DUAL CHANNEL CLOSED LOOP SUPPLY CHAINS: A STATE OF THE ART REVIEW

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ABSTRACT

Due to the need to protect the environment and some circumstances beyond a manufacturer's control (such as product recalls), product returns have been introduced to the supply chain. Introducing product returns has led to the formation of closed loop supply chains, that is, situations in which organisations both manufacture and remanufacture their own products. Closed loop supply chains have been known to be uncertain in the timing, quality and quantity of the returns. In addition to these uncertainties, most organisations lack the necessary infrastructure and technology to perform reverse logistics operations on their own. For this reason, they seek assistance from external parties. Whilst the rapid pace of e-commerce has led to manufacturers adopting dual channels for selling their products, in closed loop supply chains, the dual channel has been defined by more than just selling products both offline and online. This paper investigated how dual channel have been utilisied to address issues in closed loop supply chains. A content-based analysis was carried out for 57 papers. The identified characteristics of these papers were classified into 9 categories. By reviewing literature on dual channel supply chains, the paper was able to identify the ways in which different channels are formed in closed loop supply chains. The purpose of the paper was threefold. Firstly, the literature review described the general characteristics of dual channel closed loop supply chains based on what was revealed by existing literature. The review also classified literature based on the definition of dual channel CLSC, research methodology and. Finally, the research proposed some meaningful gaps and directions for future research. The results of the review showed that there is need to expand literature on the competition of channels, greening strategies and carbon emmissions and supply chain dynamics and stability in dual channel closed loop supply chains. Future research should also consider relaxing some assumptions and incorporating real case studies.

Keywords: closed-loop supply chains, dual channels, multi-channels, reverse logistics, circular economy

1. INTRODUCTION

Reverse logistics (RL) has gained momentum as a means of saving natural resources, energy and protecting the environment. Whilst most organisations delegate reverse logistics activities to third parties, some organisations perform these activities on their own. In such cases, the products return to their original supply chain to form a closed-loop supply chain (CLSC). Prahinski and Kocabasoglu (2006) defined a closed-loop supply chain as, "a supply chain designed to consider the processes required for product returns in addition to the traditional forward chain processes". They state that in closed-loop supply chains, the product returns to the original equipment manufacturer (OEM) and that they can lead to a business making adjustments in product design and procurement practices. "As a means for realising the circular economy (CE), the closed-loop supply chain can minimise resource input, waste emissions and energy leakage through remanufacturing, reuse, refurbishing and recycling"-(Wells, Seitz, & Seitz, 2005). Guide Jr and van Wassenhove (2009) mentioned that the closed-loop supply chain is not only a means for minimising costs, but it is a way of gradually increasing revenue for the manufacturer. This reverse logistics of used products means that an OEM has two classes of the

same product, new and remanufactured products and they have to find ways of marketing and distributing these two classes of products.

Traditionally, the manufacturer sells both new and remanufactured products through independent retailers. "However, this leads the manufacturer at risk of the retailer's opportunism behaviour to sell the remanufactured products as new products which might do harm to the manufacturer's reputation as well as its profitability"-(Wang, Wang, & Wang, 2016). In 2010, HP was involved in a scandal of selling remanufactured computers as new after Hong Hengchang (the biggest retailer of HP and Acer in Asia) made false representations in China. This damaged HP's reputation. A similar case was recorded for DELL and their reseller TigerDirect. Because of this, a solution was needed where new and remanufactured products were differentiated. At the same time, the growth of the internet has brought about evolution in supply chains. Most supply chains have seen the introduction of more than one channel for selling and marketing products. Tetteh and Xu (2014), Cuellar-Healey and Dyson (2013) and de Carvalho and Campomar (2014) identified the different types of distribution channels used by manufacturers. These distribution types are summarised in Table 1.

Table 1 shows four different channels that resulted in supply chains because of the growth in internet technologies. These channels are the single direct channel, the dual channel, the multiple channels and the Omni-channels. The Omni-channel is the most recent development in distribution channels to provide a seamless customer experience by integrating the use of both online and offline channels.

The dual or multi-channel distribution channel has been defined by Zhang, Wang, and Liu(2015) as "a supply chain in which a manufacturer sells products not only directly to customers but also through its retailers". Because of this dual channel, consumers can now shop for a product in an offline store and purchase it online at a lower price. Zhang et al.(2015) also mentioned how the increase in the number of customers purchasing products online has helped prominent companies such as IBM and Nike to access customer segments that they could not reach through traditional retail channels. However, although the online channel has grown, the offline store still plays a significant role in the market, as sales efforts play in the offline stores are critical in promoting a product. Zhang et al.(2015) mention sales efforts in the offline stores such as mailing advertisement, providing attractive shelf space, offering trial samples and educating customers on how to use products. Companies like Abercrombie & Fitch and Costco that reserve shelf space for specific items of clothing for extended periods and offering free samples of food products respectively have exemplified this.

The dual channel has not only been incorporated in the forward chain, but also in CLSCs. The growth in internet technology and the need to collect as much products as possible from the end user has led to many companies employing more than one channel in the CLSC. Hong, Wang, Wang, and Zhang (2013) give an example of how companies utilise many channels for the collection of used products by giving an example of Xerox corporation. The authors mention that Xerox commits its vendors to collect products during sale and installation of the products and at the same time, the company uses prepaid mailboxes so that customers can return products to Xerox without incurring any costs. This is meant to cater for the uncertainties in product returns such as the timing, location, quality and quantity. Multiple channels have not been used just for collection of used products only but also for the recycling of products. Wu, Chen, and Zhang (2020) give an example of how in 2017 Love Recycling (a company based in China) recycled more than 11 million Waste Electrical and Electronic Equipment (WEE) through internet channels. The same authors mention how online recycling actively develops a reverse supply chain based on website apps and reverse vending machines to increase the recycling amount and rate.

Because of these developments, the use of dual or multi-channels in CLSCs has not only attracted the attention of recycling companies but also that of academia. As a result, there has been many publications on the employment of dual channels and multi-channels in CLSCs. Based on these recent developments in dual and multi-channel CLSCs, it is necessary to have a review that details the growth of dual channel CLSC research and identify future research directions. There has been no research on dual channel closed loop supply chains recently, although there have been many reviews on CLSCs. This paper covers a gap in dual channel CLSCs by reviewing, categorizing and analysing papers on this topic published up to June 2020. The rest of the paper is structured as follows: Section 2 discusses some recent reviews on RL and CLSCs. The Research methodology is explained in Section 3. Classifications of reviewed papers are carried out in Section 4. Research gaps and future research directions are identified in Section 5. Finally, Section 6 gives the conclusion of the paper.

2. LITERATURE REVIEW

To explain the importance of this review, a summary of some of the most recent reviews in RL and CLSC research have been summarised in Table 2.

Table 2 shows an increase in studies on CLSC reviews (since 11 of the 18 reviews mentioned were published after 2016). From the list of reviews, there are 3 comprehensive reviews (reviews with more than 200 papers) by Govindan, Soleimani, and Kannan (2015), Master, Shen, Liao, Xue, and Wang (2020) and Shekarian (2020). The rest of the papers are review papers with less than 200 articles. These papers used methods such as bibliometric analysis, content analysis, critical review, and tutorials.

Most of the reviews on RL and CLSCs cover specific aspects of CLSCS, for example Shekarian (2020) focused on factors affecting CLSCs based on game theory, Braz et al. (2018) focused specifically on the Bullwhip Effect in CLSCs and Tombido, Louw, and van Eeden (2018) focused on the use of 3PLs in reverse logistics and CLSCs. The more generalised reviews by Souza (2013), Govindan and Soleimani (2017) and Govindan et al. (2015) may have included some of the papers in this review, although they did not specifically focus on the use of multi-channels in CLSCs. On the list of reviews, the only paper that is closer to this review is by Shekarian (2020). This is because this paper focuses on the use of game theory in CLSCs and most of the papers in this review applied game theory as a method of research, so most of them appeared in the review by Shekarian (2020). However, the paper by Shekarian (2020) did not focus on issues on the use of dual channels or multi-channels in CLSCs. This makes it completely different from this review.

Whilst the dual channel in the forward chain has been defined by the use of more than one selling channels, the same cannot be said for the dual channel in closed-loop supply chains. The purpose of this review is to 1. Define the "dual channel" as applied to CLSCs, 2. Identify classifications of research on dual channels in CLSCs and methodology used and 3. Identify research gaps in dual channel CLSCs. The last role in Table 2 explains the purpose of this review.

