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Packaging requirements in retail distribution networks: the impact of connected automation initiatives

Sandra Brüel Grönberg

Department of Technology Management and Economics, Chalmers University of Technology, Gothenburg, Sweden

ABSTRACT

This paper explores how connectedness among automation initiatives impacts packaging requirements in retail distribution networks. Drawing on a single case study involving three connected automation initiatives – the extension of unloading automation by a logistics service provider, the adoption of warehouse automation by a retailer, and the introduction of packing automation by a producer – the study examines how automation implemented in one part of a retail distribution network influences packaging requirements across connected firms. The findings show that while automation often enhances internal efficiency, it also generates cross-firm alignments and misalignments in packaging requirements. These alignments and misalignments create challenges for packaging development, particularly when packaging is adapted to meet the technical and operational demands of partners' automation solutions and thereby constrain packaging flexibility. The study highlights the importance of recognising automation initiatives not only as firm-internal investments but as connected change initiatives with consequences for packaging efficiency and sustainability-related outcomes. Packaging decisions therefore require attention to changes in resource interfaces across connected relationships.

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Retail; distribution; packaging; automation; business network

Introduction

Retail distribution undergoes several changes, including the growth of e-commerce, an increasing number of last-mile delivery options, heightened attention to sustainability, stronger regulatory pressure, and the adoption of omni-channel strategies (Fahim et al. 2025). Additionally, products are often shipped globally, with production, assembly, delivery, and consumption taking place in different parts of the world (Koberg and Longoni 2019). In line with technological advancements and these ongoing shifts, actors involved in retail distribution – such as producers, retailers, and logistics service providers – are increasingly implementing automation (Baker and Halim 2007; Nitsche, Straube, and Wirth 2021). In this paper, automation is defined as 'the full or partial replacement of a function previously carried out by the human operator' (Parasuraman, Sheridan, and Wickens 2000, p. 287). Yet, while automation is increasingly implemented across multiple

CONTACT Sandra Brüel Grönberg bruel@chalmers.se

parts of retail distribution networks, its consequences for shared resources that must function across organisational boundaries remain insufficiently understood.

The introduction of automation often requires adjustments to resources that go beyond the direct substitution of human tasks, thereby influencing broader operational and strategic configurations. For instance, automation may unintentionally reduce coordination in supply chains or constrain firms' flexibility in decision making, as highlighted by Li and Li (2022), who show how AI-driven automation can backfire in retail settings by introducing new tensions between efficiency and adaptability. Despite these insights, much of the existing literature addresses automation as a firm-level or dyadic phenomenon, offering limited insight into its network-level effects on interdependent resources.

Analysing automation initiatives as resource-related changes that affect and are affected by other resources – such as packaging – highlights their interconnectedness and influence across firm boundaries. Packaging is particularly exposed to such interconnected changes, as it has interfaces with multiple automation solutions across distribution activities and organisational contexts. Building on Industrial Network Theory on stability and change in network relationships (Gadde and Mattsson 1987), this study focuses on how automation initiatives contribute to both coupling and decoupling dynamics in retail distribution networks. While tightly coupled automation–packaging interfaces may enhance efficiency locally, they may simultaneously create both alignment and misalignment elsewhere in the network. This tension points to a central but underexplored problem: how efficiency-driven automation initiatives influence packaging requirements beyond the boundaries of the implementing firm.

Packaging plays a critical role for efficiency in retail distribution (Jahre and Hatteland 2004; Naidoo and Gasparatos 2018), as it is handled by multiple business actors across retail distribution networks involved in moving goods from production to consumption. It provides protection, containment, preservation, and communication, and supports handling and transport through unitisation and apportionment (Hellström and Saghir 2007). These functions depend on its interaction with logistics processes, requiring packaging to be tailored to various distribution contexts and product characteristics (ibid.).

Packaging decisions directly affect both costs and sustainability-related outcomes, ranging from packaging material procurement, design, and development, to logistics and end-of-life handling (Pålsson 2018). In this paper, sustainability is treated as an empirical performance category, reflected in how actors evaluate packaging in relation to, for example, material intensity, damage rates, and transport volume efficiency. This clarifies sustainability as an outcome of how resources are combined and evaluated in practice, rather than as a property inherent in the theoretical framework itself.

This paper contributes to theory by examining automation not as a firm-specific investment, but as a network-embedded, resource-affecting change initiative. It applies the Industrial Network Approach (Håkansson and Snehota 1995) to analyse how resource changes initiated through automation initiatives are connected to changes in other resources across business relationships. By doing so, the study extends discussions on coupling and decoupling systems (Orton and Weick 1990; Weick 1976) by demonstrating how such dynamics unfold across multiple, interconnected automation initiatives rather than within isolated organisational units. In line with this, *the aim of this paper is to explore how connectedness among automation initiatives impacts packaging requirements in retail distribution networks.*

The remaining part of the paper is structured as follows: First, a review of previous research is presented on automation and packaging in retail distribution. Second, the analytical framework and research question are introduced, focusing on connectedness among resource-related change initiatives in retail distribution networks. Third, the methodological approach is outlined Fourth, the empirical material is presented and analysed using the analytical framework. Finally, the paper ends with conclusions, including theoretical and practical implications.

Automation and packaging in retail distribution

As the retail sector adapts to the growth of e-commerce and the rise of omni-channel strategies, changes in distribution and warehousing systems have emerged (Risberg 2023). Consequently, omni-channel logistics has become a critical and complex function of retail operations, requiring coordination of various delivery modes and fulfilment options across multiple interdependent actors involved in retail distribution (ibid.). Simultaneously, firms are increasingly investing in automation to improve operational efficiency, reduce costs, enhance the working environment, and meet customer expectations (Dubey and Veeramani 2024). However, the success of these investments is linked to how well automation solutions are integrated beyond firm boundaries in the supply chain context (Nitsche 2021).

