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Paradoxical tensions impacting small-series production implementation in high-cost contexts: insights from the EU apparel industry

Sara Harper
Department of Business Administration and Textile Management, University of Borås, Borås, Sweden

Abstract

Purpose – While localized small-series production is a significant opportunity, various tensions challenge implementation in high-cost contexts. This paper explores how managers view and respond to different tensions in small-series production implementation by adopting a paradox-based perspective.

Design/methodology/approach – The paper presents a multiple case study addressing small-series production within EU's apparel industry, as key context to address managerial awareness, and responses to tensions regarding location and supply network configuration decisions. Seven cases were selected for variation in customization and implementation (early/established), ownership, location and company size, to identity commonalities.

Findings – The study highlights performing tensions related to sustainability, and risk, in addition to confirming traditional goal-related tensions predominantly impacting small volume production. With on-demand/custom production, tensions include costs in conflict with process scale, and several process-related tensions (flexibility, expansion/development, risk management). Identified multidimensional responses do not include location or structural decisions, instead focusing on synthesis, through product-operations efficiency, knowledge development and process innovation and supply chain collaboration. Temporal separation is found with customization, including reducing product/process complexity short-term with enhancing process development, which suggests latent learning tensions and limited awareness.

Research limitations/implications – Future research should address the extent to which tensions can be resolved or remain paradoxical, as well as dynamic decision-making and latent tensions.

Originality/value – The paper shows how paradox theory facilitates a deeper understanding of complex network configuration decisions, including reshoring/localization. The findings identify organizing tensions/elements and elaborate upon performing/performing-organizing tensions suggested with small-series production, location decisions and supply chain management.

Keywords Supply network configuration, Supply chain design, Paradox theory, Customization, Textile and apparel industry

Paper type Research paper

1. Introduction

In recent years, offshoring challenges and global supply chain disruptions are driving increasing focus on competitive manufacturing in high-cost contexts (e.g. de Treville *et al.*, 2017;

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Mirzaei *et al.*, 2021), and reshoring (e.g. Gray *et al.*, 2017; Kinkel and Maloca, 2009; Tate *et al.*, 2014). While motivations for reshoring have been well-studied (cf. Barbieri *et al.*, 2018; Wiesmann *et al.*, 2017), research is relatively sparse regarding decision-making and implementation (Barbieri *et al.*, 2018; Benstead *et al.*, 2017; Boffelli and Johansson, 2020; Gray *et al.*, 2017) and challenges or barriers (Moradlou *et al.*, 2021). Location decision-making processes are complex with numerous factors that must be considered and balanced (Tate *et al.*, 2014), including tensions and paradoxes that are challenging on both manufacturing and supply chain levels (Mirzaei *et al.*, 2021). Such location decisions should be considered together with other configuration decisions within high-cost locations (Van Hoek and Dobrzykowski, 2021), including supply chain co-location (Ketokivi *et al.*, 2017; Lica *et al.*, 2020; Sirilertsuwan *et al.*, 2019). While literature reviews have broadly characterized reshoring, several authors stress the need to consider the impact of various contingency factors. These include industry and company size (Bals *et al.*, 2016; Benstead *et al.*, 2017; Moore *et al.*, 2018; Moradlou *et al.*, 2021), and crucially, product level characteristics (Ketokivi *et al.*, 2017) such as market segment, price point, small volume production and customization (Benstead *et al.*, 2017; Kinkel and Maloca, 2009; Martínez-Mora and Merino, 2014; Moore *et al.*, 2018).

Small-series production models that are defined by customization and product-process complexity motivate, and are facilitated by, supply chain co-location and reshoring (Fratocchi and Di Stefano, 2019; Lica *et al.*, 2020; Pal *et al.*, 2018) because of high levels of dyadic interdependence (Ketokivi *et al.*, 2017). Consequently, reshoring is more likely with competition based on responsiveness (Gray *et al.*, 2017), as local sourcing offers benefits *"if the sought-after advantages are linked to customization, lead-times and flexibility"* (Hilletofth *et al.*, 2019, p. 5) within the customer/market interface. While customization is an important contingency factor impacting high-cost location decisions (Benstead *et al.*, 2017; Moore *et al.*, 2018), limited research has captured how higher customization levels shape decision-making and implementation processes. When addressing such product-level contingencies together with reshoring drivers, Moore *et al.* (2018) found no clear relationships with customization. While the authors attributed this finding to limited variability in the data, another likely explanation is the complex interactions suggested in other studies, which include tensions, or paradoxes, among various priorities including customization (Pal *et al.*, 2018) and small volume production (Mirzaei *et al.*, 2021). Moreover, various tensions have been indicated in literature regarding product/process enablers for customization with complex synergistic and cancellation effects (Salvador *et al.*, 2015), and the need to balance customization levels, production ownership and levels of data transparency (Culot *et al.*, 2020). Whereas the impact of customization on such supply chain design decisions are less understood compared to time and flexibility-related motivations for reshoring (e.g. Gray *et al.*, 2017; Kinkel and Maloca, 2009; Moradlou *et al.*, 2021), literature suggests several tensions and challenges relevant to location and supply chain decision-making and implementation.

To study supply chain design for small-series production (e.g. Macchion and Fornasiero, 2020; Macchion *et al.*, 2017; Suzić *et al.*, 2018), holistic, context-specific research is required (Suzić *et al.*, 2018). Such research must extend the focus beyond (re)location decisions for final assembly (like studied by Ketokivi *et al.* (2017)), to capture co-location (Lica *et al.*, 2020; Sirilertsuwan *et al.*, 2019) throughout supply networks (Barbieri *et al.*, 2018; Van Hoek and Dobrzykowski, 2021). This holistic perspective can be enabled by adopting the supply network configuration (SNC) framework (Srai and Gregory, 2008), which encompasses interdependent network structure, product, operations and relationship design decisions. According to both research (Culot *et al.*, 2020; Fratocchi and Di Stefano, 2019; Pal *et al.*, 2018; Van Hoek and Dobrzykowski, 2021), and practice (Andersson *et al.*, 2018), the apparel industry is a relevant context in which to address tensions regarding location decisions and small-series production.

Considering the above discussion, the impact of small-series production (including higher levels of customization) on SNC decisions and implementation should be addressed to capture associated complex tensions and challenges. Research should address how managers identify and respond to these tensions, including paradoxes defined by elements that are *"contradictory yet interrelated (. . .) and persist over time"* (Smith and Lewis, 2011, p. 382). Literature suggests, awareness and management of such paradoxes, 'paradoxical sensemaking' (Schad *et al.*, 2016; Xiao *et al.*, 2019), enables practitioner understanding of complex decision-making processes. While previous research has identified paradoxes in similar contexts (Sandberg, 2017; Zehendner *et al.*, 2021; Zhang *et al.*, 2021), the managerial perspective on decision-making and implementation is missing regarding location and configuration for small-series production. Paradox theory can support comprehensive identification of the tensions and paradoxes relevant to the managers within this production context; here with focus on the SNC level (Srai and Gregory, 2008). Thus, the aim of the paper is *to explore managerial awareness and responses to tensions (paradoxes) impacting small-series production in high-cost locations*, which is addressed through the question:

RQ. How do managers view and manage tensions in small-series production decision-making and implementation within high-cost contexts?

The remainder of the paper is organized as follows; Section 2 discusses the theoretical background that provides a foundation for exploring small-series production tensions and response strategies. Thereafter, Section 3 details the multiple case study methods. Section 4 presents the cross-case analysis results. These findings are discussed in Section 5; finally, conclusions and implications are presented in Section 6 with orientations for future research.

2. Theoretical background: a paradox-based view of small-series production

2.1 Network configuration in high-cost contexts

The supply network should be considered together with location and reshoring decisions (Barbieri *et al.*, 2018; Srai *et al.*, 2020; Van Hoek and Dobrzykowski, 2021), as research suggests it is central to understanding various issues in operations and supply chain management (Choi and Krause, 2006; Srai and Gregory, 2008). SNC encompasses the internal and external partners within an integrated network, which is defined by four component elements (Srai and Gregory, 2008): (1) value structure, or *products*; (2) *operations* or process flows; (3) network *structures* and (4) *relationships*, both inter- and intra-organizational. These elements are driven by priorities, that is desired outcomes (Melnyk *et al.*, 2014). In high-cost contexts, these priorities include responsiveness, for example time, flexibility and customization (de Treville *et al.*, 2017; Gray *et al.*, 2017; Hilletofth *et al.*, 2019; Kinkel and Maloca, 2009; Mirzaei *et al.*, 2021; Moradlou *et al.*, 2021). Studies show supply chain proximity is linked to customization, high variety or small-series production and product complexity (e.g. Lica *et al.*, 2020; Macchion *et al.*, 2015; Martínez-Mora and Merino, 2014; Pal *et al.*, 2018; Sirilertsuwan *et al.*, 2019). Although alignment among product-process characteristics and priorities and location decisions is stressed (Hilletofth *et al.*, 2019), due to dyadic interdependence (Ketokivi *et al.*, 2017) and required responsiveness (Fisher, 1997), additional research is required to understand how higher levels of customization act as a contingency factor impacting location decisions (Benstead *et al.*, 2017; Moore *et al.*, 2018). Thus, to understand the impact of increasingly small production volumes on decision-making and implementation in high-cost contexts (Mirzaei *et al.*, 2021; Pal *et al.*, 2018), broader SNCs should be addressed to illuminate the organizational levels on which crucial tensions emerge. The main tensions suggested in the literature are related to conflicting priorities with high-cost location decisions (e.g. structural), and complexity balancing product-, operations- and relationship-enablers with customization.

