Designing circular supply chains in start-up companies: evidence from Italian fashion and construction start-ups

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Abstract

Purpose – The theory of complex adaptive systems (CASs) represents an interesting perspective to study the characteristics of circular supply chains (CSCs). In this regard, the current literature lacks evidence regarding coordination and integration mechanisms, characteristics of the environment and emerging system properties of CSCs. This paper aims to fill this gap and focuses on how and why companies design (i.e. configure and coordinate) their CSCs and what value these design choices help to create across different industries.

Design/methodology/approach – The authors use a multiple case study approach and analyze data collected from a sample of five sustainable start-ups operating in the fashion and construction industries in Italy to better understand how these companies design (i.e. configure and coordinate) their CSCs.

Findings – Results reveal that in the two industries under investigation, the design of CSCs built around open and closed–loop logic is triggered by the intention to solve a negative sustainability impact. The sustainability impact determines whether the value is restored within the same supply chain, in another, or inside or outside the same industry. Interestingly, start-ups appear to coordinate other CSC actors with three leading roles: (1) orchestrator, (2) integrated orchestrator and (3) circular manufacturer. The coordination role of the start-ups differs in each supply chain configuration based on the level of vertical integration of manufacturing activities.

Originality/value – From a theoretical perspective, the authors' results expand previous supply chain management (SCM) literature by presenting an empirical analysis of the configuration and coordination of CSCs, and discussing the drivers for creating such circularity from a CAS perspective. From a managerial perspective, the authors offer a practical experience to entrepreneurs on how to transform circular and sustainable business model aspirations into CSC practices.

Keywords Circular supply chains, Supply chain configuration, Supply chain coordination, Complex adaptive systems

Paper type Research paper

1. Introduction

The pressure exerted by the current economic patterns on using natural resources and critical raw materials sharply rose in the last few years. Waste generation is a phenomenon that affects different supply chains, but it is a particularly relevant problem in some industries,

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e.g. food, construction and fashion (Meinlschmidt *et al.*, 2018; Bukhari *et al.*, 2018). Inappropriate waste management practices increase costs and have severe environmental impacts connected to the disposal of this waste (Hicks *et al.*, 2004). Policymakers have been working to make civil society and businesses more sensitive in this regard. In 2015, The European Commission adopted an action plan to set up clear measures and control mechanisms to promote and support the shift toward circular economy (CE) systems (European Commission, 2018a). Recently, the European Green Deal (2019) included, among its most important goals, the decoupling of economic growth from the use of resources. These EU directives are tied up with the Sustainable Development Goals set by the United Nations, which incorporate in goal SDG12 sustainable consumption and production patterns to limit waste generation and management (Eurostat, 2015).

These new challenges have pushed companies to adopt supply chain practices oriented toward the CE paradigm, first defined by Ellen MacArthur Foundation (EMF) as an approach to building restorative and regenerative systems aiming at extracting new value from waste (EMF, 2013, 2017). CE aims to keep products, materials and components at maximum utilization and value throughout their manufacturing and biological cycles (Farooque *et al.*, 2019). As such, transitioning toward CE means a radical change in how the products are designed and manufacturing processes implemented. This requires companies to rethink their business models (Lewandowski, 2016) and, following the view of supply chains as complex adaptive systems (CASs; Surana *et al.*, 2005), evolve their network structures toward circular supply chains (CSCs) that "*promote transformation from a linear to a circular model of flow of products [. . .] to provide a coherent framework for redesigning systems to enable a restorative economy, based on a benefit from the flow of resources and products over their lifetime, limiting the material input to society*" (González-Sánchez *et al.*, 2020, p. 2).

To close the loop and extract new value out of what traditionally has been considered waste and/or prevent or reduce waste, supply chains need to design and manage new processes and flows that require organizations to involve new actors and develop new relationships (Nasir *et al.*, 2017; De Angelis *et al.*, 2018). The transformation of CSC has also caused a shift from supply chain management (SCM) toward circular SCM (CSCM; Farooque *et al.*, 2019). While the literature on CSC has been growing in the last years (Zhang *et al.*, 2021), the characteristics of these supply chains are still overlooked from a CAS theory perspective (Braz and de Mello, 2022).

Particularly, regarding the three typical features of strategic network design, i.e. collaboration, coordination and configuration (Hieber, 2002), previous CSCM studies have been primarily focused on the first aspect, discussing how supply chain collaborations can help in implementing CSCs and what the main drivers and barriers for such collaborations are (e.g. Zhang *et al.*, 2021). Much less is known, instead, regarding coordination mechanisms and types of configurations that are necessary to implement these collaborations. Further, while previous CSCM research has mostly focused on the economic and environmental benefits of circularity (Zhang *et al.*, 2021), we also recognize that CSCs have the potential to create social value for the supply chain actors and society, so it becomes interesting to study collaborations for CSCs regarding this type of value creation.

In line with the idea of studying CSCs as CAS (Batista *et al.*, 2019) and in response to the recent call for more empirical research of CSC contexts (Zhang *et al.*, 2021), our study investigates how organizations (re)design their supply chains in the context of CSCM (inside and across industries and for both close and open-loops supply chains), if and how these supply chain design choices depend on specific contextual factors, and what value CSCs create. These objectives can be summarized through the following research question:

RQ1. How and why do organizations design CSCs and coordinate among supply chain members?

To answer this question, we decided to focus on a specific type of company: start-ups. Start-ups are "*small firms, recently founded and that have a relatively small market share*" (Hockerts and Wüstenhagen, 2010, p. 483). As start-ups are more straightforward than big and established companies, using them as a unit of analysis to explore the above research question allows us to investigate CSC design choices connected to the early stages of an organization's lifecycle and identify the main antecedents of these choices. In this study, we collected data from a sample of five start-ups that developed CSCs in the fashion and construction sectors, two industries that are very committed to environmental sustainability and CE practices (e.g. Nasir *et al.*, 2017; Wang *et al.*, 2020; Chen *et al.*, 2021; Majumdar *et al.*, 2022). Particularly, the analysis of the CSC designed by these companies focuses on how the waste generated can be transformed into an additional resource to manufacture and distribute products in the start-up supply chain. As such, with reference to the SCOR model for SCM (Huan *et al.*, 2004), this study considers the source, make and deliver processes but excludes from the analysis the management of the end-of-life activities of these products (i.e. return).

The paper is structured as follows. In the next *section 2*, we introduce the theoretical background and motivations of the research. *Section 3* describes, in detail, the methodology adopted. *Section 4* provides the details of our case studies under investigation, while the findings are shown in *section 5*. Finally, the main implications and limitations of the work are discussed in *section 6*.

2. Theoretical background

2.1 The characteristics of circular supply chains and circular supply chain management

To address the "unsustainability" of the *take-make-dispose* linear economy model, companies are increasingly investing in new ways to shift their traditional business models toward the *take-make-restore* principles (Nasir *et al.*, 2017; De Angelis *et al.*, 2018).

Closing resource loops implies that a share of the value of products or components is taken back into the system (Batista *et al.*, 2018). This means either using "inner loops" and thus relying on repair and refurbishing, reusing with little or no changes and remanufacturing or leveraging outer loops with recycling (World Economic Forum, 2014; Hazen *et al.*, 2021). Instead, slowing the resource loop implies the extension of the product life cycle so that products can last longer and the pace of the use of resources decreases (Bocken *et al.*, 2016). Companies can obtain higher efficiency by narrowing the resource flows (Winans *et al.*, 2017).

