A review of factors affecting closed-loop supply chain models

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Review

A review of factors affecting closed-loop supply chain models

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ABSTRACT

Closed-loop supply chain (CLSC) as one of the important configurations of the circular economy (CE) has received considerable attention in sustainability matters. It is composed of characteristics that, when identified, studied, and categorized, help not only to a better understanding of the current contributions in the literature but also lead to formulating new models. This research presents one of the first in-depth studies to investigate factors influencing CLSCs. It concerns the investigation of the models which are designed based on the game theory (GT). Therefore, the reviewed works focused on cooperation and competition among the game participants. A systematic literature review is implemented as a four-step process consisting of material collection, a descriptive analysis, category selection, and evaluation stage to review and discuss the works that focus on CLSC and use GT simultaneously. A content-based analysis is carried for the final works, which include 215 papers. The identified characteristics of these papers are classified into 12 main categories. Moreover, they are divided into subcategories to highlight the contribution of each paper. Accordingly, results are derived, and gaps are explained.

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Keywords:
Supply chain management
Closed-loop supply chain
Literature review
Categorization

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1. Introduction

Due to a large number of researches (Merli et al., 2018; Prieto-Sandoval et al., 2018) conducted recently, there is evidence that the topic of CE and its interconnected disciplines, concepts and applications (Winans et al., 2017) is a hot research area, and will remain so even in the near future. While the concept of CE is found in old textbooks (Boulding, 1966), its definition is still being revised (Geisendorf and Pietrulla, 2018). Based on semantic analysis, Homrich et al. (2018) defined CE as a strategy that has emerged to oppose the conventional open-ended system, aiming to address the challenge of resource scarcity and waste disposal in a win-win approach using an economic and value perspective. This opposition, which is referred to as a closed-loop (CL) in manufacturing processes and supply chain management (SCM) activities, has gained the attention of scholars and practitioners.

As a particular configuration of the CE in supply chains, CLs deal with the sustainability process, such as the collection of returned end-of-life/use (EoL/U) products (cores) for recovery, remanufacturing, refurbishing, reusing and recycling (Masi et al., 2017). CLs integrate material, financial, and information flows connecting downstream to upstream enterprises through a supply chain to construct a unique system; see Mishra et al. (2018) for examples of real cases. The literature introduces the CLSC’s term as “the design, control, and operation of a system, maximizing value creation/ profit over the entire life cycle of an item with the dynamic recovery of value from different types and volumes of cores over time” (Guide Jr and Van Wassenhove, 2009). Overall, CLSCs augment the forward follow with a reverse flow; thus, they involve a broader range of activities and usually, more players, in comparison to traditional supply chains.

Identifying the metrics and derivation of essential factors in the processes, as mentioned above, provides an appropriate framework, leading to faster movement, and even a jump from the linear economy to the CE. Some previous studies have focused on extracting essential elements in the area of sustainability (Ahi and Searcy, 2015; Hassini et al., 2012; Taticchi et al., 2015), green supply chain (Björklund et al., 2012; Hervani et al., 2005) and the CE (Ghisellini et al., 2016; Kalmykova et al., 2018; Pieroni et al., 2019) from related literature. Likewise, CLSC models consist of many characteristics; identifying and classifying these help researchers formulate new models (Souza, 2013; Govindan et al., 2015) and adopt or change the current process to the efficient methods. Identification of CLSCs metrics determines the catalyzers for development into the CE. Thus, this paper presents a literature review of previously published articles to address the classification of CLSC models in order to formulate new models.

Different methods and approaches, ranging from mathematical (Bazan et al., 2016) to operations research techniques (Barbosa-Póvoa et al., 2018), have been applied in different parts of the green and sustainable SCM (G/SSCM) (Seuring, 2013; Srivastava, 2007), reverse logistics (RL) (Fleischmann et al., 1997) and CLSCs. Among the investigated methods, GT, a powerful tool for analyzing situations, is widely used in supply chains and operations management (Shekarian and Moshtari, 2019). Cachon and Netessine (2006) surveyed the applications of GT to supply chain analysis; they discussed both noncooperative and cooperative GT in static and dynamic settings. Applications of cooperative GT to supply chain management were investigated by Nagarajan and So (2008). Moreover, GT concepts have been studied to reflect different forms of distribution of power and channel leadership within the supply chains’ cooperative advertising (Aust and Buscher, 2014; Jørgensen and Zaccour, 2014) and supply chain contracts with a focus on RL systems (Guo et al., 2017), to name a few studies.

Barbosa-Póvoa et al. (2018) concluded that GT approaches could be applied in the presence of different objectives that may even appear to be conflicting, allowing the identification of win-win solutions without being overly simplistic. Operations in CLSCs have predominantly shifted to exploiting the techniques provided by GT to analyze the behavior of rational players, stakeholder choices, and the development of voluntary extended producer responsibility policies (Guo et al., 2017). Accordingly, in the present research, important factors are identified, especially those that are quantitatively applied in the formulation of CLSCs. These factors are categorized into several classes, which helps develop new CLSCs and identify the research gaps.

The reviewed works address cooperation or competition among the game participants (i.e., manufacturers, retailers, consumers, etc.) in the loop, which is known as centralized or decentralized frameworks, respectively. Fig. 1 shows the structure of investigated papers in three phases as a combination of CLSC and GT. The investigated elements in the papers that affect the models are according to the aim(s) of each paper. The focus of this review is the CLSC models, which are solved based on GT. However, in the present work, we do not stress the characteristics of the investigated CLSCs related to GT.

The related literature was searched in four stages: an initial search, a filtering step, an analysis step, and a final search. More than 1000 papers were identified based on an initial search in Web
network, industry 4.0, and internet of thing (IoT). However, there are only three papers (Bensalem and Kin, 2019; Govindan and Soleimani, 2017; Govindan et al., 2015) that considered the whole area of CLSC and RL.

When considering the type and contribution, as well as focus studied, five groups of reviews can be identified. The first group (3 papers) includes the critical reviews exploring selected essential papers with a general research view and an emphasis on classification (Atasu et al., 2008a; Guide Jr and Van Wassenhove, 2009; Souza, 2013). The second group (3 papers) contemplates bibliometric analysis with specific stress on the solution approach of network design (Akçalı et al., 2009) and general views to identify major research themes and future research gaps (Bensalem and Kin, 2019; Wang et al., 2017a). The third group considers two literature reviews studying applications and case studies in industries (Sahamie et al., 2013; Stindt and Sahamie, 2014).

Having a broad scope, the fourth group (8 papers) looks into literature with a general view on their structures and investigated methods. Classification of the gathered papers is an essential contribution in this category (Agrawal et al., 2015; Gaur and Mani, 2018; Govindan and Soleimani, 2017; Govindan et al., 2015; Ilgin and Gupta, 2010; Pohkarel and Mutha, 2009; Rajeev et al., 2017; Rubio et al., 2008). Finally, the fifth group (16 papers) composes the ones in which target a specific field, emphasizing an especial area and concept as inventory (Akçalı and Çetinkaya, 2011; Bazan et al., 2016; Braz et al., 2018; Cannella et al., 2016), value creation (Schenkel et al., 2015), return and acquisition process (Glock, 2017; Jena and Sarmah, 2016; Wei et al., 2015b), uncertainty and complexity (Coenen et al., 2018), Waste Electrical and Electronic Equipment (WEEE) (Islam and Huda, 2018), financial performance (Larsen et al., 2018), GT and contract in forward and reverse (Govindan et al., 2013; Guo et al., 2017), quality, reliability, maintenance, remanufacturing, risk issues, and mathematical tools (Diallo et al., 2017), return functions and coordination (De Giovanni and Zaccour, 2019) and Industry 4.0 (Manavalan and Jayakrishna, 2019).

