Wholesaler echelon and Industry 4.0 in circular supply chains – a systematic review

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Abstract

Purpose – This paper aims to analyse systematically previous literature that sought to understand the formation of circular supply chains (CSCs) and propose a research agenda for implementing circular economy 4.0 in the wholesale industry.

Design/methodology/approach – The research is based on a systematic literature review.

Findings – There is a prevalence of research related to manufacturing and how industrial complexes can establish practices linked to the circular economy. The reviewed papers in this study can be classified into three perspectives: systemic analysis, institutional perspective and operational perspective. Considering these categories and the wholesaler perspective, there is a scope to explore Industry 4.0 technologies applications with wholesale distributors and their contributions to the reverse flow of waste along the CSC. In addition, it is interesting to examine the interpretation of wholesale distributors on circularity, and how these members can contribute to filling the information gaps between industries and retailers based on the concepts of circular economy and Industry 4.0, and how they can contribute to establishing public policies for proper waste recycling methods.

Originality/value – First, this research considers the wholesaler the exclusive supply chain member under the influence of Industry 4.0 and highlights its importance in firms' circular operations. Second, it provides an inclusive plan for the other stakeholders to interact with the wholesaler echelon to design and operate under 4.0 technologies to consolidate effective CSCs.

Keywords Wholesale, Sustainability, Distribution, Sustainable supply chain management, Closed-loop supply chain, Reverse logistics

Paper type Research paper

1. Introduction

The increased use of natural resources has raised questions about the planet's capability to use them sustainably, with less impact on the environment. The Sustainable Development

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Goals (SDGs), environmental pressure and conscious consumer awareness have significantly pressed the organisations to review their operations that impact the environment (Garza-Reyes *et al.*, 2018). This discussion heats the role of questioning organisations' activities and their externalities for people and the natural environment (Sauvé *et al.*, 2015). Despite that, organisations face operational quality and efficiency challenges even though they keep sustainability as one of their pillars of management vision. Technological advancement reduces natural resources by greater productive manufacturing efficiency and optimising a consumer's experience as an ongoing process. *Cyber-physical spaces (CPSs), big data analytics, cloud services, the Internet of things (IoT)* and *3D printing* (Prause and Atari, 2017; Stock *et al.*, 2018) are examples that can assist and "clean" traditional production processes.

In general, the wholesaler echelon is the crucial link between manufacturing firms and the end-consumers, which warrants a high level of communication, logistics and transportations systems. The third industrial revolution brought wholesalers' organisations automation, facilitating efficient daily operations. Technologies such as *IoT* and *big data* help to transform supply chains into an increasingly interoperable, networked business with open communication and data sharing to provide real-time information. This interoperability brings agile internal information and broadens the economic network of agents and stakeholders, making decision-makers balance financial and environmental returns to plan their demand for resources (Kalverkamp, 2018).

Effectively, this transition aims to reduce the impact on the environment. The wholesale phase is critical to support manufacturing companies to their environmental indicators (Ghisellini *et al.*, 2016; Batista *et al.*, 2018; Bernon *et al.*, 2018; Bressanelli *et al.*, 2018), allowing their logistic process to be cleaner (Sauvé *et al.*, 2015; Franco, 2017). By systems approach, we can affirm that supply chain members should integrate their operations (Batista *et al.*, 2018; Franco, 2017). Wholesalers are the critical technological adopters to engage in this no-turning-back business sustainability process.

Circular supply chains (CSCs), adopting CE paradigms, enable this transition to more sustainable production modes, distribution and consumption. CE has a positive impact on production indicators (Gicquel *et al.*, 2016; Franco, 2017; Flygansvær *et al.*, 2018; Bressanelli *et al.*, 2018; Kalverkamp, 2018; Garza-Reyes *et al.*, 2018; Piyathanavong *et al.*, 2019), revenue increase (Larsen *et al.*, 2017), performance analysis (Butzer *et al.*, 2017), overall management (Bressanelli *et al.*, 2018; Batista *et al.*, 2018; Geisendorf and Pietrulla, 2018) and for their supply members partners (Bernon *et al.*, 2018).

Previous studies have highlighted how wholesalers can contribute to the integration of operating systems and expand traceability using blockchain in supply chains (Ada *et al.*, 2021; Casino *et al.*, 2021), or how the sharing of information between the value chain ensures greater operational efficiency (Hänninen *et al.*, 2021). Concerning the environmental needs and integration to achieve better performance for circularity to the supply chain, studies sought to understand how exchanging information for product development brings greater efficiency to the supply chain and pricing (Fang *et al.*, 2021).