Literature addressing location decisions (e.g. Boffelli and Johansson, 2020; Hilletofth *et al.*, 2019), highlight complex considerations including trade-offs and tensions related to conflicting goals and/or processes in high-cost contexts (Pal *et al.*, 2018; Mirzaei *et al.*, 2021; Sirilertsuwan *et al.*, 2019; Van Hoek and Dobrzykowski, 2021). For instance, conflicting priorities, for example lead time and cost, can both drive (Macchion and Fornasiero, 2020; Sandberg, 2017) and challenge (or constrain) local, small-series production (Mirzaei *et al.*, 2021; Pal *et al.*, 2018). While proximity sourcing and manufacturing is shown to be associated with product complexity and customization (e.g. Grandinetti and Tabacco, 2015; Hilletofth *et al.*, 2019; Lica *et al.*, 2020), further research is required to understand the implications of customization on supply chain design (Macchion and Fornasiero, 2020; Macchion *et al.*, 2017; Suzić *et al.*, 2018), including network configuration. Despite the need for alignment between product level contingencies including market segment, price point, small volume production and customization (Benstead *et al.*, 2017; Kinkel and Maloca, 2009; Martínez-Mora and Merino, 2014; Moore *et al.*, 2018) and supply chain design (Fisher, 1997), conflicting results indicate the need for context-specific studies (Pashaei and Olhager, 2015). Although lower customization levels have been more common in apparel (Senanayake and Little, 2010), rapid technological development is both reducing cost trade-offs (tensions) regarding localization (Andersson *et al.*, 2018), and is likely to intensify tensions, together with increasing environmental volatility (Smith and Lewis, 2011). Thus, while research indicates tensions regarding location decisions including conflicts related to customization, other supply chain design and network structure dimensions have not been sufficiently addressed in relation to small-series production, for example upstream/downstream complexity, flexibility, tier structure and co-location beyond the final assembly stage.

Regarding small-series production and high levels of customization, beyond tensions related to (re)location decisions, literature suggests several tensions due to the need to balance various interdependent enablers or antecedents. For instance, both complementary and cancellation effects have been indicated among product-process-supply chain enablers for mass customization (Salvador *et al.*, 2015). Specifically, the combined benefits from three antecedents: (1) customer integration, (2) flexible manufacturing resources, for example employees, machines, modular products, processes, suppliers and (3) digital technology, for example configurators, data management systems, business intelligence applications, are not found when one is at a high level. However, if one resource is at a low level, the study shows the other two are complementary. Thus, manufacturers must carefully balance levels of flexible resources (including suppliers), customer closeness and digital technologies to minimize complexity. Regarding apparel and footwear, enablers/barriers to local manufacturing include supplier competence and minimum order sizes (Martínez-Mora and Merino, 2014; Pal *et al.*, 2018; Sirilertsuwan *et al.*, 2019). Additional tensions and trade-offs are closely related to new technology developments, due to the need to balance customization levels, ownership and data transparency in accordance with industry, technology and product characteristics (Culot *et al.*, 2020). For instance, opportunities related to increasingly customized apparel production and high margin products, are challenged by technology limitations.

Thus, literature has suggested various tensions and challenges on different SNC levels, which can benefit from adoption of a paradox perspective.

2.2 Tensions and paradoxes in small-series production

As discussed, extant literature suggests several tensions that can impact small-series production location and configuration decisions. While SNC supports identification of the levels on which tensions emerge, adopting a paradox-based perspective enables categorization of such tensions, and identification of associated paradoxes, which are defined by *"contradictory yet interrelated elements that exist simultaneously and persist over*

time" (Smith and Lewis, 2011, p. 382). Due to the fast rate of changes and increased levels of complexity in the business environment, paradoxes are expected to intensify (Schad *et al.*, 2016; Smith and Lewis, 2011). Paradox theory offers a fruitful perspective to apply in this domain, as it enables comprehensive analysis of complex tensions relevant to companies and supply chains (Sandberg, 2017; Zehendner *et al.*, 2021; Zhang *et al.*, 2021). This perspective enables researchers in supply chain management to investigate the *"not-so-frequently explored territories beyond trade-offs"* (Zhang *et al.*, 2021, p. 12), for deeper understanding of complex topics like small-series production decision-making and implementation. Nonetheless, paradox-based research is still emerging regarding supply chain management topics (Sandberg, 2017; Zhang *et al.*, 2021), and managerial responses. However, various studies suggest benefits resulting from 'paradoxical sensemaking', that is awareness and management of paradoxical tensions, include improved innovation, creativity (Schad *et al.*, 2016) and sustainability (Xiao *et al.*, 2019). Thus, research should address the extent to which tensions (paradoxes) emerge as salient to the researcher or practitioners (Jay, 2013; Schad *et al.*, 2016). In this paper, paradox theory supports exploration of tensions impacting small-series production models, to determine the extent to which tensions are viewed as paradoxes, and to identify management responses.

Whereas several tensions are highlighted among the key challenges to competitiveness in high-cost locations (e.g. Mirzaei *et al.*, 2021; Pal *et al.*, 2018), and suggested within complex implementation considerations for customization (e.g. Salvador *et al.*, 2015), these issues can benefit from adoption of a paradox lens. Previous research has often framed these issues as dilemmas or trade-offs, which can limit understanding of the complexity regarding these considerations. For instance, such tensions can be paradoxical in the long run, as choices or responses may provide only temporary benefits (Smith and Lewis, 2011). Moreover, paradoxes are distinguishable from dilemmas like make/buy decisions, wherein each choice has different advantages and disadvantages, as benefits are gained from adopting 'both/and' management responses to perceived contradictions (Lewis and Smith, 2014). *Management responses* to deal with tensions form cycles of cognition and action, which begin with awareness of contractions (e.g. Smith and Lewis, 2011; Schad *et al.*, 2016; Zehendner *et al.*, 2021). Responses include both individual and collective activities (Schad *et al.*, 2016) that can focus on acceptance of tensions or resolution through (temporal/spatial) separation or synthesis (Poole and Van de Ven, 1989). While knowledge specifically related to paradox responses is limited, recent contributions regarding sustainability paradoxes/tensions identify contextualization strategies (Xiao *et al.*, 2019), taking into consideration the larger context to make addressing learning/performing tensions more feasible (Zehendner *et al.*, 2021).

As organizations frequently face multiple interrelated tensions (or paradoxes), researchers have stressed the need to capture systemic interactions (Jarzabkowski *et al.*, 2013; Schad *et al.*, 2016; Schad and Bansal, 2018; Smith and Lewis, 2011). The definitions provided by Smith and Lewis (2011) enable holistic analysis of tensions related to the four main organizational activities or elements: (1) *learning*, regarding knowledge; (2) *belonging*, regarding identity in interpersonal or supply chain relationships; (3) *organizing*, regarding conflicting processes and (4) *performing*, regarding conflicting goals or desired outcomes, and tensions existing between these types. With respect to small-series production, the key tensions suggested are related to *performing* and *organizing* elements (particularly regarding mass customization and high-cost locations). While studies regarding small-series production have indicated various tensions or paradoxes, for example balancing priorities, processes and costs (Duray *et al.*, 2000; Suzić *et al.*, 2018), within high-cost contexts (Mirzaei *et al.*, 2021; Pal *et al.*, 2018), research addressing paradoxes in supply chain management is better established. Specifically, *performing* and *organizing* paradox elements, are found to be well-represented in a recent systematic literature review (Zhang *et al.*, 2021). Learning tension

elements were least represented; however, researchers have stressed that these tensions can be difficult to observe in isolation (Jarzabkowski *et al.*, 2013), as they underpin other paradoxes (Smith and Lewis, 2011). This provides further motivation for a systemic perspective to understand tensions (and responses), regarding small-series production and SNC decision-making.