Taking a closer look at the last group, the ones with a narrower scope, there are only three papers in which, to some extent, investigate CLSCs from the GT viewpoint. By focusing on the coordination of contracts of the forward and reverse supply chains, Govindan et al. (2013) reviewed the distribution of contracting literature based on the type of contract approached for analysis and offered a classification of coordination contracts. Guo et al. (2017)
| Review paper | Area | Scope | Type | Main contribution | Database | Year (papers) |
|-------------|------|-------|------|-------------------|----------|---------------|
| Atasu et al. (2008a) | CLSC | Business economics of product reuse | C1 | Classification/Industrial practice | Selected papers | 1995–2008 |
| Rubio et al. (2008) | RL/CLSC | Production and operations management | LR | Classification/Derivation of main characteristics | 26 selected journals based on JCR | 1995–2005 |
| Akçalı et al. (2009) | RL/CLSC | Network design | BA | Operational characteristics of models/Brief description of significant computational work | WoS | Until 2008 (22) |
| Guide Jr and Van Wassenhove (2009) | CLSC | Business perspective/Profitable value recovery from cores | C1 | Classification/Introducing five phases to describe the CLSCs evolution | Selected papers | 1984–2008 |
| Pokharel and Mutha (2009) | RL/CLSC | Logistics, business, production and operations management | LR | Classification/Characteristics of RL processes | GoogleScholar/ScienceDirect/Emerald Insight/Inderscience | 1971–2008 (164) |
| Ilgin and Gupta (2010) | CLSC | Environmentally conscious manufacturing and product recovery | CR | Organizing into appropriate categories/Classification | n.a. | 1999–2009 (540) |
| Akçalı and Çetinkaya (2011) | CLSC | Inventory and production planning | CR | Classifications | n.a. | Until 2009 (n.a.) |
| Souza (2013) | CLSC | Strategic and tactical decisions | T/C | Presenting basic terminology/Basic modeling frameworks | Selected papers | 1986–2015 (242) |
| Govindan et al. (2013) | RL/CLSC | Type of contracts | CR/BA | Classification of coordination contracts | EBSCO/IEEEExplore/Elsevier/Taylor&Francis/Wiley/Emerald/Springer | 1961–2012 (234) |
| Sahamie et al. (2013) | CLSC | Applications to interdisciplinary and transdisciplinary industries | LR/CR | Connection with other fields and industries | ScienceDirect/EBSCO | Until 2012 (178) |
| Stindt and Sahamie (2014) | CLSC | Process industry | CB/CR | Analyzing and describing the main characteristics of CLSC planning | ScienceDirect/EBSCO | Until 2012 (167) |
| Agrawal et al. (2015) | RL/CLSC | Disposition/Adoption and implementation/Forecasting return/Outsourcing/Networks from secondary market perspective | CB/CR | Classification of the references | GoogleScholar/Scopus | 1986–2015 (242) |
| Govindan et al. (2015) | RL/CLSC | The whole area in RL and CLSC | CB/CR | Analyzing and categorizing to construct a useful foundation of past research | GoogleScholar/Scopus/WoS | 2007–2013 (382) |
| Schenkel et al. (2015) | RL/CLSC | Value creation through the recovery of returned products | LR/CR | Categorizing value adding concepts | Business Source Premier//ScienceDirect/Scopus/Emerald | 1998–2014 (144) |
| Wei et al. (2015b) | CLSC | Core acquisition management | LR | Classification | ScienceDirect/Scopus | Until 2014 (87) |
| Bazan et al. (2016) | RL/CLSC | Economic order/production quantity and joint economic lot size inventory models | LR/CR | Analyzing the mathematics involved in capturing the main characteristic of related processes | GoogleScholar | 1967–2015 (183) |
| Cannella et al. (2016) | CLSC | The inventory and order flow dynamics | LR | Analyzing the relationships between some RL factors in order and inventory variance amplification | ABI/Inform Global/Business Source Complete/JSTOR/Scopus/WoS | Until 2015 (40) |
| Jena and Sarmah (2016) | CLSC | Remanufacturing/Acquisition management of returned items | LR/CR | Devising pricing policies to attract used products | GoogleScholar/ScienceDirect/Inform/Scopus/Willy | 2000–2014 (100) |
| Diallo et al. (2017) | CLSC | Quality/Reliability/Maintenance and warranty for recovered products issues with remanufacturing | LR/CR | Classification/Deriving mathematical tools and techniques | Engineering village (Compende)/Proquest/GoogleScholar | 1985–2016 (104) |
| Glock (2017) | CLSC | Decision support models for returnable transport items | CR | Four groups are identified. | Scopus | 1980–2016 (190) |
| Govindan and Soleimani (2017) | RL/CLSC | The whole area in RL and CLSC | LR/CR | Categorizing/Evaluating | Journal of Cleaner Production | Until 2014 (83) |
| Guo et al. (2017) | RL/CLSC | Supply chain contracts/Coordination/Channel leaderships | LR | Classification and examining literature with respect to the supply chain structure | WOS/GoogleScholar | 2006–2016 (62) |
| Rajeev et al. (2017) | SSCM/CLSC | Economic/Environmental/Social dimensions | CR | Conceptual framework/Classification various factors along the triple bottom line of sustainability issues based on supply chains | EBSCO/SCOPUS | 2000–2015 (1068) |
| Wang et al. (2017a) | RL/CLSC | Remanufacturing/Recycling/Return management/Product recovery and EoL | BA | Identifying major research themes/knowledge groups/Future research gaps | WOS | 1992–2015 (912) |
| Braz et al. (2018) | CLSC | Bullwhip effect | LR/CR | Comparing the causes and mitigating factors/Classification | Scopus/WoS | 2004–2018 (56) |
| Coenen et al. (2018) | CLSC | Dynamic complexity/Deep uncertainty | LR/CR | Identification of conceptual/process/methodological gaps | WOS/Business Source Complete/ScienceDirect/IEEE/Wiley/Emerald Group | Until 2017 (64) |
studied 62 papers of the recent literature on supply chain contracts with a focal point on RL, focusing two perspectives, namely the supply chain structure and the channel leadership based on the GT. The literature is classified concerning the supply chain structure and channel leaderships. De Giovanni and Zaccour (2019) analyzed the game-theoretic literature in CLSCs containing 73 papers, with a focus on two key issues: (i) the return function and (ii) the coordination mechanisms (i.e., per-return incentive, contracts, and incentives, as well as of government interventions and chain structure changes) put forward by the CLSC members to improve their payoffs. The review is restricted to games involving at least two tiers of the CLSCs, in which firms create incentives, put in place ad-hoc strategies, get subsidies from governments, and also change their chain structure to pursue Pareto-improving payoffs.

In addition to the researches, as mentioned earlier, there are two more reviews in the fourth and fifth groups that investigated RL/CLSC models considering different factors. In the fifth group, Diallo et al. (2017) surveyed 104 papers during the period 1985–2016 dealing with quality, reliability, maintenance, and warranty models in CLSC for remanufacturing and classified using both the problem context and methodology. The wide array of mathematical tools and techniques used in the literature is then identified and mapped. Moreover, in the fourth group, utilizing the method proposed by Mayringer (2003), Govindan et al. (2015) studied 382 papers that fall into four main classes, including RL, CLSC, sustainable, and green with 152, 190, 24 and 16 papers respectively. They considered GT as one out of thirteen considered approaches in modeling various problems of RL/CLSC and derived 23 papers accordingly. It is concluded that almost all pricing and coordination problems are set up by GT approaches (22 out of 23 papers), and the main methods in GT approaches are analytical and exact.

After a careful analysis of the above five reviews, it is our understanding that the literature still lacking a comprehensive updated-research in terms of fundamental dimensions of CLSC. Previous works studied CLSC models with a few elements (Diallo et al., 2017) and a narrow scope regarding the GT (De Giovanni and Zaccour, 2019; Govindan et al., 2013, 2015; Guo et al., 2017). So far, none of the mentioned reviews investigated all elements of CLSC models that are designed based on GT from different perspectives simultaneously.

This review can provide an opportunity for researchers and practitioners to identify the factors with high priority in CLSC, especially in a competitive business environment that GT can be a useful tool to formulate cooperation or competition. It helps to realize and reveal the mutual and multiple relations between and among the investigated factors leading to the identification of the gaps. Content analysis of the investigated papers, as it is explained in section 4, contributes to compare the literature in detail regarding the discussed factors. An elegant categorization is implemented with more divisions to subcategories for main factors (i.e., incentive mechanism, environmental, economic, and financial) that enables the reader to distinguish the factors.

3. Objective and methodology

A systematic literature review was carried out based on the methodology suggested by Mey and Mruck (2010), which introduced a four-step process consisting of material collection, descriptive analysis, category selection, and evaluation stage. This review attempts to answer the main questions of the research:

RQ1. Which factors affect the formulation of CLSC models that are designed based on GT?
RQ2. How can we categorize the factors that affect CLSC models?
3.1. Literature search

The search to find the related papers consisted of four steps: an initial search, a filtering step, an analyzing step, and a final search. Initially, the keywords “closed-loop supply chain,” “closed-loop,” and “CLSC” are searched through the WoS database, focusing only on articles written in English from 2004 until 2018. According to a systematic analysis of keywords used in the literature (Gurtu et al., 2015), “closed-loop supply chain” is one of the high-frequency terms mainly used in green supply chains. The initial search resulted in 700 hits. In the second step, filtering the abstracts, and keywords of the derived papers were read and checked in relation to the concept of CLSC; this led to 450 papers.

