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RESEARCH ARTICLE

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Industry 4.0 and the circular economy: A literature review and recommendations for future research

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Abstract

Research regarding the Fourth Industrial Revolution (Industry 4.0) and the circular economy has gained traction since 2014. Paralleling the growth in the internet of things (IoT), the circular economy poses both risks and opportunities to various stakeholders in its development. This literature review aims to identify Industry 4.0 stakeholders' interests and expectations regarding how the IoT can be part of circular economy management. Contributions include identifying various IoT tools for dealing with circular economy challenges while also addressing implementation best practices. The transition of the circular economy within Industry 4.0 requires a better understanding of government, suppliers, international organizational interests, and expectations regarding the IoT. This study enables future research on circular economy practices and their potential sustainability benefits for manufacturing firms. This study's findings allow practitioners and researchers to understand the literature and critical elements of the transition toward a more circular economy.

KEYWORDS

circular economy, Industry 4.0, internet of things, manufacturing firms, recycling, reuse, stakeholders

1 | INTRODUCTION

The Fourth Industrial Revolution (Industry 4.0) is the ongoing automation of traditional manufacturing and industrial practices using modern smart technology (Moore, 2019). The integration of machine-to-machine communication and the internet of things (IoT) help to increase automation and improve communication and self-monitoring and the development of smart machines that can analyze and diagnose potential issues. Industry 4.0, when combined with the circular economy, represents two industrial paradigms enabling new natural resource strategies (Rosa, Sassanelli, Urbinati, Chiaroni, & Terzi, 2020). In turn, the circular economy is driving more attention (Centobelli, Cerchione, Chiaroni, Del Vecchio, & Urbinati, 2020) in support of innovative life cycle management, communication, and the development of smarter systems reconceptualizing waste as intrinsically valuable (Perey, Benn, Agarwal, & Edwards, 2018). This industrial revolution relies on digital technologies such as wireless connectivity and sensors connected everything to everyone to gather data to analyze, visualize the entire production system, and provide applicable information to the business system (Wang, Wan, Zhang, Li, & Zhang, 2016). According to Rüßmann et al. (2015), Industry 4.0 is a combination of different technologies as additive manufacturing, simulation, autonomous robots and vehicles, augmented and virtual reality, IoT, cloud, and cyber security.

Studies of Industry 4.0 appear in a broad range of fields with great potential to reduce impacts on the environment (Reinhard, Jesper, & Stefan, 2016). Whereas some see Industry 4.0 primarily as a means of protecting the environment, others see it as an opportunity to reducing risk and improving productivity (Stock & Seliger, 2016). In this study, we argue that these views reflect the supportive aspects of IoT. Industry 4.0 provides opportunities to help address circular economy problems. For example, IoT is used in many industries to reuse, recycle, and repair items, allowing the circular economy to develop faster (Valerio, 2017). For this study, the circular economy is an economic system based on reuse, reduction, recycling, and extraction of materials from end-of-life products to accomplish long-term sustainable development goals (Kirchherr, Reike, & Hekkert, 2017). In this way, sustaining a circular economy happens when creating a restorative and regenerative system by design. This design keeps products, components, and materials in closed-loop systems delivering positive impacts on society while reducing negative impacts on the environment (MacArthur, 2013).

Industry 4.0 and the circular economy have sustained rapid growth over the last few years and represent one of our current digital era's essential themes. Much work in this domain has focused on studying the link between Industry 4.0 and productivity (see, e.g., Buer, Strandhagen, & Chan, 2018) along with challenges to implementing a circular economy (Rajput & Singh, 2019b). Some scholars have started putting Industry 4.0 at the forefront of their research agenda (de Sousa Jabbour, Jabbour, Godinho Filho, & Roubaud, 2018; Rajput & Singh, 2019a). Prior studies on the circular economy have explicitly focused on exploring Industry 4.0 technologies implementation (Luiz Mattos Nascimento et al., 2018). The circular economy interface and digital technologies have recently emerged as an area of focus (Okorie et al., 2018). Here, we agree with prior research noting the importance of the IoT to a circular economy (Bressanelli, Adrodegari, Perona, & Saccani, 2018).

There is a rich literature on Industry 4.0 and circular economy, particularly in the manufacturing industry, which has improved our understanding of the capacity of the IoT in the circular economy (Nobre & Tavares, 2017; Okorie et al., 2018). However, this literature's primary focus has been on explaining IoT benefits on circular economy initiatives. We see a gap in the literature explaining stakeholder interests and expectations when implementing and developing infrastructure (Bakker, Maat, & van Wee, 2014). To this end, there is a lack of research examining the interest and expectations of multistakeholders when attempting to implement circular economy initiatives from an organization's perspective.

To investigate the opportunities to enhance the implementation of IoT and circular economy initiatives, an understanding of stakeholder expectations and attitudes (government customers and suppliers) is required (Wen et al., 2018). Within the circular economy and IoT, only a few studies have considered what it means for Industry 4.0 to contribute to the circular economy (Esposito, 2017). Instead, most studies have focused on assessing the link between the circular economy and Industry 4.0 (Ingemarsdotter, Jamsin, & Balkenende, 2020; Rosa et al., 2020). The need to consider the linkages between circular economy initiatives and understanding stakeholders' interests and expectations has been acknowledged (e.g., Govindan & Hasanagic, 2018). Manavalan and Jayakrishna (2019) have called for more understanding of IoT requirements from different stakeholders' perspectives. Alcayaga, Wiener, and Hansen (2019) have called for developing a better understanding of the different external and internal elements, such as stakeholders and organizational culture, for the successful implementation of remanufacturing and recycling services.

Previous studies have investigated the implications of IoT on production and a product's life cycle management and circular economy. Organizing stakeholders' interests and expectations is not clear in the circular economy. To fill this research gap, we draw on Industry 4.0 and circular economy research to review the literature. From this, we explain the stakeholders' interests and expectations and identify future research streams. We start by dividing the available literature in Industry 4.0 into two significant areas: the circular economy and IoT. We examine the literature that either concurrently or independently discusses the circular economy and IoT with an Industry 4.0 perspective. Later, we extend this discussion to provide future research avenues while considering the individual interest and expectations established among the Industry 4.0 stakeholders. Thus, the objective of our literature review is twofold. First, we provide an updated overview of the literature in rapidly growing areas in the field of circular economy and Industry 4.0. This objective is to help structure research fields of circular economy in the context of Industry 4.0 as a current industrial revolution, identify an emerging field of research themes, and highlight significant research gaps. Second, we aim to synthesize the literature analysis to identify Industry 4.0 stakeholder interest and expectations regarding how the IoT enables circular economy management.

In this study, we take a systematic approach to the analysis of prior work on circular economy concerning the IoT, identifying stakeholders' expectations and interests in the context of Industry 4.0. The essential advantage of the systematic literature review method is its ability to curtail bias and provide of collective understanding of the phenomena under study (Thomé, Scavarda, Ceryno, & Remmen, 2016). This methodology's contributions include but are not limited to advancing the understanding of the circular economy in Industry 4.0. Here, we propose advancing understanding from a supply-side perspective. This perspective is essential for several reasons. First, we increase the knowledge regarding how stakeholders' interests and expectations affect Industry 4.0 in circular economy practices.

This study thus promotes an understanding of how stakeholders' roles interact. From a manufacturing industry perspective, our findings reveal the essential roles of suppliers, customers, and competitors regarding their impacts on circular economy practices. Second, we respond to the call for research by Govindan and Hasanagic (2018) to understand how multistakeholders' involvement is a prerequisite to successfully implementing circular economy practices. To this end, we can identify external stakeholder interests and expectations to implement reuse and remanufacturing practices. Finally, we can offer insights about which companies ought to anticipate benefits or pressure from stakeholders and why companies face high or low stakeholders' pressure. Managers can gain insights regarding how they can direct efforts and resources toward product system design for circular economy options and remanufacturing with IoT to improve operations.

2 | LITERATURE REVIEW

2.1 | Prior literature

A recent literature review study on Industry 4.0 has dealt with a circular economy and waste management (Sarc et al., 2019).

Kerin and Pham (2019) add to this literature a thorough analysis of Industry 4.0 technologies in production, focusing on the IoT in remanufacturing. They suggested that future research must focus on a broader scale of adoption of IoT in remanufacturing. The Industry 4.0 area is of interest to many researchers in the context of a circular economy. Kerin and Pham (2019) summarized the literature review findings, discussing benefits from Industry 4.0, including greater cooperation among stakeholders, the use of artificial in decision making, and expand product service system as ways to developing new service or products. Also, considering IoT applications like embedded sensors or RFID, Kerin and Pham (2019) discussed disassembly and remanufacturing opportunities. One literature review by Lopes de Sousa Jabbour et al. (2019) analyzes the development of a circular business model (CBM) in operation management and focuses on interorganizational technologies.