Single channel	Brick and mortar only	Customer demand at retail store is met by on-hand inventory from bottom echelon. Retail warehouse communicates product shortage to manufacturer by stock on hand, triggering replenishment order.	Buying a Nike shoe from a Nike retail shop.	Can facilitate manufacturer's entrance to traditional markets and/or new markets, reaching geographically scattered customers. Speedy delivery of products in small quantities. New products are easy to launch, monitor and control. Less costly to operate. Able to bring the products or services to convenient places in a timely fashion.	Lower profitability. Lower product coverage.	
	Direct channel	Customer demand is satisfied directly with on-hand inventory from the top echelon. Manufacturer operates the channel and they can easily detect inventory shortage by inventory bookkeeping.	Buying a Nike shoe online	Convenient and fast. Less storage of goods. Accurate product information. Total control of how products are sold and serviced. Ability to respond quickly to changes in the market, customers' needs or both.		Can be faster a

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The manufacturer has to take on
both the marketing and distribution
functions, hence it is more
challenging.

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Dual or Multichannel	N/A	Manufacturers use both brick and mortar and direct channel to distribute their products. Each distribution channel has as target- market a different segment of consumers, or even aims at serving different needs of the same clients. The use of multichannel has as a goal to reach the same kinds of consumers by means of different channels, but integrated.		More than one channel to enlarge product outreach to customers. Higher profits compared to the single distribution channel. Product enhancement and development are attained easily and quickly. Allows the company to develop lasting relations with their clients, offering at the same time a great deal of information, products, supports (and combination of them).	It is difficult to launch and control.
Multiple channel	N/A	The use of multiple marketing channels foresees the company to use different distribution channels in order to attend different types and consumers segments.	Using personal sales for big clients and using retailers for small clients.		
Omni-channel	N/A	Related to the Idea that the clients can Access the on-line information concerning the products even being inside a physical store, having contact with countless information, including	Centauro, Brazil. experience of the consumer with the sports brand allows him to research at the store, buy it in e-	Seamless experience for customers. Network expansion. Helps in developi bran	Customers are lost in the early engagement stage of the Omni-channel due to inconsistent

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promotions, prices advantages and negotiations. This new concept shows the need of two sales models – on-line and off-line – provide synergy to the sales.	commerce and come back to physical store in case he needs to exchange the product.	ng advocacy.	d	communication across different channels. Retailers are faced with the challenges of understanding the definition mission and placement of Omni distribution in their organisation. Omni-channel has leapfrogged cross-distribution, which should not be so.

3.1 Material Collection

The study covers all accepted papers (available online) up to June 2020. There were 5 stages in the material collection procedure:

- **Initial search in Web of Science** resulted in 15 pages of search with 150 papers.
- **In the second stage, the same keywords were entered into Google Scholar** and papers were obtained.
- **Papers from Web of Science were cross checked with those from Google Scholar** to remove duplicates and ensure reliability of the search.
- **Manual analysis of selected papers by reading abstracts** to find relevant papers based on inclusion and exclusion criteria.
- **Search for additional articles** by backward/forward snowball searches for all papers in the included articles.

Literature was not limited to specific journals and it was first searched for in the citation databases Web of Science and Scopus. Thomé, Scavarda, and Scavarda (2016) mentioned that "citation databases ensure a broader diversification of studies as they index journals and vendors all in one location". Scopus and Web of Science are two large databases that include over 20000 peer reviewed journals in the fields of science, technology, medicine, social sciences and arts and humanities. These peer-reviewed journals belong to various publishing houses including Elsevier, Emerald, Hindawi, Taylor and Francis, Springer and Inder-Science.

The inclusion and exclusion criteria, keywords and keyword search and article validity are summarised in the review protocol in Table 3.

Table 3. Review Protocol

Filter type	Description and Guidelines	Results
Inclusion criteria	Topic: Only articles focusing on dual/multi-channels in RL or CLSCS Language: Limited to English Time Span: All accepted articles (available online) up to June 2020 Article type: Only accepted articles in peer reviewed journals available online.	150

Exclusion criteria	Topic: Articles looking into dual channel supply chains but not into RL or CLSCs. Language: Articles published in Chinese or any other language. Article Type: Book sections, conference papers and grey literature.	75
Keywords	Depended on Boolean operators AND and OR. "Dual channel" AND "closed loop supply chain" OR "dual recycling channel" OR "dual channel" AND "reverse logistics"	75
Material validation	1. Manual analysis of abstract. 2. Reading all papers left in the sample.	47
Snowball Approach	Forward searches mostly from recommended articles on Elsevier. Backward searches mostly in references of selected articles.	10
Final sample size		57

From Table 3, the final sample size was 57 papers. These are the papers that are reviewed and classified in the current study.

3.2 Descriptive Analysis

The distribution of the 57 publications on the use of dual and multi-channels in RL and CLSC based on year published is shown by the graph in Figure 1. Figure 1 shows that the first publications on this topic were in 2010.
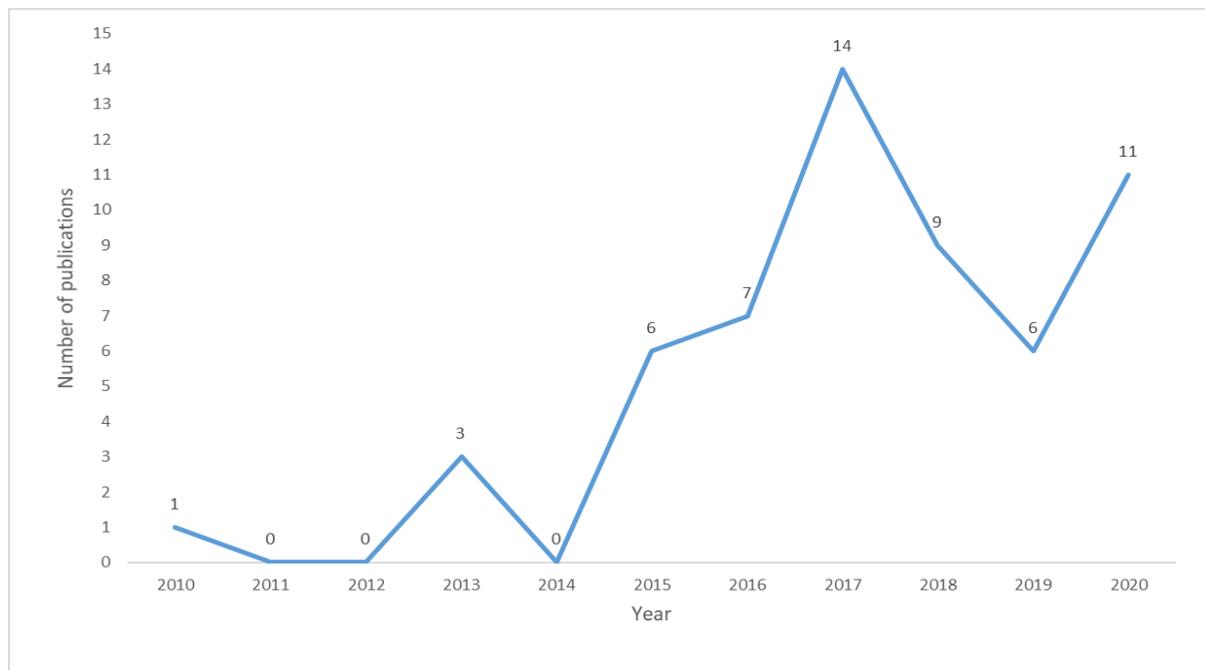

Figure 1. Distribution of publications on dual channel CLSCs over the years

The distribution of publications from 2010 to 2014 was erratic, with the years, 2011, 2012 and 2014 having no publications. After 2014, the general trend was an increase in the number of publications on the dual channel closed loop supply chain. The year 2017 had the most publications. However, the year 2020 promises an increase in the number of publications (since this review was done in the beginning of 2020). The total number of publications (57) over the

last 10 years shows that the topic is still growing. The year 2017 had the most publications with only 14 publications; this also shows that the topic is still growing. Table 4 and Figure 2 show the distribution of the articles among the peer-reviewed journals.

Table 4 and Figure 2 show that the topic is spread across a variety of journals and the majority of these journals have a publication each. There are only 7 journals with 2 or more publications. The Journal of Cleaner production has the most publications on dual channel closed loop supply chains (12), followed by Sustainability (6), International Journal of Production Economics (4), European Journal of Operational Research (3), Mathematical Problems in Engineering (3), International Journal of Production Research (2) and Entropy (2). It should be noted that most of the journals appearing on this list are mostly quantitative and analytic journals. This shows the nature of most of the research on dual and multi-channel closed loop supply chains.

4. CATEGORY SELECTION

Seuring and Gold (2012) mentioned that segmentation into separate process steps is a crucial feature of qualitative content analysis as it " allows for traceability and intersubjective verifiability".