In the third step, the main body of the identified papers was analyzed to find which of the papers technically used GT in the form of models such as Stackelberg and Nash. This attempt resulted in a total of 170 articles. In the final step, a snowball was conducted on the references of these articles, and 45 additional papers were identified that fell within the scope of the search.

The papers selected for the subsequent phase of descriptive analysis are 215. Fig. 2 shows a brief overview of the literature search method that was used. The works concerning other areas of sustainability, such as “reverse logistics” and “green supply chain,” were excluded because they were beyond the scope of the present review. Moreover, papers that were based on the design and network of the loops were also out of the scope of the present review. We consider the models that loop is built upon one of the CL targets, such as recycling, remanufacturing, and refurbishing.

3.2. Descriptive analysis

Fig. 3 shows the peer-reviewed journals based on the number of papers that were published, focusing on the investigated topic from 2004 to the end of 2018. A total of 62 journals were searched. However, Fig. 2 only lists the journals that published at least three papers (21 journals overall), “Sustainability” consists of the largest number of research articles ($\approx 12\%$). In terms of establishing an active integration between CLSC and GT, the International Journal of Production Economics (IJPE) made the second-largest contribution (22 papers $\approx 10\%$) to the total number of pertinent articles. That is followed by the Journal of Cleaner Production (JCLP) (18 papers), European Journal of Operational Research (EJOR) (17 papers), International Journal of Production Research (IJPR) (14 papers), and Production and Operations Management (POM) (10 papers). Using the functionalities provided by the Journal Citation Reports (JCR) platform, IJPE, EJOR, and IJPR are ranked as Quartile 1 (Q1) in the field of Operations Research & Management Science, and Sustainability and JCLP are in Quartile 2 (Q2) and Q1, respectively, in the field of Environmental Sciences.

Fig. 4 illustrates the trend in the number of articles published. As seen, there is an overall increase in the total number of articles published after 2011. An intermittent peak is apparent in 2013 when 20 papers were published, decreasing to 17 papers in 2014. Roughly (76%) of the research papers were published over the last five years, highlighting the importance of this field. A significant percentage of papers were published in 2016 (16%), 2017 (20%) and 2018 (23%). Although the first paper by Savaskan et al. (2004) retrieved in the present review was published in 2004, it seems that game-based CLSCs did not, initially, receive enough attention. However, in recent years, trends show that research on this topic has increased.

3.3. Category selection

Considered factors are derived according to studying the whole of the selected papers and the objects of the model(s). To do so, after screening each paper carefully, especially studying the notations used in the formulation of CLSC models, the explained factors are derived according to the target of the model(s) in each paper. The intention was to assign each factor to a specific class; however, whenever an overlap was seen between two categories, the factor was assigned to the nearest classes.

Fig. 5 shows the categorization of the derived factors. Totally, 12 major groups are extracted in which based on the content-analyzed are organized into five main categories: (1) economic, (2) environmental, (3) incentive mechanism, (4) financial, and (5) single groups. The last one refers to “E-tail” and other factors in which are subdivided only one time (such as inventory).

The first group, economic, is subclassified into four different categories, which mainly can be regarded as economic factors such as the discount for the remanufactured products. The second one, environmental, is related to the actions to care about the environment, such as the governmental actions to deal with the effect of carbon emission mentioned as government policy. Incentive mechanism refers to the operations that improve the performance of the loops regarding the sustainability processes such as the subsidy considered for the manufacturer by social planner if he involves in remanufacturing (Mitra and Webster, 2008). The fourth group, financial, deals with the financial factors such as disruption, which is, for example, a fluctuation of the remanufacturing cost due to occurring a natural phenomenon (Huang and Wang, 2018). Finally, there are factors called “single groups,” which are studied independently, such as trade-in (Genc and De Giovanni, 2017). (Sub)categorizes are explained in Section 5 when the content of each paper is analyzed.

3.4. Evaluation stage

The reliability and validity of the gathered papers are evaluated by the author, where deductive and inductive methods are implemented. In order to derive the structural dimensions which are led to correct classifications, in the deductive approach, the papers are chosen and then analyzed, while in the inductive technique, these dimensions are developed from the material using generalization (Mey and Mruck, 2010). The collected papers were again cross-checked with Scopus that it is one of the most comprehensive academic databases.

4. Content analysis

The content analysis method, as an observational research one, is adopted to systematically evaluate the body of the collected papers.
(Pokharel and Mutha, 2009). It also helps to identify the literature in terms of the notifications applied in the formulating of CLSCs, leading to various categories, thereby creating a realm of research opportunities. The results of this section are summarized in Table 2 for a better comparison and are explained as follows. It should be noticed there were 21 papers, as presented in Table 3, with the focus solely on the structure of the CLSC network, such as the one related to Savaskan et al. (2004). They considered the effect of a different relation of the players in the loop with different structures, and none of the investigated factors could be found in the model.

4.1. Economic

4.1.1. Advertising

Advertisement is the cost of the party to increase the selling of the new product and motivate the consumers to return the cores. It is also defined as sales/collection efforts in CLSC and plays a vital role on returning of the cores and reverse channel performance, supply chain members’ pricing and profit, demand expansion (Johnson, 2013), and consumer acceptance of remanufactured products (Sabharwal and Garg, 2013). It is subcategorized into three classes: advertisement in (i) forward direction, (ii) reverse direction, and (iii) both directions. They are shown as a, b, and c, respectively, in the first column (A) of Table 2.

Generally, the advertisement can be implemented in forward and/or reverse operations by only one party or more, which is usually the manufacturer and/or the retailer. The effect of advertising is examined mostly in forward/selling direction. Considering advertisement in reverse direction, Jena et al. (2017) considered advertising solely as a means to persuade consumers to return the cores in a remanufacturing environment.

4.1.2. Discount

Discount practically is a strategy that motivates the consumers to participate in the sustainability process of the loops. For example, Prebate recycling program suggested by Lexmark offers a discount price in exchange for customer’s agreement to return empty cartridges for reuse.

In CLSC literature, the discount factor is vastly applied in different forms. However, it is usually considered as a consumer’s willingness-to-pay (WTP) (i) for a remanufactured product, which is a fraction of his/her WTP for the corresponding new product in (ii) single- or multi-period. Other forms of discount are included in (iii) demand, (iv) profit functions, (v) different channels, (vi) reverse
process, (vii) trade-in, and (viii) quantity. Therefore, as it is shown in Fig. 5, the class of discount is subdivided into eight subcategories. These eight subcategories are shown in the second column (B) of Table 2 as a, b, ..., and h, respectively, for the related references.

4.1.3. Service

Service usually refers to characteristics such as providing product information, after-sales maintenance, warranty repair agreements provided by the seller (retailer/manufacturer) to the customers. The third column (C) of Table 2 presents this character for the investigated models determined as "a." It is studied in different forms such as the influence of service competition (Wu, 2012a), the cost of retail service as service level (He et al., 2016; Kong et al., 2017; Zhang et al., 2015), reverse-channel services (Xie et al., 2018), and ability to satisfy random demands (Zhu and Yu, 2018), just to name a few types.

4.1.4. Cost

Different costs are considered in operations related to forward and reverse directions of CLSCs. These costs are investigated and classified into (i) the cost of design, and (re) manufacturing, (ii) recycling cost, and (iii) collection cost. The reviewed references are summarized in the fourth column of Table 2 and are presented as a, b, and c, respectively. These include costs such as fixed costs in producing the refillable bottle (Grimes-Casey et al., 2007) and interchangeable product (Wu, 2013), manufacturing cost for high- and low-end manufacturers (Atasu and Subramanian, 2012), the cost of the desktop computers produced by a hazardous substance-free and hazardous substance (Kaushal and Nema, 2013a), cost of technology (Modak et al., 2018), R&D cost (Sun et al., 2018), and remanufacturing process cost (Ferguson and Toktay, 2006). Moreover, cost of collection, recycling, and disposal process (Atasu et al., 2013; Jacobs and Subramanian, 2012; Kaushal and Nema, 2013b).
Table 2: Categorization of the investigated factors in the developed models.

