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Disembedding air from e-commerce parcels: A joint challenge for supply chain actors

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ABSTRACT

The increasing use of e-commerce has brought attention to the problem of excessive air in e-commerce parcels. Within this context, the paper sets out to illustrate how e-commerce parcels are embedded in a network of resources controlled by various actors, each with their own perspective on how to tackle the problem of excessive air in e-commerce parcels and its associated challenges. The findings are derived from a single case study relying on 33 interviews, field visits, a workshop and secondary data. The article is grounded in Industrial Network Theory and particularly the Resource Interaction Approach, which enables an analysis of how air as a resource can be disembedded from e-commerce parcels. The results offer insights for firms involved in e-commerce supply chains into various actors' perspectives on air in e-commerce parcels and how firms can start tackling the challenge of reducing it. The paper concludes that even though excessive air in parcels has received much attention lately, this problem is not always highly prioritised and only one of many considerations for firms.

1. Introduction

The use of e-commerce is growing rapidly, and in 2019 it accounted for 14.1% of total retail sales globally (Statista, 2021). In 2020, more than 131 billion e-commerce parcels were shipped within and across the world's 13 major markets (Pitney Bowes, 2022). This, together with the fact that expectations of cheap, or even free, deliveries and short delivery times to end-customers have become the norm in many industries, has increased pressure on supply chains (Luo & Sun, 2016; Nguyen, de Leeuw, & Dullaert, 2018). Furthermore, these expectations often result in inefficient use of logistics and transport resources in supply chains (Halldórsson & Wehner, 2020; Rizet, Browne, Cornelis, & Leonardi, 2012), and the logistics capacity, especially within e-commerce, has therefore become an important factor in companies' competitiveness (Rodrigue, 2020; Wang, Jia, Schoenherr, Gong, & Chen, 2020) and the way they configure their e-commerce models (Gaudenzi, Mola, & Rossignoli, 2021). One important aspect of e-commerce is packaging (Trafikanalys, 2019) and excess packaging, or 'overpackaging', results in overuse of both energy and materials and increases the environmental impact of transportation and production processes (Lu, Yang, Liu, & Jia, 2020; Monnot, Reniou, Parguel, & Elgaaied-Gambier, 2019). Hence, packaging is an important issue for actors involved in e-commerce in business-to-business markets. Although this article focuses on e-commerce, packaging in general has been highlighted as a key concern for industrial marketers for a long time, as Easton (1978, p. 323) states, "the cost of packaging is an integral part of the costs of getting the product to the customer in good condition" and that industrial marketers should "have more than a passing interest in the subject" (ibid., p. 316).

1.1. Packaging in e-commerce

Packaging serves several functions from a supply chain perspective (Hellström & Saghir, 2007). According to Pålsson and Hellström (2016, p. 351), packaging "affects the logistical and environmental efficiency of supply chains." First, packaging protects its content from being damaged during material handling and transportation (Pålsson & Hellström, 2016). Second, it can prolong the life of products such as food (Keränen, Komulainen, Lehtimäki, & Ulkuniemi, 2021). Third, it provides protection from theft (Pålsson & Hellström, 2016). Fourth, it determines the shapes and sizes of parcels and thereby affects material handling, transport efficiency and consolidation in last-mile logistics (Hagberg & Hulthén, 2022). Fifth, it serves as a carrier of information (Lindh, Williams, Olsson, & Wikström, 2016). Sixth, it constitutes an important part of the so-called unboxing experience for end-customers and reinforces the image of products and brands (Prendergast & Pitt, 1996).

It has become increasingly important for packaging solutions to be

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sustainable. One aspect of this is the type of packaging material used. The types and qualities of materials used and issues such as the share of primary fibres in paper affect the recyclability of packaging (Escursell, Llorach-Massana, & Roncero, 2021; Keränen et al., 2021). Most countries within the EU have established producer responsibility schemes for packaging, which make companies that produce or sell goods legally responsible for managing their packaging materials after consumption (European Parliament, 1994). This has become an increasingly important issue due to the rising levels of e-commerce, which results in greater consumption of packaging material (Alberto, Giulia, Mauro, & Cristina, 2014).

Another issue relates to greenhouse gas emissions. The EU aims to be climate-neutral by 2050 and the commission has proposed raising the 2030 greenhouse gas reduction target from 40% to 55% from 1990 levels (European Commission, 2020). Some EU countries have set even higher goals. Sweden, for example, has set a goal to reduce carbon dioxide emissions from transport by 70% from 2010 levels by 2030 and be climate-neutral by 2045 (Swedish Energy Agency, 2017). In 2017, the transport sector accounted for 27% of total greenhouse gas emissions in the EU (Martin, Pestiaux, Schobbens, Emmrich, & Hagemann, 2020). Between 2013 and 2019, greenhouse gas emissions from transport increased steadily, diverging significantly from other sectors during the same period of time (European Environment Agency, 2021). How e-commerce parcels are packed affects fill rates and thereby has the potential to reduce the numbers of transports used and hence also carbon dioxide emissions.

However, other considerations, including working environments and economic factors such as efficiency and resource utilisation, are also important for firms (Colim et al., 2020; Haekal, Hanum, & Adi Prasetio, 2020). Hence, what constitutes 'a sustainable packaging solution' is unclear and needs to be discussed from many perspectives. The various actors involved in a business network, such as producers, wholesalers, retailers, logistics and transportation firms, packaging suppliers, packing machine suppliers and IT providers will have different views on this matter. Furthermore, various functions within a firm, such as production, product development, purchasing, marketing and logistics, will have different views on what constitutes a sustainable packaging solution. Introducing changes that promote sustainable packaging solutions is therefore a complex matter. Pålsson and Hellström (2016, p. 352) argue that "The increased need for coordination and integration among supply chain members to tackle supply chain performance of packaging involves the challenge of considering requirements from all involved actors."

1.2. Air in e-commerce parcels

This paper focuses on a specific issue related to packaging: air in e-commerce parcels. This is an important issue for firms involved in supply chains that need to balance the protection of products to prevent damage with increasing efficiency and meeting the demands of sustainability (Lu et al., 2020). One of the major logistics service providers in Sweden estimates that the parcels handled in its e-commerce business contain (at least) 30% 'unnecessary' air (PostNord, 2021). Similarly, Stora Enso (2017) estimates that e-commerce parcels in Sweden contain 100 million litres of excessive air annually, equivalent to about 1000 empty trucks. A South Korean study showed that about 50% of measured e-commerce parcels exceeded a 50% empty space ratio (Oh, Jo, Suh, & Lee, 2019). This is also an issue highlighted by many consumers reacting to small items being sent in relatively large boxes, resulting in hashtags on social media such as #stopsendingair. Collectively this has led many actors involved in e-commerce supply chains to call for a reduction in excessive air in e-commerce parcels. However, air plays an important role in, for example, shock absorption when a parcel is handled in the supply chain. Additionally, a focus on reducing plastic waste may impede the maximisation of fill rates for both packaging and transportation (Nguyen, Parker, Brennan, & Lockrey, 2020). Air in parcels may include the packaging material itself, for example a cardboard box that includes layers of air as part of its inherent structure. The primary packaging, i.e. the packaging closest to the product, may also contain air by design, often to make it appealing in physical stores (Xie et al., 2021). However, the focus of this paper is air inside e-commerce parcels, i.e. the empty space ratio between the content and parcel size. *E*-commerce parcels, especially those containing fragile products, must include some air to facilitate protection and shock absorption, but too much may lead to the content being squeezed or shaken during transport and result in damaged content (Azzi, Battini, Persona, & Sgarbossa, 2012; Williams, Wikström, & Löfgren, 2008). 'Overpacked' products may also contribute to excessive material use, less efficient transportation and consumer dissatisfaction (Hellweg & Canals, 2014; Molina-Besch & Pålsson, 2020).

