Unpacking the Relationship Between Circular Economy and Interorganizational Collaboration: An Exploratory Study and an Analytical Framework

Silvia Lisi, Benito Mignacca, Michele Grimaldi, and Marco Greco

***Abstract*—Collaboration among different organizations could be a vital enabler of a circular economy (CE). However, few studies examine the role of interorganizational collaboration in CE initiatives. Particularly obscure is the relationship between different types of interorganizational collaboration and specific CE initiatives. This article explores such a relationship in the automotive sector through a content analysis of 73 nonfinancial reports disseminated by the world's largest automakers in 2021 and 2022. This article shows that focal firms primarily leverage interorganizational collaboration with suppliers to implement CE initiatives, mainly recycling and reducing initiatives. Focal firms relatively often collaborate with multiple actors and customers to implement CE initiatives, particularly recycling initiatives. Of note, collaboration with universities and research institutes plays a minor role in CE initiatives, assuming only a relatively higher relevance in CE initiatives with the highest degree of circularity. Last, this article provides a novel analytical framework to examine the relationship between interorganizational collaboration and CE.**

***Index Terms*—Circular economy (CE), circularity, interorganizational collaboration, open innovation, sustainability report.**

I. Introduction

THERE is a growing and long-standing debate about how economic growth neglects the constraints imposed by our planet (e.g., finite resources) and the impact of human activities on the environment (e.g., emission of greenhouse gasses) [1], [2], [3]. To optimize the use of finite resources and limit the consequences of the traditional linear economy, academics, practitioners, and policymakers are increasingly discussing the transition toward a circular economy (CE) [4], [5], [6], [7]. There is a plethora of definitions of CE, as reviewed by Kirchherr et al. [8]. This article is based on the definition of Morseletto [9], who defines CE as "*an economic model aimed at the efficient use of resources through waste minimisation, long-term value retention, reduction of primary resources, and closed loops of products, product parts, and materials within the boundaries of environmental protection and socioeconomic benefits*" [9, p. 1]. It is worth clarifying, right at the start, the relationship between CE and sustainability, which is often unclear [10]. There are hundreds of definitions of sustainability [10], [11]. For instance, McMichael et al. [12, p. 1919] argue that sustainability means "*transforming our ways of living to maximize the chances that environmental and social conditions will indefinitely support human security, wellbeing, and health.*" Therefore, sustainability and CE are related but distinct concepts [13], [14]. In this vein, Geissdoerfer et al. [10] clarify the conceptual relationship between CE and sustainability, highlighting similarities and differences. On one hand, the authors point out several similarities, such as the intra- and intergenerational commitments and the multi- or interdisciplinary approaches to integrate noneconomic aspects into development; additionally, both CE and sustainability view cooperation as imperative to reach their goals. On the other hand, the authors also stressed the differences between the two concepts. For instance, the concepts of sustainability and CE differ in terms of goals (e.g., multiple goals depending on the agent versus closed loops and reduced resource input), the systems being prioritized (e.g., horizontal triple bottom line versus hierarchical economic system) and the timeframe of changes (e.g., open-ended versus theoretical and practical limits). Therefore, they are two different concepts and should be treated as such. This article focuses on the CE [9].

As mentioned, the interest in transitioning to a CE is long-standing. However, surprisingly, our global economy is becoming less rather than more circular [15], [16]. In this vein, many studies examine the elements influencing the implementation of CE initiatives in different contexts [17], [18], [19], [20], [21]. Among the several elements, collaboration among different organizations (e.g., focal firms, suppliers, universities) could be pivotal to developing CE solutions, ultimately contributing to the transition to a CE [22], [23]. The importance of collaboration aligns with the resource dependency theory perspective [24], which postulates that firms rely on external organizations because achieving complete self-sufficiency is not feasible. Interorganizational collaboration allows for obtaining the resources needed and supplementing those already possessed. Collaborating with various external entities, including universities, customers, suppliers, and competitors, can help bridge these gaps [25] and promote mutual learning [26] as the

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open innovation paradigm advances [27]. Indeed, interorganizational collaboration is a key component of the open innovation paradigm [27], [28], [29]. Remarkably, only a few studies deal with the relationship between interorganizational collaboration and CE [30], [31], [32]. In this vein, several calls for papers recently emerged on this topic [33], [34].

In addition to the scarcity of studies about the relationship between interorganizational collaboration and CE [35], [36], particularly obscure is the relationship between “different” types of interorganizational collaboration (e.g., focal firm–competitor, focal firm–supplier) and “specific” CE initiatives (e.g., reuse, recycle). Indeed, previous studies dealing with interorganizational collaborations and CE embrace a broad perspective [31], [32] without focusing on specific types of interorganizational collaborations and specific CE initiatives. This latter is particularly relevant, considering that different CE initiatives have different degrees of circularity, complexity, and impact [37]. In other words, there is a need to increase the granularity of the research dealing with CE-related interorganizational collaborations.

Thus, this article aims to fill this gap in knowledge by examining the relationship between different types of interorganizational collaboration and specific CE initiatives in the automotive sector. The automotive sector is a particularly interesting empirical setting for examining CE-related interorganizational collaborations. Indeed, it is historically based on a linear economy with a high environmental impact [38], [39], and it has a vast potential to contribute toward a CE [40], [41]. In this vein, there is a growing interest from academics in examining CE solutions that can potentially reduce its environmental impact, such as a design optimization for a reverse supply chain network for reusable car frames [42], car subscription business models [43], and car sharing and its rebound effects [44]. Furthermore, the focal firm (i.e., the automaker) often collaborates with organizations involved in many different upstream (e.g., steel, chemical) and downstream industries (e.g., repair service, mobility services) [45]. More generally, the automotive sector is characterized by knowledge diffusion through supply chain collaboration [46]. This makes the automotive sector an ideal empirical setting to identify and examine CE-related interorganizational collaborations.

Hence, this article addresses the following research question: *Which types of interorganizational collaboration do focal firms leverage to implement CE initiatives in the automotive sector?*

It is worth stressing that the unit of analysis is the CE-related interorganizational collaboration, embracing the micro perspective of the focal firm implementing the initiative. Therefore, other sustainability initiatives are out of the scope of our analysis. This choice is motivated by the fact that they are different concepts and should be treated as such [13], [14]. It is worth pointing out that the role of each concept can change over time, considering the ever-changing nature of the industry transitioning to electric vehicles [47], [48].

In our analysis, since the institutional theory advances that firms’ decisions derive from the institutional pressures exerted by society [49], we consider that firms implement CE initiatives due to these pressures. For the same reason, firms are also likely to disseminate their CE initiatives as much as possible to show society how they respond to the call for higher circularity.

In this vein, we analyzed 73 nonfinancial reports—which are key instruments for disseminating CE initiatives—published in 2021 and 2022 by the 59 largest automakers by market capitalization [50] to address the research question.

This study provides at least two key contributions. First, it sheds light on the relationship between different types of interorganizational collaboration and specific categories of CE initiatives. Indeed, the article shows how focal firms in the automotive industry leverage specific types of interorganizational collaborations to implement CE initiatives with different degrees of circularity. Second, this article concludes with a novel analytical framework to examine the relationship between interorganizational collaboration and CE.