| Author (year) | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V |
|---------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heese et al. (2005) | g | | | | | | | | | | | | | | | | | | | | | | | |
| Bhattacharya et al. (2006) | b | | | | | | | | | | | | | | | | | | | | | | | |
| Ferguson and Toktay (2006) | | a | | | | | | | | | | | | | | | | | | | | | | |
| Ferrer and Swaminathan (2006) | b | | | | | | | | | | | | | | | | | | | | | | | |
| Savaskan and Van Wassenhove (2006) | (a) | | | | | | | | | | | | | | | | | | | | | | | |
| Grimes-Casey et al. (2007) | | a | a | c | | | | | | | | | | | | | | | | | | | |
| Atasu et al. (2008b) | a | a | a | a | | | | | | | | | | | | | | | | | | | |
| Chung et al. (2008) | | | | | | | | | | | | | | | | | | | | | | | | |
| Mitra and Webster (2008) | | a | | | | | | | | | | | | | | | | | | | | | | |
| Atasu et al. (2009) | a | b | a | a | | | | | | | | | | | | | | | | | | | |
| Subramanian et al. (2009) | b | | | | | | | | | | | | | | | | | | | | | | | |
| Yang et al. (2010) | c | b | | | | | | | | | | | | | | | | | | | | | | |
| Yuan and Gao (2010) | | b | | | | | | | | | | | | | | | | | | | | | | |
| Bernard (2011) | a | a | b | a | | | | | | | | | | | | | | | | | | | |
| Jung and Hwang (2011) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Kogan (2011) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Lee et al. (2011) | b | | | | | | | | | | | | | | | | | | | | | | | |
| Atasu and Subramanian (2012) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Chen and Chang (2012) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Jacobs and Subramanian (2012) | b | | | | | | | | | | | | | | | | | | | | | | | |
| Ma et al. (2013) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Nie et al. (2013) | c | c | a | b | | | | | | | | | | | | | | | | | | | |
| Shi and Min (2013) | a | b | | | | | | | | | | | | | | | | | | | | | | |
| Si and Ma (2013) | c | | | | | | | | | | | | | | | | | | | | | | | |
| Subramanian et al. (2013) | | b | | | | | | | | | | | | | | | | | | | | | | |
| Toyasaki et al. (2013) | a | b | | | | | | | | | | | | | | | | | | | | | | |
| Watanabe et al. (2013) | a | b | a | b | | | | | | | | | | | | | | | | | | | |
| Wu et al. (2013) | c | | | | | | | | | | | | | | | | | | | | | | | |
| Xiong et al. (2013) | a | b | a | b | a | | | | | | | | | | | | | | | | | |
| Zhou et al. (2013) | c | | | | | | | | | | | | | | | | | | | | | | | |
| Bulmus et al. (2014) | | d | | | | | | | | | | | | | | | | | | | | | | |
| Chen (2014) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Chuang et al. (2014) | b | | | | | | | | | | | | | | | | | | | | | | | |
| De Giovanni (2014) | a | b | | | | | | | | | | | | | | | | | | | | | | |
| De Giovanni and Zaccour (2014) | b | a | b | a | | | | | | | | | | | | | | | | | | | |
| Jena and Sarmah (2014a) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Jena and Sarmah (2014b) | b | a | d | | | | | | | | | | | | | | | | | | | | | |
| Li et al. (2014a) | d | | | | | | | | | | | | | | | | | | | | | | | |
| Li et al. (2014b) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Wang et al. (2014) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Watanabe and Kusukawa (2014) | a | b | a | c | b | | | | | | | | | | | | | | | | | |
| Wilhite et al. (2014) | a | a | a | a | | | | | | | | | | | | | | | | | | | |
| Zhang et al. (2014) | a | a | a | a | | | | | | | | | | | | | | | | | | | |
| Gan et al. (2015) | b | | | | | | | | | | | | | | | | | | | | | | | |
| Giri and Sharma (2015) | a | b | b | | | | | | | | | | | | | | | | | | | | | |
| He (2015) | a | a | a | b | | | | | | | | | | | | | | | | | | | |
| Hong et al. (2015) | a | b | a | a | c | b | a | | | | | | | | | | | | | | | | | | | | | |
| Kusukawa and Alozawa (2015) | a | b | a | a | c | b | a | | | | | | | | | | | | | | | | | | | | | |
| Li et al. (2015) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Maiti and Giri (2015) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Shi et al. (2015b) | c | | | | | | | | | | | | | | | | | | | | | | | |
| Wang et al. (2015) | b | a | | | | | | | | | | | | | | | | | | | | | | |
| Wei et al. (2015a) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Wu (2015) | c | b | | | | | | | | | | | | | | | | | | | | | | |
| Yan et al. (2015) | a | b | | | | | | | | | | | | | | | | | | | | | | |
| Yang et al. (2015) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Yoo et al. (2015) | a | | | | | | | | | | | | | | | | | | | | | | | |
| Yuan et al. (2015) | b | a | | | | | | | | | | | | | | | | | | | | | | |
| Zhang et al. (2015) | a | b | | | | | | | | | | | | | | | | | | | | | | |
| Zou and Ye (2015) | b | | | | | | | | | | | | | | | | | | | | | | | |

(continued on next page)
Table 2 (continued)

| Author (year) | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V |
|---------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agrawal et al. (2016) | g | b | a |  |
| Bhattacharya (2016) |  |  |  | b |
| Chen et al. (2016) | a |  |  |  |
| De Giovanni (2016) | d | b |  |  |
| De Giovanni et al. (2016) | d | b |  |  |
| Esmaeili et al. (2016) | c | b | d | d | a |  |
| Gao et al. (2016a) | c |  |  |  |
| Gao et al. (2016b) |  | a | a |  |
| Han et al. (2016) |  |  |  | a |
| He et al. (2016) | a | a | b | a | b | a |
| Hong et al. (2016) | a |  |  |  |
| Hu et al. (2016) |  | a | b |  |
| Li and Ouyang (2016) | c |  |  |  |
| Li et al. (2016) |  | a |  |  |
| Mirza (2016) | a |  |  |  |
| Modak et al. (2016) | b |  |  |  |
| Ran et al. (2016) |  | b |  |  |
| Sabbagh et al. (2016) | e | a | b | c |
| Saha et al. (2016) |  |  |  | a |
| Shi et al. (2016) | b |  |  |  |
| Wang and Tang (2016) |  |  |  | a |
| Weng and Chen (2016) | c | c |  |  |
| Wu and Wu (2016) | a |  |  |  |
| Xiong and Yan (2016) |  | a |  |  |
| Xiong et al. (2016) | c | a |  |  |
| Xu et al. (2016) | a |  |  |  |
| Yenipazari (2016) | a | a | b | b |  |
| Zhang and Ren (2016) | b | a | a |  |
| Zhu et al. (2016) | c | c | a | a |
| Zou et al. (2016) | c | a |  |  |
| Zu-Jun et al. (2016) | c | c | d | b |  |
| Dai et al. (2017) |  |  |  |  |
| De Giovanni (2017) | d | b | a | b | a |  |
| Esenduran et al. (2017) | a | c |  |  |
| Gan et al. (2017) | b | d |  |  |
| Genc and De Giovanni (2017) | g | a |  |  |
| Giri et al. (2017) |  | a |  |  |
| Han et al. (2017) | b |  |  |  |
| He (2017) |  |  |  | a |
| Hong et al. (2017) | c | b |  |  |
| Huang and Wang (2017a) | c |  |  |  |
| Huang and Wang (2017b) |  |  |  | a |
| Huang and Wang (2017c) | b | a | a |  |
| Huang and Wang (2017d) |  | a |  |  |
| Huang et al. (2017a) | c |  |  |  |
| Huang et al. (2017b) |  | a |  |  |
| Jena et al. (2017) | b | c | a |  |
| Jin et al. (2017) | a | b |  |  |
| Kong et al. (2017) | a | d | d |  |
| Li et al. (2017a) | a | c | d |  |
| Li et al. (2017b) | c | d |  |  |
| Li et al. (2017c) | a |  |  |  |
| Liu et al. (2017) | c |  |  |  |
| Ma et al. (2017) |  | a |  |  |
| Maiti and Giri (2017) | b |  |  |  |
| Miao et al. (2017) | g | b | c | b | d | a |
| Panda et al. (2017) |  |  |  |  |
| Ramani and De Giovanni (2017) | a | b | a |  |
| Shu et al. (2017) |  | a |  |  |
| Talezadeh et al. (2017) | c | b |  |  |
| Wang and Zhang (2017) |  |  |  | a |
| Wang et al. (2017b) | a | c | b | a | a |
| Wang et al. (2017c) | a | b | a |  |
| Xiao et al. (2017) |  |  |  |  |
| Xie et al. (2017) | a | b | a |  |
| Zhang and Xiong (2017) | a | b | a |  |
| Zhao et al. (2017) |  |  | a |  |
| Zhao et al. (2017c) | a |  |  |  |
| Zheng et al. (2017) |  |  |  |  |
| Zhou et al. (2017) | f | a | c | a | b |  |
| Zhu et al. (2017) | b |  |  |  |
| Arshad et al. (2018) | b |  |  |  |
| Chu et al. (2018) |  |  |  | a |
| De Giovanni (2018) | d | b | b |  |
| Famil Alamdar et al. (2018) | a | b |  |  |
are studied that can be considered as a high collection effort level or low collection effort level (Wang et al., 2017c).