1.3. Aim and research questions

The paper takes its point of departure from the view that every e-commerce parcel needs to fit into a technical and organisational system that includes other resources controlled by different actors in the business network. Actors will likely have different perspectives on (1) the role of air in e-commerce parcels and (2) how excessive air can be reduced, as well as the effects of such efforts. These different perspectives create trade-offs that need to be handled (Lai, Harjati, McGinnis, Zhou, & Guldberg, 2008). It is therefore important that the analysis is expanded beyond firms to supply chains and networks (Huang, Surface, & Zhang, 2022) to understand the embeddedness of e-commerce parcels in a network of other resources (Brüel Grönberg & Hulthén, 2022) and the various perspectives (Pålsson & Hellström, 2016).

In line with this, the aim of the paper is to analyse the role of air in e-commerce parcels. In relation to this, two research questions are addressed: (1) How is air in e-commerce parcels embedded with other resources? (2) What challenges are related to disembedding excessive air in e-commerce parcels?

2. Conceptualising air as an embedded resource

Theoretically, the paper is grounded in Industrial Network Theory (e.g. Håkansson & Snehota, 1995), focusing on the interactive nature of business. This approach relies on three different but interrelated pillars: activities, resources and actors. In this paper we focus particularly on the resource dimension and rely on the so-called 4R model (Håkansson & Waluszewski, 2002). This approach enables systematic analysis of two types of technical resources (products and facilities) and two types of organisational resources (business units and business relationships). A central notion of the model is that resource interaction forms resource interfaces (Wedin, 2001). See the left side of Fig. 1 for a generic description of the 4R model. Furthermore, resource interfaces create both opportunities and barriers for value creation (Håkansson & Waluszewski, 2002). Therefore, if two resources do not match, an interface will not be able to act as a base for value creation. This is nicely illustrated in Prenkert, Hasche, and Linton (2019), who exemplify the mismatch between a rail wagon and a rail track. If these resources do not fit together, both their values will diminish. Hence, interactions between resources means that they do not have a predefined value but are, by definition, heterogeneous. This also means that the value of a resource is defined by (1) how it is combined with other resources and (2) how it is used (Jahre, Gadde, Håkansson, Harrison, & Persson, 2006). Furthermore, new combinations of resources can always emerge and reveal features of existing resources that were previously 'hidden'. Scrutinising how a focal resource is embedded in a network of other resources enables the identification of interfaces between the resources and the effects of such interfaces in terms of interdependencies.

Huemer and Wang (2021) build on this notion by problematising resources (for example the rail track and rail wagon in the example by Prenkert et al., 2019) pointing to that each of these resources can be

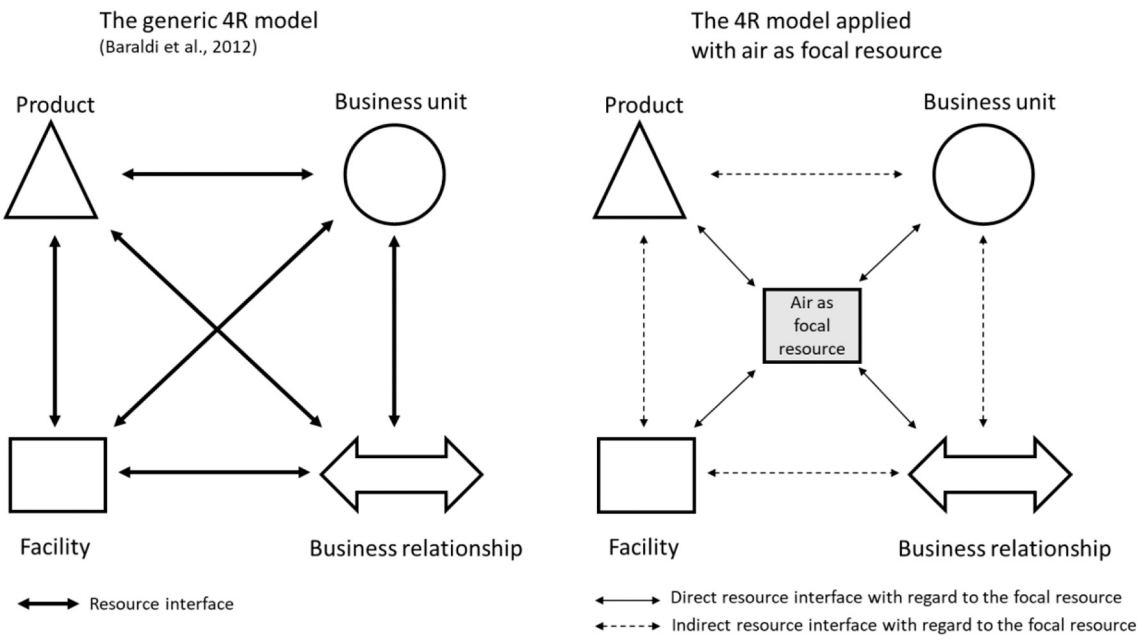

Fig. 1. The generic 4R model (left) and the 4R model as applied in this paper (right)
(Inspired by Baraldi, Gressetvold, & Harrison, 2012).

regarded as a bundle of resources in itself. Hence, a rail track is composed of rails, fasteners, ballast, etc. and each of these will also be bundles of resources and so forth. This means that "one manager's resource bundle is another's resource; consider, for instance, how resources are perceived to create value at different tiers of a supply chain" (Huemer & Wang, 2021, p. 721). Therefore, a 'bundle perspective' on resources acknowledges "that resources may or may not match with each other when utilised together" (ibid.). Furthermore, resources are controlled by various actors, for example producers, retailers, wholesalers, logistics and transportation firms and consumers. Jahre et al. (2006) argue that actors try to economise on internal as well as external resources to create value by combining resources in new ways. In line with this, Jahre and Fabbe-Costes (2005, p. 146) state that "a small change at the resource level, for example changing the size of a package, could and probably would impact on a number of other resources in the logistics chain and in the network and may require changes in them as well."

To approach the issue of air in e-commerce parcels, we conceptualise an e-commerce parcel as a resource bundle in which air is one resource among a number of others such as packaging material, tape, filling material, strapping and labels. Baraldi et al. (2012, p. 268) argue that:

> *the two linked resources are not utilized or developed in a vacuum. Instead, through connected interfaces with other resources each of the two resources will receive "imprints". These are in the form of pressures to develop certain other features that may be unimportant for a focal interface, but that are necessary for satisfying the technical, social or economic requirements of other resources in order to fit better in a network context. Therefore, each resource becomes embedded not only in its individual direct interface but also in a complex texture of many indirect interfaces with other resources.*

This approach was recently used to analyse how e-commerce packaging is embedded in three different network settings: product development, packing and sorting (Brüel Grönberg & Hulthén, 2022).