Table 4. Distribution of publications across journals

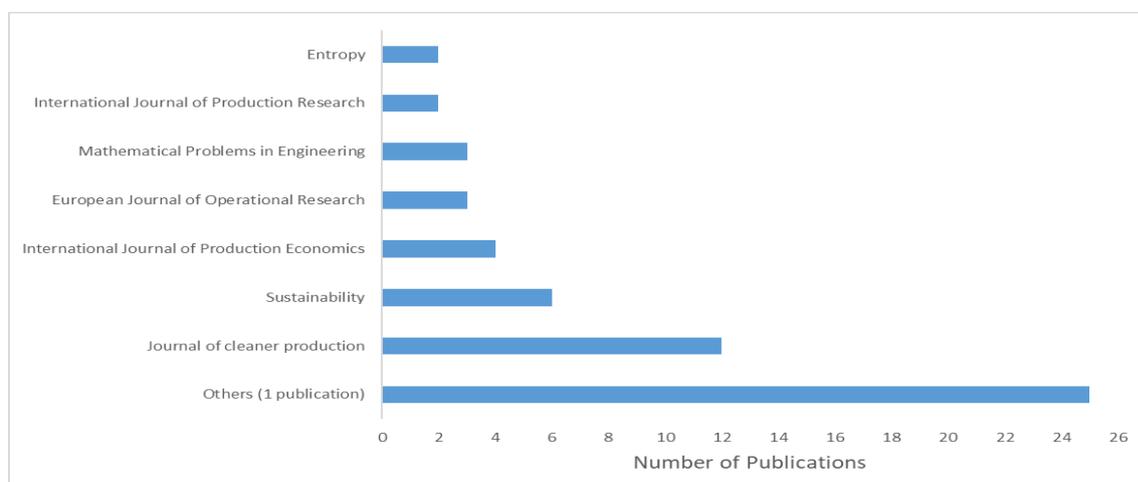| Journal	Year of Publication								
	2010	2013	2015	2016	2017	2018	2019	2020	Total
Others (1 publication)	1	1	3	2	4	3	4	7	25
Journal of Cleaner Production	0	0	0	2	3	2	1	4	12
Sustainability	0	0	2	0	2	2	0	0	6
International Journal of Production Economics	0	1	0	0	2	1	0	0	4
European Journal of Operational Research	0	1	1	0	1	0	0	0	3
Mathematical Problems in Engineering	0	0	0	2	0	1	0	0	3
International Journal of Production Research	0	0	0	1	1	0	0	0	2
Entropy	0	0	0	0	1	0	1	0	2
Total	1	3	6	7	14	9	6	11	57

Figure 2. Distribution of publications across journals

The same authors gave two ways of defining categories:

- Deductive approach- Analytic categories are assessed before the material is analysed i.e. based on existing theory.
- Inductive approach-Categories are derived from the material under examination itself, employing an iterative process of category building, testing and revising by constantly comparing categories and data.

Both these approaches are used in this review.

4.1 Deductive approach

In the deductive approach, literature is first classified according to the classes defined by Souza (2013). The author classified CLSC problems into strategic, tactical and operational issues. Another deductive classification was separating the studies into either RL or CLSCs. Table 5 and Figure 3 summarise the deductive approach of classifying studies in this paper and the number of papers per class. Table 5 shows that the majority of publications are on CLSCs (approx. 84%). The majority of publications also focused on strategic issues (approx. 79%). There were no publications on operational issues in CLSCs.

Table 5: Classification of studies, deductive approach

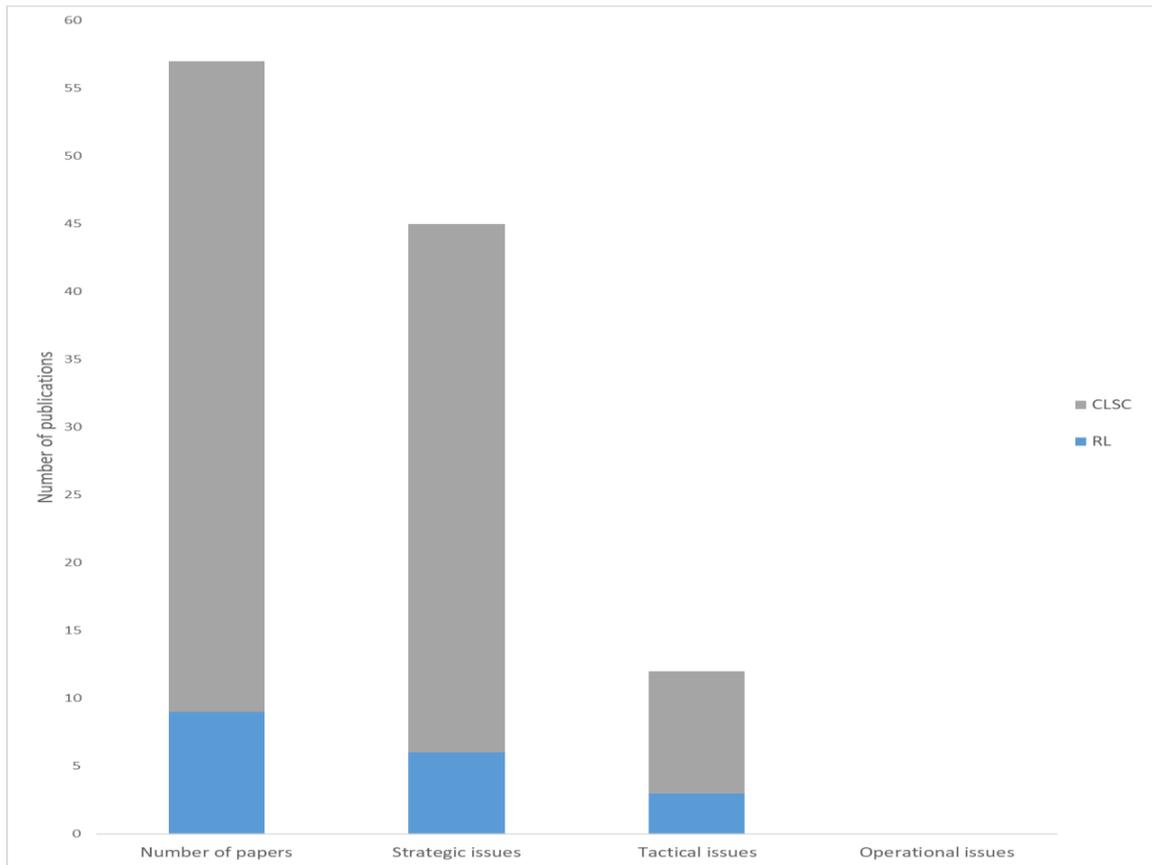| Main categories	Number of papers	Strategic issues		Tactical issues		Operational issues	
		Example problems	Number of papers	Example problems	Number of papers	Example problems	Number of papers
RL	9	Network design-location and size of facilities Collection strategies -should consumers return products directly to OEM or not? Should the OEM remanufacture? Leasing or selling? Trade in and buy back programs Supply chain coordination-contracts and incentives Response to take-back legislation Impact of recovery activities on new product design	6	Product acquisition-when, how many and which quality? Disposition of returns-remanufacturing, reuse, recycling or cannibalisation.	3	Disassembly planning: sequence and depth of disassembly Scheduling, priority rules, lot sizing, and routing in the remanufacturing shop	0
CLSC	48		39		9		0
Total	57		45		12		0

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Figure 3. Distribution of papers across categories

4.2 Inductive approach

The inductive approach included classifying papers based on classes defined by the author. The first category is how the dual channel is defined. In a dual channel forward chain, the manufacturer either sells products directly (online) to customers or indirectly (through retailers, wholesalers etc.), hence the concept of dual channels is defined through selling channels only. The same cannot be said for reverse supply chains and CLSCs. Blackburn, Guide, Souza, and van Wassenhove (2004) mentioned the main activities of reverse logistics such as collection/acquisition, inspection, disposition and distribution and sales. In CLSCs, the dual channel has been defined based on each of the activities. Figure 4 is a pie chart showing the distribution of how different papers defined a dual channel closed loop supply chain.

From the pie chart, 61% (35 papers) defined a dual channel based on selling channels. This was similar to the definition in the original forward chain where the manufacturer sells both new and remanufactured products both online and offline. A different definition to this dual channel for CLSCs was offered by Yan, Xiong, Xiong, and Guo (2015) and Gan, Pujawan, Suparno, and Widodo (2017). The authors define a dual-channel in which the manufacturer sells new products offline and remanufactured products online.

