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Review

Conceptualising Collaborations beyond Industrial Boundaries: A Literature Review and a Theoretical Proposition to Understand Cross-Industrial Collaborations in the Circular Supply Network

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Abstract: This state-of-the-art review paper aims to provide an overview of the current research in supply chain and management on cross-industrial collaborations. It also formulates a theoretical proposition to study them. This research on cross-industrial collaborations is carried out in the more specific context of the circular economy, as the scale-up of this economic model has the particularity of requiring collaborations between organisations from different industrial sectors, a subject that remains to date relatively unexplored. The paper is divided into two parts. The first part is a literature review. A presentation on current knowledge on supply-chain collaborations for the circular economy is realised, followed by a literature gap exploration of cross-industrial collaborations. The second part is a theoretical proposition. Concepts of the network theory and of the inter-organisational proximity framework and their relevance are explained, followed by a proposition of a combination of the two views to conceptualise cross-industrial collaborations. The objective of this concept paper is to provide a thematic and theoretical background for future studies to understand how to connect non-traditional actors within a supply network, how companies from different industries manage to collaborate, and to assess the opportunities and pitfalls of these collaborations for the scale-up of the circular economy.

Keywords: supply networks; circular economy; collaboration; cross-industry innovation; inter-organisational proximity

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1. Introduction

From the beginning of organised societies until the industrial era, "closing loops" was an integral part of value-creating economies [1]. The industrial revolution, by offering the possibility of providing for human needs effectively and at low cost, opened the Pandora's box [2] of an economic model with infinite growth perspectives in a world of limited resources [3]. While this paradigm has improved the lot of people everywhere, thus becoming synonymous with progress, its negative externalities that will lead them to downfall have long been unanticipated and remain uncontrolled.

Renouncing the dominant model by decoupling resource extraction, waste generation and carbon emissions from economic activity is the circular economy proposition. Companies can contribute to this by operating circular supply chains intensifying, slowing, narrowing, dematerialising and closing the resource loops in their operations [4]. In concrete terms, it means integrating activities of reuse, repair, remanufacturing or recycling to their business models [5]. Collaboration is central to the adoption of the circular economy [6] and recent systematic literature reviews confirm the central roles of collaborative practices among circular supply networks with the particularity of involving non-traditional actors [7,8]. Among them, systemic operations involving collaborations going beyond

traditional sectoral or industrial boundaries could be a lever for scaling up [9,10] as already demonstrated in the adjacent research field of industrial symbiosis [11]. Supporting this point, numbers of private and public initiatives emerge, such as the Circlean-Symbiosis missioned by the European Commission or the Material Marketplace run by the United States Business Council for Sustainable Development, both platforms aimed at connecting the demand and supply of by-products from one industry to another. We also see the publication of recent white papers such as Scaling Up Cross-sector Collaboration for a Circular Economy: Insights from current practice, in 2017 commissioned by the European Union or Germany's transition to a circular economy: How to unlock the potential of cross-industry collaboration, in 2021, ordered by a German business consortium. Another signal is the flourishing of consultancies offering matchmaking services between companies wishing to create innovative circular collaborations. The value offer of their services is to break down the sectoral barriers between firms through the identification of potential players and the management of relationships with yet unknown partners. The range of evidence coming from both research and business practice leads us towards this study. In order to understand and to explain practices in a complex network of collaborating companies it is necessary to draw on several organisational theories and frameworks in combination [12]. It has moreover been recently highlighted that these new perspectives are required to understand emerging supply-chain phenomena such as the ones developing in the sustainable context [13]. For this purpose, constructs of network theory related to connection between distant members of a network, combined with an explanatory framework of the dynamics of inter-organisational collaboration, provide interesting lenses [14–17]. In this paper we aim to answer the three following research questions:

RQ1: What do we know about supply collaborative practices for circularity?
RQ2: What do we know about cross-industrial collaborations?
RQ3: What novel theoretical lenses can be used to explore cross-industrial circular collaborations in the supply network?

In response to those questions, the paper is articulated in a literature review section and a theoretical development section. The literature review first exposes the current state of knowledge in supply management and operations on collaborative circular practices and then explores the literature gap on cross-industrial collaborations in the supply, innovation and management fields, that are to date scarcely studied. These two streams of literature are reconciled through the second section of the paper proposing a conceptual development bringing together constructs of network theory [18,19] and the five dimensions of inter-organisational proximity [20] to conceptualise and explore cross-industrial circular collaborations.

2. Literature Review

This first part is a literature review. We found that there have been recent systematic literature reviews on circular economy research [21], as well as on collaborative practices in circular supply chains [7,8]. We thus deducted that the stake was less to conduct an additional one that would have been redundant than to propose a summary of what has already been established (Section 2.1) and to highlight the gaps in the literature regarding the exploration of circular cross-industry collaborations thus allowing us to justify our research angle (Section 2.2). We then explore this gap with a literature search focused on cross-industry collaborative practices. We detail our methods (Section 2.3) and results (Section 2.4) and discuss a novel perspective to adopt to study them in future empirical research in the context of the circular economy (Section 2.5).

2.1. Background

In a world of limited resources [3], the race towards consumption threatens the Earth system and has resulted in 2022 in the transgression of the sixth of the nine planetary boundaries [22,23], bringing even closer a global disruption of the system disabling the preservation of favourable conditions of human habitation of the planet. Sustainable

development [24], consisting of economic performance guaranteeing along the way social and environmental capital protection and restoration, has become imperative [4]. The reversal of the current economic paradigm requires the full commitment of all actors in society, including companies, whose actions in favour of sustainability are scrutinised by their stakeholders [25]. Paradoxically, but understandably, the management of their supply chains is the key: in the current model supply chains are the instruments through which firms exert pressure on the environment but their sustainable conversion can drastically transform their impact [26].

In this context, the adoption of circular economy is seen as a pathway leading to a more sustainable development and a harmonious society [27]. Our present linear model of production and consumption processes takes in raw materials to generate products to be sold then disposed of along with the waste generated. It allows Humans needs to be met effectively and at low cost but turns out to be the Pandora's box of the industrial era [2]. Yet, long before the emergence and then dominance of this development pattern, closed loops were integral to growing economies [1] and the circular economy proposes to come back to this cyclical, cradle to cradle model [28,29]. The origin of the term "circular economy" is debated [30] and, while its scope varies slightly [31], it can be defined as "a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" [4] (p. 3).