A previous study relating to the smart product-service system and future perspective reveals that a human-centric life cycle management approach is required (Zheng, Wang, Chen, & Pheng, 2019). A prior literature review has explored the linkage between Industry 4.0 and the circular economy (Cezarino, Liboni, Oliveira Stefanelli, Oliveira, & Stocco, 2019). They highlighted that Industry 4.0 tools could be useful for a circular economy if there is clear articulation among different actors regarding how to promote the digitization of business models. Other literature reviews focus on new business models that enable a circular economy by applying new digital technologies (Bressanelli et al., 2018). The literature on digitization and the circular economy (Okorie et al., 2018) examines articles published between 2019 and 2000. The literature review was limited to a SCOPUS search. From what we can see from the literature, future studies need to explore the connection between the circular economy and Industry 4.0. Why? Because there is an expectation that the IoT could serve as a vital tool in manufacturing depending on the current IT infrastructure level. Interestingly, Franciosi, Lambiase, and Miranda (2017) discussed the benefits posed to IoT's increasing reliance when Industry 4.0 could upgrade and boost remanufactured and used spare parts.

Combined with IoT tools, decision-makers could evaluate data for product maintenance or extend product life by replacing parts or components. Within the existing studies, we find little evidence focused on Industry 4.0 tools, with an overlooked opportunity to investigate the interests and expectations of Industry 4.0 stakeholders (i.e., management, international regulators, society, customers, and suppliers) regarding IoT application in improving circularity of products and materials. The above-discussed studies show that most of the literature on reconnecting Industry 4.0 tools and implementing the circular economy. However, we find a gap in the literature reviews examining Industry 4.0 interests and expectations. There is an essential need for research about IoT and circular economy, as this field of inquiry is experiencing an unprecedented rate of progress. It is imperative to contribute a summary of the most recent works, particularly in the realm of IoT and circular economy, to uncover best practices and help guide future research. A review of prior research informing this study on integrating Industry 4.0 and the circular economy is in Table 1.

2.2 | Industry 4.0 and IoT

The phrase "Internet of things" was first presented in the latter part of the 1990s by business owner Kevin Ashton. One of the pioneers of the Auto-Id program at the Massachusetts Institute of Technology (MIT) participated in a group that identified how to link material appliances to the internet using RFID labels. Later in 2011, Germany was the first country to establish the term Industry 4.0 to increase industrial efficiency, productivity, safety, and transparency. The notion of Industry 4.0 is still in its beginning stages. It is one of the axions of a cyber-physical production system representing information exchange and collaboration within business units and across the global value chain (Szalavetz, 2019). The concept of Industry 4.0 rooted in a smart production concept called a smart factory or smart manufacturing (Kang et al., 2016). As introduced by the German government, the Industrial Revolution is a mindset, a lens through which to consider the application of digitization technologies, so they potentially offer a competitive advantage (Kagermann, Lukas, & Wahlster, 2011). One of the core tenets of Industry 4.0 is that it offers digital automation and the exchange of data in production. This includes industrial internet of things (IIOT) (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014), cloud computing, artificial intelligence (AI; Manyika et al., 2013), smart manufacturing (E. Hofmann & Rüsch, 2017), and the "smart factory" (Brettel, Friederichsen, Keller, & Rosenberg, 2014).

Although the Industry 4.0 concept was developed primarily in manufacturing, it is related to different areas other than automation in production and services. In this view, IoT offers many opportunities for industries to develop and exploit recycled or reused products to increase their marketability. IoT has significant benefits for product development to recover parts and components after the end of life products. IoT has applications in different fields such as marketing and supply chain and can be expanded o smart cities. There are two essential categories of IoT. Internet of services (IoS) is referred as follows: "Internet of Services (IoS) harmonizes various applications into interoperable services and uses semantics for understanding, combining, and processing data and information from different service providers, sources, and formats" (Scuotto, Ferraris, & Bresciani, 2016). Second, the Internet of people (IoP) summarizes as "people becoming part of ubiquitous intelligent networks having the potential to seamlessly connect, interact, and exchange information about themselves and their social context and environment" (Hernández-Muñoz et al., 2011, p. 449).

Applications of IoT and Industry 4.0 can be found in previous studies. Bienhaus and Haddud (2018) studied Industry 4.0 influence on procurement (along with Dolgui, Ivanov, Sethi, & Sokolov, 2019) production schedules, "real-time visibility on machines, component, and status" (Cheng-Hsin Chuang et al., 2017), improvements in product quality, (Majeed & Rupasinghe, 2017) Industry 4.0, and IoT embracing. IoT has also been used to study in different Industries such as households, e-retailers, hospitals, energy management, fire fighting, construction, product life-cycle energy management, and telecommunications. The literature reveals that Industry 4.0 offers many research

TABLE 1 Summary of previous literature review

Author	Title	Data source
(Kerin & Pham, 2019)	"A review of emerging industry 4.0 technologies in remanufacturing"	How virtual reality (VR) and augmented reality (AR) support circular business models
Van Fan, Lee, Lim, Klemeš, and Le (2019)	"Cross-disciplinary approaches towards a smart, resilient and sustainable circular economy"	Identified approaches for the sustainable circular economy
Sarc et al. (2019)	"Digitalisation and intelligent robotics in the value chain of circular economy-oriented waste management—A review	This study focuses on analyzing the needs, requirements, and trends for waste management in Industry 4.0
Nord, Koohang, and Paliszkiewicz (2019)	"The internet of things: Review and theoretical framework"	Review, develop a conceptual framework considering IoT stakeholders, IoT adoption, challenges, and priority areas of research.
Manavalan and Jayakrishna (2019)	"A review of the internet of things (IoT) embedded sustainable supply chain for Industry 4.0 requirements"	Explore potential research files in the context of IoT and Industry 4.0
Alcayaga et al. (2019)	"Towards a framework of smart-circular systems: An integrative literature review"	This study focuses on the use of IoT for maintenance, reuse, and remanufacturing
Lopes de Sousa Jabbour et al. (2019)	"Circular economy business models and operations management"	The research stream on IoT is relatively new. Future research studies need to explore the connection between the circular economy and the internet of things.
Zheng et al. (2019)	"A survey of smart product-service systems: Key aspects, challenges, and future perspectives"	Future challenges: Embedded IT with a product requires a human-centric perspective and circular lifecycle management approach in a digital environment.
Bressanelli et al. (2018)	"Exploring how usage-focused business models enable circular economy through digital technologies"	Do IoT technologies help to promote the circular economy
Okorie et al. (2018)	"Digitisation and the circular economy: A review of current research and future trends"	Lack of research on how digital technologies enable a circular economy. The literature review was limited to the SCOPUS search database and a systematic review conducted on articles published between 2018 and 2000.
Zhong, Xu, Klotz, and Newman (2017)	"Intelligent manufacturing in the context of Industry 4.0: A review"	

opportunities primarily due to all of the different industry sectors it touches. Hence, integrating the role of Industry 4.0 can shed light on the consequences of flexible manufacturing. The key concept of Industry 4.0 technologies is promising to promote Reconfigurable Manufacturing Systems (RMS) (Dalenogare, Benitez, Ayala, & Frank, 2018). Within the modular structured Smart Factories of I4.0, "CPS monitors physical processes, creates a virtual copy of the physical world, and makes decentralized decisions" (Boyes, Hallaq, Cunningham, & Watson, 2018).

This allows an increasingly balanced production process, can increase flexibility, improve quality, and help achieve industrial performance (Dalenogare et al., 2018) and advancement of resource consumption (Kagermann, Helbig, Hellinger, & Wahlster, 2013). Achievement of resource consumption has become an established means of Industry 4.0 for resource efficiency. IoT may be the most beneficial source from which the new policy and market orientation concept of the circular economy could find theoretical guidance. IoT has been a long tradition in a different industry from different perspective, with the aim of in-depth analysis of organization understanding on stakeholders interests and expectations toward IoT. Industry 4.0 technologies are creating opportunities for intelligent manufacturing systems and improving production and process performance in the industrial environment. See Table 2 for a summary of relevant information regarding the history of Industry 4.0.

3 | REVIEW METHODOLOGY

We utilized a systematic literature search methodology supported by Okoli and Schabram (2010). The systematic literature review aims to

TABLE 2 The history of Industry 4.0

Prior Developments	Time Period
Digital manufacturing	During the 1970s
Computer integrated manufacturing (CIM)	During the 1990s
Digital factory	From 2000
Factory 2.0	From 2005 onward
Smart factory	From around 2007
Industry 4.0	From 2011 onward
Adapted (Roser, 2016)	

summarize existing literature to answer a specific scientific question (Koutsos, Menexes, & Dordas, 2019). The systematic review reflects the notion that review is based on selected criteria to answer a focused question, leading to a conclusion (Schünemann et al., 2020). We apply a systematic literature review technique used in the study to identify existing ideas and existing knowledge in specific areas. A literature review is an accepted method of studying the topic and provide a proper context. A systematic literature review is a more objective and organized review of existing literature on a scientific topic (Munn, Stern, Aromataris, Lockwood, & Jordan, 2018). Systematic reviews provide a particular and replicable method of reducing bias in selecting and evaluating articles. The systematic literature review method has identified relevant studies via structured query searches to assess if they relevant to the focused scientific questions (see, e.g., Moher, Liberati, Tetzlaff, Altman, & Prisma Group, 2009). We selected a systematic review for several reasons. First, it helps to obtain an interdisciplinary and detailed overview of a topic. Second, it helps to answer a focused question (Sargeant, Rajic, Read, & Ohlsson, 2006). A systematic literature review presents research on emerging issues by identifying the research and specifying future research studies (Govindan, Soleimani, & Kannan, 2015).