In line with the above, in this paper air is considered the focal resource under scrutiny. However, air is seen as one resource in the bundled resource 'e-commerce parcel'. The applied theoretical lens enables the identification of other resources that 'air' interfaces with, either directly or indirectly, and provides an analytical tool for resource embeddedness. Thereby, it also enables the identification and analysis of challenges and opportunities related to how to 'disembed' air from the 'resource bundle' e-commerce parcel. See the right side of Fig. 1 for a description of how the 4R model can be used to analyse direct and indirect resource interfaces with regard to a focal resource (in this case 'air').

3. Method

Considering the aim of the paper and the nature of the research questions, a single case study with embedded sub-cases was conducted (Halinen & Törnroos, 2005). The role of air in e-commerce parcels in the Swedish retail context was analysed. The point of departure for the case was a large logistics service provider (LSP Inc.) and its efforts to manage an increasing number of shipments related to e-commerce. Data collection took place between September 2020 and November 2021. The main source of data was interviews, which were complemented with study visits, a workshop and secondary data, including firm documents, websites and seminars. A snowball method was used (Cassell & Symon, 1994), and the starting point for the interviews was two representatives from one packaging supplier and one logistics service provider (LSP Inc.). The snowball method enabled the identification of interviewees who (1) had knowledge about relevant issues related to the research questions, (2) could elaborate on and validate statements from other interviewees and (3) could identify additional interviewees that would not have been identified by the researchers themselves. Some interviewees provided detailed information concerning a specific firm or contextual issue and others were 'packaging experts', providing more general knowledge within the area of packaging. According to Bogner, Littig, and Menz (2009), expert interviews can be used for exploring a field of study and to provide a thematic structure. The interviews cover two packaging suppliers, three packing machine suppliers, five retailers (representing beauty products, home appliances, and daily commodities), one third party logistics provider (TPL) and one logistics service provider (LSP Inc.). In total, 33 interviews were conducted with a total of 36 interviewees. Interviews that were not conducted face to face were conducted through video calls by Zoom or Teams, and all interviews lasted between 30 min and 3 h. The interviews were semi-structured using guiding themes rather than directed by detailed questions. The

interviewees were given the opportunity to introduce their specific area of knowledge and related views at the beginning of the interview. This allowed them to bring up possible areas of interest that may not have been considered by the researchers and to provide their perspectives without direction from indicative questions. For a detailed list of interviews see Table 1.

Table 1
List of interviews.

Firm	Position of interviewee	Interview theme(s)	Time (h)
Logistics service provider (LSP Inc.)	Head of Security and Claims	Safe packaging, reasons for claims	2
	Project Manager, Process Manager	Production, processes, work environment	2
	Key Account Manager	Service points	1.5
	Marketing Manager	Design of consumer delivery bags	1.5
	Packaging Consultant	Damaged and lost parcels	1,5
	President and CEO	Cooperation, sustainability, strategy	1
	Production Manager	Production logistics – Parcel deliveries	1
	Production Manager	Production logistics – Letter deliveries	1
Retailer Home appliances	Transport Manager Outbound	Outbound and omni-channel logistics	1.75
	E-Com fulfilment Operations Manager	Feeder store logistics	2
	Internal Procurement Manager	Purchasing and supply of packaging	2
	Packaging Manager	Designing product packages	1.5
	Sustainability Manager	Sustainability and sustainable packaging	1.5
	Compliance Specialist	Product sustainability	1
	Transport Coordinator	Transport coordination and e-commerce	1.5
	Team Managers e-commerce	Working environment	1
	Warehouse employee	Operations assistance	1
	Process Developer, Engineer	Automation in e-commerce	1
	Outbound Transport Manager	Central warehouse processes	0.5
Retailer Beauty products 1	Sustainability Manager	Packaging strategies and transportation	1.5
Retailer Beauty products 2	Purchasing and Logistics Manager	Logistics in e-commerce	1.5
Retailer Daily commodities	Chief Logistics Officer	Logistics and packing machines	2
Retailer Furniture	Packaging Leader	Packaging strategies	1.5
Packaging Supplier 1	Design Manager, Nordic Sales Manager	Packaging development, collaboration	1.5
	Packaging Specialist	Packing automation	2
	Customer Value Manager	Packaging development, value tools	1.5
	Operations Compliance Manager	Recycling, re-use	1.5
	Pack Right Centre Manager	Packaging development, customer projects	1.5
Packaging Supplier 2	Sales and Packmaster	Packaging, packing, load carriers	0.5
Packing Machine Supplier 1	Business Developer Manager	Packing automation	1.5
Packing Machine Supplier 2	Marketing and Sales Manager	Packing machines, logistical challenges	1
Packing Machine Supplier 3	Engineer and consultant	Innovation in packing automation	1.5
Third-Party Logistics Provider	Sustainability Manager	Processes and sustainability	3

Table 2
List of study visits.

Firm	Position of participant	Main theme(s) of study visits
Third-Party Logistics Provider	Sustainability Manager	Logistics in main terminal
LSP Inc.	Production Manager	Logistics of parcel deliveries
LSP Inc.	Production Manager	Logistics of letter deliveries
Retailer Home Appliances	Transport Manager Outbound	*E*-Com logistics in central warehouse

In addition to the interviews, one study visit at a TPL provider, two study visits at the facilities of LSP Inc. and one study visit at a home appliance retailer's central warehouse were conducted; see details in Table 2. Each study visit was conducted by two researchers and their observations were supplemented with additional follow-up questions. Photos from each study visit were also filed and used in the analysis. The reason more study visits were not carried out was the presence of restrictions related to the Covid-19 pandemic during 2020–2021.

To tune in to and raise issues at a group level, a workshop with 'Retailer home appliances' was organised. The focus was to get feedback on preliminary findings and to discuss relationships with key actors from the perspectives of the workshop participants. The participants were the Transport Manager Outbound, the e-Com fulfilment Operations Manager, the Packaging Manager and the Transport Coordinator. The workshop consisted of a single 1.5-h session. The workshop was video recorded to ensure the opportunity to go back and capture certain discussions and perspectives. It also made it easier to study the processes by which meaning was collectively constructed during the session (Bell, Bryman, & Harley, 2019). The workshop session was transcribed and thematically analysed.

Regarding data analysis, each interview was recorded and transcribed. This was followed by a manual identification and categorisation of resources with any connection to the focal resource 'air'. The analytical framework was developed by continuously matching the empirical material through systematic combining (Dubois & Gadde, 2002). Identification and categorisation were conducted based on the 4R model, which has been the foundation of the analytical framework. Following this categorisation, the qualitative data analysis tool NVivo was used to capture resource interfaces and interdependencies from various actors' perspectives. Based on this analysis, the actors' perspectives were linked to the respective resources. The analysis was primarily focused on direct interfaces (see Sections 4.1 and 4.2). However, Section 4.3 provides examples of indirect interfaces to illustrate the importance of also identifying and analysing these.