The idea of creating value using input materials from another industrial context (or another supply chain) is a core principle of the CE paradigm, usually referred to as "the power of cascaded use." It suggests that supply chains can generate additional value by leveraging material flows across different industries (De Angelis *et al.*, 2018). Cascaded flows, also called open-loop flows, are part of the CE narrative and are generally associated with an extended view of closed-loop flows (Batista *et al.*, 2018). Nevertheless, previous literature supports the idea that they should be treated differently (e.g. Batista *et al.*, 2018; De Angelis *et al.*, 2018). Open-loop flows are characterized by higher complexity than closed-loop flows because they require the involvement of actors that are external to the linear supply chain (Mishra *et al.*, 2022). Additionally, while the concept of circular value creation in closed-loop networks primarily relates to the output of manufacturing processes, open-loop networks usually consider by-products and other sources of waste in the contribution to value creation (Batista *et al.*, 2018).

To achieve circularity in both open and closed-loop systems, companies must adopt a network perspective and appropriately implement CE in their supply chains (e.g. Geissdoerfer *et al.*, 2018). In this regard, CSCM is defined as the coordination and configuration of internal organizational units as well as of external business units and organizations to *"close, slow,* *intensify, narrow, and dematerialize material and energy loops to minimize resource input into and waste and emission leakage out of the system"* (Geissdoerfer *et al.*, 2018, p. 713). This focus on configuration and coordination is jeopardized by the need to integrate two different supply chains (the forward and the reverse supply chains). While in closed-loop networks, the supply chain actors in both supply chains are the same, in the case of open-loop flows, these two supply chains can include various actors from different industries (Farooque *et al.*, 2019; Mishra *et al.*, 2022).

The SCM literature has emphasized that different drivers, barriers and enablers of CSCM exist (e.g. Zhang *et al.*, 2021). These aspects strongly depend on geographical and industrial contexts (Farooque *et al.*, 2019). For example, in comparing the environmental impact of linear supply chains and CSCs in the construction industry, Nasir *et al.* (2017) conclude that the main challenges connected to CSCM relate to specific market dynamics, such as customers' skepticism related to the quality features of construction materials from recycled sources. In their study focused on the household appliance industry, Bressanelli *et al.* (2019) identify a set of challenges for implementing CSC, including, among others, product characteristics (such as fashion changes), industry standards and the uncertainty of the return flow. Recently, Kazancoglu *et al.* (2022) focused on the textile industry and concluded that the reluctance to accept CE models and the lack of knowledge on collecting, sorting and recycling materials are among the highest barriers to deploying CE principles in textile supply chains. Instead, Kumar *et al.* (2022) identified 15 critical challenges for CSCs in the food industry, including incentives, government policy support and enforcing environmental regulations for supply chain partners as the most critical aspects to consider.

2.2 Circular supply chain models: collaboration, configuration and coordination

Effectively shifting toward circular models requires supply chains to change three strategic aspects: configuration, collaboration and coordination (Bressanelli *et al.*, 2019).

Previous SCM literature has primarily focused on how developing new supply chain collaborations or updating existing ones is necessary to obtain CSCs. For example, integration and communication with customers and/or charities are needed to re-collect materials (e.g. textiles) for recycling (Sandvik and Stubbs, 2019). Instead, collaboration practices with strategic suppliers are needed to implement circular/green purchasing (Sudusinghe and Seuring, 2022). Such collaborations can be focal company-driven, generated from joint initiatives with customers or suppliers, or involve multiple supply chain stakeholders (e.g. Xu *et al.*, 2022). In some cases, they can even consist of industrial symbiosis partnerships (e.g. Lombardi and Laybourn, 2012; Gibbs and Deutz, 2007). In their recent review, Sudusinghe and Seuring (2022) have conceptualized several vertical and horizontal collaborative practices in CE contexts. In this regard, the authors distinguished between relational practices (such as penalties, incentives, long-term agreements and sharing responsibility for product recovery) and operational collaboration practices (such as product design, technological integration, quality improvement, logistical integration, cost control and supplier monitoring). They also emphasized the need for future research to focus on ways to prioritize such practices and how their implementation in CSCs relates to other supply chain collaboration-related variables (e.g. trust). Previous empirically grounded research touched upon these aspects, with a focus on collaboration models for the implementation of CSCs in specific industries, such as steel production (e.g. Berlin *et al.*, 2022), building construction (e.g. Leising *et al.*, 2018), food (e.g. Ciccullo *et al.*, 2021) and pharma (e.g. Khan and Ali, 2022).

While collaboration plays a central role in CSCM, two additional aspects need to be taken into account to understand the dynamics within CSCs: configuration and coordination.

CSCs are based on new and improved physical flows. So, their implementation usually requires an evolution of the network configuration (Masi *et al.*, 2017). This means that several network design decisions need to be revised, such as facility location, characteristics and nature of distribution channels, supplier selection and evaluation approaches, inventory policies and location (Batista *et al.*, 2018; González-Sánchez *et al.*, 2020; MahmoumGonbadi *et al.*, 2021).

Running CSCs also means planning and coordinating the reverse flows that go back from the point of production or use to the, e.g. recycling stage (Vegter *et al.*, 2020). The lack of coordination among actors has been identified as one of the main barriers to implementing CSCs (Khan and Ali, 2022). Improving the information flow and the quality of information shared between supply chain actors represent fundamental prerequisites to reaching an appropriate level of coordination in CSCs (Jäger-Roschko and Petersen, 2022). Previous studies have tried to model the effect of contracts and channel coordination in CSCs (e.g. Agrawal *et al.*, 2022), also considering the role of advanced technologies and supply chain digitalization (Chen *et al.*, 2022).

2.3 Circular supply chains, sustainability and value creation

Ultimately, companies create CSCs to obtain higher economic value (e.g. through the use of resources in a more efficient way; Geissodoerfer *et al.*, 2018) and increase supply chain sustainability outcomes (e.g. waste reduction; Nasir *et al.*, 2017). Previous SCM literature has largely considered the difference between circular and non-CSCs regarding the environmental impact. Compared to open-loop supply chains, CSCs are recognized as having a more positive impact on the environment as they increase the residual value of a product, limiting the use of virgin raw materials (e.g. Govindan *et al.*, 2016; Kortmann and Piller, 2016; Kalverkamp and Yang, 2019). Instead, CSCs' ability to generate social value is much less known. Geissodoerfer *et al.* (2018) were among the first authors to promote the idea that CSCs contribute to creating higher social value thanks to a stronger interaction between many stakeholders. Mishra *et al.* (2018) further mentioned the impact CSCs have on local communities. CSCs potentially favor the creation of new jobs in the local area and positively impact customers, co-workers and society at large. Rovanto and Bask (2021) reinforced these results, as they concluded that CSCs created by "circular economy-native" enterprises generate long-term value for society, while CSCs created by "adopters" (i.e. established companies that decide to shift toward CE) have a higher orientation toward the creation of economic value.

2.4 Circular supply chains as complex adaptive systems: existing gaps

The SCM literature promotes the idea that supply chains should be analyzed from the perspective of CASs (Choi *et al.*, 2001). The CAS theory considers the supply chain as "*a network of dynamical elements where the states of both the nodes and the edges can change, and the topology of the network itself often evolves in time in a nonlinear and heterogenous fashion*" (Surana *et al.*, 2005, p. 4238). When studying supply chain as CAS, there are three elements to be taken into account (Nair and Reed-Tsochas, 2019).

(1) The interaction mechanisms between decision-making agents.

(2) The constant and interdependent changes that characterize the environment and push supply chains to evolve.

(3) The emergent system properties that result from the interaction between the decision-making agents and the environments.

These aspects become particularly important in the context of circular business models and CSCM (Batista *et al.*, 2019; Braz and de Mello, 2022). Based on the current literature, three gaps still limit a comprehensive understanding of CSCs from a CAS perspective.

Firstly, when studying CSCs, there seems to be a research gap concerning the area of interaction mechanisms. While several studies have debated about forms of collaboration needed for implementing these models, the problems of (1) how to design the CSC network structure and (2) how coordination is obtained between actors in the CSC have been overlooked in the SCM literature, especially from an empirical perspective (MahmoumGonbadi *et al.*, 2021).