The rest of this article is structured as follows. Section II introduces the main areas investigated in this article. Section III details the methodology adopted. Section IV presents the findings. Section V discusses the findings, ultimately presenting a novel analytical framework to deal with CE-related interorganizational collaborations. Section VI concludes this article.

II. Theoretical Background

This section introduces the two managerial theories leveraged in this study and the main areas investigated.

A. Institutional Theory and Resource Dependency Theory

This study leverages two managerial theories: institutional theory and resource dependency theory. The institutional theory describes how coercive, mimetic, and normative forces affect firms’ decisions [49]. Coercive forces are those exerted by society, which expects firms to behave in a certain way and may induce them to act accordingly through formal coercive processes (e.g., regulations) or more informal pressures. Such pressures align with the attitude of the society on certain topics, such as CE. Mimetic forces leverage the concept of isomorphism [51], which brings firms to imitate the successful behavior of their competitors. Normative processes derive from formal education and professional networks. These forces can affect a firm’s decision to embrace CE. Society is increasingly sensitive to the environmental concerns that CE may address, and several nations are introducing regulations to force or incentivize CE initiatives. When leading firms publicly disseminate their response to these coercive pressures by, for instance, reporting their CE initiatives, others are likely to imitate them. Furthermore, virtuous industrial practices such as CE initiatives are increasingly discussed in formal education, often from primary schools to master programs. This can affect firms’ behavior and decisions. However, since the implementation of CE initiatives requires significant and specialized resources that often lie outside the organizational boundaries [30], interorganizational collaboration emerges as a viable solution to acquire them. The resource dependency theory [24] postulates that a firm cannot be seen as a closed system since it relies on external subjects—including other organizations and institutions—to obtain the resources needed. In this vein, independent organizations depend on each other [52]. Therefore, collaboration with innovation partners is necessary [53].

The institutional theory and resource dependency theory are often used to examine CE initiatives and interorganizational collaboration. For example, Ranta et al. [54] leveraged the institutional theory to map the role of institutional indicators (e.g., laws, norms, and beliefs) in influencing the implementation of CE practices. Cricelli et al. [30] leveraged both the resource dependency theory and the institutional theory to analyze interorganizational collaboration and reverse logistics innovation, an important element of a CE. These are complementary lenses that can provide a comprehensive examination of the dynamics facing contemporary firms [30]; they are often used to formulate hypotheses, analyze data, and interpret the findings in CE studies [55], [56]. In this case, we first leveraged the institutional theory to justify—from an epistemological perspective—the analysis of nonfinancial reports. Indeed, as the introduction mentions, since the institutional theory points out that "firms" decisions are triggered by the institutional pressures exerted by society [49], we consider that firms implement CE initiatives due to these pressures. For the same reason, firms are likely to disseminate and report their CE initiatives as much as possible to show society how they respond to the call for higher circularity.

Second, we leveraged the resource-dependency theory to explain why firms need to rely on other organizations to pursue their CE initiatives and to interpret the findings of this study.

B. *Circular Economy and Interorganizational Collaboration*

The open innovation paradigm is gaining significant attention in CE studies [57], [58]. Interorganizational collaboration is one of the typical approaches firms use to embrace the open innovation paradigm [27]. It enables acquiring the resources needed and supplementing those already possessed [58], favoring mutual learning [59]. Considering the substantial innovation efforts required to implement CE initiatives, inter-organizational collaborations could foster a rapid scale-up of CE initiatives [19], [30], [33].

Few studies examine the link between CE and interorganizational collaboration. Among them, Chan [60] highlights that manufacturers and suppliers can gain mutual benefits through collaborative packaging redesign. According to Simpson [61], suppliers can participate in packaging redesign to minimize material usage. Simpson [61] also highlights how interorganizational collaboration between competitors can be beneficial for dealing with waste materials that are not economically feasible to recycle in small quantities. In the same vein, Ohnishi et al. [62] show that recycling facilities collaborating rather than competing can achieve superior outcomes compared to those not collaborating. In their study, this advantage assumes higher relevance in the case of shared supply chain segments—such as wholesalers, logistics partners, or distributors—between competitors. Furthermore, collaboration with suppliers can also be relevant for reducing purchasing costs and addressing technical challenges [63]. Paula et al. [64] focus on the collaboration between firms, their customers, and suppliers, highlighting its relevant role in reducing transaction costs and increasing resource and knowledge sharing. In addition, interorganizational collaboration with universities and research institutes allows organizations to acquire knowledge to obtain value from waste [65]. More in general, trust among partners is critical for successful collaboration in circular ecosystems [66]. However, without the right balance between formal, informal, and individual characteristics, it could result in exclusivity and challenges in achieving a circular proposition [23]. Köhler et al. [31] point out that interorganizational collaboration needs a balance between knowledge protection and sharing; this balance can be obtained by mixing formal and informal agreements to establish how to regulate knowledge-sharing practices and protect intellectual property [31]. Moreover, Sudusinghe and Seuring [67] highlight that implementing CE initiatives encourages relational and operational collaboration among stakeholders in circular supply chains, linking them into a CE system.

C. *Circular Economy and Interorganizational Collaboration in the Automotive Sector*

The relationship between CE and interorganizational collaboration in the automotive sector is neglected. Therefore, this section briefly overviews the two domains—CE and interorganizational collaboration—in the automotive sector separately.

1) Circular Economy in the Automotive Sector: The CE initiatives in the automotive sector often discussed in the literature include recycling, remanufacturing, and reusing systems, components, and materials. Regarding recycling initiatives, the literature highlights how, in some cases, using recycled materials in manufacturing can be more cost-effective than using raw materials. According to Gu et al. [68], recycled plastics are particularly suitable for car parts when formulated and treated properly (e.g., improved by adding fillers). Additionally, recyclable materials from end-of-life vehicles can be used in the building construction sector, such as in roofing options and flooring materials, reducing the need for raw materials [69]. Regarding remanufacturing initiatives, Shao et al. [70] point out that one of the main challenges in implementing CE initiatives is the lack of appropriate products and technologies, leading to poor-quality remanufactured parts.

Furthermore, the benefits of remanufacturing initiatives are often unclear [71]. Regarding reuse initiatives, Van Loon and Van Wassenhove [72] suggest that the manufacturing costs of reused products remain higher than those of new products. However, with the increasing waste of electric vehicle batteries, there is a push toward their second-life reuse. Reusing steel scrap in the automotive sector is common due to its economic and environmental benefits. Ali et al. [73] point out that reusing steel metal scrap from a production system is less expensive than producing the same metal facade using new steel. Rentizelas and Trivyza [42] suggest a design optimization for a reverse supply chain network for reusable car frames.

Several authors discuss CE initiatives more in general. For instance, Urbinati et al. [39] provide an overview of enablers and barriers influencing the implementation of a circular business model. Enablers include the availability of partners for a reverse supply chain, their geographical proximity, and the availability of technical solutions. Barriers include the frequent change of market requests and high investments in terms of time and costs. Furthermore, according to Rodríguez-González et al. [74], the reuse and recycling of materials from vehicles and industrial waste reduce production costs and industrial waste while increasing financial performance as waste is sold to other recycling companies. Furthermore, Smania et al. [43] investigate the implementation of car subscription business models from the automaker's perspective, highlighting, among others, the benefits of such business models, including the improved use of resources and the expanded revenue and customer base.

