considered the most central one. This is because the in-depth assessment concluded that this threat is the only direct effect within this cluster, i.e. an effect that occurs today but can also increasingly occur in the future. In addition, the three other threats (assessed as being indirect ones) strongly relate to this effect, since a complex network of economic actors and products being difficult to monitor poses challenges to enforcement (as not all activities would be tracked) and indeed can foster incompliance with common market regulations – happening potentially intentionally, as in the EPR free-rider effect, or unintentionally.

In general, options for action in the context of this cluster include the promotion of further cooperation/information exchange between Member State enforcement authorities on issues regarding market surveillance and E-commerce, the further development of enforcement (IT-)tools and methods which enable/support the tracing of products sold via E-

commerce arrangements, and the mapping of the magnitude and forms of E-commerce sales of high-risk products from third countries.

5.3.6 Cluster – Logistics and transport

"Logistics and transport" is an often-mentioned topic in the public discourse about environmental impacts of E-commerce, but it can be concluded, although the data availability is quite limited, that the individual shopping trips typical for traditional retail tend to have a higher impact than the delivery in E-commerce. However, it must be pointed out that further studies are recommended in order to clearly identify the real differences between brick-and-mortar and E-commerce within the rural and urban areas.

The induced parcel transport, although showing different peculiarities in the five selected countries, is found to be responsible for up to 80% of carbon intensity in the urban areas and up to 70% in the rural areas. Comparing the urban and rural scenario, the pick-up of parcels is more carbon dioxide-intense in rural areas due to the higher share of transportation by car. Overall, the carbon intensity between urban and rural areas varies in general by a factor of 2.5. This implies that different measures might need to be taken in rural and urban areas. For example, mainly light duty vehicles (<3,5 t) are used today e.g. for delivery packages, whereas 97% are fossil fuel and only 3% are battery-electric vehicles (BEV). BEVs might be a better choice for urban areas, and HFCV for longer distances in the upcoming years. Technological changes such as the use of drones are expected to increase in importance particularly for rural regions and should be further investigated.

The transport demand is significantly affected by parcel returns, one of the more obvious and well-known challenges of E-commerce. On average, the return rate is considerably higher for E-commerce (>13%) compared to brick-and-mortar retail (8%).

The positive effect on the Circular Economy arising from the substitution of individual shopping trips might be outweighed by an increased consumption promoted by E-commerce, especially if the number of items per shipment will remain low. The increase of failures in delivery attempts might play a greater role, too, as well as the availability of fast delivery options. Improved packaging, reduced damages on delivery and especially optimised parcel dimensions help to reduce the CO_2e-emissions per fulfilled unit in transport and should be supported. Nonetheless, it is expected that any measure could only soften the negative effects that will arise from the increase of faster delivery services, assuming that slower and thus more utilised delivery options will remain to be more transport efficient and environmentally friendlier. In conclusion, the optimisation of the entire supply chain is and will continue to be highly relevant.

5.3.7 Cluster – Packaging

The assessment of effects in the cluster "Packaging" confirms significant negative impacts on the Circular Economy arising from E-Commerce. This is particularly due to the fact that the transport to the customer creates the need for an additional layer of packaging that does not apply to brick-and-mortar. The highest negative impacts on the Circular Economy originate from the product categories with the largest volumes in size and pieces sold, consequently major furniture and major household appliances. The negative impact on the Circular Economy increases further when considering not only the outer layer of the packaging but also the excessive use of protective packaging of vulnerable products (e.g. electronics) which increases the consumption of various plastic types or paper with uncertain recyclability conditions.

The majority of the suggested mitigation-oriented packaging solutions (e.g. reusable packaging) will help in reducing the demand of materials within the E-commerce value chain but will not eliminate the need for additional packaging. Nevertheless, opportunities such as frustration-free packaging and reusable packaging, where the packaging material itself is not owned by the customer but offered as a service, should be promoted. Moreover, the development of an optimal return infrastructure should be addressed. Another option to reduce the impact is represented by the implementation of dimensional shipping fees, where parcel size and parcel weight are factored in.

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7 Glossary of terms and abbreviations

7.1 Terms

Availability of information

Extensive product information can be provided on-line, including technical information, demonstration videos and customer feedback, allowing consumers to have a detailed picture of the products in terms of usefulness, reliability or durability before the purchase.

Big data / meta data

Big data is described as the high-speed analysis of large amounts of data from multiple sources. It enables the companies to leverage the available information and to provide personalised information to the consumers, therefore increasing the potential to influence their shopping behaviour.

Circular Economy

"In a circular economy the value of products and materials is maintained for as long as possible; waste and resource use are minimised, and resources are kept within the economy when a product has reached the end of its life, to be used again and again to create further value. This model can create secure jobs in Europe, promote innovations that give a competitive advantage and provide a level of protection for humans and the environment that Europe is proud of. It can also provide consumers with more durable and innovative products that provide monetary savings and an increased quality of life."[15]

Circular Economy Indicators

Indicators are commonly understood as either a variable (parameter) or a function of variables but may also be the result of composite information relying on quantitative and qualitative information (Moraga *et al.*, 2019). Moreover, an inherent feature of any indicator is that they usually refer to a comparison value or reference (Waas *et al.*, 2014). To this end, the specific traditional value chain characteristics or scenarios are considered as the baseline.

A comprehensive literature review on micro-scale indicators referring to single products conducted by Moraga et al. (2019) identified the following CE indicators and corresponding measurement scopes:

- Technological cycles without aspects of Life Cycle Thinking:
  - eDiM (ease of Disassembly metric)
- Technological cycles with aspects of Life Cycle Thinking:
  - TRP (Total Restored Products)
  - Longevity
  - MCI (Material Circularity Indicator)
- Cause-and-effect modelling with/without Life Cycle Thinking:
  - EVR (Eco-cost value ratio)
  - PLCM (Product-level Circularity Metric)
  - SCI (Sustainable Circular Index)

Collaboration between companies and partnering with waste management suppliers

E-commerce can enable successful collaboration between online or multi-channel retailers, packaging companies and waste management providers, all of which is necessary to mitigate the environmental impacts along the whole supply chain and product life cycle.

[15] http://europa.eu/rapid/press-release_MEMO-15-6204_en.htm

Cross-selling and up-selling

Both cross-selling and up-selling are techniques used to promote additional products during the search for a product or during and after the purchase. In this context, it is seen as threat as it directly promotes consumption.

Damage on delivery

The delivery of products to end-consumers instead of delivery to retail shops typically increases the handling of products. This can increase the number of products that have already been delivered defective, which in return increases the impact on transport and the environment.