The following review of previous research begins with an overview of automation in retail distribution, particularly in the context of e-commerce growth and omni-channel logistics. It then reviews packaging requirements, focusing on how the efficiency and sustainability-related performance of established packaging systems are challenged by these shifts. Despite their interdependence in practice, prior research largely treats automation and packaging as firm-level design issues, offering limited insight into how multiple, connected automation initiatives impact packaging requirements across firms.

Automation in retail distribution

During the Covid-19 pandemic, which began in early 2020, many consumers shifted to online shopping out of necessity, but continued by choice (Sheth 2020). Online sales are expected to grow to approximately 30 % of retail sales in Europe by 2030, and consumer journeys increasingly mix online and offline interactions, making a seamless hybrid shopping experience essential (Lone, Weltevreden, and Luharuwala 2023). Over the past decade, store-based enterprises have transitioned into dual-channel, cross-channel, multi-channel, and omni-channel formats (Raza and Govindaluri 2021). Despite the rising sales volumes of e-commerce, the majority of retail sales still occur in physical stores. The coexistence of online and physical store channels, however, places new demands on warehouses and distribution centres, mainly due to varying order characteristics across different channels (Kembro and Norrman 2020). For example, physical stores typically handle high-volume, low-mix orders (few variants, large quantities), whereas e-commerce handles low-volume, high-mix consumer orders (many variants, small quantities) (Boysen, de Koster, and Füßler 2021). E-commerce often requires faster deliveries, while store deliveries are more cyclic and predictable (ibid.). The integration of omni-channel services, such as click-and-collect from physical

stores, further increases logistical complexity (Wollenburg et al. 2018). Seasonal sales peaks place additional strain on warehousing systems, particularly those with rigid automation facilities, such as conveyors and automated lifts designed for vertical movements, as these systems often lack the flexibility to increase operational speed in response to rising sales (Carlo and Vis 2012). Collectively, these shifts necessitate changes in how retailers, logistics service providers, packaging suppliers, and producers plan and manage their operations and involved resources.

Automation requirements in the context of retail distribution

The changes outlined above involve automation initiatives within warehouses and distribution centres. Several factors influence how these facilities operate – including physical layout, types of storage racks, handling equipment, information systems, labour organisation, and levels of automation (Kembro, Norrman, and Eriksson 2018). Firms are increasingly customising their warehouse and distribution centre designs based on the facility's purpose, product mix, order characteristics, and demand patterns, aiming to enhance cost efficiency and customer satisfaction (ibid.). At the same time, these design efforts are challenged by increasingly diverging and sometimes conflicting contextual requirements in today's retail distribution. To meet expectations for faster deliveries, more flexible delivery options, and operational efficiency, many firms have invested in or are planning to invest in automation (Kembro and Norrman 2020). Such investments are often justified by short-term considerations, such as return on investment (ROI), while longer-term consequences for supply chain coordination, resource independence, and cross-firm alignment are frequently overlooked (Tagashira 2022).

Packaging in retail distribution

Over time, packaging has been adapted to the prevailing conditions in retail distribution. Yet, the growth of e-commerce and omni-channel distribution has complicated packaging development, as products now move through multiple, partially overlapping distribution contexts. Packaging must therefore perform across a wide range of handling, storage, and transport conditions. The following sections discuss packaging as a system and how packaging requirements are affected by shifting conditions in retail distribution.

The packaging system and shifting demands in retail distribution

Hellström and Saghir (2007) provide an overview of the interactions between packaging and logistics processes in retail supply chains, emphasising that effective packaging decisions are critical for improving supply chain efficiency and effectiveness. Traditionally, the mainstream packaging system in retail has been adapted for physical store sales and delivery and consists of three levels: product (primary) packaging, store (secondary) packaging, and transport (tertiary) packaging (Hellström and Saghir 2007). Over time, producers, retailers, and logistics service providers have adapted production, packing, and delivery processes to this system. The growth of e-commerce and omni-channel distribution challenges these established adaptations, as involved actors have to balance the different demands for packaging entailed by the increased number of distribution options (Freichel, Wollenburg, and Wörtge 2020). Moreover, packaging is interdependent with a variety of logistics and operational resources – such as storage

systems, handling equipment, and transport solutions – which are controlled and influenced by different actors who hold diverging perspectives and requirements regarding packaging (Brüel Grönberg and Hulthén 2022; Jahre and Hatteland 2004).

Packaging requirements in the context of retail distribution

Improving packaging is vital for improving efficiency and reducing the environmental impact of the transport and logistics sector (Pålsson and Sandberg 2020). For example, Ahmad et al. (2022) argue that reducing the empty space ratio, as well as the weight and volume of packaging, is essential for enabling more sustainable retail distribution. Moreover, packaging waste has risen by nearly 25% over the past decade, and unless further actions are taken, it is projected to grow by an additional 19% by 2030 (European Council 2024). In response, a new regulatory framework has been adopted to make packaging more sustainable and to reduce packaging waste (ibid.). Packaging waste occurs at various stages across supply chains and includes all three packaging levels (Morashti, An, and Jang 2022). Despite growing regulatory pressure and sustainable ambitions, economic considerations still dominate packaging redesign efforts (Gustavo et al. 2018). As a result, what is considered effective, efficient, and sustainable packaging is closely tied to cost considerations and operational constraints, including those introduced or reinforced by automation initiatives.

Analytical framework and research question

This research is theoretically grounded in the Industrial Network Approach (INA) (Håkansson and Snehota 1995), focusing on resource interaction in inter-organisational business networks (Håkansson and Waluszewski 2002). A key concept within INA is connectedness, which emphasises how individual business relationships are influenced by indirect connections and interdependencies within a business network (Araujo and Easton 1996). This means that initiatives involving a resource in one part of the network – such as the implementation of automation – can generate effects that extend beyond the focal relationship, influencing other resources across connected business relationships. Harrison et al. (2023, A10) emphasise that 'connectedness enables coordination and cooperation at the network level'.

