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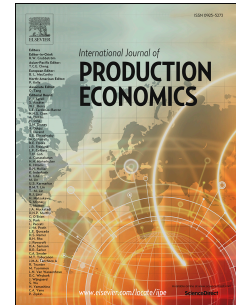## Circular Economy and the evolution of industrial districts: A supply chain perspective

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Circular Economy and the Evolution of Industrial Districts: A Supply Chain Perspective

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Abstract

Circular Economy promises to achieve sustainability by decoupling economic growth from resource extraction and environmental losses. However, it requires a systemic change in the design of products, business models and supply chains. In this study the evolution of the supply chain structure and relationships is addressed in the specific context of industrial districts – i.e., agglomerations of small–medium-sized firms territorially concentrated and specialised in one or more phases of a production process – undergoing a transition to Circular Economy. Through the study of the textile industrial district in Prato (Italy), this study addresses two topics that have been limitedly investigated in the literature. First, the potential role of Circular Economy in revitalising an industrial district in a decline phase. Second, how supply chain structures and relationships should evolve in an industrial district transitioning to Circular Economy. This study outlines the causes triggering industrial districts decline and discusses the factors that can induce a Circular Economy based re-organisation of industrial districts. Consequently, we provide insight to managers on how to successfully couple Circular Economy practices and technological or business model innovations with supply chain management practices. We also provide indications to policymakers on how local and regional actors can support a Circular Economy driven reorganisation of industrial districts. Finally, this study links contributions concerned with the Circular Economy transition, supply chain structure and relationships and evolution trajectories of industrial districts, thus paving the way for a deeper understanding of the interplay among these phenomena.

Keywords: Circular Economy; Sustainability; Supply Chain Management; Industrial Districts; Textile and Fashion industry; Circular Supply Chain

1 Introduction

Circular Economy (CE) is a promising way to achieve sustainability by decoupling economic growth from resource extraction and environmental losses (Genovese et al., 2017), replacing the end-of-life with reuse of products and recycling of materials (Bukhari et al., 2018). The textile industry mostly adopts a traditional linear model, and only 20% of all textiles are recycled worldwide (Ellen MacArthur Foundation, 2017). Each year, it consumes 98 million tonnes of non-renewable resources, over 93 billion m^3 of water and emits about 1.2 billion tonnes of CO_2 (Ellen MacArthur Foundation, 2017; Jia et al., 2020; Sandvik and Stubbs, 2019). Therefore, adopting CE in the textile industry promises an impressive reduction in pollution, greenhouse gas emissions and resource consumption (Sandin and Peters, 2018).

However, moving to CE requires a systemic change in the design of products, business models and supply chains (SC) (Bressanelli et al., 2019). In particular, CE impacts SC structure and relationships, since it requires integrating or interacting with a complex business ecosystem (Batista et al., 2018; Farooque et al., 2019). Despite the growing attention on circular supply chain management, several areas are open for investigation, such as SC integration, collaboration and coordination mechanisms. For instance, coordination and information sharing in CE are hindered because of competition among SC tiers, information sensitivity, poor information system integration, or a lack of SC planning activities (Bressanelli et al., 2019; Govindan et al., 2014).

In this study the domain of SC structure and relationships in CE is addressed in the specific context of industrial districts (IDs). IDs are characterised by the localisation of many small- and medium-sized businesses in a given industry, integrated through a complex network of economic and social interrelationships (Becattini, 1990). IDs tend to follow an evolutionary cycle, encountering growth, maturity and decline phases, following either a linear or an adaptive process. In the last decades, the ID as a socio-economic organisational model has been suffering from the effects of globalisation (Dei Ottati, 2018). As a consequence, several manufacturing IDs

in Western countries are facing decline trajectories. However, features such as proximity and networking foster knowledge spillovers and eco-innovation (Taddeo et al., 2017), and may therefore enable a CE-oriented evolution of IDs. Transitioning to CE has the potential to change the destiny of a declining ID towards new growth. Despite that, neither the potential role of CE in the evolution of IDs nor how CE transition reshapes SC structures and relationships within IDs have been investigated to date in the literature.

Our study stands at the intersection among the three research domains of CE, SC management and IDs, and addresses the abovementioned gaps through two research questions:

RQ1) How can CE turn an ID trajectory from decline to reorganisation and new growth, and through which factors?

RQ2) How do the SC structure and relationships evolve in an ID transitioning to a CE?

To address RQ1 we rely on the adaptive lifecycle model of IDs (Martin and Sunley, 2011) as a conceptual framework and link the literature streams on ID evolution and CE. To address RQ2 we connect the literature streams on ID evolution and circular SC and adopt a SC structure and relationship framework based on Carbonara et al. (2002) and Cannon and Perreault (1999). With these conceptual tools we analysed the Italian textile ID of Prato and case studies of companies successfully implementing the CE paradigm.

The remainder of the paper is organised as follows. Section 2 provides the background of the research. It discusses the notion of IDs and their evolution patterns (Section 2.1); of CE and its potential role in unleashing adaptation and reversing decline trajectories in IDs (Section 2.2); and of SC structure and relationships within IDs (Section 2.3). The research methodology is outlined in Section 3. Section 4 presents the empirical study of the Prato textile ID. Section 5 discusses the RQs. Finally, Section 6 summarises the conceptual contributions, managerial implications and limitations of the study.

2 Conceptual Background

2.1 Industrial Districts and their Evolution

IDs are agglomerations of small–medium-sized firms (SMEs), located in a specific historically determined territorial area, specialised in one or more phases of a production process and integrated through a complex network of economic and social interrelationships (Becattini, 1990). In IDs, institutional players generate positive externalities for local enterprises that both compete and cooperate. In addition, in IDs geographical proximity coincides with social and cultural proximity (Boschma, 2005; De Marchi and Grandinetti, 2014; Knoben and Oerlemans, 2006).

The literature has suggested that IDs follow an evolutionary process. Typical lifecycle models propose a linear evolution through the stages of Emergence, Growth, Maturity, and Decline (Menzel and Fornahl, 2010). However, IDs have multiple possible evolutionary paths (De Marchi and Grandinetti, 2014; Elola et al., 2012; Martin and Sunley, 2011): thus, they may be analysed as Complex Adaptive Systems that shift their form and nature over time, responding to external shocks and recombining resources (Carli and Morrison, 2018; Dei Ottati, 2018; Pendall et al., 2010). The evolution of IDs can therefore be conceptualised through an *adaptive cycle model* (Martin and Sunley, 2011), as illustrated in Figure 1, where IDs follow a process of continuous adjustment through different phases.
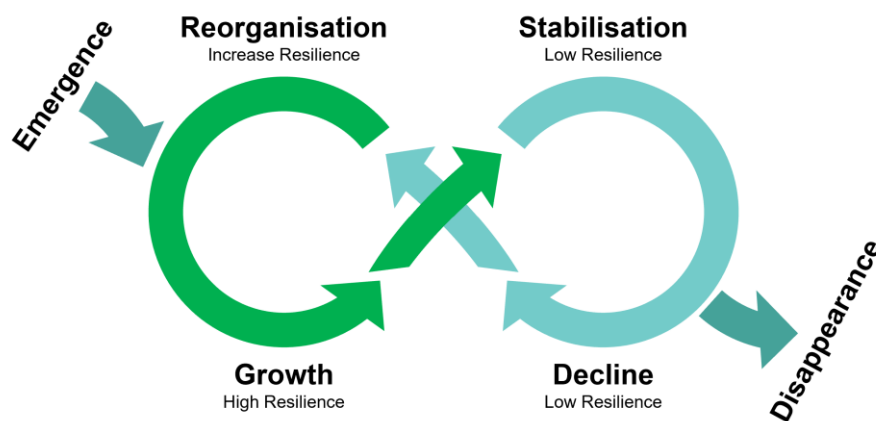