Otherwise, logistics are one of the essential parts of operations. Minimal changes can strongly impact the costs (Boyaci and Gallego, 2004), operations management, technology adoption (Vijayaraman and Osyk, 2006) and strategies adopted by the members of a supply chain. This study relies on circular economy (CE) and Industry 4.0 integration as a non-reverse trend, once it has been given importance for research that aims to understand the flow of material alongside the supply chain. By considering the implications of Industry 4.0 technologies and applying the CE principles by the supply chain and its new possible configurations, the supply chain can assume new strategies on its operations to achieve better environmental performance. That said, understanding the wholesaler echelon and its contribution to supply chains' information and material flow contributes to understanding the impact of implementing CE 4.0 by the wholesale industry.

Against this background, this systematic review attempts to answer the following question: "*What role should wholesale distributors play in CSCs in the context of Industry 4.0?*". Thus, it aims to analyse systematically previous literature that sought to understand the formation of CSCs and propose a research agenda for implementing CE 4.0 in the wholesale industry. The study adopts a systematic literature review process to study this question (Tranfield *et al.*, 2003). The paper has a few significant contributions. First, the pioneering research considers the wholesaler the exclusive echelon under the influence of Industry 4.0 and highlights its importance in firms' circular operations. Second, it provides an inclusive plan for the other stakeholders to interact with the wholesaler echelon to design and operate under 4.0 technologies to aim for effective CSCs.

The structure of the paper is as follows. Following this introduction, Section 2 discusses background literature. Sections 3 and 4 provide methodology and analysis. Section 5 deliberates the future agenda. Section 6 concludes the article.

2. Background

2.1 Sustainable supply chains (SSC)

The first step in exploring the CSC literature is differentiation with *sustainable supply chains* (SSCs). SSC is structured from the interaction between economic agents who share interests and products within a production process. With the increase in international competitiveness and the demand for best performance at the industry and continental level, the number of agents that make up a supply chain grows dramatically, increasing its complexity. Materials and information flow both downstream and upstream in a supply chain, making supply chain management the integration point between these activities from the relationship between members to achieve a sustainable competitive advantage (Seuring and Müller, 2008; Beske and Seuring, 2014).

SSC seeks to integrate environmental perspectives by organisations to reduce negative externalities arising from production and consumption processes (Nasir *et al.*, 2017). Three aspects can make it difficult to structure an SSC: high costs; coordination between members and complexity; nonexistent or inefficient communication (Seuring and Müller, 2008). SSC can be defined as:

> [...] managing the flow of material, information, and capital as well as cooperation between companies along the supply chain while taking on objectives linked to the three dimensions of sustainable development, considering that they derive from the demands of consumers and other stakeholders (Seuring and Müller, 2008, p. 1700)

2.2 Circular economy (CE)

Understanding the economy as a linear system based on decision-making and resource allocation along the supply chain is no longer enough (Ness, 2008). As the dizzying exploitation of resources, robust discussion of the possibility of maintaining current production levels in the face of natural resource depletion has become topical (Haas *et al.*, 2015). This system ignores the environmental impacts of using resources and waste disposal, contrary to the circular economy. As an effect, the system creates closed cycles in which the productive resources are in circular movements allowing its use and subsequent reuse throughout the product life cycle (Sauvé *et al.*, 2015). This new approach stands out from the economic perspective, gaining more and more space by both the academic universe and the market widely discussed (Geng and Doberstein, 2008; Geisendorf and Pietrulla, 2018).

Furthermore, the CE concept encourages organisations' optimised usage of environmental resources. It enables creating more dynamic systems and innovative production processes that contribute to the economic growth achieved by countries that seek to structure, develop and implement sustainable development. However, the concept is still incipient in developing

countries compared to developed countries' applications (Goyal *et al.*, 2018). This system allows for several sustainability-related gains as better resource allocation in the production system, reducing the need for primary inputs such as energy and raw materials for efficiency gains (Ghisellini *et al.*, 2016). The regeneration process can contribute to this (closed) circular flow of materials and the use of raw materials and energy through multiple phases (Yuan *et al.*, 2006).

Thus, CE transforms goods that have reached their end of usefulness into productive resources by returning them to the production of new goods, closing cycles of industrial ecosystems and minimising waste (Stahel, 2016). Moreover, it contributes to increasing domestic and regional competitiveness by increasing resource allocation, utilisation and productivity (Su *et al.*, 2013). Different conceptualisation emerges every day as it consolidates itself as a field of research and knowledge production. Table 1 summarises some of the key definitions.