Resource interaction is defined as '. . . the process of combination, re-combination, and co-development of resources that happen through the interaction among organizations' (Baraldi, Gressetvold, and Harrison 2012, 266). These interactions are influenced by the current set of resource interfaces (Håkansson and Waluszewski 2002). Resource interfaces refer to 'the contact points along which two specific resources interact or influence each other's technical, economic, and social features' (Baraldi, Gressetvold, and Harrison 2012, p. 267). Such interfaces are central to resource efficiency and the emergence of new resource combinations. Often, these combinations require resources to interface across organisational boundaries, involving multiple actors who influence those resources (Cantù, Corsaro, and Snehota 2012). This reflects resource heterogeneity – the idea that resources are inherently diverse and derive value from how they are combined with others (Penrose 1959).

In this study, packaging is conceptualised as a resource embedded within a network of connected resources, including automation, that interacts across firm boundaries.

Automation initiatives are implemented through business relationships (e.g. between automation suppliers and customers) and often lead to changes that extend beyond these business relationships. Each initiative alters the current set of resource interfaces and influences how packaging is perceived, evaluated, and developed by the involved business actors. The analysis therefore focuses on how connected automation initiatives unfold within retail distribution networks, and how they impact packaging requirements through changes in resource interfaces.

In line with this, the research is guided by the following research question: How does connectedness among automation initiatives impact packaging requirements in retail distribution networks?

Methodology

This research is based on a single case study approach with embedded subcases, which is well suited for examining resource interaction and connectedness in business networks. Such an approach enables in-depth exploration of how resource-related change initiatives unfold within and across business relationships (Holmen 2001). The case is bounded around packaging as a focal resource within a retail distribution network, and the unit of analysis is business relationships.

The study began with packaging as a focal resource, mapping resources with direct and indirect interfaces to it within business relationships between a producer, a logistics service provider, and a retailer. Although automation initiatives were not initially the focus of the study, they emerged through an abductive research process involving systematic movement between empirical material and theory (Dubois and Gadde 2002). Over time, automation initiatives were identified as a recurring theme influencing packaging requirements across these business relationships. Consequently, actors from different organisational levels and functions involved in adaptations of the focal resource (i.e. packaging), as well as those involved in resources related to the automation initiatives, were further scrutinised.

Data were collected continuously over a four-year period. The empirical material presented in this paper is drawn from a study focusing on packaging in retail distribution, conducted between early 2021 and October 2024. All interviews were recorded in video or audio format and conducted as semi-structured interviews with guiding themes. This format allowed interviewees to introduce unanticipated topics, and the study aimed to gain insights into their individual experiences and perspectives on a set of specific issues (DiCicco-Bloom and Crabtree 2006). All participants were informed about the purpose of the study, informed consent was obtained prior to each interview, and anonymity and confidentiality were assured. All firms included in the study are either directly or indirectly connected through business relationships, and each automation initiative is treated as an embedded subcase within the single case.

The study took place in the Swedish beauty sector and began with interviews with representatives from the Logistics Service Provider, the Retailer, and the Producer – all directly connected through business relationships. This sector was selected because it is characterised by high packaging intensity, omni-channel distribution, and increasing investments in automation, making it particularly suitable for studying interactions between automation and packaging. Additional interviewees were identified through

a snowball sampling approach (Biernacki and Waldorf 1981), in which initial participants recommended others with relevant insights. Although interviewees were not pre-selected, the snowball approach was guided by certain criteria: (1) all participants should be involved in retail distribution, (2) all participants should be directly or indirectly connected through business relationships, and (3) participants should either be experts in, or closely involved with, packaging in retail distribution.

The main source of data was interviews, supplemented by study visits and secondary material, including photos, videos, and firm documents. In total, 27 interviews (see Table 1) and four study visits (see Table 2) were conducted with representatives from the Logistics Service Provider, the Retailer, the Producer, two packaging suppliers of secondary packaging, one packaging supplier of primary packaging, and a packaging alliance organisation. The analytical focus throughout was on actors' perspectives on packaging and how packaging, as a focal resource, interacts with other resources through resource interfaces.

The analytical boundaries of the case were expanded as new connections and interdependencies emerged during the empirical work (Holmen 2001). The analysis proceeded through iterative cycles of coding, comparison, and abstraction, moving between empirical material and the analytical framework. This process enabled theoretical refinement while remaining grounded in empirical observations, and facilitated the identification of connected automation initiatives and their impact on packaging requirements that may have remained obscured in more traditional, firm-centric or dyadic case study designs.

The initial data analysis focused on mapping resources having direct and indirect interfaces with the focal resource – packaging – and tracing how changes in these interfaces unfolded across connected business relationships. This involved identifying how packaging interacted with other resources (e.g. warehouse and packing automation, sorting facilities, handling equipment) within business relationships, at different stages of the distribution process, and how actors evaluated these resource interfaces in terms of operational performance (e.g. throughput, damage risk, handling effort) and sustainability-related outcomes (e.g. material intensity, transport volume efficiency). The analysis progressively narrowed to three automation initiatives and their impact on packaging requirements, as these automation initiatives were repeatedly referred to as critical influences on packaging practices and constraints.

Interview material was then coded around packaging requirements, resource interfaces, and experienced constraints and opportunities. Automation-related statements were clustered and compared across organisations (e.g. tipping and sorting constraints, single-item unpacking, storage, and picking logics, packing standardisation and format lock-in). This systemic cross-actor comparison enabled the analysis of three connected automation initiatives and how they generated alignments and misalignments in packaging requirements across business relationships.

Case description

The case illustrates three connected automation initiatives that impact packaging requirements in a retail distribution network – the Logistics Service Provider's extension of automation in unloading (Automation initiative 1), the Retailer's adoption of warehouse automation (Automation initiative 2), and the Producer's introduction of automation in

Table 1. List of interviews.