Secondly, a gap also seems to exist regarding the characteristics of the environment. While the SCM literature provided different nuances concerning motivations and enablers for implementing CSCs, research remains scattered and single-industry focused. Cross-industry comparisons are still under-investigated, especially from an empirical perspective (Zhang *et al.*, 2021). This represents an opportunity for further research, as an industry comparison would allow a better characterization of different industry environments and a better understanding of CSCM best practices (Luthra *et al.*, 2022).

Lastly, the emerging system properties of CSCs are also understudied, particularly from a value creation perspective. While existing research supported the idea that CSCs are associated with higher environmental and social value creation, it is still unclear what this value is and how it is generated (especially for the social dimension), and further evidence seems necessary (Geissodoerfer *et al.*, 2018).

3. Methodology

To contribute to these three areas, we adopted exploratory multiple case study research to answer the research question presented in the introduction. Case study research fits our purpose of answering *how* and *why* research questions (Yin, 2009), and it seems to be the most suitable approach due to the novel nature of the study and the need to enrich the limited understanding of the phenomenon and observe real industry practices (Barrat *et al.*, 2011). Our cases consider start-up companies in two particular industries – fashion and construction. The relevance of these units of analysis is explained in the following.

3.1 Case study sample: company and industry focus

We made two peculiar design choices in selecting suitable companies for our case study sample.

To answer the call for more empirical, cross-industry research, we first decided to focus our analysis on two industries that could provide solid examples of CSCs: fashion and construction. The construction and housing industries are among the most polluting ones (Adams *et al.*, 2017). In Europe, they generate one-third of the total waste (Eurostat, 2018). Traditionally, these industries rely on a linear take-make-dispose logic, thus generating high pressure related to resource exploitation (Asante *et al.*, 2022). Given the high recoverability of construction materials, there is a high potential for waste generated in demolitions to be revalued, and the design and implementation of CSCs have become an attractive investment for construction companies (Patrucco *et al.*, 2020). Nevertheless, construction projects are characterized by a temporal gap between building construction and demolition, which induces complexity in closing the loop (Christensen *et al.*, 2022). The fashion industry also represents a relevant unit of analysis for the research problem. Companies that operate in this sector use materials and manufacture products that can easily be managed through a closed loop (e.g. through charities and donations; Brydges, 2021). As a result, several companies have implemented interesting initiatives to increase the circularity of their supply chains (e.g. Bukhari *et al.*, 2018; Ki *et al.*, 2020). These supply chains also face several challenges related to social conditions and resource depletion, and the sustainability of their supply chains is continuously scrutinized by the public media (Koszewska, 2018; Hartley *et al.*, 2022).

When deciding the type of organizations to be interviewed in these industries, we opted for start-up companies in Italy. Particularly, we focused on so-called "*born-sustainable start-ups*," i.e. companies whose value proposition is explicitly focused on sustainability since the conceptualization of their business idea. This represents a unique choice for the existing CSCM literature, and it can be considered relevant for three main reasons (Veleva and Bodkin, 2018).

(1) Because start-ups are organizations characterized by less organizational complexity than larger companies, there is the possibility for more precise analysis and characterization of CSC models.

(2) This research aims to use industry examples that can help identify the characteristics of CSCs based on the explicit circular nature of the business model. While large established companies need to manage trade-offs between competitive priorities that prevent them from shaping their supply chain network solely around sustainability objectives, start-ups can focus their value proposition only on sustainability objectives, thus providing a more authentic representation of CSCs.

(3) As start-ups are organizations at the beginning of their life cycle, they also become an interesting unit of analysis to capture the antecedents that push companies to adopt circular business models and how these antecedents lead to CSCs with different features.

Two different motivating factors drove the choice of Italy as a reference country. Firstly – many start-ups build their competitive advantage on their unique value proposition and/or business model characteristics. Consequently, there is a high risk of reluctance to share strategic business features with untrusted people outside the company. For these reasons, we decided to use our network of contacts (in Italy) to increase the probability of participation in the research project and maximize the information quality. Secondly, considering the objective of the study, Italy represents a relevant country to focus on as, according to Dealroom (https://app.dealroom.co/lists/17066), it is one of the European countries with the highest number of start-ups that are currently addressing UN Sustainable Development goals.

Cases were selected using literal and theoretical replication approaches (Yin, 2018). We searched for start-ups that use waste as input in the fashion and construction industries. We were particularly interested in those cases with similar or different features in terms of (1) ease of regeneration and use of waste and (2) type of applications (and customers) following waste regeneration. For instance, regenerated wool, leather scrap and rice waste are easily integrated into existing manufacturing processes, while scraps from marble require more innovative manufacturing processes.

As a result of this process, we obtained interviews and secondary data from five start-up companies (two in the fashion industry and three in the construction industry). Table 1 summarizes the characteristics of the company included in the sample.

3.2 Data collection

We collected information in two rounds of semi-structured interviews with the founding team members of the start-ups.

The two questionnaires adopted for data collection were both organized into two sections, reported in Appendix 1. The first set of questions for the first round of interviews collected general information regarding the company's business model, while the second section captured the main features of the circular business model, the sustainable value associated with such business model, with a focus on the industry-specific environmental and social challenges that the start-up aimed to solve.

In the second interview round, we first included questions to understand more in-depth the traits of the circular business model, its sustainability and the challenges related to waste

Table 1.
Company sample characteristics

Case	Industry	Product	Foundation year	Turnover (2020/2021)	Industry where the major waste is generated	Waste used	Interviewee and number of interviews	Secondary sources used to complement interviews
F1	Fashion	T-shirts, scarves, gloves, etc.	2017	≈2,000,000 €	Fashion	Scraps during production of wool and cotton garments and used garments	Founder (2)	Company website, founder's interviews released in the local and national press
F2	Fashion	Bags and wallets	2015	≈150,000 €	Fashion	Leather scraps	Founder (1)	Company website, founder's interviews released in the local and national press
C1	Construction	Plasters and panels	2016	≈3,000,000 €	Agri-food	Scraps from the production of rice: husks, straw, chaff	Founder (2)	Company website and company presentations shared during a dissemination event
C2	Construction	Paving materials (concrete and asphalt)	2015	≈335,000 €	Mining and construction	Marble, debris and gravel	Founder (1) Head of Marketing and Sales (1)	Company website and company web portal for customers and suppliers (accessed during the interview)
C3	Construction	Bricks	2015	Unclear at the time of the interview	Mining and construction	Marble, debris and gravel	Founder (2)	Company website and technical documents on the technology adopted (shared by the founder)

management that the company faced and needed to handle. Instead, the second set of questions aimed at understanding the antecedents that led the company to develop a CSC, the choices made concerning CSC configuration and the practices used for CSC coordination, with a specific focus on order management.

For both rounds, interviews lasted around 90 min. To properly log data to support the following data coding steps, all the interviews were taped and transcribed under the consensus of the people interviewed (Weston *et al.*, 2001).

3.3 Coding and data analysis

The research team members separately conducted a deductive coding process to label the constructs related to the types of CSC deployed by the different companies in the sample. To assign categories, we considered the studies from Nasir *et al.* (2017), Batista *et al.* (2018), and Farooque *et al.* (2019). They distinguished between closed-loop, open-loop supply chains and a combination of the two. Once we built the proper knowledge about the theoretical constructs, the research team performed independent coding activities and met to converge on the final categories.

Instead, the other relevant variables were analyzed using an inductive coding approach, with categories emerging directly from data without establishing apriori theoretical constructs. The main reasons for developing a CSC were discussed directly through interviews, considering both the industry where the start-ups operated and the industry where the waste was generated.

The coordination role of the start-up was an additional element characterizing the CSC configurations. We inductively identified three roles (that will be described in detail in section 6): (1) the orchestrator, (2) the integrated orchestrator and (3) the circular manufacturer.

