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Fostering closed-loop supply chain orientation by leveraging strategic green capabilities for circular economy performance: empirical evidence from Malaysian electrical and electronics manufacturing firms

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Abstract
In recent years, the concept of a circular economy (CE) has gained importance and attracted significant attention among scholars and practitioners. Research that examines the firm's supply chain capabilities and orientation for performance is well established nonetheless still lacking in supporting the transition from a linear economy to a circular economy. The firms can foster a closed-loop supply chain orientation (CLSCO) through strategic green capabilities as an alternative obtainable to SC firms to achieve CE performance. Thus, this study is interested to examine the antecedents and outcomes of CLSCO by applying the Resource-Based View and Natural Resource-Based View theories. In total, 150 Malaysian manufacturers responded to the survey and were analysed using the SEM Lisrel method. Among the hypotheses tested, only one had no direct effect on CLSCO, and that was the recovery capacities. The remaining hypothesis indicates that CLSCO is positively affected by integration and production capabilities. In contrast, the results of CLSCO indicate that the extent of a company's CLSCO does affect its success in the circular economy. The study concludes, based on the RBV and NRBV principles, that the success of firms in optimising their resources would enable them to use the CLSCO and attain CE performance. Thus, there are numerous ways in which this study can provide practitioners with valuable research insights.

Keywords Capability · Green · Closed-loop · Circular economy · Performance

1 Introduction

The concept of a circular economy (CE) has garnered substantial attention due to the mounting pressure on policymakers and governments to introduce policies to ensure sustainability, bio-based products, and sustainable processing (Agrawal & Singh, 2020). The implementation of a CE represents a sustainable development initiative that aims to reduce

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Extended author information available on the last page of the article linear material and energy flows by employing material cycles as well as renewable and cascade-type energy flows (Korhonen et al., 2018). Furthermore, the CE brings significant benefits such as efficient use of resources, material supply security, and environmental and economic sustainability (Antonini et al., 2020). The successful transition to a CE is a challenging task that implies systematic and radical changes in both production and consumption systems (Ford & Fisher, 2019). According to them, such a transformation may require products to be designed with recycling and reuse in mind and encourages designers to work with recycled and reclaimed materials.

As Malaysia is one of the fastest emerging economies and most diversified developing countries in Southeast Asia, therefore, this circumstance has seized the country into the challenges of managing its waste in the sustainable ways. The country is succumbed with the higher rate of waste with only 19,000 tons per day in 2005 to 100 percent increase with 38,000 tons per day in 2018, after over a period of thirteen years. In 2019, the scheduled wastes generated as high as 4.0 million tonnes (DOS, 2020). The rate of recycling is slow in progress as compared with the development of industries from 5% in the year 2005 to only 17.5% in the year 2018 (MIDA, 2021). The plastic manufacturing industry is an excellent example of the waste management dilemma the country is facing today. This industry has been one of the biggest progressive industries since 2000 (GESB, 2011) and achieved substantial plastic production industries globally (MESTECC, 2018). Nevertheless, the waste management systems are poor and imbalance with the volume of waste plastic generated. The country's primary methods of handling plastic waste are still through landfill disposals and incineration (Ng & Iacovidou, 2020). In addition, the recovery support from third-party, mainly plastic and metal waste, is inadequate (Chen et al., 2021), and unsustainable recovery practices are limited to disassembling or dismantling by the scrap dealers for used items with the resale value only (Shaharudin et al., 2015). Thus, despite the continuous government's incentive to enhance the ecosystem of green technology in Malaysia (MIDA, 2021), the solution to industrial waste seems far-reaching to reality.

At this point in time, the implementation and advancement of industrial waste in Malaysia has not yet caught up to the level of achievement shown in industrialised countries although Malaysia is experiencing rapid urbanisation and population growth. Because there is a limited amount of space for landfills and rising expenses associated with disposal, there is an increased amount of pressure and an urgent need to address the issue of waste management and lessen the impact on both the environment and the overall well-being of the people. Thus, Malaysia has taken a methodical, step-by-step strategy to privatising and centralising its solid waste management in order to improve its existing waste management system. Reusing, reducing, recycling, treating, and finally disposing of garbage are the five fundamental levels that make up the typical waste management hierarchy. At the moment, the phase that sees the greatest number of applications in Malaysia is disposal. The government of Malaysia is continuing its efforts to encourage a more efficient form of waste management by promoting the reuse and reduction approach and, ultimately, lowering the amount of waste that is dumped in landfills (MIDA Insights, 2022). The development of a sustainable method for the management of solid waste requires meticulous planning in addition to the effective distribution and administration of available resources.

Accordingly, closed-loop supply chain (CLSC) is one of the superior product circular systems in supply chain management that has driven environmental sustainability efforts (Mishra et al., 2018). CLSC deals with the tremendous change of the traditional business model focusing on resource efficiencies, waste reduction and capitalizes on the value of recovery (Awasthi et al., 2019). On the other hand, CLSC is a strategic tactic where returned goods are transformed into saleable goods via the reverse supply chain (Olugu

& Wong, 2012; Shaharudin et al., 2015) and forward supply chain (Talbot et al., 2007). It relates to the original manufacturer's design, control, and system in managing the dynamic attributes of product returns for a maximum value of recovery (Guide & Van Wassenhove, 2001). CLSC is a perfect concept implementation by transforming the existing supply chain management practices from the design drawing board until the production process (Gonzalez et al., 2019). The importance of CLSC is imminent when several consumers and NGOs in developing countries in Asia are inspiring firms to adopt CLSC practices to reduce, recycling, and reuse waste (Hsu et al., 2013).