Firm	Position of participant	Main themes discussed	Date/ Duration
The Logistics Service Provider	Head of Security and Claims	Packaging safety and claims	Q1 2021/ 2 h
	Project Manager and Process Manager	Work environment issues	Q1 2021/ 2 h
	Key Account Manager	Last-mile delivery options and service points	Q2 2021/ 1.5 h
	Packaging Consultant	Reasons for claims and packing procedures	Q2 2021/ 1.5 h
	Production Manager	Parcel deliveries and distribution terminal	Q4 2021/ 1 h
	Category Manager	Purchasing of packaging	Q1 2022/ 1.5 h
The Retailer	Operation Excellence Manager	Operations in central warehouse and packaging	Q3 2023/ 1.5 h
	Head of Production	Own production units	Q3 2023/ 1.5 h
	Sustainability Manager	Sustainable packaging	Q4 2023/ 1 h
	Quality Manager and Production Manager	Production and packaging	Q4 2023/ 0.5 h
	Project Manager Logistics	Implementation of automation in central warehouse	Q1 2024/ 1.5 h
	Operation Excellence Manager	Logistics in central warehouse	Q2 2024/ 2.5 h
	Head of Supply Chain & Logistics	Sustainability and logistics development	Q2 2024/ 1 h
	External Logistics Lead	Transport purchasing and supplier relationships	Q2 2024/ 1 h
The Producer	Supply Chain Manager	Outbound packaging solutions	Q4 2023/ 1 h
	Director of Operations	Operations management	Q4 2023/ 1.5 h
	Logistics Manager	Inbound and outbound logistics processes	Q1 2024/ 1 h
	Supply Chain Manager and Director of Operations	Production processes	Q2 2024/ 2 h
	Technical Process Manager	Implementation of packing automation	Q2 2024/ 0.5 h
	Purchaser	Design of product packaging	Q2 2024/ 0.5 h
	Key Account Manager	Packaging design for private label customers	Q2 2024/ 1 h
	Supply Chain Purchaser	Supplier relationships	Q2 2024/ 2 h
Packaging Supplier 1	Sales	Customer relationships, focus on the Retailer	Q4 2023/ 1.5 h
	Responsible for automation and packaging development	Automation and packaging development at the Retailer	Q4 2023/ 1.5 h
Packaging Supplier 2	CEO	Business relationships with supplier and customers	Q4 2023/ 0.5 h
Packaging Supplier 3	Export Area Manager	Development and production of product packaging	Q2 2024/ 1 h
Packaging Alliance	CEO	Coordinating purchasing from packaging suppliers	Q3 2024/ 1 h

packing (Automation initiative 3) – as they unfold within and across business relationships. The study shows how the implementation of automation in different parts of a retail distribution network affects packaging requirements across firms, influencing actors' perspectives on what constitutes effective, efficient, and sustainable packaging.

Table 2. List of study visits.

Firm	Position of participant	Main themes of study visit	Date/ Duration
The Logistics Service Provider	Production Manager	Logistics of parcel deliveries	Q4 2021/2 h
The Retailer	Quality Manager	Production processes	Q4 2023/2 h
	Operation Excellence Manager	Logistics in central warehouse	Q2 2024/7 h
The Producer	Supply Chain Manager and Director of Operations	Production processes	Q2 2024/3 h

The Logistics service provider's extension of unloading automation – automation initiative 1

The growth of e-commerce increased the number of packages handled by the Logistics Service Provider (henceforth referred to as the LSP), creating pressure to expand automation for operational efficiency. Another driving force behind the extended automation was the inspections by the Work Environment Authority, which had been mandated to review working conditions in the e-commerce sector. By reviewing operations and working methods, the LSP aimed to reduce the frequency and intensity of the physical workload required of terminal workers through extending unloading automation, thereby enhancing workplace safety. As stated by the Project Manager at the LSP, 'from a work environment perspective, our goal is to handle more goods that can be tipped [onto the sorting equipment's conveyor belts], reducing the need for manual handling by terminal workers.' Figure 1 illustrates the key business actors and business relationships directly connected to Automation initiative 1, including automation suppliers and business customers, such as the Retailer and the Producer.

The implementation of automation

The automated sorting equipment at the terminals includes singulation mechanisms to organise packages into a single file, followed by sorting carousels that direct them to appropriate destinations. The terminals handle a diverse range of packaging, such as individual packages stacked in cages and palletised items. While manual unloading is common for the palletised items, packages arriving in cages are tipped automatically onto the sorting equipment's conveyor belts. Although different package types require various

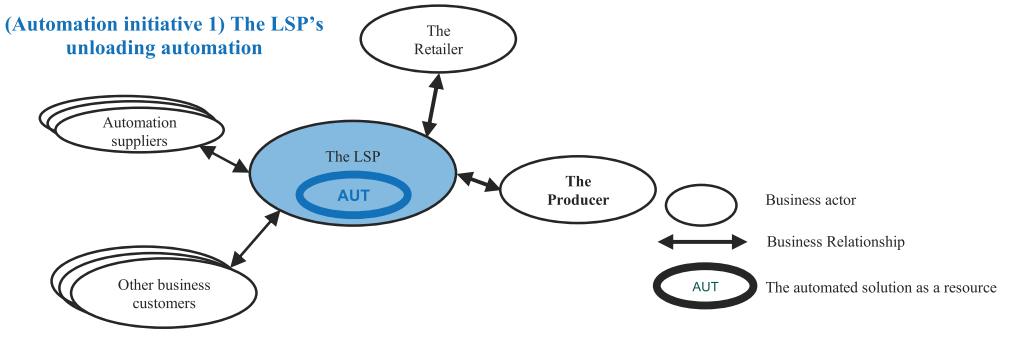

Figure 1. Key business actors and business relationships directly connected to automation initiative 1.

handling techniques, the priority is operational speed over differentiated handling. It was suggested that increasing the use of loose-loaded packages in cages, which are tipped onto conveyor belts, would improve efficiency and working conditions in the LSP's terminal operations.