2.3 Industry 4.0 and wholesalers

Industry 4.0 has become substantially studied by several researchers, given the novelty of this topic and its contributions to new technologies that have emerged for production and distribution processes. The application of new technologies (Trotta and Garengo, 2018) such as *cloud computing* (Ghouri *et al.*, 2021), IoT (Prause and Atari, 2017) and *big data analytics* has contributed to the structuring of smart industries and more efficient production processes (Kiel *et al.*, 2017; Vrchota *et al.*, 2020) by optimising the resources utilisation that makes a significant contribution to sustainability (Stock *et al.*, 2018). These new configurations also bring new dynamics to supply chains, based on new business models and production chains (Vrchota *et al.*, 2020).

Wholesalers play an important role since they allow integration between industries and retail. Consumers provide a large amount of information, and technologies such as cloud computing can enable greater integration between members of the chain through the processing of data in real-time (Ghouri *et al.*, 2021). Technologies such as IoT, in turn, allow wholesalers and retailers to monitor their customers (de Souza *et al.*, 2020).

Blockchain emerges as an essential means for product control and traceability throughout the supply chain (Casino *et al.*, 2021). Besides, the greater integration of a supply chain based on the digitisation of processes causes wholesalers and other members to collaborate and share this information (Hänninen *et al.*, 2021). Ensuring collaboration between supply chain members based on information sharing based on technologies from Industry 4.0 contributes

Authors	Definition
Yuan *et al.* (2006)	Although there is no commonly accepted definition of CE so far, CE's core is the circular (closed) flow of materials and the use of raw materials and energy through multiple phases
Ellen Macarthur Foundation (2013)	An industrial system that is restorative or regenerative by intention and design
Tse *et al.* (2015)	[. . .] represents a paradigm from which waste is transformed into resources through reuse of recreation and an economic gain in resource efficiency and industrial transformation [. . .]
Geisendorf and Pietrulla (2018)	A system in which the value of products and materials is maintained, waste is avoided, and resources are held in that system when the product reaches its end of life

Table 1.
Circular economy definitions

Source(s): Yuan *et al.* (2006), Ellen Macarthur Foundation (2013), Tse *et al.* (2015), Geisendorf and Pietrulla (2018)

to the formation of more SSCs (Bressanelli *et al.*, 2018; Batista *et al.*, 2018), complementing the application of CE precepts, especially when considering the reduction, reuse, recycling, recovery and regeneration (5R's) (Pan *et al.*, 2015) and their contribution to the return of materials to the production chain.

Applying technologies linked to the Industry 4.0 phenomenon contributes to increasing operational efficiency (Jabbour *et al.*, 2018; Xu *et al.*, 2018). However, concerns are raised about the digitisation of systems and processes from the adoption of these technologies and the resulting impact on energy consumption (An *et al.*, 2020; Wang *et al.*, 2022), and the possibility of generating negative environmental externalities (Luan *et al.*, 2022). This point is highlighted, as warehouse systems, for example, by adding robotisation and application of other technological inputs, can contribute to increased energy consumption, which goes against issues related to sustainability. With this, the adoption of technologies such as big data and blockchain, in addition to the integration of other systems such as IoT or investment in infrastructure for the operation of these systems from robotisation, contributes to increasing the operational efficiency of the supply chain; however, with the possibility of increased energy expenditure, such as electricity and increased environmental impact from the more significant emission of CO_2 into the atmosphere (An *et al.*, 2020).

3. Methodology

We used systematic reviews by *Scopus* and *Web of Science* platforms to observe the publications on the subject. Only papers published in "journals" and "conference proceedings" were considered for all performed searches with no period. We manually excluded some documents that did not approach the subject directly. Table 2 presents the search terms and the number of papers from the initial search. We obtained 46 papers for the *circular economy, supply chain and reverse logistics in its last stage*.

3.1 Systematic review

Systematic review as a research method allows the researcher to map and evaluate the domain knowledge by defining a research proposal that contributes to developing an area (Tranfield *et al.*, 2003). Thus, by clearly defining a research question, the researcher can find relevant studies and present the results (Khan *et al.*, 2003). Based on this reasoning, we performed a systematic review in three stages: review planning, conducting an examination, reporting and dissemination. Table 3 summarises the steps defined for the study of available literature.

3.2 Paper coding process

Based on the analysis of the considered papers, we coded using letters and numbers (Amui *et al.*, 2017), in Table 4. The applied categories allow evaluating the relationship of the works found from the method, sector, context, origin of the researchers and focus of the supply chain, that is, the main object of the study. Graph 1 presents the ratio of the number of papers by category.