Internally, to improve the implementation of CLSC, commitment is required, such as management support, awareness training, incentive systems (Zhu et al., 2008, Zhu, Sarkis & Geng, 2005; Zhu, Sarkis & Lai, 2012; Zhu et al., 2008 & Walker, Sisto & McBain, 2008). In fact, commitment is necessary for implementing any new initiatives, particularly for the success of reduction, reuse, and recycling programs (Hsu et al, 2013). A long-term business commitment represents the firm's strategic orientation (Shaharudin et al., 2015). They added, to successfully implement sustainable management of supply chains, the firm requires a long-term orientation. A strategic orientation is a key direction that leads firms to take appropriate measures for the persistent improvement of their business performance (Shaharudin et al., 2015). With the aim in creating a sustainable supply chain, a closed-loop supply chain orientation (CLSCO) is argued to contribute to a sustainable production and waste management in in the manufacturing operation (Sahamie et al., 2013); thus, CLSCO can be used to facilitate the successful implementation of circular economy.

Nevertheless, Sarkis (2001) highlighted that a better internal environmental management system or capabilities help firms to mitigate the environmental effects. Prior studies are highlighted many capabilities, such as expert knowledge, inter-functional communication, and environmental management system as the importance element in achieving an efficient CLSCO (Shaharudin et al., 2015). Green capability is an imperative in predicting a firm green behaviour, strategy, and practices (e.g. Liu et al., (2020); Mao et al., (2019); Hassini et al., (2012)). Against this backdrop, this study suggesting an effective CLSCO should be also encompassed of green processes capabilities. Despite the vital connection suggested between green capability and CLSCO in the literature (Shaharudin et al., 2015; Bhatia et al., 2020), a very limited facet of green capabilities has been studied that hinders the understanding and application into the practice. Hassini et al., (2012) highlighted that green process capability plays an important role for the firms in gaining competitiveness. However, majority of the studies has scrutinized the role of green capabilities on the sustainable strategy adoption, and there is a dearth of empirical studies regarding green capabilities effect on the CLSCO.

Subsequently, the study offers three main contributions to the literature. The first is to propose a new framework for a process-based strategic orientation, i.e. a set of strategic green capabilities for closed-loop supply chain orientation (CLSCO). The second contribution is the development of a reliable and valid measure of CLSCO to link the conceptual framework with empirical indicators. To the best of our knowledge, there is no previous research that has developed a valid measure of a proposed strategic orientation for CLSCO. The operational measure proposed herein is expected to provide specific guidance for its implementation. The third contribution is to investigate the relationships between CLSCO and circular economy performance using survey data collected from manufacturers in Malaysia. This will provide empirical evidence as to whether green capabilities can influence the degree of CLSCO and thus affect a firm's circular economy performance. Accordingly, the findings provide several contributes to the knowledge. (1) This study empirically evidences the green capabilities that determine the CLSCO and effect of the CLSCO to the

CE performance in a single framework. (2) This study is attempting to assess CLSCO as a construct measured by several indicators; (3) there is no general agreement in the literature pertaining to specific performance measurement to measure the performance of CE from the perspective of CLSCO.

The remainder of the paper is structured as follows. In the next section, we review the wider literature on CE, strategic orientation of CLSC, and strategy green capabilities before presenting the conceptual framework of CE in the context of CLSCO in Sect. 3. In Sect. 4, we present the theoretical framework and develop the hypotheses. We then outline the research methods in Sect. 5, before presenting our empirical test results. We discuss the findings and highlight both theoretical and managerial implications, before outlining limitations and further research avenues, and conclusions.

2 Literature review

2.1 Circular economy

The circular economy (CE) thinking is embedding into business strategy for the sustainability, and it has begun to be recognized as of great potential to drive organizations towards achieving sustainability performance (Hobson, 2016; Stewart & Niero, 2018). According to Alhawari et al. (2021), CE is an industrial system that could be seen as a system that integrates economy with ecological design considerations and proposes a completely different way of resource utilization. However, there have been many different conceptualizations developed to attempt to describe and comprehend CE, but none of them are without controversy (Betancourt Morales & Zartha-Sossa, 2020). The realization of closed-loop material flow in the full economic system is what is meant when people talk about CE (Ning, et al., 2008).

CE first gained traction and currently championed by the western world particularly in the European region which most initiatives, achievements, studies, and collaboration found among the country members. Marino and Pariso (2020) elaborated thirty-five reports issued from 2015 to 2019 on the information of framework regarding circular economy framework, implementation actions, possibilities, and opportunities for improvement. The assessment shown that UK, Germany, France, and Italy have the highest average circular investments over the period of one decade from 2006 to 2016 out of 28 countries in European Union. The list for top four countries remained the same in 2018 reported by 2018 Environmental Performance Index EPI, (2018). In the similar report, Germany is ranked the top with 1260 patents related to circular economy since 2000 followed by France (542), Poland (298), Italy (294), and UK (292). Giannakitsidou, Giannikos, and Chondrou (2020) found that Belgium has the best environmental and circular economy performance among countries in Europe for studies done in 2014 and 2017.