The impact on packaging requirements

The LSP's decision to extend the use of automated tipping from cages directly impacted packaging requirements in its business relationships with customers. The Retailer, which prepares loose-loaded packages in cages, noted through its Operation Excellence Manager that the automated unloading process involves drops and impacts during tipping and therefore requires additional protective packaging. The LSP's Project Manager likewise noted that increased automation may necessitate stricter packaging requirements for customers and that this poses a challenge, as overly strict instructions could be difficult for customers to follow, potentially leading to a loss of business for the LSP. This difficulty is in line with the Packaging Consultant's observation that customers who have invested in packing automation are often reluctant to adjust their processes in response to the LSP's shifting requirements. This reluctance may be reinforced by other automation initiatives – such as those made by both the Retailer and the Producer – which will be discussed later in this chapter.

As a result, tensions emerged between the LSP and its customers (e.g. retailers), as more protective packaging was needed to prevent product damage. This led to increased packaging costs and operational complexity for the LSP's customers, such as the Retailer and the Producer.

The retailer's adoption of warehouse automation – automation initiative 2

The Retailer had its main business online, but it also served its own physical stores and the physical stores of business customers. As the Retailer's business grew, the number of orders rapidly increased. The company aimed to handle 100,000 order lines per day, which proved unachievable without warehouse automation due to the limitations of manual picking and packing. To manage the growing order volumes, the Retailer adopted warehouse automation with single-storage, single-picking, and e-commerce packing (i.e. packing online orders into cardboard boxes). To streamline operations in line with the adopted automation, the Retailer aimed to adapt to single-packed products in both outbound and inbound operations. As stated by the Operation Excellence Manager, 'I believe that the more warehouse automation is developed for e-commerce distribution, the more we recognise that this [i.e. single-packed products] is a more efficient way of packing goods for this type of distribution.' The packaging adaptations affected the Retailer's own physical stores as well as its relationships with business customers operating physical stores, logistics service providers such as the LSP, product suppliers like the Producer, and other actors, including a packaging supplier and automation suppliers.

Figure 2 illustrates the key business actors and business relationships directly connected to Automation initiative 2, including automation suppliers, a packaging supplier, logistics service providers, such as the LSP, product suppliers (e.g. a major product supplier and the Producer), and business customers.

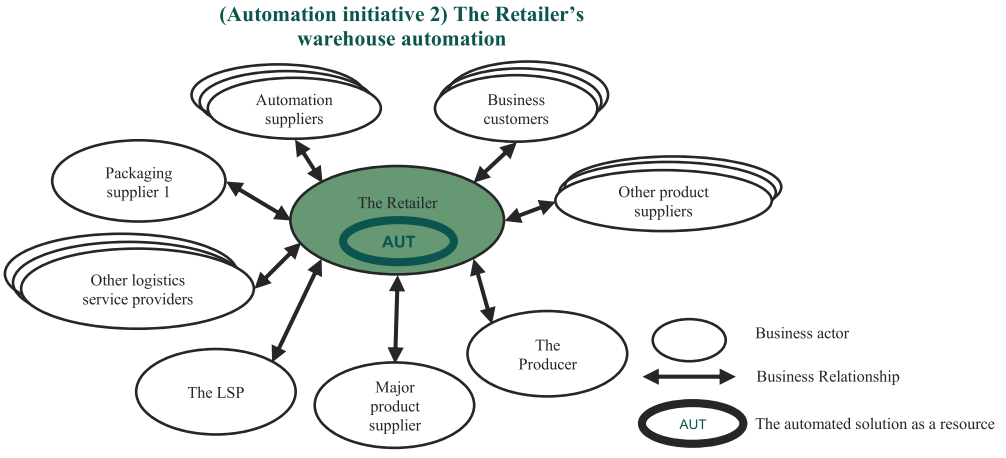

Figure 2. Key business actors and business relationships directly connected to automation initiative 2.

The implementation of automation

The change towards automation began with the implementation of an automated single-storage warehouse system, which included the picking of single products for individual orders. Shortly afterward, packing automation was also implemented, transitioning from 48 manual pack stations to a system where 80–90% of packing was automated. The impact was immediate, reducing the need for manual packing to only a few stations, increasing efficiency, and enabling the Retailer to keep pace with growing order volumes. As stated by the Responsible for automation and packaging development at Packaging Supplier 1, 'Previously, many e-commerce players experienced rapid growth, but without profitability. We want to support our customers in addressing this. One way is to create automation that adjusts the boxes [either cuts them down or adds creases] based on the content.'

The impact on packaging requirements in the retailer's outbound context

While automation improved efficiency in online operations, it created inefficiencies in other areas, such as distributing larger volumes to physical stores. These tensions became visible in the Retailer's business relationships with the Logistics Service Provider and business customers with physical stores. In agreement with its own stores, the Retailer began delivering products packed the same way as e-commerce orders – with a large number of products single-picked from the single-storage system, packed in larger cardboard boxes, and delivered as e-commerce packages by logistics service providers, such as the LSP. This shift involved moving away from store packaging, which is part of the traditional three-level packaging system, in favour of e-commerce packaging.