4. Empirical analysis

The empirical analysis takes its starting point in LSP Inc. (a major logistics service provider) and its efforts to manage an increasing number of shipments related to e-commerce. Currently, e-commerce-related shipments account for about 75% of its total shipments. In recent years, LSP Inc. has become increasingly frustrated by what it describes as a 'disproportional' amount of air being shipped via its transport and logistics system. Based on its internal calculations, LSP Inc. estimates that e-commerce parcels on average contain at least 30% air. To approach this issue, LSP Inc. is currently interacting with some of its retail customers to discuss various possibilities for reducing excessive air in e-commerce parcels. However, the initial conclusions from these discussions show that this is a complex issue since the way e-commerce parcels are packed, and thereby also the amount of air they contain, depends on a variety of factors, some of which retailers have no control over.

To illustrate the complexity of this task, the paper focuses on analysing a focal e-commerce parcel from the perspective of air. Air is considered one resource in the larger resource bundle 'e-commerce

parcel', and the mapping is focused on this resource being interdependent on other technical resources (products and facilities) and organisational resources (business units and business relationships). The analysis should not be considered 'complete' in the sense that it covers all resources with which e-commerce parcels could be embedded with regard to 'air', but rather as an example of such resources and resource interfaces.

In Sections 4.1 and 4.2, we first elaborate on the embeddedness of the focal resource (air) in the direct resource interfaces of the technical and organisational resources identified in the study (see Fig. 2). In Section 4.3, an example of an indirect resource interface from the perspective of the focal resource is provided (see Fig. 3).

In the subsequent Sections 4.1 and 4.2, fifteen resource interfaces are identified and analysed. The interfaces are identified based on how various resources relate to the focal resource, i.e. air in e-commerce parcels.

4.1. Air in e-commerce parcels embedded in technical resource interfaces

4.1.1. Interface 1: Product

The first interface relates to the product that is exchanged between a retailer and consumer. The shape, size and weight of the product impacts the choice of packaging. Furthermore, LSP Inc.'s available logistics services set limitations for e-commerce packaging based on a combination of weight, volume and dimensions, each using different guiding principles (so-called product terms; see Table 4 in Section 4.2.1). For example, many retailers use a number of standard boxes, and the choice of box size is often made based on the maximum measurements allowed according to LSP Inc.'s product terms. If a product does not fit in a small box the next size of box is chosen, which often result in it containing excessive air.

The product (and product package) itself may possess properties that provide support and stability to the parcel, which means less packaging (e.g. filling material and air) is required to protect it during storing, sorting, and transportation. The product packaging itself may also contain air for legal reasons (e.g. statutory dissemination of information related to the product and package), marketing reasons (e.g. to attract attention and/or give consumers the impression of a product being valuable) and store planning reasons (e.g. for greater visibility on spear hangers in stores). The sensitivity of the product also influences the need for protection during material handling and transport. In this case a certain amount of air, and packaging material, may provide necessary shock absorption.

Furthermore, the individual product is part of a retailer's product assortment. This impacts packaging since the whole assortment, and not only a single product, needs to be taken into consideration when deciding on packaging strategies. The more diverse a product assortment is in terms of, for example, shape, size, value and sensitivity, the more difficult it is to optimise the packaging to reduce excessive air. Some retailers have very similarly sized products and can therefore work with a small number of standard boxes, reducing excessive air to a minimum. However, other retailers have a wider variety of products, in terms of size, weight, sensitivity and value, which can mean that orders from consumers result in non-optimal combinations of products with regard to air in parcels. Some of the products also have dimensions (for example gift wrapping paper on rolls) that do not fit well within the dimensions of standard boxes, which again results in them containing more excessive air.

4.1.2. Interface 2: Packing equipment

Packing can be done manually or using various degrees of automation. Packing involves resources such as packing machines, packing personnel, packing stations, strapping machines, wrapping machines, packaging material (e.g. cardboard boxes, tape, plastic bags, plastic wrap) and filling material (e.g. paper, bubble wrap, styrofoam). An automated solution used by a retailer in our study automatically transfers products to boxes of different sizes. The decision of which box should be used is based on data stored in the IT system about each

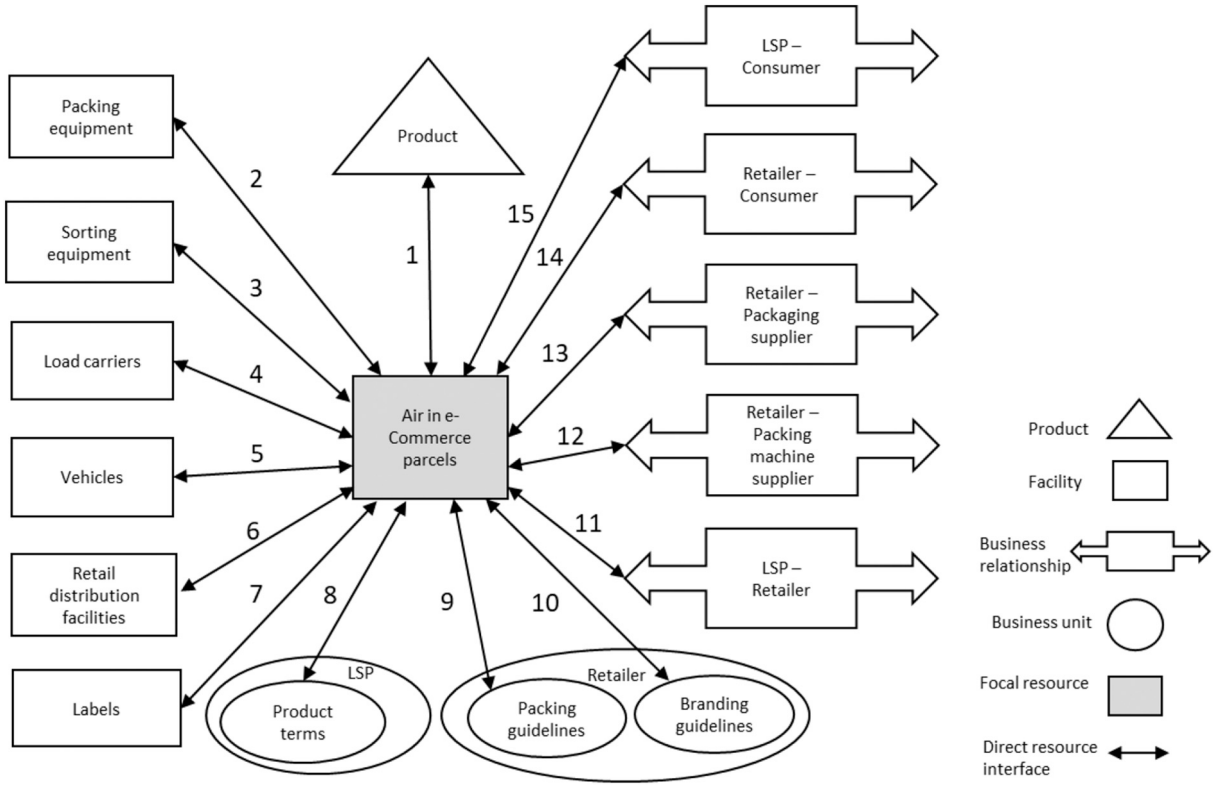

Fig. 2. Air in e-commerce parcels as embedded in direct resource interfaces.

product's size, weight, etc. Hence, correct data are crucial to avoid excessive air in boxes. The boxes in this example are sized extra small, small, medium and large, each with a standardised bottom surface area. The dimensions of the packing machines limit the bottom surface area of the boxes. However, height can be adjusted based on the size of the product(s). One retailer in our study pointed out that investments in automated packing machines are long-term decisions since they lock a retailer into a certain 'box assortment' with specific dimensions for a long time.