Generally, CE is gaining popularity in industrial player, policymaker, and academician. Integrating CE into SCM can provide advantages from a sustainability viewpoint (Genovese et al., 2017; Nasir et al., 2017). Consequently, there is enthusiasm and a growing interest for CE among the researchers and among them are Ying & Li-jun, 2012; Aminoff & Kettunen, 2016; Darom & Hishamuddin, 2016; Batista et al., 2018; Batista et al., 2019; Bressanelli et al., 2018; De Angelis et al., 2018; Govindan and Hasanagic, 2018; Howard et al., 2018; Kazancoglu et al., 2021; Liu et al., 2018. To have a clearer on the trend of research in circular economy, this study has compiled the related literature in Fig.1 shows

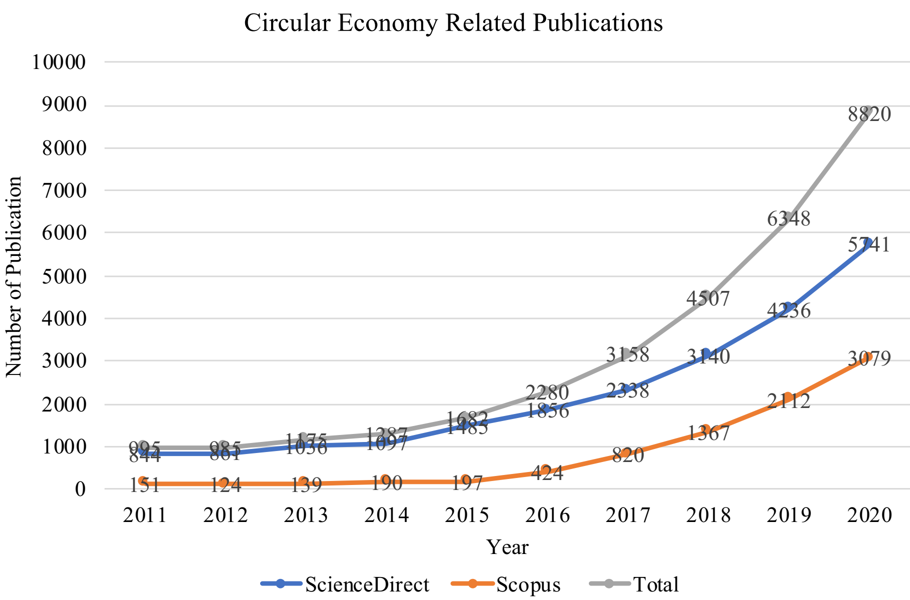

Fig. 1 Online Database of ScienceDirect and Scopus as of May 2021. Source: The study compilation

the exponential curve of publications from 2016 to 2020 in both ScienceDirect and Scopus database. Despite pandemic COVID-19 with most of the country's lockdown in 2020, there is increasing number of publications continuing to thrive to the highest number of publications done throughout the decade. Most of the research and studies done focused in developed countries especially European region where circular economy first introduced and implemented. Grafström & Aasma (2021) discussed on how to break circular economy barriers, while Kirchherr et al., (2018) focused on the evidence barriers to circular economy and Boyer et al., (2021) investigated consumer spending behaviour towards circular economy.

Currently the implementation and progress of circular economy in Malaysia has yet to match the developed countries' achievement. To align with international sustainable development commitment, Malaysia joined 192 other countries in 2030 Agenda at United Nations General Assembly in New York on 25 September 2015 which inclusive of 17 SDGs. Mahadi and Joshi (2020) have reported via MalayMail that recent proposal of Budget 2021 by Finance Minister Datuk Seri Tengku Zafrul Abdul Aziz on 4 November 2020 has reflected the government's commitment to align itself to sustainable development goals (SDGs). Noted that the finance minister is appointed in the new ministry cabinet as the change in power happened in early 2020; hence, Datuk Seri Tengku Zafrul has less than one year in position upon the Budget 2021 proposal. This shows that despite the change of country leader with different philosophy but the commitment from Malaysia towards SDG implementation remained intact and consistent.

The study from Yong et al. (2021) found that 45% of total municipal solid waste (MSW) is organic waste which has potential biogas and bio-fertilizer production via anaerobic digestion. The expected production of electrical energy is 3941 MWh/day, and bio-fertilizer is 2500 ton/day which translate into an estimated total of RM1.04 billion revenue generation. This sum excludes the potential saving from landfill disposal and leachate treatment in landfill management that could translate into business revenue and economic activities. Deduction from the study shows the tremendous potential for circular economy implementation in Malaysia landscape. The study by Yong et al. (2021), however, is one of the few studies that could be found in Malaysia context, indicating that lack of research and development for circular economy-related activities.

2.2 Closed-Loop supply chain (CLSC)

Liu et al., (2012) state that CLSC began to appear in the early twenty-first century. The initial stream of CLSC study was widely known as 'reverse supply chains' (for examples, Dowlatshahi, 2000; Kocabasoglu et al., 2007; Rogers & Tibben-Lembke, 2001). Prior studies began to explore the CLSC area through different methodologies including descriptive statistics, case studies, and network modelling, for instance, Fleischmann et al., (2003) who studied inventory control in CLSC, and Guide Jr. et al. (2003) who examined the perspectives and potential for future study in CLSC. CLSC studies have called for the discussion of the topic in other recent scope of environmental studies such as sustainable supply chain management, industrial ecology, circular economy, and circular supply chain management. Although the application may be different, these concepts are having similar prospect of achieving the economic, social, and environmental sustainability. Nevertheless, the CLSC term is extremely wide, covering many different value activities and challenging in the adoption (Mishra et al., 2018).