These different roles could also be differentiated according to the type of processes directly controlled by the start-ups. We coded this aspect with reference to the SCOR model (Huan *et al.*, 2004).

Table 2 reports exemplary quotes used in this inductive coding procedure.

4. Within-case characteristics

Sub-sections 4.1 through 4.5 describe the different cases and the main elements of their CSCs. Each company is presented according to its coordination role in the CSC. Additionally, we describe each case considering the environmental and social impact that triggered the CSC design. Appendix 2 provides a more detailed representation of these elements.

4.1 The circular supply chain of F1

F1 developed a CSC that follows an open-loop structure, sourcing products from the same industry (but from a different supply chain). The company sources scraps originating from other wool or cotton-based garments manufacturers or post-use from customers. Sourcing from garment manufacturers is made locally and mediated by public enterprises that collect the scraps. Instead, sourcing from final customers and their post-use garments is made through charitable organizations. Manufacturing of F1 garments relies on the existing industrial capacity of the local districts, and it is delegated to players specializing in producing regenerated yarns and fabrics. Orders from the final customers are collected through an e-commerce platform developed by F1.

The fashion industry has a negative environmental impact when sourcing virgin raw materials. Wool and cotton have a natural origin, and the continuous pressure on their usage might cause depletion. For example, cotton cultivations employ a critical amount of water. The production process for fashion garments is subjected to overproduction, resulting in a large

Variable	Type of sources of evidence	Quotation	Codes
Type of CSC	Primary	*"We are a company producing materials for construction, (. . .) we aim to find a new usage for all the materials that are abandoned, like marble, all the residue coming from the excavation of porphyry and granite and also to all the gravel generated during the demolitions of buildings."* Founder of C2	*Open loop* (from two different industries)
Main triggers for designing CSCs as environmental and/ or social impact	Primary	*"We achieve the true environmental impact avoiding burning the by-products from rice production, assigning a new value to them rather than having waste of resources and CO2 emissions"* Founder of C1	Environmental impact
		"The choice (of relying on local manufacturers for regenerated yarns) is linked to a reason of social responsibility, to invest in the creation of jobs locally" Founder of F1	Social impact
Start-up coordination role	Primary	*"In most of the cases we don't get directly in contact with those that generate the scraps, sometimes we choose among the scraps collected, the yarn and the fabrics to be used. Then, we let specialized manufacturers for regenerated yarns of the local district, to realize the garment and we buy the finished product (. . .). We coordinate the work of all these actors"* Founder of F1	Orchestrator
Processes controlled by the start-up	Primary	*"Our choice is to rely on existing processes and capability in the industry (. . .) We rely on 10 processing centers of other companies, we couldn't have owned 10 plants ourselves (. . .) we focus on the R&D."* Founder of C1	Make is outsourced

Table 2.
Example of inductive coding process for the main variables under investigation

volume of scraps and extra inventory. The end-of-life is another critical step in the supply chain of fashion garments, given the high amount of product discarded by final customers.

4.2 The circular supply chain of F2

F2 developed a CSC that follows an open-loop structure. The company uses scraps originating from the production of leather products from other supply chains but within the same industry. F2 buys leather from an industrial district of leather goods manufacturers but does not reuse the leather sold through their supply chain. Thanks to this CSC model, F2 benefits from a decreased pressure on animal adoption, no extra-tannery operations performed and a more efficient assembling process. So, this model avoids several negative consequences traditionally associated with producing leather products. F2 has complete control over the manufacturing activities to produce accessories made from leather scraps, and they have a small shop floor to perform labor-intensive production activities. Leather bags and accessories (such as wallets and belts) are sold through traditional distribution channels. F1 operates in the leather segment of the fashion industry.

Leather has a negative sustainability impact when sourcing virgin raw materials. This unsustainability concerns the animal origin of leather, with slaughterhouse operations characterized by unsustainable practices. Further, in the manufacturing process, the tanning process destroys part of the environmental value, which uses many chemicals and water to produce both liquid and solid waste. Garments, accessories and footwear manufacturing is another stage in the leather goods supply chain characterized by the generation of a large amount of scrapped leather. Finally, end-of-life is another critical process from an environmental point of view, as it is connected to the disposal of toxic substances.

4.3 The circular supply chain of C1

C1 developed a CSC in the construction industry that follows an open-loop structure. The company sources rice husk and chaff from rice mills and rice straw from rice farmers. The manufacturing of plasters and panels is then outsourced to ten local specialized companies that have established partnerships with C1. C1 customers (i.e. construction companies and architectural firms) issue orders through the C1 website, and C1 distributes them.

The rice supply chain (where C1 sources materials) is characterized by a negative environmental impact when sourcing virgin raw materials. The unsustainability in the sourcing phase relates to the depletion of natural resources and the generation of a large volume of scraps by farmers and rice mills, which are currently not revalued. In addition, there is also a share of negative environmental impact during the end-of-life process. On the one hand, in a traditional linear agri-food supply chain, scraps from rice production are generally burnt with consequent CO_2 emissions. On the other hand, the supply chain of construction materials where C1 sells its products (i.e. plasters and panels) destroys a large portion of the environmental value due to an energy-intensive production process.

4.4 The circular supply chain of C2

C2 developed a CSC in the construction industry that follows an open-loop structure. The company sources input materials from other industries and supply chains (such as mines and other construction companies). After sourcing marble scraps, debris and gravel from mines and companies in charge of demolitions, C2 delegates the production of its innovative products to specialized companies. These companies share with C2 investments in specific production technologies to produce innovative products and mix of material (proposed by C2). C2 has also developed a web portal for customers in the construction industry to issue their orders, and the company manages the final product delivery directly to the construction site.

The CSC developed by C2 can reduce several negative impacts otherwise present. The construction and mining supply chains from which C2 source materials are characterized by a negative environmental impact in the sourcing phase. The mining industry indeed suffers from the issue of producing excessive waste during raw material extraction. The negative impact on the environment is due to open-pit storage operations after marble extraction, which, if prolonged, can damage the surrounding landscape. The construction industry, instead, is characterized by the generation of a large quantity of debris and gravel from the demolition of buildings, which are generally collected by companies in charge of the demolition process to be sold to companies producing concrete and asphalt with a traditional method. This traditional method also implies an energy-intensive production process and a negative environmental impact during this phase.

4.5 The circular supply chain of C3

Similarly to C2, C3 sources gravel and debris from the construction supply chain and marble scraps from the mining industry. However, compared to C2, C3 has developed a CSC with an open-loop structure for the flows that come from mines, while a local closed-loop supply chain characterizes the flow of input materials from the construction industry.

C3 proposes bricks with an innovative formula, leveraging an energy-efficient production process. Bricks manufacturing is delegated to specialized companies but with a joint investment in a new industrial press to realize the new proprietary blend. The industrial press to produce bricks can be installed on-site, thus realizing a local closed-loop flow, where bricks for a new building are produced with demolition debris and gravels of the building are demolished on the same site. The main unsustainability aspects of the construction supply chain relate to producing large quantities of waste generated for building demolitions. However, this model (which was still in the pilot stage at the time of the interview) would also offer a solution to the negative environmental impact of transportation. Transporting debris and marble scraps requires polluting and costly logistics operations, generally performed by companies in charge of demolitions, who have transportation as their core business.

Regarding order management, C3 collects orders from customers only in an informal way, without any investment in digital technologies to support information sharing.

5. Cross-case analysis

Table 3 summarizes and compares the characteristics of the cases in our sample concerning the CSC design and their determinants.

5.1 Circular supply chain configuration choices

All the start-up companies in the sample use an open-loop supply chain structure.

For the fashion industry, F1 buys yarns and fabrics regenerated post-use or coming from production scraps or extra-inventories generated by manufacturers in the local district. Garments and yarn that enter the loop are collected from charities and third-sector organizations, except for a small amount that comes from F1's own sold garments, which are taken back to the store after customer use. Overall, the logic of F1 CSC can be considered open-loop, with input and flows coming from the same industry but from different supply chains. F2, instead, adopts a slightly different approach for different products (i.e. leather accessories). The company processes waste and scraps generated within the same industry as part of a new supply chain.