18% (10 papers) defined a dual channel CLSC based on collection of used products. The first definition was when used products were collected using both online and offline channels. This definition was used by only one paper by Taleizadeh, Moshtagh, and Moon (2018). In defining dual channels by collecting channels, the majority of authors used dual collection without the use of an e-tail. In this

definition, collection was either done simultaneously by the manufacturer and retailer, manufacturer and third party (3P), and retailer and 3P. Such authors include Huang, Song, Lee, and Ching (2013), Liu, Wang, Xu, Hong, and Govindan (2017), Yi, Huang, Guo, and Shi (2016), Zhao, Wei, and Li (2017), Wei, Wang, and Zhao (2018) and Wang, Zhou, Zhang, Sun, and He (2018). Li, Xu, and Zhao (2017) defined a dual channel collection mode whereby the government and the informal sector simultaneously collected used products. A different definition in using collection channels was offered by Huang, Yi, and Shi (2017) who used triple collection channels, OEM, retailer and secondary market.
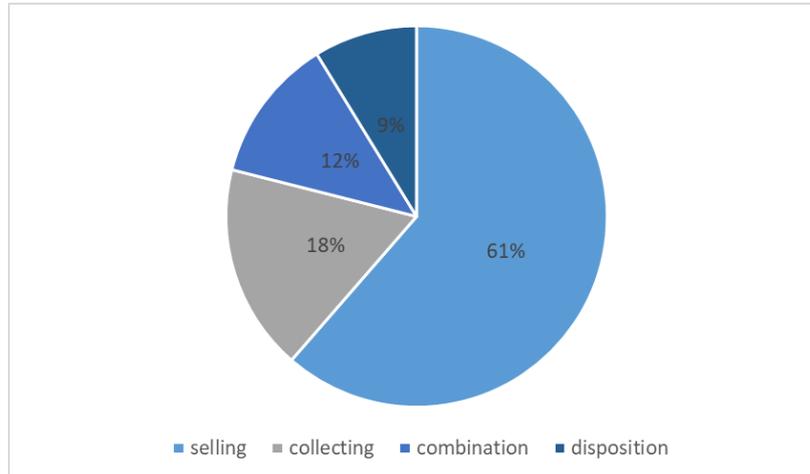

Figure 4. Definition of dual channel CLSCs

Figure 4 shows that 9% (5 papers) defined dual channels using disposition. In this case, the manufacturer uses both traditional and online recycling channels. Authors such as Feng, Govindan, and Li (2017), Huang and Wang (2017) and Yuan, Yang, Li, and Li (2020) used this definition. Xing, Shi, Zhang, Cheng, and Lin (2020) and Ran, Chen, Wu, and Liu (2016) defined dual recycling channels where two 3Ps recycled and manufacturer and retailer recycled (respectively) without an e-channel.

The last definition of dual channel CLSCs was when authors combined more than one dual channel. This was used by 12% (7 papers) of the publications. Giri, Chakraborty, and Maiti (2017) defined a dual channel CLSC whereby products were sold both online and offline and the same products were collected by a 3P and an e-tail. Taleizadeh et al.(2018) and Xu (2020) defined a dual selling channel and a dual recycling channel. In Wang, Li, Lu, Yang, and Wang (2020), the dual channel had e-bicycles being collected offline and recycled online. Dual channels in which products were sold and collected both online and offline were defined by Mondal, Giri, and Maiti (2019) and Chen, Zhang, Shi, and Xia (2019). Finally, Ma, Ren, Yu, and Zhu (2018) defined two dual channels with no e-tail where products were collected and recycled by both the manufacturer and the 3P.

The second category was based on content analysis.

4.3 Content Analysis

In carrying out a detailed analysis of the literature, the following classifications were identified by the author:

1. Pricing strategies
2. Supply chain coordination
3. Supply chain design
4. Pricing and reverse channel decisions
5. Channel competition

6. Combination of categories
7. Others (unclassified)

Table 6 gives a brief description of these categories and the number of papers in each category.

Table 6:. Categories of papers on dual channel CLSCs

Category	Category description	Number of papers
Pricing strategies	A focus on different pricing strategies based on different factors to improve profits, collection and remanufacturing of used products.	7
Supply chain coordination	A focus on the coordination of contracts and channels	11
Supply chain design	A focus on the design of the RL network	7
Channel competition	A focus on competition between channels either for sales, or for cores.	4
Pricing and reverse channel decisions	A special focus on both pricing decisions with a combination of either collection channel or reverse channel decisions	12
Combination	A combination of any of the above mentioned categories	4
Greening strategies and carbon emissions	A focus on carbon emissions and greening in dual channel CLSCs.	4
Supply chain dynamics and stability	A focus on chaos in the model and structural dynamics like the Bullwhip effect.	4
Others (unclassified)	A focus on other issues that do not fall in any of the categories mentioned.	3

Table 6 shows that the majority of the publications focus on pricing and reverse channel decisions, although publications seem to be almost equally distributed between the categories of pricing, supply chain coordination and pricing and reverse channel decisions. The least number of publications are found in the channel competition and combination categories. The following subsections explain and allocate the papers to these categories.

4.3.1. Pricing strategies

This is one of the most looked into category. The category focuses on pricing decisions made by the dual channel players based on different factors in order to increase either profit or the collection and remanufacturing of used products. A brief summary of papers on pricing strategies is provided in Table 7.

Table 7 shows that the most common methodology used is game theory, although two authors used simulation. The acceptance of the channel and the acceptance of the remanufactured products by the consumer were also the most looked into factors. New factors such as the consideration of loss neutral and loss averse customers were introduced by Liao and Li (2018) and these present a gap for further investigation as only one publication looked into this aspect.

A unique dual channel CLSC was presented by Gan et al.(2017) whereby the manufacturer sold remanufactured products online and new products offline. More dual channels with this structure need to be looked into, since the majority of the dual channels look at both new and remanufactured products being sold online and offline.

4.3.2 Supply Chain Coordination

Supply chain coordination issues in dual channel CLSCs look into the coordination of contracts and channels in the CLSC. Of the 57 articles, 11 looked into this issue.

Table 7. Summary of literature on pricing strategies

Author and Year	Factors under investigation	Methodology	Conclusions
Jiang, Xu, and Sheng (2010)	customer preference of selling channel direct channel cost remanufactured unit cost	Agent based modelling Learning search algorithm	Optimal profits are increased by introducing direct channel and remanufacturing.
Zhang et al.(2015)	Retail services Degree of customer loyalty to the retail channel	Game theory	Retail services have a great impact on the manufacturer and retailer's pricing strategies. Retail services, retail price and direct sale price are all strongly influenced by the degree of customer loyalty the retail channel.
Gao, Wang, Yang, and Zhong (2016)	Customer acceptance of direct channel	Game theory	When customer acceptance of direct channel changes in a certain range, wholesale price, retail price and expected profits of retailer decrease. Optimal recycling transfer price and acquisition price of used products are unaffected by customer acceptance of direct channel.
Liu, Guo, Guo, and Lei (2016)	Mutual restriction of product prices of retailers and e-tailers Customer preference of remanufactured products	Game theory	Consumers' preferences for remanufactured products were positively correlated with supply chain members and manufacturers profit growth significantly more than with that of retailers and e-tailers. When consumer demand reaches a certain level, the total profits of retailers are higher due to participation in remanufacturing.
Gan et al.(2017)	Remanufacturing acceptance Direct channel preference	Game theory	Separate sales channels have higher profits than single channel. The best scenario for the overall supply chain is not the best for the individual. Direct channel preference is most effective in borderline no remanufacturing scenario.

Liao and Li (2018)	Loss neutral and loss averse customers	Game theory	Loss averse consumers have a major influence on the manufacturer's profit. An increase in loss averse degree may benefit the manufacturer in both channels.
Zhang and Ma (2018)	Channel loyalty Reference prices	System s dynam ics	As the channel loyalty parameter increases, the collection rate and the manufacturer's profit decrease, the retailer's profits increase. With the increase of the reference price coefficient, the collection rate increases, the profit of the manufacturer decreases and the profit of the retailer increases.

In considering the involvement of government in CLSCs, Ma, Zhao, and Ke (2013) investigated decisions made by channel members before and after the introduction of a government consumption subsidy. The influence of consumption-subsidy was also considered from the perspective of the consumers, the scale of closed-loop supply chain and the enterprises. The authors concluded that the government consumption subsidy is conducive for the expansion of the supply chain and that all players in the exception of the e-tail are certain beneficiaries of the consumption subsidy. Similarly, Li et al.(2017) investigated governance mechanisms between the government and the informal collection channel in China. The effectiveness of the governance mechanisms were determined by channel preferences of consumers and the economic value of WEEE.

Yi et al.(2016) used game theory to explore how a manufacturer should properly allocate collection efforts between a retailer and 3P in a dual collection CLSC. In order to eliminate profit loss because of decentralised decision making, Yuan et al.(2020) analysed the necessary conditions for manufacturers, retailers and third-party online recyclers to achieve interest coordination under equilibrium conditions. The authors concluded that in order to make the total profit of decentralized decision- making equivalent to that of centralized decision-making, the recycling cost of retailers and third-party recyclers must be the same and new products must be shipped at zero profit. The results implied that multi-channel recycling must be carried out under the premise of uniform recycling costs. There was an investigation on how a firm's organisational structure can affect marketing decisions by Shi, Chhajed, Wan, and Liu (2020). The authors compared a decentralized firm with separate manufacturing and remanufacturing divisions, one with centralised and consolidated manufacturing and remanufacturing and dual dedicated channels. The authors concluded that a decentralized firm with separate manufacturing and remanufacturing divisions can benefit from indirect selling with higher firm profit, supply chain profit, and total consumer demand thanit does from direct selling. In contrast, a centralized firm in which the manufacturing and remanufacturing divisions are consolidated is intuitively better off by choosing direct selling. In the case of dual dedicated channels, direct selling of remanufactured products and indirect selling of new products can better induce higher supply chain profit but it is not in the best interest of the firm in terms of total sales and firm profit. Feng and Mu (2019) also devised a decision making model for a dual channel CLSC where recycling was carried out by the retailer by considering the retailer's retail service in dealing with the competition with the e-commerce direct sales channel. The research showed that the profit of each member and the supply chain profits are affected by the degree of preference of the consumer direct selling channel and the sensitivity of the service quality to the service level and the service cost.