Terms	Keywords	Publications number
Circular economy and circular supply chain	*"Circular Economy"*	7,679
	"Circular Economy" and "Supply Chain"	591
	"Circular Economy" and "Supply Chain" and "Reverse Logistics"	46

Table 2.
Bibliometric research

Steps	Processes	Action
Review planning	Identification of the need for a survey	Literature survey from the question "How have recent studies pointed to the link between circular economy and Supply Chains?"
	Preparation of a research proposal	Preparation of objectives and preliminary search criteria
	Development of a protocol	Definition of the platform and search terms used
Conducting the review	Search gap identification	Validation of selection criteria
	Study selection	Search for material from defined terms
	Evaluation of study quality	Application of pre-read and search filters to evaluate study quality
	Data extraction and control	Categorisation of papers and application of classification codes
	Data synthesis	Data analysis using VosViewer to identify keyword clusters
		Preparation of tables for comparison of studies
Publishing and Disclosure	Publishing and recommendations	Research agenda elaboration and indication for future research
	Managerial impacts	Expert validation of the framework

Source(s): Tranfield *et al.* (2003)

Table 3.
Systematic review structure

Analytic category		Codes
Method	Qualitative	A1
	Quantitative	A2
	Theoretical	A3
	Empirical	A4
	Case studies	A5
	Survey	A6
Sector	Public	B1
	Private	B2
	Not applicable	B3
Context	Developed countries	C1
	Developing countries	C2
	Not applicable	C3
Researchers' origin	Latin America	D1
	North America	D2
	Europe	D3
	Asia	D4
	Oceania	D5
	Africa	D6
Supply chain focus	Manufacture	E1
	Services	E2
	Agriculture	E3
	Not applicable	E4

Table 4.
Applied codes

From the results, he observes the predominance of empirical and qualitative studies. Another point is the predominance of papers that study private sector organisations. It is noteworthy that most of the studies sought to understand the formation of CSCs in developing countries, which brings a new perspective to this area of study. However, most of the researchers who developed a study in *CSCs* are in Europe, which demonstrates the relationship between the

search for the development of this area of studies by researchers who are in Europe, however, applying the concepts of CE and supply chains in developing countries.

Further, category E allows the assessment of the application of studies by sector; it observes the predominance of studies that sought to analyse the manufacturing industry. Studies that apply the concept of CE are primarily used in the manufacturing industry. There is a search for researchers to understand the behaviour of other supply chain members for the circularity of materials and information along the supply chain. However, little was analysed of the service sector that comprises the field wholesalers and distributors among the studies analysed (see Figure 1).

4. Analysis

Supply chains from the CE perspective contribute to the value recovery of goods produced through the cycles formed by reuse and renewal, which contributes to economic and environmental gains (Masi *et al.*, 2017). The design stage considers the business model for which the product is being developed, inducing integration among supply chain members (Bernon *et al.*, 2018). Eco-design can be one of the means of product development. It enables incorporating environmental aspects into the production system and the product (Su *et al.*, 2013) and biomimetics, green design and cradle-to-cradle design (Masi *et al.*, 2017). This is necessary because the type of material used and its flow throughout the product life cycle depends on the purpose for which the organisation wishes to work. Some businesses may use inputs that retain their value throughout a product's life cycle. Others may use materials that return to nature or are reused in other industrial processes. However, some of these materials cannot be reused from the perspective of circularity due to their product characteristics, such as low added value, noticeably short life cycles with disassembly, and recovery processes that do not make the process economically viable (Bernon *et al.*, 2018) (see Table 5).

Technological processes for eco-efficiency, eco-design and data security are critical points for this change (Bressanelli *et al.*, 2018). Larsen *et al.* (2017) show that corporate profit enables a new possibility from two product categories: recovered products from consumers and reused products.

The distinction between these new product categories derives from the commercial relationships of used and reclaimed products to existing or new markets. The level of uncertainty is imposed by the moment of the product's return by the consumer, the number of possible resources, and the quality to enable its reuse cannot be controlled (Gicquel *et al.*, 2016;