Development of dedicated optimised packaging solutions

In recent years, there has been a significant development in dedicated packaging solutions that focus on a more sustainable use of materials and a flexible design of packaging that fits the products' specific transportation requirements, potentially decreasing the demands for plastic and cardboard and the generation of waste.

Difficulty to monitor

The easier access to international markets enabled by E-commerce results in an increase in complexity of international trade in comparison to traditional retail. This is also reflected by the difficulties to monitor product streams entering and leaving the EU via online trade.

Digital goods

Digital goods can be defined as goods that are stored, delivered and consumed in an electronic format. Consequently, digital goods are "shipped" electronically to the consumer through direct download from the Internet.

Ease of shopping

The effort required to conduct a purchase is considered to be significantly decreased in E-commerce. Especially the combination of mobile connectivity and dedicated web store solutions makes online shopping both easily accessible and intuitive for users. Since this way of shopping is so convenient for the customer, impulse or stimulus purchases can increase.

End-of-Life challenges

End-of-life challenges in E-commerce mainly arise from potentially hazardous waste groups, e.g. electronic equipment. The main issue presents itself in disposal of such products that need special collection points.

Enforcement

Compliance of imported products with environmental and products legislation is an important factor for the current policy efforts to increase recycling and market uptake of secondary raw materials on the one hand, while ensuring safe and toxic-free product life cycles on the other. However, there are indication that the enforcement of environmental and products legislation is made more difficult due to increased entry of products to the internal market via E-commerce arrangements.

EPR – Free-Rider Effect

The extended producer responsibility (EPR) is an established policy instrument within the context of waste management and resource efficiency in the EU. Various sources highlight that E-commerce is leading to a free-rider effect, which means that specific producers which are subject to EPR obligations do not comply with applicable obligations or do not take part in nor financially contribute to respective organisations.

Excessive protective packaging

Products purchased via E-commerce are typically sent to consumers in packages that use different types of protective material to ensure that the product is delivered unharmed. Even though protection is necessary to avoid damage during transportation, some products are still protected in a way that can be considered as excessive and wasteful.

Extended product selling cycle

Online retailers have nearly unlimited amount of (digital) retail space as well as larger warehouse capabilities to offer products to consumers on their websites. This makes it easier to offer old/out of trend products for a longer time, mostly with a discount.

Food waste

Although still a minor segment of the E-commerce market, (fresh) food delivery is gaining more focus and more customers each year. The delivery of food could contribute to food waste (e.g. in case of damage during delivery) or reduce it by promoting a more targeted purchase (e.g. shopping-list focused purchase, no purchases induced by the display of food in the shop).

E-commerce

"E-commerce can be defined generally as the sale or purchase of goods or services, whether between businesses, households, individuals or private organisations, through electronic transactions conducted via the internet or other computer-mediated (online communication) networks."[16]

"Any form of business transaction in which the parties interact electronically rather than by physical exchanges or direct physical contact" (Abukhader and Jonson, 2004).

Hub and spoke

In transportation, the terms 'hub and spoke' describe a type of delivery model. The origin of a parcel and its final destination is usually not directly connected, but via a so-called hub. The connection between two points (e.g. hub and consumer) is called spoke. In E-commerce, each central location (hub) is usually shared by several E-commerce actors with differing pick-up times, which hampers the consolidation of parcels (deliveries) to end customers. Thus, parcel delivery routes are highly affected by delays in the central warehouse (Hong *et al.*, 2018; Prümm, Kauschke and Peiseler, 2018).

In-House Fulfilment

This opportunity applies to small E-commerce businesses that operate from home and do not have any additional storage place. It promotes competition and reduces the impacts linked to the necessity of storage space and transport.

Individual product delivery

This threat describes the individual delivery of products that originates from a purchase of a basket of several products. Instead of delivering all products together, sometimes each product is delivered individually.

Induced freight traffic to remote locations

The effects of online trade on urban and rural areas can vary considerably. Deliveries to rural areas are characterised, among other things, by particularly long delivery routes and lower efficiency in logistics. This entails the danger of increased environmental influences, especially in connection with fast delivery options and individual deliveries.

Induced parcel transport

E-commerce implies that parcels with the purchased products are sent to the consumer, which can have a significant impact on environmental aspects related to transport and logistics. Here, we focus on the induced parcel transport represented by the last mile delivery.

[16] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:E-commerce

Inefficient transport

The E-commerce's promise of very short delivery times can favour less efficient utilisation of trucks and other means of transport whose loading capacities are not optimally utilised.

Inferior types of transportation

Online shops often offer a range of fast delivery options (e.g. same day or next day delivery) that are still in high demand from customers. This, among others, has an impact on the choice of the means of transport.

Innovation

E-commerce can foster innovation in combination with concepts such as crowdfunding, making it possible to overcome common hurdles such as high investment costs and enabling small companies and start-ups to easily promote and put on the market their ideas, thus supporting the transition to a sustainable development.

International market access

The (easy) access to markets around the world allows consumers to purchase products from everywhere. This has an impact on the international traffic of commodities and might increase the emissions due to international trade.

IT, Internet, E-commerce

"It is important to clearly differentiate between terms that are sometime used as synonyms in literature. E-commerce is one activity that is provided by the internet, which in turn is one functionality that can be provided by IT" (Abukhader and Jonson, 2004).

"The technology itself (information and communication technologies, Internet) does not determine sustainability, but rather its design, use, and regulation" (Stefansdotter *et al.*, 2016).

Lack of compliance with common market regulations

Various EU regulations lay down requirements for products which are placed on the internal market. Often, access for these products to the internal market is contingent upon their compliance with these requirements. In various product regulations, requirements pertain to human health and environmental aspects of the product placed on the market. The international market access obtained through E-commerce increases the threat for a lack of compliance with common market regulations.

Last mile delivery

Last mile delivery is defined as the movement of goods from a transportation hub to the final delivery destination. The final delivery destination is typically a personal residence. The focus of last mile logistics is to deliver items to the end user as fast as possible.

Light goods vehicles (LGV) and heavy goods vehicles (HGV)

"Light goods vehicles (LGVs) – up to and including 3.5 tonnes gross weight – [...] heavy goods vehicles (HGV) – over 3.5 tonnes gross weight [...]" (Allen *et al.*, 2017).

"Unlike HGVs (which are almost entirely used for goods movement), LGVs are used for a wider range of purposes, including the provision of services, the transportation of goods and commuting (as many LGVs are taken home by workers overnight). Fig. 1 illustrates the LGV sector in terms of the distinction between fleet LGVs (i.e. those operated by companies with sizeable fleets) and those operated by self-employed individuals and small businesses. It is also important to note that the van owner and van user can differ, and that vehicles may be sold to a company considered by the vehicle manufacturer to be a fleet buyer (for example the rental and leasing companies) although these vehicles may subsequently be rented or leased to another company, small business or individual" (Allen *et al.*, 2017).