4.2. Sharing mechanism

Traditionally, players of a loop are individual entities, who act independently and opportunistically to optimize their profits. However, an effective supply chain network requires a cooperative relationship among participants. Although the centralized model can generally yield more profit than the decentralized one from the perspective of the entire supply chain, it is not prevalent unless all parties can gain more profit than their decentralized profit. A sharing mechanism, such as a revenue-sharing contract (RSC), is an efficient approach to overcome this issue (Panda et al., 2017).

Accordingly, all types of processes related to the sharing mechanism are derived and presented in the fifth column of Table 2 shown as "E". These mechanisms are considered in three subcategories as (i) sharing on the demand, (ii) revenue-cost-profit sharing, and (iii) sharing on collection process, and are identified as a, b, and c, respectively, in Table 2.

Table 3
The studies with simple network.

| Author (year) | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V |
|---------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Genc and De Giovanni (2018) | b | b | a | c | a | a | b |
| Giri et al. (2018) | b | b | a | a | b | c | a |
| Gu et al. (2018a) | b | b | a | a | b | c | a |
| Gu et al. (2018b) | b | b | a | a | b | c | a |
| He et al. (2018) | b | b | a | a | b | c | a |
| Huang (2018) | b | b | a | a | b | c | a |
| Huang and Wang (2018) | b | b | a | a | b | c | a |
| Jiang et al. (2018) | b | b | a | a | b | c | a |
| Ke et al. (2018) | b | b | a | a | b | c | a |
| Kleber et al. (2018) | b | b | a | a | b | c | a |
| Liu and Zhang (2018) | b | b | a | a | b | c | a |
| Liu et al. (2018a) | b | b | a | a | b | c | a |
| Liu et al. (2018b) | b | b | a | a | b | c | a |
| Ma et al. (2018) | b | b | a | a | b | c | a |
| Ma et al. (2018b) | b | b | a | a | b | c | a |
| Mi et al. (2018) | b | b | a | a | b | c | a |
| Modak et al. (2018) | b | b | a | a | b | c | a |
| Raz and Souza (2018) | b | b | a | a | b | c | a |
| Shu et al. (2018a) | b | b | a | a | b | c | a |
| Shu et al. (2018b) | b | b | a | a | b | c | a |
| Shu et al. (2018c) | b | b | a | a | b | c | a |
| Sun et al. (2018) | b | b | a | a | b | c | a |
| Taleizadeh et al. (2018a) | b | b | a | a | b | c | a |
| Taleizadeh et al. (2018b) | b | b | a | a | b | c | a |
| Wan (2018) | b | b | a | a | b | c | a |
| Wang et al. (2018a) | b | b | a | a | b | c | a |
| Wang et al. (2018b) | b | b | a | a | b | c | a |
| Wu and Kao (2018) | b | b | a | a | b | c | a |
| Wu et al. (2018) | b | b | a | a | b | c | a |
| Xie et al. (2018) | b | b | a | a | b | c | a |
| Xu and Wang (2018) | b | b | a | a | b | c | a |
| Yan et al. (2018a) | b | b | a | a | b | c | a |
| Yan et al. (2018b) | b | b | a | a | b | c | a |
| Yang et al. (2018a) | b | b | a | a | b | c | a |
| Yang et al. (2018b) | b | b | a | a | b | c | a |
| Zerang et al. (2018) | b | b | a | a | b | c | a |
| Zhang et al. (2018a) | b | b | a | a | b | c | a |
| Zhang et al. (2018b) | b | b | a | a | b | c | a |
| Zhang et al. (2018c) | b | b | a | a | b | c | a |
| Zhu and Yu (2018) | b | b | a | a | b | c | a |
| Zou et al. (2018) | b | b | a | a | b | c | a |
| Giri et al. (2019) | b | b | a | a | b | c | a |
| Huang et al. (2019) | b | b | a | a | b | c | a |

A: advertising; B: discount; C: service; D: cost; E: sharing mechanism; F: carbon emission; G: green activity; H: impact and regulation; I: subsidy; J: reward-penalty; K: two-part tariff contract; L: disruption; M: risk; N: licensing; O: franchise; P: 3D; Q: inventory; R: information systems; S: quality; T: cannibalization; U: e-tail; V: trade-in.

are studied that can be considered as a high collection effort level or low collection effort level (Wang et al., 2017c).

4.2. Sharing mechanism

Traditionally, players of a loop are individual entities, who act independently and opportunistically to optimize their profits. However, an effective supply chain network requires a cooperative relationship among participants. Although the centralized model can generally yield more profit than the decentralized one from the perspective of the entire supply chain, it is not prevalent unless all parties can gain more profit than their decentralized profit. A sharing mechanism, such as a revenue-sharing contract (RSC), is an efficient approach to overcome this issue (Panda et al., 2017).
Considering the second subcategory, Choi et al. (2013), Zou and Ye (2015), De Giovanni (2017), Han et al. (2017), Wu et al. (2018) and Zhu and Yu (2018) considered RSCs in their models. Other forms composed of a profit-sharing mechanism as the Nash bargaining model (Hong et al., 2013; Modak et al., 2016), a reverse RSC (De Giovanni, 2014; Shi et al., 2016), sharing of surplus generated in the system (Jena and Sarmah, 2014b), a revenue-and-expense sharing contract (Xie et al., 2018; Zhang and Ren, 2016), sharing the sale profits and recycling costs (Zhu et al., 2017) and an R&D joint venture mechanisms (Wu and Kao, 2018).

There are other works regarding sharing on the collection process such as Physical Sharing on the collective recycling responsibility (Nie et al., 2013), collecting process sharing (Esmaeili et al., 2016), sharing on the return rate (Esenduran et al., 2017; Hong et al., 2017; Huang et al., 2017a; Liu et al., 2017; Weng and Chen, 2016; Zu-Jun et al., 2016) and sharing on recycling market (Zhou et al., 2017).

4.3. Environmental

4.3.1. Carbon emission (CAE)

The emission is produced in the process of producing raw materials from nature (Li et al., 2014a; Shu et al., 2018a), or during life cycle of a product (He et al., 2016) and it is influenced by the level of design, recyclability and the product’s physical properties (e.g., volume or weight) (Yenipazarli, 2016). Concerning the emission issues, there are carbon cap-and-trade (CCT) system in which the government allocates a proportion of CAEs quotas to manufacturers for (re)manufactured product (Hu et al., 2016). Moreover, in order to improve the emission-reduction level or set a target level, the government can use other policies such as forcing the manufacturer by imposing a carbon tax (Dai et al., 2017; Zhang et al., 2018b). However, manufacturers can invest in reducing the level of emission by employing low-carbon technologies (Li et al., 2017a). Therefore, there are different approaches on CAE in the reviewed models categorized as (i) focusing on emission quantity, (ii) CCT system, (iii) policy established by the government, and (iv) reduction level in which are determined as a, b, c, and d, respectively in column six, Table 2.

4.3.2. Green activity

In some games, the CLSC’s consumers are divided into primary and green consumers. The former ones give the remanufactured products a lower value than the new products and the later ones are likely more concerned about environmental impacts of their consumption and the functionality of the product rather than its newness (Atasu et al., 2008b; Sabbaghi et al., 2016; Wu, 2012b). To boost the number of returns, a parameter related to the activities called green activity programs is considered in a series of papers. It consists of several atypical strategies such as product acquisition, RL, points of use and disposal, testing, sorting, refurbishing, recovery, recycling, re-marketing, communications campaigns about the recycling policies, monetary and symbolic incentives, and employees-training programs (De Giovanni, 2014, 2016; 2017, 2018; De Giovanni et al., 2016; De Giovanni and Zaccour, 2014).

Green activity refers to the identification of (i) green consumers and also (ii) investments of entities in different areas such as recycling and returning to improve the performance of the loops. They are shown as a, and b, respectively, in the column called “G” in Table 2.

4.3.3. Impact and regulation

There are CLSCs that measure (i) the impacts and study (ii) the policies which are related to the environment. Shi and Min (2013) measured the environmental impact (EI) of the loop by the land-fill quantity. Xiong et al. (2016) analyzed the EI discount for the remanufactured product. Yenipazarli (2016) described that EI depends on quantities of the manufactured items.