To standardise operations in its new automated warehouse, the Retailer attempted to convince business customers with physical stores of the benefits of e-commerce packaging and distribution. However, delivering heavier e-commerce packages containing multiple products through the LSP's automated unloading resulted in damaged products and customer dissatisfaction. As stated by the Operation Excellence Manager at the Retailer, 'Due to the LSP's 1.5-metre drops [when packages are tipped onto the sorting

equipment's conveyor belts], they couldn't handle the larger packages we use for B2B deliveries [packaging and products were damaged], so we had to switch to another provider that does not handle goods in the same way as the LSP.' Although the Retailer stopped sending products to business customers with physical stores through the LSP, products damaged in the LSP's terminals remained a key reason for customers rejecting e-commerce packaging. In response, the Retailer now offers dual packaging options, allowing business customers with physical stores to choose between store packaging and e-commerce packaging. This case illustrates how automation initiatives, such as the LSP's extended automation in unloading and the Retailer's adoption of warehouse automation, are connected, as both have interfaces with packaging.

The impact on packaging requirements in the retailer's inbound context

Products arrive at the Retailer's distribution centre on pallets, packed according to the three-level packaging system (i.e. product packages are packed into store packaging, which is then placed in additional transport packaging). To transfer the product packages from store and transport packaging into the single-storage warehouse, manual unpacking is necessary. This process is time-consuming and generates significant packaging waste. As stated by the inbound Team Leader at the Retailer during the study visit, 'This is currently the major bottleneck in our flow. In the long term, we are working with our suppliers to eliminate unnecessary packing material, but in the short term, we need to solve this internally.'

In efforts to reduce the labour-intensive unpacking, packaging waste, and to save transport costs, the Retailer approached its product suppliers with a request to receive products single-packed on pallets instead of the three-level packaging system. However, this turned out to be more challenging than expected. One of the Retailer's major product suppliers refused to change its standard (i.e. store) packaging, stating that exceptions could not be made for a single customer and that the requested packaging format would not align with the request from other customers.

Recently, the Retailer adjusted its newly acquired production facilities to enable single-packed products to be delivered between production sites and the central warehouse. With the lessons learned from these internal tests, the Retailer approached another product supplier (henceforth referred to as the Producer), whose production facilities were similar. By committing to two larger orders per year, the Producer agreed to single-pack products on pallets for made-to-order products. This change reduced the use of packaging material, increased the number of products per pallet, and improved efficiency both for the Retailer and the Producer. It also demonstrated how packaging adaptations became possible when commitments within business relationships were aligned.

The producer's introduction of packing automation – automation initiative 3

The Producer developed and produced both its own brand and private label products for business customers. Although the majority of its volume was sold through business customers, it also operated an online sales platform to offer products directly to consumers. To support rapid growth and market expansion, it prioritised operational efficiency and invested in packing automation to scale capacity, reduce manual labour, and improve internal efficiency while maintaining existing packaging formats. The

introduction of store packing automation (i.e. 6–12 pcs packed in a cardboard box) improved service to store customers. However, this also impacted its online packing strategies for consumers and its business relationship with the Retailer. Additionally, the initiative to implement packing automation involved business relationships with other business customers, as well as its packaging supplier, automation suppliers, and logistics service providers such as the LSP. Figure 3 illustrates the key business actors and business relationships directly connected to Automation initiative 3, including automation suppliers, a packaging supplier, business customers such as the Retailer, and logistics service providers such as the LSP.

The implementation of automation

Recently, the Producer invested in two automated packing machines to improve efficiency in its packing process. As stated by the Supply Chain Manager at the Producer, 'We are now investing in an overwrap machine to fill B-packs [i.e. store packaging] more efficiently in production, and to save "hands and feet"'. These machines integrate various steps that were previously carried out manually and support the three-level packaging system used in deliveries to most business customers. Additionally, automation allows multiple lines to run in parallel, increasing capacity without expanding the workforce, which is essential given the facility's space constraints and growth plans.

The impact on packaging requirements

Transitioning to fully automated packing involves phasing out all packaging materials used for manual packing, leaving no manual back-up if the machines are interrupted, since the cardboard boxes used in automated packing are glued in the packing process and cannot be packed manually.

The Producer's investment in automated packing marks a step towards reducing manual labour and improving efficiency. However, automation also eliminates packaging

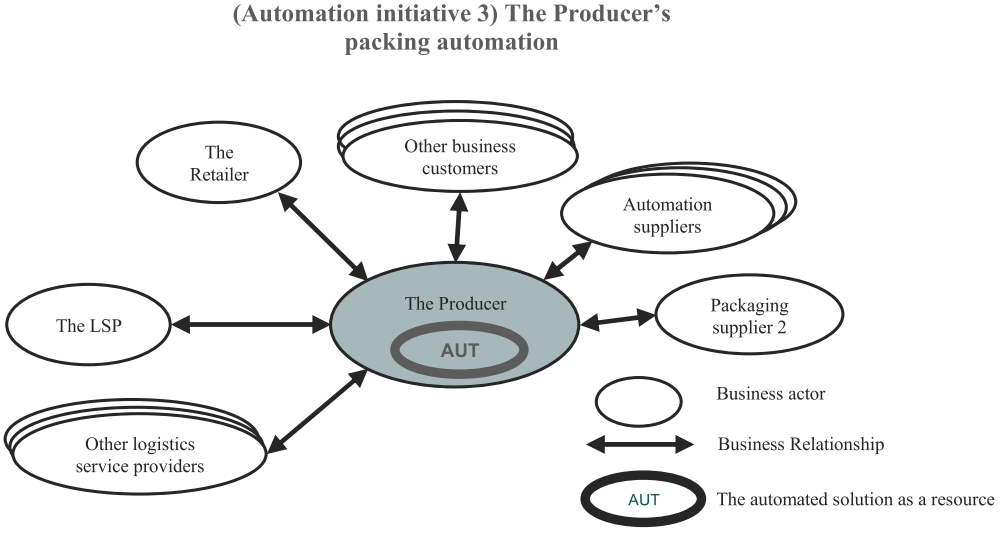

Figure 3. Key business actors and business relationships directly connected to automation initiative 3.

flexibility, reducing the willingness to accommodate customer-specific packaging requests, such as single products on pallets prepared for the Retailer.