Manufacturer

A manufacturer is a person or a registered company which makes finished products from raw materials [...]. The goods are later distributed to wholesalers and retailers who then sell to customers." (ecommerce platforms, 2019)

A manufacturer can act as a vendor if it sells its products directly to end customers and other parties. It is sometimes referred to first-party seller. Third-party sellers (often simply called 'seller') act as a kind of intermediary that purchase products from one party and sells to another party or end consumer. (Hartmann, 2017)

Market access to online aftermarkets

E-commerce can promote the possibility for consumers to extend the lifetime of a product by facilitating the access to online aftermarket where consumers can purchase spare parts to repair their product.

Network slicing

"Network Slicing to Enable Scalability and Flexibility in 5G Mobile Networks discussion, we have generally defined "slice" as an isolated set of programmable resources to implement network functions and application services through software programs for accommodating individual network functions and application services within each slice without interfering with the other functions and services on the coexisting slices. Network slicing is considered one of the most important concepts to realize "extreme flexibility" in 5G mobile networks. The current mobile networks are optimized to serve only mobile phones. However, 5G mobile networks need to serve a variety of devices with very different, heterogeneous quality of service (QoS) requirements without interference among one another" (Nakao *et al.*, 2017).

Nudging

"Nudging can be defined as a way to design a situation of choice and the way options are presented (also called choice architecture), in order to change people's behaviour in a predictable way without any elimination of opportunities or change of incentives" (Stefansdotter *et al.*, 2016).

"[...] nudging is about changing people's behaviour while presuming that they already have the attitudes necessary to demonstrate this behaviour" (Stefansdotter *et al.*, 2016) .

Operation of network infrastructure

The underlying network infrastructure, which is necessary for creating and operating E-commerce activities, requires electricity to run. Although E-commerce is merely one of many features running on a specific network infrastructure, it still contributes to an increase in energy consumption of respective network devices.

Optimisation of supply chain

Although enormous efforts have been made by manufacturers of all kinds to optimise their respective supply chains, further optimisation opportunities in the automation of the manufacturing process, the various delivery routes and the payment processes of end customers are attributed to E-commerce.

Parcel return

Sending packages back (parcel return) is one of the more obvious and well-known challenges of E-commerce, bringing additional pressure to the transport sector.

Personalised design

The increased ease of ordering personalised products online might lead to decreased positive mass production effects, such as minimising waste arising during manufacturing processes, or optimisation of the product chain.

Primary packaging

The primary package concerns the structural nature of the package; it is usually the smallest unit of distribution or use and is the package in direct contact with the contents (Regattieri, 2015).

Primary Packaging contains the finished or final products, sometimes called retail or consumer packaging. This packaging is used to contain, preserve, protect and inform the end user. The primary pack can be made of a number of components, e.g. for a multi-pack of beers this would include the bottles, their labels and the card sleeve or shrink film. Primary packaging should include all packaging up to the point of sale, but does not include carrier bags (single use and bags for life) and delivery boxes (WRAP, no date).

Product portfolio

A pronounced and at the same time well sorted and easily accessible selection of products enables customers to make more targeted purchases. The customer is less tied to small product portfolios and has the opportunity to select the most suitable product from a comprehensive selection.

Product take-back

The development of reverse logistics allows for an efficient chain of re-use, repair and recycling possibilities. E-commerce has the potential to increase customer retention and thus also the producer's possibility to establish a profound reverse logistic.

Raw Material Consumption

"The RMC measures the global material use associated with domestic production and consumption activities, equalling DEU (domestic extraction used) plus imports in RME (raw material equivalents) minus export in RME" (Vercalsteren, Christis and Van Hoof, 2017).

"In a successful CE the RMC decreases. As more materials circulate, there is a decreasing need for primary raw materials reflected via a decreasing RMC" (Vercalsteren, Christis and Van Hoof, 2017).

ReCommerce: Second-hand E-commerce / online auctioning

"ReCommerce" encompasses the re-sale of used consumer goods via the internet. It prolongs a product's useful life and decreases the environmental impact due to a reduced demand for new items.

Reduction of retail space

Retail space is a necessity in traditional retail stores, with size demands depending on the kind of products sold. In contrast, an E-commerce enterprise only needs a warehouse to fulfil orders, something a brick-and-mortar store most likely has in addition to the retail space.

Retailer

A business that sells goods to the consumer, as opposed to a wholesaler or supplier, who normally sell their goods to another business. A retailer can sell goods in stores and/or on the internet. Retailers that sell goods only in stores are referred to as "brick-and-mortar" retailers, whereas retailers that sell goods only on the internet are referred to as "E-commerce retailers". Eventually, retailers that sell goods both in stores and on the internet, are referred to as "omni-channel" retailers.

Secondary packaging

The secondary package relates to the issues of visual communication and it is used to group primary packages together (Regattieri, 2015).

Packaging additional to the primary packaging and that is used for protection and collation of individual units during storage, transport and distribution. They can be used in some sectors to display primary packs on shelf. Sometimes called grouped or display packaging. This category also includes packaging purposely made to display multiple product units for sale, in order to speed restocking from storeroom to shelf. Also known as retail-ready packaging (RRP), shelf-ready packaging (SRP) or counter-top display units (CDUs) (WRAP, no date).

Sharing models and services

In recent years, a series of sharing models have been developed that allow consumers to share specific products, such as tools or devices. Although this type of sharing is possible without any online activity, online sales platforms significantly increase reach and visibility, making it easier for consumers to access relevant markets.

Shopping frenzy

Shopping events, mostly on a fixed date, that attract customers with special offers, promote the so-called "shopping frenzy". Such events are starting to have a significant impact on online shopping and can lead to additional consumption.

Substitution of individual shopping trips

Traditional commerce via brick-and-mortar stores requires customers to travel to the shop physically, which causes pressure on traffic and infrastructure. E-commerce alters this way of shopping by allowing customers to order from home or on the go and have their order delivered to their front door, without any need to visit the physical store.

Substitution of printed marketing material

Digital marketing is a natural aspect of E-commerce business models. However, it is not exclusive and thus not a unique feature to set this channel apart from traditional retail. It has the theoretical potential to substitute part of the printed advertising material, depending on the target audience.

Tertiary packaging

The tertiary package is used for warehouse storage and transport shipping (Regattieri, 2015).