Initially, CLSC was referred to as "reverse supply chains", an area in which the practices were popularly discussed among the experts in the area. In the twentieth century, prior studies conducted studies on the flow of CLSC by using different terms altogether. For instance, Thierry et al. (1995) referred to CLSC as "the integrated supply chain" by describing the combination of forward and reverse flow chains for the product returns and recovery management. The integrated supply chain consists of activities involving three main processes—waste management, product recovery, direct re-use. The integrated supply chain occurs when the returned products are re-located to eight different points of the three main processes for further recovery, reuse, or disposals. For direct re-use, this usually happens for returns due to the sales predicament (unsold products) without any product quality issue. However, only the recent studies have provided a clear definition of CLSC. Indeed, it seems that the definition of CLSC has reached to a common consensus from prior studies. In this context, CLSC has been widely defined as a combination of the existing traditional forward supply chains with the reverse supply chains in which the recoverable products after going through the recovery process in the reverse chains re-enters the forward chains (Kannan et al., 2010; Talbot et al., 2007) for reuse or remarketing of the products. Thus, CLSC involves the conventional activities in the forward supply chain and the additional activities in the reverse flow chains with the potential to alleviate the standards of operations and eventually increase the green performance of manufacturing organizations (Pappis et al., 2004).

2.2.1 Closed-loop supply chain orientation (CLSCO)

Practically, firms adopt CLSC because of the additional revenues from returned goods which would otherwise need to be disposed (Guide Jr et al., 2003). In addition, the effective reverse logistic system not only reduces logistics cost, but also enhances relationship with customers (Sisodia et al., 2007). In a study by Wei et al. (2018), they discovered that the CLSC collaboration between manufacturers and retailers can eventually bring the benefits to the consumers. For instance, the world's largest commercial carpet provider, Interface Inc., changed its business model from selling to leasing its carpets. Interface Inc. retains ownership of the carpets, and off-lease goods are recovered for residual value via the CLSC (Agrawal & Toktay, 2010). Similarly, Kodak created an incentive system to encourage customers to return used cameras so that parts are salvaged and reused in new cameras (Savaskan et al., 2004). Filabot, Replay3D and ReDetec are the examples of recycling firms that developed the recycling machines that converted the plastic waste into raw materials such as 3D filaments as the raw materials for the three-dimensional printing (3DP) process (Sun et al., 2020). These practices supported the development of environmentally responsible CLSC concepts because the companies are not only involved with the manufacturing and selling products, but they also implementing the CLSC strategies (Wu et al., 2020).

According to the resource-based view (RBV), a firm gains a competitive advantage by exploiting its internal resources which include the assets, information, skills, knowledge, etc., of a firm that enable the firm to develop and implement strategies to improve its efficiency and effectiveness (Barney, 1991). It is acknowledged that the strategic orientation guides the focused commitment of resources to achieve desired outcomes Grawe et al. (2009). It has been defined as the strategic direction that leads firms to take appropriate measures for the persistent improvement of their business performance. Strategic orientation provides a unifying organization-wide focus and guides the direction of the commitment (Kohli & Jaworski, 1990). Accordingly, Defee et al. (2009) argued that the firms are guided to focus resources towards the development of capabilities to achieve competitive advantage. The pressures from customers, competitors, and environmental groups, as well as the effects of regulations, globalization, and concerns about their corporate reputation have contributed to the implementation of closed-loop supply chain management. Following this, Defee et al. (2009) added that a firm's closed-loop supply chain orientation (CLSCO) will direct resources to support closed-loop supply chain management to be a source of competitive advantage. However, SCM research is still at a nascent stage when it comes to conceptualizing how to advance strategic orientation to help realize the vision and potential of a CLSCO.

2.3 Circular economy and closed-loop supply chain orientation

The integration of CE into SCM has increased global economic competition and growing importance of environmental issues which has force manufacturers to consider implementation of closed-loop supply chain (CLSC) ensuring recovery of end-of-life products (EOL) for recycling or reuse (Du et al., 2010; Genovese et al., 2017; Nasir et al., 2017). A CLSC improves environmental performance by bringing back goods and packaging to the manufactures to recover value (Guide & Van Wassenhove, 2006), where CE will generate zero waste because it is designed to systematically restore and regenerate resources in the industrial and natural ecosystem in which it is embedded (Weetman, 2017). Figure 2 contrasts a circular economy (Fig. 2c) with a traditional (linear) supply chain (Fig. 2a) and a closed-loop supply chain (Fig. 2b).

The management towards closed loop in a supply chain needs a strategic orientation which it is far more systemic process in nature rather than a linear process and, thus, need firm's commitment, employee support, time, and resources (Ali et al., 2021). Moreover, CLSC has strong internal and external linkages, possessing multidimensional,

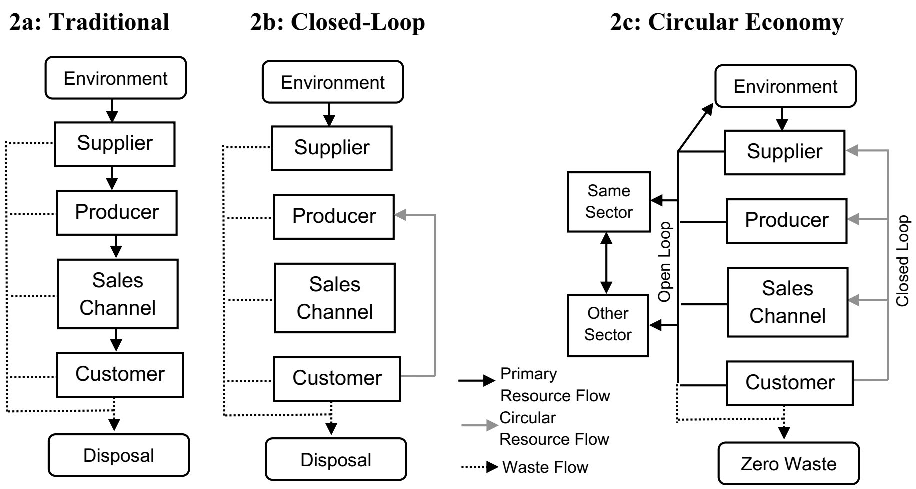

Fig. 2 Traditional, Closed-Loop Supply Chain and Circular Economy. Source: Farooque et al. (2019)