4.1.3. Interface 3: Sorting equipment

The sorting equipment of LSPs sets conditions for how product terms (see Table 4) are specified, thereby influencing packaging and packing. Some of the large LSPs' sorting equipment was developed before the 'e-commerce boom' and are optimised for speed rather than the 'delicate handling' of parcels. This is the case for LSP Inc., LSP 1 and LSP 2, as shown in Table 4. For example, a parcel should be able to survive a fall of a certain height when parcels in cages are tipped onto the sorting equipment. Furthermore, the parcels need to be within certain dimensions to match those of the sorting equipment. Hence, parcels need to be small enough to fit on the conveyer belt but big enough (see for example limitations in minimum weight and size for LSP Inc.) to not be 'thrown off' it. Some of the newly established LSPs (for example LSP 3 and LSP 4 in Table 4) focused on e-commerce distribution have developed sorting equipment that allows for more delicate handling and thus do not require such restrictive product terms. For example, LSP 3 has developed sorting equipment that does not involve 'parcels falling' onto a conveyer belt. Such equipment can provide opportunities for retailers to use less filling material inside parcels or reduce the thickness of cardboard used in their boxes, in turn reducing the amount of air used to protect products. Some retailers in our study point to the sorting equipment of LSPs as being the main limitation to reducing packaging protection (air and packaging material). Since many large retailers work with a range of different LSPs that use different sorting equipment and therefore different product terms, all standardised packaging needs to meet the strictest requirements set by any one LSP. This is because it would be too resource intensive to adapt packaging and packing for each LSP's product terms.

4.1.4. Interface 4: Load carriers

The use of load carriers in the distribution network is closely linked to the amount of air in e-commerce parcels. LSPs use different load carrier systems, such as parcel cages or pallets. Some of these operate based on standardised dimensions, such as the EU pallet system based on dimensions of 120 × 80 cm, while others use load carrier systems that work based on company-specific measurements. LSP Inc., for example, uses a company-specific system of parcel cages mounted on wheels used in outbound distribution. The bottom surface area of the parcel cage is 120 × 75 cm and the cage is thereby designed to be compatible with the EU pallet system. Like LSP Inc., a number of other LSPs use load carrier systems that rely on the EU pallet standard, while others use systems that are unique or rely on other standards. For retailers, matching parcels to these load carrier systems becomes an important and tricky consideration, especially for those that work with more than one LSP. Hence, they need to adapt their packaging and parcel dimensions to these load carrier systems to ensure that the capacity of the load carriers is used in the best possible way.

4.1.5. Interface 5: Vehicles

Packaging determines how the capacity (e.g. weight and volume) of a vehicle is used. Assuming the weight limitation of a vehicle is not reached, how its volume capacity is used is crucial for transport efficiency. If parcels are loaded into parcel cages, as in the case of LSP Inc., the main challenge is loading the cages efficiently, since the number of cages that a given vehicle (e.g. a truck) can carry is fixed. Furthermore, in the case of LSP Inc., the dimensions of the cages are based on the same standard (EU pallet) as the trailers, which means that there is a good fit between the cages and trailers. However, sometimes, for example in transport between terminals, parcels are loaded directly into a vehicle. In this case, the loading of parcels is decisive to how much of the volume capacity can be utilised. Some packaging allows for parcels to be stacked and some not, which presents further limitations for loading.

4.1.6. Interface 6: Retail distribution facilities

The amount of air in e-commerce parcels is related to various retail distribution facilities, such as retail stores, pick-up points, consumer homes, delivery boxes and postboxes. As discussed earlier, it is the choice of logistics services (e.g. letter, parcel, pallet) that determines which of these facilities are used in the distribution of a certain product. Regarding postboxes, these have standard dimensions that limit the use of specific logistics services. For example, excessive air in e-commerce parcels can lead to parcels being too big to fit into postbox throws. Postboxes are adapted primarily for the 'letter logistics service', which is defined by specific product terms. Goods sent with the 'parcel logistics service' may be small enough to fit in postboxes but still be delivered via pick-up points or home delivery due to the choice of logistics service. For pick-up points, such as service stations and convenience stores, which handle many e-commerce parcels, the amount of excessive air in parcels plays a crucial role for how they utilise storage space. It also relates to the handling of parcels by personnel and therefore work environment issues. Furthermore, so-called delivery boxes have specific dimensions that restrict the size of parcels (see maximum sizes for parcels for LSP 3 and LSP 4 in Table 4). Hence, excessive air in parcels can mean delivery boxes not being available as a delivery option.

4.1.7. Interface 7: Labels

E-commerce parcels also carry information. The standard transport label (the STE label) includes the name and address of both the receiver and sender, as well as information about the shipment (volume and weight). Different LSPs have varying requirements regarding the amount of information required and the size of this label (see Table 3). Other requirements also set limitations for the size of a parcel; for example, LSP 2 requires that the transport label fit on the top of the parcel so it is visible. Retailers that work with many LSPs need to respond to these differences and adapt their packaging to the strictest labelling requirements. This means that all parcels (directed to all LSPs) will have the same, 'largest' label. Sometimes this means that the size of the label is the limiting aspect for the dimensions of parcels.

Hence, the requirements of sizes and positions (on top of the parcel) of labels can lead to parcels containing excessive air. Regarding the amount of information on the label, one retailer in our study argued that the necessary information could 'easily' be replaced with a QR code, enabling smaller labels. However, the standard label (STE) is used by many LSPs and is designed to be used with an established infrastructure of optical scanners and IT systems in their logistics and sorting equipment, which means it is not easily changed. There are also legal aspects related to the visibility of information.

Table 3
Different LSPs' requirements on transport labels.

	LSP Inc.	LSP 1	LSP 2	LSP 3	LSP 4
STE label (size) mm	102 × 192	105 × 220	105 × 251	N/A	100 × 150
Other aspects	N/A	N/A	The transport label must fit in its totality on top of the parcel	N/A	N/A

4.2. Air in e-commerce parcels embedded in organisational resource interfaces

4.2.1. Interface 8: Product terms

Different guiding principles impact on packaging. Some guidelines are directly related to the so-called product terms stipulated by the LSPs (see Table 4). These product terms, in turn, relate to the various logistics services provided by the LSPs. In our study, LSP Inc. operates three logistics services: (1) letters, (2) parcels and (3) pallets. Each of these relates to product terms that specify the size, weight and packaging requirements of what is being shipped, for example that a parcel should be able to survive a fall from a certain height. This, in turn, requires certain protective features of the parcel that affect filling material and air.