Yan et al. (2015) discussed how different channel structures for marketing remanufactured products could affect environmental performance. The total impact of products on the environment is calculated by Miao et al. (2017) in the form of life cycle assessment. Sun et al. (2018) addressed EI to find the best strategy that is more beneficial for the environment? The references are categorized in the eighth column in Table 2. The ones that include impact and regulation are shown with a, and b, respectively.

4.4. Incentive mechanism

4.4.1. Subsidy

The subsidy is the support by the social planner, which is usually the government, to a party to increase the performance of the CLSC (Atasu et al., 2009). In order to stimulate consumption, curb pollution and decreasing carbon (Esmaeili et al., 2016; Li et al., 2014a; Wan, 2018), developing the CE, and recycling activities (He et al., 2016; Ma et al., 2018a; Zhou et al., 2017), the subsidy is an important motivation to support different players of a loop. Based on the literature, four subcategories are derived from different types of subsidy shown in Table 2 as (re)manufacturing-subsidy, recycling-subsidy, trade-in subsidy, and unit carbon subsidy identified as a, b, c, and d, respectively, in the column called “I.”

4.4.2. Reward-penalty (RP)

If the incentive mechanism has a two-sided effect, which means includes not only an incentive but also a penalty, it is considered as an RP. The papers in this class are categorized into four parts shown as a, b, c, d, respectively in column “I” in Table 2. The first part is devoted to the models in which RP mechanism (RPM) affects the collection process where government sets a target collection/quantity rate for two manufacturers to motivate their recycling efforts on collecting WEEE (Wang et al., 2017b, Wang et al., 2018a, Wang et al., 2018b). In the second part, RPM is due to the emission, such as imposing emissions taxes by the regulator as a penalty to the manufacturers (Yenipazarli, 2016; Zhang et al., 2018b). The third part targets consumers (Kaushal and Nema, 2013b). Finally, RPM can be implemented because of not remanufacturing (Esmaeili et al., 2016; Zhang et al., 2018a).

4.4.3. Two-part tariff contract (TPTC)

TPTC is generally a contract in which through it, usually, the manufacturer pays a fixed amount to the retailer to motivate him for the recycling. It can be employed to encourage the manufacturer and the retailer to achieve the same performances as same as a centralized system. Dobos et al. (2013), Hong et al. (2015), and Shi et al. (2016) formulated CLSCs that a manufacturer provides a retailer with a TPTC to integrate him into the collection activities. Huang et al. (2017b) and Taleizadeh et al. (2018b) studied the channel coordination under a TPTC provided by a manufacturer to a retailer. Zhang and Ren (2016) considered a CLSC system consisting of an original manufacturer, third-party remanufacturer, and two-part tariffs. Zheng et al. (2017) designed a modified TPTC to coordinate dual-channel CLSCs. The derived works are distinguished in a column called “K” in Table 2.

4.5. Financial

4.5.1. Disruption

The disruption is related to analyzing the fluctuations in the (re)
manufacturing cost (Han et al., 2016, 2017; Huang and Wang, 2017b; Wu et al., 2018) and order quantity, price, and demand (Huang and Wang, 2018; Xu et al., 2016). CLSCs face disruption due to some haphazard phenomena such as the great earthquake that happened in 2011 in Japan which led to serious disruptions to the market demand and in supply products of national and international companies. The more the intensity of disruption, the more the impact on the CLSC is uncontrollable. Specifically, it makes remanufacturing and labor costs volatile. Hereupon, it is vital to understand how disruptions affect CLSC. The relevant works are determined with “a” in a column called “L” in Table 2.

4.5.2. Risk
The question of how to resolve different types of risk such as the supply chain risk of a sole-source supplier (Wilhite et al., 2014), risk reduction of demand (He, 2015), remanufacturing risks (Han et al., 2016), supply risk-sharing contracts (He, 2017), the effect of fairness concern and risk aversion behaviors (He et al., 2018) in a CLSC is particularly important. For example, when players display risk-averse characteristics, the risk aversion coefficients can affect their decisions. Risk attitudes of the players in a loop may have significant influences on their own and others’ pricing and remanufacturing decisions. Related references are shown in the relevant column shown as “M” in Table 2.

4.5.3. Licensing
Licensing method is a payment to the manufacturer by the third-party/distributor (Huang and Wang, 2017a, Huang and Wang, 2017c; Liu et al., 2018a; Zou et al., 2016), and the remanufacturer (Sun et al., 2018; Yan et al., 2018b; Zhang and Ren, 2016; Zhang et al., 2018a) in the form of patent licensing fee. It is an effective method that not only can promote the performance of CLSCs but also improves the company’s profitability. An interesting challenge in competitive markets that OEMs face is deciding on whether to license an IR to remanufacture their cores.

Some papers considered two licensing patterns as fixed fee versus royalty (Ma et al., 2018b; Wu and Kao, 2018). Hong et al. (2017) addressed two types of technology licensing as (i) fixed fee licensing (i.e., the manufacturer offers a license to the remanufacturer and charges a fixed fee in one lump sum), and (ii) royalty licensing (i.e., the remanufacturer pays the manufacturer a royalty licensing for each unit she remanufactures). Papers that applied normal and royalty licensing are marked as a, and b in the column called “N” in Table 2.

4.5.4. Franchise
The franchise fee is a common phenomenon in practice, such as a franchised store. It represents the fee paid by the retailer to the manufacturer for the sale of the product. Three papers considered the term franchise for the formulated fee, as shown in the column called “O” in Table 2. Zhang et al. (2014) addressed a lump-sum side payment, which depends on the order quantity of the retailer in the profit functions of the retailer and manufacturer. Wang et al. (2017c) and Wang et al. (2018b) set a franchise as a fee that manufacturer charges to the collector entities when they choose a contract designed according to the high or low collection effort.

4.6. 3D
There are three essential concepts: (i) defective item, (ii) depreciation rate and (iii) deterioration rate of items during their life that is appeared in the formulation of the CLSCs. Giri et al. (2018) supposed that the manufacturer accepts the defective items during the warranty period returned directly by the customers. Yang et al. (2010) investigated two CLSCs, considering the deterioration rate for each finished/used product. Ma et al. (2018b) and Shu et al. (2018a) considered a durability parameter for new products reflecting the deterioration rate. Orapiopoulos et al. (2012) and Miao et al. (2017) assumed the product depreciates with use. Sabbaghi et al. (2016) noticed that the product depreciation status could affect the return decision of consumers. Mi et al. (2018) formulated a depreciation ratio for the return rate for the dynamic return rate. The related studies that use these elements are gathered in a category called “P” in Table 2, and the mentioned elements are marked as a, b, and c, respectively, for the relevant references.

4.7. Inventory system
There are extant CLSC researches focusing on inventory control. Remanufacturing, as an important CLSC’s concept, causes saving in labor, material and energy costs, shorter production lead times, balanced production lines, new market development opportunities; thus, it affects all types of inventory control (McConochia and Speh, 1991). In Table 2, the works are categorized as the ones, which developed inventory systems (marked with b) and the others, which considered inventory parameters (marked with a).

Chen and Chang (2012) set holding and shortage costs for both new and remanufactured products in the CLSCs. Chen and Chang (2012) also implemented applying holding cost of unsold products and the shortage penalty cost of unsatisfied demand (Watanabe et al., 2013; Watanabe and Kusukawa, 2014) and shortage penalty cost of unsatisfied demand and inventory holding cost per unsold products (Kusukawa and Alozawa, 2015). Moreover, inventory systems are discussed, such as CLSC production models (Giri and Sharma, 2015; Yang et al., 2010), joint economic lot size (Dobos et al., 2013), and a single-period newsvendor model (Chuang et al., 2014).

4.8. Information systems
Information flows throughout both forward and reverse chains are crucial to support sustainability goals. Generally, the works on the information system can be classified on those addressing symmetric and/or asymmetric information. Accordingly, a game is usually developed where upstream’s (downstream’s) information might not be accessible to the downstream’s (upstream’s) party (De Giovanni, 2017; Li et al., 2012b, Li et al., 2014b; Wang et al., 2017c). Besides, some CLSCs works on the availability of information for a specific parameter such as the demand (Watanabe and Kusukawa, 2014) or product recovery (Toyasaki et al., 2013). The references in this section are categorized into three classes like those that considered (i) symmetric and asymmetric information simultaneously, (ii) asymmetric information only, and (iii) information of a specific parameter; and are shown in column “R” in Table 2 as a, b, and c, respectively.