Outer packaging, including pallets, slip sheets, stretch wrap, strapping any labels, used for the shipment and distribution of goods. This packaging is also referred to as transport or transit packaging and is rarely seen by the final consumer. The final destination will often deal with this via its own internal reuse or recycle routes. (WRAP, no date)

Ubiquity

Ubiquity describes the possibility for consumers to access E-commerce at any time and from almost anywhere. It is an inherent peculiarity of nowadays E-commerce and seen as a threat as it induces consumption.

Waste from returns

Returns are commonly accepted for items sold online and constitute a necessary right of the consumer since there is no possibility to completely and realistically examine the product before delivery. The returned products are subject to different fates, one of which is the disposal as waste.

7.2 Abbreviations

ABBREVIATION	TERM
0-9	
2G, 3G, 4G	Second-, third-, and fourth-generation cellular technology standards
A	
APASS	Amazon Support and Supplier Network
B	
B2B	Business-to-Business
B2C	Business-to-Customer
BEV	Battery Electrified Vehicle
C2C	Costumer-to-Costumer
C2X	Customer-to-Everyone
C	
CE	Circular Economy
CED	Cumulative Energy Demand
CEPI	Confederation of European Paper Industries
CO_2e	CO_2 equivalents
CP	Consumer preferences
CPA	Classification of Products by Activity
E	
EAP	Environmental Action Programme
EC	European Commission
ECHA	European Chemicals
EEA	European Environment Agency
EEE	Electrical and electronic equipment
ELCD	European Reference Life Cycle Database
EoL	End-of-Life
EPD	Environmental Product Declaration
EPR	Extended Producer Responsibility
ERRT	European Retail Round Table
EWOM	Electronic word-of-mouth
F	
FCEL	Fuel Cell Electrified Vehicle
FMCG	Fast Moving Consumer Goods
FU	Functional Unit

ABBREVIATION	TERM
G	
GB	Gigabyte
GR	Growth rate
H	
HDV	Heavy Duty Vehicles
HFCV	Hydrogen Fuel Cell vehicles
HGV	Heavy Goods Vehicle
I	
ICE	Internal Combustion Engine
ICT	Information and Communications Technology
IoT	Internet of Things
IREU	InternetRetailing Europe
ISA	International Organisation for Standardisation
K	
kWh	Kilowatt-hour
L	
LCA	Life-cycle assessment
LDPE	Low-density Polyethylene foil
LDV	Light Duty Vehicles
LPI	Logistics Performance Index
M	
MB	Megabyte
M-Commerce	Mobile Commerce
MR	Market relevance
O	
OECD	The Organisation for Economic Co-operation and Development
P	
P2P	Peer-to-Peer
PEF	Production Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PHEV	Plug-in Hybrid Vehicle
PRO	Producer Responsibility Organisation
PS	Polystyrene
Prodcom	Production Communautaire
R	

ABBREVIATION	TERM
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
REAP	Retailers' Environmental Action Programme
S	
SMCG	Slow Moving Consumer Goods
SVHC	Substance of very high concern
T	
tkm	tonne-kilometre
U	
U-Commerce	Ubiquitous Commerce
UGC	User-generated content
W	
WEEE	Waste of Electrical and Electronic Equipment

8 List of figures

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10 Annexes

10.1 Annex 1: Tables - Selection of relevant products for assessment of opportunities and threats

Table 51: Results of the application of the screening criteria to the initial set of product categories. The product categories coloured in green represent the final 7 product categories selected for the study

Product categories	Product category type		Market Relevance				Level of circularity				Consumer behaviour			
	Product category diversity		Current purchases (2019)		Online growth rate purchases (2021 vs 2019)		Return rates		Packaging		Purchase frequency		Consumer preferences	
	Diversity (A to J)		*Relevance (high/medium/low)*				*Diversity (A, B, C)*		*Diversity (A, B, C, D)*		*Diversity (A, B)*		*Relevance (high/medium/low)*	
	Product type	Score	Total [mio €]	Rank	Online growth rate	Score	Return rate	Score	Nr. of items per parcel	Score	SMCG/ FMCG	Score	% for online purchases	Score
Accessories	Accessories and eyewear	A	53,209	13	1.15	low	n/a	n/a	n/a	n/a	SMCG	A	22%	medium
Apparel	Apparel and footwear	B	393,946	1	1.14	low	19.3%	B	3-4	B	FMCG	B	19%	medium
Beverages	Food, beverages and tobacco	D	275,024	2	1.10	low	< 10%	A	> 6	D	FMCG	B	3.05%	low
Chilled foods	Food, beverages and tobacco	D	65,189	12	1.26	medium	< 10%	A	> 6	D	FMCG	B	3%	low
Cosmetics and personal care	Personal care and home care	I	80,928	11	1.17	low	< 10%	A	1-2	A	FMCG	B	14%	medium
Deep-frozen foods	Food, beverages and tobacco	D	88,583	10	1.30	medium	< 10%	A	> 6	D	FMCG	B	3%	low

Product categories	Product category type		Market Relevance				Level of circularity				Consumer behaviour			
	Product category diversity		**Current purchases (2019)**		**Online growth rate purchases (2021 vs 2019)**		**Return rates**		**Packaging**		**Purchase frequency**		**Consumer preferences**	
	Diversity (A to J)		*Relevance (high/medium/low)*				*Diversity (A, B, C)*		*Diversity (A, B, C, D)*		*Diversity (A, B)*		*Relevance (high/medium/low)*	
	Product type	Score	Total [mio €]	Rank	Online growth rate	Score	Return rate	Score	Nr. of items per parcel	Score	SMCG/ FMCG	Score	% for online purchases	Score
Eyewear	Accessories and eyewear	A	50,816	14	1.14	low	< 10%	A	1-2	A	FMCG	B	10%	medium
Footwear	Apparel and footwear	B	100,196	8	1.17	low	19,3%	A	3-4	B	FMCG	B	23%	medium
Fresh bakery products	Food, beverages and tobacco	D	116,653	7	1.29	medium	< 10%	A	> 6	D	FMCG	B	3%	low
Fresh fruits and vegetables	Food, beverages and tobacco	D	0	26	0.00	low	< 10%	A	> 6	D	FMCG	B	3%	low
Home and laundry care	Personal care and home care	I	31,314	19	1.01	low	< 10%	A	1-2	A	FMCG	B	3%	low
Luxury goods	Luxury goods	H	99,134	9	0.00	low	n/a	n/a	n/a	n/a	SMCG	A	10%	medium
Major furnishings	Furnishings	E	252,140	3	1.25	medium	1.9%	A	> 6	D	SMCG	A	9%	low
Major household appliances	Household appliances	F	32,532	18	1.18	low	6.5%	A	1-2	A	SMCG	A	37%	high