C1 offers a different example of an open-loop supply chain in the construction industry by realizing innovative natural plasters using scraps from rice production. Instead, C2 and C3 combine waste from two different industries: construction and mining. The CSC of C2 follows an open-loop structure since both the gravel and marble scraps do not come from the same supply chain. On the other hand, C3 attempts to build a perfect closed-loop system (although still at the pilot stage), where new construction materials are realized with scraps from a demolished building directly on site.

Both F1 and F2 leverage their strategic location in a relevant industrial district to organize the inbound flows of their CSCs. F1 buys scraps and wool and cotton leftovers from local companies. Then, they either supply these materials to specialized manufacturers that regenerate yarns or buy regenerated yarns and fabrics directly from these companies (but

Table 3. Cross case analysis

		CSC configuration		CSC coordination		Why?
Case	Type of CSC	Inbound supply chain flows	Input materials	Upstream order management	Customer order management	Environmental and social impact that trigger CSC design
F1	Open-loop (same industry, different supply chain)	• 1- Industrial scraps are collected from companies in the textile district by public enterprises or directly from the suppliers that produce regenerated yarns (which, in some cases, directly leverage agreements with the local textile companies) • 2- Charities and other not-for-profit organizations collect post-used fabrics and send them to specialized companies for producing regenerated yarns	• Yarns (1-industrial scraps) • Fabrics (2-post-consumption)	• Regenerated yarns and fabrics are purchased from specialized manufacturers based on customer orders (*Make-to-Order*)	• Customer orders are collected through a proprietary e-commerce system	• Scraps are a waste of resources, and they are generally burned or sent to landfill • The mission is to create a positive social impact by relaunching the local textile district
F2	Open-loop (same industry, different supply chain)	• Leather scraps come from companies in the local district. F2 directly produces bags or wallets from leather scraps	• Leather scraps	• Leather scraps are purchased from time to time, generating stocks. The geographical proximity to the providers of scraps allows the implementation of a *Purchase-to-Order* strategy, when needed	• Orders from final users are collected through an e-commerce platform • Other customer orders are collected using traditional tools	• When disposed of, leather scraps produce toxic substances • Producing new leather products threatens animal welfare

(*continued*)

Table 3.

Case	Type of CSC	CSC configuration: Inbound supply chain flows	CSC configuration: Input materials	CSC coordination: Upstream order management	CSC coordination: Customer order management	Why? Environmental and social impact that trigger CSC design
C1	Open-loop (different industry)	• Farms and rice mills sell scraps to C1 which provides them to specialized players	• Scraps from rice production: straw, husk and chaff	• The husk is purchased monthly from rice mills based on customer orders (*Purchase-to-Order*) • The straw is purchased yearly from farmers based on the forecasted demand	• Customer orders are collected using traditional tools	• Scraps from rice production are generally burned, causing waste of resources and CO_2 emissions • C1 provides construction items that favor higher energy efficiency of buildings
C2	Open-loop (two different industries)	• Marble quarries sell scraps to C2 which provides them to specialized manufacturers • Demolition companies sell scraps to C2 which provides them to specialized companies	• Gravel and marble scraps	• Gravel is purchased from marble quarries and from demolition companies based on customer orders (*Purchase-to-Order*)	• Customer orders are collected through a proprietary online platform	• Gravel is traditionally used to manufacture concrete or asphalt, which are not sustainable products • C2 proposes an alternative, less energy-intensive production process for manufacturing concrete and asphalt

(*continued*)

		CSC configuration		CSC coordination		Why?
Case	Type of CSC	Inbound supply chain flows	Input materials	Upstream order management	Customer order management	Environmental and social impact that trigger CSC design
C3	Open-loop (mining industry) Closed-loop (construction industry, with on-site production)	• Marble quarries sell scraps to C3 which provides them to specialized manufacturer • Demolition companies sell scraps to C3 which provides them to specialized companies	• Gravel and marble scraps	• The start-up is still running a pilot test, but the plan is to purchase gravel based on customer orders, to perform production directly on site (*Purchase-to-Order*)	• Customer orders are collected using traditional tools	• Demolitions generate several debris and extractions from marble quarries lead to a high scrap volume • Stocking debris has a negative impact on the landscape (e.g. scraps end up deposited in rivers) • Transporting debris and scraps increases pollution and it is expensive • C3 proposes an alternative, less energy-intensive production process for bricks

Table 3.

without buying the original raw materials from them). Using a similar approach, F2 also buys leather scraps from companies producing leather in a well-known industrial district in Italy.

C1, C2 and C3 use different approaches to organizing inbound flows. C1 buys scraps from rice production from two stages of the rice supply chain: farmers (to buy straw) and rice mills (to buy husk). Then, these raw materials are supplied with a specific formula designed by C1 for specialized manufacturers. The resulting plasters are then sold using C1's brand. C2 and C3 both buy gravel from companies in charge of demolitions and marble scraps from marble extraction companies. C2 leverages a partnership with a specialized manufacturer to produce innovative asphalt and concrete. In this case, production is outsourced to this single specialized manufacturer but with a joint investment in innovative production technologies. C3 has similar inbound flows (although still in the ramp-up phase), where production is delegated to a specialized company. This company uses production presses (used for traditional bricks) to deploy a distributed manufacturing model, and it produces bricks from scraps at the construction site.

5.2 Supply chain coordination choices

At the time of data collection, coordination and interaction between the different supply chain partners seemed to happen primarily to manage orders effectively.

To manage upstream orders (i.e. orders from start-ups to companies producing waste), all the companies in the sample purchase scraps according to customer orders (following a *purchase-to-order* strategy). For example, C2 purchases gravel from marble caves to produce concrete and asphalt based on the orders received from construction companies. Customers are willing to wait for a longer lead time in all these cases. Exceptions to this strategy are present in C1 and partially in F2. C1 has an agreement with rice farmers to purchase straw yearly, according to forecasted demand and considering the available quantity that the farmers can promise. In practice, farmers plan to harvest the rice straw once per year based on the quantity that C1 plans to use to satisfy the demand of construction companies. F2, instead, purchases leather scraps from time to time but relies on partnerships with local suppliers to ensure order flexibility. This allows the company to obtain timely supplies even when sudden requests occur.

To manage downstream demand, three start-ups (i.e. F1, C1 and C2) collect final customer orders using online platforms. In contrast, F2 collects orders using a showroom, open to final customers and multi-brand shops. Instead, C2 relies on an informal approach to collect orders without the support of digital technologies or other physical assets.

5.3 Environmental and social motivations triggering circular supply chain design

For all the companies included in our sample, the choice to design and implement CSCs is motivated by sustainability issues, i.e. the willingness to reduce the environmental impact of waste or to use the waste to generate a positive impact on the local community. This happens both in the supply chain where the waste is generated and in the supply chain where the waste is used. In practice, the supply chain where the waste is generated poses sustainability challenges that can be addressed and overcome through the design of CSCs. This way companies enhance the sustainability impact of their products by realizing them with waste resources and selling them through the supply chain where the waste is used.

For the fashion companies in the sample, sustainability concerns are mainly present in the sourcing process (i.e. during the raw material extraction phase), given that high pressure is put on these finite resources (such as cotton and wool) and/or because the process to obtain them is considered not sustainable. In the F1 case, for example: *"[. . .] Our value lies in assigning a new life to waste, especially in Europe where there are almost no more raw materials and where raw materials prices constantly fluctuate."* F1 is also an excellent example of the intent to create a positive social value through the design of CSCs. By sourcing from local producers of regenerated yarns and fabrics, the company aims to relaunch the local textile district, which has been suffering from the entrance of bigger international competitors. For F2, instead, the sustainable issues related to the leather sourcing phase include animal welfare and the use of hazardous substances in the tanning process.