Figure 1 – Evolution of IDs as Complex Adaptive Systems—adapted from Martin and Sunley (2011)

After the initial *emergence*, the *growth* phase is characterised by exploitation and resource accumulation, and the ID rapidly develops. *Growth* is followed by a *stabilisation* phase, in which the ID becomes well-established but also 'rigid'. When a major shock occurs (generally due to the external market, e.g., a prolonged demand stagnation or sudden collapse), the ID enters a *decline* phase, where it contracts (in the number of firms and their relationships) and declines. This either leads to the *disappearance* of the ID or to a *reorganisation* phase of resource reconfiguration, experimentation and restructuring, which eventually entails a new cycle of *growth* and *stabilisation* (Martin and Sunley, 2011). The ID may be replaced by a new one that builds on some of the resources and relationships of the 'previous' ID. In alternative, it can *reorganise* itself around technological innovation or new specialisation in a reorientation process (De Marchi and Grandinetti, 2014).

The concept of resilience explains the capability of IDs to respond to shocks and reorganise (Lazzeretti et al., 2019). During a *stabilisation* phase, resilience is reduced, and IDs limitedly react to external changes. De Marchi and Grandinetti (2014) have indicated factors that reduce the resilience of IDs: the massive advent of migrant workers and hence of a multi-ethnic society, which depletes the sense of belonging to the ID; the discontinuity induced by generational turnover in family businesses; an increased heterogeneity in the ID due to the displacement of capital and entrepreneurial energy towards businesses that are not related to the activities of the ID; globalisation, often resulting in fierce competition with low-cost countries, inducing a contraction in the number of firms that hinders the reproducibility of the ID structure.

2.2   The Role of Circular Economy in the Evolution of Industrial Districts

CE can be approached at the micro, meso and macro levels (Geng and Doberstein, 2008; Ghisellini et al., 2016). At the micro level, embracing the CE paradigm can be a differentiation strategy for a company, and a potential source of growth, increased market share and profitability (Hopkinson et al., 2018). Examples of CE at the meso level are eco-industrial parks and industrial symbiosis. They generate environmental and economic advantages, such as lower resource consumption, raw materials savings and lower treatment costs (Wen and Meng, 2015). The adoption of circular supply chain practices and the design of closed-loop supply chains are also considered

at the meso level (Bressanelli et al., 2019; Masi et al., 2017). At the macro level, the CE paradigm involves cities, regions and nations (Murray et al., 2017). At this level, CE also fits with the ecological modernisation approach, which suggests to reconcile economic growth with ecological sustainability through technological innovation and more efficient production and consumption systems (Leipold, 2021; Sarkis et al., 2011; Sehnem et al., 2021).

The role of CE in IDs has been overlooked to date. Research has explored the potential of CE for a particular cluster (e.g. Oliveira et al. (2018)) without suggesting generalisations or addressing the development of industrial symbiosis on a larger geographical scale (Baldassarre et al., 2019; Martin and Harris, 2018; Taddeo et al., 2017). However, it has been suggested that IDs, given their characteristics of geographical proximity and networking, are suitable environments for implementing and maintaining a CE (Garcia-Muiña et al., 2018; Mazzoni, 2020). Geographical proximity and networking facilitate (environmental) knowledge spillovers and the sharing of resources, thereby enhancing technological and eco-innovation (Cainelli, 2008; Mazzanti and Zoboli, 2008). For instance, Taddeo et al. (2017) suggested that industrial symbiosis may constitute a revitalisation opportunity in the stabilisation or decline phases of IDs. Overall, while the literature suggests that CE may influence ID evolution, studies addressing the role of CE in IDs' evolution trajectories are almost absent.

2.3 Supply Chains within Industrial Districts

An ID can be seen as a collection of supply chains (Carbonara et al., 2002, p. 160), where interdependent relationships (often informal) 'naturally' exist between economic agents (Garcia-Muiña et al., 2018). Therefore, SC structure and relationships are important aspects of IDs, as highlighted in previous literature. Carbonara et al. (2002) proposed specific configurations of SC organisational dimensions across the ID lifecycle phases of emergence, growth and stabilisation. De Marchi and Grandinetti (2014) suggested that the existence of hub firms and the way they organise SC relationships within the ID vary considerably across the reorganisation trajectories of Oligopoly, Hierarchisation and Global-local reproduction. Statsenko et al. (2018) coupled an ID perspective with the analysis of SC structure and relationships and found that there is no simple

hierarchical multi-tiered SC structure, but rather a flexible and dynamic one, allowing for a variety of possible arrangements and connections among companies. Giannoccaro (2015) addressed SC within IDs, and linked SC configurations to learning capabilities as mechanisms to build resilience. Dei Ottati (2018) conceptualised the evolution of relationships among firms in IDs to face globalisation, finding that during a decline phase few firms increase in size and revenues, while many others struggle. The former tend to reorganise the supply chain either by vertically integrating with suppliers or customers, or through long-term contractual agreements with key suppliers (or customers) accompanied by the definition of a hierarchical and multi-tier supply chain structure. Finally, Cannon and Perreault (1999) developed one of the best-established frameworks to characterise buyer-supplier relationships, based on the following aspects: information exchange, the development of operational linkages, the establishment of legal bonds, relationship-specific adaptations and cooperative norms. From this literature overview, and particularly resorting to Carbonara et al. (2002) and Cannon and Perreault (1999), we list in the framework of Table 1 a set of aspects that characterises SC structure and relationships in IDs. However, despite SC structure and relationships within IDs have been studied in the literature, their linkages with a CE-driven reorganization of IDs have not been investigated to date.

Table 1 Supply chain structure and relationships framework (adapted from Cannon and Perreault, 1999; Carbonara et al., 2002)

Supply Chain Dimension	Variable	Description
Structure	Control	Whether hub firms exist and organise their relationships with other firms (suppliers or customers) within the ID. Dyadic if first-level suppliers are considered; external if also second-level suppliers are controlled by the hub firm; network if the hub firm controls horizontal relationships besides the vertical ones.
	Vertical Integration	The extent to which hub firms own the whole production process.
	Contractual power	The extent to which the contractual power is distributed in the network (centralised or decentralised).
	Structural flexibility	The rapidity/ability to responsively reconfigure the SC based on customer needs.
	Type of knowledge	The extent to which the knowledge is tacit or codified.
Relationships	Level of cooperation	The level of cooperation among SC actors.
	Time horizon	The time horizon of SC relationships (short- vs long-term).
	Aim	Whether the aim of relationships is capacity or specialisation.