Product categories	Product category type		Market Relevance				Level of circularity				Consumer behaviour			
	Product category diversity		**Current purchases (2019)**		**Online growth rate purchases (2021 vs 2019)**		**Return rates**		**Packaging**		**Purchase frequency**		**Consumer preferences**	
	Diversity (A to J)		*Relevance (high/medium/low)*				*Diversity (A, B, C)*		*Diversity (A, B, C, D)*		*Diversity (A, B)*		*Relevance (high/medium/low)*	
	Product type	Score	Total [mio €]	Rank	Online growth rate	Score	Return rate	Score	Nr. of items per parcel	Score	SMCG/ FMCG	Score	% for online purchases	Score
Major information and communication technology	Information and communication technology	G	34,281	17	1.11	low	6.5%	A	1-2	A	SMCG	A	36%	high
Media and entertainment products/services	Cultural and recreational goods	C	18,870	22	1.55	high	1.3%	A	1-2	A	FMCG	B	60%	high
Musical instruments	Cultural and recreational goods	C	3,798	25	1.09	low	n/a	n/a	n/a	n/a	SMCG	A	25%	high
Non-perishable foods	Food, beverages and tobacco	D	247.157	4	1.30	medium	< 10%	A	> 6	D	FMCG	B	3%	low
Nonprescription pharmaceuticals and healthcare	Personal care and home care	I	20.096	21	1.13	low	< 10%	A	1-2	A	FMCG	B	13%	medium
Pet foods and supplies	Pet foods and supplies	J	20.280	20	1.34	medium	n/a	n/a	n/a	n/a	FMCG	B	3%	low
Small furnishings	Furnishings	E	50.034	15	1.26	medium	1.9%	A	> 6	D	SMCG	A	9%	low

Product categories	Product category type		Market Relevance				Level of circularity				Consumer behaviour			
	Product category diversity		**Current purchases (2019)**		**Online growth rate purchases (2021 vs 2019)**		**Return rates**		**Packaging**		**Purchase frequency**		**Consumer preferences**	
	Diversity (A to J)		*Relevance (high/medium/low)*				*Diversity (A, B, C)*		*Diversity (A, B, C, D)*		*Diversity (A, B)*		*Relevance (high/medium/low)*	
	Product type	Score	Total [mio €]	Rank	Online growth rate	Score	Return rate	Score	Nr. of items per parcel	Score	SMCG/ FMCG	Score	% for online purchases	Score
Small household appliances	Household appliances	F	15.626	24	1.19	low	6.5%	A	1-2	A	SMCG	A	37%	high
Small information and communication technology	Information and communication technology	G	120.570	6	1.16	low	6.5%	A	1-2	A	SMCG	A	36%	high
Sports and leisure equipment	Cultural and recreational goods	C	16.109	23	1.09	low	1.7%	A	1-2	A	SMCG	A	25%	high
Tobacco products	Food, beverages and tobacco	D	148.902	5	1.02	low	n/a	n/a	n/a	n/a	FMCG	B	0.10%	low
Toys and games	Cultural and recreational goods	C	35.677	16	1.09	low	2.2%	A	1-2	A	SMCG	A	25%	high

Table 52: Initial range for the selection of the final 7 product categories, classification information and statistical/market data matching

N.	Product categories	Classification information	Statistical/Market Data Matching			
		Eurostat 3-digit categories (CPA/PRODCOM) C – MANUFACTURED PRODUCTS	Statista Market Outlook 2021	Postnord: E-commerce in Europe 2018 (Top E-commerce products in Europe)	KPMG: 2017 Global Online Consumer Report (Top categories for online consumption)	Ecommerce Europe (Popular product groups)
1	**Accessories**	Tanned and dressed leather; luggage, handbags, saddlery and harness; dressed and dyed fur Jewellery, bijouterie and related articles	Watches & Jewellery Watches Jewellery Luggage & Bags Suitcases & Briefcases Handbags Wallets & Little Cases Bags & Containers	-	Accessories Bags/leather goods Fine jewellery/watches	-
2	**Apparel**	Wearing apparel, except fur apparel articles of fur Knitted and crocheted apparel	Women's & Girls' Apparel: Coats & Jackets, Blazers Suits & Ensembles, Dresses & Skirts, Trousers, Blouses, Jerseys, Sweatshirts & Pullovers. Men's & Boys' Apparel: Coats & Jackets, Blazers, Suits, Trousers, Shirts, Jerseys, Sweatshirts & Pullovers. Sports & Swimwear: Track & Jogging Suits (unisex), Swimwear (women & girls), Swimwear (men & boys). Underwear: Night & Underwear (women & girls), Night & Underwear (men & boys). T-Shirts & Singlets Hosiery Tights & Stockings Socks Clothing Accessories & Other Clothes Leather Clothes Baby Clothes Gloves Neckwear Hats & Caps Other Clothing Accessories & Clothes	Clothing and footwear	Apparel-women Apparel-men Apparel-children	Clothing

N.	Product categories	Classification information	Statistical/Market Data Matching			
		Eurostat 3-digit categories (CPA/PRODCOM) C – MANUFACTURED PRODUCTS	Statista Market Outlook 2021	Postnord: E-commerce in Europe 2018 (Top E-commerce products in Europe)	KPMG: 2017 Global Online Consumer Report (Top categories for online consumption)	Ecommerce Europe (Popular product groups)
3	**Beverages**	Beverages	Liqueurs & Other Spirits Wine Still Wine Sparkling Wine Fortified Wine Cider, Perry & Rice Wine Non-Alcoholic Drinks Bottled Water Soft Drinks Juices Orange Juice Apple Juice Grapefruit Juice Pineapple Juice Grape Juice Other Juice, Juice Mixtures & Smoothies Hot Drinks Coffee Roast Coffee Instant Coffee Tea Cocoa	Food	Wine Liquor Beer	Food/ Nearfood
4	**Chilled foods**	Dairy products Preserved meat and meat products	Confectionery Chocolate Confectionery Sugar Confectionery Cookies & Crackers	Food	Food/groceries	Food/ Nearfood