Adopting the circular economy requires companies to redesign their models and operations. Within the immense variety of business models six main patterns have been identified: repair and maintenance; reuse and redistribution; refurbishment and remanufacturing; recycling; cascading and repurposing; and organic feedstock [32]. Reshaping business models towards circularity is enabled by circular supply chains, defined as "the coordinated forward and reverse supply chains via purposeful business ecosystem integration for value creation from products/services, by-products and useful waste flows through prolonged life cycles that improve the economic, social and environmental sustainability of organisations" [33] (p. 10). However, switching from linear to circular encounters a number of difficulties, and the process of transition sees a wide spectrum of political, cultural, human, economic and technological constraints [34]. From the supply-chain point of view, it implies a redesign of products and processes (through standardisation for example), along with a reshaping of all the facets of the operations, including those that are not traditionally considered as value-creation stages (such as end-of-life management). Material and non-material resource flows such as information and finance also need to be reconfigured and the overall circularisation process necessitates significant investment [9]. Despite the obstacles, there are ways towards the circularisation of supply chains, which could be guided by four principles: circular supply chains involve shifts from product ownership to servitisation; they must be integrated into a regional ecosystem that includes SMEs and innovators in order to establish flexible and local loops; these loops must be both closed and open and involve technical and biological cycles; they should be supported through ambitious procurement policies, more binding than legal minimums; and finally circular supply chains are enabled by close collaborative practices with suppliers, product designers and regulators, as well with actors within and beyond their immediate industrial boundaries [9].

The fact that close collaborations are essential to successful circular products and initiatives [6] leads us to a deeper investigation of the dynamics more generally at work in collaboration practices within supply chains. Building long-term relationships with key suppliers is central to supply-chain management [35], and both practitioners and academics have an interest in supply-chain collaboration [36]. Supply-chain collaboration is the sharing of information, the taking of joint decisions and the sharing of benefits and risks between two or more chain members with the aim of achieving greater profitability and customer satisfaction, the idea being to reach these goals with more efficiency by acting to-

gether rather than working alone [36]. Supply-chain collaborations take various forms [35]: they vary according to their degree of commitment [37] and of formalisation [38], and can be vertical (involving suppliers and customers) or horizontal (engaging competitors or NGOs) [39]. When well executed, supply-chain collaborations bring a wide range of benefits, including the decrease of excess inventories, the avoiding of costly bullwhip effects, the enhancing of quality, flexibility and joint innovation. This ultimately translates into a competitive advantage improving the firm's individual financial and overall performance [40] as well as that of the entire chain [41]. Despite their advantages, these collaborative practices have been proved challenging to implement. Among the most commonly encountered difficulties are the inability to determine who to collaborate with, tensions in decision making process and the lack of trust between partners [36,40]. However, these obstacles must be overcome in order to reach a better sustainability of the supply chain. This objective can only be achieved through actions that go beyond organisation boundaries [42], especially in a context where companies are held accountable for the environmental performance of their suppliers [25]. These collaborations are essential for implementing environmental practices [43] and to improve their performance [44]. For example, they contribute to robustness and resilience [45], to lower carbon emissions [46] and to supply-chain sustainable innovation [39,47,48].

As the lack of collaboration is one of the major barriers hindering the implementation of circular models [49], companies shape their circular supply chains in close relationship with their suppliers. Management researchers have repeatedly called for further exploration of the dynamics and implications of collaborative practices [21,50,51]. A recent systematic review of the literature has been performed to make a snapshot of the current knowledge on the subject [7]. It builds on previous work adopting the same approach for sustainable collaborative supply chains [39] and confirms that circular collaborative supply chains can in the same way be distinguished according to whether they implement practices that are internal (for example cross-functional coordination or process integration), external vertical (such as the sharing of information with suppliers and customers) or external horizontal. This last sub-category has been modified to incorporate one of the specificities of the circular supply chain: the integration of unusual key players. While the preceding classification proposed mainly collaborations with NGOs and competitors, this new typology, as already suggested by the literature [52], integrates government, entrepreneurs, innovators, industry associations and research institutions [7]. These non-traditional actors can play a variety of facilitating roles, such as helping to match virgin resource demand and equivalent by-product supply or developing integrated approaches to eco-industrial development [4].

These circular collaborative practices can be distinguished depending on their nature: they can be called relational, operational or so named "stakeholder practices". The relational ones are aimed at gaining a competitive advantages derived from relational rents, that are the general benefits resulting from the relations established with the network [53]. The operational ones are the ones specifically related to supply chain and operations. The "stakeholder practice" ones are those established with the members of the network who are not parties to the collaboration, but who assist the parties in its realisation [7]. In this category we can note for example the entrepreneurs and innovators who provide solutions or technologies helping to achieve circularity. The gathering of these new actors, previously unconnected, allows a greater circular ecosystem innovation by ensuring that challenges are approached with multiple and previously unrecognised angles [48].

It is stressed that future research should take into consideration supply-chain evolutions necessary to reach a greater circularity, one of the most important being the shift from a dyadic perspective to a network perspective [7]. This recommendation is in line with the fact that the business ecosystem should be the appropriate point of view to capture the mechanisms that enable the move towards circularity [54]. This enables a better investigation of the coordination processes between stakeholders and the integration of the diversity of their perspectives, especially if the said stakeholders are diverse [51]. Reinforcing this idea, a same invitation to adopt this level of analysis [52] and to study the distant actors

of the network was made earlier, with regard to the more general objective sustainability of supply chains [55]. Another evolution specific to circularisation is the involvement of unconventional stakeholders [7], among which are economic actors previously unseen within the traditional limits of the supply network. The facilitation of relationships with these new stakeholders can be realised by intermediaries [8]. This is aligned with the principle stating that, in order to transition to a circular value system, secondary material flows need to continuously cross industry boundaries [10]. It echoes that, more broadly, circular supply chains are enabled by close collaboration between partners situated beyond their immediate industrial boundaries [9].

In this background section, we have summarised what we know about collaboration within the supply network for circularity. We explained the circular model and the switch from linear supply chains to circular ones. We detailed collaborative practices in circular supply chains. We emphasised their specifics in terms of involvement of non-traditional actors and the necessity of adopting the perspective of the network for their analysis.