Performing-organizing tensions impacting small-series production include a key paradox defining mass customization, balancing costs with flexible manufacturing processes for unique (custom) products (Duray *et al.*, 2000), which has been highlighted as challenging in high-cost contexts (Mirzaei *et al.*, 2021; Pal *et al.*, 2018). This research suggests that mass customization is a crucial *management response*, which enables resolution of such conflicts (Duray *et al.*, 2000) through adoption of enablers such as digital technology, flexible manufacturing systems and product modularity (Suzić *et al.*, 2018). However, technology and efficiency improvement costs within high-cost contexts present additional challenges including labour/knowledge-intensity trade-offs for small batch production, and tensions between current and future competitive priorities (Mirzaei *et al.*, 2021), which suggests *learning* tensions underpin such goal-process tensions.

Various *performing* tensions are associated with small-series production, as several authors define mass customization as the ability to offer customization without trade-offs between cost, quality, delivery and flexibility performance goals (e.g. Suzić *et al.*, 2018). This highlights conflicting goals that can emerge from different stakeholder priorities, and the plurality of views in the network (Smith and Lewis, 2011), as different stakeholders can view desired outcomes differently (Schad *et al.*, 2016; Jay, 2013). Despite this potential to overcome goal-related tensions, complex relationships among mass customization enablers have been indicated (e.g. Salvador *et al.*, 2015), as discussed in section 2.1, which indicates potential *organizing* (process) tensions that can impact implementation. Additionally, literature suggests competing performance goals can be managed by balancing global and local sourcing to overcome tensions between total supply chain costs and lead time performance (Macchion and Fornasiero, 2020; Sandberg, 2017), in alignment with product attributes (e.g. Macchion *et al.*, 2015). However, such performance benefits are suggested for both custom (small volume) and standard production (Macchion and Fornasiero, 2020), which indicates additional complexity regarding small-series production configurations and location decision-making.

In light of the above discussion, research is required to build upon emerging insights regarding such tensions and management responses in the context. Table 1 provides an overview of key issues from the literature.

3. Methods

To explore tensions impacting small-series production in high-cost contexts, a multiple case study approach was undertaken (Yin, 2018) for in-depth understanding of concepts that are emerging and thus relatively unknown, like paradoxes in supply chain management (Zhang *et al.*, 2021; Sandberg, 2017). Cases were selected from the EU apparel industry, to capture variety in small-series production models (as discussed below), based on this being a crucial context to address such tensions and location decisions (Fratocchi and Di Stefano, 2019; Pal *et al.*, 2018; Van Hoek and Dobrzykowski, 2021). For instance, industry-specific literature highlights conflicting priorities related to customization, high costs and barriers to automation (Pal *et al.*, 2018; Sirilertsuwan *et al.*, 2019). While competence can be an enabler and barrier of local production (Sirilertsuwan *et al.*, 2019), rapid technological development is enabling localization of increasingly customized production to reduce waste and overproduction (e.g. 3D knitting) (Andersson *et al.*, 2018). Consequently, local manufacturing opportunities differ with respect to industry due to variation in current

Table 1.
Paradoxes/tensions and responses in small-series production and high-cost contexts

Paradox category (Smith and Lewis, 2011)	Key paradoxes/tensions and responses[a] in small-series production and high-cost location decisions	
- Elements/themes from supply chain management (adapted from Zhang *et al.*, 2021)		
Performing tensions		
- Service (e.g. lead time) - Specific (e.g. innovation) - Sustainability (e.g. resource efficiency, well-being) - Overall (e.g. value, supply chain performance) - Cost - Investment (e.g. IT investments) - Forecast	- Cost vs Quality, Delivery, Flexibility (customization and/or high-cost location) - Cost vs Service-lead time/enhanced value (customization and/or high-cost location)	Pal *et al.* (2018), Suzić *et al.* (2018) and Suzić and Forza (2021) Macchion and Fornasiero (2020), Mirzaei *et al.* (2021) and Sandberg (2017)
	Performing tension responses	
	- Synthesis-Mass customization - Separation-Balancing local and global sourcing/production (customization and standard products)	Suzić *et al.* (2018), Suzić and Forza (2021) and Zhang *et al.* (2019) Macchion and Fornasiero (2020) and Sandberg (2017)
Performing-organizing tensions	- Cost/performance vs Unique/craft manufacturing product-processes (flexibility and customization enablers/antecedents)	Duray *et al.* (2000), Mirzaei *et al.* (2021), Pal *et al.* (2018) and Salvador *et al.* (2015)
	Performing-organizing tension responses	Duray *et al.* (2000)
	- Synthesis-Mass customization	
Organizing tensions		
- Collaboration (e.g. supply chain integration and coordination) - Efficiency and control (e.g. automation, trust for control, supply chain transparency, traditional forms of organizing) - Exploration (e.g. flexibility, creativity, new forms of organizing) - Competition - Other (e.g. unique/craft manufacturing)		
Learning tensions		
- New (e.g. knowledge in new relationships, product/process innovation) - Present (e.g. analytics capabilities) - Old (e.g. learning in old relationship)		
Belonging tensions		
- Single entity (e.g. individual preference or expertise) - Multiple entities (e.g. collective/group, supply chain stakeholders)		

[a] Categorized according to definitions from Poole and Van de Ven (1989)

customization levels, and opportunities for development related to industry infrastructure, labour-intensity and technology levels (Culot *et al.*, 2020; Kumar *et al.*, 2020; Srai *et al.*, 2020), which highlights the need for industry-specific research. Through selecting multiple diverse cases, conclusions resulting from the case study can be strengthened (Yin, 2018). Figure 1 presents an overview of the main steps in the research, as detailed in the following sections.

3.1 Case selection

The selection of company cases followed a purposive sampling procedure to provide rich information on the units of analysis (tensions and management responses) and maximize variation regarding small-series production SNCs, see Table A1 for case details. While research addressing such production models has focused mainly on mass customized manufacturing, cases in this study were selected to include diversity in ownership, for example brands, producers and brand/producers, and to include both small volume (Macchion and Fornasiero, 2020; Macchion *et al.*, 2017) and custom/on-demand production (Culot *et al.*, 2020; Suzić *et al.*, 2018). Cases additionally vary regarding small-series production implementation, to capture differences between early and established production models. Companies were selected from those participating within a multi-year research project on SNC, wherein some tensions/paradoxes were indicated within earlier research stages. The companies additionally vary with respect to headquarter locations, to overcome limitations with single country

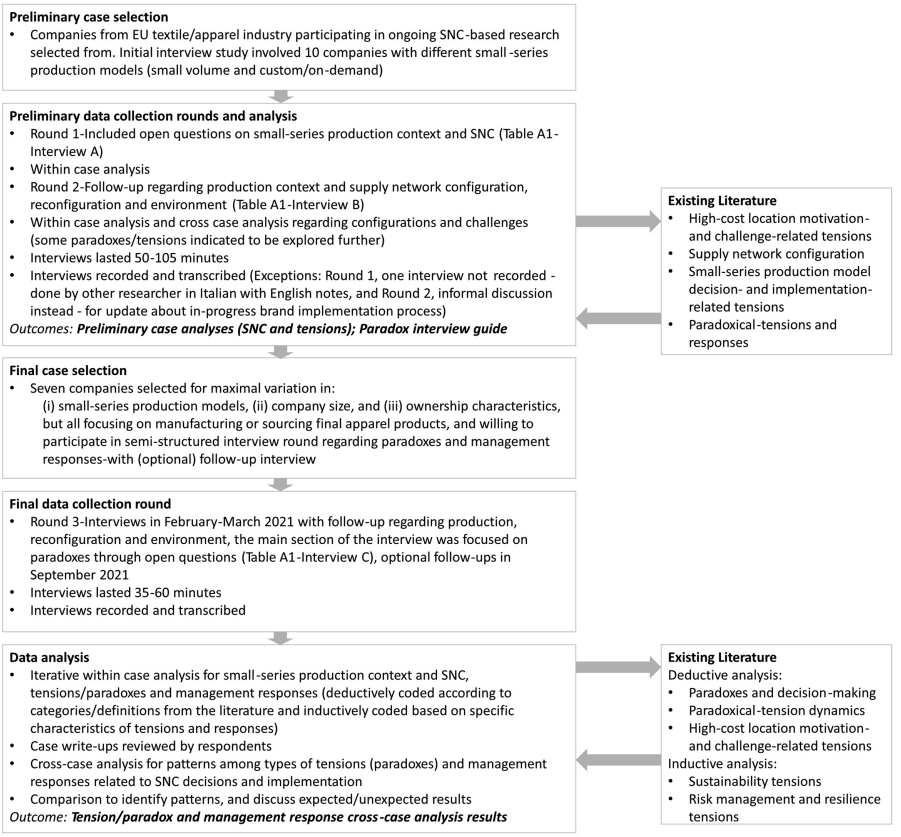

Figure 1.
Overview of research process

studies, and sizes, to capture both large retailers and smaller company perspectives, as both are crucial to consider in EU's apparel industry (European Commission, n.d.). Table A1 provides company details with data-collection methods, respondent characteristics and triangulation (as discussed in the following section).