4.2.2. Interface 9: Packing guidelines

Some retailers have detailed packing instructions that direct personnel to certain choices of packaging material, box size and procedure. Other retailers use guiding values such as 'transporting air is costly', 'always try a smaller box first' or 'speed is the most important issue'. Manual packing is a time-consuming activity. To position the product(s) in an e-commerce parcel is a cognitive task that may have significant impact on how much air is ultimately included in a parcel. The perception of the product(s) being packed, for example its sensitivity and weight, also provide packing personnel with indications of how to pack it. Manual packing can hence result in parcels containing more or less air depending on many parameters, for example the skills and experience of the packing personnel, the packaging material available (e.g. number of different box sizes) and how the balance between speed and thoroughness is prioritised.

4.2.3. Interface 10: Branding guidelines

With increasing e-commerce, some retailers want their brand displayed on the parcel for visibility. In such cases the packaging procedure sometimes becomes more complex. For example, when taping a cardboard box, the tape should not cover the printed logotype or brand. Another issue relates to the fact that some paper qualities are not suitable for printing, which impacts on the packaging material that can be chosen for certain parcels. Companies' brand strategies may lead to larger parcels, and thereby more excessive air, to fit logotypes and branding.

4.2.4. Interface 11: LSP – Retailer

When a retailer and LSP Inc. initiate a relationship, the retailer has very little influence on the guidelines that affect packaging procedures (for example transport label sizes and product terms), which impacts their ability to reduce excessive air in e-commerce parcels. Instead, retailers need to adapt to the requirements (product terms) set by LSP Inc. As mentioned previously, many retailers work with more than one LSP, each with unique requirements. Due to the need for standard procedures in packaging, retailers tend to adapt their ways of working to the LSP with the strictest requirements. This may lead to 'overpackaging' of parcels handled by LSPs with less strict product terms.

4.2.5. Interface 12: Retailer – Packing machine supplier

For retailers using packing machines, relationships with the suppliers of such equipment are crucial. This kind of equipment is often a significant investment and is expected to have a long lifetime. In our study, the main issues discussed in relation to such investments were how packing machine suppliers could help retailers to achieve efficiency and speed of packing. Issues discussed are often of a technical nature, relating to, for example, choice of packaging material and the technical fit between the packaging material and packing machine. The study indicates that retailers with highly varied product ranges, with regard to, e.g., shape and size, seem to prioritise speed and standardisation of box sizes rather than reducing excessive air.

4.2.6. Interface 13: Retailer – Packaging supplier

Packaging supplier 1 has a set of analysis and planning tools to evaluate the overall packaging strategy of a retailer. This analysis is based on the retailer's product assortment and delivery structure, e.g. where and how parcels are delivered, and includes, for example, choices of materials and box sizes. A significant concern relates to the number of different box sizes to use to cover the available product assortment and whether packaging (boxes) should be adaptable. Some boxes are designed to be cut down in height but have a standard bottom surface area. These choices (number of standardised box sizes or the degree of adaptability of boxes) play a crucial role in how air can be reduced in e-commerce parcels. When starting a new business relationship between a retailer and packaging supplier, it is common procedure for the retailer to provide the supplier with a detailed specification of their packaging requirements, including parcel size range and material specifications. This information is then used as the basis for price calculations and discussions that mainly relate to price, delivery and storage of packaging material. How to improve the packaging strategy, in relation to, for example air, seems not to be an important topic in these discussions.

4.2.7. Interface 14: Retailer – Consumer

Retailers in our study highlighted the fact that consumers react strongly to what they perceive to be excessive air in e-commerce parcels and that this frustration is often communicated back to retailers' customer service departments. Other ways customers show their frustration over this is by uploading images of parcels to social media and tagging the retailer, which can create bad will.

4.2.8. Interface 15: LSP – Consumer

Although LSP Inc. does not have a formal business relationship with the consumers, it does interact with consumers during last-mile distribution, for example when communicating delivery information about a shipment. Furthermore, consumers interact with drivers as well as

Table 4
Different LSPs' product terms (regarding size and weight) for B2C parcels within the Nordic countries.

Product terms	LSP Inc.	LSP 1	LSP 2	LSP 3	LSP 4
Maximum size (mm)	*Home delivery*: Length 1750. Length + circumference 3000 *Service point delivery*: Length 1500. Length + circumference 3000	*Home delivery*: 1500x500x500 *Service point delivery*: Length 1500. Length + circumference 3000 *Box delivery*: 680x480x600	*Home delivery*: Length 2000. Length + circumference 3000. *Service point delivery*: Length 1800. Length + circumference 3000	*Box delivery*: 400x400x600	*Home delivery*: Length 1200. Length + circumference 3000. *Box delivery*: 400x600x300
Minimum size (mm)	140x90x15	150 × 110 × 35	The transport label must fit on the top of the package. Height 20	N/A	N/A
Maximum weight (kg)	*Home delivery*: 35 *Service point delivery*: 20	*Home delivery*: 35 *Service point delivery*: 20	*Home delivery*: 30 *Service point delivery*: 20	*Box delivery:* 20	*Home and box delivery:* 20
Minimum weight (kg)	0.15	N/A	N/A	N/A	N/A

various pick-up points. The study points to consumers often regarding LSP Inc., as well as other LSPs, as being responsible for the excessive air in e-commerce parcels. As in interface 14, the frustration about excessive air is often communicated back to the LSPs' customer service departments or expressed using tagged photos on social media, which, in turn, creates bad will.

4.3. Air in e-commerce parcels embedded in indirect resource interfaces

In Sections 4.1 and 4.2, fifteen direct resource interfaces between the focal resource, air in e-commerce parcels, and other resources were identified and analysed. Each of these resources could be mapped in a similar way to 'air in e-commerce parcels' and thereby treated as a 'focal' resource. In the forthcoming analysis, the focus is on identifying and analysing indirect interfaces (regarding air in e-commerce parcels) by using a different resource as the focal resource. The analysis uses sorting equipment as the focal resource and highlights the interfaces that can be identified from the perspective of the sorting equipment regarding 'air in e-commerce parcels' (see Fig. 3). Three of the identified interfaces are identical to those in Fig. 2, specifically 3, 4 and 7. Two of the remaining resources that have no direct interfaces to 'air in e-commerce parcels' (bar code scanners and LSP personnel) are also identified since they indirectly impact and are impacted by air in e-commerce parcels. Hence, Fig. 3 illustrates how both direct and indirect resource interfaces impact air in e-commerce parcels through the embeddedness of the focal resource (sorting equipment).

First, there is an interface between the sorting equipment and labels (interface a). In the previous section it is obvious that both the sorting equipment and labels have interfaces to air in e-commerce parcels (interface 3 and interface 4). However, the interfaces between barcode scanners and sorting equipment (interface b) and barcode scanners and labels (interface c) imply that these resources are interconnected through technological interdependencies and are thereby hard to change, limiting their adaptability (in the short run) to enable the use of smaller parcels and hence reduce excessive air.

Second, there is an interface between LSP personnel and the sorting equipment (interface d). How parcels arrive to the terminal of an LSP partly determines how they can be placed on the conveyer belt of the sorting equipment. If parcels arrive in parcel cages, they can be automatically tipped onto the conveyer belt (interface e between sorting equipment and load carriers). However, if they arrive on pallets the LSP personnel must manually unload them from the pallet onto the conveyer belt. Hence, there is also a resource interface between LSP personnel and load carriers (interface f). The shape, weight and size of parcels influence the working environment of the personnel, and excessive air and packaging material influence ergonomic conditions and impact their ability to handle parcels in a delicate manner. Furthermore, when automatically tipped onto a conveyer belt, parcels at the bottom must be able to cope with the weight of those being tipped on top of them. When parcels are manually loaded onto the conveyer belt, requirements for speed might mean LSP personnel not having time to handle parcels delicately (e.g. parcels may be 'thrown' on the belt). To prevent parcels being damaged, they might be 'overpacked' with excessive air.