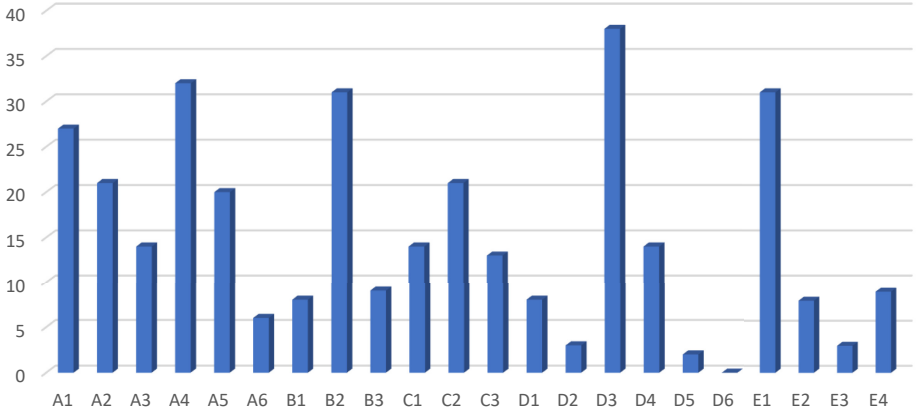

Figure 1.
Resume of applied categories

Authors	Title	Journal	Citations	Country
Franco (2017)	Circular economy at the micro-level: A dynamic view of incumbents' struggles and challenges in the textile industry	Journal of Cleaner Production	64	Switzerland
Mangla *et al.* (2018)	Barriers to effective circular supply chain management in a developing country context	Production Planning and Control	51	England/Wales/ India
Nascimento *et al.* (2019)	Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context A business model proposal	Journal of Manufacturing Technology Management	43	England/Brazil/ Mexico
De Angelis *et al.* (2018)	Supply chain management and the circular economy: towards the circular supply chain	Production Planning and Control	43	England
Geisendorf and Pietrulla (2018)	The circular economy and circular economic concepts—a literature analysis and redefinition	Thunderbird International Business Review	38	Germany
Zhu *et al.* (2017)	A comparison of regulatory awareness and green supply chain management practices among Chinese and Japanese manufacturers	Business Strategy and the Environment	37	China/Japan
Yang *et al.* (2018)	Product-service systems business models for circular supply chains	Production Planning and Control	27	England
Batista *et al.* (2018)	In search of a circular supply chain archetype – a content-analysis-based literature review	Production Planning and Control	24	England
Goyal *et al.* (2018)	Circular economy business models in developing economies: Lessons from India on reduce, recycle and reuse paradigms	Thunderbird International Business Review	23	India/France/ USA
Piyathanavong *et al.* (2019)	The adoption of operational environmental sustainability approaches in the Thai manufacturing sector	Journal of Cleaner Production	21	England/Mexico
Mishra *et al.* (2018)	Value creation from circular economy-led closed-loop supply chains: a case study of fast-moving consumer goods	Production Planning and Control	21	England
Bernon *et al.* (2018)	Aligning retail reverse logistics practice with circular economy values: an exploratory framework	Production Planning and Control	20	England/ Indonesia
Garza-Reyes *et al.* (2018)	Total quality environmental management: adoption status in the Chinese manufacturing sector	TQM Journal	16	England

Table 5.
Key literature in systematic review

(*continued*)

Authors	Title	Journal	Citations	Country
Banguera *et al.* (2018)	Reverse logistics network design under extended producer responsibility: the case of out-of-use tires in the Gran Santiago city of Chile	International Journal of Production Economics	14	Chile/Ecuador
Goltsos *et al.* (2019)	The boomerang returns: accounting for the impact of uncertainties on the dynamics of remanufacturing systems	International Journal of Production Research	13	England/Wales
Alamerew and Brissaud (2020)	Modelling reverse supply chain through system dynamics for realising the transition towards the circular economy: a case study on electric vehicle batteries	Journal of Cleaner Production	11	France
Batista *et al.* (2019)	Circular supply chains in emerging economies – a comparative study of packaging recovery ecosystems in China and Brazil	International Journal of Production Research	10	England/Brazil
Flygansvær *et al.* (2018)	Exploring the pursuit of sustainability in reverse supply chains for electronics	Journal of Cleaner Production	9	Norway/USA
Werning and Spinler (2020)	Transition to the circular economy on firm-level: barrier identification and prioritisation along the value chain	Journal of Cleaner Production	8	Germany
de Oliveira *et al.* (2019)	Understanding the Brazilian expanded polystyrene supply chain and its reverse logistics towards the circular economy	Journal of Cleaner Production	8	Brazil
Vlajic *et al.* (2018)	Creating loops with value recovery: an empirical study of fresh food supply chains	Production Planning and Control	7	Serbia/North Ireland
Rahman *et al.* (2019)	Evaluating barriers to implementing green supply chain management: an example from an emerging economy	Production Planning and Control	7	England/ Bangladesh
Tsiliyannis (2018)	Markov chain modelling and forecasting of product returns in remanufacturing based on stock mean-age	European Journal of Operational Research	6	Greece
Jain *et al.* (2018)	Strategic framework towards measuring a circular supply chain management	Benchmarking – An International Journal	6	India
Abuabara *et al.* (2019)	Consumers' values and behaviour in the Brazilian coffee-in-capsules market: promoting circular economy	International Journal of Production Research	5	England/Brazil

(*continued*)

Table 5.