On the coordination of contracts, Zhu, Wang, and Tang (2017) devised a revenue and expense sharing contract for a manufacturer, retailer and 3P where products were sold offline

but recycled online. In their research, the authors investigated the impact of customer behaviour on centralised and decentralised decision-making. Xie, Liang, Liu, and Ieromonachou (2017) also developed a revenue sharing contract based on the recycle rate by taking the relationship between the recycle rate and the recycle revenue sharing ratio into consideration. The authors also derived optimal online and offline prices, wholesale price and advertisement investment by comparing centralised and manufacturer led decentralised decisions. In trying to mitigate poor quality recycling due to information asymmetry in the recycling channel by grading collection, Xie et al.(2018) combined a revenue sharing contract in the forward channel with the channel investment cost sharing contract. The proposed contract was meant to increase the supply chain profits by properly setting the revenue sharing ratio and the cost sharing ratio. Taleizadeh, Sane-Zerang, and Choi (2018) investigated the effect of exerting marketing effort on the optimal decisions and profits of supply chain members by considering several marketing effort supported models. The authors also proposed a two-part tariff contract for coordinating the CLSC.

A different research by Shi, Geng, and Sheu (2020) investigated the optimal supply chain integration strategy for the manufacturer in a stylised dual-channel closed-loop supply chain (CLSC) consisting of one manufacturer, one retailer, and one recycler. The manufacturer had to choose one of three strategies: forwardly integrating the retailer, reversely integrating the recycler, or integrating neither. The authors concluded that supply chain integration in whichever direction always offers an incentive and that reverse integration generates more industry profit than forward integration if the recycler collects used products at a high efficiency or if the manufacturer saves a great deal from remanufacturing.

4.3.3 Supply Chain Design

Articles that looked into supply chain design considered how a manufactures selected their RL network and also the location, allocation and size of RL facilities. Only 7 papers looked into this issue.

A structural model to explore the appropriate reverse channel structure for the manufacturer was developed by Hong et al.(2013). In their model, the authors assumed a manufacturer who had three reverse hybrid collection channel structures to choose: (1) manufacturer and retailer collecting used products at the same time, (2) manufacturer contracting the collection of used products to a retailer and a third party, and (3) manufacturer and third party collecting used products at the same time. Hong et al.(2013) concluded that the manufacturer and the retailer hybrid collection channel is the most effective reverse channel structure for the manufacturer. By introducing consumer preference for the online recycling channel into the model, Feng et al.(2017) examined the challenge of strategically designing the reverse channel structure. They alo considered three scenarios: single traditional recycling channel, single online-recycling channel, and a hybrid dual-recycling channel in both centralised and deccentrlised cases. Their results showed that the dual-recycling channel always outperforms its single channel counterparts from the recyclable dealer's and system's perspectives.

Wang et al. (2016) explored the supply chain design by looking at marketing strategies used by a manufacturer. They considered three channel strategies adopted by a manufacturer to market products: (1) marketing both new and remanufactured products through an independent retailer; (2) marketing the remanufactured products through the independent retailer, while controlling the new product sales by using its own online channel; (3) marketing the remanufactured products through the manufacturer-owned online channel, while selling new products through the independent retailer. They concluded that the manufacturer prefers to differentiate new and remanufactured products by opening a direct online channel, no matter how the system parameters change. However, which type of products (new or remanufactured) the manufacturer should sell through the online channel depends on the cost saving from

remanufacturing, the customer's acceptance of remanufactured products and the online inconvenience cost. Marketing strategies were also looked into by Yan et al.(2015). The authors considered a manufacturer who sells new units through an independent retailer but with two options for marketing remanufactured products: (1) marketing through its own e-channel (Model M) or (2) subcontracting the marketing activity to a third party (Model 3P). Their results showed that although Model M is always greener than Model 3P. However, firms have less incentive to adopt Model M because both the manufacturer and retailer may be worse off when the manufacturer sells remanufactured products through its own e-channel rather than subcontracting to a third party.

Under the location of facilities, Yazdi and Honarvar (2015) designed integrated forward/reverse logistics based on pricing policy in direct and indirect sales channel. The proposed model included producers, disposal centre, distributers and final customers but the location of final customers was assumed to be fixed. A mixed integer nonlinear program was developed by Chen, Zhang, Shi and Xia(2019) to determine the optimal network and prices of both online and office return, with the objective of maximizing the manufacturer's profit. Rahmani, Qaisari, Abadi, and Hosseininezhad (2020) developed a model based on a dual channel system for green supply chain design. The model focused on decisions on location, product transfer, pricing and the kind of technology to be used in each established plant. To improve the greening of the product.

4.3.4 Channel Competition

With the introduction of the online channel and the use of multi-channels, channel competition became an issue in most dual channel supply chains. Kong, Liu, Pan, Xie, and Yang (2017) mention how the online channel, Nike town, established by Nike in Chicago was considered to be a threat to Nike's brand retailers. They also mentioned how Levi failed to coordinate the relationship with other brand retailers and was forced to close its online platform. With channel competition becoming an issue, one would expect it to be the most explored topic. However, in the case of dual channel CLSCs, it is one of the least looked into topic. Only 3 papers looked into channel competition. Zheng, Yang, Yang and Zhang (2017) examined the effect of forward channel competition and power structure on dual- channel CLSCs. The authors considered the joint effects of channel substitution rate and relative channel status on system's performance. They concluded that channel substitution rate and relative channel status do have great influence on the dual-channel CLSC. Taleizadeh and Sadeghi (2018) considered two collecting reverse supply chains consisting of a retailer and a manufacturer who competed by proposing more rewards to customers. This was a different article as one of these chains tried to obtain more market share in the collection process by using both the direct and traditional channels while the other chain used only the traditional channel. The model had two types of competition, internal and external competition. "Internal competition" referred to competition between the traditional and e-channel of one chain. "External competition" referred to the competition between the two channels. Their main conclusions were that, the e-channel provided more rewards for customers as it is less costly than the traditional channel and that the acceptance rate of the channel can have the significant positive effect on the member's profit, entire SC and decision variables.

In a situation where collection effort was considered to be private information, Wang et al. (2018) investigated a CLSC where the retailer and the third-party recycler competed to collect WEEE. The authors concluded that all CLSC members' expected profits are improved if both two-collection agents select a high collection effort level with or without the government's reward penalty mechanism.

4.3.5 Pricing and Reverse channel decisions

A large number of articles combine pricing strategies in dual channel supply chains with reverse channel decisions. These articles have been summarised in Table 8.

Table 8 shows that 12 articles focused on pricing and reverse channel strategies. Almost all these articles used game theory as the method of analysis. Two of the articles, one by Mondal et al.(2019) and the other by Wei et al.(2018) included greening strategies in addition to pricing and reverse channel decisions. These two articles presented a future research gap whereby greening strategies can be incorporated into the dual channel CLSC.

It would also be interesting to have more studies with dual channels present in both the forward and the reverse channels. Examples of studies with such a network structure are those of Giri et al.(2017), Mondal et al.(2019) and Xu (2020). In these three articles, products in the forward chain are sold both online and offline and used products in the reverse channel are collected both online and offline. The three articles present a research gap where more studies have to investigate the collection and the recycling of used products using both a traditional and an e-channel.

4.3.6 Supply chain dynamics and stability

A unique research, to measure and control the Bullwhip effect in a dual channel CLSC was done by Guo (2015). In this research, the author developed a state space dynamic model of a dual-channel e- commerce closed-loop supply chain networks and described the l2 norm of the model's transfer function as a method to quantify the Bullwhip effect.