2) Interorganizational Collaboration in the Automotive Sector: Few studies deal with interorganizational collaboration in the automotive sector. For instance, Agostini and Caviggioli [75] point out that collaborative activities in the R&D automotive industry are concentrated in specific areas of innovation, such as powertrain technologies, safety systems, and autonomous driving. Subramonian and Rasiah [76] highlight that creating social capital through strong R&D relationships is an essential source of competitive advantage. In particular, the partnership between universities and industry facilitates knowledge transfer by reducing barriers (e.g., lack of resources, cultural differences) and fostering technological innovation. Sung et al. [77] examine the collaboration between companies and their suppliers, pointing out that the level of collaboration can be improved by leveraging an "IT collaboration system", which can lead to reduced costs and increased profits. Moreover, Canonico et al. [78] show that adopting a common goal across various stages of a typical university-industry research project can lead to effective knowledge translation (e.g., sharing frameworks and developing a common language). Additionally, Han et al. [79] highlight that automakers tend to choose suppliers with advanced technology and a good reputation, giving them a dominant position in the relationship; similarly, suppliers can upgrade their performance by collaborating with manufacturers.

III. Methodology

In order to address the research question "*Which types of interorganizational collaboration do focal firms leverage to implement CE initiatives in the automotive sector*?" we adapted the methodology used by Stewart and Niero [80] and Opferkuch et al. [17]. This section details the main steps of the methodology adopted in this study.

A. Research Approach and Empirical Setting

Given the exploratory nature of this research, the authors adopted an inductive approach. The inductive approach is suitable for exploring a new phenomenon and identifying patterns, thereby leading to new generalization [81], [82]. In adopting an inductive approach, the researcher collects data to explore a phenomenon, identify themes and/or patterns, and create a framework [82]. Regarding the ontology and epistemology of this study, this research is based on pragmatism philosophy. It posits that the nature of reality (ontology)—which is considered complex, rich, and external—is the practical consequence of ideas and practices, and what constitutes acceptable knowledge (epistemology) is the practical meaning of knowledge in a specific context [82]. For a pragmatist, the research question is the most important determinant for the research design and informing future practice is a key contribution [82]. The empirical setting of this research is the automotive sector. The automotive sector drives economic growth, provides employment opportunities, and advances technological innovation. It is one of the most resource-intensive manufacturing sectors, significantly impacting the environment and natural resources and contributing to over 10% of industrial emissions [83], [84]. The automotive sector can substantially benefit from adopting CE practices, such as waste reduction, enhanced resource efficiency, and circular revenue streams [85], [86]. Indeed, it is historically based on a linear economy with a high environmental impact [38], [39], and it has a relevant potential to contribute toward a CE [40], [41]. Of note, as aforementioned, the focal firm (i.e., the automaker) often collaborates with organizations involved in different upstream and downstream industries [45]. Furthermore, knowledge diffusion through supply chain collaboration characterizes the automotive sector [46]. Thus, it is an ideal empirical setting to investigate CE-related collaborations.

B. Data Collection and Data Analysis

Firms embracing CE in response to institutional pressures [49] will also want to show society how they respond to its expectations. The quintessential instrument for disseminating CE initiatives is the nonfinancial report. The European Directive 2014/95/EU [87] defines a nonfinancial report as a statement including "*information to the extent necessary for an understanding of the undertaking's development, performance, position and impact of its activity, relating to, as a minimum, environmental, social and employee matters, respect for human rights, anti-corruption and bribery matters*" (p. 4). Examples of nonfinancial reports are sustainability reports, integrated reports, and business responsibility reports [88]. Firms often disclose their CE initiatives in nonfinancial reports to fulfil stakeholders' needs and legitimate operations [89], which aligns with the institutional theory [49]. Indeed, if we assume that firms implement CE initiatives in response to institutional pressures [49], it is also reasonable that firms want to show Society how they respond to its expectations. In this vein, several studies examined CE disclosure in nonfinancial reports in several industries and countries and with different units of analysis [17], [90]. Therefore, we collected nonfinancial reports published in 2021 and 2022 by the largest automakers by market capitalization [50]. Out of 59 firms in the initial sample, 38 firms published at least one nonfinancial report in 2021 or 2022, with a total of 83 nonfinancial reports published in 2021 and/or 2022 retrieved. Corporate Register [91], an online database that provides information on firms' sustainability and corporate social responsibility performance, was our main source for the reports; it was selected due to its comprehensive coverage of various types of nonfinancial reports. If the reports were unavailable in the database, they were extracted from the company website. Overall, 73 reports were extracted from the online directory provided by Corporate Register, while 10 reports were collected from company websites. From the initial sample of 83 reports, we excluded those not written in English, obtaining a sample of 80 nonfinancial reports. Then,

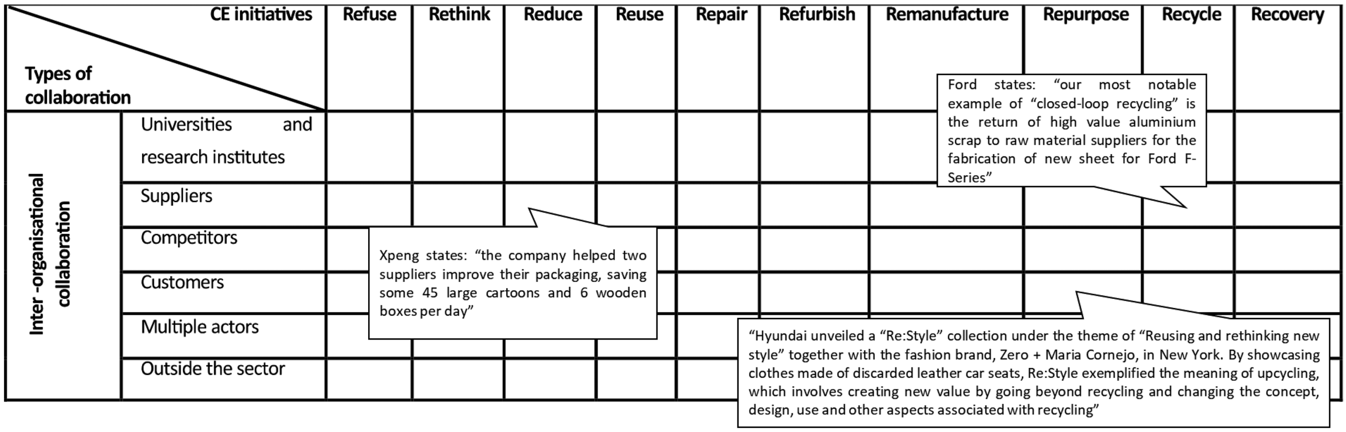

Fig. 1. Example of data categorization.