For C1, the design of a CSC is pushed by the need to provide a solution to the high amount of waste generated in the production of rice (by farmers and/or rice mills) that, otherwise, would be burnt with a negative impact on the environment. C2 designs a CSC to propose a more durable and fully draining paving system to construction companies as a more sustainable alternative product than the current one. The need to stimulate the local economy and create jobs in the area is also another major trigger for the design of these CSCs. Finally, C3 designs the CSC with the motivation to solve a clear sustainability challenge: reducing the environmental impact that holding debris in stock for too long would have on the area (i.e. rivers and landscape). C1, C2 and C3 are all motivated by the possibility of reducing the environmental impact of the production process of the supply chain where the waste is being generated. These negative environmental impacts consist of the energy-intensive and pollutant production of cement and low energy-efficient buildings in the use phase. Hence, re-processing the same materials to extract new value would not be effective in the construction industry. Using the materials traditionally used in the industry would lead to replicating the same production process, thus not solving the environmental issue that the adoption of radically innovative materials could only solve. As explained by the founder of C2 when describing the properties of newly produced materials: "*[. . .] For every brick realized, we obtain important energy savings. If you think that furnaces work on average at 800°-1,200°, you can easily understand that huge energy consumption is needed to keep furnaces operative, while in our case, we need energy just for a few seconds to compress the material.*" Therefore, in this context, there is the need to innovate more on the material side and to find "substitute" materials that utilized by other industries.

Some consumption or production patterns can increase the relevance of the problem. For instance, in the fashion industry, the high consumption of some items increases the sustainability problem of the depletion of natural resources. In the fashion industry, the production of scraps is associated with overproduction due to overconsumption. In contrast, in the construction industry, waste generation depends on overproduction due to the need to extract a high quantity of raw materials for technical reasons (i.e. C2 and C3).

5.4 The ability of circular supply chains to create social value

As summarized in Table 4, our results also highlight that the cases in our sample developed initiatives to create social value that target different stakeholders.

Our cases show that, when designing CSCs, start-ups aim to create four types of sustainability outcomes: (1) the dissemination of knowledge to young generations regarding their sustainable model, (2) the creation of a substantial impact on the local community, (3) the improvement of social inclusion and well-being of previously under-addressed and marginalized people and (4) the increase of customer awareness about the need for more sustainable production and consumption models. While these outcomes are not present in all the cases, each company showed tangible value creation in at least one of the previous areas. Regarding knowledge dissemination, F2 is the only company that shows an explicit commitment to training future generations of leather artisans with resource efficiency principles by stressing the value associated to waste. Instead, start-ups F1, F2 and C2 are strongly committed to deploying initiatives that create value for the local communities. Particularly, F1 links the creation of social value to the generation of economic value. The company donates part of the product margin originating from the market sales to local not-for-profit associations that support local communities. In other cases (e.g. F2 and C1), the impact on local communities is related to sourcing leather scraps only from companies that belong to a local district (e.g. the leather district in the center of Italy).

Case	Knowledge dissemination to young generations	Impact on the local community	Social inclusion of marginalized people	Spread awareness on sustainable production and consumption model
F1	NA	• Collaborating with local voluntary associations (each sale of F1 products generates a donation to associations operating in the local area) • Contributing to regenerating the local fashion manufacturing district (which has witnessed a loss of jobs and orders)	NA	NA
F2	• Training future generations of leather craftsmen	• Purchasing leather scraps from companies in the local leather district • Continuing the local leather craftsmanship tradition	• Employing young men under house arrest (by collaborating with local third-sector organizations)	NA
C1	NA	• Building a customer base composed of local construction companies	NA	• Effectively communicating the peculiar energy-efficient features of the new bricks
C2	NA	NA	• Employing people with disabilities to develop caskets containing C2 samples (by collaborating with local third-sector organizations)	• Selling products with user manuals where the environmentally friendly properties of the materials are showcased
C3	NA	NA	NA	• Effectively communicating the peculiar energy-efficient features of the new bricks

Note(s): NA = not present in the case

Table 4.
Empirical evidence on the social value generated in each case

For one company in the sample (i.e. C1), social value creation implies inclusivity, with leads to the involvement of marginalized people. This involvement happens thanks to the collaboration with social cooperatives, allowing companies to employ people with disabilities or criminal records.

Due to their investments in highly innovative materials to be used in construction, C1 and C2 also devote specific attention to communicating the specific sustainability features of these materials to final customers.

6. Discussion

The cross-case evidence presented in the previous section allows us to provide a detailed answer to our research question, which also advances the understanding of CSCs from a CAS perspective.

6.1 Why do start-ups design circular supply chains?

All our cases reflects situations where CSCs were initiated by actors (i.e. the start-ups) that were new to the existing supply chains. This evidence reinforces the idea that start-ups (and SMEs) represent successful initiators of CSCs thanks to their ability to implement waste reduction practices, in line with previous research (e.g. De Angelis *et al.*, 2018).

The reasons start-ups set up the CSCs are various and include situations where:

(1) The actors already part of the supply chain do not want, for commercial reasons, to use the waste (i.e. commercial gap, as in the case of F2).

(2) The actors already part of the supply chain cannot sell products realized using the waste (i.e. commercial competence gap, as in the case of F1).

(3) The actors already part of the supply chain do not have the technical/product innovation competencies to use the waste (i.e. innovation/technical competence gap, as in the cases of C1, C2 and C3).

This suggests that start-ups act differently inside open-loop supply chains according to the industry they are part of. Start-up organizations in the construction sector seem to act as know-how providers, bringing technologically oriented solutions that CSCs need to create value from waste and reduce the environmental impact of the industry (Guerra *et al.*, 2021). Start-up organizations in the fashion industry, instead, act more as traditional brand owners as they operate in CSCs to fill a commercial gap, either because the actors already part of the supply chain do not want to initiate a new activity or because they are not willing to develop a new brand (in line with what concluded by Dissanayake and Weerasinghe, 2022).

6.2 How do start-ups create value with circular supply chains?

Effective CSCM should create both environmental and social value. While the impact on the environment is more evident and measurable due to a reduction and better use of the generated waste, the positive implications for society and the community connected with the CSC are more nuanced.

Investing in the design of CSCs can directly contribute to the development of local economies and the survival of industrial districts (as shown in the cases of F1 and C2). However, the mission of start-up organizations to positively impact society can also generate value indirectly, as these organizations can use the new network to increase the social impact of their supply chains. Examples include the employment of disadvantaged and/or socially marginalized people through collaboration with local associations (as in the cases of F1, F2 and C2). These findings corroborate the previous exploratory evidence provided by Geissdoerfer *et al.* (2018), who concluded that, in CSCs, social value creation originates from proactive approaches toward different stakeholders. In line with Geissdoerfer *et al.* (2018), our study concludes that the connection between CSCs and social goals is case-specific. These results also complement Rovanto and Bask (2021), who proposed that start-ups that develop CSCs from their origin (i.e. CE-natives companies) can also implement society-level actions to extend their environmental and social value creation effort.

6.3 How do start-ups coordinate circular supply chains?

When looking at how start-ups coordinate CSCs, our cases suggest that three different roles exist: (1) the orchestrator, (2) the integrated orchestrator and (3) the circular manufacturer. The characteristics of these roles are summarized in Table 5 and differentiated based on the level of vertical integration of manufacturing activities that the start-up has in the CSC.