Authors	Title	Journal	Citations	Country
Habibi *et al.* (2019)	Sample average approximation for the multi-vehicle collection-disassembly problem under uncertainty	International Journal of Production Research	4	India/France
Frei *et al.* (2020)	Sustainable reverse supply chains and circular economy in multichannel retail returns	Business Strategy and the Environment	4	England
Sehnem *et al.* (2019)	Circular economy: benefits, impacts and overlapping	Supply Chain Management – An International Journal	3	England/Brazil
Yang *et al.* (2019)	Complementarity of circular economy practices: an empirical analysis of Chinese manufacturers	International Journal of Production Research	3	England/China
Ponte *et al.* (2019)	The value of regulating returns for enhancing the dynamic behaviour of hybrid manufacturing-remanufacturing systems	European Journal of Operational Research	3	England/Wales
Bhatia and Srivastava (2019)	Antecedents of implementation success in the closed-loop supply chain: an empirical investigation	International Journal of Production Research	2	India
Kalverkamp (2018)	Hidden potentials in open-loop supply chains for remanufacturing	International Journal of Logistics Management	2	Germany
Lechner and Reimann (2020)	Integrated decision-making in reverse logistics: an optimisation of interacting acquisition, grading and disposition processes	International Journal of Production Research	2	Austria
Sehnem *et al.* (2019)	Is sustainability a driver of the circular economy?	Social Responsibility Journal	2	Brazil
Suzanne *et al.* (2020)	Towards circular economy in production planning: challenges and opportunities	European Journal of Operational Research	2	France
Susanty *et al.* (2020)	An investigation into circular economy practices in the traditional wooden furniture industry	Production Planning and Control	1	England/ Indonesia
Dominguez *et al.* (2020)	On the dynamics of closed-loop supply chains under remanufacturing lead time variability	Omega-International Journal of Management Science	1	England/Italy
Kazancoglu *et al.* (2020)	Performance evaluation of reverse logistics in food supply chains in a circular economy using system dynamics	Business Strategy and the Environment	1	England/Turkey
Ren *et al.* (2020)	A GIS-based green supply chain model for assessing the effects of carbon price uncertainty on plastic recycling	International Journal of Production Research	0	China/Austria/ Norway

Table 5. (*continued*)

Authors	Title	Journal	Citations	Country
Kazancoglu *et al.* (2020)	Circular economy and the policy: a framework for improving the corporate environmental management in supply chains	Business Strategy and the Environment	0	England/Turkey
Moktadir *et al.* (2020)	Critical success factors for a circular economy: Implications for business strategy and the environment	Business Strategy and the Environment	0	England/ Bangladesh/ Australia/ Netherlands
Liao *et al.* (2020)	Designing a closed-loop supply chain network for citrus fruits crates considering environmental and economic issues	Journal of Manufacturing Systems	0	China/USA/Iran/ United Arab Emirates
Hickey and Kozlovski (2020)	E-strategies for aftermarket facilitation in the global semiconductor manufacturing industry	Journal of Enterprise Information Management	0	England/Ireland
Cesur *et al.* (2020)	The optimal number of remanufacturing in a circular economy platform	International Journal of Logistics – Research and Applications	0	England/Turkey
Khandelwal and Barua (2020)	Prioritising circular supply chain management barriers using fuzzy AHP: case of the Indian plastic industry	Global Business Review	0	India
Dominguez *et al.* (2020)	Remanufacturing configuration in complex supply chains	Omega (United Kingdom)	0	Italy/Spain

Table 5.

Kalverkamp, 2018). Supply chains considering the closed-loop perspective present high uncertainty compared to traditional supply chains. They have several challenges related to their circularity characteristics, many sources of recycled/remanufactured products that can be accessed (Kalverkamp, 2018). Companies seeking to restructure their supply chain to adopt a circular approach should consider the linear and reverse material flow (Batista *et al.*, 2018; Geisendorf and Pietrulla, 2018). For that, we should consider both the flow of materials efficiently and the sustainability gains inherent in the integration process (Kalverkamp, 2018).

CSCs can also contribute to the company's revenue growth creating new markets for their products and inserting them in markets where this would not be possible (Larsen *et al.*, 2017). As Aminoff and Kettunen (2016) stress, CSCs clearly distinguish between owning a product and having access to it and using materials and consuming them. And that creates a need for new supply chain requirements. This need for system changes, and insertions influences supply chain management to a large extent. Consumers have begun to demand transparency throughout the supply chain and have come to advocate for responsible business practices and products.

Further, it is essential to highlight the difference between reverse logistics and closed-loop supply chains since the former is related to the movement of materials from consumers to producers and their logistical role for the reconditioning and reuse of materials in the production chain. The second concept relates to how logistics and supply chain structures are

organised to allow the flow of used and reconditioned materials, as well as being a viable end-to-end chain integration that creates restorative systems for reuse of refurbished material and disposal of material that no longer meets the required quality levels (Batista *et al.*, 2018). Highlighting the difference between applications for material return to the production process, it is understood that these supply chains have their production reversibility process motivated by their focus on the environment, operating profitability, efficiency and waste reduction, product development, search by raw materials, production processes and transportation (Geisendorf and Pietrulla, 2018).