2.2. Gaps and Justification of the Research

We have seen that collaborative practices with non-traditional stakeholders is one of the characteristics of the implementation of the circular model. This echoes one of the main principles of the circular economy, that is the mobilisation of diversity in the development of circular solutions [56]. This diversity brings a plurality of perspectives and a culture of exchange and participatory change to coordinate the development, integration and implementation of circular strategies between all actors and at all societal scales. Among the unusual and diverse stakeholder collaborative practices, some have been investigated more than others. Collaborations with government and the public sector have been studied, as well as those with academic institutions, innovation entrepreneurs, NGOs and competitors. However, despite the call of the literature to explore circular collaborations operating beyond traditional industrial boundaries [9,10], recent literature reviews on the subject have not reported studies of circular collaborations involving different industries [7,8].

We proceeded to a first scan of the scientific literature databases to confirm this gap. We found that there was a field of research related to ours that could provide a first basis for our research and also confirmed the importance of investigating circular cross-industrial collaborations. We have found that most of the knowledge provided about cross-industrial collaborations in a circularity perspective belongs to the field of study of industrial and territorial ecology and more particularly of industrial symbiosis that "engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity" [57] (p. 1). It is therefore a question of cross-industrial collaborations with materials (often by-products) or water and energy loops, within a given territory. It is argued that the subject of our study, circular supply networks, is a rather broader one as it includes more applications of the circular economy (such as remanufacturing or reuse) and is not limited to a circumscribed territory (although there is a recent debate in the literature arguing for an exclusion of this criterion in the term industrial symbiosis [58]). Despite these slight points of divergence in terms of scope, the contribution of industrial symbiosis research to our object of study is indisputable. Particular attention has been paid to scanning the latest developments in the literature [11]. We found a specific focus on the types of industries and their associated co-products most often engaged [59] and the assertion that the diversity of industries is something that industrial parks should strive for [60]. Indeed, research on industrial ecosystems has shown that cultivating a diversity of industries engaged in synergies in a territory can make it more resilient by fostering innovation and the introduction of new ideas [61]. Similarly, the areas with the richest industrial diversity are those with the most companies engaged in symbioses. As a result, these territories have higher rates of recycled resources and higher productivity [62].

These findings in the area of industrial symbiosis thus support our initial premise that cross-industrial collaborations should be investigated further in regard to their potential to reach a greater level of circularity. Nevertheless, these studies were more discussions of the conditions of emergence of industrial symbiosis rather than a specific focus on the matching of distant industrial sectors and how their differences could contribute to the achievement of circularity. We concluded that, despite the contributions of research on industrial symbiosis, studies are still needed to understand the functioning of circular cross-industry collaborations. We therefore decided to conduct a literature review to explore this gap, whose process is presented in the next section.

2.3. Materials and Methods

We set the background for this study in the previous section where we summarised recent reviews of the systematic literature on collaborative circular practices [7,11,39]. A first scan of the literature on the intersection between the circular economy and cross-industry collaborative practices provided some preliminary evidence through studies on the benefits obtained from the richness and diversity of industries represented in industrial ecosystems [11,61,62]. This has confirmed both their potential value to the circular economy in general and the importance of further study of their mechanisms. Not having found any other results related to cross-industry collaborations in the context of the circular economy or sustainability than those related to industrial symbiosis already described in the previous section, we decided to conduct this research in a broad way. We explored cross-industrial collaborative practices as a whole in order to gather as much knowledge as possible on the subject. The literature search took place during winter 2022–2023. The queries were undertaken in the Web of Science database, using combinations of the following key words:

- Related to the cross-industry dimension, we enlarged our research to supposed synonyms "inter-industry" and "multi-industry".
- Related to collaboration, we adopted related key words such as "partnerships", "relationships", "integration", "cooperation", coordination" and "cooperation".
- As our research is at the crossroads of supply-chain and management disciplines, we used the key words of "supply", "operations", "management" and "innovation" in order to capture articles that lay within the two scopes.

The initial search retrieved 1053 articles. After removing results that did not fit our research areas (i.e., that belonged to the fields of engineering, chemistry, materials, computer science, intellectual property law, etc. and were more generally not business and management oriented) the results set was reduced to 479 articles. We then excluded studies that were not peer-reviewed journal articles (i.e., conference proceedings, early access, retracted publications or book chapters) in English language and obtained 342 articles of which we screened the titles, abstract and key words to refine our sample. A vast majority of the articles were excluded because the term "cross-industrial" and other synonyms did not refer to research objects that actually straddled several industrial sectors but to samples where several industrial sectors were represented, reducing the number of articles to 29. Finally, a reading of the content of the articles allowed us to determine whether the research addressed empirical fields that were de facto cross-industrial without this particular dimension and its implications being specifically investigated, or if the studies were conducted on cases where cross-industry collaborations and their specific mechanisms were the object of the research. We have selected the latter option, ultimately reaching a number of 10 articles. Special attention was given to the studies with a sustainability dimension when reading the sample. Figure 1 summarises the literature review steps.

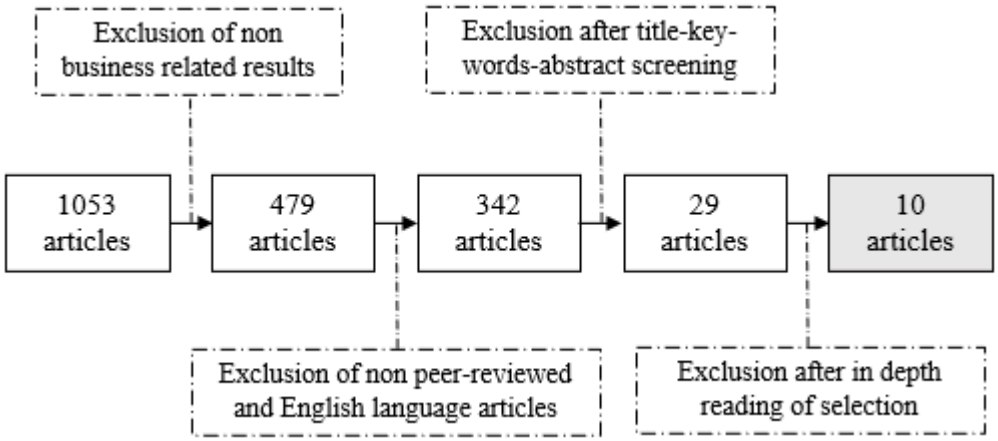

Figure 1. A summary of the literature review steps conducted in this study.