Table 5. Types of start-up roles in circular supply chains

Start-up coordination role (relevant theories)	Companies	Ownership of the circular supply chain processes Source	Make	Deliver	Description	Antecedents
Orchestrator (transaction cost economics)	F1, C1	Fully controlled	Outsourced	Fully controlled	• The start-up collects the customer needs (by controlling sales and distribution channels) and purchases the material (waste or regenerated) • They coordinate the network of actors to collect the waste and process it	• No changes to the production process • Availability of production capacity • No expertise of the founder in manufacturing activities
Integrated orchestrator (transaction cost economics and shared value)	F2	Fully controlled	Partially controlled	Fully controlled	• The start-up collects the customer needs (by controlling sales and distribution channels) and coordinates the network of actors to collect the waste and process it • The start-up partially owns the manufacturing facilities	• Innovative (sometimes patented) technologies for manufacturing
Pure manufacturer (shared value)	C2, C3	Fully controlled	Fully controlled	Fully controlled	• The start-up collects the customer needs (by controlling sales and distribution channels) • The start-up owns the manufacturing facilities	• No changes to the production process • Availability of production capacity • Strong expertise of the founder in manufacturing activities

For the pure manufacturer role, the start-up controls the waste material collection, the production of new products made from waste and its distribution and sales. For the orchestrator role, the start-up controls the collection of waste materials and the distribution and sales of products while relying on external actors to manufacture products from waste. Finally, for the integrated orchestrator role, the start-up controls the waste collection, distribution and sales while financially supporting external actors to invest in the manufacturing facilities to produce products from waste.

The role of the CSC orchestrator is not new to the literature, as Zucchella and Previtali (2019) already suggested that to develop a circular business model, a focal firm must assume assumes the role of the orchestrator for the entire ecosystem. Our study uses start-ups as a unit of analysis and further distinguishes this coordinator role into three typologies.

To explain why start-up companies choose one coordinator role over the other, we can refer to the combination of transaction cost theory (TCE; Coase, 1937; Williamson, 1975, 1985) and the shared value perspectives (Porter and Kramer, 2011). TCE is based on the idea that when transaction costs are high, companies choose vertical integration (make), while they opt for the market (buy) when transaction costs are low. There are three main drivers of transaction costs, i.e. transaction frequency, transaction uncertainty and asset specificity. Out of these three, asset specificity is the most critical variable (Williamson, 1975, 1985). Under the shared value perspective, companies should align their success with the success of their community, so they should simultaneously act to create economic, social and environmental value (Porter and Kramer, 2011).

The choice of the orchestrator role happens when the start-up (as in the case of F1 and C1) can count on the external production capacity available. The asset specificity of this solution is low, and in line with the TCE, the start-up decides to rely on external manufacturers. Our empirical evidence shows that these external manufacturers are likely to be local. In the case of F1, for example, the company was moved by the intent to revitalize the local fashion manufacturing district (which was suffering from job and order losses). According to the shared value perspective, when a company aims to create both economic and social value for the community, the supply chain design choices tend to favor local businesses.

The choice of the pure manufacturer role relies on different motivations. While the start-up (i.e. F2) can still count on external production capacity available (and low asset specificity), the solution is not to reach out to external manufacturers but to directly govern manufacturing activities related to waste. While this contradicts the TCE principles, this solution can be motivated using the shared value perspective. In the case of F2, in fact, the entrepreneur inherited the company and, moved by the family responsibility to continue running a successful business in the best interest of the employees, decided to directly execute these value-adding activities (that, although labor-intensive, did not require high resource investments).

Finally, the choice of the integrated manufacturer is even more peculiar. Due to the capital needs required to invest in additional construction activities, the TCE theory would suggest that the start-ups (in our case, F2 and F3) directly control manufacturing activities because of the high asset specificity and transaction uncertainty associated with them. However, start-ups are usually unable to sustain such extensive investments, so they collaborate with external manufacturers by co-funding their investments in production resources and machinery (to reduce specificity and uncertainty). Successful collaborations between start-ups and manufacturers are enabled by the potential value creation resulting from the interaction between large incumbent firms and small sustainability-oriented enterprises (Hockerts and Wüstenhagen, 2010; Riandita *et al.*, 2022). On the one hand, integrated orchestrator start-ups rely on large incumbent companies to decrease their investment needs, access additional funding and benefit from a more extensive network. On the other hand, large companies can promote their partnerships with start-ups to obtain or increase their social legitimacy.

7. Conclusions and main contributions of the study

This study presents the results of an empirical analysis of how and why start-ups design and coordinate CSCs.

From a theoretical perspective, our study advances the understanding of CSCs and CSCM from the perspective of CASs (Batista *et al.*, 2019; Braz and de Mello, 2022). Regarding the interaction mechanisms, extending previous literature (e.g. Zuccarella and Previtali, 2019), we conceptualize three different start-up coordination roles that emerged from the data: orchestrator, integrated orchestrator and pure manufacturer. These roles can be differentiated based on the level of vertical integration of the manufacturing activity. The TCE theory and the shared value perspective help better understand why start-ups opt for one role over the others. These two theoretical perspectives are relevant because economic value does not represent the only driver for make-or-buy decisions for the managers in these start-ups. These actors also value creating a social impact on the local community and/or future generations. Additionally, the limited financial means of the start-ups limit their ability to insource manufacturing activities. By focusing on start-ups, our study shows that CSCs are complex systems that can originate from actors that are not part of the current supply chains. This answers the calls by e.g. De Angelis *et al.* (2018) and Rovanto and Bask (2021) for more research on the innovation capabilities of non-traditional companies in deploying CSCs.

Regarding the drivers that push supply chain ecosystems to evolve, our results show that the existence of different gaps in different contexts (i.e. commercial and innovation/technical gaps) pushes start-up organizations (actors outside the original supply chain) to set up and coordinate CSC models with different characteristics. This confirms the idea that the enacted environment of the supply chain generates interdependent changes that, to be handled, can require the involvement of actors within and outside the boundaries of the system (Braz and de Mello, 2022). Last, regarding the emergent system properties, our exploratory results show that CSCs can also create social value – other than contributing to economic and environmental outcomes (Geissdoerfer *et al.*, 2018).

From a managerial perspective, our work can support sustainable entrepreneurs and companies in their mission to generate environmental and social values through their supply chains.

From the point of view of a sustainable entrepreneur willing to invest in sustainable business models, our results suggest several aspects that start-ups can look at to understand how to design CSCs and what role they can play. Particularly, the possibility for a start-up to contribute to developing a profitable CSC is higher when the companies already in the supply chain are not interested in nor possess the technical knowledge to do that. From the point of view of the supply chain actors, our results provide empirical evidence of the value that start-ups can offer in setting up CSC, how they can facilitate the design and deployment of circular networks, and how they can best support them in their actions.

This study also presents some limitations that open opportunities for future research. From a methodological perspective, although a similar sampling strategy has been previously adopted in the SCM literature for multiple cross-industry case studies (e.g. Meinlschmidt *et al.*, 2018), the choice to focus on just two industries limits the coverage of the possible scenarios and the generalizability of the results. From a sample size perspective, having only five companies did not allow finding more than two examples for each category of coordination role of the start-up in the CSC, thus limiting its empirical validity. Further research is needed better to explore the features and nuances of each role, particularly to clarify the different degrees of governance and control of the main CSCM processes by the start-ups. From an industry perspective, future studies should include more industries and cover multiple stages of CSCs to validate and/or expand the categories presented in this study.

Last, our empirical evidence is limited to companies belonging to the Italian context. While start-up organizations are less subjected to country-level variables, and this choice also allowed us to avoid regulatory differences between countries related to start-up companies, we also recognized that this prevented the possibility of capturing other general country-specific factors, such as the characteristics of local industrial districts and cultural aspects more-or-less oriented toward the creation of social value.

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Appendix 1
Interview protocol

Round 1 Interview (to start-ups developing CSCs)

Company and circular business model

(1) Which are the vision and the main values which drive your company?

(2) Which are your key activities, resources, and technology? (Value creation)

(3) Why should customers choose your products? (Value proposition)

(4) Which are your revenue streams and main costs? (Value capture)

Circularity and sustainability value

(1) What does "create value from waste" mean for your company? And how would you define this concept in your sector (fashion or construction)?