4.9. Quality considerations
Quality generally refers to overall aspects such as design and conformance in the production process (Bernard, 2011; Giri et al., 2019; Subramanian et al., 2013). However, the literature mainly focuses on the quality condition of the returned items collected by a collection party (Gan et al., 2015, 2017) that generally are sorted into an ordered scale (Xie et al., 2018). As companies do not have enough information about the quality of cores, the amount of remanufacturable parts that can be recovered is subject to the uncertainty (Giri and Sharma, 2015; He, 2015; Zou and Ye, 2015). Moreover, the quality of the product can influence the preferences of the customers, which is studied by another part of the work (Xu et al., 2016). The more the quality of products and services, the more the satisfaction of the customers (Liu et al., 2018a). It leads to
a reduction in the number of returns. Finally, there are models that the demand is pertinent to the quality (Taleizadeh et al., 2017; Taleizadeh et al., 2018a). Accordingly, studies are categorized into four parts, like the ones that consider (i) quality of new and remanufactured products, (ii) cores quality, (iii) consumer preferences, and (iv) quality-based demand. These groups are determined as a, b, c, and d in the relevant column (S) for the derived references in Table 2.

### 4.10. Cannibalization

As a general rule, remanufacturing leads to the cannibalization of new product sales. Although proponents of remanufacturing say that remanufacturing may not necessarily lead to cannibalization for all categories of products (Guide Jr and Li, 2010), some evidence such as the one by Ramani and De Giovanni (2017) showed that unlike the findings from the marketing literature, cannibalization does not lower the manufacturers sales; however, it does negatively impact the manufacturer’s profit.

The effects of cannibalization are classified as (i) sale, (ii) design, (iii) competition, and (iv) location perspectives. They are identified as a, b, c, and d in the related column (T) in Table 2. Regarding the sale, the effect of cannibalization is investigated on new product sales (Atasu et al., 2008b), the sales of used products (Oraiopoulos et al., 2012), remanufacturing of the manufacturer (Xiong et al., 2013). In the second subcategory, models studied the influence of cannibalization on the degree of disassemblability (Wu, 2012b), commonality (Subramaniam et al., 2013), interchangeability (Wu, 2013) and upgrading (Sun et al., 2018).

Jung and Hwang (2011) explained the interaction between an OEM and a remanufacturer where remanufactured products cannibalize the OEM’s market. The effect of cannibalization is investigated when a third-party firm refurbishing the EoL items competes with a manufacturer (Wang and Tang, 2016). Moreover, there are models that investigate the internal cannibalization (Zhou et al., 2013), propose new and remanufactured products in different locations (Gan et al., 2017), suggest in-house remanufacturing (Jin et al., 2017), and consider one-roof policy of Apple or two-roof policy of Dell (Liu et al., 2018b).

### 4.11. E-tail

E-tail is online operations, which usually are defined as online retailing via the Internet. Nowadays, firms distribute their products not only through offline retail stores but also via online e-tailers (He et al., 2016; Ma et al., 2013). The Internet has provided a new way for consumers to interact with the loops in CLSCs in emerging markets (Liu and Zhang, 2018; Taleizadeh et al., 2018b; Xie et al., 2018; Yang et al., 2015). The related references are marked with “a” in the related column (U) of Table 2.

### 4.12. Trade-in

Trade-in is simply a strong connection between collection and sale. In this form of trade-in, the consumers bring the used/discarded items to the collector and then, the collector proposes a discount/direct subsidy to them when they latter buy new goods (Genc and De Giovanni, 2017; Grimes-Casey et al., 2007; Huang et al., 2019). It has drawn much attention in CLSCs by the researchers providing managerial suggestions for prominent firms such as Lenovo and ASUS. The second form is the concept of emission trading, which is based on the initial permission for releasing a certain amount of emission received by the manufacturer from the regulator free of charge (Yenipazarli, 2016). These two types are identified as a, and b in the last column (V) of Table 2.

### 5. Review results

Totally 406 characteristics are derived from the investigated papers as it is discussed in section 4. Fig. 6 presents the contribution of each group based on the discussed categorizations in section 3.3. It is also possible to compare the frequency percentage of eight categories called single groups with each other in the smaller pie chart derived from the related slice. Analysis of the main categories shows that the economic characteristics with 22% got priority among the others in the CLSC models when there is a game between the players. It shows a tendency of tying economic targets to the CLSC as a growing sustainable concept. Trade-in and 3D have received the least attention in the literature.

The focus of researches in CLSC models dealing with incentive mechanisms is same as the ones that consider sharing mechanisms with 14% indicated bold in pie charts. Although CLSC is a concept to preserve the environment, integrating environmental elements (second group) to the CLSCs still needs more attention with a current 12% frequency among the main groups. In addition, a small fraction of the factors in the investigated models is related to the financial group, with only 8%. In the fifth group (i.e., single groups), “quality considerations” represents the substantial portion of factors with 8%.

Fig. 7 derived by Tableau Software, compares the application of classified metrics with more details on all divided subcategories. It is cleared sharing structures on revenue, cost, and profit among the players of CLSCs is an important topic. Besides, sharing operations on the collection process of the returned items have received considerable attention. The literature focuses on the discount from different points. Thus, the discount is a flexible factor that can be used in different parts. The concentration on the quality of the cores and using the Internet through the loop known as e-tail are other topics which are highlighted by the CLSC models.

In Fig. 8, a bubble chart is provided by Microsoft Excel in which is a symmetric matrix. It shows a two-dimensional characteristic of the existent CLSC models addressed on the topic considering 22 factors. On the one hand, the blue bubble’s number shows how many times two factors are applied and integrated through the investigated CLSCs. For example, the green circles present that cost and discount are repeated six times together in the investigated CLSC models in the literature. On the other hand, blank places determine the gaps for future research. As an example, there is not any research integrating parameters related to the carbon emission with licensing matters considering the scope of the present review. Besides, the number of orange bubbles specifies how many times a factor is used solely. It is identified that the sharing mechanism is repeated 16 times solely, as a sample. A multi-dimensional diagram is also applicable, which could be more complicated than the present analysis.

Fig. 9 presents the complexity of the designed models regarding the investigated factors. Regardless of the 21 papers that only concern the effect of different structures of the players (i.e., manufacturer, retailer, third-party, etc.) in the models and do not include any of the discussed factors, each paper includes averagely two factors (406 / (215 – 21) = 2). The more the number of discussed factors in the studied CLSC model, the less paper can be found. It shows that modeling real cases in this area is rather difficult.
Moreover, an analysis is performed regarding the trend of important factors separately. Fig. 10 illustrates the results of the frequency of these factors throughout the study. As it is clear, sharing mechanisms and reward–penalty mechanisms are two effective factors in which are growing almost consistently during the considered time horizon. Factors such as quality considerations, advertising, and two-part tariff contract have received more attention and are applied incrementally in recent years after 2012. Developing CLSCs related to the inventory systems and cannibalization has been slowly decreasing recently. The results of the presented bar charts can be used as a guideline in the CLSC area for future research.

6. Discussion and suggestions for future research

Regarding the economic group, it was found most of the CLSC models, having the advertisement activities, concentrate on applying advertisement on the sales of the new product rather than returning the cores. Thus, the study to know the effects of advertising on the reverse direction, and especially remanufacturing, still need more investigations. The essential factor in the first group is the discount. Integrating the discount in different types is always interesting. A potential area of research is studying the discount in an uncertain situation such as a stochastic case, which is almost ignored in previous works. A novel area of research in this section is a combination of the studied factors. In this case, advertising specifically on service and discount for remanufactured product to motivate the consumers is a promising topic.

The categorization of the second group to more subcategories with a specific domain highlights the different aspects of CLSCs in connection with environmental matters. Although the CLSC is an advanced concept that can be employed to reduce environmental pollutants, particularly carbon emission, it seems that the research in this area is still in its infancy. The developed models are applicable. However, they are straightforward. A vital point is stress on the consuming process instead of producing process by devoting the sources to the consumers instead of producers, for example, by informing the market that how much carbon emission can be harmful to the environment.

In the third group, the subsidy is a powerful method, that usually affects the loop externally, by the social planner/government. The literature shows that government subsidy on remanufacturer can increase remanufacturing activity and result in lower prices of remanufactured products, thus leading to higher consumer surplus. It allows the remanufacturer to compete with the manufacturer. Although the literature assumes the subsidy usually a simple parameter, it is helpful to consider it as a function of carbon emission. Other forms of incentives that are called RPM usually are imposed from the internal of the loop. The interaction of these mechanisms with a subsidy is an interesting topic for the ones who aim to study CLSC in different economic systems.