Circular economy systems are related to the ability to ensure economic development without being detached from the reduction of the environmental impact generated by production processes, which should be based on the principles of 5R's (Pan *et al.*, 2015). By integrating these principles into organisational processes, CSCs can be formed, and material flow can be realised with less waste generation. For this movement of both downstream and upstream materials to occur in a CSC, there must be a shared effort among stakeholders. Thus, for these chains to be structured, there is a need for external coordination with upstream partners to obtain environmental contributions and downstream for these partners to cooperate in environmental management practices from the return, reuse activities and product recycling (Masi *et al.*, 2017). There are three possible configurations to ensure the circularity of this material along the chain. These arrangements can be of the following types: eco-industrial, environmental parks in which companies maintain a symbiosis relationship based on information sharing and constant material transfer along the chain; green supply chains are those that can extrapolate the concept of eco-industrial parks by including suppliers and consumers integrated into an efficient logistics, warehousing and procurement system; closed-loop supply chains from which the material flow can be either open – from relationships with external suppliers – or closed, where the supply chain is developed from a single manufacturing perspective (Batista *et al.*, 2018), and in these cases, the importance of reverse logistics is emphasised as an approach that minimises the generation of waste without value (Masi *et al.*, 2017). Still, product design is essential so that the materials used can meet basic quality requirements, thus ensuring their return to the production process from their update, repair, reconditioning or remanufacturing (Franco, 2017; Masi *et al.*, 2017; Goyal *et al.*, 2018). Therefore, CSCs can be defined as:

> [. . .] Direct and reverse supply chains coordinated through business ecosystem integration to create value from products and services, by-products, and functional waste streams throughout life cycles that improve organisations' economic, social and environmental sustainability (Batista *et al.*, 2018, p. 446).

The product flow along the supply chain can be maximised by adopting the 5R principles of reduction, reuse, recycling, recovery and regeneration. Reduction means the process of productive readjustment. The raw material used goes from non-renewable materials with substantial environmental impact to biodegradable and easily recoverable materials to the production chain (Goyal *et al.*, 2018). The principle of reuse is related to the use of unmodified materials by extending the useful life of a product to its most whole and being used for another purpose (Batista *et al.*, 2018; Goyal *et al.*, 2018), which provides new opportunities for business (Larsen *et al.*, 2017). Recycling is an essential phase of the process. Through this activity, materials used in a product can be transformed into raw materials for new products (Batista *et al.*, 2018), reducing waste volume and generating waste that returns to nature (Goyal *et al.*, 2018). Recovery can be achieved by reconditioning and remanufacturing materials to return them to the production system, but not under the same initial conditions of use (Batista *et al.*, 2018). Finally, regeneration is related to the impacts that activities generate on the environment and its resilience to absorb this impact (Pan *et al.*, 2015).

5. Research agenda

Based on the analysed studies, there is a prevalence of research related to manufacturing and how industrial complexes can establish practices linked to CE that ensure the return of waste to the production chain. However, this paper starts with the following research question "*What role should wholesale distributors play in CSCs in the context of Industry 4.0?*" to understand how wholesale distributors can contribute to the formation of CSCs, supported by the Industry 4.0 technologies. Some studies highlight the complexity of forming CSCs based on how the strategic stakeholders can share and establish mechanisms that integrate the supply chain, highlighting the reverse logistics concept as part of the operational strategy. Thus, studies can be classified into three perspectives for analysis, based on their contributions to both theory and management practice: (1) perspective of systemic analysis, by analysing the possible roles that each member of the supply chain plays for the reverse logistics and practices of the CE; (2) institutional perspective, when assessing how companies and other stakeholders influence the formation of policies for the establishment of CSCs, and (3) operational perspective, with which the mechanisms adopted by productive, distribution and retail systems are evaluated up to the arrival of the product to the consumer and how the return of waste to the production chain is ensured.

From the macro perspective, the problems faced by developing countries stand out from the barriers imposed on organisations, such as the high cost of eco-friendly materials and informal waste collection channels (Khandelwal and Barua, 2020), or even the insufficient participation of governments, policymakers, non-governmental organisations (NGOs), as well as other stakeholders in proposing public policies that ensure the correct waste management and waste management along the production chain (Kazancoglu *et al.*, 2020).