While tensions and management responses on the SNC level are the units of analysis, observation is on the company level according to individual managerial perspectives. This has implications on defining the boundaries of the analysis, which is guided by the network horizon concept (e.g. Halinen and Törnroos, 2005; Carter *et al.*, 2015; Srai *et al.*, 2020), in which the relevance of network actors and characteristics are guided by decision-maker perceptions. While this design does not allow for multi-tier analysis, selection of diverse cases that represent different roles in supply networks overcomes these limitations to some extent, and enables identification of commonalities among different configurations like with intensity sampling (Patton, 2015).

3.2 Data collection

As shown in Table A1, data related to small-series production SNCs according to each participating company was collected during multiple interview rounds (December 2018–March 2021), which were undertaken with key managers at each company. The two initial interview rounds included questions focused on understanding small-series production configurations, interrelationships among different SNC elements, decision motivations and challenges. These interview rounds provided a rich context for investigating tensions and responses.

In line with the purpose of the study, the final interviews were focused on identification of tensions/paradoxes based on the individual practitioner perspectives, and their responses to these tensions. This approach differs from studies that explored latent tensions within a broader system without asking explicitly about the paradox concept (e.g. Zehendner *et al.*, 2021). Within this study, this approach is necessary, as paradoxical tensions become salient (and thus relevant to decision-making and implementation processes) through awareness and social construction despite potentially being inherent (Schad *et al.*, 2016; Smith and Lewis, 2011). Within this interview round, interview guides were provided to explain the four major types of paradoxical tensions (Smith and Lewis, 2011). These explanations were followed by open questions designed to identify which tensions were considered relevant to the case small-series SNCs, and what were the corresponding management responses (Table A1). The semi-structured interview process allowed for flexibility to discuss emerging issues indicated by the respondents. Supplementary material was gathered predominantly from company websites for the purposes of data triangulation.

3.3 Data analysis

The multiple interview rounds were transcribed for coding and data analysis. The interview data was translated into case write-ups, which were structured along the research framework dimensions; see Table 2 for reduced-form data, in line with Miles and Huberman (1994). The process of coding was conducted on two levels with successive stages. First, analysis focused on tensions/paradoxes identified as relevant to different case company SNCs, categorized according to paradox classes (Smith and Lewis, 2011); second, management responses were identified and categorized based on definitions from Poole and Van de Ven (1989). This coding process was iterative between the dimensions of the research framework and the specificities regarding tensions indicated by interviewees (see Table A1 for operationalization of the coding structure based on definitions of SNC (Srai and Gregory, 2008), tensions/paradoxes and management responses). Coding was based on explicit definitions from literature to reduce the risk of bias, which was enabled by NVivo software.

Table 2.
Cross-case analysis of tensions and management responses

Tensions/ Paradoxes	Cases	Details	Themes (Case #)	Management responses	Cases	Details	Themes (Case #)
Performing tensions	Case 1	*Goal-related tensions* between: (i) performance goals like *quality, speed* and *cost* - challenging with *high costs* and *long material lead times;* (ii) *large* company *volumes* and *small-series* production *volumes* - due to existing company structures and relationships (i.e. *stakeholders*)	• Sustainability (2,3,7) • Costs (1,2,4) • Variety/volume (1,2) • Lead times (1,4) • Quality (1,4) • Risks (2)	Performing tension management	Case 1	(i) Cost tension requires selection of suppliers (or internal development) for *high technology levels* to *reduce labor inputs-costs* (ii) Variety/volume tensions managed through step-by-step implementation (first 5–10% test)-limited to *certain product types*	*Synthesis* **Products:** • Efficiency (Materials) (7) • Learning/ Development (2) **Operations:** • Learning/ Development (2,3) • Efficiency (Labor/ Production) (1,7) • Flexibility (4) **Relationships:** • Customer collaboration (4) • Cross-functional collaboration (2) • Supplier collaboration (1,2)
	Case 2	*Goal-related tensions* between: (i) Internal and external brand *variety*; (ii) Internal *small volume priorities* and supplier *volume* demands-*risks;* (iii) *Sustainability* and *costs* - due to *costs* (sustainability) and *stakeholder demands* (variety/ volumes/risks)			Case 2	General focus on *learning and adapting;* (i) *Sourcing/products/marketing depts.* to agree on same focus; (ii) Importance of *close supplier relationships;* (iii) *Careful approach to sustainability (material/process) improvements* - step by step	
	Case 3	*Goal-related tension* between ambitious *sustainability* goals and availability of *certified suppliers/innovation* levels - due to *limited supplier resources*			Case 3	Tension requires *internal developments* for the required *product/process sustainability* levels through *control*	
	Case 4	*Goal-related tensions* among *customer demands* (*quality*, *speed*, lower *prices*) as normal way of doing business-challenges differ depending on product type (e.g. production complexity) - due to divergent *stakeholder demands*			Case 4	*Flexibility required* to find compromises in *collaboration with customers;* Balancing tensions supports the ability to *increase work* from customer orders	*Separation (spatial)* **Products:** • Product segmentation (1)
	Case 7	Only *goal-related tensions* because of *sustainability paradoxes* in fashion, with trade-offs between different improvements (e.g. organic material carbon footprint) - due to complexity related to sustainability and *limited company resources*			Case 7	Sustainability tensions require company to *target efforts on a specific goal,* waste minimization throughout the supply chain (prioritizing carbon when there is a trade-off) and for *product design,* to *improve multiple metrics*	

(*continued*)

Table 2.

Tensions/ Paradoxes	Cases	Details	Themes (Case #)	Management responses	Cases	Details	Themes (Case #)
Organizing tensions	Case 5	Tensions between *different small series production processes* based on the amount of *development required* and *risks, on-demand* vs *flexible capacity, retailer* vs *online sales* processes with *higher costs*, etc. - due to *limited company resources*	• Risk minimization and management (5,6) • Expansion/ development (5,6) • Flexible capacity (5,6) • Costs (5,6) • Sustainability (processes) (6)	Organizing tension management	Case 5	*Minimize development complexity* for flexibility, Brand growth (new processes) to *stabilize production,* with separate structure eventually. *Slow development* of retailer relationships for *learning*	*Synthesis* **Products:** • Minimize complexity/slow development* (5,6) **Operations:** • Minimize complexity/slow development* (5,6) • New process development* (5,6) **Relationships:** • Customer relationships-learning (5); collaborative decision-making (6)
	Case 6	Tensions among: (i) *Risk management*, innovation and *expansion*; and (ii) *Growing demand,* sourcing/ manufacturing *lead times, sustainable logistics, capacity* and *costs* - due to limited company resources			Case 6	*Innovation and expansion focus after risks; No direct solutions*-flying as a last mile option introduced, with novel carbon footprint calculator, *customers to pay some added logistics costs and to make choices*	*Separation (spatial)* **Operations** • Separate structure (5) *Separation (temporal)* **Products** • Minimize complexity/slow development* (5,6) **Operations:** • Minimize complexity/slow development* (5,6) • Separate structure (5)

(*continued*)

Tensions/ Paradoxes	Cases	Details	Themes (Case #)	Management responses	Cases	Details	Themes (Case #)
Performing-Organizing tensions	Case 6	Tension between *customer demand* for *low prices* (driving lower market scale), and business model *processes and performance* benefits related to *customization and sustainability* - due to *scale* because of divergent *stakeholder demands*	• Customer demands-Costs (6) • Scale (Processes) (6) • Customization (Processes) (6) • Sustainability (Processes) (6)	Performing-Organizing tension management	Case 6	*Prices raised* (doubled) over 15 years to overcome lower than expected market scale; Expected that in the long run business model benefits, sustainability, etc., *will lead to stronger performance*	*Synthesis* **Operations:** • Price (short-term)* (6) • Long-term view* (6)

Note(s): Tension/paradox response strategies highlighting latent learning tensions marked with (*)

Table 2.

Transparency and a chain of evidence for conclusions drawn are provided in Table 2, together with supporting quotations presented in section 4. The reduced-form data facilitated a cross-case analysis to identify significant themes related to the two units of analysis, tensions and responses.