2.4. Findings

The final sample mainly belonged to journals specialised in the management of innovation (R&D Management (3), International Journal of Innovation and Technology Management (1), International Journal of Innovation Management (1), Creativity and Innovation Management (1), Technovation (1), Technological Forecasting and Social Change (1), Strategic Management Journal (1), Journal of Cleaner Production (1)). The small number of articles found allowed an analysis based on an inductive approach to identify the key themes of the research area. The content of the selected papers has been read and summarised below and in Table 1.

At the term of this literature search, we found that cross-industry cooperations lead to significantly more innovative products than traditional approaches [63]. It can be explained by the fact that exchanges that occur without an underlying competition context enable an open learning climate and prevented intra-company power struggles, ultimately resulting in an exploration of wide varieties of perspectives [64]. The theoretical approach of absorptive capacity has often been mobilised to help the firms to prepare to engage in distant collaboration [65] on various fronts. For example, the management of cognitive heterogeneity of firms belonging to distinct industrial background has been discussed. In this context, knowledge transfer operates through an iterative pattern of conveying starting with knowledge discovery, then transits ultimately outcoming to integration [66]. It happens through a process of retranslation [67,68] and a management of the motivation and behaviours of the experts engaged [69]. Another example is the importance of socialisation that has also been highlighted: shared common social activities and personal interactions have been proved to allow a better consideration of the partner's background standards, knowledge and values. They also increase the partner's commitment and ultimately lead to the emergence of a common language with no industry-specific differences [70]. Finally, a specific focus dedicated to facilitators bridging different industries [71] has been realised, resulting in a typology: innovation multipliers, leveragers and broadeners, each relying on a different combination of competencies to either transfer innovations from a sector to another or to coordinate competences from distinct sectors in order to elaborate them. A number of related concepts revolve around the field of cross-industrial collaborations, such as the notion of boundaries work, which is relatively broad, dealing with the collective efforts among organisations [72] and industry alignment [73].

The question of collaborations between stakeholders with diverse profiles for the scale-up of sustainability [74,75] or for optimum resource sharing [76] is still emerging and there are few works that have especially focused on cross-industry collaborations in a sustainable context. The two only examples of the result of our literature review are in the field of the bioeconomy on possible industrial bridges with the very specific sector of agroforestry [77] or for the case of phosphate by-product recovery [78].

Table 1. Overview of the literature themes and findings relevant to our study.

Article	Findings Related to Our Research
On innovation outcomes of cross-industrial collaborations	
Kotabe, M.; Scott Swan, K. The Role of Strategic Alliances in High-Technology New Product Development. *Strategic Management Journal* **1995**, *16*, 621–636.	Innovations resulting from cross-industry cooperations tend to produce significantly more innovative products than products introduced by firms that are cooperating within the same industry [63].
Carraresi, L.; Berg, S.; Bröring, S. Emerging Value Chains within the Bioeconomy: Structural Changes in the Case of Phosphate Recovery. *Journal of Cleaner Production* **2018**, *183*, 87–101.	Among the challenges hindering the emergence of novel value chains are missing complementary competencies and difficulties in integrating different industrial sectors to engage in cross-industry innovation [78].
Heil, S.; Bornemann, T. Creating Shareholder Value via Collaborative Innovation: The Role of Industry and Resource Alignment in Knowledge Exploration. *R&D Management* **2018**, *48*, 394–409.	Differences in the focal and partner firms' industry domains contribute to the value of collaborative innovation. There is a positive relationship between industry distance and investors' valuation of the collaboration's expected future performance [73].
Gattringer, R.; Damm, F.; Kranewitter, P.; Wiener, M. Prospective Collaborative Sensemaking for Identifying the Potential Impact of Emerging Technologies. *Creativity and Innovation Management* **2021**, *30*, 651–673.	Due to the cross-industry approach (without competitors), an open learning climate could evolve, intracompany power struggles were prevented and there was no need to develop a 'common sense', which facilitated adopting a wide variety of perspectives and thinking in scenarios [64].
On knowledge aspects related to cross-industrial collaborations	
Enkel, E.; Gassmann, O. Creative Imitation: Exploring the Case of Cross-Industry Innovation. *R&D Management* **2010**, *40*, 256–270.	Cognitive distance cannot be confirmed as having a positive or negative effect on the innovation outcome in cross-industry innovation [65].
Enkel, E.; Heil, S. Preparing for Distant Collaboration: Antecedents to Potential Absorptive Capacity in Cross-Industry Innovation. *Technovation* **2014**, *34*, 242–260.	Inter-organisational cognitive distance can be measured. Three approaches are proposed to prepare for cross-industrial collaboration based on the degree of technology centralisation and the amount of resources of the firms wishing to engage in cross-industry innovation [66].
Lyng, H.B.; Brun, E.C. Knowledge Transition: A Conceptual Model of Knowledge Transfer for Cross-Industry Innovation. *Int. J. Innovation Technol. Management* **2018**, *15*, 1850043.	Knowledge transfer for cross-industry innovation can be understood as a three-phase process: knowledge discovery, knowledge transit and knowledge integration [67].
Lyng, H.B.; Brun, E.C. Making Your Knowledge Mine: The Integration of External Knowledge in Cross-Industry Innovation. *Int. J. Innov. Mgt.* **2019**, 2050050.	Knowledge adoption in cross-industry innovation is developed through a process of iterations between knowledge conveyance and knowledge convergence until the actors are able to adopt the external knowledge. Retranslation is a highly facilitative communicative enabler to adopt an external knowledge [68].
On social aspects related to cross-industrial collaborations	
Dingler, A.; Enkel, E. Socialization and Innovation: Insights from Collaboration across Industry Boundaries. *Technological Forecasting and Social Change* **2016**, *109*, 50–60.	Socialisation is made of shared social experiences, common activities and personal interactions. Socialisation influences knowledge transfer among industries by enabling the partners' background knowledge, prevalent standards and values to be taken into account ultimately resulting in the knowledge being presented in the partner's industry-specific language. The outcome is the emergence of a distinct language with no industry-specific differences. It increases the commitment of the partner [70].
On intermediaries facilitating cross-industrial collaborations	
Gassmann, O.; Daiber, M.; Enkel, E. The Role of Intermediaries in Cross-Industry Innovation Processes. *R&d Management* **2011**, *41*, 457–469.	There are three types of intermediaries who bridge gaps between industries for cross-industrial innovation: innovation broadeners, leveragers and multipliers. They have different combinations of technological or methodological skills or reliance on their network to either develop cross-industrial innovations or to transfer innovations from an industry to another [71].