This literature review has become prominent among academic scholars from diverse disciplines (Dubey, Gunasekaran, Childe, Papadopoulos, & Fosso Wamba, 2017). We conducted a literature review involving three researchers and consulted on all the selected articles to be considered for review. The purpose of conducting a systematic review is to synthesize previous research work and then briefly present the advances on a scientific research topic (Koutsos et al., 2019). Prior literature review studies have used a similar approach (Andoni et al., 2019; Brauer & Wiersema, 2018). Previous systematic literature review studies have also followed a similar approach. For this study, we next review the methodology and how we operationalized the literature review within the context of our primary research question and objectives. This process is enabled by the use of databases to help collect and organize the relevant literature. The rationale behind using Scopus and the web of science data for keyword searches is that both databases contain peer-reviewed scientific publications.

To this end, we are particularly interested in work published since 2006 in the circular economy and IoT field. These databases help the review process to be transparent, focused, and can provide evidence to inform practitioners and researchers. Following the previous studies' recommendation, we identified the relevant published papers for our literature review, which specially focused on both fields: circular economy and Industry 4.0. We searched Scopus and web of science databases for academic articles containing key terms. The keywords used in our initial research are in Table 3. This key search strategy generated 473 articles. To locate the relevant articles, we required that the titles, abstract, and keywords of articles have either the circular economy or Industry 4.0 or both.

We removed articles that did not mention or dealt with the requirements above. After gathering the articles from both databases, we inspected and identified all of them that debated the circular economy and Industry 4.0. Some articles did not individually examine

TABLE 3 List of keywords used in search

Web of science		Total
Key terms	"Internet of things" AND "stakeholder"	47
	"Stakeholder" AND"circular economy"	59
Article types. Article and review articles Journal(s): All The search field(s): Topic	"Industry 4.0" AND "stakeholder "	04
	"Industry 4.0" AND "circular economy "	13
	"Digital technologies" AND"circular economy"	05
Scopus		
The search field(s): Title, abstract and keywords Scientific areas(s): All Journal(s): All Article type: Journal, review papers Publication storage: Final	"Internet of things" AND "stakeholder"	203
	"Stakeholder" AND"circular economy"	187
	"Industry 4.0" AND "stakeholder "	37
	"Industry 4.0" AND "circular economy "	34
	"Digital technologies" AND"circular economy"	07
Exclusion criteria	Book reviews, conference proceedings, articles in the press, editorial review.	
Inclusion criteria	Published articles, literature review articles conducted in any country, must address circular economy	
Time period	2006–2019	
Data collected	August 2019	

circular economy from a manufacturing perspective or Industry 4.0. Some articles have appeared in both databases, so we did a duplication check test using Mendeley. After deleting the duplicate articles, we reviewed 596 articles. See Figure 1 to depict the methodological research scheme adopted by (Moher, Liberati, Tetzlaff, & Altman, 2009). This study focuses on the existing published literature concerning the Industry 4.0 interest and expectations, including areas of the circular economy related to IoT (Figure 2).

4 | ANALYSIS

4.1 | Circular economy

According to MacArthur (2013, p. 14), a circular economy is "an industrial economy that is restorative or regenerative by intention and design." However Geissdoerfer, Savaget, Bocken, and Hultink (2017) argue that a circular economy is "a regenerative system in which resource input and waste emission and energy leakage are minimized by slowing, closing and narrowing material and energy loops." The cornerstone of Industry 4.0 is the company stock of connected devices, which is based on information flow from products to a producer. Early work on circular economy put forward 3R foundational premises (references), which were expanded later to 6 R. Later still, these foundational premises have been condensed to 7R. The 5R circular economy model provides the core aspects of the framework. It was not aimed at being restricted to the industrial domain.

Scholars in the circular economy and strategic management have shown interest in how responsible production and consumption within a system generate economic value through waste management and recycling (Betancourt Morales & Zartha Sossa, 2020). According to F. Hofmann and Jaeger-Erben (2020, p. 2), a circular economy "connects post-use and process waste with production through processes such as recycling and repurposing of by-products, and attempts to preserve the inherent value of products and product components by maximizing the number of consecutive use phases and use time in each of these phases via repair, maintenance, upgrade, resale, refurbishment, remanufacturing."

A circular economy uses waste as an input in other parts of the value chain and widely focuses on closed-loop materials (Barreiro-Gen & Lozano, 2020). Subsequently, the circular economy research stream has generally started in emerging countries (Awan, Kraslawski, & Huiskonen, 2018). Each of these circular economy dimensions can be tied directly into a sustainability context.

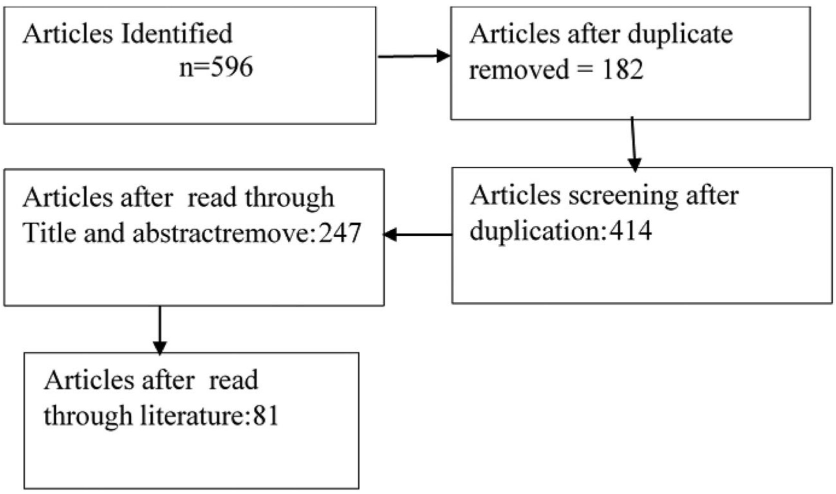

FIGURE 1 Articles selected

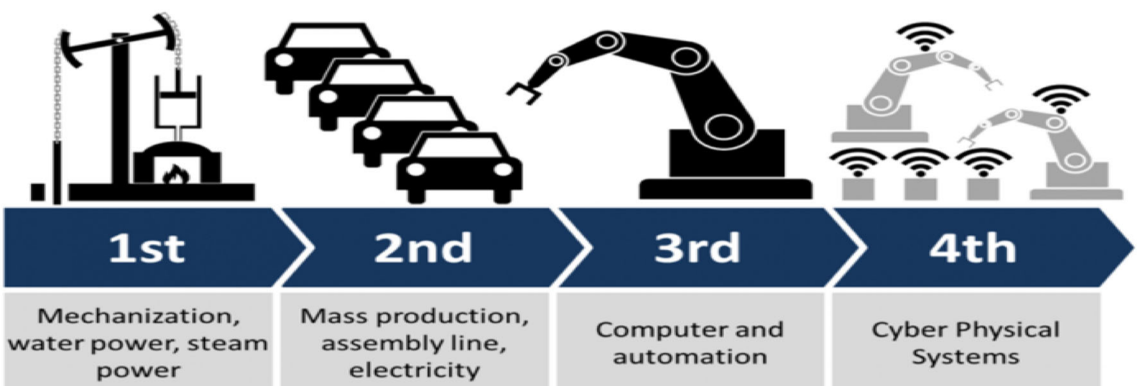

FIGURE 2 Industry 4.0. Adapted from Roser (2016)

We also find Industry 4.0 becoming more approachable and workable regarding a circular economy in emerging countries (Daú, Scavarda, Scavarda, & Portugal, 2019). Turner et al. (2019) analyze literature on sustainable production with a focus on the circular economy. The circular economy is defined by Kirchherr et al. (2017) as an economic system based on reuse, reduction, recycling, and extraction of materials from the end-of-life products to accomplish long-term sustainable development goals. Some take-back laws have even been implemented in Belgium, China, and some states in the United States (Chia-Hung Chuang, Wang, & Zhao, 2014). The CBM is considered a vital determinant of the extent to which firms can apply reuse and remanufacturing business models to reduce cost and radical reductions in environmental impact (Linder & Williander, 2017).

The term recycling has been in the literature for some time, and it is fundamental to the circular economy and linked to resource cycling (Murray, Skene, & Haynes, 2017). Recycling is limited to resource cycling and focuses on enhancing the life of reused material, parts, and products through better maintenance of operations and manufacturing processes. The concept of recycling refers to “any recovery operations by which waste materials are reprocessed into products, materials, whether for the original or other purposes” (European Commission, 2008). The reuse refers to using the product to the product's maximum life (Stahel, 2014). The reuse principle refers to “any operation by which products or components that are not waste are used again for the same purpose they were conceived” (European Commission, 2008). Figure 3 shows product reuse, remanufacturing, recycling, and disposal demands fewer resources and less energy.

4.2 | Research at the intersection of industry 4.0 and CE

Today, many firms have started to implement IoT to improve and maintain operational efficiency (Tarifa-Fernández, Sánchez-Pérez, & Cruz-Rambaud, 2019). The implementation of IoT may cut costs, reduce waste, and resources can be used elsewhere. IoT can be applied in the remanufacturing process for improving quality. The improvement in product quality leads to reduce waste, lower transportation, higher sales, and increase customer satisfaction (Fathym, n.d.). For example, in the repair process, the parts embedded with the sensor can transmit real data on the customers' quality standards, thus building better customer relationship management. IoT can help inform the managers before the end of life of the parts or components, so the manager proactively replaces the parts and acquires the end-of-life product for recycling purposes. IoT is becoming essential for the industries who intend to transition toward circular economy paths. IoT provides a set of practices that can deliver circular economy advantages.