Information Exchange	The extent of information sharing between SC actors.
Operational linkages	The degree to which systems, procedures and routines have been linked to facilitating operations (independently or intercoupled).
Legal bonds (formalisation of coordination)	Whether relationships are formalised through binding contractual agreements or other governance mechanisms that can be used to simulate hierarchy.
Relationship-specific adaptation	Investments in adaptations to processes, products or procedures, which have no value outside the relations.
Cooperative norms	Expectations to achieve mutual and individual goals about working together.

2.4 Nexus among the evolution of Industrial Districts, Circular Economy and Supply Chain structure and relationships

The above literature review pointed out some gaps in the research at the intersection of the three domains of ID evolution, CE and SC structure and relationships. We argue that knowledge accumulation on these linkages is relevant both at a theoretical and practical level. In fact, IDs as a socio-economic organisational model are at stake in Western economies because of globalisation and related factors. Research should move forward in understanding what factors and dynamics support the successful reorganisation of IDs. CE has emerged as a new paradigm, promising a transformation of industries and society as a whole. This transformation can be applied also at an ID level: being a recent phenomenon, there is the need to develop an understanding of how CE can be related to ID evolution. Moreover, successful CE implementation even at a micro level requires collaboration among supply chain actors (Parida et al., 2019), but SC management in CE entails several challenges (Bressanelli et al., 2019). At the same time it is an under-investigated domain, as CE endeavours have been most often investigated as the efforts of single firms (Bressanelli et al., 2021). Therefore, there is a need to increase the understanding of SC dynamics in the CE transition, especially regarding orchestration and leadership capabilities in closed-loop SCs (Mokhtar et al., 2019). This is of utmost importance within an ID dimension. Exploring how such SC dynamics are enacted at an ID level is fundamental to understand how successful CE transformation cases can be replicated, to entail the transformation of an ID as a whole. At the practitioners' level, insights from research may support decision-making at the macro level, such

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as policymaking by institutions, as well at the meso and micro levels (e.g., suggesting how to successfully move towards CE and integrate SC partners within an ID).

3   Research Method

We focus on the Prato textile ID for different reasons. First, CE transition in the textile industry is most needed but far from being achieved (Shirvanimoghaddam et al., 2020). Second, the SC literature regarding CE in the textile industry generally lacks a systemic perspective (Wiedemann et al., 2020) and rarely investigates the upstream relationships (Mejías et al., 2019). Third, the textile industry in developed economies has historically relied on IDs as socio-economic organisational models, which are now declining (such as the Prato one). Finally, the Prato ID has long-term leadership in the production of regenerated wool.

The empirical investigation was split into three phases. The first phase (Section 4.1) was devoted to understanding how the district evolved and whether it is ready to seize the opportunities generated by CE. We reviewed the scientific (Becattini, 1990; Bellandi, 2011; Dei Ottati, 2018, 2009; Lazzeretti and Capone, 2017) and 'grey' literature (e.g. Confindustria Toscana Nord, 2016) on Prato ID history and evolution. Then we took part in a meeting with delegates of the Prato's Industrial Association and four senior managers/CEOs of district's companies. From the meeting it emerged that the management of buyer-supplier relationships was a key issue needing further empirical investigation.

Thus, the second phase (Section 4.2) aimed at investigating the state-of-the-art of the wool regeneration SC structure and relationships within the Prato ID. We held a meeting with around 50 textile entrepreneurs to discuss, following the framework of Table 1, how SC structure and buyer–supplier relationships were evolving in the district after years of crisis. As a second step, we conducted semi-structured interviews in thirteen companies (**Error! Reference source not found.**) involved in the regenerated wool yarn and fabric production process. The sample included first-tier suppliers (i.e., companies holding the relationship with the fashion brands and coordinating the production process), and phase suppliers (i.e., suppliers of these first-tier suppliers

specialised in a single stage of the production process such as spinning, weaving, dyeing, finishing, etc.). The interviews were conducted face-to-face with the company's owners and/or top managers, within the companies' premises. Interviewees were asked to describe the relationships with their key buyers or suppliers within the ID, as well as the role that CE could play in contrasting the district decline. The main results of the study were presented and discussed with all the participants in a second plenary meeting. Preliminary interviews allowed drawing a clear picture of the state-of-the-art of buyer-supplier relationships and confirmed a generalised interest in implementing CE initiatives and a CE-oriented marketing strategy and narrative.

Table 2 –Companies interviewed in the second phase (PS = Phase Supplier, FTS = First-Tier Supplier)

Company	Turnover 2019 [Euro]	Employees 2019 [#]	Role in the Supply Chain
PS1	1,500,000	17	Carded spinning
PS2	17,800,000	161	Dyeing/Finishing
PS3	12,200,000	60	Dyeing/Finishing
PS4	7,000,000	65	Dyeing/Finishing
PS5	1,000,598	9	Spinning
PS6	3,000,000	32	Weaving
FTS1	11,600,000	12	Yarn supplier
FTS2	11,700,000	53	Yarn supplier
FTS3	8,800,000	49	Fabric supplier
FTS4	5,800,000	23	Fabric supplier
FTS5	13,400,000	35	Fabric supplier
FTS6	21,500,000	39	Fabric supplier
FTS7	24,800,000	34	Fabric supplier

The third phase (Section 4.3) aimed to investigate how SC relationships were managed by three successful companies thoroughly embracing the CE paradigm. This step also allowed gaining a deeper understanding of the potential role of CE as a driver for a reorganisation phase of the Prato ID. Following the second meeting, we selected three companies and conducted a multiple case study (Yin, 2009). Table 3 describes the cases analysed. The case selection was purposive. We chose companies whose excellence was recognised

within and outside the ID, with different degrees of integration, size and position in the SC. Selected companies also have directly and deliberately undertaken circular initiatives in the recent past. We interviewed the companies' CEOs/top managers and triangulated the information collected with secondary sources. The interviews aimed at understanding how companies managed their supplier base, the CE initiatives they were pursuing and how being part of the ID supported or harmed their CE initiatives and their business as a whole.

Table 3 – Companies involved in the multiple case study analysis

Company	Gamma	Delta	Epsilon
Main supply chain role	First-tier supplier	First-tier supplier	Apparel and fashion brand
Employees 2019 (Number)	20–50	< 30	< 20
Turnover 2019 (M€)	around 90	around 30	< 5
Role of respondents	CEO	Top Manager Specialised workers	CEO
Interviews	Face to face	Face to face	Face to face Web Call
Time	2 h 30 min 1 h 30 min	2 h 15 min 2 h 00 min	2 h 00 min 1 h 00 min

4   Empirical Study

4.1   The Prato Textile ID Historical Evolution and the Role of CE

The history of the Prato Textile ID has been the object of a sizeable number of works (e.g., Becattini, 1990; Bellandi, 2011; Dei Ottati, 2018). Referring to the framework of Figure 1, it can be roughly divided into the following phases, summarized in Table 4.

Emergence (prior to 1900–1950) – The Italian city of Prato was established at the end of the nineteenth century as a centre for textile production of international relevance, with a strong specialisation in the production of regenerated wool from rags. Large verticalized companies produced simple and undifferentiated products (plaids, military blankets) with significant cost advantages with respect to competitors using virgin fibres.