N.	Product categories	Classification information	Statistical/Market Data Matching			
		Eurostat 3-digit categories (CPA/PRODCOM) C – MANUFACTURED PRODUCTS	Statista Market Outlook 2021	Postnord: E-commerce in Europe 2018 (Top E-commerce products in Europe)	KPMG: 2017 Global Online Consumer Report (Top categories for online consumption)	Ecommerce Europe (Popular product groups)
5	**Cosmetics and personal care**	Soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations Articles of paper and paperboard	Cosmetics Skin Care Personal Hygiene Hair Care Fragrances Oral Care Tissue & Hygiene Paper Toilet Paper Paper Tissues Household Paper Feminine Hygiene Baby Diapers Incontinence	Cosmetics, skincare and haircare	Cosmetics/skin care Perfume/cologne	Health & Beauty
6	**Deep-frozen foods**	Dairy products	Canned, Dried & Frozen Vegetables Canned, Dried & Frozen Fruit Ice Cream Convenience Food Ready Meals	Food	Food/groceries	Food/ Nearfood
7	**Eyewear**	Medical and dental instruments and supplies	Spectacle Lenses Sunglasses Eyewear Frames Plastic Eyewear Frames Non-Plastic Eyewear Frames Contact Lenses		Eyewear	
8	**Footwear**	Footwear	Leather Footwear Athletic Footwear Sandals, Textile & Other Footwear	Clothing and footwear	Shoes-women Shoes-men Shoes-children	Shoes and Lifestyle
9	**Fresh bakery products**	Bakery and farinaceous products	Bread	Food	Food/groceries	Food/ Nearfood

N.	Product categories	Classification information	Statistical/Market Data Matching			
		Eurostat 3-digit categories (CPA/PRODCOM) C – MANUFACTURED PRODUCTS	Statista Market Outlook 2021	Postnord: E-commerce in Europe 2018 (Top E-commerce products in Europe)	KPMG: 2017 Global Online Consumer Report (Top categories for online consumption)	Ecommerce Europe (Popular product groups)
10	**Fresh fruits and vegetables**	Products of agriculture, forestry and fishing	-	Food	Food/groceries	Food/ Nearfood
11	**Home and laundry care**	Soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	Laundry Care Household Cleaners Dishwashing Detergents Polishes, Room Scents & Insecticides	-	-	-
12	**Luxury goods**	Jewellery, bijouterie and related articles	Luxury Leather Goods Luxury Watches & Jewellery Luxury Watches Luxury Jewellery Luxury Fashion Luxury Apparel Luxury Footwear Luxury Eyewear Prestige Cosmetics & Fragrances Prestige Cosmetics Prestige Skin Care Prestige Fragrances		Fine jewellery/watches	
13	**Major furnishings**	Furniture	Living-room & Dining-room Furniture Seats & Sofas Wooden Furniture for Living & Dining-room Bedroom Furniture Beds Mattresses Closets, Nightstands & Dressers Kitchen Furniture Plastic & Other Furniture Office Furniture Floor Covering	Home furnishings	Furniture/ home decor	Home and Garden

N.	Product categories	Classification information	Statistical/Market Data Matching			
		Eurostat 3-digit categories (CPA/PRODCOM) C – MANUFACTURED PRODUCTS	Statista Market Outlook 2021	Postnord: E-commerce in Europe 2018 (Top E-commerce products in Europe)	KPMG: 2017 Global Online Consumer Report (Top categories for online consumption)	Ecommerce Europe (Popular product groups)
14	**Major household appliances**	Domestic appliances	Refrigerators Freezers Dishwashing Machines Washing Machines Cookers & Ovens	Home electronics	Household goods and appliances	Household Electronics
15	**Major information and communication technology**	Computers and peripheral equipment Communication equipment Consumer electronics	Televisions Desktop PCs PC Monitors and Projectors Printers and Copiers	Home electronics	Electronics/ computers/ peripherals	Information Technology Consumer Electronics
16	**Media and entertainment products/services**	Printing services and services related to printing Reproduction services of recorded media	-	Books/ audiobooks Films CDs	Books/ Music	Media and Entertainment
17	**Musical instruments**	Musical instruments	Acoustic Pianos & Stringed Keyboard Instruments String Instruments Wind Instruments Percussion Instruments Electronic & Electromechanical Musical Instruments Parts & Accessories of Musical Instruments	-	-	-

N.	Product categories	Classification information	Statistical/Market Data Matching			
		Eurostat 3-digit categories (CPA/PRODCOM) C – MANUFACTURED PRODUCTS	Statista Market Outlook 2021	Postnord: E-commerce in Europe 2018 (Top E-commerce products in Europe)	KPMG: 2017 Global Online Consumer Report (Top categories for online consumption)	Ecommerce Europe (Popular product groups)
18	**Non-perishable food**	Preserved meat and meat products Processed and preserved fish, crustaceans and molluscs Processed and preserved fruit and vegetables Vegetable and animal oils and fats Grain mill products, starches and starch products Other food products	Processed Fish & Seafood Canned, Dried & Smoked Fish Fish Fingers & Portions Processed Vegetables, Fruit & Potatoes Preserved Pastry Goods & Cakes Pasta & Rice Pasta & Noodles Sauces & Condiments Tomato Ketchup Sauces & Condiments (without ketchup) Breakfast Products Breakfast Cereals Jams, Jellies, Purées & Marmalade Chocolate Spreads Peanut Butter Snack Food Tortilla Chips, Flips & Pretzels Potato Chips Nuts & Seeds Baby Food	Food	Food/ groceries	Food/ Nearfood
19	**Non-prescription pharmaceuticals and healthcare**	Basic pharmaceutical products Pharmaceutical preparations	Analgesics Cold & Cough Remedies Digestives & Intestinal Remedies Skin Treatment Vitamins & Minerals	-	Pharmacy/ healthcare	-
20	**Pet foods and supplies**	Prepared animal feeds	Pet Food	-	Pet food and supplies	-
21	**Small furnishings**	Furniture	Lamps & Lighting	Home furnishings	Furniture/ home decor	Home and Garden

N.	Product categories	Classification information	Statistical/Market Data Matching			
		Eurostat 3-digit categories (CPA/PRODCOM) C – MANUFACTURED PRODUCTS	Statista Market Outlook 2021	Postnord: E-commerce in Europe 2018 (Top E-commerce products in Europe)	KPMG: 2017 Global Online Consumer Report (Top categories for online consumption)	Ecommerce Europe (Popular product groups)
22	**Small household appliances**	Domestic appliances Manufactured goods n.e.c.	Vacuum Cleaner Small Kitchen Appliances Hair Clippers Irons Toasters Grills & Roasters Hair Dryers	Home electronics	Household goods and appliances	Household Electronics
23	**Small information and communication technology**	Consumer electronics Electronic components and boards Communication equipment Measuring, testing and navigating equipment; watches and clocks Optical instruments and photographic equipment	Smartphones Video Game Consoles Landline Phones Laptops Tablet PCs Keyboards Headphones Speakers Cameras	Home electronics	Electronics/ computers/ peripherals Telecommunications/ phones	Information Technology Telecom Consumer Electronics
24	**Sports and leisure equipment**	Sports goods	Winter Sports Equipment Summer Sports Equipment Other Sports Equipment Fishing Articles & Equipment	Sports and leisure products	Sporting goods/ equipment	Sports & Recreation
25	Tobacco products	Tobacco products	Cigarettes Smoking Tobacco Cigars	-	-	-
26	**Toys and games**	Games and toys	Dolls & Stuffed Toys Construction Sets & Models Card Games Puzzles Toys for Toddlers & Kids Plastic & Other Toys	Toys Children's items	Toys/ games/ video games	Toys