IoT can aid in asset retrieval so that it can be recycled into its components. By embedding IoT with products can remotely monitor the product conditions, thereby allowing predictive maintenance immediately or developing a schedule for repairing the product (Esposito, 2017). The product embedded IoT devices and provides feedback when it requires repair, maintenance, and end of life and can be considered a smart product. This smart product enables companies to develop new business models and create service providers and manufacturers (Frank, Dalenogare, & Ayala, 2019). As indicated by Wollschlaeger, Sauter, and Jasperneite (2017), digitization advancement increased productivity and reduced energy waste from processes and machines. The interaction between the cyber-physical system of Industry 4.0 and the integration of stakeholders cooperations is a prerequisite for circular manufacturing. According to Park (2016), a hyperconnected network is essential for creating an opportunity to develop new products embedded in internal competencies. Park (2016) stated that hyperautomation generates hyperconnectivity, which connects humans' operational performance with high automation and technology. Thus, an investigation of hyperconnectivity's role will be another theoretical and practical contribution of the study.

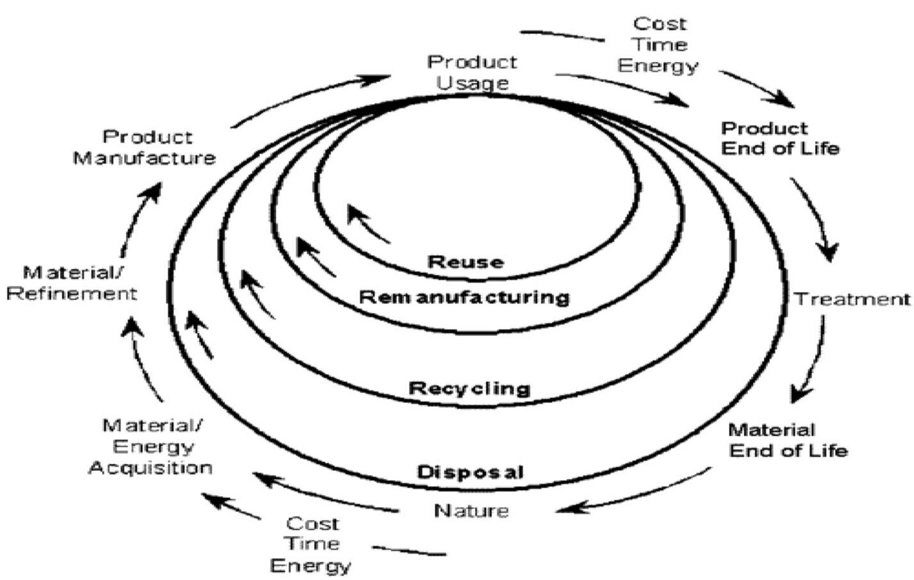

FIGURE 3 Circular economy practices (Mihelcic et al., 2003)

Previous studies have pointed out that Industry 4.0 can be used to better support material efficiency, feedback information, and "facilitating collection points for reuse and recycling" (Luiz Mattos Nascimento et al., 2018).

Despite some barriers and challenges of implementing circular economy practices, the future implementation of an IoT-enhanced circular economy is fruitful for manufacturing firms (Esposito, 2017). Industry 4.0 aims to combine many technologies for the common good to achieve responsiveness and enhance a production system's quality. The intended purpose of elements of Industry 4.0 is to improve and advance in production efficiency. Automatic detection of a fault in the product promotes enhanced self-governing automation in the manufacturing process.

AI is designed to monitor and forecast failures, repair, and support another task that enhances accuracy. Tao, Qi, Liu, and Kusiak (2018) pointed out that AI, which contains elements of the IoT, enables predictive maintenance. From a production efficiency perspective, Tao et al. (2018) suggested that AI helps increase quality and identify nonconformities in the early stages of product development. Industry 4.0 elements are an exchange of information at its most superficial level and provide feedback to improve production efficiencies to reduce waste generation and control air pollution. IoT is an application to produce smart products. Smart products can be considered beneficial to provide early warning signals for predictive maintenance or fault signals or broke down any machine parts.

Within an IoT, the environment is involved in creating circularity products, for example, IoT, cloud computing, cyber-physical system, smart manufacturing, smart product, and AI. To the part of the circular economy products, each of these elements of the IoT environment integrates resources in a way that helps to achieve objectives. The circular economy embedded with the IoT in every industrial sector has a significant opportunity to monitor and automate reuse, repair, and remanufacturing processes. With the application of IoT, it provides real-time information about how actually product used and handled by logistic clients and end-user. The key benefit of circular practices embedded with the IoT is the ability to make an informed decision. Firms may plan the repair schedule based on the sensor data and understand when maintenance or repair is a need. This information may help to redesign the parts, components, and products to extend the product's life cycle and provide more sustained benefits.

The use of IoT sensors in product recovery enables proactive maintenance alerts. There are many opportunities to redesign products when they deviate from their intended performance. For example, a sensor can be used in TVs to monitor screen resolution. Manufacturers can then actively monitor which part or component is not performing to standards to redesign the product to reduce costs and product return time while increasing customer satisfaction. With the IoT's help, they can recover the product from an actual user and deliver the new one before they launch the complaint. Finally, to further closing the loop of materials and products, current practices of the circular economy need to depart from the traditional practices and embraced the Industry 4.0 digitization tools for the green economy and prevent negative impacts on the natural environment. Table 4 provide summaries of the selected papers.

4.3 | A stakeholder view

A stakeholder refers to "any group or individual who can affect or is affected by the achievement of the firm's objectives" (Parmar et al., 2010). Industry 4.0 organizational stakeholders can affect the organization or are affected by them can compromise but are not scant to international Institutional Regulations, suppliers, and customers. Although some studied interfirm stakeholders partnership in the manufacturing context (Lieder, Asif, Rashid, Mihelič, & Kotnik, 2017), there remains a need for literature review on understanding the stakeholder's interest and expectations on implementation of circular economy practices. The process of stakeholder interest and expectations affecting the implementation of creative ideas into the circular economy is not clear. According to Parmar et al. (2010), "stakeholders are those active groups whose action can significantly impact the firm operational objective." With changes in the internal patterns, much can be gained from incremental technology improvements, but to attain the European Commission roadmap for 2050 for moving to a competitive low-carbon economy in 2050 (European Commision, 2012).

Advances in technology development have brought interest in the green environment. For example, for companies to become more environmentally friendly, reduce greenhouse gases, and fewer materials, firms need to consider full circular economy practices. In another example, Black and Decker are starting to produce a durable drill, which is equipped with IoT to charge people per minute use and indicate when the replacement is needed. Institutions can play an active role in push a circular economy at the consumption level. European Union (EU) initiatives on product design and extending product life positively impact consumption through durability, reparability, and functionality (Alonso-Almeida, Rodríguez-Antón, Bagur-Femenías, & Perramon, 2020). At the end of the drill's life, many parts of the product will be reused for new products of the same size or smaller size (Valerio, 2017). As a result, the government and international organizations worldwide have already implemented product take-back laws and regulations. In this study, stakeholder interest is considered from an organization's perspective. It refers to different stakeholders (international legislation organizations, customers, and suppliers) who want to know and hold the attention to catch the Industrial Revolution's emerging opportunities. In this study, expectations consider present and future organization interests. Stakeholder expectations are referred to as optimism that the organization should achieve.

5 | DISCUSSION

5.1 | Stakeholders interests and expectations

Our review revealed that a limited number of articles have emerged over the last few years in the Industry 4.0 and circular economy