Author and Year	Definition of dual channel	Methodology	Focus	Conclusions
Huang et al.(2013)	Retailer and 3PL both collecting and recycling products	Game theory	Pricing and recycling strategies for decentralised and centralised scenarios. Compared single recycling channels with dual recycling channels.	The beneficial choice of recycling channels depends on the competition intensity, regardless of manufactuer's or consumer's perspective. Dual recycling channel dominates single recycling channel when competition in recycling is not very strong.
Saha, Sarmah, & Moon (2016)	Products sold both online and offline	Mathematical model	Reward driven policy for acquiring used products for remanufacturing. Model characterised pricing decisions and remanufacturing strategies.	In a non-cooperative environment, neither the retailer nor the manufacturer benefit from delegating the collection of used products to the 3P. If customers are sensitive to reward, then the manufacturer should conduct recycling.
Liu et al.(2017)	Products collected by two parties either, manufacturer and 3PL, manufacturer and retailer or retailer and 3PL	Game theory	Competition between the dual recycling channels in investigating pricing and reverse channel decisions.	Ranking of certain optimal values among 3 optimal models are independent of the competition intensity. OEM and retailer dual collecting model is the best option for the OEM regardless of the competition intensity.
Giri et al.(2017)	Products sold both online and offline. Products recycled by both e-tail and 3PL.	Game theory	Pricing and return collection decisions under 5 scenarios, centralised, decentralised, manufacturer led, retailer led and 3P led.	The retailer led scenario provides more profit than other decentralised scenarios. The performance of the manufacturer led scenario is the best from the perspective of the whole system. The performance of the 3P led scenario is the best from the manufacturer profit perspective.
Zhao et al.(2017)	Dual collection of used products between retailer and 3P	Mathematical model	Optimal choice of collecting channel, the optimal pricing and collecting effort decision by considering collecting channels competition.	The manufacturer's best effort for collection of products is to ensure that the retailer is engaged in collection, regardless of single or dual collection. Manufacturer's best choice to improve environmental performance is to increase dual channel collection channels. Intensity of competition between dual channels affect the product's optimal wholesale and retail price.
Huang et al.(2017)	Three collectors, OEM, retailer and secondary market	Game theory	Optimal prices and collection allocation strategies. Impacts of reverse logistics cost coefficient, competition coefficient and buy-back price coefficient on supply chain performance analysed.	Retailer should properly allocate the collection efforts of the OEM, secondary market and itself according to reverse logistics cost coefficient, competition coefficient and buy-back price coefficient. For the retailer, it is important to reduce these three to drive profits in the remanufacturing process.
Ma et al.(2018)	Collection and recycling performed by both manufacturer and 3P.	Game theory	Investigated pricing decisions and recycling strategies.	Precipitous speed of recycling price adjustment of the manufacturer or the 3P will both lead the system into a chaotic state and an increase in the entropy of the system. Manufacturer and 3P should cooperate in taking some measures to prevent and control chaos.

Table 8: Summary of literature on Pricing and Reverse Channel decisions

Wei et al.(2018)	Retailer and manufacturer collect and recycle products.	Game theory	Effects of manufacturer collection options of used products and profit discount in the on the pricing, greening and remanufacturing strategies.	Dual collecting pattern not only increases the manufacturer's and retailer's profits but also enhances the product's green degree in the first period and improves total collection effort. In the static scenario, the manufacturer's profit is independent of who is in charge of collection of used products under single collection channel.
Arshad, Khalid, Lloret, & Leon (2018)	Products sold both online and offline	Game theory	Impact of horizontal fairness behaviour on the pricing strategies and utility of decision makers under different recycling models. Proposed a 3 way revenue sharing contract to achieve optimal coordination of the closed loop supply chain when there is horizontal fairness concern among retailers.	The manufacturer's direct recycling channel is superior to the 3P recycling. Under the direct recycling, horizontal concern behaviour of the offline retailer has caused the two retailers to compete in price reduction and recovery rate and improves the utility of the entire closed loop supply chain.
Mondal et al.(2019)	Products sold both online and offline. Also, products collected both online and offline.	Game theory	Pricing and greening strategies for the channel members and the whole supply chain under centralised and 3 decentralised scenarios, manufacturer led, retailer led and Nash game.	The retail price in the centralised scenario is higher than in the decentralised ones. The retailer led decentralised scenario provides higher profit of the whole supply chain. Channel members gain more profit when the retailer only collects the used products.
Zhang & Hu (2019)	Products sold both online and offline	Game theory	Optimal recovery rate, price decision and system efficiency of a closed-loop supply chain under the competition of an online and a traditional retailer.	In the market structure dominated by the manufacturer, the manufacturer's profit is higher than that of the retailer, and the benefits of the total system are small. In the market structure dominated by retailers, the benefits of retailers and consumers and the total system are higher than that of the manufacturer being the leader.

Xu (2020)	Products sold both online and offline. Dual collection between retailer and manufacturer	Game theory	Pricing strategies and collection decisions in a closed loop supply chain with a dual channel forward channel and reverse logistics. Identified the relationship between consumer preference and high and low pollution products.	Optimal pricing decisions for the wholesale price, direct price and retail price in the manufacturer RL scenario are not associated with transfer price. Lower difference of production costs between new and remanufactured products means that the manufacturer would choose to produce via new raw materials as the transfer price increases.

Guo (2015) also applied the linear matrix inequality approach to design H∞ control strategy under the uncertain conditions as a way of minimising the upper bound of the Bullwhip effect. This research by Guo (2015) not only measured the Bullwhip effect and supply chain dynamics in dual channel CLSCs but it also looked for a way to minimise the phenomenon and both these aspects present a notable research gap.

Zhang and Zhao (2015) constructed a dynamic discrete switched dual-channel closed-loop supply chain (CLSC) model with a time delay in remanufacturing , uncertainties of cost parameters, gratuitous return rate, remanufacturing/disposal rates, preference rate of the customer to the Internet channel, and the customer's demand under the Internet based on cost switching. The authors analysed the robust operation in the CLSC system using the fuzzy robust control method to present a sufficient condition for the quadratic asymptotic stability and to stabilize the switching laws of the output- dependent form. This was done to inhibit the operation fluctuation caused by the processes in the CLSC system. This research was unique in that it analysed the stability of the dual channel CLSC and supply chain dynamics by considering the uncertainty of certain factors in a CLSC with an internet channel. Dai, Si, and Wang (2017) also used bifurcation diagram, entropy diagram, attractor, and time series diagram to analyse the influence of delay parameters, the adjustment speed of wholesale price, recovery rate of waste products, direct price, carbon quota subsidy, and carbon tax on the stability and complexity of a CLSC model. The authors that the mentioned variables mentioned above must be within a reasonable range otherwise the model will lose stability or enter chaos. In addition, the government could effectively adjust manufacturers' profit through carbon tax and carbon quota subsidy, and encourage manufacturers to reduce carbon emissions and increase the remanufacturing of waste products.

A similar research into the stability of the CLSC was by Li, Shi, Deng, and Huang (2019) who explored the stability and entropy of a Stackelberg and centralised game models in static and dynamic states using bifurcation, the basin of attraction, chaotic attractors. The authors also discussed the influence of service level and profit distribution rate on the system's profit. The results showed that higher price adjustment speed will lead to the system lose stability with a larger entropy value. In the Stackelberg game model, the stability of the system increased as the service value and the recovery rate increased. In the centralized model, the stability of the system decreased with the increase of the service value and increased with the increase in the recovery rate.

Research on supply chain dynamics and stability of the CLSC show only one article on the measurement of the Bullwhip effect. This presents a research gap for measuring the Bullwhip effect in the presence of e-channels. One author only has looked into this.

4.3.7 Greening strategies and carbon emissions

There are articles that looked into the greening aspects and minimisation of carbon emissions in dual channel CLSCs. In the review, only four articles looked into these issues.

A research by He, Xiong, and Lin (2016) focused on the impact of consumer free riding and government e-commerce tax on carbon emissions in a product's life cycle across a dual channel CLSC. The authors used mathematical models to make systematic comparisons between cases in which consumers do or do not free ride. Their results showed that although manufacturers gained economic benefits from consumer free riding behaviour, total carbon emissions across the supply chain increased. The government tax on e-commerce helped in reducing consumer free riding and total carbon emissions. Xing, Shi, Zhang, Cheng and Lin (2020) also focused on carbon emissions but from a different perspective and a different structure of CLSC. In their CLSC, there was no e-channel but two 3PLs with risk-aversion characteristics competing to recycle products. The authors also focused

on maximizing the economic and environmental benefits of low-carbon behaviour in enterprises. Their study made a comparison of the impact of carbon emission trading price, consumers' low-carbon awareness, carbon emission and competition of third-party recyclers in

three emission reduction models. The results showed that, carbon emission-trading price, consumers' low-carbon awareness and carbon emission were negatively correlated with the expected utility of the manufacturer and retailer. In addition, the third- party recyclers' competition degree was negatively correlated with the expected utility of manufacturer and 3P recyclers. The revenue sharing and cost-sharing contracts had little impact on the manufacturer's low-carbon production.