3.4 Assessment of research quality

To ensure robustness, several actions were taken during data collection, analysis and presentation of results. Triangulation was used, which included multiple interview rounds with different questions focused on small-series production SNCs, and information gathered (primarily) from company websites. Respondent review was used throughout data-collection processes, as findings were presented for verification/elaboration, and additional informal updates and email correspondence were used for case validation. These activities provided opportunities for feedback from company representatives (Voss *et al.*, 2002; Yin, 2018), and thus enhanced alignment between researcher interpretations and data. As indicated above, both deductive and inductive coding was guided by definitions from extant literature to ensure accuracy and consistency. Specific efforts were made to establish clear chains of evidence for confirmability (Voss *et al.*, 2002; Yin, 2018), as reduced form data displays (Miles and Huberman, 1994) and supporting quotations illustrate how conclusions were drawn. The paper presents context and methods in detail, to provide transparency, and the information required to assess transferability of study findings.

4. Cross-case analysis results

The cases (numbered 1–7) reveal different tensions and levels of managerial awareness; Table 2 presents an overview of the cross-case analysis. Cases frequently highlight multiple tensions related to goals and/or processes, including *performing*, *performing-organizing* and *organizing* tension elements. Key similarities are revealed regarding these tensions and the management responses associated. Tensions mainly emerge from operations- and relationship-related resource limitations and divergent stakeholder goals/priorities. However, goal-related tensions are less often associated with high customization levels. Management responses are frequently multidimensional, and are predominantly related to operations, product and relationship strategies targeting synthesis. These strategies are combined with (spatial) separation, for example product segmentation or separate business structures, for implementation of new production models. The main themes, and associated sub-themes, are presented with supporting quotations along the different paradox categories (section 4.1), and types of management responses (section 4.2). Additionally, tension interrelationships and dynamics are both indicated by respondents, as cases often face multiple tensions, and are revealed through analysis, as latent *learning* tensions emerge from responses.

4.1 Tension (paradox) awareness

Case respondents identified several tensions directly relevant to their small-series SNCs that were considered paradoxical (Table 2). Despite the diversity of small-series production models, several similarities are found. The cases show *performing* tensions are more often associated with small volume than on-demand production. In addition to traditional goal related tensions, risk and sustainability tensions are highlighted. *Organizing* tensions are only found with on-demand production, either with other process tensions or a *performing-organizing* tension. These results are discussed below.

4.1.1 Performing tensions. All case company SNCs focused on small volume production and one focused on on-demand production face conflicting priorities, that is *performing* tensions.

Sustainability priorities/goals are identified among the common *performing* tension elements (alone or with cost and innovation goals). Such tensions result from the variety of definitions of sustainability, and conflicts between improvement strategies and corresponding impacts; *"When you go organic, you do not necessarily improve your carbon footprint, often you will actually see the opposite"* [case 7]. This tension is described as applicable to the industry at large but is described as particularly challenging for a small company with limited resources. Beyond sustainability goals themselves being complex and contradictory, the availability of certified suppliers for components or processes creates tensions between ambitious company goals and supplier resources, as one production company highlighted that *"the most difficult thing to do is to find a certified partner or supplier"* [case 3]. Another significant tension is balancing sustainability improvements with costs; *"The sustainable goal that we have now is a little bit conflicting with our margins and our profit"* [case 2]. This tension is described as increasingly challenging in response to higher supply chain volatility during the COVID-19 pandemic, because of higher costs, and challenges related to material/capacity availability, and delivery delays with certified materials.

Cases focused on small volume production models show costs and profit margins must be balanced with other goals driving increasingly localized production, like lead time and quality. As a brand implementing local sourcing, while there are requirements to control *"processes for a particular customized product, with a particular quality, speed and price"* [case 1], cost is described as the primary metric to determine reshoring potential from China to Europe. As a producer, conflicting (B2B) customer demands are described as the norm; *"The customer has conflicting requests; they want to have delivery as soon as possible with reduced cost and with increased quality. Which is not possible, because if you want to increase the quality, you have to increase is the cost, so this must be managed"* [case 4]. This is considered more challenging for products with higher requirements for manual labour.

Some of the same cases additionally show variety/volume tensions, often due to conflicts between small volumes locally sourced, and large volumes associated with global sourcing [case 1], or conflicting stakeholder goals/priorities more broadly. Divergent (internal/external) stakeholder goals create tensions, as production priorities can conflict with customer demands; *"When you buy external brands, you have attraction for the customer, but then you cannot control the supply chain and their quantities"*. Additional tensions relate to small order volumes causing reduced supplier dependence, and increased risk, as they cannot be dependent on the brand; *"(W)e cannot be a big buyer because of our smaller quantities. From that scope, it can be a risk if a supplier chooses to work with a few customers with higher quantities"* [case 2]. Thus, there is a tension between the goals of small volume production, namely to improve customer responsiveness, production flow and turn rate and supplier priorities for larger production volumes. This is more challenging with capacity restrictions and increased competition from other brands for nearshore sourcing capacity due to COVID-19. Viewing such tensions as paradoxes is considered valuable to enhance supply chain relationships in particular, through enhanced understanding of suppliers and their situations.

4.1.2 Organizing tensions. Companies scaling, or implementing, production on-demand indicate several *organizing* tensions related to risk management, expansion/development and flexibility processes.

One brand highlighted a tension regarding risk management, marketing and expansion, as there was need to postpone developments and marketing to fight 'fire' in the short-term due to limited resources, *"in order to push again when the time will be better"* [case 6]. This risk management focus also relates to the reduced rate of new product introduction, despite an initial acceleration to capitalize on changing demands. As a producer, resource limitations drive tensions between high-risk projects and flexibility processes, thus demanding reduced

focus on *"complex missions, like developing a completely new product"*, as new products and projects can disturb, or *"risk the existing production and existing orders"* [case 5]. Likewise, several interrelated process tensions result from the impacts of the COVID-19 pandemic on the supply chain, as increased demand levels conflict with production capacity availability, delivery speed and costs and with sustainable (logistics) processes [case 6].

Regarding flexible production capacity more broadly, an additional tension related to the need to balance flexibility for (B2B) customers, with growth of an internal brand was highlighted; *"We have good flexibility in our production; we can take on a lot of different products. If we make 50% jeans (own brand), we cannot take in so many other things (. . .) at the moment it's not that big of a problem, but if it's growing, then it will be more challenging to manage external customers and internal production capacity"* [case 5]. Another tension related to internal brand production was the conflict between direct-to-consumer sales and retailer sales processes, particularly due to the increased complexity and costs associated with higher sales volumes, together with lower product margins. Considering these tensions as paradoxical was described as valuable to understand conflicting processes and enable learning [case 5].

4.1.3 Performing-Organizing tensions. One *performing-organizing* tension was identified with other process tensions, which was related to conflicts between customer cost/price requirements, and the scale required for processes designed for customization and sustainability. This conflict reflects difficulties scaling up the business model, which was a "major issue", described as follows: *"(. . .) everybody expected that people would be prepared to pay more for made-to-measure, but today the average price of shirts went down (...) it's the best (model) that you can have on all issues, on all levels. More loyalty, good sizing system, products lasting longer, no returns (. . .) (but) we did not get the necessary volume. We could not generate the necessary advantage of scale, or market potential fast enough"* [case 6]. In this way, the processes designed for sustainability and on-demand production are in conflict with customer demands for low prices in the apparel industry. Nonetheless, awareness of this tension as paradoxical was considered valuable to understand inherent conflicts impacting on-demand production models.

4.2 Tension (paradox) management dynamics

Multiple cases show tension responses related to operations (all seven cases), products (five cases) and relationships (five cases) (Table 2). While strategies focused on synthesis were identified with all cases, spatial separation strategies were specifically associated with implementation of new small-series production models, and temporal separation strategies were associated with scaling on-demand production models.

4.2.1 Synthesis response strategies. Across all cases in the study, synthesis strategies were identified in response to different tensions. Most responses were multidimensional, while few focused solely on operations. Some synthesis strategies are found together with (temporal) separation responses to process tensions; specifically, minimizing product and operations development/complexity in the short-term to increase focus on product sustainability and circular product design/development in the future, together with enhancing process development. This suggests a latent *learning* tension.

Among the multidimensional synthesis strategies responding to *performing* tensions, several cases were able to resolve conflicting goals through product-operations efficiency, either internally or through supplier relationships. Case 1 stressed the importance of efficiency (together with product segmentation) gained from production/suppliers with *"high levels of investment in equipment"*, to overcome cost tensions and enable reshoring implementation. Another case highlighted product-process design decisions oriented towards efficiency, for example (carbon) waste minimization through zero waste design and processes (production on-demand), as crucial strategies in response to sustainability

tensions, as reducing waste *"benefits almost all issues"* [case 7]. Other responses to sustainability tensions emphasized knowledge, learning and development, as introducing sustainable products/materials must be done carefully to balance, benefits, costs and risks [case 2], or requires development in-house for control [case 3]. Thus, sustainability goal-related tensions are frequently managed through synthesis strategies related to product and process design.