TABLE 4 Provide summaries of the selected papers

Authors	Title	Methods	Findings
Van Fan et al. (2019)	"Disciplinary approaches towards smart, resilient and sustainable circular economy"	Review	Building consensus among stakeholders, identification of common barriers involvement of stakeholder
Gupta, Chen, Hazen, Kaur, and Santibañez Gonzalez (2019)	"Circular economy and big data analytics: A stakeholder perspective"	Qualitative	An understanding of the stakeholder perspective on big data analytics is necessary for the circular economy.
Rajput and Singh (2019b)	"Industry 4.0—Challenges to implement a circular economy"	Literature review	Identify barriers and challenges. This study identifies cyber-physical systems standards and specifications, sensor technology is the most influential Industry 4.0 barriers for achieving a circular economy:
Lopes de Sousa Jabbour et al. (2019)	"Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations"	Literature review	Future researchers should investigate the connection of cyber-physical systems to the IoT to support smart remanufacturing
Cezarino et al. (2019)	"Diving into emerging economies bottleneck: Industry 4.0 and implications for a circular economy"	Literature review	How IoT and circular economy can contribute to the development of a competitive advantage.
Kerin and Pham (2019)	"A review of emerging Industry 4.0 technologies in remanufacturing"	Literature review	Future researchers explore the connection between IoT to support smart remanufacturing
Chauhan, Sharma, and Singh (2019)	"An SAP-LAP linkages framework for integrating Industry 4.0 and circular economy"	Muticriteria decision making	IoT is the most important for a circular economy.
Zheng et al. (2019)	"A survey of smart product-service systems: Key aspects, challenges, and future perspectives"	Literature review	Key aspects in achieving circular economy: smart reconfiguration, predictive maintenance, sensor-embedded products or end of life prediction, the vision of shared value,
Sarc et al. (2019)	"Digitalisation and intelligent robotics in the value chain of circular economy-oriented waste management—A review"	Literature review	Industry 4.0 enablers circular economy by bringing transparency
Rajput and Singh (2019a)	"Connecting the circular economy and Industry 4.0"	Muticriteria decision making	Industry 4.0 and organizational sustainability
Charnley et al. (2019)	"Simulation to enable a data-driven circular economy"	Modeling	4th Industrial Revolution (I4.0) and the IoT can increase digital intelligence
Manavalan and Jayakrishna (2019)	"A review of IoT embedded sustainable supply chain for Industry 4.0 requirements"	Literature review	Invest in technology to increase the well-being of Industry 4.0.
Alcayaga et al. (2019)	"Towards a framework of smart-circular systems: Integrative literature review"	Literature review	IoT could disrupt business models and has the potential to foster a circular economy
Nascimento et al. (2019)	"Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context"	Qualitative	Future researchers should explore how rising technologies from Industry 4.0 can be integrated with circular economy practices
Varela, Araújo, Ávila, Castro, and Putnik (2019)	"Evaluation of the relation between lean manufacturing, Industry 4.0, and sustainability"	Empirical analysis	Industry 4.0, and sustainability are salient topic for the companies.
Kusiak (2019)	"Fundamentals of smart manufacturing: A multi-thread perspective"	Modeling	Industry 4.0 tools provide the extraction of meaningful information on labeling material for the environmental and evolution stage of the new learning.

(Continues)

TABLE 4 (Continued)

Authors	Title	Methods	Findings
Daú et al. (2019)	"The healthcare sustainable supply chain 4.0: The circular economy transition conceptual framework with the corporate social responsibility mirror"	Empirical analysis	The fourth industrial revolution integrates, bringing circularity to the process and contributing to sustainable development goals.
Nord et al. (2019)	"The internet of things: Review and theoretical framework"	Literature review	Further research should be conducted regarding IoT priority areas to guide IoT implementation teams.
Martín-Gómez, Aguayo-González, and Luque (2019)	"A colonic framework for managing the sustainable supply chain in emerging economies with smart connected metabolism"	Mathematical modeling	Industry 4.0 may give rise to the development of circularity solutions and allows analysis of distributed complex systems.
Castelo-Branco, Cruz-Jesus, and Oliveira (2019)	"Assessing Industry 4.0 readiness in manufacturing: Evidence for the European Union"	Empirical	This study examines the existence of the factors that characterize Industry 4.0 in manufacturing across EU countries.
Turner et al. (2019)	"Sustainable production in a circular economy: A business model for re-distributed manufacturing"	Case study	Increase in customer involvement influences on redistributed model implementation
Bressanelli et al. (2018)	"Exploring how usage-focused business models enable circular economy through digital technologies"	Literature review	Lack of research on how digital technologies enable the circular economy transition. Digitization improving product design, attracting target customers, and provision of preventive and predictive maintenance,
Wen et al. (2018)	"Design, implementation, and evaluation of an internet of things (IoT) a network system for restaurant food waste management"	Literature review	The IoT-based system has had net positive effects for the stakeholders involved,
Lin (2018)	"User experience-based product design for smart production to empower Industry 4.0 in the glass recycling circular economy"	Literature review	Industry 4.0 for smart production in the glass recycling
Asdecker and Felch (2018)	"When stakeholder pressure drives the circular economy measuring the mediating role of innovation capabilities"	Mathematical modeling	Industry 4.0 can be useful in industrial companies for value creation at both ends
Bonilla, Silva, da Silva, Gonçalves, and Sacomano (2018)	"Industry 4.0 and sustainability implications: A scenario-based analysis of the impacts and challenges"	Qualitative analysis	Application of Industry 4.0 is closely dependent on societal reactions, public policies, and legal frameworks.
Yang, Raghavendra, Kaminski, and Pepin (2018)	"Opportunities for Industry 4.0 to support remanufacturing"	Literature review	Increase reliability and efficiency can be supported by a variety for Industry 4.0 tools.
Bachér, Pihkola, Kujanpää, and Mroueh (2018)	"Advancing the circular economy through group decision-making and stakeholder involvement"	Muticriteria decision making	Transparent and real-time information on the material flow analysis within value chains is essential for advancing a circular economy. Development of transparent information requires a more well-planned application of new technological solutions
Okorie et al. (2018)	"Digitisation and the circular economy: A review of current research and future trends"	Literature review	The findings from the study highlight that Industry 4.0 (I4.0) would be essential for a circular industrial system.

(Continues)

TABLE 4 (Continued)

Authors	Title	Methods	Findings
Dalenogare et al. (2018)	"The expected contribution of Industry 4.0 technologies for industrial performance"	Empirical	This study shows that a better understanding of the sociotechnical perspective, human factors, and organizational perspective are relevant to implement Industry 4.0 for manufacturing performance outcomes.
Pagoropoulos, Pigosso, and McAloone (2017)	"The emergent role of digital technologies in the circular economy: A review"	Literature review	This study reconnects the concept of digital technologies to broader challenges of the circular economy.
Li et al. (2017)	"A review of industrial wireless networks in the context of Industry 4.0, wireless networks"	Literature review	Lack of research on the use and application of AI in the Industry 4.0 framework
Zhong et al. (2017)	"Intelligent manufacturing in the context of Industry 4.0: A review"	Review	This study suggests that intelligent manufacturing plays an economically significant role in mass customization, better quality, and improved productivity.
Lieder and Rashid (2016)	"Towards circular economy implementation: A comprehensive review in the context of the manufacturing industry"	Literature review	This review suggests that the support of all stakeholders is necessary in order to implement the circular economy concept.
Su, Heshmati, Geng, and Yu (2013)	"A review of the circular economy in China: Moving from rhetoric to implementation"	Review	The findings suggest that technology is a key factor in the development of a circular economy. Each of the three circular economy principles requires advanced technology and development and the updating of facilities and equipment.
Standing, Jackson, Sarkis, and Zhu (2008)	"Information technology and systems in China's circular economy"	Literature review	The first study to develop a link between information technology and the circular economy to make further environmental performance. a circular economy can make further progress with the help of technological innovation.
Yuan, Bi, and Moriguichi (2006)	"The circular economy A new development strategy in China"	Literature review	The circular economy strategy is a more likely path to achieving improvements in resource productivity and eco-efficiency.

research category. Based on the literature review analysis, most of the existing literature only briefly presents the Industry 4.0 system design ideas. The majority of research studies focus on the application of IoT and circular economy. At present, many manufacturing industries have begun to put into practice circular economy awareness and thinking into traditional operational practices driven by demands from regulators, institutions, and customers. See Table 5 for Industry 4.0 stakeholders' interests and expectations. For example, a literature review study (Garcia-Muiña et al., 2019) investigates the relationship between Industry 4.0 and the manufacturing context's circular economy. They suggested that Industry 4.0 allows real-time redesigning solutions. Wen et al. (2018) have also examined the potential of using the IoT for the implementation and evaluation of food waste. These studies suggest that a detailed analysis of IoT and circular economy in the Industry 4.0 perspective is lacking. The literature review by Sarc et al. (2019) illustrates how digitalization tools will make it feasible to optimize waste management in advancing a circular economy. Lin (2018) examines how customer experience accelerates transition "or smart production to empower Industry 4.0 in the glass recycling circular economy."

On the other hand, the role and impact of stakeholders' interests appear much more complicated at the circular economy level. For example, Genovese, Acquaye, Figueroa, and Koh (2017) and Su et al. (2013) stress that government initiatives lead to an even more substantial benefit from the circular economy practices because this pressure led to the development of the policy of raw material procurement.