Parallel to these large verticalized companies, smaller ones were set up, specialised in single phases of the textile production process.

Growth (1950–1980) – After the Second World War, large verticalized companies became unfit to respond to the rising demand for lighter and more sophisticated products. This led to a deverticalization of the SC. Verticalized companies were progressively replaced by first-tier suppliers relying on a large base of specialised phase suppliers. This new configuration allowed higher volume and mix flexibility, and fostered the diffusion of process and stylistic innovation throughout the ID. From the 1970s, the ID expanded the spectrum of its products well beyond those related to regenerated wool. Between 1950 and 1981 the number of people employed in the Prato ID grew from 22,000 to 60,000, and the number of companies from 800 to more than 14,000 (Figure 2).
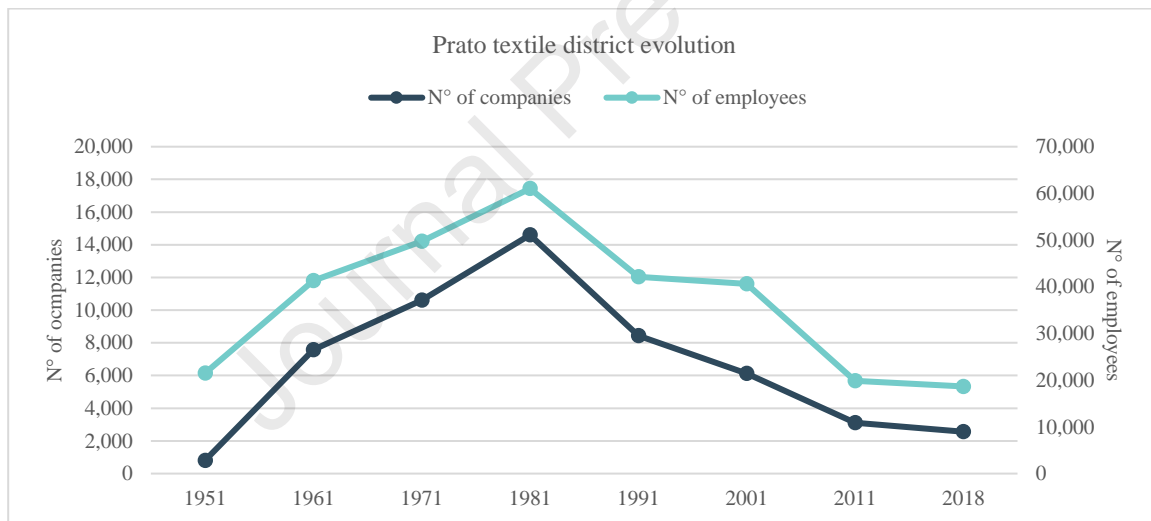

Figure 2 – Prato textile ID historical evolution (source: Centro Studi Confindustria Toscana Nord, 2020)

Stabilisation, Decline and Reorganisation (1980–2000) – After a short stabilisation phase, in which the ID modernised its infrastructure creating a new fully equipped industrial area and a centralised wastewater recycling system, the ID experienced a major crisis. In the second half of the 1980s, new lifestyles, mass motorisation and home heating systems led to a request for lighter clothing fabrics, and consequently to an increase in the demand for cotton, linen and polyester fabrics to the detriment of carded wool. Approximately

37% of the firms in the district closed or went bankrupt. However, the ID responded to this decline vigorously, diversifying its production to include new types of fabrics (such as linen, cotton, silk/linen blends, velvet, viscose, etc.) and strengthening the service content of its offering. The Prato ID thus successfully reorganised and repositioned itself from the historical capital of 'rags' to a fashion district. Such a reorganisation was characterised by substantial economic growth of the companies in the finishing stages, by an increase in the number of first-tier suppliers and by a substantial decrease in the number of suppliers in the upstream phases (spinning and weaving) of the production process. Overall, the number of companies operating in the ID dropped from approximately 9,000 to 6,500, while the number of employees remained quite stable at over 40,000.

Decline #2 (2001 onward) – A second major external shock occurred in the 2000s as an effect of globalisation and was exacerbated by the global recession in 2008. It was caused by several intertwined factors: a recession in Europe, an unfavourable euro/dollar exchange rate, global apparel retailers adopting sourcing policies strongly oriented to cost advantages granted by suppliers in emerging countries (Dei Ottati, 2009), the offshoring of manufacturing processes (chiefly spinning and weaving) by companies in the ID (Scarpinato, 2008) and, finally, an increased import of semi-finished products (raw fabric) from low-cost countries. Again, this decline phase caused the loss of around half of the ID employees (−51%) and companies (−52%) in ten years (2001–2011). Concurrently, Prato experienced a massive wave of incoming migrants, especially from China, setting up a large number of small companies, sourcing fabrics and yarns from *outside* the district, and producing low-cost knitwear and ready-made garments (Dei Ottati, 2009). The opportunity to sell or rent sheds and production facilities to Chinese entrepreneurs encouraged local ones to close down struggling businesses in order to secure less risky real estate returns. These years of crisis and the consequent 'escape from fixed costs' exacerbated the supply chain deverticalization and fragmentation of the production process. While the district keeps high flexibility and service level to the fashion industry, it is limitedly efficient to adequately remunerate all actors in the local SC, especially phase suppliers (Prato Chamber of Commerce, 2014). Furthermore, the distinctive skills related to textile processes are at risk since they are mainly held by people close to retirement,

and a proper generational turnover is not taking place. Skilled Italian workforce is being replaced by immigrant workers with limited experience. This undermines the mix of common language, shared values, meanings and customs constituting a typical success factor of IDs. In 2020, the ID was also hit by the effects of the Covid19 pandemic which led to a decrease of the industrial production by more than 21% compared to 2019 (Confindustria Toscana Nord, 2021).

Current efforts towards CE transition – Within this difficult context, economic and institutional actors operating in the district invested significant resources in CE initiatives to convey an image of Prato as a 'circular' city and textile district. First, each year in the Prato ID about 22,000 tonnes of 'rags' are regenerated, leading to savings of about 60 million kWh of energy, 500,000 m^3 of water, and 18,000 tonnes of CO_2 (Prato Chamber of Commerce, 2019). Additionally, an increasing number of companies are investing in Life Cycle Assessment analyses to objectivise the environmental performances of their production processes, and are certifying their products (yarns, fabrics) with green labels (e.g., the GRS certification). They are also emphasising their circular initiatives in marketing plans. Local industrial associations and other institutions are lobbying for the recognition of a prominent role at the European level for Prato in the treatment of textile waste. Finally, the municipality of Prato has launched several projects focused on sustainability and circularity to promote its image as a 'circular' city and district.