With the aim of maximizing social welfare by improving greening strategies, Zand, Yaghoubi, and Sadjadi (2019) analysed the effects of government anticipated greening activity on members' optimal decisions and profit. The authors used game theory to illustrate the goal-seeking behaviour of the government in the process of decision-making and to compare optimal decisions under different cases. Their work concluded that government direct limitation on the green level of the products positively contributes to the amount of the collected used products and that this intervention policy is beneficial for the retailer since it increases the retailer's profit. Another article that looked into carbon emissions and social welfare was by Zhang, Li, and Qi (2020). The authors analysed the effect of government reward-penalty policies on the decisions of a dual-channel CLSC. An analysis of government decision variables to maximize social welfare was done by building four decision-making models: 1. without reward penalty policies, 2. with carbon emission reward penalty policy, 3. with recycling amount reward penalty policy, and 4. with double reward penalty policy. By using a Stackelberg dynamic game between the government and supply chain members, The results showed that in the four models, there exist optimal prices and reward-penalty coefficients to maximize the supply chain members' profits and social welfare.

Greening strategies and carbon emissions present a gap in dual channel CLSCs as only four articles covered these aspects. The articles by Zand et al.(2019) and Zhang et al.(2020) also present a unique gap as it also looks into the dimension of social sustainability.

4.3.8 Others

There were articles that could not fit into the mentioned categories. These articles explored other issues. Because each of these articles looked at something very different, articles in this category can present research gaps into dual channel CLSCs. Only three articles could not match into these categories.

A comparison of CLSCs before and after introducing the dual channel was done by Batarfi, Jaber, and Aljazzar (2017) who investigated examine the effect of different return policies on the behaviour of supply chain systems before and after adopting the dual-channel. In both strategies, the paper used mathematical models to analyse the changes in the profit, the pricing and inventory decisions. Their findings demonstrated that in both strategies, the more generous the return policy, the higher the demand, the selling prices and the overall profit and that adopting a dual-channel strategy was more profitable to the supply chain.

Huang and Wang (2017) investigated cost disruptions of new and remanufactured products in a closed-loop supply chain where a manufacturer and a third-party collector recycle used products through online-recycling and offline-recycling channels, respectively. A game theoretic approach was used to acquire the equilibrium decisions of dual-recycling and single-recycling channels and to analyse how cost disruptions affect the manufacturer's production and collection strategies. The authors concluded that, cost disruption of new products produces a positive impact whilst the remanufacturing cost disruption has a negative impact on collection quantity of used products.

Similarly, negative cost disruptions of both new and remanufactured products could be profitable to the manufacturer. As for the manufacturer's channel choice, the dual-recycling channel dominates single-recycling channels when new product cost faces positive disruption, since the manufacturer acted as both a buyer and a competitor to the collector and could determine an appropriate acquisition price and transfer price to coordinate the online-offline recycling channel. In addition, if cost disruption of new products is negative, the manufacturer prefers the dual-recycling channel instead of single-recycling channels only if the remanufacturing cost faces large size of negative disruption. The issue of cost disruptions in dual recycling channels has not been looked into by any of the authors.

An exploratory research into the status of recycling of e-bicycle batteries in China by Wang et al. (2020) reviewed the status of recycling of e-bicycle batteries in China and tried to solve the dilemma of recycling end-of-life batteries. The system used had three subsystems: "Internet þ" to logistics recovery system, online network recycling system, and traceability management system. The authors considered the participation of consumers and government, reward-penalty mechanism, "Internet þ" development, and other strategies to improve recycling systems throughout life cycle of the products. The proposed recycling system had a potential to increase the waste battery-recycling rate by 2.59% under the reward-penalty mechanism, and reduce carbon dioxide emissions by 58%. This was a special article as it was empirical with a real case study and real results. Most of the studies in the review were not empirical.

4.3.9 Combination of categories

There are authors that combined the listed categories and looked into two or more issues. These articles have been summarised in Table 9. Table 9 shows that only 5 articles combined the different categories. All these articles combined pricing and supply chain coordination issues. A different article by Alizadeh-basban and Taleizadeh (2020) combined more than two categories by adding location issues to the combination of pricing and supply chain coordination.

5. DISCUSSIONS AND FUTURE RESEARCH DIRECTIONS

To begin, the topic on dual channel CLSCs is still in its developing stages as the first paper appeared in 2010 and to date, only 57 articles were found on the topic. This shows that there is still potential and gaps for the topic to develop.

5.1 Network structure

In terms of definition, in the forward chain with no returns, the dual channel has been defined by an organisation selling products both online and offline. This is different from the reverse supply chains and CLSCs as the dual channel CLSC can be defined by: 1. Products being sold both online and offline in the forward chain 2. Products being sold offline in the forward chain and collection or remanufacturing being performed online, 3. Having more than one supply chain player collecting or remanufacturing (dual recycling) in the reverse channel without an e-channel and 4. Having products sold both online and offline in the forward channel and having products collected and remanufactured both online and offline in the reverse channel. Using these definitions of the dual channel CLSC, almost 60% of the articles defined dual channel CLSC s using definition 1 and about 18% of the publications (7) papers had more than one dual channel. From these definitions, the following gaps have been identified:

Table 9. Summary of articles with combined categories

Author and Year	Categories combined	What they investigated	Methodology	Conclusions
Ran et al.(2016)	Pricing and supply chain coordination	Analysed supply chain profit under a dual recycling program. Developed a new model to coordinate manufacturers and retailers under a revenue sharing contract.	Game theory	Dual recycling channel will always dominate the single recycling channel regardless of the product price, quality, profit or operational efficiency of the supply chain.
Kong et al.(2017)	Pricing and supply chain competition	Analysed the optimal pricing and service decision under centralisation and decentralisation. Designed revenue sharing contract led by the manufacturer, exploring what scenario the contract would realise Pareto optimal. Factors of importance were the revenue sharing factor, wholesale price, recycling price and transfer payment coefficient.	Benchmarking	Optimal price and service levels correlate positively in the centralised scenario. Relationship between price and service level also relies on the relative value of increased service cost and remanufacturing saved cost.
Taleizadeh et al.(2018)	Pricing and supply chain coordination	Investigated the pricing strategies and quality level and effort decisions of the manufacturer, retailer and 3P operating in two types of closed loop supply chains: 1) single channel forward chain with dual recycling channel (SD) and 2) dual channel forward chain with dual recycling channel (DD). Introduced a novel coordination model to reduce channel conflicts.	Game theory	The DD is the best for the manufacturer and the optimal channel structure for the retailer depends on the retailer market share. By applying a novel coordination mechanism, all three members of the closed loop supply chain can benefit from the introduction of an online selling channel. The quality of products in the DD model is always greater than it is for products in the SD model. The recycling channel member with a predominant market share exerts greater collection efforts and offers lower buyback prices than others in the collection channel.
Zhang, Liu, and Niu (2020)	Pricing and supply chain coordination	Discuss how to decide on the quality level in a vertical dual channel closed loop supply chain when the manufacturer has the flexibility to adjust product quality. Showed influence of quality decisions on price competition across channels and effectiveness of coordination. They looked at two types of returns, repairs and waste.	Mathematical model	There is no simple linear relationship between product quality and optimal retail/online price, rather they are concave functions with respect to product quality. Optimal retail and online price have the same growth rate and both decrease with an increase of revenue sharing ratio.
Alizadeh-basban and Taleizadeh (2020)	Pricing, Network design and supply chain coordination	Made decisions on location, products transfer and pricing. Considered the strategic decisions about the type of production technology in the plant to create a green product. Different transport modes each with different lead times and GHG emmissions are considered. Pricing of different channels.	Mathematical model	Devising SM game has more profit than other games, while the optimal remanufacturing rate is low. It means that the manufacturer remanufactures most of the returns, while the distributor paying the refund price collects them

- There is still need to expand on the various versions of dual channel CLSCs, especially those with double dual channels where products are being sold both online and offline in the forward chain, at the same time product are being collected and remanufactured both online and offline similar to the works of Mondal et al.(2019). In terms of defining dual channels using dual collection and recycling modes without an e-channel, there is need to explore the use of informal sectors in the collection of used products as this is most popular in most countries. Only 1 article explored the use of the informal sector in the collection of used products.
- There were variants in the definition of dual channel CLSCs using selling articles. The definition by Gan et al.(2017) who defined a CLSC where new products were sold offline and remanufactured products were sold online. According to Wang et al.(2016), manufacturers sell new and remanufactured products in different selling channel structures to protect the manufacturer from the retailer's opportunism behaviour of selling remanufactured products as new ones. This was the case between DELL and its reseller TigerDirect. More should be looked into concerning these dual channel CLSCs. Where selling channels between new and remanufactured products have to be differentiated.
- Furthermore, in the definition of the dual channel CLSCs, there have been articles focusing on dual recycling channels where products were recycled online. This is something new that still needs in depth exploration on how online recycling is coordinated. Online recycling services help to relax the constraint of traditional recycling due to physical distance and space as mentioned by Feng et al.(2017). The authors give examples of how recycling dealers such as Changhong Green Group Company limited and Shanghai Xin Jingqiaio Environmental Protection Company limited who collected WEEEs through the traditional channel shifted to the online channel. There is need to have more in-depth exploration into CLSCs with online recycling.
- In terms of network structure, all publications assumed a serial supply chain structure in the forward chain. A serial network assumption simplifies supply chains especially for mathematical modelling but in reality, supply chains are interconnected and more complex. It would be interesting to investigate the different supply network structures mentioned by Beamon and Chen (2001) such as divergent, convergent and conjoined supply chain networks combined with the use of online channels.
- All publications also assumed single products being manufactured and remanufactured. It would also be interesting to have investigations on dual channel CLSC s in multi-product settings where inventories of different products interact.