dynamic characteristics, and complexity (Geissdoerfer et al., 2017). The characteristics of CLSC require special attention in terms of resource commitment within a firm (Holgado & Aminoff, 2019). Literature suggests that top and middle manager support, promoting awareness amongst employees, introducing incentive systems, and stakeholder (Lacy & Rutqvist, 2015). It is therefore the directions that enable the firm to outperform the competition in CLSC must be managed with the focused commitment of resources (Day, 1994). Day (1994) further highlighted the critical importance of top management commitment is to build a strategic orientation as it is focusing on the management of processes and activities associated with returns, reverse logistics, gatekeeping, and avoidance within and across supply chain firms (Rogers et al., 2002), which are the embodiment of a firm's strategic orientation (Blomsma et al., 2019).

Meanwhile, the extant literature on CE and CLSC remains fragmented where some key principles of CE are reflected at a strategic level and others around CLSC functions such as design, procurement, production. Some recent reviews on integrating CE into SCM have a rather narrow scope (Batista et al., 2018; Govindan and Hasanagic, 2018). In the SCM literature on sustainability, a number of concepts, such as sustainable supply chains, green supply chains, environmental supply chains, and closed-loop supply chains, have been introduced and used interchangeably (Gurtu et al., 2015) to express the integration of sustainability concepts in SCM (Ahi & Searcy, 2015). While these concepts represent different degrees of integrating sustainable thinking into supply chains, none of them have systematically integrated circular thinking into strategic orientation of CLSC. For example, to implement the CE in the firm, the top management must make a clear commitment which should be demonstrated through deeds and time spent to reflect the real priorities, e.g. reshaping the firms' culture by taking actions such as proposing a challenging vision of the CE culture or setting a major performance improvement (Mishra et al., 2018). Nevertheless, there is very little research that linked strategic orientation of CLSC to the implementation of CE.

2.4 Strategic green capabilities

Capability defines as a collection of complex individual skills, assets, and knowledge applied in organizational practices that enable firms to organize the activities and resource utilization (Olavarrieta & Ellinger, 1997) to achieve the firm's goals and objectives. It refers to the regular operation activities on how firms match the environmental functions against the competitors in the market (Ray et al., 2004). Capabilities are normally built and inculcated internally with tacit knowledge that is difficult to comprehend (Dierickx & Cool, 1989). The inimitable capabilities are normally in existence because of the continuous organizational learning (Schroeder et al., 2002). As a consequent, the competitors may find it difficult to copy easily and remain as a secretive tool for firms to compete in the market (Yee et al., 2021). One of the types of capabilities that received the attention from the business firms today is about the capabilities to adopt the environmental functions and practices in the organization. This is because environmental capabilities affected the firms's environmental performance (Bae, 2017). By having appropriate green capabilities, firm is in the greatest position to improve their resources and achieve competitiveness in the market (Salem, 2019). However, most of the past study on green capabilities failed to incorporate from the perspective of manager's experience and interpretation (Kabongo & Boiral, 2017). Hence, there is not much is known about the practical of the real green capabilities for the environmental management in the organisations.

Environmental capabilities and green capabilities are the similar terms that have utilized interchangeably in a study (Lee & Klassen, 2008). Green capabilities also have been associated with the firm's dynamic capability to exploit the resources and knowledge to meet the swift changes of market towards the environmental products offerings (Chen & Chang, 2013). Prior studies have described on the notion of green dynamic capabilities. For instance, Sarkis et al. (2011), dynamic capabilities are a kind of organization-related learning by nurturing knowledge resources internally, through in-house systems on the green adoption. Supply chain system on environmental practices helps the internal learning organization by sharing resources throughout the chains through inter-organizational learning. The adoption of green practices such as CLSC is contingent on the green capabilities that the firms nurture internally (Nkrumah et al., 2020). Without such contribution, the lack of capabilities and resources occurred, and this impedes the adoption of reverse logistics practices (González-Torre et al., 2010). Hence, green dynamic capabilities are considered vital in contributing to the implementation of reverse logistics and CLSC.

Despite numerous reports on CLSCs and the circular economy, very limited studies discuss the linkages between green capabilities, CLSCO, and CE performance. However, they were mostly mathematical modelling and not easily generalizable to a specific sector. The statistics in Table 1 illustrate that many studies on green capabilities cover the empirical type (89%) and specific modelling type (85%). In contrast, few studies have utilized survey methodology and case studies in reverse logistics and CLSC domains. Therefore, the survey methodology and case study approach are scarce and need more research to contribute to the existing body of knowledge. Significantly, the findings warranted employing the survey methodology in this study.

A review of the literature of green capabilities in the firm's environmental actions had been utilized in the previous study. A summary of green capabilities in Table 1 provides the summary of 73 studies on the green capabilities. Based on these studies, thirteen categories of green capabilities are identified: environmental capabilities, purchasing capabilities, design capabilities, manufacturing capabilities, recovery capabilities, integration capabilities, organizational capability, resource-based capabilities, information-related capabilities, strategic capabilities, financial capabilities, capability to market, and innovative capabilities. From the total number of capabilities, there are three that highly types of green capabilities discussed in the previous study. These top three capabilities are integration capabilities with the highest of 22.9% (25 times), followed by recovery capabilities with 16.5% (18 times), and lastly, manufacturing capabilities with 12.0% (13 times). On this basis, all three green capabilities (integration capabilities, recovery capabilities, and manufacturing capabilities) frequently mentioned in the past literature have been selected as the independent variables (input).