5. Concluding discussion

The next section is divided into four parts. In 5.1 a discussion on the embeddedness and disembedding of air in e-commerce parcels is provided. This is followed by implications for research and managers in 5.2 and 5.3 respectively. The section ends with some final comments and suggestions for future research in 5.4.

5.1. Disembedding air in e-commerce parcels

The paper set out to analyse the role of air in e-commerce parcels by focusing on two research questions: (1) How is air in e-commerce parcels embedded with other resources? (2) What challenges are related to disembedding excessive air in e-commerce parcels?

5.1.1. Air in e-commerce parcels is an embedded resource in a business network

The paper shows that air in e-commerce parcels is embedded in a structure of technical and organisational resources. Furthermore, each of the resources with which it has a direct resource interface is also embedded in a similar way. This means that air, as part of a larger resource bundle, is embedded both directly and indirectly in an intrinsic network of technical and organisational resources in line with the arguments of Baraldi et al. (2012).

5.1.2. Limited network horizons make relevant resource interfaces invisible for actors

The resource interfaces between air and other resources (as well as those between the other resources) are more or less visible, some being readily apparent and others more hidden. This is a result of the fact that each actor has a limited view of the business network they are part of. This limited network horizon (see, e.g., Holmen & Pedersen, 2003;

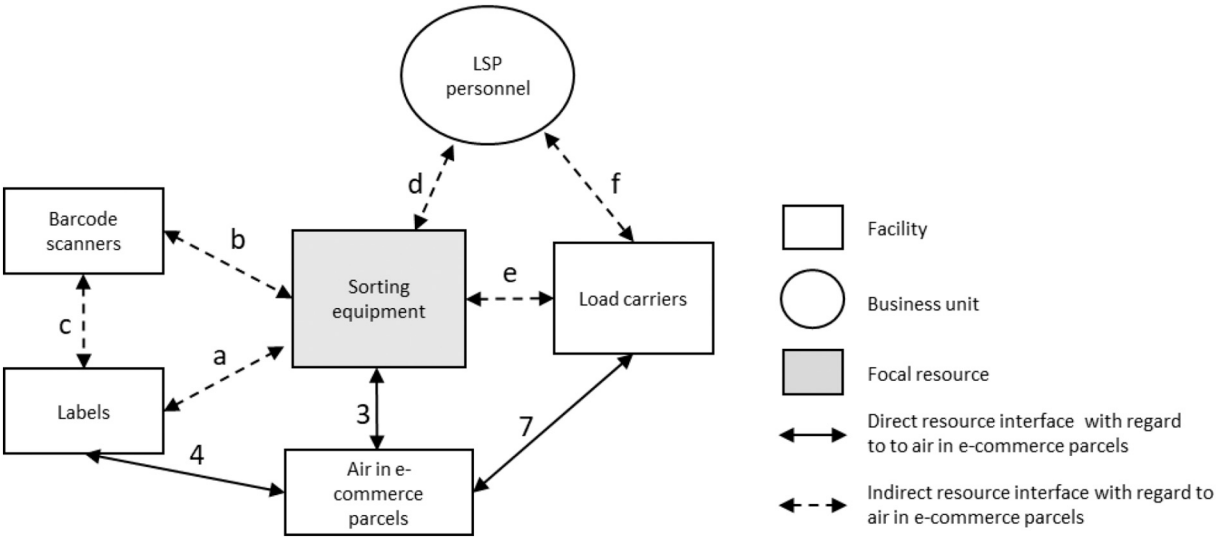

Fig. 3. Air in e-commerce parcels embedded in direct and indirect resource interfaces through the focal resource (sorting equipment).

Eriksson, Hulthén, & Pedersen, 2021) can be exemplified by consumers not understanding the efforts involved in packing and delivering a certain e-commerce order, or packing personnel not understanding the processes and handling of parcels on their way to consumers. This is in accordance with Marshall, McCarthy, Claudy, and McGrath (2019), who in their study showed that managers responsible for sustainable supply chain management often do not see beyond the first tier of suppliers in their upstream supply chains.

5.1.3. Many types of actors are affected by air in e-commerce parcels

The paper illustrates that many different kinds of actors have an impact on and are impacted by 'air in ecommerce parcels', e.g. retailers, LSPs, packaging suppliers, packing machine suppliers, product suppliers and consumers. Many of the involved actors try to economise on packaging in different ways to increase cost-efficiency and reduce environmental impact. Furthermore, in line with Jahre et al. (2006), each actor has its own view on how to combine resources to enable sustainable packaging solutions, for example reducing excessive air in e-commerce parcels. Retailers often strive for efficiency and speed and thereby aim for standardisation of packing activities and routines. This leads to retailers being hesitant to adapt packaging procedures to different requirements set by various LSPs, in turn leading to retailers organising packing routines by adapting to the LSP with the strictest product terms. This may lead to 'overpackaging', resulting in overuse of energy and materials and an increased negative environmental impact from transportation and production processes (Lu et al., 2020; Monnot et al., 2019).

5.1.4. Different performance criteria steer actors in different directions

The study points to the many potential benefits of removing excessive air in e-commerce parcels. First, LSPs could increase fill rates in load carriers such as cages and operate fewer delivery transports. Furthermore, other facilities, such as pick-up points, could make better use of their space. Smaller parcels could more easily make use of letter services, being delivered to postboxes. The handling of parcels, both for consumers and personnel at LSPs and retailers, would benefit from smaller parcels.

However, the study also points to the presence of a number of contradictions, for example regarding the choice of packaging material, where cardboard has a higher recyclability rate, while plastics may result in less air and higher fill rates. Hence, different perspectives create contradictions that need to be managed (Huang et al., 2022; Lai et al., 2008).

Moreover, to handle the growing number of online orders, retailers increasingly turn to automated packaging solutions. However, when it comes to air in e-commerce parcels, it is difficult to minimise excessive air at the same time as prioritising speed in packing, a key concern for many retailers due to the increasing demand for short delivery times to consumers. In manual packing, packing personnel are an important resource for removing excessive air in parcels. The study points to the fact that skilled packing personnel, encouraged by corporate culture, can adapt packaging and remove excessive air to a large degree. However, this is often time-consuming and labour intensive and is thereby also seen as costly. For low value products this obviously becomes a challenge.