Table 4 - Prato textile ID historical evolution

- Phase	- Period	- Main Facts and characteristics	- Drivers / Factors
- **Emergence**	1900-1950	- Large verticalized companies - Specialisation in the production of simple and undifferentiated products made with regenerated wool from rags	- Cost advantages
- **Growth**	1950-1980	- Deverticalization	- Demand for lighter and more sophisticated products, flexibility in volumes and stylistic innovation

-	**Stabilisation, Decline and Reorganisation**	1980-2000	-	Stabilisation in the number and characteristics of the companies in the ID	-	Request for lighter and innovative clothing fabrics
			-	Bankrupts of 37% of firms		
			-	Diversification to include new fabrics and improvement of the service level		
			-	Import of intermediate products from outside the ID		
			-	Repositioning from the historical capital of 'rags' to a fashion district		
			-	Creation of the district wastewater recycling system		
-	**Decline #2**	2001-onward	-	Loss of around half of the ID employees and companies	-	Globalization
			-	Exacerbation of supply chain deverticalization and fragmentation	-	Massive immigration
			-	Investments in CE initiatives	-	2008 Global recession
					-	Covid19 pandemic

4.2   Wool regeneration Supply Chain structure and relationships: state-of-the-art and issues

The Prato ID successfully implemented a wool regeneration process since 1850 (Borsacchi et al., 2018). Such process allows obtaining regenerated wool fibres from rags and scraps, which subsequently can be used as a cost-effective alternative to virgin fibres for the production of new woven or knit garments (Ravasio and Rodewald, 2018).

The SC structure of the Prato ID is an open multi-tier one, characterised by deverticalization and by the division of labour through a considerable number of phase suppliers and first-tier suppliers, which supply apparel and fashion brands usually located outside the ID (Figure 3). Multi-tier supply chains are characterised by dyadic relationships between the first-tier supplier and several phase suppliers (Mena et al., 2013). In the Prato ID, phase suppliers are industrial or artisan firms that are highly specialised in one or more phases of the production process. First-tier (yarn or fabric) suppliers are firms located within the district that design and engineer the 'intermediate' product (yarn or fabric), buy raw materials and coordinate material and information flows of production processes outsourced to phase suppliers. Therefore, first-tier suppliers sell yarns or fabrics and are responsible for their design and for coordinating a network of phase suppliers. Apparel and fashion

brands buy yarns and fabrics from first-tier suppliers, design and make the final garment. Thus, they have almost no direct contact with phase suppliers.
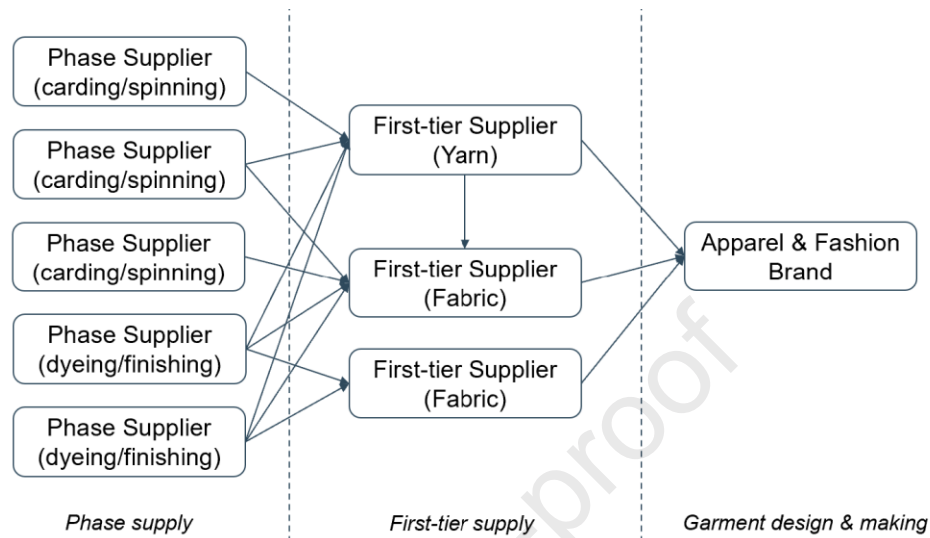

Figure 3 - Prato regenerated wool open multi-tier supply chain

Buyer–supplier relationships are weak on all the aspects referred in our framework of Table 1. Information exchange is often limited to operational issues. The supplier involvement in strategic processes such as the design of the collections is quite rare. The variability and seasonality of the demand makes difficult to share even short-term demand forecasts that would allow phase suppliers to better plan their production. Operational linkages are limited to the administrative process (invoices and payments). Smaller first-tier suppliers, having long lost their manufacturing skills and with little expertise in production planning and control, fail to effectively coordinate phase suppliers. For many years, investments in production equipment (and even more so the relationship-specific ones) have been very limited. Given the great uncertainty that characterises the demand regarding both volumes and mixes, relationship-specific investments expose phase suppliers to great risks. Similarly, first-tier suppliers are reluctant to invest in phase suppliers, since the low volumes they can ensure make the return and appropriability of their investment far from granted (there is a high risk that a supplier tries to saturate its capacity with a competitor). Thus, phase suppliers for years have not upgraded their production equipment to meet the needs of a market that has changed radically (smaller production batches and

reduction of lead times). Obsolete equipment designed for large production batches does not allow achieving operational efficiency. Additionally, rarely phase suppliers proactively take part in R&D processes. Legal bonds are mostly absent. While this is quite typical of IDs, the uncertainty associated with demand has progressively made first-tier suppliers unwilling to make medium-term contractual commitments. As for cooperative norms, the shrinkage of margins made the players unwilling to provide each other with informal guarantees. Generally, there is a tendency to take for granted the availability of phase suppliers and to interact with them on a spot basis. Moreover, since first-tier companies share most of their supplier's bases, it is difficult to protect stylistic innovations and achieve differentiation. Imitations are frequent and unavoidable, as first-tier suppliers often deploy their own employees within the supplier premises to control and coordinate the production process. As an overall result, the squeeze of the margins for the first-tier suppliers turns over on the phase suppliers, which struggle to survive. The majority of first-tier suppliers are too small to invest in marketing and product development (e.g. 80% of fabric first-tier companies have a turnover lower than 10 million €) and, as such, they fail to attract large orders from the fashion industry's top players (Prato Chamber of Commerce, 2014).

4.3   Circular Economy based reorganisation opportunities: a multiple case study

4.3.1   Gamma

Gamma is a first-tier supplier selling fabrics and jerseys to apparel and fashion brands worldwide. It directly carries out the design, sales, marketing and quality control processes, and outsources production to phase suppliers. It progressively achieved impressive financial performances for the Prato ID, with a turnover of around 90 M€ and a ROE of 30% (2019).

Regenerated wool has always been the company's core business. Gamma has created an internal unit devoted to gathering the scraps and leftovers generated by both its phase suppliers—from the spinning phase to the finishing phase—and by garment makers. These scraps and offcuts are then used as secondary raw material for the production of regenerated wool. Gamma coordinates the whole closed-loop SC and allows garment makers to track their (by)products. Gamma has patented chemicals-free, dyes-free processes and developed a

collection of more than 100 no-dye colour recipes. Fabrics manufactured in Gamma are subject to certified Life Cycle Assessment calculation and marketed with a clear quantification of water consumption, CO_2 emissions and energy consumption. The wastewater produced in Gamma's processes is treated and recycled by the district's wastewater treatment plant. Gamma has also set up a corporate academy where professionals and students from all over the world can learn and experience the art of textile making and the values related to sustainability and CE.