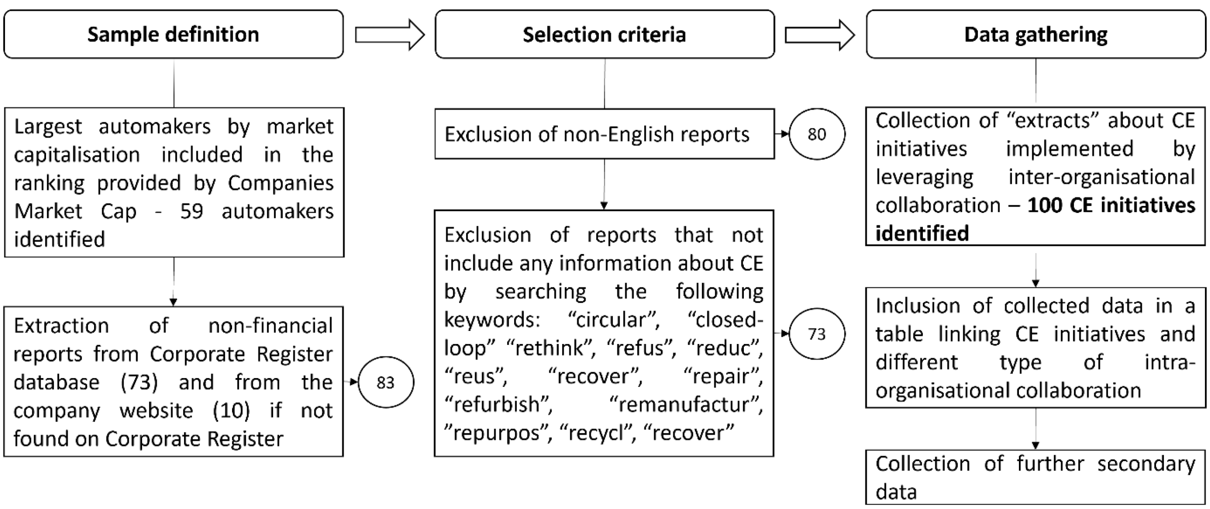

Fig. 2. Data collection process.

we searched for information about CE-related collaborations by searching the following keywords in the report: circular, closed-loop, rethink*, refus*, reduc*, reus*, recover*, repair*, refurbish*, remanufact*, repurpos*, recycl*. The 10R presented by Potting et al. [37] triggered the choice of the keywords, as in previous similar studies [80], [92]. Furthermore, the words "circular" and "closed-loop" are generally used in systematic searches in CE studies [17], [93]. Consequently, we excluded those that did not include information about CE initiatives, obtaining a final sample of 73 nonfinancial reports to be analyzed. Table I in the Appendix shows the 38 firms, their nationality, and the number of reports analyzed per firm. To support the analysis of the reports, we developed the tool in Fig. 1, where CE initiatives were extracted from Potting et al. [37], and the different types of interorganizational collaboration from Fitjar and Rodríguez-Pose [94] and Haus-Reve et al. [95]. Table II in the Appendix defines each CE initiative that we leveraged to analyze and categorize the extracts. After collecting the 73 reports (for a total of 9009 pages), one of the authors read each relevant section of the report and extracted the information about CE initiatives and interorganizational collaboration, ultimately including the extracts in the appropriate box in Fig. 1. Fig. 1 shows three examples of data categorization. In categorizing the extracts in the appropriate box, the focus was on the interorganizational collaborations leveraged by the focal firm (e.g., Ford, Hyundai, Stellantis) to implement CE initiatives. This process led to the identification and categorization of 100 extracts describing CE initiatives implemented by leveraging interorganizational collaborations. When the information in the report was insufficient to categorize the information in one of the boxes in Fig.1, we collected secondary data (e.g., news, institutional reports) to clarify the type of CE initiative and interorganizational collaboration. The "claims" about CE initiatives and interorganizational collaboration were excluded. For example, claims such as "*we are collaborating with our plastics suppliers to advance circular economy practices and support the responsible utilization of resources*" were excluded. Fig. 2 summarizes the data collection process.

The 100 extracts were then analyzed through content analysis, adapting the technique used by Stewart and Niero [80] and Opferkuch et al. [17]. Differently from a "thematic" analysis, a "content" analysis is not "limited" to the examination and

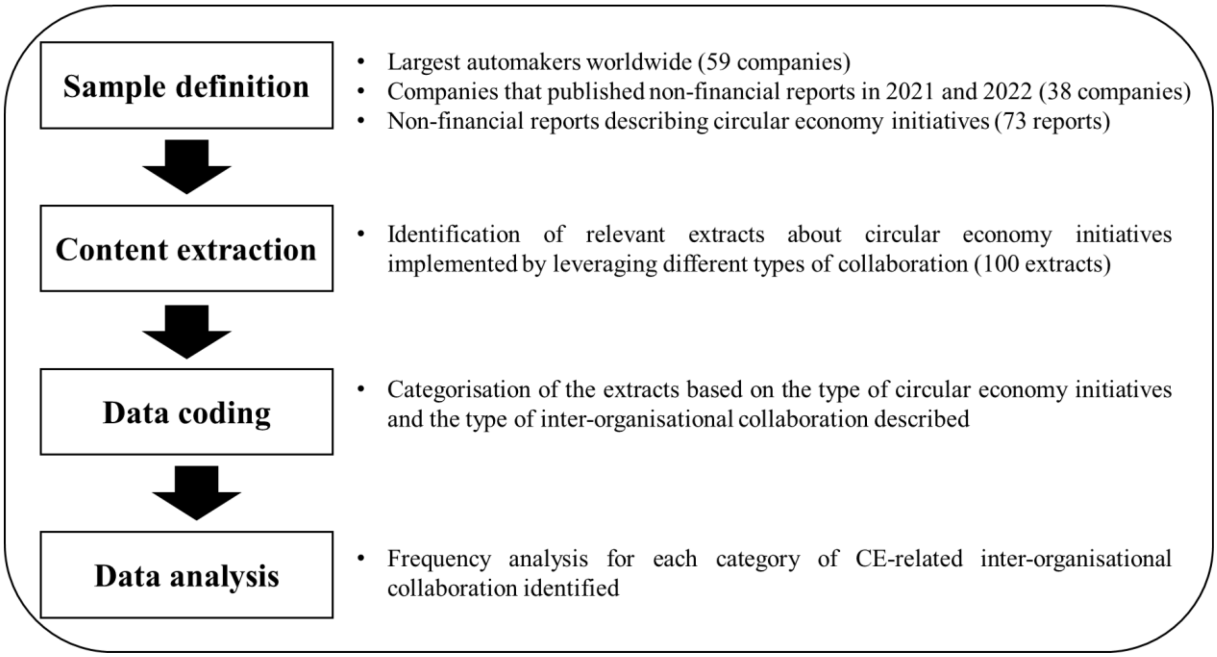

Fig. 3. Main steps of the data collection and data analysis.

interpretation of the content; the content analysis quantifies the frequency of subcategories and codes to identify patterns and trends [82], [96]. A content analysis was preferred considering the research question, which aligns with a "semi-quantitative" approach. In particular, we quantified the CE initiatives implemented by leveraging different types of collaboration in each category. The categories correspond to the boxes in Fig. 1. In other words, we conducted a frequency analysis for each category. As aforementioned, in examining and categorizing the extracts, our focus was on the CE initiatives implemented by the focal firm and the different types of interorganizational collaboration leveraged by the focal firm to implement CE initiatives. Fig. 3 summarizes the main steps of the data collection and data analysis process.