It is concluded that TPTCs are applicable and effective tools to push the linear economies to the circular ones. As the performance of the whole system increases in these contracts similar to the centralized cases, these forms can be exploited while the competition is kept. Moreover, extending the current contracts to more complicated ones could be an interesting idea, such as paired-contracts systems that can be employed to involve more parties.

Studying the financial group clear that managing disruption in the CLSC is an important issue, and resilience to CLSC disruptions has become a top priority for big companies such as GM. Investigating the literature shows that disruption usually is studied on one or two factors. However, extending the studied models to multiple disruption factors such as demand, remanufacturing cost, and collection cost, among others, helps to mitigate the effects of disruptions and develop a robust production plan which requires further research.

To mitigate the adverse effects of different risks, manufacturers and retailers need to choose an appropriate strategy. However, most of the literature concerning CLSC problems assumes that all the channel members are risk-neutral. Different supply risk-sharing contracts may result in different optimal quantity. Therefore, relaxing the mentioned assumption in most of the existing models provides new models.

Although licensing is a useful method to facilitate remanufacturing, there is scant literature investigating the decision on technology licensing through CLSCs. There are some gaps in this area, such as focusing on fixed-fee licensing and royalty licensing on refurbishing and recycling that leads to a better understanding of the remanufacturing systems in the CLSC and involving consumer surplus. Determining the threshold of the fixed-fee to establish an optimal licensing strategy is another topic for future works. Although franchising and licensing have some similarities, there are essential differences in details such as the degree of control over the operations and processes, support, and training. It seems that the present CLSC models are more concern about licensing than franchising. Therefore, there are opportunities to develop CLSC based on franchise contracts.
The results show that much effort is implemented in developing a sharing system in the CLSC models, and it is a well-discussed area chiefly sharing on the collection process, revenue, cost, and profit. An interesting suggestion for future works could be examining the effect of sharing these parameters between two separated loops (Wu and Zhou, 2017), for example, sharing the return rate between two collector parties from two loops.

Future research can work on multi-echelon multi-period stochastic CLSC inventory models. An important element is the impact of (un)certain return policy/rate on inventory costs that are potential researches for the future (Shekarian et al., 2016).

The role of information discipline has devoted growing attention in CLSCs, especially the ones based on GT. There are several possible extensions for future research working on a new idea, such as information value/investment/selling, and their impact on the performance of the players is discussable. Although information sharing can improve the efficiency of CLSCs, independent companies endowed with private information often face a dilemma in determining whom they should share information with (Huang and Wang, 2017d). Particularly, controlling the sharing of information or the degree that the information can be shared is discussable. Examining horizontal and vertical information sharing among the players of a game is also an interesting idea. In this regard, the Bayesian approach to study the value of information could be a new room.

Findings show that CLSC’s attention to quality is remarkable. Based on the results, the quality and the return rate are in mutual interaction. It is possible to control the remanufacturing cost and quantity by knowing the variability of quality. More specifically, studying the threshold so-called reference quality, which affects
the sales and profit of CLSC entities, is worthy of analyzing, leading to efficient strategies. On the one hand, high quality increases the demand, and on the other hand, it increases the selling price, which reduces the demand. Regarding these relations, analyzing and obtaining optimal points of prices in demand function is important.

As a rule of thumb, if the remanufacturing cost is sufficiently low to overcome the negative impact of new product cannibalization, OEM’s remanufacturing is justifiable. However, the negative impact of cannibalization can be overcome by using an appropriate pricing strategy and market segmentation. A basic line for future research is investigating the optimal degree of cannibalization when remanufacturing is an industry choice. Moreover, it can be a discussable question that cannibalization of which party can decrease or increase the performance of the loop.

Online retailing is a significant part of the loop by e-tail enterprises such as OLX.in, Amazon.com, and Crutchfield.com that accept returns on most items within 30 days and pay for return shipping only for their own mistakes. E-tail channel entry affects the player’s payoffs, who benefits from the e-tail channel entry. Some interesting issues can be investigated in the e-tail section, such as consumer free-riding behavior and analyzing the contrast of e-tail and traditional brick-and-mortar stores regarding some matters like information system and prices. Furthermore, studying the effect of cannibalization via e-tail channels is another topic that could be noticeable. Table 4 briefly shows the current trend on the categorized factors, and some directions for the future researches is presented.

7. Conclusion

The CE is becoming a pivotal concept that can play a vital role in today’s modern economic systems, specifically in the developed countries. The CE suggests replacing end-of-life products/materials with the reused, recycled, or recovered ones (Kalmykova et al., 2018). In this context, at a micro-level (i.e., activities related to the products, markets, consumers, and enterprises), CLSC operates as an effective approach. Determination of CLSCs characteristics enhances the speed of the transmission of a linear system to a circular one. It facilitates change from the present inefficient linear economic systems to the circular one that not only considers economic targets but also can create a friendly environment system.

After clearing that there is a lack in the literature regarding a holistic study of CLSC models, present comprehensive research is conducted on the CLSCs. Furthermore, in order to narrow the scope of the review among a vast literature, the models that are structured based on the GT were investigated. Characteristics of these models shown quantitatively in the formulation were derived and categorized according to a content analysis approach. A factors-cross-referenced database is provided that shows a clear map of the discussed models with details. Comparisons of these combinations in pairs lead to identifying the gaps in the literature while it allows addressing CLSCs with the novel combination(s) for new cases. The mentioned factors and studied papers are classified according to the descriptive statistics such as the year of publication, journal, frequency, etc. Patterns and research streams are found.

The results of this study certainly can serve companies and
practitioners when playing and deciding in operational closed-loops. It is shown that updated versions of CLSC models exploit more factors addressing the real situation as compared to the initial models. Results clear that among the categorized factors, sharing mechanism has got the priority by the researchers. However, other areas, such as the disruption, which is an appropriate approach to control the market fluctuations, still need to be investigated more thoroughly.

There are lots of opportunities to extend the current study for future research. Although the focus of the review was on CLSCs in the framework of GT, the features of the models that are according to GT, were not discussed. This is the extending line of this paper that the author is following. Moreover, each of the categorized factors could be a topic for more investigations. Finally, the assumption of game-based structure can be relaxed, and characteristics of CLSCs can be viewed with other mathematical or operational research methods.
Table 4
A summary of present researches and directions for future works.

| Factor          | The current focus of the literature                                                                 | The direction and specific research for future                                             |
|-----------------|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| Advertising     | On sales of new product Manufacturing and remanufacturing costs                                    | Targeting advertisement on returning the cores                                            |
| Cost            | Remanufactured product and trade-in process and dynamic discount                                   | Attention to the collection cost and cost breakdown for the different processes such as collecting, sorting, and recycling |
| Discount        | Different types of service level Quantity of the released carbon emission                          | Considering demand in different channels, discount based on order quantity, and a quantity discount type of contract in the form of a two-part tariff |
| Service         | Green activity Investments of entities in different area such as recycling and returning          | Competition on servicing for the remanufactured product between two parties               |
| Carbon emission | Impact and regulation Measuring the environmental impact                                            | Motivating the consumer to buy the product with less pollution and considering the other sources of pollution |
| Subsidy         | On remanufacturing and recycling Regulated by the government as an external force                   | Concentration on the market such as giving more attention to green consumers to incentive non-green consumers |
| TP TC           | The simple mechanism between two parties                                                          | A complex system such as paired-part tariff contracts between supplier and manufacturer and retailer |
| Disruption      | Single or double disruption All the channel members are risk-neutral                               | Multi-disruption                                                                           |
| Risk            | Licensing on remanufacturing Limited use                                                          | Relaxing the risk-neutral assumption and decreasing risk in reverse process                |
| Franchise       | 3D Considering simple parameters as deterioration and depreciation                                  | Focusing on fixed-fee licensing and royalty licensing on other areas such as refurbishing and recycling |
| Sharing         | Sharing on the demand, collection process, revenue, cost, and profit                              | Considering the franchise in different channels for different players                      |
| mechanism       | Simple and deterministic inventory systems                                                          | Working on the warranty period                                                              |
| Inventory       | Information systems Symmetric and asymmetric information                                           | Sharing the parameters of the reverse process between two loops                            |
| system          | Quality considerations Quality of the cores                                                      | Multi-echelon multi-period stochastic CLSC inventory models                                |
| Cannibalization | The effect of cannibalization on sale and design                                                   | Controlling the sharing of information, information value/investment/selling, examining horizontal and vertical information sharing and the Bayesian approach |
| E-tail          | On selling the item                                                                                | The variability of quality, reference quality, finding the optimal price regarding the quality |
| Trade-in        | The two-step process for replacing the used product                                                | Finding the optimal degree of cannibalization and the party in charge of cannibalization   |

Declaration of competing interests

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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