2.5. Discussion

We have made progress in our understanding of industrial collaborations. Four themes have been previously explored by the research: outcomes of cross-industrial innovations, knowledge aspects of cross-industrial innovations, social aspects of cross-industrial innovations and cross-industrial intermediaries.

We draw the following conclusions from this literature review: Most of the studies have been carried out at the level of the organisation and the individuals that make it up, and the resulting knowledge therefore focuses on this level of analysis, and it remains

to discover the dynamics at play at the organisational network level. The angle of the supply chain and operations remain uncovered, along with the specificities of sustainable or circular aspects. Although a typology of intermediaries facilitating the elaboration of innovations between different industries or the transfer of innovations from an industry to another has been realised, the knowledge remains embryonic on the emergence of these collaborations, especially concerning the mechanisms of connection between firms of distinct industrial sectors. We argue that further research could explore these current uncovered areas. In a perspective of dissemination of the circular economy conditional on the establishment of collaborations beyond the industrial boundaries of the network, it seems important to study a number of areas among which are the following:

- The mechanisms of connections between companies belonging to distinct industrial sectors (mutual awareness, approach, contact, selection of the relevant partners);
- The mechanisms of functioning of collaborations between companies belonging to distinct industrial sectors (initiation and functioning, dynamics of circulation of resources and information between the partners);
- The facilitating and hindering factors in all these processes.

In this first literature review section, we have summarised the current state of knowledge on collaborative supply practices in the context of the circular economy. We have also reviewed what we know about cross-industrial collaborations, that are a lever for the scale-up of the circular model. We have finally stated that further explorations of mechanisms underpinning cross-industrial collaborations within the supply network need to be realised in order to facilitate their realisation in the objective of contributing to a broader diffusion of the circular model.

3. Theoretical Proposition

This section exposes a novel theoretical approach to analyse the dynamics of cross-industrial collaborations occurring in supply networks and to propose a generalisation of the results.

We recall that one of the principles of the circular economy is its holistic nature: it takes a whole system approach to understand the challenges and the potential of proposed solutions for a sustainable circular economy [58]. This echoes the fact that circular change needs to happen at all scales, with collaborations operating at multiple levels and particularly at the level of the network of organisations [8]. In this sense, the production of research mobilising the network theoretical framework is encouraged [21], as it should have the potential to advance research on circular supply chains [79]. Our theoretical proposal will therefore be based primarily on network theory and we argue in this sense in the following section.

3.1. Network Theory to Understand Dynamics of Resources Circulation and Connection Practices

One specific theoretical framework stands out as particularly suitable for exploring networks in the discipline of supply-chain management as it provides an overview of inter-organisational interactions, emphasises the influence of partner relationships on an organisation's activities and focuses on the fit between organisations that plan to enter into cooperative relationships. This is network theory, which postulates that the performance of a company depends not only on the effectiveness of its cooperation with its direct partners but also on the quality of its partners' cooperation with their own partners. The idea is that cooperation between network members combining their resources achieves more benefits than the sum of each member's individual efforts. Network theory is one of the most relevant tools for the discipline and is used preferentially when mapping supply-chain actors, activities and resources since it emphasises the construction of long-term cooperative relationships between the parties but also their mutual adaptation through exchange processes [12].

These exchanges concern the circulation of resources of all kinds, material and immaterial, between the organisations involved in the network. This circulation takes place

according to dynamics that are based on two major and complementary concepts. The first concerns the "strength of weak ties". According to Granovetter (who anchors his postulate in sociology, i.e., in relationships between individuals), the strength of a tie is estimated according to the amount of time spent together, the emotional intensity and the degree of intimacy between two subjects. Strong ties bring cohesion but, paradoxically, as they are established between individuals who are very close and therefore most of whose interactions take place within their mutual relationship, there is little chance that it is through them that a new opportunity will arise. For this reason, it is the weak links, those established with individuals who are more distant, whose interactions present more of an interface with the outside world, that are the most valuable [19]. Later, he extended his thinking from the level of the individual to that of groups and organisations [80]. In the management discipline, the objects of studies are companies, which are also connected by ties of varying strength. Strong ties are established between firms with a high degree of congruence in their business relationships while ties between companies with less close relationships are comparatively weaker. These companies that are linked through weak ties, however, present strong links with other unknown parties. These yet unknown partners are those who have novel resources towards which these weak ties build bridges. This is the "strength of weak ties" between organisations: the less intense ties are the channels through which the new resources that companies are likely to need circulate. The second concept is that of "structural holes", which follows the same logic. This construct describes how the mesh of a network, its structure, constitutes a competitive advantage for some of its members over others. Within a network, structural holes separate firms whose relationships are not tightly knit together. These firms are often linked by unique ties which means that through this linkage these firms expand their respective networks to a more diverse set of contacts and are the only ones to have access to the resources offered by this connection, that ultimately translate into entrepreneurial opportunities. These companies can therefore act as intermediaries between organisations situated on opposite sides of the bridge they form, and thus broker the flow of information or control the form of projects on opposite sides of the structural hole [18]. When there is a lack of weak ties or structural holes within the networks, it results in a phenomenon of "embeddedness" leading to a low potential for novel opportunities.

Our research is a study of the collaborations between companies belonging to different industrial sectors. These collaborations therefore imply that companies establish links outside their usual field of influence. The resulting network thus has a high probability of weak links or structural holes, opening opportunities to important exchanges. A summary of these concepts and their relevance to our research is presented in Table 2.