To respond to conflicts among traditional performance demands, including cost and lead time tensions, several synthesis strategies were highlighted that focused on collaboration. Producer flexibility and collaboration was required to find compromises related to tensions [case 4], and *"cooperation and long-term relationships with the supplier"* were required to overcome dependence risks [case 2]. The ability to manage goal-related tensions was considered valuable to improve relationships, and increase sales. Additionally, cross-functional collaboration was required to define the balance of production volumes with external brand sales [case 2]. Thus, several goal-related tensions are managed through enhanced internal and external (supplier/customer) collaboration and flexibility.

Several multidimensional synthesis strategies were identified in response to *organizing* tensions. Due to limited resources, companies alternate between focusing on product expansion or development processes and risk management activities in the short-term, while maintaining enhanced process development. This highlights temporal separation (see Section 4.2.2) together with synthesis strategies focused on process development. Case 6 showed how conflicting processes related to COVID-19 disruptions are managed through the introduction of a new digital process (a carbon footprint calculator) to support collaborative decision-making with customers and provide transparency. Similarly, with implementation of on-demand production (process development), complexity related to new retailer relationships is minimized through slowing development and expansion, to manage conflicts between e-commerce and retailer sales processes, volumes and costs through learning [case 5]. Thus, process-related tensions are managed primarily through learning and collaboration downstream (customers/retailers).

To respond to the *performing-organizing tension* found with case 6 related to insufficient scale of customized production, the awareness of such inherent conflicts within on-demand business models required balancing short-term cost trade-offs (e.g. raising prices) with long-term views on business model competitiveness. In the long-run, processes designed for customization and sustainability are expected to become increasingly competitive due to environmental benefits, due to no returns and enabling circularity (e.g. recycled materials).

4.2.2 Separation response strategies. As mentioned, responses associated with implementation of new small-series production models include spatial separation strategies in response to *performing* or *organizing* tensions. Responses adopted by cases with established small-series production models include temporal separation of product/process development together with synthesis strategies focused on process development.

Regarding variety/volume *performing* tensions, case 1 shows spatial separation (product segmentation) within the organization, and geographically within network structures when implementing small volume production with standard global sourcing, as only high priced products can be sourced locally or regionally. Likewise, in response to *organizing* tensions impacting implementation of on-demand production, a separate business structure is required to overcome capacity trade-offs, that is spatial separation within the organization.

Two cases highlight temporal separation, in response to *organizing* tensions, when facing volatility in the business environment (e.g. COVID-19, BREXIT), as expansion efforts are delayed to prioritize existing customers and prepare for marketing and product development in the future. Case 6 showed COVID-19 risks forced new product introduction to be stopped short-term, despite the growing opportunities to meet changing demands. New product introduction was planned to be accelerated after the period of risk management, with focus on

increasing the variety of sustainable material options, *"fabrics which are bio, organic or recycled"*, and circular product design. Likewise, case 5 showed flexible capacity must be maintained by avoiding complex projects short-term, for example new product development and low production volumes, to focus on core competences and established processes, to reduce risks and challenges charging for development time. While the growth of on-demand production (new processes) is expected to stabilize volatile production, related tensions resulting from new and conflicting retailer processes demand slowed development, to gain intended marketing benefits and learn within these new relationships. Thus, case 5 suggests an interplay between spatial/temporal separation and synthesis strategies to manage increasing complexity related to implementing and scaling on-demand production models.

4.2.3 Tension (paradox) interrelationships and dynamics. As discussed, cases highlighted multiple *performing* [cases 1,2,4] or *organizing* tensions [case 5], or multiple *organizing/performing-organizing* tensions [case 6], which indicates managerial awareness of interrelationships among tensions. In response to these tensions, most cases adopted multidimensional strategies, which highlights the importance of considering holistic configurations. Although tensions are driven by challenges in network relationships, and collaboration-related strategies are highlighted among the multidimensional responses to tensions, *belonging* tensions were not explicitly identified by respondents. Among the responses to tensions indicated, several suggest latent *learning* tensions, and others highlight the importance of knowledge and learning; however, managerial awareness is limited. Figure 2 visualizes these interrelationships and dynamics together.

Within the figure, arrow 1 highlights the origin of tensions according to the practitioners, which shows how different types of tensions are driven by similar issues related to conflicting demands in relationships and limited resources. Arrows 2–3 show multidimensional response strategies are commonly indicated by respondents, although arrow 4 shows the response to a *performing-organizing* tension focused on operations. Arrow 5 shows *learning* tensions result from product-operations configuration, balancing current products/processes with development and innovation and short-term/long-term views on competitiveness (**L1**-**L2**). Thus, while practitioners are frequently aware of multiple interacting tensions, this awareness is limited.

5. Discussion

Through adopting a paradox-based perspective, the multiple case study focused on the EU apparel industry context reveals several unexpected insights regarding tensions impacting small-series production. Specifically, the cases capture the holistic production context and suggest different levels of management awareness of and responses to tensions; however, some degree of tension/paradox awareness is commonly found. This finding highlights the relevance of the paradox perspective for decision-makers in the context. Multiple interacting *performing* and *organizing* tensions were indicated and were associated with multi-dimensional management responses, most frequently related to operations, relationships and products. *Belonging tensions*, and *management responses* related to structures were not found, whereas *learning tensions* were found to emerge from responses to other tensions related to products-operations configuration decisions. By capturing such issues at the supply chain level, the study addresses interrelated gaps in the literature regarding context-specific small-series production implementation (e.g. Kumar *et al.*, 2020; Suzić *et al.*, 2018), location decisions (e.g. Hilletofth *et al.*, 2019; Van Hoek and Dobrzykowski, 2021) and tensions related to high-cost locations (e.g. Mirzaei *et al.*, 2021; Pal *et al.*, 2018). The insights gained specifically add to tensions/paradoxes identified in supply chain management (e.g. Sandberg, 2017; Zhang *et al.*, 2021), as discussed in the following sections.

Note(s): Arrows (or arrow groups) illustrating key interrelationships numbered 1-5; Arrow 1-origin of tensions; Arrow 2-4-tensions management responses; Arrow 5-Interrelationships between management responses and emergent/latent tensions (Marked with *)

Figure 2.
Visualization of tensions and dynamics

5.1 Tension (paradox) awareness

The findings suggest managers are aware of multiple tensions that are viewed as paradoxes (Table 2). While the results show that tensions differ depending on the type of small-series production model (on-demand/small volume, and early vs established), tensions emerge from similar challenges (Figure 2). Beyond elaborating upon tensions suggested in extant literature (Table 1), the findings illuminate several *organizing* tensions, and suggest latent learning tensions (**L1**, **L2**). These findings add to commonly identified tensions in supply chain management (cf. Zhang *et al.*, 2021), and illuminate the extent to which paradoxes in the context emerge as salient to practitioners (Jay, 2013; Schad *et al.*, 2016). The lack of managerial awareness found with underlying *learning* and *belonging* tensions (Smith and Lewis, 2011) highlights the need to expand perspectives to different systemic levels to identify latent tensions (Schad and Bansal, 2018) that relate to known *performing* and *organizing* tensions (e.g. Zehendner *et al.*, 2021). However, as evidenced by indicated responses to process- and goal-process-related tensions, managers have implicit awareness of the need to balance development levels as well as priorities and processes over time when scaling on-demand production.

The findings additionally show managerial awareness of *performing* tensions related to sustainability (**P2**) and risk considerations (**P3**), in addition to traditional performance goals related to cost, variety, volumes, lead time and quality (**P1**). These tensions are frequently experienced together because of pressures related to divergent stakeholder priorities like suggested in the literature regarding paradoxes (Smith and Lewis, 2011), and conflicting goals related to high-cost contexts (Mirzaei *et al.*, 2021). The companies facing only one tension, either face traditional performance goals due to inherent challenges with small volume production [case 1,4], or sustainability tensions (e.g. Zehendner *et al.*, 2021), due to conflicts between the priority and resources [case 3,7]. Sustainability tensions suggested include costs and environmental impacts conflicting with intended improvements [case 2,7], together with resource and competence constraints [case 3,7]. Beyond expected cost trade-offs, the increased impacts (carbon footprint) linked to common strategies for sustainability improvement (organic materials) highlights the need to consider unintended consequences in the context. The results additionally identify a risk tension element when sourcing small volumes from suppliers [case 2], highlighting how buyer-supplier relationships are often the source of performing tensions [case 2,4], which adds to the list of performing paradox elements from Zhang *et al.* (2021). This finding extends the discussion regarding priority tensions related to high-cost contexts (Mirzaei *et al.*, 2021), and reshoring/right-shoring decisions (Hilletofth *et al.*, 2019; Van Hoek and Dobrzykowski, 2021).