2.5 Underlying theories

Many studies in the supply chain in the past have combined the application of RBV and dynamic capabilities concepts to leverage better elucidation from the lens of both theories (e.g. Aslam et al., 2020; Chowdhury et al., 2019; Dubey et al., 2019). The combination of RBV and dynamic capabilities concept can enhance understanding the impact of dynamic resources on the transformation of capabilities to meet the volatile market and eventually attain a competitive advantage. In relation to this, the dynamic of green capabilities signified the decisive influence on the CLSCO and the attainment towards the CE. Such effect provides the basis of understanding the reconfiguration of the firm's cross-organizational CLSCO process to meet the changing internal and external environments to achieve competitiveness in the marketplace (Aslam et al., 2020). Hence, the implication of this study is significant by providing a better understanding of the basic knowledge of the types and effects of green capabilities in RBV and NRBV entailed from the past literature. Moreover, the foundation of the study includes the dynamic effects of the capabilities the firms may encounter in response to the need for the strategic orientation of CLSCO.

The resource-based view (RBV) theory and Natural Resource-Based View (NRBV) were used in this study. The RBV has been revived from various aspects which include a focus on sustainability. It takes a large investment of resources to improve social performance in supply chain relationships (Awan, 2019). In this context, (Hart, 1995) presents the relationship between RBV and sustainability through the NRBV, which examines the relationship between companies and the natural environment. Composed of three interconnected strategies: pollution prevention, product stewardship, and sustainable development, NRBV brought to light some ideas regarding the proposed strategy's connections with the acquisition of a sustainable competitive advantage, thereby establishing a new area of research in the field of strategy. NRBV is explicitly grounded based on understanding how social and environmental factors could influence the development of firms' capabilities (Hart & Dowell, 2010). NRBV proposes that firms achieve competitiveness from the non-imitate of green practices and access to unique resources required to increase environmental performance.

In the context of this study, RBV supports the determinants (inputs) of recovery capabilities, integration capabilities, and manufacturing capabilities towards the implementation of CLSCO, which lead to the CE performance. Firms need to manage their activities, routines, and business process efficiently and effectively to utilize the highly competitive resources and capabilities in possession fully, so that the green firm's performance is improved with a higher competitive advantage in the market (Ray et al., 2004). In addition, NRBV theory provides support by conceptualizing the effects in deriving the outcomes for the CLSCO since this study investigates the impact of green capabilities on the adoption of green activities. The NRBV explains how firms gain superior performance through adopting green activities such as the CLSCO. It becomes part of corporate sustainable development strategies that firms utilize to enhance the firm performance and competitive advantage (Hart & Dowell, 2010). In this study, RBV and NRBV theories provide the theoretical base for understanding the effects of green capabilities on the adoption of green activities, on which the effectiveness outcomes are eventually derived for such adoption.

This study contains three different variables in a single study that comprises the green capabilities (recovery, integration, and manufacturing) as independent variables determinants to CLSCO while assessing it towards CE performance. Thus, the model helps manufacturing firms in Malaysia understand the relationships among green capabilities, CLSCO, and CE performance. Given the current recognition of the need to improve sustainability, the findings of this study are of utmost importance the CLSCO in enhancing the manufacturing firm's performance in CE.

2.6 *Hypothesis developm*ent

2.6.1 Recovery capabilities on the CLSCO

The expansion of scope in reverse supply chains is the reason why firms are extending the CLSCO activities such as product acquisition, reverse distribution, inspection, and disposition, refurbishing and re-marketing. Among the popular recovery practices include recycling and remanufacturing (Masi et al., 2018), which can be treated through the CLSC adoption (Panda et al., 2017). Such involvement is imperative in view of the responsibilities towards circular economy is getting higher globally and has putting firms into consideration on finding ways to revamp and integrate with present SCM operations (Hsu et al., 2013). Nevertheless, not all firms are capable in the recovery operations of their own products. On the frequent, firms may find difficulties to integrate the existing structures of SCM for the managing of the recovered products (Seitz & Peattie, 2004), which burden them with an additional cost due to the isolated and split operations. In this case, firms without the recovery capabilities normally initiate linkages or connections with the firms that already possessed the assets and skills capabilities in the product recovery (Toffel, 2003) of the reverse supply chains. Recovery capabilities with waste reduction in the product returns process can significantly aid firms in obtaining the advantages of CLSCO (Bhatia et al., 2020). In addition, the governments typically supported the CLSCO adoption through providing incentives and grants to enhance the firm's remanufacturing capabilities (Jin & Zhou, 2020). Hence, the recovery capabilities are imperative in the adoption of product recovery, which has been determined as one of the key activities in CLSCO. Therefore, this leads to the following hypothesis:

H_1: Recovery capabilities have a positive effect on CLSCO.