This automation initiative illustrates the impact of automation on the Producer's packaging practices – both for deliveries to the Retailer and for products prepared for its own online sales, which are partly delivered by the LSP. These operations now have to relate to the new capabilities and constraints introduced by automation. In this context, automation acts as a catalyst for change in the retail distribution network, creating both immediate and future challenges and opportunities for packaging practices.

Case analysis

The three automation initiatives – the LSP's extension of unloading automation, the Retailer's adoption of warehouse automation, and the Producer's introduction of packing automation – each have direct interfaces with packaging in the retail distribution network and are interconnected through business relationships. Figure 4 illustrates these connected automation initiatives, their resource interfaces with packaging, and the key business actors and business relationships that are directly and indirectly connected to the automation initiatives.

Each initiative both influences, and is influenced by, the others – enhancing local operational efficiencies while simultaneously introducing tensions between business actors by producing diverging packaging requirements across business relationships.

The LSP's extension of unloading automation (Automation initiative 1) was introduced to enhance the speed of handling packages and workplace safety. However, automated tipping required more robust packaging to withstand mechanical handling. This stabilised the interface between packaging and sorting equipment, but simultaneously placed stricter requirements on the packaging provided by upstream actors like the Retailer and the Producer. As a result, additional protective packaging was introduced, leading to increased material use, excessive air inside the e-commerce packages, and increased packaging waste – outcomes that counteracted both sustainability and efficiency ambitions in the retail distribution network.

These requirements were closely connected to the Retailer's adoption of warehouse automation (Automation initiative 2), which involved automated single-picking and standardised e-commerce packing. Once these solutions were implemented, the flexibility to adjust packaging formats was reduced, as packaging became tightly coupled to the logic of the automated warehouse system. Although the LSP's current requirements were considered, the Retailer's ability and willingness to adapt packaging further was constrained by significant investments and format standardisation embedded in warehouse automation.

Similarly, the LSP's packaging requirements affected the Producer's operations. The Producer's introduction of packing automation (Automation initiative 3) was primarily designed for traditional store packaging. This investment 'locked in' specific packaging formats, reducing the Producer's capacity to accommodate alternative formats. As a result, the Producer's automated packing solution did not align easily with the Retailer's request for single-packed products suitable for e-commerce distribution. Adjusting to these requirements would be operationally burdensome and financially inefficient for the Producer, given its new automation set-up. These constraints limited

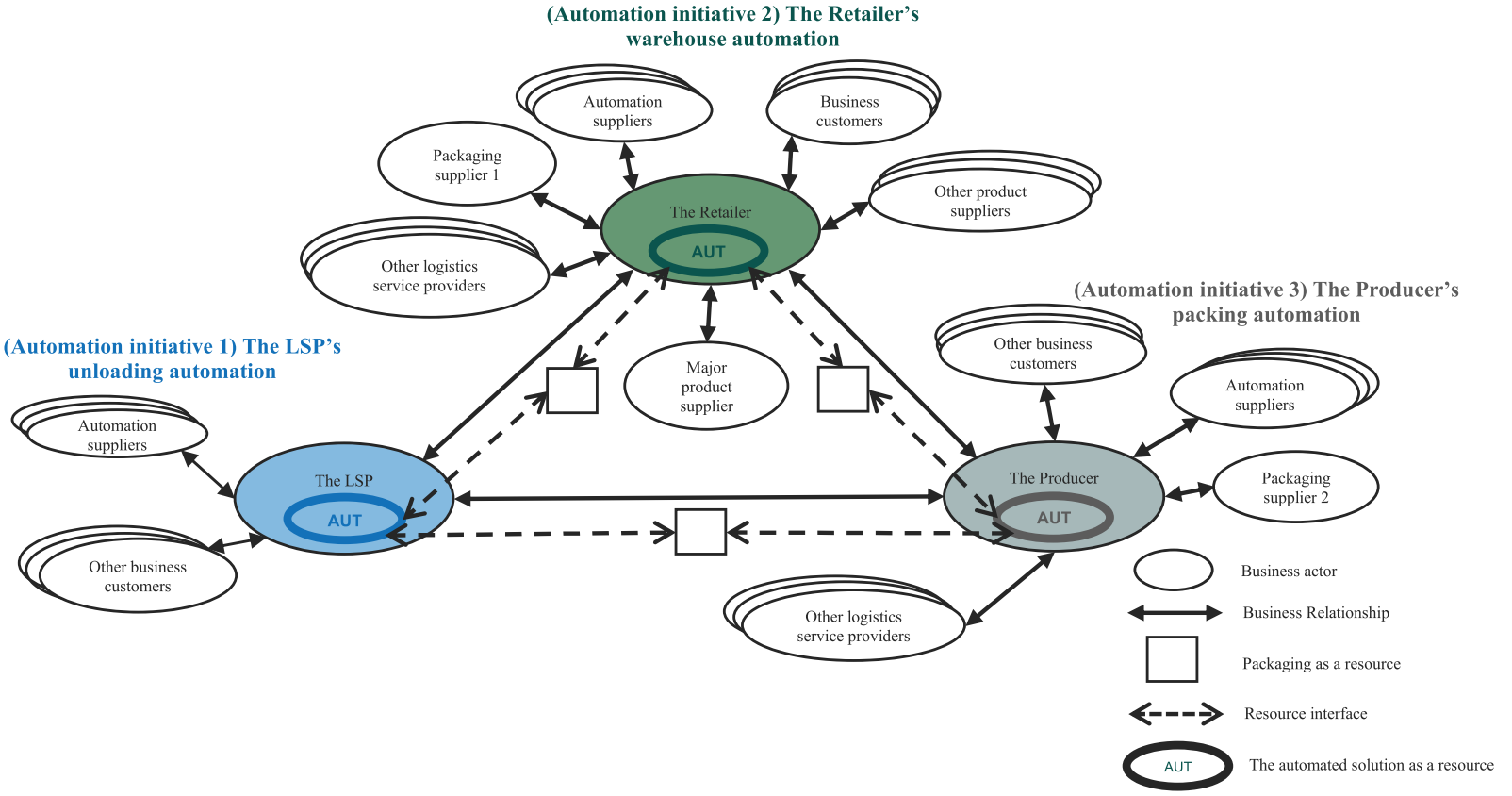

Figure 4. Connected automation initiatives in a retail distribution network, their resource interfaces with packaging, and the key business actors and business relationships directly and indirectly connected to the automation initiatives.

the Producer's flexibility and willingness to pursue packaging adaptations within its business relationship with the Retailer, even when such adaptations could have reduced packaging material and waste and improved the efficiency in the Retailer's inbound operations.