The postulate of the strength of the weak ties has been supported in the field of sustainable supply-chain management, where weakly connected network members are pivotal to introducing innovations [81]. Brokers, organisations that bridge two sides of a structural hole, fulfil this role by establishing connections that allow the emergence of new opportunities within the network. The connection practices of brokers have been analysed with a finer granularity in the sustainable context, the outcome being that their positioning in the supply network allows the mobilisation of stakeholders for different purposes. The degree to which they are embedded and the way in which they interface with other nodes condition specific types of exchanges that are of particular use at different stages of the realisation of sustainable initiatives: five types of interfacing with the network have been described, resulting in five types of brokers (coordinator, consultant, gatekeeper, representative and liaison) [82]. These five types of exchanges present different advantages for creating, disseminating and adopting sustainable initiatives. Other facets of the benefits offered by brokers in monitoring sustainability performance or developing sustainability capabilities have been further developed and reported in a recent comprehensive review of the literature on the intersection of network theory and sustainable supply-chain management [83]. The importance of these actors has also been discussed in other related theoretical streams, as in intermediation theory, where intermediaries, actors dedicated

to the support of supply-chain management [84] through the circulation of information, development of knowledge and the management of supply risk [85] contribute to the tackling of sustainability grand challenges [86].

In the more precise perspective of circularity, a first discussion on this type of actor has recently taken place. The constructs of brokers and structural holes have been explored for the facilitation of the circularity of the food supply chain. A first definition of the circularity broker has been established: "circularity brokers are positioned along a supply chain and connect actors with products or materials that have no value to them, on one side, with other actors that can use those products or materials for their own consumption or as inputs for their activities, on the other side. The circularity broker may bring together disconnected parties or link actors who are already tied to one another for certain supply chain activities but are disconnected for the transfer of waste." [87] (p. 6). The authors complete this definition by proposing that circularity brokers bridge the circularity holes through six brokering roles that are connecting, informing, protecting, mobilising, integrating and measuring.

Table 2. Congruence of the subject of the study with network theory.

Network Theory Constructs	Relevance to Circularity and Cross-Industrial Supply-Chain Collaboration
Tie strength	Effective supply networks are those that are aware of their ecosystem, within which all companies matter, even if the links between them are of different strengths. What differentiates strong and weak ties are the number of connections, the frequency of the exchanges and the reciprocity of the ties. Weak ties are the more prone to allow a good circulation of information and resources [19].
Structural holes	In a network, a structural hole appears between organisations who are weakly connected. Structural holes allow novel resources to be accessed and mobilised between organisations positioned opposite to the structural gap [18].
Circularity holes	Building on the concept of structural holes, circularity holes are missing connexions in the supply network. The link through which waste can be transferred to recover its value with another agent is not yet established and there is a potentiality to create circularity [87].
Brokers	They establish ties and are situated across a structural hole. They form a bridge that facilitate knowledge and resource transfer and coordinate efforts on both sides of the bridge they form. Brokers are considered as key players in networks and their specific positioning grants them particular abilities for the development, diffusion or implementation of sustainable initiatives [82].

3.2. Proximity Approach to Understand Mechanisms of Collaboration Practices

Once the challenging work of connexion between companies belonging to different industries is completed, the issue becomes to function properly together. Following a homophily logic postulating that it is easier to interact and a fortiori collaborate with a partner that is different in number of ways, it sounds challenging or less probable for firms to create successful cross-industrial partnerships. Belonging to different industries induces what has been described as a form of distance between firms [65,66].

The notion of inter-organisational distance takes roots in the study of proximity, the spatial distance between two subjects, a construct naturally mobilised in the geographic and economics fields. It was also adopted in a more metaphoric understanding by the discipline of sociology that defines that proximity should be measured through the number and strength of interactions between subjects: between close actors, interactions are more probable and stronger. In the management sciences, the subject was discussed in the early 2000s in France under the umbrella term of "proximity dynamics" [88–90]. Several proximity frameworks coexist and there is a call for a unification of the lenses to perform effective studies of supply-chain problematics [91]. The proximities frame proposed by Boschma [20], that is the more mobilised one, was developed for understanding the mech-

anisms underpinning innovation. It postulates that proximity can be broken down into five subcategories.

- Cognitive proximity, the amount of shared knowledge between actors, as a needed basis to allow communication, understanding and processing information.
- Organisational proximity, the degree of similarity in the style of governance and control of the organisations. It can be extended to the types of channels used to coordinate, transfer and exchange information within and between the organisations.
- Social proximity, the relations formed at the individual level: trust, friendship and shared experiences.
- Institutional proximity, the equivalent of social proximity at the group level: the set of common habits, routines, practices, rules and laws shared by individuals at the collective level.
- Geographic proximity, the spatial distance between actors. This proximity by itself is neither a prerequisite nor a sufficient condition for effective innovation: it facilitates interactions by reinforcing the four other dimensions of proximity.

The proximities frame under its different forms does not have a linear effect: there is an optimal degree for each form of proximity. "Too much and too little proximity are both detrimental to learning and innovation" [20] (p. 7). To function properly, proximity requires some, but not too great, distance between actors or organisations. The different dimensions of inter-organisational proximities and their associated challenges are summarised in Table 3.

Table 3. Forms and features of proximities and management means associated, from Boschma (2005) [20].

Form of Proximity	Key Dimension	Too Little Proximity	Too Much Proximity	Possible Solutions
Geographical	Spatial distance	No spatial externalities	Lack of geographical openness	Mix of local "buzz" and extra local linkages
Cognitive	Knowledge gap	Misunderstanding	Lack of source of novelty	Common knowledge base with diverse but complementary capabilities
Organisational	Coordination and control	Opportunism	Bureaucracy	Loosely coupled system
Social	Trust based on social relations (micro-level)	Opportunism	No economic rationale	Mixture of embedded and market relations
Institutional	Trust based on formal (laws or rules) and informal (cultural norms and habits) institutions (macro-level)	Opportunism	Lock in and inertia	Institutional checks and balances

In the supply management field, the literature has focused on certain dimensions of these proximities with different theoretical approaches, such as cognitive proximity with for example focus on knowledge diffusion [92] or on learning mechanisms within a supply network using the knowledge-based-view theory [93,94]. These approaches are particularly useful as they enable going into the details of the mechanisms of a proximity dimension and grasping its fine workings. The inter-organisational proximity approach is complementary because it allows a coordinated vision of the five dimensions and their potential interactions. However, supply-chain management literature using the proximity lenses remains scarce and is mainly of a conceptual nature. The studies are usually exploratory and operating under the methodology of the case study although their mobilisation can improve the understanding of complex and collective activities of the supply network [91,95] by allowing the study of the intangible dynamics of coordination processes such as the social or organisational factors associated with the different forms of collaboration between firms [58,96,97]. In the specific field of collaborative supply chains, given the expected benefits already cited, the proximities framework seems underused, only once to our knowledge [98], out of the 87 studies censed by a recent systematic literature review [99].