2.6.2 Integration capabilities on the CLSCO

Collaboration is the general terms that define the integration to provide new interaction opportunities and facilities among the joined parties (Hofmann et al., 2012) in the adoption of green activities over extended period (Gao et al., 2015). As the matter of fact, many studies in the past have shown the effectiveness of integration in deriving higher environmental benefits in the actual practice (Florida, 1996). For instance, Insanic and Gadde (2014) study exhibited the prominence role of integration capabilities towards managing the product recovery operations, in view of the strong support by the inter-firms communication capabilities that are exceptionally needed to optimize the complex recovery networks. The capability of third-party collection centres motivates the manufacturers to diversify the product acquisitions from the market by integrating the process with the third parties (Wang, et al., 2020). Limited resources have forced the manufacturers to improve their integration capabilities for both manufacturing and remanufacturing operations (Farrokh et al., 2018). Moreover, to ensure the successful CLSCO, firms should be capable of integrating with the supplier's operations (De Angelis et al., 2018). The selection of supply chain partners that appreciate the CLSCO is crucial for managers to coordinate the CLSCO process (Bhatia et al., 2020). The integration capabilities may create the ability to increase the acceptance of risk, interaction competences as well as improved the internal organization learning (Anand & Khanna, 2000) and are crucial to be enhanced and achieved significant advantage by the collaborated parties, beyond than just managing the relationships. It seems clear that firms with effective internal capabilities are capable and more acquainted in managing the returns (Rizzi et al., 2013) and eventually lead to a better CLSCO. Hence, this leads to the following hypothesis:

H_2: Integration capabilities have a positive effect on CLSCO.

2.6.3 Manufacturing capabilities on the CLSCO

Firms need to have the internal capabilities to implement effective reverse supply chain actions (González-Torre et al., 2010) including the manufacturing capabilities towards the CLSCO, to convert the returns or waste into products for subsequent usage in other production (Sarkis, 2001). This is because certain type of product returns requires inventive process and technology capabilities (Sarkis et al., 2010) particularly in the manufacturing to improve the ordinary process of recovery that may not be effective. Hence, such capabilities potentially determine the successful implementation of environmental efforts including the CLSCO. In relation to this, the most prevailing view comes from Robotis et al., (2012) who stated that firms must make significant investment in their CLSCO capabilities (green capabilities) to capitalize the environmental and economic advantage of the CLSCO, such as remanufacturing. However, to overcome the constraints in resource and infrastructure, manufacturing operations are required to combine with the product return operations (Bhatia et al., 2020). Among the capabilities in remanufacturing that firms need to consider is the product design, the support for disassembly and inspection, product reusable, and enhancing the component lasting and durability. By enhancing these capabilities, firms will be able to achieve a greater sustainability in supply chain internally and externally from the CLSCO (Yang & Xu, 2019). As such, failing to incorporate the elements of green during production of goods and services can cause a difficulty to realise the green practices adoption (Susanty et al., 2019). Hence, this leads to the following hypothesis:

H_3: Manufacturing capabilities have a positive effect on CLSCO.

2.6.4 CLSCO on the CE

Russo and Fouts (1997) have made the point that by actively managing their CLSCO, firms increase the effectiveness by achieving higher engineering capabilities and competitive advantage in the long run. Similarly, according to Gobbi (2011) the overall performance of strengthening the market position and enhancing the firm's image is achieved if the reverse supply chains are managed in a strategic way effectively. This is because an effective management in the reverse supply chains improved the overall processing of the product returns and raised the labour productivity to meet the customer expectations and demands (Autry et al., 2001). In addition, the effective management of the reverse supply chains may increase the firm's performance in the environmental, regulatory compliance as well as providing economic advantage to the firms (Guide Jr. et al., 2003). Significantly, firms that sought for sustainability performance will focus on the CLSCO (Kannan et al., 2010; Mangla et al., 2018). Likewise, the CLSCO can nurture the sustainable development and eventually leads to competitive advantage (Bhatia et al., 2020). Moreover, many companies engaged in CLSCO to reduce the manufacturing cost and eventually increase the effectiveness of their products in the market. The reason is mainly due to lessen the cost for remanufacturing (part of CLSCO) because of waste reduction, saving of landfill space, and energy saving instead of producing products from fresh material (Jeihoonian et al., 2017). Thus, this study hypothesizes that:

H_4: CLSCO has a positive effect on the CE performance.

2.7 Methodology

The population of this study consisted of environmental management system (EMS) ISO 14001-certified manufacturing firms in Malaysia. In Malaysia, EMS-certified companies showed better performance than non-certified companies in the reverse supply chain operations (Kumar et al., 2014). A population frame of 600 certified ISO 14001 manufacturing firms in Malaysia was established. The study used all the population as the sampling frame due to the likelihood of low responses from the mail survey (Sekaran, 2003), and as such, this study has reasonably employed the census sampling technique. This study made a mail survey of a total of 581 ISO 14001-certified firms in Malaysia after deducting the 19 participating companies during preliminary study from the total population of 600 companies.

The questionnaires were distributed to 11 states in Malaysia. The states of Selangor, Pulau Pinang, and Johor have the largest number of ISO 14001-certified companies and thus are the major sampling frame of this survey. The structural equation modelling (SEM) was conducted to assess the fitness between the proposed models with the data collected from the field.

In terms of the SEM estimation procedure, this study has utilized the Maximum Likelihood Estimation (MLE) and SIMPLIS in the analysis of data through the application software of SEM Lisrel Version 8.7. This method is a popular method of SEM in business and social science since it reduces the impact of the variance. Since it can model composites and factors, it is a powerful statistical tool for studying emerging concepts such as the circular economy. In light of this, the first step in SEM is to apply the CFA process to evaluate, verify, and improve the model fit for each of the constructs included in the measurement model (Kelloway, 1996). Subsequently, the study examined the structural model and developed the causal path (Anderson & Gerbing, 1988; Bollen, 1989). At this point, numerous diagnostic tests are measured for conformance before testing the hypotheses. In the end, the model route analysis, the testing of hypotheses, and specific path analyses were carried out.