An empirical case study on Subaru Indiana steel exemplifies, reducing the scrap by changing the steel coils during the supplier's

TABLE 5 Industry 4.0 stakeholders interest and expectations

Stakeholders	
Institutions	Interest concerns • Assist maintenance using IoT can generate more tax on reuse material. • Improved waste management. • Better decision making on financial support to industry on reuse and developing resilience supply chain. • Management and evaluation of real-time information on waste generation, recycling, reuse, recovery, and remanufacturing. • Monitoring energy, waste, and water usage patterns and discourage illegal dumping of waste. • Strengthen industrial relationships with different actors to improve take-back solutions. Expectations • Industry 4.0 and virtual intelligent manufacturing technologies (virtual reality and augmented reality implementation) for the circular economy will be essential for greening the industries. • Ensure global access to the affordable product for all. • Achieve a high level of economic stability and productivity. • Mobilizing small enterprisers to enable smart technology and source material from local where appropriate Strategies • Incentives for e-procurement and provided more support for building infrastructure to support the circular economy (reuse, remanufacturing, recovery, recycling, and upcycling). • By setting promotional marketing programs for a product-service system • Provide financial support initiatives and investments for digitizing industry for the circular economy. • Support for research funding on developing machine learning approaches and use of artificial intelligence. • Develop better regulations for public-private partnership and global reverse networks
Suppliers	Interest concerns • Improve predictive maintenance. • Institutional incentives for the application of cloud computing to reduce the cost of communications. • Increase product traceability throughout the entire product life cycle. • Anticipate customer demand, quality improvement, and reduction of delivery time. • Improving the security and safety of reverse logistics. Expectations • Experiment with chargers (and fast chargers) at fuel stations to. • Learn about the use and possible business models. • Flexible and reconfigurable production scheduling for cradle to cradle product design and distributed and collaborative decision-making. • Product flow monitoring, quality control of remanufactured products, and adaptive pricing mechanism. Strategies • Long-term business relationship and freedom of collaboration. • Strength global reverse networks for recovery of critical raw material and resource mobilization. • Participate in optimization and seize more relationship development opportunities to facilitate the efficient flow of material.
International organizations	Interest concerns • Improve operational efficiency and close the global, local, and regional loop. • Utilization of artificial intelligence, big data analytics, cloud computing for effective decision making. • Aligned incentives to redesign circular business models. • Market expansion of reuse products across geographies and improve reverse cycle infrastructure. • Transform markets to use of renewable resources and set global reverse networks. Expectations • Reorganize production planning and control for lean manufacturing with Industry 4.0. • Focus on, reuse and recovery of material for upcycling form end of life products, and redeployment of infrastructure to steer changing circular economy. • Improving capabilities concerning business intelligence, big data analytics, application of machine learning approaches, monitoring, and recovery of materials. • Help to job creation, decent circular economy entrepreneurship, and innovation • Encourage and growth of small and medium enterprises. Strategies • Establish collaboration with reverse logistic suppliers and participate in circular design activities. • Facilitate technology development and sustainable infrastructure for demand forecast and inventory control. • Upgrade the circular economy technological capabilities of Industry 4.0. • Integration of digital capabilities for multilevel data sharing across organizations and networks. For real-time, data-driven, and collaborative. • Increase the use of efficient and adoption of cleaner production technologies • Monitor CO_2 emission.

environmental initiation program (Schroeder & Robinson, 2010). Government support and development of policies are crucial to the firms to change the behavior to make decisions (Govindan & Hasanagic, 2018). Government regulations can play a vital role in improving infrastructure and reducing the tax on import or development of IoT infrastructure for Industry 4.0. Governments have tremendous power to increase the implementation of the regulatory framework of Industry 4.0 to support their business using the IoT. The Governments switched to IoT smart meters for its energy and water usage monitoring, and recycling may improve immediate decision-making and save taxes. Government, international organizations, and suppliers can influence Industry 4.0 implementation. The direct data available may enable the fundamental shift government to act as a proactive service orientated that provides the industry with a marked service experience. For the supplier's firm, with the help of IoT using sensor data, detect when the product shipped, may detect early warning signals of quality standards and when likely to occur failure.

The process of implementation of circular economy practices in Industry 4.0 is primarily influenced by stakeholder interest. If there is no stakeholder expectation, any implementation will likely cease to exist. However, all the firms are likely not too familiar with all the practices and activities relevant to the greening environment. Therefore, companies need to obtain support, necessary information, and input from external stakeholders, such as customers, suppliers, and governments. However, strategy formulation and value cocreation activities for implementing circular economy practices are more complex, as it involves various stakeholders in different stages of the supply chain. This view is also supported by Ghisellini, Cialani, and Ulgiati (2016), who suggested that the circular economy practices are continually changing. Companies need to consider stakeholders' expectations at all stages. In this way, managing external stakeholders' expectations are fundamental. The performance outcomes may depend on the level of firm involvement in circular economy practices. If firms acquire new resources and then apply knowledge to the production to develop products using circular economy practices, it will be more successful in reducing the environmental impact, reducing cost, and promoting new employability. Customer demand for green products is continually increasing and will become stronger in the future. Demand from the end-markets is the primary trigger for business and digital transformation. Every company is part of the supply chain, and buyers can pressure the companies to comply with the international environmental standards and be subject to the third-party certification assessment of their circular economy practices.

Customers have a significant and complex role in firms to gain a competitive advantage. Another study Balch (2018) shows a direct and positive relationship between consumers' demands on taking back used products. Supplier's Interest is also a significant factor in bringing circular economy practices. Govindan and Hasanagic (2018) confirm that government regulatory focus is a significant motive for implementing circular economy practices. Especially internal-external stakeholders (Tyl, Vallet, Bocken, & Real, 2015). Previous literature has provided little guidance to help manufacturers integrate various circular economy initiatives into an operational strategy. As a result, manufacturing firms are now under pressure to implement initiatives that balance firms' internal and external stakeholder perspectives.

Even though some leading businesses, including IKEA and H&M, have introduced proactive circular economy initiatives, some studies mention that circular economy implementations are due to the coerced pressure by regulations. Institutional regulatory pressure is also considered a key driver that encourages companies to motivate the implement. Industrial competing demands have brought on companies to undertake reuse practices (Mathews & Tan, 2011). It has been suggested that one-way to take back used product is due to competitive pressure (Ferguson, Guide, & Souza, 2006). Stakeholders can affect the firm in achieving its objectives and goals (Parmar et al., 2010). The implementation of circular economy practices has two fundamental challenges: identifying stakeholders (Tyl et al., 2015) and the extension of circular economy practices across the value chain (Kalmykova, Sadagopan, & Rosado, 2017). The key stakeholders can initiate, lead, and identify the value proposition and ultimate outcomes as an integrated system for remanufacturing, reuse, and recycling (Tyl et al., 2015). Thus, it is essential for manufacturing firms to focus on reuse and remanufacturing practices (Golinska-Dawson, 2018).

There is an increasing interest in examining how firms develop effective circular economy practices in an open and closed-loop production system. The manufacturing firms potentially intended to implement circular economy practices when they perceive stakeholders to provide knowledge-driven practices and resources. As such, the manufacturing firm recognizes the opportunity to combine the knowledge possessed by their employees. The manufacturing industry faces the challenge of reducing its overall use of virgin resources and focusing on end-of-life products' continuous use. For example, most electronic manufacturing companies such as Sony, Huwai, and Apple do not allow storage upgrades on a large number of their smartphone models. They want their users to replace their batteries with their service centers to support and develop more circular economy initiatives. These components and parts embedded with Industry 4.0 tools may help support much faster circular economy initiatives than those without focusing on digital transformation. Thus, for better management of the take-back product, we argue that the IoT is a prerequisite. Our review also indicates that scholars have paid little attention to redesigning the operation and production system. Because previously, manufacturer firms often design systems to track and trace the products within the transportation or at the early stages of product development. The idea of IoT embedded in parts and components has been around since the dawn of Industry 4.0. The idea has been practiced, accompanied by the argument that it stimulates new design and redesign manufacturing and remanufacturing practices to develop new and innovative products.

5.2 | Future research opportunities

Our literature review provides evidence that research on integrating Industry 4.0 tools in the circular economy is still far from maturity.

Many of the findings enable opportunities for further examinations, and several other themes are worth investigating. Strategic management scholars, those working on integrating Industry 4.0 tools into operational strategy, should more affirmingly realize the pivotal role of stakeholders' interests and expectations. We have generated valuable insights regarding the relationship between Industry 4.0 and the circular economy. We believe that the successful implementation of Industry 4.0 and circular economy practices requires clarity regarding relevant stakeholders' interests and expectations.

Table 6 summarizes future research directions and essential research questions, especially in four research streams: consequences of stakeholders' influences, relationship between contextual constraints and big data analytics capabilities, the impact of big data on intelligent manufacturing and strategic options, and creating sustainable value. Several studies have been conducted over the past years that have concentrated on Industry 4.0 and circular economy. These studies' findings have provided a further understanding of this phenomenon and outline its importance from the stakeholder

TABLE 6 Summary of future research direction

Research streams	Future research questions	Influential authors
Consequences of stakeholders influences	• How can institutional stakeholders provide support for an effective and efficient circular economy? • How do supplier collaboration and interorganizational capabilities impact the gaining data insights for effective decision making and the enhancement of circular economy? • How can organizations extend big data analytics capabilities in guiding organizational performance? • What is the impact on institutional change and circular economy practices? • Must all relevant stakeholders contribute to increase efficiency and improve the management of natural resources with the use of IoT?	Govindan and Hasanagic (2018) de Sousa Jabbour et al. (2018) Alcayaga et al. (2019); Pagoropoulos et al. (2017) Schulz, Hjaltadóttir, and Hild (2019)
Relationship between contextual constrains and big data analytics capabilities	• How does the presence of multiple stakeholder expectations affect the implementation of big data analytics on organizational decision making? • What different external and internal factors affect the choice of implementing IoT and its impact on improved product quality and lean production approaches? • Which has a stronger impact on the financial performance of the organization, circular economy, and IoT practices (virtualization, decentralization, modularity, and real-time capability)	Marques, Agostinho, Zacharewicz, and Jardim-Gonçalves (2017) Qian, Zhong, and Du (2017) Brettel et al. (2014)
Impact of big data on intelligent manufacturing	• What is the effect of big data management capabilities on the design of a value-added product-service system, and how does it affect the firm's reputation? • Do data insights reflect effective decision making? • What external and internal factors increase or decrease the effect of data insights on organizational performance? • How do deviation from the use of big data analytics affect the performance of decision making? How do intelligence manufacturing technologies and infrastructure impact the collaboration for the product-service system? • How do industry characteristics interact with big data analytics to influence decision making and long term organizational performance?	Wamba et al. (2017) Zhang, Ren, Liu, and Si (2017) Sanders, Elangeswaran, and Wulfsberg (2016)
Strategic options and creating sustaining value	• How do big data analytics orientation and contextual factors are driving the circular economy practices? • Why do organizations retain strategic options (AI, ML, and cloud) to support supply chain optimization and facilitation of remanufacturing and recycling? • How can the application of AI tools (machine learning, predictive analytics, neural networks, and deep learning) meaningfully inform management practices and increase decision making effectiveness? • What organizational capabilities impact on identifying synergies and the potential for cooperation and alliance building for the circular economy?	Kamble, Gunasekaran, and Gawankar (2018) Stock and Seliger (2016) Wang et al. (2016) Fosso Wamba, Akter, Edwards, Chopin, and Gnanzou (2015)

perspective. Future research needs to study under what mechanism (digital transformation capabilities or digital change) organizations' readiness to change organizational innovation impacts. A future research scholar may investigate the global knowledge integration and organization structure impact on the firm-level innovation in the Industry 4.0 context.