Table 53: Selection criteria for I, II and III screening rounds

Current market relevance (MR)	Growth rate (GR)	Consumer preferences (CP)	Result
I screening (Current market relevance - first 10 product categories)			
high	low	medium	**SELECTED**
high	low	high	**SELECTED**
high	medium	low	**POSSIBLE**
high	low	low	**EXCLUDED**
medium	low	medium	**POSSIBLE**
medium	medium	low	**POSSIBLE**
II screening (HIGH consumer preference)			
high	low	high	**SELECTED**
low	high	high	**SELECTED**
low	low	high	**POSSIBLE**
III screening (MEDIUM consumer preference)			
high	low	medium	**SELECTED**
medium	low	medium	**POSSIBLE**
low	low	medium	**EXCLUDED**

10.2 Annex 2: Tables – Correlations between identified opportunities and threats

Table 54: Attribution matrix: correlations between identified opportunities and threats

			E-commerce feature									Life cycle stage where O/T originates from									Effect order		Clusters						
T/O	Ranking according report	Name	(Non-physical) online shops and platforms	Automatization of processes	Automatization of data analytics	Availability of information	Availability of products	Digital and mobile connectivity	Digital purchasing and transaction process	Easier/broader market access	Shipping of products	Primaary packaging	Distribution from manufacturer	E-fulfilment center operations (warehouse)	E-fulfilment purchasing (ICT)	E-fulfilment - after sales (secondary packaging)	Shipping (transport to parcel network/last mile)	Return (transport and E-fulfilment operations)	Unboxing (packaging waste)	EoL (reuse, repair)	Direct	Indirect	Accessibility of information	Consumer needs and behaviour	Digitalization	EoL	Legal framework	Logistics and transport	Packaging
O	1	Availability of information				●									●						●		●						
O	2	Big data/ meta data			●										●						●		●						
O	3	Innovation								●					●						●	●	●						
O	4	Market access to online aftermarket								●										●	●		●						
O	5	Product portfolio					●								●						●		●						
T	6	International market access								●			●									●	●						
T	7	Ubiquity						●							●							●	●						
O	8	Nudging				●									●							●		●					
O	9	Sharing models and services								●										●	●			●					
T	10	Cross-selling and up-selling			●										●							●		●					
T	11	Ease of shopping						●	●						●							●		●					
T	12	Personalised design					●						●									●		●					
T	13	Shopping frenzy								●					●							●		●					
O	14	Digital goods						●									●				●				●				
O	15	Reduction of retail space	●											●								●			●				
O	16	Substitution of printed marketing material						●							●							●			●				
T	17	Operation of network infrastructure	●											●							●				●				
O	18	Extended product selling cycle	●																	●		●				●			
O	19	Product take-back		●																●		●				●			
O	20	ReCommerce: Second-hand E-commerce /online auctioning								●										●	●					●			
O/T	21	Food waste							●											●		●				●			
T	22	End-of-Life challenges	●																	●		●				●			
T	23	Waste from returns									●							●				●				●			

			E-commerce feature									Life cycle stage where O/T originates from									Effect order		Clusters						
T/O	Ranking according report	Name	(Non-physical) online shops and platforms	Automatization of processes	Automatization of data analytics	Availability of information	Availability of products	Digital and mobile connectivity	Digital purchasing and transaction process	Easier/broader market access	Shipping of products	Primary packaging	Distribution from manufacturer	E-fulfilment center operations (warehouse)	E-fulfilment purchasing (ICT)	E-fulfilment - after sales (secondary packaging)	Shipping (transport to parcel network/last mile)	Return (transport and E-fulfilment operations)	Unboxing (packaging waste)	EoL (reuse, repair)	Direct	Indirect	Accessibility of information	Consumer needs and behaviour	Digitalization	EoL	Legal framework	Logistics and transport	Packaging
T	24	Difficulty to monitor								●			●									●					●		
T	25	Enforcement								●							●					●					●		
T	26	EPR free-rider effect								●			●									●					●		
T	27	Lack of compliance with common market regulation								●			●								●						●		
O	28	In-House Fulfilment								●			●									●						●	
O	29	Collaboration between companies and partnering with waste management suppliers		●																●		●							
O	30	Optimisation of supply chain		●													●					●						●	
O	31	Substitution of individual shopping trips									●						●				●							●	
T	32	Damage on delivery									●						●					●						●	
T	33	Individual product delivery									●						●					●						●	
T	34	Induced freight traffic to remote locations								●							●					●						●	
T	35	Induced parcel transport									●						●				●							●	
T	36	Inefficient transport									●						●					●						●	
T	37	Inferior types of transportation									●						●					●						●	
T	38	Parcel return									●							●			●							●	
O	39	Development of dedicated optimised packaging solutions									●	●										●							●
T	40	Excessive protective packaging									●					●						●							●
T	41	Secondary Packaging									●					●					●								●

10.3 Annex 2: Tables – In depth assessment of opportunities and threats for selected product categories

Table 55: Shipped units 2017 (Source: Postnord 2018, Statista and Eurostat)

Country	Apparel items [items]	small ICT items [items]	Major household appliances [items]	Media products [total]	n-p food [items]	major furniture [items]
Poland	224,820,000	17,424,000	1,086,000	40,112,000	31,392,000	8,284,000
Sweden (Nordics)	119,880,000	8,280,000	582,000	17,260,800	15,177,600	2,827,200
Spain	458,460,000	28,476,000	1,938,000	71,688,000	74,160,000	10,506,000
France	651,780,000	46,260,000	3,507,000	113,900,000	96,900,000	17,000,000
Germany	903,780,000	51,624,000	4,524,000	207,548,000	97,944,000	31,482,000
EU 28	7,708,680,000	474,811,917	34,785,000	n.a.	n.a.	n.a.