IV. Findings

A. Sample Description

Fig. 4 summarizes how companies in our sample responded to institutional pressures [49] by publishing different types of nonfinancial reports. The types of nonfinancial reports mostly published by automakers are "sustainability reports" (52,1%), followed by "environmental, social and governance reports" (15,1%), and "corporate social responsibility reports" (11%). However, regarding the information about CE initiatives, no relevant difference emerged among the different types of reports. Therefore, all the reports in Fig. 4 are potentially relevant data sources about CE initiatives.

B. Which Types of Interorganizational Collaboration Do Focal Firms Leverage to Implement CE Initiatives in the Automotive Sector?

By analyzing the aforementioned 73 nonfinancial reports, we identified 100 CE initiatives that focal firms implemented or are implementing by leveraging interorganizational collaboration. Each report presents at least one CE initiative implemented by leveraging interorganizational collaboration.

Fig. 5 summarizes how the examined focal firms leverage different types of collaboration to implement CE initiatives. Among the different types of interorganizational collaboration, the focal firms often (44%) collaborate with their suppliers to implement CE initiatives. The key role of supplier–customer collaborations in enabling CE is in line with previous studies [61], [97], as discussed in Section V. Furthermore, focal firms relatively often (17%) collaborate with multiple actors simultaneously to implement CE initiatives, as well as with their customers (15%) and with actors outside the automotive sector (14%). Collaboration with competitors plays a minor role (5%), as well as—remarkably—collaboration with universities and research institutes (5%).

The following sections detail the role played by the different types of collaboration to implement specific CE initiatives. The sections are presented per type of CE initiative in decreasing frequency order, starting from the most frequent CE initiative type (recycling) to the least frequent (remanufacturing). Furthermore, the last section provides a critical summary of the findings.

1) Recycling Initiatives and Types of Collaboration: Most focal firms (44,1%) collaborate with their suppliers to implement recycling initiatives. For instance, Ford states: "Our most notable example of 'closed-loop recycling' is the return of high-value aluminum scrap to raw material suppliers for the fabrication of new sheet for Ford F-Series." The importance of closing the aluminum loop in the automotive industry was also recently mentioned by Bocken and Ritala [19]. Furthermore, focal firms collaborate in several cases (20,3%) with their customers to implement recycling initiatives. For instance, Honda "collects and recycles end-of-life components generated from repair, replacement, etc., from dealers nationwide." Additionally, focal firms relatively often (18,6%) implement recycling initiatives

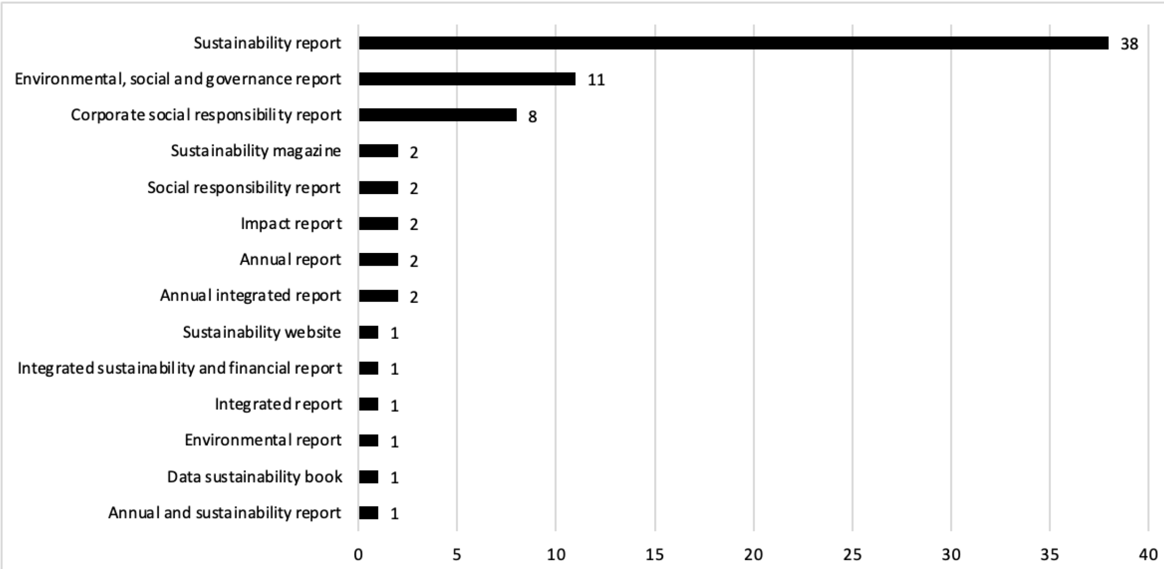

Fig. 4. Different types of nonfinancial reports.

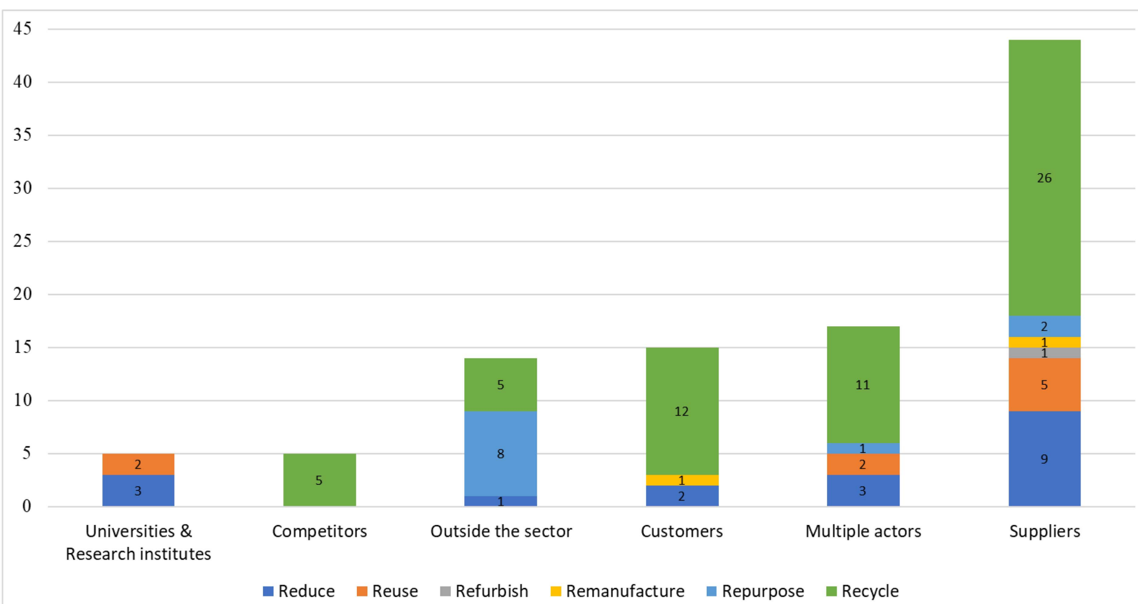

Fig. 5. Relationship between CE initiatives and different types of collaboration.

involving multiple actors simultaneously. A practical example is Volkswagen, which, in the SykuRA project, "*is working on feeding the plastic components from shredder residues from end-of-life vehicles into high-quality recycling […]. In addition to Volkswagen, the Öko-Institut, the chemical company BASF, processing specialist SICON, and the Clausthal University of Technology are also involved in the project, which is supported by the Federal Ministry of Research."* Focal firms collaborate to a lesser extent with competitors (85%) and companies outside the automotive sector (85%) to implement recycling initiatives.