The role of risks and risk management is additionally highlighted within interacting process (*organizing*) tensions, which are identified specifically with on-demand production (**O1-O5**), because of limited company resources. Cases show high-level conflicts, between efficiency and exploration while managing risks, and difficulties related to the costs and risks of conflicting and disrupted processes [cases 5,6]. Identification of these interrelated tensions in the context adds to those suggested in extant literature (Table 1), consistent with research suggesting scarcity and change makes tensions salient (Smith and Lewis, 2011). The prominence of such risk management and resilience related issues within *organizing* tensions can be explained by the significant impacts of COVID-19, which is likely to have varied impacts on long-term location decision-making (Van Hoek and Dobrzykowski, 2021).

The hybrid goal and process-related tension identified with on-demand production revealed conflicts between customer demands for low-costs and the scale of processes designed for customization and sustainability required to reduce costs (**P-O1-P-O2**), which is highlighted as a key challenge [Case 6]. This indicates process scaling is a barrier to overcoming tensions through mass customization in the context, which adds to potential tensions related to balancing enabler (antecedent) levels (Salvador *et al.*, 2015). Such scaling

difficulties continue to be challenging in the short-term due to the nature of apparel industry demand, despite a balanced operations strategy.

Regarding the implementation and scaling of customized/local production (Kumar *et al.*, 2020; Srai *et al.*, 2020), these findings illuminate several context-specific tensions.

5.2 Tension (paradox) management dynamics

Results show cases predominantly adopt multidimensional response strategies for synthesis and separation, which included products, operations and relationship strategies rather than structural or location design considerations (cf. Figure 2 and Table 2). This finding conflicts with suggestions from literature that balancing global/local location decisions, that is spatial separation, can overcome performing tensions (e.g. Macchion and Fornasiero, 2020; Sandberg, 2017), which indicates localization could cause rather than overcome such tensions in this production context. The limited exposure to *performing* tensions found with on-demand production confirms definitions of mass customization as a strategy that overcomes such tensions (e.g. Suzić *et al.*, 2018). While all case show synthesis strategies, some additionally show spatial and temporal separation strategies related to operations and product design, in particular, when implementing and scaling new/on-demand production models. The prevalence of multidimensional responses identified confirms benefits of adopting a holistic SNC-based perspective to understand tensions and management strategies.

Several synthesis strategies, as defined by Poole and Van de Ven (1989), were highlighted in response to *performing* tensions. Interrelated (product-operations–relationship) configuration decisions were designed to balance various conflicting goals. Arrow 2 shows sustainability-related tensions (**P2**) drive operations strategies and development, to overcome cost tensions [case 2] and limited company/supplier resources [cases 3,7], through enhanced control and focus on key environmental goals (*reduce waste*) to overcome inherent sustainability conflicts. Traditional performing tensions (**P1**) are shown to drive various relationship strategies, as companies must balance supplier relationships (long-term, high-technology) [case 1,2] with risks of supplier dependence (**P3**), and *cross-functional collaboration* is required to determine this balance [case 2]. Likewise, *customer collaboration* is required for a producer, together with focus on *flexibility* to balance such conflicts [case 4]. These findings confirm and extend research, through identifying multidimensional synthesis strategies in response to different tensions depending on production model. Regarding established on-demand business models, development is focused on reducing (product-operations) waste rather than prioritizing certified organic materials due to inherent sustainability conflicts. Established small volume sourcing requires supplier collaboration to overcome increased risks that conflict with intended responsiveness benefits motivating localization. When implementing small-series production and reshoring, case 1 shows spatial separation (*product segmentation*), is required to overcome cost tensions, together with synthesis strategies focused on efficiency through high levels of supplier technology.

Synthesis strategies focused on operations are also identified in response to *organizing* tensions, together with temporal separation strategies (Poole and Van de Ven, 1989) (Arrow 3). Companies restrict complexity through limiting low product volumes [case 5], complicated new product development projects [cases 5,6] and delaying expansion efforts in the short-term [cases 5,6] (i.e. temporal separation) to balance risk management (**O4**) with process flexibility, costs, etc. While these results indicate companies alternate focusing on development and efficiency, cases show process development is simultaneously both reduced and enhanced. Specifically, new sales processes (with associated retailer/customer relationships) are both constrained, to support improved learning concurrent with brand development [case 5] and enhanced for collaborative decision-making in the face of risks [case

6]. These responses focus on temporal separation to *reduce complexity* (product/process), which together with synthesis strategies focused on process *learning/development* and reveal a latent learning tension (**L1**). This finding indicates multi-dimensional responses predominantly target learning and relational closeness within downstream supply chain relationships. The latent tension suggested (Arrow 5), is consistent with dynamics discussed by Smith and Lewis (2011), as management responses to tensions can reveal latent tensions within a dynamic cycle of cognition and action.

Additionally, Arrow 4 shows response to *performing-organizing* tension focused on balancing short- and long-term perspectives [case 6], which reveals another *learning* tension (**L2**) related to conflicting processes for current and future competitiveness in high-cost contexts (e.g. Mirzaei *et al.*, 2021). Identification of such *learning* tensions as emergent within network configuration processes is expected given the difficulty of identifying such issues in isolation (Jarzabkowski *et al.*, 2013; Smith and Lewis, 2011). Thus, through the findings in this study, such tensions can be made salient for practitioners. These results contribute to better understanding of paradox dynamics and interrelationships (Smith and Lewis, 2011; Schad *et al.*, 2016), in response to various complex challenges impacting small-series production model implementation and scaling. The critical roles of both advanced processes (technology) and balancing resource allocation for current and future development are highlighted. However, such development is likely to be challenging because of comparatively low levels of advanced technology adoption in the industry (Andersson *et al.*, 2018; Fratocchi and Di Stefano, 2019).

Thus, synthesis strategies are combined with spatial separation to implement new small-series production models, and with temporal separation to overcome multiple process (scaling) tensions. The specific responses indicate that new tensions emerge from the need to balance exploration (development) with exploitation of processes, and risk management.

6. Conclusions

The main contribution of this paper is a detailed understanding of paradoxical sensemaking regarding small-series production location and configuration decision-making/implementation, through a multiple case study within EU's apparel industry. The study addresses gaps in the literature related to supply chain design for small-series production (e.g. Suzić *et al.*, 2018), and customization as a contingency factor impacting location decisions (Benstead *et al.*, 2017; Moore *et al.*, 2018), as well as challenges and tensions (Kumar *et al.*, 2020; Mirzaei *et al.*, 2021; Pal *et al.*, 2018). The applicability of a paradox perspective is confirmed, as every case indicated at least one relevant tension, and several additional insights are revealed. First, while the study confirmed multiple *performing* and *performing-organizing* tensions, several *performing* and *organizing* tensions were additionally stressed related to sustainability, risk management and scaling.

Second, the results suggest high-cost location decisions drive, rather than resolve, tensions. This finding conflicts with literature suggesting local (with global) production as responses to performance tensions (e.g. Sandberg, 2017). Rather than adopting structural configuration decisions, multi-dimensional responses to such tensions focus on product/process efficiency and complexity reduction, knowledge and development and/or collaborative supply chain relationships. These strategies all target synthesis in response to tensions, which is combined with (temporal/spatial) separation when implementing and scaling small volume and on-demand production models, due to limited resources in the network, and conflicting stakeholder demands.

Third, product/process efficiency and development strategies revealed latent *learning* tensions with on-demand production models. These tensions emerged from responses to tensions related to process flexibility, development and risk management, due to resource limitations. Despite limited awareness of these tensions, managers highlight the need to balance

conflicting responses regarding new product/process development levels with efficiency and flexibility, as well as balancing short-term cost/scale challenges with long-term growth. Moreover, while no *belonging* tensions are explicitly identified, relationship characteristics are among the drivers of tensions and collaborative relationships are key response strategies.

Finally, the findings suggest that challenges related to performance tensions are largely absent with on-demand production models (vs small volumes), which suggests customization can reduce the salience of such tensions, in line with extant literature regarding mass customization. These insights can be seen as a starting point for understanding paradoxes and responses in industries that are traditionally labour-intensive and facing rapid technological development, as well as increasing opportunities for customization.

6.1 Practical implications

The results of this study provide insights for practitioners within industries like apparel, that are characterized by customer-driven supply chains, global supply chains, low technology levels and high labour intensity. The study indicates managers must consider small-series production tensions holistically to capture dynamics among tensions/paradoxes together with responses related to (products, processes and supply chain relationship) (re) configuration. Rather than providing in-depth guidance, the results offer an overview of the production context that can offer insights for practitioners regarding conflicting performance demands (e.g. sustainability, traditional performance goals, risks) and processes (e.g. development, flexibility, risk management), and scale challenges (Table 2). The combined framework presented in the paper can support analysis of such dynamics and reveal latent tensions (cf. Figure 2).