Gamma's success has a foundation in its sustainability-focused marketing strategy and in its superior SC orchestration capabilities. Gamma produces a large amount of fabrics (more than 8,000,000 m in 2019), marketed as medium-to-high-end products. Moreover, Gamma successfully manages a zero-mile SC with 50 phase suppliers located in the Prato district. The relationship between Gamma and its phase suppliers is based on long-term agreements with mutual benefits. Phase suppliers are ensured capacity saturation, even in months of low demand. They are financially supported in the upgrade of the production equipment needed to follow Gamma's ever-increasing quality standards. Finally, they receive training and workforce skills upgrade. Gamma, in turn, secures capacity in months of high demand and obtains favourable supply conditions regarding prices, lead times and service level. To facilitate coordination with these suppliers and ensure the visibility of its SC to final customers, Gamma has recently set up an IT platform to exchange production, accounting and environmental data (such as energy and water consumption) with suppliers.

4.3.2 Delta

Founded in the 1950s, Delta is a first-tier supplier of carded yarns and fabrics. Delta regenerates both pre- and post-consumer textile waste, transforming about five million kg of textile waste each year.

Delta has recently undertaken significant circular initiatives. First, to preserve the fragile ecosystem of small and micro companies involved in the collection, sorting and production of regenerated fibres, Delta plays a proactive role in the Italian Recycled Textile Association. Additionally, Delta is setting up a consortium specialising in the sorting of second-hand clothes collected by charitable organisations, which involves about 50

micro enterprises located in Prato. This consortium aims to respond to the new European regulations that require the separate collection of the textile fraction of municipal waste. Finally, to raise awareness about eco-design and CE, Delta has started producing garments designed, in collaboration with a local Art Institute, to be easily repaired and regenerated (non-toxic colours, natural fabrics, no applications of thermo-adhesives or inserts of synthetic materials).

Delta has built its success around upstream vertical integration and its advanced knowledge of regenerated yarn and fabric design. The company owns carbonisation and water-shredding plants, through which it performs the entire process from rags to regenerated wool fibres. This allows Delta to produce regenerated fibres of over 250 colours, which can subsequently be mixed to obtain 'no-dye' yarns with many colour variations and shades. Delta designs its yarns and fabrics and outsources the carding, spinning and weaving processes to phase suppliers. Overall, Delta coordinates more than 10 spinning mills and four weaving mills, mostly located in the Prato ID. Delta products are marketed with a QR code through which it is possible to check the product composition, track the suppliers involved in the production and obtain an independent third-party assessment of product impact regarding water, energy and CO_2 consumption.

4.3.3 Epsilon

Epsilon is an apparel and fashion brand start-up founded in 2017, which designs and sells eco-compatible and fully recyclable garments (sweaters, gloves, socks, towels, shawls) made in Prato almost entirely from regenerated fibres.

Epsilon has involved its customers in its circular business model, engaging them in the collection of used clothes and fostering sustainable and circular lifestyles. To encourage repair and regeneration, customers can return their old cashmere sweaters receiving a 10 € voucher, but only after at least two years from purchase. Moreover, Epsilon allows customers to opt for reusable and returnable packaging: customers can send the package back to a third-party provider in exchange for a 10% discount voucher. Recently, Epsilon has also launched a project to involve customers in garment co-design.

Epsilon's success is to be found in its ability to take advantage of skills available in the ID and exploit the market interest in circular products. The image of Epsilon is intrinsically linked to its artisan suppliers and to the territory they come from (90% of Epsilon's suppliers are located in the ID). All the artisans working with Epsilon sign a code of conduct and are committed to respect the values of sustainability, ethics and transparency. In return, they receive visibility and credits through the company website. Also, Epsilon is committed to reducing inventories throughout the SC and facilitating capacity planning to its suppliers. For this reason, Epsilon refuses to adhere to marketing initiatives such as Black Friday. When launching a new product, Epsilon puts it on pre-sale to facilitate its craftsman production scheduling with longer lead times. Epsilon garments are full of extra-economic meanings, valued by final customers that accept to pay a premium price. This allows fair remuneration of all the SC actors. The linkages between Epsilon, its customers and the local community are further reinforced by social responsibility initiatives: for every purchase, Epsilon donates two euros to a local social project or charity selected by the customer. As an overall result, Epsilon's turnover doubled last year, despite Covid19.

5   Discussion

5.1   Circular Economy transition as a reorganisation trigger for Industrial Districts (RQ1)

The analysis of the Prato textile ID allowed us to specify several internal and external factors that reduce resilience and make IDs more vulnerable. They are listed in Table 5 - Factors that, which also connect them to previous literature on IDs.

Table 5 - Factors that contributed to decreased resilience and led to the decline of the Prato ID

Factor	Classification	Description	Reference in the literature
Globalisation of competition	External	Competition from low-cost countries leads to ever increased pressure on costs and offshoring by some larger companies. Falling demand for woollen fabrics.	(Bellandi, 2011; Chiarvesio et al., 2010; De Marchi and Grandinetti, 2014; Dei Ottati, 2009; Scarpinato, 2008)
Global Recession, Pandemic	External	Factors at a macroeconomic level that hit the markets served by the district contribute to generating shocks.	(Bailey et al., 2010; Bellini and Leonardi, 2021; Lowe and Vinodrai, 2020)

Change in external supply chain structure	External	A growing customers concentration at a global level, with an increasingly focal role and bargaining power by global apparel retailers.	(De Marchi and Grandinetti, 2014; Dei Ottati, 2009)	
Firms' reduction/concentration	Internal	Sourcing of intermediate products from low-cost countries contributes to the reduction of the number of phase suppliers and (very limited) concentration of the "surviving" ones. This may lead to instability and fragility, thus reducing resilience.	(De Marchi and Grandinetti, 2014; Martin and Sunley, 2011; Suire and Vicente, 2009)	
Poor ICT system integration in the ID	Internal	Poor ICT system integration among companies in the district leads to poor coordination mechanisms.	(Bressanelli et al., 2019; De Marchi and Grandinetti, 2014)	
Immigrant labour and entrepreneurship	Internal	Low integration of immigrant workforce decreased cultural homogeneity. Transition from entrepreneurial activities to real estate income by former company owners.	(Dei Ottati, 2009; Lazzeretti and Capone, 2017; Lombardi and Sforzi, 2016)	
Generational turnover	Internal	Young generation unwillingness to take over family-run businesses. Difficult transfer of specialised and tacit skills to young people.	(De Marchi and Grandinetti, 2014; Leal Filho et al., 2019)	

After recovering from the mid-eighties external transformations and crisis, the Prato ID has entered a new decline phase with the new century. Dei Ottati (2009, p. 1818) suggested that the dynamics entailed in the eighties left fragilities exacerbated by the new decline and that '*the semi-automatic adjustments resulting from the normal functioning of the district reproductive processes can be inappropriate to ensure the radical economic, social and institutional changes necessary to trigger a new trajectory of local development'*. A major reorientation that involves single companies, but also the SC and institutional levels, is required to successfully overcome such decline phase.

In this context, we analyse the endeavours towards CE and their contribution to the evolution of Prato ID. The role of CE for ID revitalisation has not been investigated to date, with (limited) exceptions in the domains of industrial symbiosis and eco-industrial parks. Based on the empirical study and referencing the literature, Table 5 lists a set of factors entailed by a CE approach that can contribute to restore resilience and lead to a new reorganisation phase of the ID.