Table 56: Product category-specific return rates per country (Source: Postnord 2018 and Eurostat)

Country	share of citizens who returned apparel [%]	Return rates small ICT [%]	Return rates major household appliances [%]	Media return rate average [%]	assumed return rate non-perishable food, based on expert opinion	Share of citizens who returned home furniture [%]
Poland	13%	4%	4%	1%	2%	2%
Sweden (Nordics)	22%	5%	5%	1%	2%	2%
Spain	17%	12%	12%	1%	2%	1%
France	19%	7%	7%	2%	2%	2%
Germany	28%	7%	7%	3%	2%	3%
EU 28 (average of above)	20%	7%	7%	2%	2%	2%

Table 57: Package weight material LDPE foil. Own calculation based on: DIN EN 13724 (2013), packaging retailer and service providers (Karton Center Germany; DB Schenker Europe (2019))

Parcel type	Dimensions LxWxH in [mm]			Area in [m^2]	Thickness 60µm in [m]	Foil volume in [m^3]	Density LDPE foil 0.93 g/cm^3 in [g/m^3]	Packaging weight per item in [g]
Standard Letterbox	229	324	35	0.187	0.00006	0.0000112	930000	10.4
Standard Shoebox	313	215	120	0.261	0.00006	0.0000157		14.6
Standard Large Box	600	300	150	0.630	0.00006	0.0000378		35.2

Table 58: Package material weight cardboard. Own calculation based on: DIN EN 13724 (2013), packaging retailer and service providers (Karton Center Germany; DB Schenker Europe (2019))

Parcel type	Dimensions LxWxH in [mm]			Area in [m^2]	Average area density in [g/m^2]	Packaging weight per item in [g]
Standard Letterbox	229	324	35	0.187	377	71
Standard Shoebox	313	215	120	0.261	1098	287
Standard Large Box	600	300	150	0.630	1867	1176

Table 59: Units per package and packaging size (Sources: Stakeholder Survey and expert opinion for items per parcel, Allen *et al.* (2017) for typical packaging sizes per category)

Units per package and packaging size	Apparel			Small information technology			Major household appliances			Media and entertainment products			Major furniture		
	Letterbox	Shoebox	Large box	Letterbox	Shoebox	Large box	Letterbox	Shoebox	Large box	Letterbox	Shoebox	Large box	Letterbox	Shoebox	Large box
Shipped units per package applied in calculations	1	3	4	1	2	-	-	-	1.5	1	2	2	-	-	1

Table 60: Online retail growth rate (Source: Statista)

Online retail growth rate	Apparel	small ICT	Major household appliances	Media products	n-p food (pasta & rice)	major furniture
Average annual growth rate 2019-2021	7.2%	15.07%	8.9%	27.45%	15.1%	12.5%

Table 61: Shipped units, scenario 2030 (linear growth, own calculation)

Shipped units, scenario 2030 (linear) [items]					y=m*x+b	
Country	**Apparel**	**small ICT**	**Major household appliances**	**Media products**	**n-p food**	**major furniture**
Poland	377,187,470	49,284,590	2,238,385	182,259,442	91,022,856	21,357,809
Sweden (Nordics)	181,153,095	23,395,865	1,198,322	77,719,229	44,008,298	7,303,933
Spain	736,309,498	74,563,734	3,697,806	323,440,575	215,031,059	27,362,400
France	1,025,324,845	127,016,166	7,016,666	509,728,711	280,966,958	43,829,401
Germany	1,269,419,470	142,355,077	9,090,454	920,290,682	283,994,094	79,844,419
EU 28	11,983,270,414	1,308,187,438	69,836,429	n.a.	n.a.	n.a.

Table 62: Fulfilled units BAU scenario 2030 (linear growth, own calculation)

Fulfilled units, BAU scenario 2030 (linear) [items]						y=m*x+b
Country	**Apparel**	**small ICT**	**Major household appliances**	**Media products**	**n-p food**	**major furniture**
Poland	326,644,349	47,116,068	2,139,896	181,257,015	89,202,399	20,973,369
Sweden (Nordics)	141,299,414	22,343,051	1,144,397	76,592,300	43,128,132	7,187,070
Spain	610,400,574	65,988,905	3,272,558	319,397,568	210,730,437	27,143,501
France	832,563,774	117,871,002	6,511,466	499,279,273	275,347,619	43,040,472
Germany	920,329,115	132,674,932	8,472,303	893,142,107	278,314,212	77,129,709
EU 28	9,615,376,180	1,218,184,142	65,031,683	n.a.	n.a.	n.a.

Table 63: Urban and Rural Consumers per country (Eurostat, Postnord 2018, Statista)

	Urban [%]	Rural [%]	Density [capita/km2]	Capita [mio]	Urban [mio]	Rural [mio]	Return Rate
Poland	60.6	39.5	121.4	38.0	23.0	15.0	0.13
Sweden (Nordics)	86.1	13.9	22.5	10.1	8.7	1.4	0.22
Spain	80.0	20.0	92.1	46.3	37.1	9.3	0.17
France	80.0	20.0	122.1	64.8	51.8	13.0	0.19
Germany	75.7	24.3	231.2	82.8	62.7	20.1	0.28
EU 28	75.3	24.8	117.7	443.0	333.4	109.6	0.20

Table 64: Background data for delivery in urban areas (BIEK, 2017)

	Number of tours per day			Number of packages			First delivery ratio		
	a	b	c	a	b	c	a	b	c
Hamburg	664.0	234.0	314.0	169.0	147.0	193.0	94.3	91.9	95.8
Berlin	1,298.0	897.0	256.0	163.0	148.0	133.0	92.9	97.0	93.0
Munich	430.0	238.0	378.0	158.0	183.0	121.0	93.9	97.1	94.4
Average	797.3	456.3	316.0	163.3	159.3	149.0	93.7	95.3	94.4

Table 65: Transport distance per fulfilled unit (BIEK, 2017)

Urban [km/FU]				Rural [km/FU]			
Country	**1. Purchase**	**2. Return**	**Total**	**Country**	**1. Purchase**	**2. Return**	**Total**
Poland	2.7	0.2	**2.9**	**Poland**	6.7	0.9	**7.5**
Sweden	2.7	0.2	**2.9**	**Sweden**	6.6	0.9	**7.5**
Spain	2.7	0.2	**2.9**	**Spain**	6.7	0.8	**7.5**
France	2.7	0.2	**2.9**	**France**	6.7	0.9	**7.5**
Germany	2.7	0.2	**3.0**	**Germany**	6.7	1.0	**7.7**

Table 66: Carbon intensity per fulfilled unit (own calculation)

Urban [g CO_2e/FU]				Rural [g CO_2e/FU]			
Country	**1. Purchase**		**Total**	**Country**	**1. Purchase**	**2. Return**	**Total**
Poland	247.6	20.6	**268.1**	**Poland**	396.0	51.9	**447.8**
Sweden	245.7	21.7	**267.4**	**Sweden**	393.4	54.7	**448.0**
Spain	247.5	19.2	**266.8**	**Spain**	395.0	48.5	**443.5**
France	247.3	20.1	**267.4**	**France**	396.0	50.7	**446.7**
Germany	246.3	23.2	**269.4**	**Germany**	397.0	58.5	**455.5**

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