While managers are aware of the need to respond to multiple tensions through focusing limited resources for synthesis (performance/operations/relationships), together with temporal separation (operations), and spatial separation (e.g. product/operations) when implementing and scaling small-series production, limited awareness of learning tensions suggests the need for further knowledge development. The findings suggest customization can both reduce exposure to goal-related tensions/paradoxes, and be challenged by goal-process scale-related tensions. While not the focus of the study, the cases suggest benefits of paradox awareness and management (Smith and Lewis, 2011), related to improved relationships and learning.

6.2 Limitations and future research

Though multiple tensions relevant to small-series production configurations are revealed, the findings are limited to a specific geographic and industry context. Therefore, insights related to tension interrelationships and response dynamics should be explored in other industry/location contexts. In future research, management dynamics should be addressed over time, and from multiple stakeholder perspectives, as different perspectives are suggested between producers and brands, and with implementation and scaling small volume/on-demand production models. Future studies should address the extent to which tensions can be resolved or remain paradoxical, which was beyond the scope of the current study. These studies could reveal other latent tensions and elaborate upon latent *learning* tensions suggested. Moreover, because a small sample size limits the ability to draw conclusions regarding several contingencies, future research should investigate how tensions differ with respect to company size, and with one or more small-series production models (e.g. local vs global production/sourcing, or small volume vs on-demand production). Finally, the potential for customization (on-demand production) to reduce the salience of performing tensions should be investigated with large companies, as large companies in this study exclusively sourced small volumes, in contrast to micro/small companies that focused on on-demand production. The paradox- and SNC-based perspective

adopted in this paper can support analysis of tensions and paradoxical sensemaking in future research regarding dynamic supply chain decision-making, in response to increasing volatility, risks and sustainability imperatives.

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Corresponding author
Sara Harper can be contacted at: sara.harper@hb.se

Table A1.
Case descriptions and data-collection process

Case SNC[a]	Location	Size[b]	Company value chain position and product[c]	Small-series production model implementation (% total)	Respondents (# of interviews[d])	Data collection process[d]	Data triangulation
Case 1	Italy	Large	**SV-BR:** Physical retail stores, multiple brands, apparel and accessories, including high-tech sportswear	**Small volume:** *In-progress*- Proximity sourcing (reshoring) to test small-series production (5–10%)	A/B-Two Internal R&D/project managers (2), C-Internal R&D/ project manager, external project manager (1/2), C-Two internal R&D/project managers, external project manager (1/2)	A-1 h 15 min; B-1 h, C- (two parts) 1 h total; with follow-up/case validation by email	Company website
Case 2	Sweden	Large	**SV-BR:** E-commerce retailer of fashion products, e.g. trend and never out of stock apparel and shoes	**Small volume:** *Established and growing*- Growing proportion of 300–600 piece orders with proximity sourcing (~12% of apparel)	A/B/C-Sourcing manager (3)	A-1 h; B-1 h 30 min; C-1 h; Follow-up- 1 h, with case validation by email	Company website
Case 3	Italy	Large	**SV-P/B:** Complex fashion products with sustainable high-technology fabrics and innovative processes	**Small volume:** *Established*- Focus on fabric production and small volume product sustainability (100% of apparel)	A-Supply chain manager (notes), B-Internal project manager-technical department, Internal product manager, Two external project managers (1), C-Internal project manager-technical department, External project manager (1), Follow-up- Technical department representative, External project manager (1)	A- (other researcher with notes); B-1 h 45 min; C- 1 h; Follow-up- 1 h, with case validation by email	Company website, brand website, site visits
Case 4	Italy	Medium	**SV-PR:** Full-package fashion garment production	**Small volume:** *Established*- Focus on small volume products using classic and innovative technologies (100%)	A/B-Two Internal project/ product managers (2), C/Follow-up- Two Internal project/ product managers, External project manager (2)	A- 45 min; B- 1 h 20 min; C- 1 h; and follow-up- 1 h, with case validation by email	Company website, site visit

(*continued*)

Table A1.

Case SNC[a]	Location	Size[b]	Company value chain position and product[c]	Small-series production model implementation (% total)	Respondents (# of interviews[d])	Data collection process[d]	Data triangulation
Case 5	Sweden	Micro	**SV/OD-P/B:** CMT (Cut-Make-Trim) manufacturing for all products and sustainable denim brand	**Small volume:** *Established*- Focus on flexible/small volume production **Custom/on-demand:** *In-progress*- On-demand brand production (~100%)	A/B/C/Follow-up- Owner (~4)	A- 1 h 45 min; B- informal discussion to follow up on SNC (notes), C- 1 h; and follow-up- 1 h 15 min, with case validation by email	Company website, brand website, site visits
Case 6	Belgium	Micro	**MTM-BR:** Customer-driven digital business model for MTM woven fashion products	**Custom/on-demand:** *Established and growing*- Focus on high variety MTM products with proximity sourcing (~100%)	A/B/C- CEO (3), Follow-up- CEO, External project manager (1)	A- 1 h; B- 1 h 45 min; C- 1 h; and follow-up- 1 h, with case validation by email	Company website
Case 7	Denmark	Small	**MTM-BR:** Customer-driven digital business model for sustainable MTM jersey/knit products	**Custom/on-demand:** *Established and growing*- Focus on MTM product sustainability with proximity sourcing (~100%)	A/B/C- CEO (3)	A- 1 h; B- 50 min; C- 35 min; and follow-up/case validation by email	Company website, Marketing/ communication/ crowdfunding

Note(s): [a] SNC for small-series production model(s) defined according to interviewed firm network horizon (Halinen and Törnroos, 2005); [b] Size defined by employee numbers, in line with European Commission (2003); [c] Abbreviation based on product focus and ownership of brand and production (SV-Small volume, OD-On-demand, MTM-Made-to-measure, BR-Brand, PR-Producer, P/B-Producer/Brand); [d] Interview rounds-details below (A-Structured regarding SNC; B-Semi-structured regarding SNC; C-Semi-structured regarding paradoxes; Follow-up)

Interview round 1 – Structured interview (Interview A)
[Case and SNC context]

- *CONTEXT*
  (1) What are the products currently offered in small-series, and how?
  a. What production dynamics are used?
  b. What percentage of total production is offered this way?
  (2) What are the potential products that could be offered this way in the future (short/medium term)?
  (3) How does (or could) this type of production interact with the standard offering?
- *SUPPLY NETWORK CONFIGURATION*
  (1) What is required for small-series textile/apparel production throughout the supply network? [closed-SNC aspects]
  (2) How do those required elements relate to (influence) each other?
  a. How can you explain this influence? (positive/negative impacts) [open]

(*continued*)

Table A1.

Interview round 2 *- Semi-structured interview (Interview B)* *[Case and SNC context]*	• *Presentation of results to verify and elaborate upon:* • *CONTEXT* (1) Business case (2) Small-series production model • *ENVIRONMENT and RECONFIGURATION* (1) How has the business environment changed from the past, and how do you foresee it changing in the future: a. What changes to downstream demand, upstream supply? b. What changes to Products, Operations, Relationships, Structures? • *INTERRELATIONSHIPS ELABORATION* (1) How do the above described characteristics interrelate, with: a. Performance, Products, Operations, Relationships, Structures?
Interview round 3 – Semi-structured interview (Interview C) *[Case paradoxes and management]*	• *Updating and clarification of changes (if any):* - Follow-up on in progress small-series production models reconfigurations or planning - Environmental changes and impacts • *PARADOXES [Coding structure, based on Smith and Lewis (2011); Srai and Gregory (2008)]* (1) *How are the four different types of paradoxes related to, and managed with small-series production*?* (1) Learning/Knowledge – tensions between incremental and radical innovation (e.g. stability/change) (2) Belonging/Identity – tensions between individual/firm and collective (e.g. different stakeholder views) (3) Organizing/Process – tensions between competing process designs (e.g. flexibility/control) (4) Performing/Goals – competing strategies and goals (e.g. cost/lead time) *Regarding characteristics and changes related to: a. Priorities/motivations (e.g. capabilities like delivery, quality, etc. that are linked to structures and decisions) b. Products (e.g. structure, composition, variety) c. Processes (e.g. operations flow, technology-production and ICT, activities) d. Supply chain relationships (e.g. levels of trust, integration, collaboration, ownership) e. Supply chain structures (e.g. location, number of suppliers, complexity of structures) *(Follow-up: Do you see any benefits to viewing such issues from a paradox perspective; if yes, which benefits?)*