2) Reducing Initiatives and Types of Collaboration: Focal firms relatively often (50%) collaborate with their suppliers to implement "reduce" initiatives. For instance, Xpeng points out that "*the company helped two suppliers improve their packaging, saving some 45 large cartoons and 6 wooden boxes per day.*" In some cases (16,7%), focal firms collaborate with universities and research institutes. This is the case of ŠKODA, which collaborated with the Technical University of Liberec to develop a material made from sugar beet pulp used in the interior of its vehicles. Furthermore, they collaborate with multiple actors simultaneously in several cases (16,7%), such as Stellantis in the "European Raw Materials" alliance to obtain environmentally sustainable raw materials. Other focal firms collaborate with their customers (11,1%)—such as Hotai, which collaborates with its dealers to install central oil supply systems that limit the use of motor oil bottles—and with companies outside the automotive sector (55%) to implement reducing initiatives.

3) Repurposing Initiatives and Types of Collaboration: Repurpose initiatives are mostly (72,7%) implemented by leveraging collaboration with actors outside the automotive sector. This high share is inherent to the logic of repurposing, where parts of discarded products are used in new products with different functions [9], [37], which naturally favors intersectoral collaboration. For instance, Hyundai "*unveiled a 'Re:Style' collection under the theme of 'Reusing and rethinking new style' together with the fashion brand, Zero + Maria Cornejo, in New York. By showcasing clothes made of discarded leather car seats, Re:Style exemplified the meaning of upcycling, which involves creating new value by going beyond recycling and changing the concept, design, use and other aspects associated with recycling.*" Additionally, focal firms implement repurposing initiatives by collaborating with suppliers (18,2%) and multiple actors (91%).

4) Reusing Initiatives and Types of Collaborations: Different from the repurpose initiatives, reuse initiatives imply that the product maintains its original function and identity [37], [98]. Focal firms implement very few reuse initiatives, mostly (55,6%) collaborating with suppliers. For instance, Hyundai and OCI (i.e., a supplier) "*worked together to build a 300kWh ESS system using the second life EV batteries in 2020.*" Similarly, BMW partnered with Tsinghua University to develop reusable batteries. The paucity of reuse initiatives in the automotive sector is consistent with Amelia et al.'s [99] earlier findings. Indeed, their research in the Malaysian automotive sector pointed out that reuse was never practiced in newly manufactured vehicles.

5) Remanufacturing and Refurbishing Initiatives and Types of Collaborations: The findings point out how focal firms rarely leverage collaboration to implement remanufacturing and refurbishing initiatives. As shown in Fig. 5, we identified only one remanufacturing initiative and one refurbishing initiative. Regarding the remanufacturing initiative, Ford states: "*as part of our voluntary Go Green Dealer Sustainability Program, many US service centers collect the headlights, bumpers and windshield-wiper motors removed during servicing. The parts are either cleaned and remanufactured, or dismantled and recycled for use in new applications.*" Regarding the refurbishing initiative, Stellantis reports: "*through external specialised providers, FCA certifies the production of remanufactured parts in order to provide a repair solution that is equivalent to original equipment parts, and that carry the same warranty conditions as new parts.*" Since a significant subset of car components could be refurbished or remanufactured [100], our findings suggest that there is room for improvement in these CE initiatives.

6) A Critical Summary: Based on the categorization suggested by Potting [37], we classified the identified CE initiatives into three groups, whose degree of circularity increases from group C to group A:

1) C) Useful application of materials—including recycling and recovery initiatives;
2) B) *Extend the lifespan of the product and its parts and smarter product use and manufacture*—including reuse, refurbishing, remanufacturing, and repurposing initiatives;
3) A) *Smarter product use and manufacture*—including refusing, rethinking, and reducing initiatives.

Fig. 6 shows the role of the different types of interorganizational collaboration for each category.

For any group—therefore, for any level of circularity—collaboration with suppliers is the most frequent type of collaboration that focal firms leverage to implement CE initiatives in the automotive sector. Of note, the other types of interorganizational collaboration have different relevance in the various groups. For instance, the collaboration between focal firms and universities and research institutes plays no role in Group C and a very moderate (9%) role in Group B. It assumes higher relevance (17%) in group A, which presents the highest level of circularity. Furthermore, collaboration with companies outside the automotive sector plays a major role (35%) in group B, while it plays a minor role in groups C and A, 8% and 5%, respectively. Additionally, Fig. 6 shows that collaboration with customers plays a major role (20%) in implementing CE initiatives of Group C, a moderate role (11%) in Group A, and a minor role (4%) in Group B. Collaboration with multiple actors plays a relatively relevant role in group C and A, 19% and 17% respectively, and a moderate (13%) role in groups B. Fig. 6 also shows how collaboration with competitors has no role in groups B and C, but it plays a minor role (9%) in group C.

Additionally, it emerged that the vast majority of actors collaborating with the focal firms are part of the automotive sector (e.g., suppliers and competitors). Among the 22 instances of intersectoral collaboration, we identified 12 sectors, whose relative distribution is described in Fig. 7. These actors are either involved in dyadic interorganizational collaborations with the focal firm (i.e., outside the sector in Fig. 5) or in networks (i.e., multiple actors in Fig. 5).

V. Discussions

The presence of a relatively high number of CE initiatives supported by interorganizational collaboration is in line with both the resource dependency theory perspective and the CE literature [24], [65], [101]. Indeed, the resource dependence theory emphasizes the importance of resorting to external organizations to achieve the firm's purposes [24]. One-fifth of the observed CE initiatives involved multiple external partners, which allows for leveraging various competencies and resources. The reliance on multiple partners to pursue circularity was also recently observed by Khan et al. [65], who examined how four companies successfully collaborated with multiple actors, including suppliers, research institutions, public institutions, and nongovernmental organizations, to implement CE initiatives. Sahamie et al. [114] consistently highlight the importance of interdisciplinary and transdisciplinary collaboration. However, too many partner types can lead to resource dispersion, thereby reducing the effectiveness of collaboration [102], [103]. In this vein, Cricelli et al. [30] point out that resorting to multiple partners may hamper reverse logistics innovation.