Table 5 – Factors that support a CE-based increase in resilience and reorganisation of the Prato ID

Factor	**ID Classification (level)**	**CE Classification (level)**	**Description**	**Reference in the literature**

Differentiation strategy	Actor	Micro Meso	Moving towards high-end sustainable products and packaging. This is supported by certifications, labelling and traceability.	(Carli and Morrison, 2018; Chaminade et al., 2019; Hopkinson et al., 2018)
Technological innovation and hub firms' investments in CE	Actor	Micro	Case companies invest in (sustainable) processes and technological modernisation, Life Cycle Assessment, marketing activities.	(Chaminade et al., 2019; Dei Ottati, 2018)
Hub firms' investments in supply chain	Actor	Micro	Case companies support (also financially) the modernisation and cultural growth of their suppliers.	(Carbonara et al., 2002; Garcia-Muiña et al., 2018)
Diversification and heterogeneity	Actor Network	Micro Meso	Product: Extension of regeneration processes and sustainable products beyond carded wool (cotton, denim) Supply chain: new 'downstream actors' designing and selling (sustainable) garments from Prato. Knowledge: Integration of external skills.	(Carli and Morrison, 2018; Dei Ottati, 2018; Giannoccaro, 2015; Trippl et al., 2015)
Geographical proximity and networking	Network	Meso	These aspects favour the diffusion of a CE culture, best practices and an innovation mindset within the district.	(Boiten et al., 2017; Garcia-Muiña et al., 2018; Mazzoni, 2020)
Customer engagement	Actor Institutions	Micro	Promoting ethical clothing, local production and sustainable raw materials as valuable aspects improves the brand image of regenerated wool.	(Taddeo et al., 2017)
Local governance and initiatives	Institutions	Macro	Public and private institutions identify a new pattern of development and mobilise resources and consensus on it (e.g., urban regeneration, 'Recò' Festival.	(Boiten et al., 2017; Dei Ottati, 2018, 2009; Taddeo et al., 2017)
Seizing market and industry evolutions	Actor Network	Micro Macro	Green consumerism, new requirements from apparel producers, etc.	(Grazzini et al., 2021)

Factors in the table are classified according to both the CE literature categorisation at the micro, meso and macro levels (Ghisellini et al., 2016), and the ID one at the actor, network and institution levels (Fornahl et al., 2015).

First, CE appears as a differentiation strategy adopted firstly at the micro level by single companies involved in the wool regeneration process, which has not been promoted in the past. This strategy relieves from

cost competition and allows seizing opportunities from evolving consumer habits and new market requirements related to the global movement towards sustainable fashion and waste reduction. This follows the argument that IDs co-evolve with industries and technologies (Maskell and Malmberg, 2007; Ter Wal and Boschma, 2011). Companies within the district also carry out customer engagement initiatives, promoting ethical clothing, local production, collection of used clothes and sustainable raw materials as valuable aspects to improve the brand image of regenerated wool (Grazzini et al., 2021). Once elevated to a district-wide level, this strategy may transform Prato into a hub for the production of high-end sustainable and circular products. Also, increased (concentric) diversification and heterogeneity within the ID stems from CE initiatives. Innovations at the technical and at the business model level become more radical and relate to sustainability goals and heterogeneity of firm competencies (e.g., designing and marketing of their own fashion garment lines). The entry of new firms is typical of the emergence and reorganisation phases (Trippl et al., 2015): company Epsilon and other innovative start-ups in the ID follow these dynamics, which also show movements towards downstream roles in the SC (apparel retailers). Firm heterogeneity is increased integrating external knowledge from non-ID firms at a local or global level (Dei Ottati, 2018; Trippl et al., 2015), as it happens with collaborations between case companies and foreign companies to develop innovations. Besides investing in product and process innovation, leading companies invest in their SC partners, supporting their technological upgrade and moving towards long-term agreements (see Section 5.2). Geographical proximity and networking are features of IDs that facilitate reproduction and growth, and are particularly suitable for knowledge spillovers that trigger eco-innovations and CE initiatives (Cainelli, 2008; Maskell and Malmberg, 2007; Mazzanti and Zoboli, 2008; Trippl et al., 2015). Finally, the role of local institutions (public and private) in identifying the new development pattern (i.e. CE) and mobilising resources and consensus is a key factor for ID growth and precedes evolutionary trajectories (Avnimelech and Teubal, 2006; Boiten et al., 2017; Fornahl et al., 2015). Coordinating ID development efforts is more important when few larger and successful firms that have embraced innovative development paths coexist with many declining SMEs (Dei Ottati, 2018).

Aggregate data at the district level (turnover, number of companies, employees) do not allow predicting whether the Prato ID will grow to a size comparable with the previous decades. However, the dynamics of the economic, political and social environment of the ID, the presence and success of leading companies that have invested strategically in circular initiatives and the factors summarised in Table 5 suggest that CE is a way to trigger a reorganisation and growth phase of a declining ID. This conceptualisation and the factors in Table 5 constitute a main conceptual contribution of the study. They are a first attempt to systematise the links between CE and the evolutionary trajectories of IDs.

5.2 Supply Chain structure and relationships evolution in Industrial Districts favoured by a Circular Economy (RQ2)

SC structure and relationships change as IDs evolve over time, as shown by previous research (Carbonara et al., 2002; Cerruti and Delbufalo, 2009). We provide a picture of the fragmentation of the SC of the Prato ID, characterised by low margins, great uncertainty and poor coordination (Section 4.2). At the same time, case studies of successful companies show possible SC reconfigurations in a CE-driven reorganisation phase of IDs (Section 4.3). Cases point to a hierarchisation pattern (De Marchi and Grandinetti, 2014), characterised by the strengthening and formalisation of SC linkages among companies in the ID under the leadership of a hub firm that acts as an orchestrator (Chen et al., 2021). Orchestrators focus on activating, aggregating and integrating the different suppliers of outsourced activities. Orchestration capability is recognised as a critical success factor in the fashion SC, but generally at the level of the fashion brand and as a way for achieving agility and responsiveness (Christopher et al., 2004). From the case studies we observe that this capability is also activated at the level of first-tier suppliers, and as a way to guarantee stability and reduce uncertainty to phase suppliers. In the paths exemplified by the cases, the suppliers are still located in the district and there is a selection (instead of a depletion) of inter-organisational relations. The combination of our conceptual and empirical analysis led to the characterisation of how SC structure and relationships change in a possible reorganisation favoured by CE, as reported in Table 7 - Supply chain structure.