3.3. Combining the Network Theory and the Proximity Approach to Understand Cross-Industrial Circular Collaborations

In a context where it has been stressed that management sciences applied to operations management are becoming increasingly atheoretical, or that theory lies most of the time on the periphery of the inquiry [100], it is encouraged to produce theory-oriented operations and supply-chain research [79,101,102] for the purpose of contributing to make the discipline stronger [103]. One of the proposed areas of improvement is to tackle the lack of variety in the theories mobilised in the discipline by diversifying research paradigms through the mobilisation of underused theories or the creation of new alternative ones [12]. This has been recently emphasised, especially for the study of sustainable supply and purchasing problematics, as "old theories tend to lead to the same focus and the same conclusions. New theoretical lenses are required, which may be borrowed and adapted from other fields, or developed for purchasing and supply management" [13] (p. 5). For the purpose of the vitality of our discipline [103], it is among other things recommended to use several theoretical approaches [12]. For example, two theories can be used to generate complementary research questions [104]. Another example is the use of a combination of theories or rearrangement of constructs belonging to different theories to understand a management phenomenon [14–16].The combination of theories allows to be provided "useful insights" to "generate a coherent, broad, and useful explanation of management phenomena" [14] (p. 16).

We have seen in the previous paragraphs how network theory and Boschma's framework of proximities are both relevant to the study of our research object. We believe that the two approaches can enrich each other. Following the invitation to propose applications of alternative theoretical approaches, we see a potential for lenses combination [16]. This theoretical approach has advantages, such as the ability to create bridges between disciplines when the combined lenses are preferentially mobilised in distinct fields. In this way, it contributes to counter the tendency to create knowledge silos induced by the necessary specialisation of research. The first theoretical pillar of our reasoning, network theory, has been proposed as one of the four most relevant theoretical theories for the supply-chain discipline [12] and its methodological derivative, social network analysis, is the most used in the study of industrial symbioses [11]. The second pillar is the proximity approach. It has been mobilised almost exclusively in the management discipline [90] and the recent emergence of its use [105] has been encouraged [17]. In the case of our study, which is at the crossroads of these two disciplines, this combination serves the purpose of decompartmentalising research and de-siloing knowledge.

To be properly realised, the combination of lenses must be based on two dimensions: their proximity regarding the phenomena they address and the congruence of their underlying assumptions. In this case, proximity refers to the conceptual distance that exists between the phenomena that the lenses address in their original conception. The congruence of underlying assumptions refers to the degree to which the two theories follow the same mechanisms and dynamics, making them compatible [16].

We have already established above that the two theoretical bases have in common the fact of dealing with the description of the complex phenomena of cooperation within the supply network; there is thus a proximity between the two frameworks. It remains to highlight their compatibility. The central assumption of network theory is that "no strong tie is a bridge" [19] (p. 1364) meaning that the weak connections provide the best resources and opportunities. The central assumption of the proximities framework is that "to function properly, proximity requires some, but not too great, distance between organizations"[20] (p. 12). Boschma himself highlighted this congruence when he stated that the firm embeddedness level and its innovative performance follows an inverted U shape [20] and that this "positive relationship between embeddedness and innovation is more or less in line with Granovetter'idea" [20] (p. 15). The compatibility of the assumptions underpinning the theories is thus established and visually represented in Figure 2.

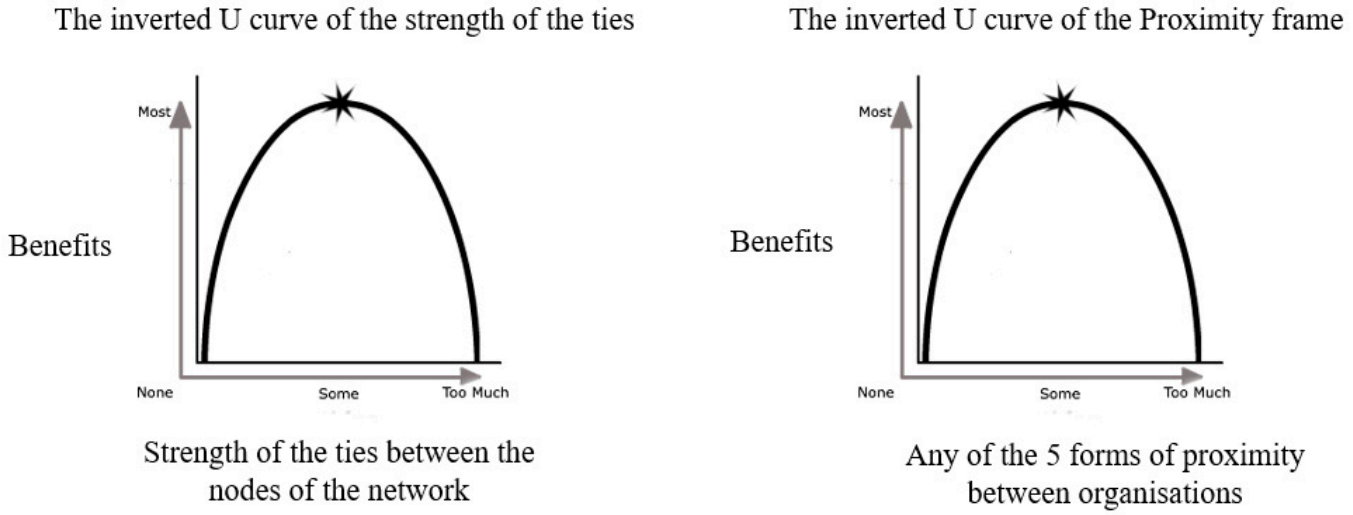

Figure 2. High compatibility between the assumptions of network theory and the proximity framework.