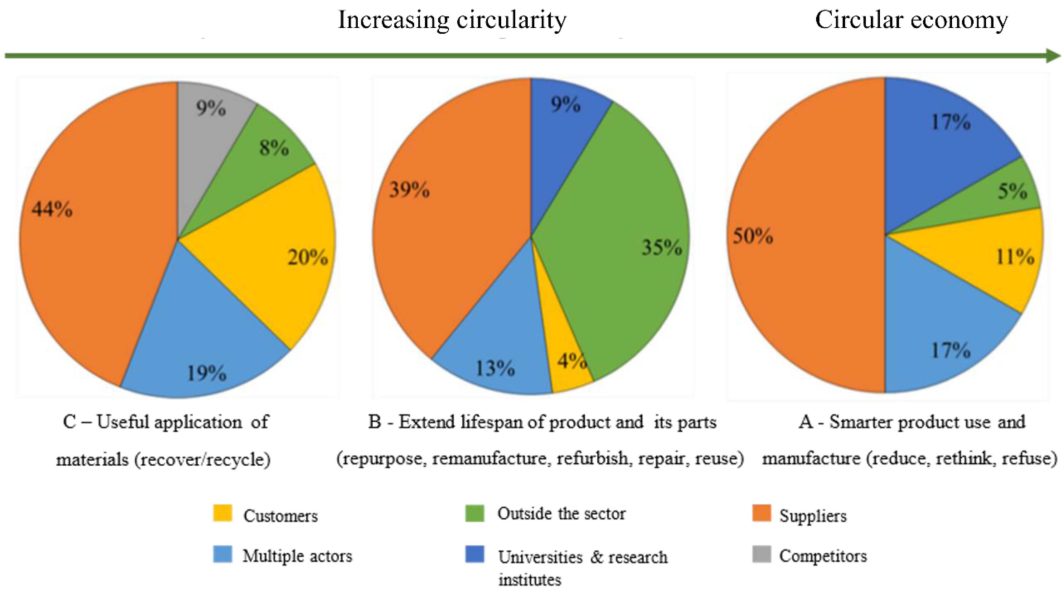

Fig. 6. CE initiatives and types of interorganizational collaboration—categorization based on Potting [37].

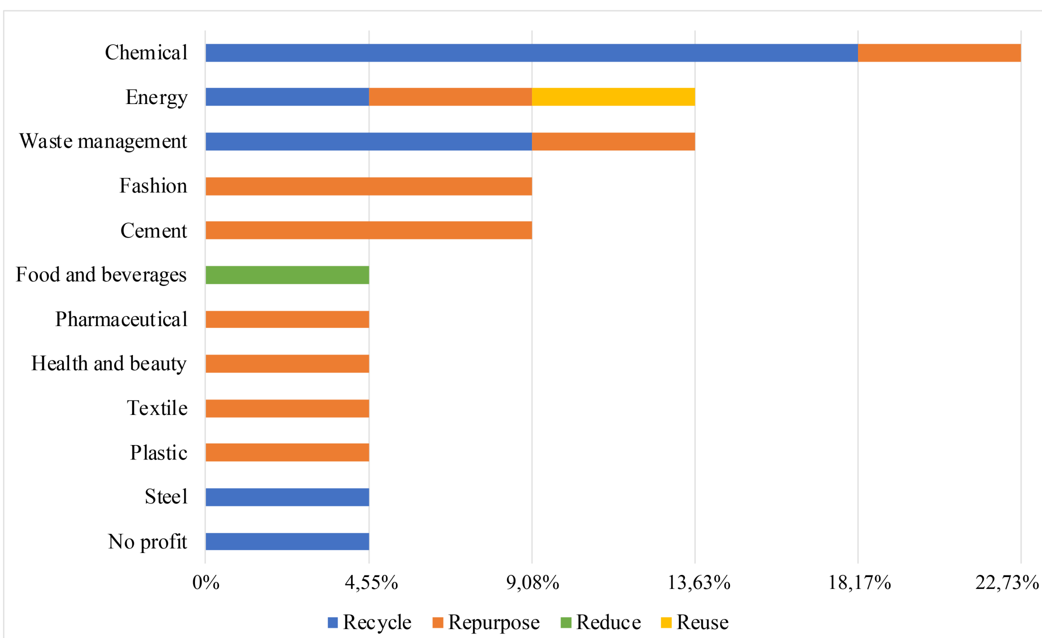

Fig. 7. Sectors involved in CE-related collaborations.

Furthermore, this study shows how different CE initiatives involved several types of interorganizational collaboration, with a prevalence of suppliers and customers and fewer collaborations with competitors, other organizations, and research institutions. The dominance of suppliers as ideal partners for CE initiatives is reasonable. Indeed, suppliers are often involved in codefining the products' design specifications [61], [97]. The result is also consistent with previous evidence on technological and environmental innovation, which most frequently occurs upstream in the supply chain [104].

Customers are the second favorite category for CE initiatives. Indeed, they may also be involved in eco-design and are of pivotal importance for successful product returns [64], [97] since the rate and quality of returns largely depend on customers' commitment [105]. The results support this view since most customer collaboration refers to recycling CE initiatives.

The preeminence of collaborations with suppliers and customers aligns with some previous studies. Indeed, De Angelis et al. [106] underline the importance of collaborating with customers and suppliers during down-stream collection, return, and during the repair, reuse, and refurbishment cycles, providing them with different incentives to engage in material return and invest in remanufacturing. Additionally, Cricelli et al. [30] point out that vertical collaboration positively affects reverse logistics innovation.

Increasing circularity →

Circular economy initiatives / Collaborations of a focal company		Group C: Useful application of materials		Group B: Extend lifespan of product and its parts					Group A: Smarter product use and manufacture		
		Recover	Recycle	Repurpose	Remanufacture	Refurbish	Repair	Reuse	Reduce	Rethink	Refuse
Vertical collaboration	Customers										
	Suppliers										
Horizontal collaboration	Competitors										
	Actors outside the sector										
Unversities and research institutes	Universities										
	Research institutes										
Multiple actors/collaboration network											

Fig. 8. Analytical framework to deal with the relationship between interorganizational collaboration and circular economy.

Even though collaboration with research institutions can enhance learning [107] and allow obtaining information on the latest CE technologies [65], firms rarely recognize collaborating with them in the analyzed nonfinancial reports. However, in these rare cases, such organizations participate in initiatives with a higher degree of circularity (Group A or B).

Almost 60% of the collected CE-related interorganizational collaborations refer to "recycling." This finding is unsurprising since most circular policies and targets focus on recycling and recovery [101]. However, as Morseletto [9] remarks, the yield rate of these initiatives is often very low, the treatments are expensive, and the product integrity is destroyed. More surprisingly, interorganizational collaborations to implement "reducing" initiatives, which pertain to Group A, require more complex design choices, and bear higher yields from a circularity perspective, are the second most frequent category in our sample.

It is worth emphasizing that this article provides a "picture" of how firms in the automotive industry implement CE initiatives by leveraging interorganizational collaboration, similar to previous studies analyzing sustainability reports in other contexts [17], [80], [90]. However, this picture may change over time.