Our review reveals that implementing circular economy practices across supply chain operations. Manufacturing firms have to consider the external stakeholder's interests and adopt a view of stakeholders' various interests. From our analysis, it is evident that Industry 4.0, when in its early stages, the organization transition toward circular economy linking Industry 4.0 should understand and prioritize stakeholders' interest. Stakeholders expect that Industry 4.0 and circular economy practices will actually meet their interests and thus perceive Industry 4.0 as a moment for greening industries. Industry 4.0 tools with circular economy business models with Industry 4.0 stakeholders' interests and expectations would allow for better environmental innovation solutions that support United Nations Sustainable Development Goals (SDGs).

It will be interesting to investigate how AI and big data shape the circular economy ecosystem and the consequences for product-service system providers. Through big data and AI, the manufacturing sector is enhanced because information on production, consumption of material resources, product delivery, purchasing decisions, and the best products to the customer at a particular area are readily available, which provides informed decisions to management. It leads to developing package recycling planning and curbs waste generated from materials, planning on which material to buy or not, which material is readily available from the end of life products, tack logistics issues, and set waste reduction targets. AI is expected to emerge as reshaping circular economy practices.

Knowing the interest and expectations of different stakeholders concerning the application of Industry 4.0 in the circular economy is key to understanding how to control and optimize materials and resource flow. This literature review highlights two critical findings. This shows that value creation necessary embedded in the collaboration, IoT application, and big data management capability is a part of easing information exchange between firms and the end-users. Industry 4.0 technologies (IoT, big data, and robotics) can enhance the product's circularity. Future research studies should explore the challenges of customer involvement in designing a redistributed business model.

5.2.1 | Consequences of stakeholders interests and expectations

As evidenced by our review, research on Industry 4.0 and circular economy is developing rapidly than in other research domains. Still, the implication of the development of new digital service business models requires further validation. Our review reveals that a multi-stakeholder perspective contributes to the emerging transition of Industry 4.0 toward a circular economy. Kotler (2011) provides evidence that companies can no longer operate as self-contained. Hence incorporating the support, collaboration, and partnership of related stakeholders may likely influence organizational performance (Govindan & Hasanagic, 2018). Consistent with this line of thinking, future research might examine how institutional stakeholders can support an effective and efficient circular economy. Future research might also embrace the knowledge management fit perspective to reveal external knowledge development and internal capabilities affecting implementing the digitization (Industry 4.0 tools) and their operational performance outcomes (de Sousa Jabbour et al., 2018).

Because the IoT continues to update the devices' information, these digital transformations are antecedent elements that impact management decisions. These include sharing data, end-of-life product information, type of the material used in the development of products among customers, and between different production units, enhanced collaboration, and enabling options for circular economy practices. However, a more in-depth understanding of the relationship between institutional change and circular economy practices is still necessary (Schulz et al., 2019) and in its infancy in many developing countries.

Further, the literature review reveals that the organizational suppliers' support paves a way forward for implementing the product-take-back system, managing quality of raw material and end-of-life products and enhancing reverse logistics means of product transportation. This literature analysis consisted of previous research findings (Supino, Malandrino, Testa, & Sica, 2016; Zhu, Geng, & Lai, 2010). Overall, we can posit that adopting a cooperative approach can ensure a firm's long-term sustainable development agenda. Literature has suggested that cooperation and collaboration with other industries can improve circular economy practices (Ghisellini et al., 2016). Also, we see a need for future research to examine how stakeholders' interests and expectations influence an organization's decision-making style. This is consistent with the view that stakeholders signal the organization to which circular economy initiatives and applications of IoT are essential. Based on the interests and expectations of stakeholders, the organization may alter its current production practices.

5.2.2 | Relationship between contextual constraints and big data analytics capabilities

Our review of the literature finds evidence that few prior research studies have paid particular attention to the implementation of digitization tools to support predictive maintenance, part recovery, and minimize the failure of a part. Besides, the successful transition toward a circular economy requires flexibility, adaptability, and big data management capabilities (Gupta et al., 2019). Prior research has widely assumed that the organization strives to adhere to business intelligence due to disruptive technological innovation.

Big data analytics applications for the organization can play an essential role in driving digital transformation and developing and interpreting data insights for circular economy performance (e.g., product design, development of product-to-service approaches, and designing reverse logistic business models). Organizations engage in developing data insights through their data analytics capabilities and decision making with multiple stakeholders. Kim, Shin, and Kwon (2012, p. 336) refer to big data management capability "as the ability to handle routines in a structured (rather than ad hoc) manner to manage IT resources following business needs and priorities."

A big data perspective is the most frequently applied absorptive capacity as internal organizational capability, and it features in some publications. Some research studies focused on big data analytics, AI in authentication, and misrepresentation of product information (Li et al., 2017). We suggest that future research studies should focus on investigating AI's application to an organization's ability to make forecasting decisions and inform material mobilization, consumption, and production patterns. The application of AI rarely appears in our literature review. The disentanglement of different stakeholders' impact on the decisions regarding the environment in operations management constitutes an exciting future avenue (Vachon & Klassen, 2007). In this context, research should investigate what stakeholder expectations affect big data analytics's organizational decision-making implementation. Much of previous research relies on the influence of stakeholders on organizational performance. There is an opportunity to expand research on how virtualization, decentralization, and network building change the manufacturing landscape (Brettel et al., 2014). Manufacturing firms tend to consider a circular economy in response to consumer demands. For example, in the UK, the consumer expects electronic retailers to have take-back options for used goods (Balch, 2018).

Future research studies may examine various issues related to the dynamic capability perspective. The other research avenues could help firms develop a strategic fit between existing resources and forecast future demands. Despite these contributions, IoT remains to need to be addressed for this area to headway advanced (Alcayaga et al., 2019; Pagoropoulos et al., 2017). The transformation from a linear to a circular economy in the manufacturing firms introduces new management challenges.

Stakeholders have to focus on applying big data analytics capabilities that lead firms through this transition successfully, whereas Gunasekaran et al. (2017) and Dubey et al. (2017) explicitly acknowledge and tested empirically big data predictive analytics impact on organizational performance and sustainability performance, respectively. Thus, an empirical investigation of how organizational absorptive capabilities affect the relationship between big data management capabilities and its impact on business analytics capabilities, decision making styles would be essential to test the casual relationship.

5.2.3 | Impact of big data analytics on intelligent manufacturing

Big data is a highly complex notion to describe, define, and understand. Big data is often defined as "often used to describe massive, complex, and real-time streaming data that require sophisticated management, analytical, and processing techniques to extract insights" (Laney, 2012). Big data concept "includes include a variety (structured or unstructured data formats), velocity (the speed at which data are created) and veracity (messiness of data) and value (the previously unknown insights)" (Davenport, 2014). Previous research frequently examines big data analytics as a circular economy (Gupta et al., 2019).

Intelligent manufacturing is considered one of the facilitators of a circular economy that drives whole value chain activities toward sustainability (Zhong et al., 2017). For example, Rajput and Singh (2019a) argued that the introduction of Industry 4.0 technology to their operations might help overcome circular economy challenges. The review uncovers various issues, and several insights can be gained from the Industry 4.0 perspective and the recognition that there are many unexplored avenues ready for future research. Except for a few studies, for example, Kerin and Pham (2019), little is known about how a shift toward intelligent manufacturing technologies affects the firm as existing circular economy practices and its underlying organizational big data management capabilities. Future research might also address what the contingent big data analytics capabilities that influence decision making styles to optimize production and produce increasingly individualized products with a short lead time to market and higher quality (Zhong et al., 2017) are.

Big data analytics framework might serve as a solution to intelligent manufacturing because intelligent manufacturing holds the promise of increased customization, flexibility, and better quality and improved product (Zhong et al., 2017). The organization should emphasize prioritizing different competing demands at achieving a circular economy and IoT outcomes that deliver a specific, more holistic value to particular stakeholders. Given the importance of Big Data Analytics Orientation (BDAO; Hyun, Hosoya, & Kamioka, 2018), it seems worthwhile to explore how BDAOs affect the organizational business intelligence and organization performance. BDAO refers to prioritizing and identifying data management capabilities and generating insights to solve organizational problems.