5.2. Implications for research

5.2.1. Contribution to the packaging literature related to packaging as a 'given system of levels'

The first contribution relates to the view of packaging as a 'given' packaging system that consists of three (or more) levels (e.g. Hellström & Saghir, 2007). Primary packaging is the packaging closest to the product (often called 'product packaging'). Secondary packaging (often called 'store packaging') contains several primary packages. Tertiary packaging (e.g. pallets or parcel cages) contains a number of primary or secondary packages. This packaging terminology works well in the upstream of supply chains where products are shipped in large batches from product suppliers to distribution centres or physical stores. However, in an omni-channel or e-commerce channel the physical flow of products is split up and directed to physical stores or e-commerce outlets respectively. Hence, in B2C e-commerce, where products or product combinations are sent to individual consumers, these different packaging levels are not always a suitable solution since products may require repacking into 'e-commerce parcels', resulting in material waste, additional unpacking and packing operations and potential excessive air. This is in line with the arguments of Spruit and Almenar (2021), who argue that the contemporary distribution structure is a heritage of a long-standing reliance on sales from physical stores, meaning that both production and distribution facilities, and their various processes and business routines, have been adapted to this logic. With new types of last-mile logistics solutions for e-commerce, new ways of delivering goods are being developed. In the future, the types of cardboard boxes often used in e-commerce might not be needed for certain delivery options (such as home deliveries and parcel box deliveries) as they can be performed by actors who may not rely on large sorting equipment that requires packaging as protection in the automated handling.

5.2.2. Contribution to the logistics and transport literature related to 'fill rates'

A second contribution relates to research in logistics and transport and the focus on fill rate (of vehicles) as a success factor (Liljestrand, 2016). Our study shows that the 'fill rate in parcels' is rarely considered and often 'hidden' from most of the actors in a supply chain since it is neither visible nor measured. This problem also relates to the price models used by LSPs, where some refer to the 'weight' of parcels rather than their 'volume'. This, in turn, creates very little incentive for retailers to focus on 'fill rates in parcels'. Furthermore, other issues that relate to the problem of fill rates in vehicles, such as limitations of work-environment policies regarding the manual loading of parcels and limitations concerning the stackability of parcels and load carriers, remove focus from fill rates in parcels and, in turn, reducing air in e-commerce parcels. However, increased attention from consumers regarding air and fill rates in e-commerce parcels has pushed this issue to the top of the agenda for many actors involved in e-commerce and its related supply chains.

5.2.3. Contribution to the IMP literature relating to 'disembedding'

A third contribution relates to the IMP stream of research and the focus on resource interfaces and embeddedness (e.g. Baraldi et al., 2012). In this paper we contribute to understanding not only the embeddedness of a particular resource (air in e-commerce parcels) but also the disembedding of this resource from a larger resource bundle (Huemer & Wang, 2021) and the related challenges of embeddedness in direct and indirect resource interfaces.

5.3. Managerial implications

Coming back to the paper's starting point and the frustration of our focal LSP at transporting 'a lot of air' in its e-commerce logistics flow, how can this issue be approached? Considering the embeddedness illustrated above, the key issue becomes how to remove excessive air from e-commerce parcels and how various actors can contribute to this challenge. Due to the embeddedness of air, this is obviously a tricky issue that cannot be solved by a single firm alone, since the resources related to air, as shown in this paper, are not controlled by one firm. Instead, the various resources are spread across firm boundaries and are controlled by different (types of) actors, each with its own business logic and perspective on the issue. In the forthcoming sections we suggest how to approach this issue, first by focusing on firm internal matters and second, by focusing on joint actions with external partners.

5.3.1. Identify internal perspectives and consider potential effects of internal adaptions

From a single firm's perspective, it is important to identify the role of 'air in e-commerce parcels' based on the different functions of the firm, e.g. marketing, logistics, etc. By starting to discuss these issues in relation to different functions within the firm, contradictory goals can be identified and managed. For example, the logistics department at one retailer in our study argued that some of its product assortment should not be available for online shopping since the cost of packing and shipping the products is far too high in relation to the price of the product and delivery. However, the marketing department argued that it is of utmost importance to have a full assortment available for consumers in the webshop. Similar contradictions were found at a product supplier where the product development, logistics and marketing departments had very different perspectives concerning the design of the product and packaging. Furthermore a firm should identify internal adaptations that could be made, based on the various perspectives discussed above, to reduce excessive air in parcels and the consequences of these adaptations on various functions of the firm and related performance criteria. This relates, for example, to changing the number of parcel sizes, automation initiatives and other innovative packaging solutions that may affect various performance criteria.

5.3.2. Identify external actors and the need for adaptions and resource 'matching'

A firm should also identify other actors that need to be involved in a certain change. For example, when a retailer tries to reduce air in e-commerce parcels by reducing their size, it does not necessarily match with the resource structures of other actors, for example the sorting equipment of LSPs. The 'matching' of resources across firm boundaries is hence necessary to accomplish sustainable packaging solutions, and this, in turn, needs to be done through interaction between various actors involved in the business network. In the example above it is the LSPs that regulate 'matching', with product terms acting as a resource interface between parcels (and its features deciding its shape, weight and size) and sorting equipment. To change this situation, either the LSP needs to adapt its sorting equipment, in which it has invested a large amount of money, or the retailers will need to find new packaging solutions that still meet the product terms set by the LSP. Another option is that the LSP and retailer jointly try to adapt the sorting equipment, packaging material, product terms or other issues, taking each other's perspectives into account. In this example, only LSPs and retailers have been discussed. However, there are more actors that are important to consider, for example product suppliers, packaging suppliers and packing machine suppliers. When starting such a process, a key aspect is searching for relevant resource interfaces, including those crossing firm boundaries, rather than neglecting them. This is in line with the arguments of Pålsson and Hellström (2016), who point to the importance of considering requirements related to packaging from different supply chain actors' perspectives and the need for coordination and integration among these actors to accomplish this exchange of perspectives.

5.4. Final comments and future research

Interpretations of how sustainable packaging solutions should be achieved are often based on an actor's own business logic and perspective, and the reduction of air in e-commerce parcels is not the main priority for all actors involved. Furthermore, approaches to the ecologic and social aspects of sustainability are often linked to economics, with actors trying to balance short-term profitability and long-term sustainability (Huang et al., 2022). This study took its departure in an LSP that is striving to reduce the amount of air transported and stored within its transport and logistics system. However, there are other actors involved in the business network that prioritise other sustainability measures. For example, the study includes a packaging supplier that cites circularity as the main driver for sustainable packaging solutions at the same time as focusing on economic growth and a retailer that strives to constantly reduce packaging material and manual packing to reduce costs.

Add to this the fact that the Swedish Work Environment Authority has been commissioned by the government to examine the e-commerce industry from a work environment perspective. This means, for example, that there will be increased pressure to remove the risks associated with any manual handling of parcels. Although the general mindset concerning sustainable development with regard to packaging is often similar between companies, for example in terms of reducing the amount of packaging material used, changing to more sustainable material, reducing air in parcels, increasing material recycling and reducing energy consumption in the production and handling of packaging, there are still diverse business logics and priorities that counteract opportunities to develop sustainable packaging solutions. This is due to the fact that various efforts and actions on sustainability may lead to counterproductive effects elsewhere in the business network. All in all, interactions and exchanges of perspectives are crucial for actors to understand their respective roles in efforts to create more sustainable packaging solutions. Reducing air is obviously not the only prioritised action.

During this study, several interviewees, representing different parts of the supply chain, have highlighted the impact and importance of various policies and regulations related to their choices concerning packaging. To develop the understanding of sustainable packaging solutions in e-commerce and how this aligns (or not) with different sustainability goals, we suggest more research to analyse the role of policies and regulations in this effort.

Data availability

The authors do not have permission to share data.

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