Collectively, the three automation initiatives illustrate how changes motivated by efficiency and improved working conditions within individual firms can reconfigure resource interfaces in ways that impact what packaging solutions business actors consider feasible, acceptable, efficient, and sustainable across the retail distribution network. Developing efficient and sustainable packaging thus emerges as a collective and relational challenge, requiring recognition and management of interdependencies among automation initiatives, resource interfaces, and business relationships.

Conclusions

By analysing three connected automation initiatives across a retail distribution network, the study shows that automation cannot be understood as a series of isolated firm-level investments, but as interdependent change initiatives with cross-firm consequences for packaging.

Automation initiatives in one part of the retail distribution network – such as extended automated unloading and the introduction of packing automation – influence, through business relationships, how packaging is perceived, used, and developed elsewhere. This connectedness produces both alignments and misalignments in packaging requirements, creating challenges and opportunities depending on how well automation initiatives are aligned with packaging development across the retail distribution network. When automation initiatives are poorly coordinated, they risk driving excess packaging use, operational inefficiencies, and misalignments between business actors, rather than system-wide improvements.

The study underscores the importance of recognising how automation interfaces with packaging, and other resources, across firm boundaries. The analysis shows how sustainability-related packaging outcomes emerge as a consequence of connected automation initiatives, and that what counts as 'sustainable' packaging depends on actors' positions within the retail distribution network and the resource interfaces they prioritise. Achieving sustainable and efficient packaging therefore emerges as a relational challenge, requiring coordinated adaptation, mutual understanding, and alignment among multiple actors and their automation initiatives. Such adaptations are rarely straightforward, as they involve balancing diverse perspectives on efficiency, operational needs, and sustainability goals.

Theoretical implications

The study contributes theoretically by framing automation not as an isolated technological shift, but as a network-embedded, resource-affecting change initiative. This perspective enriches existing research on automation in retail distribution (Kembro and Norrman 2020; Nitsche, Straube, and Wirth 2021) by deepening the understanding of how multiple automation initiatives become connected across firms and how this connectedness influences the requirements of interfacing resources, such as packaging.

The findings underscore the significance of connected business relationships, demonstrating that automation initiatives influence not only implementing firms (e.g. automation and packaging suppliers), but also reconfigure resource interfaces across a retail distribution network. This supports Harrison et al. (2023), and extends their argument by showing how connectedness operates through resource interfaces that influence operational and sustainability-related outcomes.

The study also advances research on packaging-logistics interaction (Hellström and Saghir 2007; Jahre et al. 2006; Pålsson 2018) by demonstrating how connected automation initiatives stabilise or destabilise packaging-automation interfaces across firm boundaries. In doing so, the study extends discussions of coupling and decoupling systems (Orton and Weick 1990; Weick 1976) by showing how these dynamics unfold across multiple, interconnected automation initiatives. Automation initiatives in retail distribution often tighten coupling by stabilising resource interfaces. Packaging standardisation can, in turn, act as a decoupling mechanism at the network level by reducing variation between actors and facilitating coordination across diverse distribution contexts.

Finally, the findings demonstrate that automation does not inherently promote or hinder sustainability. Its effects depend on how automation initiatives are connected, which resource interfaces are prioritised, and how actors interact around interdependent resources. Efficiency gains achieved through automation can conflict with material reduction and packaging standardisation goals, particularly when packaging must be adapted to meet the demands of several business actors' automation initiatives.

Practical implications

By analysing connected automation initiatives and their impact on packaging requirements, the study offers practical insights for managers. As firms implement automation to enhance operational efficiency, it becomes essential to understand how these decisions influence packaging requirements beyond the boundaries of the implementing firm.

Automation impacts packaging in multiple ways. For example, extended automation in unloading may require more protective and standardised packaging, while warehouse automation designed for single-storage, picking, and e-commerce packing may encourage a transition from traditional three-level packaging towards single-packed products in both inbound and outbound operations. These automation initiatives require managers to reconsider what constitutes efficient and sustainable packaging – and, conversely, what constitutes efficient and sustainable automation.

The findings also highlight the challenges managers face in understanding and managing connected automation initiatives in retail distribution networks. Decisions to automate warehouse and packing operations may affect customers, product suppliers, and logistics service providers, prompting adjustments in both packaging and logistics operations. Managers are therefore encouraged to identify which actors are affected, how resource interfaces are altered, and to incorporate these interdependencies into planning and decision-making. As (Håkansson and Ford 2002) emphasise, managing interaction in business relationships involves not only influencing others but also adapting to others' investments and constraints.

Lastly, the study points to the importance of anticipating the longer-term implications of automation initiatives. For example, investments in packing automation may reduce a firm's

ability to accommodate customer-specific packaging, potentially straining business relationships. Designing automation with flexibility in mind, or explicitly negotiating packaging constraints early with partners, may help mitigate such tensions and support continued alignment between efficiency and sustainability across the retail distribution network.

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ORCID

Sandra Brüel Grönberg http://orcid.org/0000-0002-2988-9590

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