In addition to examining the relationship between different types of interorganizational collaboration and specific CE initiatives in the automotive sector, this article shows how the data collection tool used in this article (see Fig. 1) represents a valid tool to categorize and examine the information about CE initiatives and interorganizational collaboration. First, it allows a quantitative analysis of the aforementioned relationship and could be used in future studies investigating this relationship in other sectors. It could also be used to frame and categorize a study that focuses on a specific box (e.g., implementation of reuse initiative by leveraging a collaboration with multiple actors). The proper categorization of studies can facilitate their comparison. In addition, increasing the specificity of future research could be pivotal to fostering CE solutions. The lack of specificity is often a relevant shortcoming [108] of CE literature in general. Therefore, an analytical framework [109], based on Fig. 1, can represent a valid tool to increase the specificity of future research about the relationship between interorganizational collaboration and CE initiatives. In this vein, by leveraging the literature about both CE and interorganizational collaboration, along with several discussions among the authors, we propose the analytical framework in Fig. 8. The framework presents two main differences with respect to the tool in Fig. 1. First, it categorizes the types of interorganizational collaboration into different collaboration archetypes, including vertical [64], [110] and horizontal collaboration [64], [111], and details collaboration with universities and research institutes [107] in collaboration with universities and collaboration with research institutes. Furthermore, "network collaboration" [112] is often used to refer to "collaboration with multiple actors"; therefore, we included it in the framework. Second, it categorizes the CE initiatives into three groups following the classification proposed by Potting [37] based on three different levels of circularity. The features of the analytical framework allow both an analysis at microlevel (e.g., focused on a specific link, specific CE initiative or a specific type of interorganizational collaboration) and an analysis at macrolevel (e.g., focused on a specific group of CE initiatives with a certain level of circularity or a specific group of interorganizational collaboration). The analysis at the macro/group level overcomes the broadness and vagueness of the analysis about CE in general and/or interorganizational collaboration in general; however, at the same time, it allows to group data and potentially obtain meaningful findings.

VI. Conclusion, Limitations, and Future Research Opportunities

A. Conclusion

Interorganizational collaboration could smooth the transition from a linear to a CE. Surprisingly, few studies examine the relationship between "different" types of collaboration and "specific" CE initiatives. Building on the institutional theory and resource dependence theory, this article addresses this gap in knowledge through a content analysis of nonfinancial reports disseminated in 2021 and 2022 by the 59 largest automakers by market capitalization. In particular, this article examines which types of interorganizational collaboration focal firms in the automotive sector leverage to implement specific CE initiatives. The findings show that focal firms often collaborate with suppliers to implement CE initiatives. Focal firms relatively often leverage interorganizational collaboration with customers to implement recycling initiatives. Remarkably, collaboration with universities and research institutes plays a minor role, increasing its relevance only in CE initiatives with the highest degree of circularity. Furthermore, this article provides an analytical framework to examine the relationship between interorganizational collaboration and CE initiatives.

The findings of this article contribute to the scarce body of knowledge about CE and interorganizational collaboration. Indeed, this article offers an exploratory understanding of how interorganizational collaborations are used to nurture CE. Furthermore, to the best of the authors' knowledge, this is the first paper that examines the relationship between interorganizational collaboration and CE in the automotive sector. Another element of novelty lies in linking specific CE initiatives and different types of interorganizational collaboration, along with providing an analytical framework to examine this relationship in future studies.

B. Limitations and Future Research Opportunities

This study presents at least a relevant limitation. It shows descriptive statistics about CE initiatives associated with interorganizational collaboration. However, it cannot assess the size or the environmental and economic impact of these initiatives. In this vein, future studies may investigate how collaborating with different types of partners proves more or less effective for specific CE initiatives. Future studies could also analyze different forms of collaboration (e.g., joint ventures, joint R&D), extend our study to include different open innovation practices (e.g., crowdsourcing, innovation contests, innovation labs), or consider other contextual variables (e.g., the role of local versus global collaboration, developed versus developing countries). In the same vein, future studies could explore the role played by "intraorganizational" collaboration [113] since large companies' efforts to start CE initiatives could result from interdivisional collaboration resembling typical open innovation dynamics. Future studies could also investigate the genesis of CE-related interorganizational collaborations, exploring who initiates them, why, and how they choose the type and number of partners and the collaboration modes.

Furthermore, the novel analytical framework can help increase the specificity of future research about the relationship between interorganizational collaboration and CE initiatives. This could be pivotal to fostering the development of CE solutions. For instance, understanding which specific forms of interorganizational collaboration are needed for remanufacturing and how these differ from recycling could provide valuable insights to understand the phenomena better and offer practical recommendations to firms. Each box of the analytical framework can be seen as a niche in the literature deserving investigation.

Appendix

TABLE I
Firms, Countries, Type and Number of Nonfinancial Reports Analyzed

Firm	Country	Type of report (Nº)
Aston Martin	UK	Sustainability report (2)
BMW	Germany	Sustainability report (2)
BYD	China	Social responsibility report (2)
Dongfeng Motor	China	ESG report (2)
Ferrari	Italy	Sustainability report (2)
Fisker	USA	ESG report (1)
Ford	USA	Sustainability report (1), Integrated sustainability and financial report (1)
Ford Otosan	Türkiye	Sustainability report (2)
GAC	China	ESG report (2)
Geely	China	ESG report (2)
General Motors	USA	Sustainability report (2)
Great Wall Motors	China	CSR report (2)
Honda	Japan	Sustainability report (2)
Hotai Motor	Taiwan	CSR report (2)
Hyundai	South Korea	Sustainability report (2)
Isuzu	Japan	CSR report (1), Sustainability report (1)
Kia	South Korea	Sustainability Magazine (2)
Li Auto	China	ESG report (1)
Mahindra & Mahindra	India	Sustainability report (2)
Maruti Suzuki India	India	Annual integrated report (2)
Mazda	Japan	Sustainability report (2)
Mercedes-Benz	Germany	Sustainability report (2)
Mitsubishi Motors	Japan	Sustainability report (2)
NIO	China	ESG report (1)
Nissan	Japan	Sustainability report (2)
Polaris	USA	CSR report (2)
Porsche	Germany	Sustainability report (2)
Renault	France	Annual report (1), Integrated report (1)
Sono Motors	Germany	Sustainability report (2)
Stellantis	Netherlands	Sustainability report (1), CSR report (1)
Subaru	Japan	Sustainability website (1), Sustainability report (1)
Suzuki Motor	Japan	Sustainability report (2)
Tesla	USA	Impact report (2)
Tofaş Türk Otomobil Fabrikası	Türkiye	Sustainability report (2)
Toyota	Japan	Environmental report (1), Data sustainability book (1)
Volkswagen	Germany	Sustainability report (2)
Volvo Car	Sweden	Annual report (1), Annual and sustainability report (1)
Xpeng	China	ESG report (2)

TABLE II
CIRCULAR ECONOMY INITIATIVES—TEXT EXTRACTED FROM POTTING ET AL. [37]

Initiative	Definition
Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
Rethink	Make product use more intensive (e.g. through sharing products, or by putting multi-functional products on the market)
Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources
Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
Repair	Repair and maintenance of defective product so it can be used with its original function
Refurbish	Restore an old product and bring it up to date
Remanufacture	Use parts of a discarded product in a new product with the same function
Repurpose	Use parts of a discarded product in a new product with a different function
Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
Recovery	Incineration of material with energy recovery

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