This configuration of high proximity and high compatibility of the two theoretical lenses is the most frequently encountered in theoretical combinations, as it is very straightforward to figure. Its main value is that it allows elaborating on a phenomenon in greater depth by enabling a greater nuance in reasoning. The main pitfall of this combination lies in the fact that it is easy and predictable and, therefore, more than being an actual theoretical contribution it is more usually an explanatory model adopted to observe a developing empirical phenomenon. One way to overcome this and to enhance the value of this type of theoretical combination is to "go the extra mile" and exploit the similarity in phenomena and underlying assumptions fully [16] (p. 5). We propose to move in this direction by building on the extension of network theory operated by Saunders et al. (2019) [82] that elaborated a categorisation of brokers according to their position in the network. Beyond this typology, the authors proposed that these specific places in the network offered different efficiency potentials in the performing of brokering missions. For example, the greatest added value of a broker occupying the liaison position consists in the creation of the sustainable initiative, while that of a coordinator is to putting it into practice [82]. This can be explained by the degree of embeddedness of these types of brokers: a broker with little embeddedness (e.g., a liaison), i.e., linked by weak ties to the companies in the network, imports elements to which it has access, such as new resources or contacts or, more simply, innovative ideas. It is therefore more likely to create and develop sustainable initiatives. On the other hand, an embedded broker (e.g., a coordinator) has strong links with the members of his network and contributes not to the access to new resources within his network but to its cohesion. Its added value therefore lies in the process of assimilation of the sustainable initiative within his network. Figure 3 summarises the types of brokerage exchanges and their implications.

We propose that Boschma's framework of proximities allows for a finer reading of the specific capabilities of brokers that arise from their position in the network. In the case of our study of collaborative practices between firms belonging to different industries with a view to circularity, we propose that brokers allow for the establishment of an adequate proximity so that cross-industry collaboration can take place. We develop this idea below.

Broker Type / Force to facilitate	Coordinator Exchange	Consultant Exchange	Liaison Exchange	Representative Exchange	Gatekeeper Exchange
The development of sustainable initiatives (i.e.: creating the initiative)			+++	+	++
The adoption of sustainable initiatives (i.e.: turning the initiative to practice)	+++	++		+	

Figure 3. Brokerage exchange types and associated forces for sustainability initiatives management, adapted from Saunders et al. (2019) [82].

A liaison broker acts as an agent between parties, as an intermediary [82]. To do this, it has the right position between two networks to create a bridge: it creates weak links between these two networks, i.e., a bridge through which resources, contacts or ideas from both networks can flow. In the cross-industrial supply network, it is probably the agent through which the connection between the two sectors takes place. As the industrial sectors are by nature distant, and therefore different in several dimensions of proximity, we postulate that it probably acts on all the proximities. The liaison broker is the least embedded and therefore the most versatile: it could create a large number of different proximities and covers a wide proximity amplitude. A coordinator-type broker ensures that members of the same group function together harmoniously [82]. It does this by leveraging the strong ties it has within his network. This implies that there is a great deal of knowledge and mutual trust between it and the other members and is ideally positioned to facilitate the adoption of circular collaborative practice within that network. He does this by aligning within the network the internal processes between different members so that collaboration can take place. The coordinator type broker is the most embedded, his added value could consist in creating cohesion within an already formed group. Proximities are a prerequisite for its actions, and it can only act on small amplitudes of proximities and only on a limited number of them. These theoretical intuitions will have to be confirmed in further empirical explorative studies.

In this theoretical part we have first outlined notions from network theory. The concept of brokerage explains the mechanisms of connexion and bridging between members of the network. The strength of the weak ties describes the dynamics of circulation of resources and information within the network. We then followed with a description of the proximity framework and the five dimensions of proximity to be managed for fructuous interactions between organisations. Finally, we proposed that the theoretical combination of the two theories could help to conceptualise cross-industrial collaborations in the objective of the diffusion of the circular economy model.

4. Conclusions

This paper sought to address three questions: What do we know about supply collaborative practices for circularity? What do we know about cross-industrial collaborations? What novel theoretical lenses can be used to explore cross-industrial circular collaborations in the supply network?

The paper makes contributions to the literature related to business collaboration. First, it summarises the current knowledge on collaborative practices in supply networks for sustainability and circularity. Then, it completes with a review on cross-industrial collaborations, concluding that the large body of knowledge on the subject falls within the field of innovation management. Within this scope, the cognitive and social factors

underpinning the mechanism of knowledge transfer between firms from distinct industries have been explored. It therefore argues that other aspects of collaborations should also be explored, that the perspective of the supply network should be adopted and that the specificities related to sustainability and circularity should be studied. Although the role of intermediaries facilitating collaboration by bridging different industries for the purpose of innovation was examined, the research should also investigate how these collaborations emerge and function.

The paper makes a theoretical contribution. It formulates a theoretical proposition through a combination of the network and the proximity views that can offer a finer analysis of collaborations. Analysing the resources circulation and brokerage exchanges at play in the organisational network with the reading grid of the proximity framework can help to manage the cognitive, organisational, social, institutional or geographical factors at work between the partners of the collaboration.

Building on this work, future empirical studies could explore further cross-industrial supply networks and enlighten the potential opportunities and pitfalls of these collaborations for circularity purposes. Research could unveil the mechanism of emergence of these collaborations by studying the factors facilitating mutual awareness, approaches, contacts and selection of potential partners to a collaboration. The mechanisms of functioning of these collaborations, their initiation, their operation and their outcomes could also be studied. Studies of the specifics of the circularity broker function should be envisaged, through an analysis of the proximities management they perform for the collaborations that they support. Other theoretical angles, such as the absorptive capacity lenses, could also be adopted to complete preceding studies and dive further into the mechanisms of emergence and management of collaborations between distinct industrial background partners. This future research could lead to a framework linking the capabilities of circularity brokers to issues arising in the specific cross-industrial context.

Future research on cross-industrial collaborations and their mechanisms could contribute to practitioners by providing elements to guide their decision-making process in partner selection and management. Analysis of tangible and intangible factors at play in collaborations between organisations could help them to activate geographical, cognitive, organisational, social and institutional levers to optimise their operations and their performance. Eventually, by enhancing the potential of success of circular cross-industrial collaborations, these studies could contribute to a broader implementation the circular economy model.

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