(2) Which were the main drivers that led to the conceptualization of your circular business model?

(3) Why have you chosen this industry to implement this business? What characteristics of the industry facilitate the implementation of such practices?

(4) In which ways do you think your company is contributing to sustainable development?

(5) In addition to the main sustainability drivers, do you also implement other sustainable practices in combination with the ones already described? If so, which ones?

Round 2 Interview (to start-ups developing CSCs)

Supply chain configuration and enabling factors

(1) From which companies/actors in the supply chain do you source waste? What types of materials do you purchase (production scraps/production scraps/inventories/products at the end of their useful life)?

(2) Why did you decide on this category of input material? What type of benefits do these input materials provide?

(3) What sustainability challenge/problem is associated with scraps/inventories/end product life used in input? (e.g. production requires a lot of resources that are not wasted; the management of the end of life of these products would pose essential sustainability challenges, etc.)

(4) Why do you think this material is not manageable by the same companies producing it?

(5) What difficulties do you encounter in recovering these materials? Are you coming to try to overcome them?

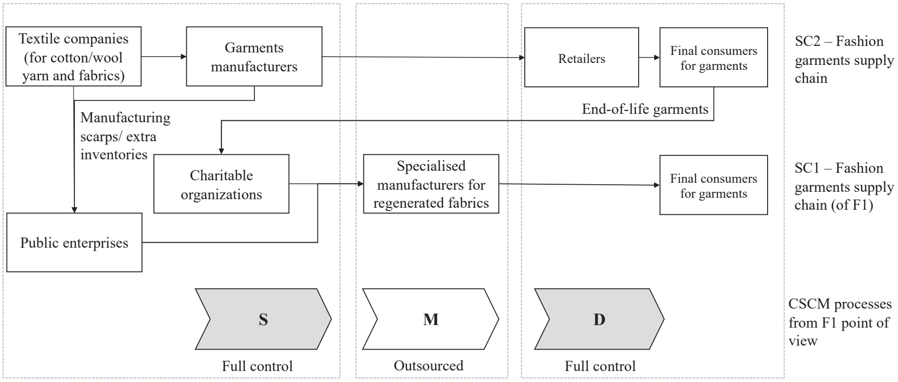
Supply chain coordination, collaboration, and enabling factors

(1) What agreements exist with supply chain partners (e.g. suppliers, any intermediaries, or third-party organizations)?

(2) How do you coordinate with these partners for the withdrawal of materials? How do you usually manage orders from them?

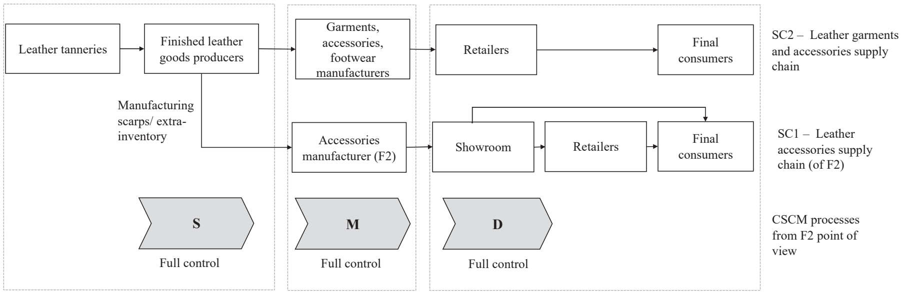
(3) Do you collaborate with these partners to improve processes and/or products?

Appendix 2
Representation of CSCs of the cases in the sample



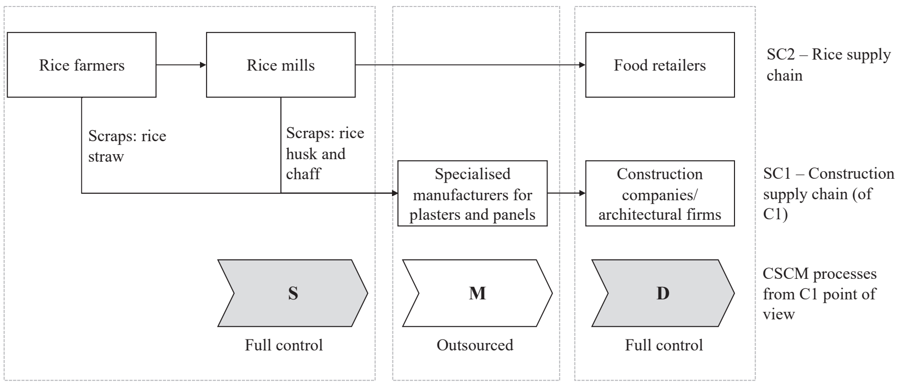
Key: S = source, M = make, D = deliver and sales;

Figure A1.
CSC of F1



Key: S = source, M = make, D = deliver and sales;

Figure A2.
CSC of F2



Key: S = source, M = make, D = deliver and sales;

Figure A3.
CSC of C1

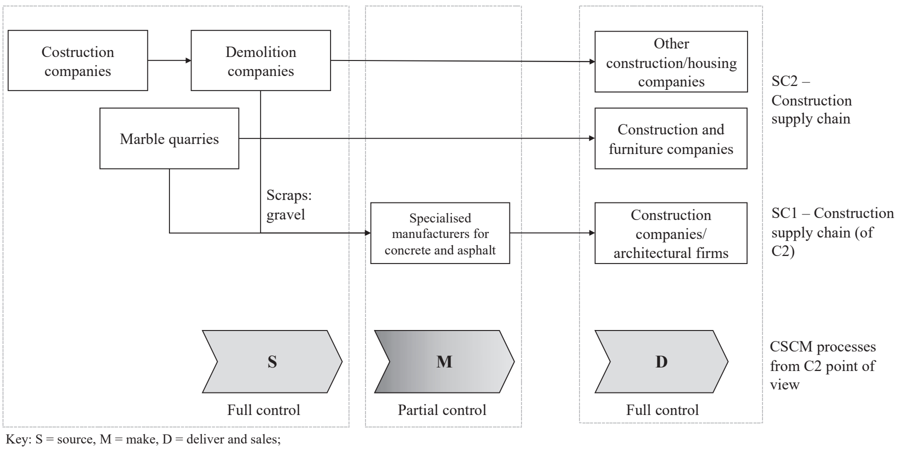


Figure A4.
CSC of C2

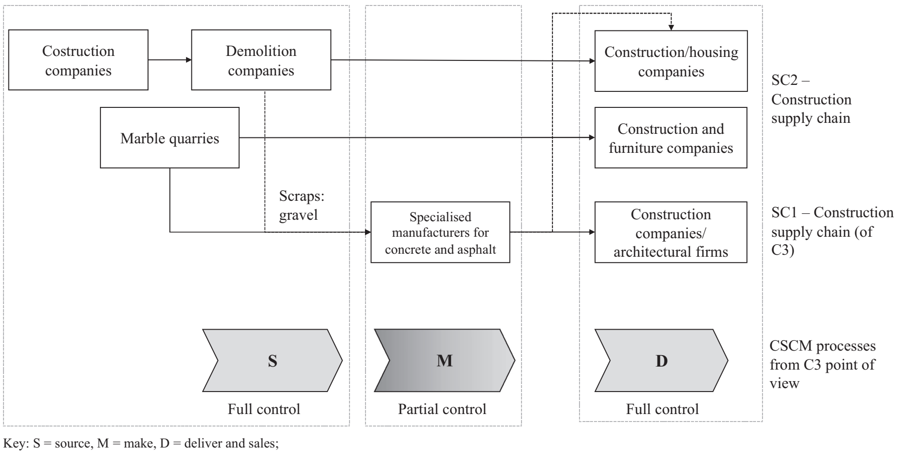


Figure A5.
CSC of C3

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