Table 7 - Supply chain structure and relationship evolution in IDs transitioning to CE

SC dimension	Variable	Decline (Section 4.3)	Reorganisation (Section 4.4)
Structure	Control	Network with little or no control	Network with orchestration
	Vertical Integration	Low	Hierarchisation
	Contractual power	Decentralised to a considerable number of small first-tier suppliers, with no leading firms	Centralised (orchestration by hub, leading firms)
	Structural flexibility	Low	High
	Type of knowledge	Tacit	Formalised
Relationships	Level of cooperation	Low	High
	Time horizon	Very short, leading to a depletion of relations	Long-term
	Aim	Specialisation	Specialisation and Capacity
	Information Exchange	Limited to purely operational issues	High
	Operational linkages	No significant operational integration	Operational process integration
	Legal bonds (formalisation of coordination)	Informal arrangements - Price and conditions are negotiated each time	Long-term contractual agreements
	Relationship-specific adaptation	Almost absent	Incentive mechanisms and adaptation
	Cooperative norms	Perception of mistrust and opportunity attitudes	Work together to provide CE products and initiatives

Specifically, the control of the SC switches from a network structure with poor control on phase suppliers to an overarching orchestration by hub firms. In the decline faced by the Prato district, smaller first-tier suppliers fail to effectively coordinate phase suppliers given their little expertise in production planning and control. In a reorganisation favoured by CE, orchestrating the network of suppliers allows developing mutual trust, commitment and long-term agreements. It also increases information sharing and operational process integration (Parida et al., 2019). Concurrently, vertical integration increases compared to the current, fragmented, open multi-tier structure (Bressanelli et al., 2019), so to fully leverage the expertise on the production of regenerated wool, as exemplified by the case of Delta. The distribution of contractual power moves away from decentralisation, where small first-tier suppliers compete against each other and it is difficult

to protect stylistic innovations, to a centralisation of contractual power in the hands by leading hub firms. Structural flexibility increases due to the greater coordination granted by orchestration (Carbonara et al., 2002). Finally, the type of knowledge switches from tacit to formalised. Knowledge is no longer held by people close to retirement. Instead, phase suppliers receive training and workforce skills upgrade, as exemplified by the Academy project led by Gamma.

At the same time, the level of cooperation strongly increases (Farooque et al., 2019): while in the decline phase we found a low level of cooperation in all the relationship dimensions (e.g. rare supplier involvement in strategic processes such as the design of collections, operational linkages limited to administrative processes, *et cetera*), the reorganisation led by hub firms enables closer process integration with phase and first-tier suppliers (from administration to operations and product development, with early involvement of phase suppliers in the design stage). The time horizon of relationships increases from short-term —where the variability and seasonality of the demand make it difficult to share even short-term demand forecasts with phase suppliers— to long-term, where phase suppliers' capacity saturation is ensured even in months of low demand. Also, the aim of relationships changes from specialisation (due to extreme deverticalization) to a coordinated situation where phase suppliers grant specialisation but also scale by ensuring production volumes to the hub firms. Information exchange, while often limited to operational issues, moves to a higher degree thanks to closer relationships with first-tier suppliers (Fraccascia and Yazan, 2018). Coordination switches from poor formalisation, where legal bonds are mostly absent, to long-term (contractual) agreements between hub firms and phase suppliers (Batista et al., 2018). Concurrently, coordination mechanisms evolve from a market price scheme—where prices and conditions are negotiated each time, leading to the squeeze of margins where first-tier suppliers turn over phase suppliers—to incentive mechanisms that involve operational process integration and relationship-specific adaptions. As exemplified by Gamma, financial support by the first-tier supplier encourages capital investments in up-to-date machinery needed to follow ever-increasing quality standards. Finally, a switch in cooperative norms occurs, from a perception of mistrust and opportunistic attitudes to the recognition by both first-tier and

phase suppliers that only close collaboration can lead to successful CE products and initiatives (Bressanelli et al., 2019).

These changes in the SC structure and relationships are aligned with suggestions from IDs and CE literature, which observe that 'pure-market' relationships are not suitable to integrate a very fragmented production process and master the frequent product and technology changes (Dei Ottati, 2018). Leading firms should adopt a critical role in ecosystem orchestration for a successful CE and environmental sustainability implementation (Chen et al., 2021; Parida et al., 2019).

6   Conclusion

This empirical study of the Prato (Italy) textile ID aims to fill a gap in the literature by investigating the role of CE in driving the evolution of declining IDs towards reorganisation and growth (RQ1) and reshaping the SC structure and relationships within IDs (RQ2). This study provides three main contributions to knowledge at the intersection among the research domains of CE, SC management and IDs.

First, the study adopts a novel approach, bringing together the research perspectives on CE, ID and SC management. While circular SC management is the object of growing interest (Farooque et al., 2019) the relationship between CE and the lifecycle of IDs has been limitedly studied. Moreover, although IDs can be viewed as collections of supply chains (Carbonara et al., 2002), a SC management lens has rarely been adopted to analyse IDs and their evolution (Giannoccaro, 2015; Statsenko et al., 2018). Adopting such an interdisciplinary approach - as advocated by the CE literature (Murray et al., 2017) - allows developing fresh knowledge on such intertwined domains and constitutes a promising perspective for future research.

Second, following an adaptive cycle model perspective on the evolutionary trajectories of IDs (Martin and Sunley, 2011), our findings suggest that a CE transition may reverse a decline trajectory of IDs hit by globalisation and economic crisis towards reorganisation and new growth. The empirical analysis of CE

initiatives and successful companies within the Prato ID induced the identification of factors that foster resilience and renewal, consistently with extant literature on IDs (Table 5).

Third, we investigated the impact of a CE-driven reorganisation of an ID on the SC structure and relationships. We compare the current dominating SC structure and relationships in Prato ID with three cases of companies successfully embracing a CE approach. The cases suggest that a CE transition requires an evolution towards a more hierarchical SC structure (De Marchi and Grandinetti, 2014), and an evolution of SC relationships from short-term and adversarial towards closer coordination. Companies embracing the CE paradigm develop orchestration capabilities and long-term relationships with selected suppliers to mobilise resources, innovation capabilities and secure capacity or even integrate vertically (upstream in the analysed ID). But the reconfiguration of the SC also includes exploring an extension of the district activities towards other roles and the ability to capture greater added value. In the analysed ID, this occurs both with established suppliers marketing their own collections of finished garments in search of higher margins (Dei Ottati, 2009) and start-up companies designing and marketing garments made in Prato orchestrating local suppliers.

Our findings also have implications for practitioners dealing with ID and CE. At the macro level, we confirm the role of public and private institutions in designing and promoting a vision of the ID evolution (towards CE) and fostering a common culture among social and entrepreneurial actors. Local and regional actors also support the CE-driven reorganisation of IDs through policies and funding (Chaminade et al., 2019; Dei Ottati, 2018; Trippl et al., 2015). This aspect should be considered by local and regional policymakers and institutional actors when planning actions, to avoid missing out the benefits of isolated successful CE initiatives. At the micro level, the three main cases show how successful companies couple CE practices and technological or business model innovations with SC management practices, particularly regarding orchestration capabilities. The abstraction of SC structure and relationship evolutions summarised in Table 7 - Supply chain structure should inspire top managers of companies undertaking a CE transition within IDs.

This study presents some limitations that suggest directions for future research. The empirical study is exploratory and limited to one sector (textile) and one specific ID (Prato). More empirical research addressing various geographical areas and industries is required to provide an empirical generalisation of our findings. Moreover, a contingency approach should be adopted to specify the conditions under which CE induces different evolutionary paths and SC structures. For instance, the Prato ID is natively 'circular' in the production of regenerated wool: this simplifies a CE transition of the whole ID. Additionally, a contingency approach should consider other geographical or policy-related factors (such as top-down vs. bottom-up approaches to CE transition (Bressanelli et al., 2020)).

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