Using the classifications by Souza (2013) of strategic, tactical and operational issues, most of the articles seem to focus on strategic issues as they look more into supply chain coordination, contracts whand incentives, response to take-back legislation and collection strategies. From this classification, the following gaps have been identified:

- Although the majority of the publications focused on strategic issues, they were mostly focused on three main issues of supply chain coordination, contracts and incentives, response to takeback legislation and collection strategies. There was little or no focus on issues such as location and allocation of facilities, impact of product recovery on new product design and choices between leasing and selling. There is a need to explore these issues.
- None of the articles focused on operational issues such as disassembly planning, sequence and depth of disassembly, scheduling, priority rules, lot sizing, and routing in the remanufacturing shop. Operational issues present a large gap in dual channel CLSCs that needs looking into.

5.2 Pricing Strategies and Reverse Channel decisions

In analysing pricing and reverse channel decisions, there are some factors that have been considered in the articles. Table 10 summarises factors that were considered in making pricing and reverse channel decisions in dual channel CLSCs and the number of articles focusing on these factors.

Table 10. Summary of factors studied in Pricing and reverse channel decisions

Factor	Number of publications
Effect of customer preference of selling channel	6
Effect of customer acceptance of remanufactured product	4
Competition between channels	4
Remanufactured unit cost	3
Direct channel cost	1
Loss neutral and loss averse consumers	1
Horizontal fairness concern behaviour	1
Reward driven policy for collection of products	1

Table 10 shows that the majority of the publications focused on the customer acceptance of the selling channel, customer acceptance of the remanufactured product and competition between the collection and selling channels. A completely different research by Liao and Li (2018) focused on loss averse and loss neutral customers. This factor has not been looked into by other publications focusing on pricing and reverse channel decisions. New factors were also introduced by Saha et al.(2016) and Arshad et al.(2018) who looked into reward driven policy for collection of products and horizontal fairness concern respectively. These two factors also present gaps for further research. In addition to these factors, the following gaps were identified in literature focusing on pricing and reverse channel decisions:

- Whilst most of the publications on pricing and reverse channel decisions focused on different factors, none of the publications looked into inventory decisions when considering reverse channel decisions. An extension would be to add inventory decisions when considering pricing decisions.
- Almost all of the publications assumed that new and remanufactured products are similar and they are sold in the same market. This is not always the case. In reality, companies like Apple sell new and remanufactured products to different markets. Having a secondary market presents a gap for dual channel CLSCs.
- It is also necessary for studies to consider quality issues in the collection of products. For example, studies like those of Saha et al. (2016) did not consider different quality levels of collected products in determining the reward driven policy. In addition, the quality level of returns should be considered in determining the remanufacturing unit cost. The assumption that returns are uniform is not always the case in reality.
- To simplify the mathematical modelling, almost all the studies assumed symmetrical information, i.e. all players in the supply chain received the same information. Again, this is not always the case in real supply chains. A gap in research would be to consider asymmetrical information between supply chain players especially those with competition between supply chain players.
- In studying pricing strategies, studies assumed a linear response by consumers to changes in prices. Another complex gap would be to consider non-linear sales response functions in modelling dual channel CLSCs.

- The majority of the publications also used deterministic demand patterns in order to simplify the model. There is a need for research to explore stochastic demand patterns in dual channel CLSCs.
- Finally, the majority of the studies focused on game theory as a method of modelling the dual channel CLSCs. There is a need to explore other quantitative models and mathematical tools to solve the channel design problems. Such tools as complexity and chaos analysis and H- infinity control can be explored.

5.3 Supply chain coordination

Under supply chain coordination issues, articles mostly focused on the use of revenue and expense sharing contracts to coordinate dual channel CLSCs. The research gaps for supply chain coordination were similar to those of pricing with a few additions listed:

- Most studies assume one manufacturer of a specific product. None of the studies considered competing manufacturers for that specific product. This is an interesting gap worth looking into.
- Another useful gap is the consideration of different grades of returns. Most studies assume that returns are al remanufacturable. An example of a study that looked into the grading of product returns was by Xie et al.(2018) who tried to mitigate the problem of poor-quality recycling due to information asymmetry in the recycling channel by grading collection. More studies should try to look into the grading of returns as this actually happens during the sorting stage of reverse logistics.
- To simplify supply chain modelling, there has been an assumption of single period collection. Future research should consider multi-period collection decisions in modelling dual channel CLSCs.

5.4 Supply Chain network design

Additional gaps identified under the supply chain network design category are listed:

- Most studies on supply chain network design mostly focused on the forward chain network design. Most studies did not look at the reverse channel structures. Future research should focus on combine both forward and reverse channel structures for dual channel CLSCs.
- Most studies on supply chain network design are based on mathematical modelling without real world case studies. There is a need for future research to be more empirical with more case studies. For the empirical studies, most publications focused on WEEEs. There is a need for future research to focus on reverse logistics of other products such as medical appliances, fashion apparel and food among others.
- A different research by Wang et al.(2016) focused on comparing marketing channels for both new and remanufactured products by comparing 1. Selling both products via an independent retailer, 2. Selling new products via an independent retailer and remanufactured products online and 3. Selling new products online and remanufactured products via an independent retailer. This research was one of its kind and this is a topic that should be explored more. However, the research only considered the online inconvenience cost only. The authors did not consider real world scenarios where a retailer can offer customers presales services in order to compete with the online channel. It is necessary for future research to consider aspects of competition between channels, no matter what factor is being investigated.
- There is a need for in depth location problems, for example recent research by Rahmani et al.(2020) who investigated the allocation, product transfer, production technology in different plants and transportation modes in the dual channel CLSC. No other research focused on these issues and they need more exploration.

5.5 Others

Additional gaps for the other categories have also been identified:

- Future research should focus on the competition between channels in a dual channel CLSC. This includes competition in selling, collection and remanufacturing. There is not much research on competition.
- Research on competition should consider looking into the risk attitude of different supply chain players as the publications on competition assumed that all players are risk neutral without considering scenarios where supply chain players can also be risk seeking or risk averse.
- There is need for more investigation into supply chain dynamics and stability of dual channel CLSCs. Future research should consider looking into extending Bullwhip issues to dual channel CLSCs as mentioned by Wang and Disney (2015) who suggested extending the Bullwhip effect to sustainability issues such as the circular economy and CLSCs. Research should also focus on how the Bullwhip effect can be mitigated in dual channel CLSCs.
- Very few studies combined greening strategies, carbon emissions and social welfare issues with the dual channel CLSC. This also presents a useful gap for the dual channel CLSC as it looks at both social and environmental sustainability.
- In terms of combining categories, most studies combined pricing strategies with supply chain coordination. However, it would be interesting to have studies focusing on all three dimensions of sustainability, i.e. economic, social and environmental sustainability by combining pricing strategies with supply chain coordination, greening issues and social welfare issues for the dual channel CLSCs. These issues can also be combined with channel competition as this seems to be inevitable in dual channel CLSCs.

6. CONCLUSIONS

This paper presented a content analysis literature review of recent and state-of-the-art papers on dual channel RL/CLSCs. In total, 57 published papers up to June 2020 were selected, reviewed, categorized, and analysed to find the future directions and opportunities of research on the dual channel RL/CLSCs. Although there was an erratic trend from 2010 up to 2014, the general trend is an increase in publications on dual channel RL/CLSCs, which shows how the field is developing. Although the literature on the dual channel RL/CLSC is growing, it is limited and still needs some attention.

It was discovered that most articles focus on the pricing decisions of the dual channel CLSC, whilst looking at consumer acceptance of both the selling channel and the remanufactured product. Not much literature focused on the competition of channels, supply chain dynamics and stability. These presented notable gaps. It was also discovered that the definition of dual channels in CLSCs is not limited only to selling channels as in forward supply chains but it can be extended to other activities such as collection and recycling channels.

Relaxing some assumptions when modelling dual channel CLSCs is necessary for future researchers for example, assumptions on remanufactured products being similar to new products and both being sold to the same market, the assumption of uniform demand patterns and uniform reaction of the market to remanufactured products. Almost all publications assumed symmetric information, future research should consider looking into asymmetrical information. The assumption that all collected products can be remanufactured does not always hold in real world case studies, so future research should also consider looking into quality issues of returned products.

There is a limitation to this review. The review was limited to published articles and articles "in-press- corrected proof". This means that books, book sections and grey literature were

excluded and this limited the number of articles in this review.

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