As the literature review provides evidence, there is little research on customer or supplier integration as a big data analyst and its effect on firm performance outcomes. The application of Industry 4.0 provides firms an opportunity to eliminate waste in production by identifying unnecessary activities (Buer et al., 2018). However, a transition to embed a close-loop-supply model through big data analytics to identify end-of-life products and their collection is a significant new frontier for the circular economy. The literature analysis reveals that there is still a need to realize the benefits of big data analytics from Industry 4.0, including cocreation and expansion of the circular economy. Additionally, no research studies investigating what big data analytics capabilities and AI management capabilities are needed for successful Industry 4.0 transformations. The IoT applications in the circular economy is underutilized. There is a lack of research studies that have been carried out regarding the implementation of Industry 4.0 in resource conservation and recycling.

Therefore, big data analytics and circular economy capabilities are additional directions for future research focused on driving sustainable manufacturing. This evidence supports big data analytics as intervening variables that link data management capabilities and circular economy performance. Based on our literature review, it appears that big data analytics is a salient predictor of a circular economy. However, prior research in this area has given less focus on its role in decision making for the circular economy.

5.2.4 | Strategic options and creating sustaining value

As evidenced by our review, few antecedent studies create value in the circular economy (Ranta, Aarikka-Stenroos, & Mäkinen, 2018). It is clear from the literature review that many research studies propose IoT applications' challenges and benefits. There are few studies regarding Industry 4.0 requirements for embedding the supply chain's circular economy (Manavalan & Jayakrishna, 2019). Much of the prior research has focused on digitalization as an enabler of the circular economy (Antikainen, Uusitalo, & Kivikytö-Reponen, 2018). We see the opportunity to the extent of the research using a digitalization context to study circular economy implementation practices.

A recent literature review of assessing the relationship between Industry 4.0 and circular economy has highlighted the business model's usefulness for creating value, generating revenue, and reducing cost within the industrial context (Rosa et al., 2020). Future research studies are needed to examine the relationship between the digital business strategy alignment impacts organizational and technological innovation. There is a lack of research on how the changing digital environment may impact the development of knowledge management capability and enhance green innovation (Awan, Nauman, & Sroufe, 2020).

As our literature review highlights the transformation of critical activities and resources to capture value, it requires specific capabilities and dynamic processes. The core elements salient in collective value creation and individual value appropriation are pursued, such as collaboration between competitors within the same relationship (Ritala & Hurmelinna-Laukkanen, 2009). For example, they realize the importance of collaboration for IoT. Realizing the requirement for an IoT approach, leading manufacturing companies started to develop the industrial internet consortium in 2014 to expedite the advancement, adoption, and widely accepted use of IoT.

The value proposition of the business model consists of the provision of continuous connectivity. The continuous connectivity of the internet and the transformation of data is essential. Value creation comes from collaboration and critical information technology management capabilities. Value creation and value appropriation research have shown that firms should simultaneously follow their strategic objective as individual entities to achieve goals (Ritala & Tidström, 2014). However, the underlying mechanism by which value creation and value appropriation occur remains an ongoing debate (Morgan, Anokhin, & Wincent, 2017). Although value creation takes on the interfirm networks ranging from supply chain to innovation, value appropriation takes place on the firm level and leads to interfirm networks (Möller & Rajala, 2007). There is evidence in the literature that IoT facilitates real-time data generation and transfer of events (Arunachalam, Kumar, & Kawalek, 2018). Different IoT types, such as RFID, sensors, and electronic data exchange, enhance collaboration and communication (Arunachalam et al., 2018). Information technology data management plays a key position role in the development of value proposition and value creation.

Future research should investigate to what extent the application of AI tools could guide future research, such as product delivery, product recovery, and predictive maintenance. AI is defined by Kaplan and Haenlein (2019, p. 17) "as a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation." Furthermore, AI tools such as machine learning (ML), predictive analytics, neural networks, and in-depth learning help solve many complex relationships in material management planning and operations. Future research can examine management's role in developing AI programs; such research might examine how to improve AI engagement in developing value cocreation for actors involved in decision making. An almost unmarked area is the application of AI in circular economy research.

Kaplan and Haenlein (2019, p. 17) defined ML as a "system's ability to perceive data (e.g., natural language processing or voice/image recognition) or to control, move, and manipulate objects based on learned information, be it a robot or another connected device." At the operational level, ML can identify the risk of hazardous material, maintenance time, and designing an appropriate manufacturing process. Our review highlights that Industry 4.0 stakeholder interest and expectations are rendering as a way forward to suggest data collected from various sources, such as IoT, can be used to develop ML models. IoT allows different networks to connect and to get the full benefits of Industry 4.0 solutions. IoT is a relatively new phenomenon and can apply in every industry field; its real benefits are infinite and unknown yet.

IIoT, Industry 4.0, and industrial internet terms are used interchangeably in the literature. IoT is not only about including interconnected smart interferences technology that connects and communicates to create value to their users and to offer new technical solutions. It is not always the IIoT benefit of new solutions due to data privacy and security issues. The application of IoT in manufacturing industries is known as a smart factory or Industry 4.0. The IIoT is mainly known as machine-to-machine communication and is connected through some centralized system to automatically respond to problems without human intervention.

The idea behind the IIoT Industry 4.0 is to reduce the operational cost, focus on predictive maintenance, and to increase automation where possible. IIoT plays a crucial role in value creation as the IoT has changed how many firms communicate and conduct business. Simultaneously, the IIoT business model is receiving interest in the manufacturing firms and is becoming a significant area of future research inquiry. However, there how the IoT creates value has received little interest. Thus, there is a need for detailed studies of the value creation process in the presence of the IoT. The existence of many IIoT tools and IoT requires inquiries into the value creation decision process. This approach requires to focus on qualitative research studies to understand more complexities inherited in the use of IoT.

6 | CONCLUSION

This study provides a systematic review of the IoT and circular economy literature to highlight the relevance of stakeholders' interests and expectations and outline a future research agenda. We explore how stakeholder's (Institutions, Suppliers, and International organization's) interests and expectations can be conceptualized by performing a systematic literature review of IoT and circular economy-related research. The contribution of this study is twofold. First, the stakeholders' interests and expectations aim to serve as a reference point to start a discussion toward IoT and circular economy ecosystem-oriented perspective and, second, to propose a discussion on existing research and identify the future research areas.

We believe that linking the interests and expectations of Industry 4.0 stakeholders could open new fruitful research areas. These areas include but are not limited to enriching academic discourse in Industry 4.0 and circular economy domains of strategic management research and contribute to the ongoing debate in circular economy business model implementations. Our reviews suggest that it would be particularly valuable to anticipate interest and acknowledging expectations to apply appropriate methods for a successful transformation toward a circular economy and Industry 4.0. We expect that stakeholders' interests and expectations have the potential to shape an organization's strategy for stakeholder orientations.

Industry 4.0 has become a salient route for firms to gain sustainable development advantage. Of all the advancements in technology, IoT can have profound implications for the circular economy. The present study limits itself to journal articles published between 2006 to 2019, and thus, there might be other insightful studies before this year. Therefore, circular economy managers and practitioners must develop an IoT with AI tools to accurately predict material usage, production, and requirements.

To date, empirical evidence of integrating IoT with circular economy practices is at an early stage. For managers, Industry 4.0 tools (IoT, CBM, and CPS) could develop a product-service business model and support more circular economy initiatives. Before implementing circular economy practices, managers must understand conflicting interests and expectations of multistakeholders on the execution of different Industry 4.0 tools. The potential benefits of incorporating Industry 4.0 tools in production systems require identifying and examining stakeholders' interests and expectations when implementing circular economy initiatives.

Our analysis shows that existing literature, either concurrently or independently, discusses the circular economy and IoT from an Industry 4.0 perspective. The significance of the global value chain is well documented in terms of theoretical and empirical contexts. The Industry 4.0 and global value chain literature that has emerged to date primarily address productivity improvement and value cocreation and understand customer needs and improvements in operational performance (Strange & Zucchella, 2017; Tortorella & Fettermann, 2018). Future research studies should explore how Industry 4.0 and the circular economy together support the governance value chain.

There have been little or no empirical research or literature review studies on the interface between Industry 4.0, circular economy, and global value chain. There is the continuing importance of stakeholders' interest in addressing the circular economy's critical issues. Therefore, we can see a growing importance for understanding the necessary technology infrastructure required for organizations to respond to changing Industry 4.0 business requirements.

This study offers several implications for managers and practitioners. To this end, we can see an evolution in the field toward long-term policies developed on reuse, remanufacturing, and recycling so that firms can strategically plan resource allocation and core capabilities. However, at a country level, few grasp the amount of interest in the circular economy and Industry 4.0 and are unsure of what action to take. Now is an excellent time to develop reuse and recycling implementation practices within global value chain management. The technology is available to entire industries to enable circular economies and a new wave of industry innovation. When developing policies and thinking about their implications, policymakers need to engage a broad group of stakeholders. When doing so, firms will need to be included in the process to decide on where and how they fit within closed-loop supply chains. Finally, we suggested that companies involve regulatory stakeholders in developing circular economy strategies. Doing so can result in better firm-level strategies while providing appropriate feedback mechanisms to policymakers for a resilient circular economy enabled by Industry 4.0 innovation.

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