The systems perspective contributes to analysing the roles of CSCs and other stakeholders as part of the environment. Thus, this analysis allows us to understand how the actions taken by the stakeholders contribute to the formation of CSCs, contributing to the circularity of productive inputs and waste along the supply chain. At this point, we highlight the role played by wholesale distributors since they bridge the existing gaps between production and consumption processes. The technologies made available by Industry 4.0 emerge as potential contributions to the integration of members of the supply chain since the volume of information to be shared increases dramatically, which allows for greater integration throughout the chain.

The concept of eco-design (Bernon *et al.*, 2018; Su *et al.*, 2013; Masi *et al.*, 2017) helps us to establish a point for analysing how information sharing among members of the supply chain enables the development of products and services that are more efficient in the use of resources, as well as may have ensured the return of waste from the end of the life cycle of the developed products. The operational perspective contributes to understanding how firms, considering their position in the supply chain, can address efforts to implement circular practices through digital technologies in the search for efficient supply chain consolidation. *Reverse logistics* emerges as an essential managerial practice to reduce the impacts of residue destination and ensure the review flow for the supply chain. Considering the potential of Industry 4.0, it is seen that the technologies made available by it contribute to the integration between members through the formation of networks, the automation of processes, and the generation and sharing of knowledge.

Regarding the wholesaler positioning in CSCs, a central supply chain member, these agents may help bridge the necessary information flow between industry and retailers. Wholesalers and their essential distribution activities may ensure, based on the relation with the industry sector, a better understanding of the supply chain needs to improve strategy alignments in a search for circularity of materials. Once more, these agents may contribute to the product design for its entire cycle by sharing essential demand and consumption

information with the supply chain, implying more efficient operational strategies and organisational systems.

These assumptions addressed by the studies make it possible to raise important points for future research that analyse the role of wholesale distributors for CSCs to be consolidated. First, there is a scope to explore Industry 4.0 technologies applications with wholesale distributors and their contributions to the reverse flow of waste along the CSC. Second, it is interesting to examine the interpretation of wholesale distributors on circularity and that can contribute to filling the information gaps between industries and retailers based on the concepts of circular economy and Industry 4.0. Third, it recommends analysing how wholesale distributors can contribute to forming public policies for proper waste recycling methods and their return to the production chain. Finally, the analysis triggers a new study on how wholesale distributors can contribute to the design process of new products since they have an intermediary role between the industry and retail sectors. This helps to understand the role of wholesalers in their central supply chain position in establishing communication between the other members of the CSC.

6. Conclusion

This study aimed to present a 4.0 distribution research plan based on the relationship between the 4.0 Industry and circular economy concepts, highlighting the role played by wholesale distributors to CSCs formation. This relationship demonstrated in the study contributes, in practical terms, for wholesale companies to assume a vital role for sustainable development, also becoming protagonists to the circularity actions taken, contributing to the overall sustainability of the business. It directly/indirectly helps expand the responsibility of all links, not just the demands on the manufacturer, where it is perceived that specific echelon is often subjected to government pressure for sustainable practices. In this way, these organisations also consider the importance of the circular economy for their national growth and development. As a critical contribution, the study presents a proposal of integration between these concepts. Thus, brings a new perspective to the wholesale sector and logistics supply chain distribution activities to integrate Industry 4.0 and circular practices.

Understanding the innovations that emerged from the Industry 4.0 phenomenon contribute to greater integration among supply chain members. It can be understood that data sharing contributes to the tracking and monitoring of waste generated throughout the distribution process, understanding the existing end-to-end relationship in the supply chain. Throughout the adoption of the circular economy concept, this new technological paradigm opens space to ensure the efficient use of resources and reduction of environmental impact caused by supply chain activities, consolidating the return and reverse flow of materials, explicitly structuring CSCs.

This study holds significant practical contributions, once it presents for practitioners, public policy managers, wholesale companies, retailers and other organisations, the implications of integrating Industry 4.0 and CE initiatives to improve sustainable operations among supply chain members and how the flow and sharing of information turn into a possibility a strong environmental performance for the sustainability of the supply chain members operations, bridged by wholesalers' echelons.

The theoretical contributions rely on how the understanding of these new paradigms can take a step forward for theory development. By integrating these two new trends, Industry 4.0, and circular economy, and how they imply for CSCs structuring, this study contributes to paving the way for research on sustainable operations and logistics integration among supply chain members for resource allocation efficiency, waste reduction and reverse flow of materials alongside the supply chain.

Concerning the study limitations, we highlight the lack of empirical research that corroborates the possible application of Industry 4.0 and CE concepts by wholesalers for CSC formation. As a complementary limitation, this study as an effort to present a research agenda does not consider the supply chain but focuses on wholesalers and how these stakeholders can unfold new supply chain relations.

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