To derive the parameter estimates for structural equation models, maximum likelihood (MLE) estimation has been employed in this study. In structural equation modelling (SEM), a model is considered to match the observed data if the indicated covariance matrix of the model is equal to the empirical covariance matrix. It is necessary to choose a technique for parameter estimation after a model has been described and the empirical covariance matrix has been provided. Different estimating techniques have various distributional presumptions as well as various discrepancy functions that need to be reduced. At this stage, assessing the model's fit is important after the estimating process has reached a plausible conclusion. The level of model fit indicates how well the structural equation model matches the sample data (Schermelleh-Engel et al., 2003).

2.8 Survey instruments

In this study, measures of variables were developed based on the literature review and depend on the available measures in the literature as well as the feedback from the interviews carried out with selected manufacturers during the preliminary stage. Recovery capabilities are defined as the ability to engage the product returns into manufacturing or production of the new goods (Hassini, et al., 2012), with the measurement items that reflect the capabilities are adapted from Shang et al. (2010); Montabon et al., (2007); Miemczyk (2008); Richey et al., (2005). Integration capabilities consist of internal and external integration capabilities (Huo, 2012). The measurement items correspond the external (supplier and customer) and internal (in-house) integration capabilities were adapted (Hofmann et al., 2012; Lai et al., 2012). Manufacturing capabilities represent the ability of firms to introduce new production technologies, improve the working environments and cost reduction of the raw materials and energy usage (Talbot et al., 2007), is measure through the items that reflect these elements were adapted from Holt and Ghobadian (2009); Shang et al., (2010); Wong et al., (2012). The measurement for the CLSCO is composed of five main activities—product acquisition, reverse distribution, inspection, and disposition, refurbishing, and remarketing. The measurement items that reflect these activities are adapted from Genchev et al., (2011); Jayaraman (2006); Jayaraman and Luo (2007); Khor and Mohamed Udin (2013); Prahinski and Kocabasoglu (2006); and Rogers et al., (2010). Finally, the CE performance is regarded as achievement to what has been expected from the CLSCO by the firms. Six items were adapted from Holt and Ghobadian, (2009); Khor and Mohamed Udin (2013); Zhu et al., (2008). The study used 5-point Likert scale for measuring all the variables.

2.9 Respondents' and company's profile

The study received only 150 usable survey questionnaires (25.8%) from the 581 questionnaires distributed to manufacturing firms across Malaysia. It used the G*Power software version 3.1.9.2 test to determine the number of samples (Faul et al., 2009). The findings showed that a sample size of at least 74 of the population of 600 respondents was a suitable sampling size for the study with the power of a statistical test of 0.95 (Cohen, 1988) and a maximum of three predictors pointing at a construct in the PLS path model (Hair et al., 2017). As such, 150 data collected were a sufficient sampling size for the study.

The analysis of the respondents' demographic profile revealed that in terms of the job title, most of the respondents (more than half) held management responsibilities with the highest posts of manager and higher in their organisations. In terms of the organisation's functions and length of working years, most of the respondents served Production, Logistics and Quality Department and consisted of experienced employees working for more than six years, with their academic qualifications of a degree or higher. Pertaining to the sector of the industry, most of the participating firms were from Electrical and Electronics (E&E) industries. It is the biggest manufacturing industry with the most recipients of Environmental Management of ISO 14001 certification in Malaysia. Besides that, the mainstream of the participating firms comprised large firms with 251–500 employees, mainly from the MNC firms, which have been operating for more than 15 years in Malaysia. There were three major reasons for the CLSCO amongst the participating firms: meeting customer requirements, fulfilling regulatory compliance, and meeting the stakeholders' demand. The level of adoption of the CLSCO activities reached by them was slightly higher than average. Most of them have achieved high CE performance from the CLSCO. As such, the overall performance achieved by the participating firms supports the selection of the sample to be the most appropriate to provide the responses to answer the study questions.

2.10 Assessment of the common method variance (CMV)

One of the methodological issues that has repeatedly emerged and which seems to be of constant debate is common method bias. This is also referred to as common method variance (CMV) by others although not strictly the same thing. It has been recognized that CMV may significantly influence the research findings if it is not controlled properly through procedural and statistical remedies Tehseen et al., (2017). Therefore, several procedural procedures have been made to decrease the effect of CMV on the study, including the selection of respondents from just the managerial-level staff. In addition, the questionnaires must be disseminated to a chosen group of departments (Production, Quality, Logistics, and Supply Chain Department) that have demonstrated competence and understanding in reverse logistics and CLSCO.

Besides that, the respondent's anonymity was ensured, with clear notification provided in the survey letter of invitation. To assess the CMV through statistical measures, Harman's one-factor test was utilized in the study (Podsakoff et al., 2003). Herman's one-factor test was performed by entering all the principal constructs into the principal components factor analysis, and the results are presented in Table 2. Referring to Table 2, the results signified that when all items were forced into one-factor, all factors accounted for 25.86 percent of the variance, far below than the threshold 50 percent of variance. Hence, this indicated that there was no substantial CMV existed in this study.

In addition, the study has divided the respondents into two groups to evaluate any threat of non-response bias. The first group and second group are separated based on surveys received during the first wave and second wave of mailing. The breakpoint between the two response waves (first and second wave) of the surveys returned was used to represent early versus late respondents. In this case, a total of 150 survey respondents were divided into early (n = 50, 33.3%) and late (n = 100, 66.7%) based on their response wave. The early responses were compared with the late responses using independent T test to identify any significant different in the mean values of the six study constructs. The results indicated that there was no significant difference between the early and late responses for all the constructs with the evidence of insignificant results at the 5% significance level for all variables of study. Hence, this has signified that there was not enough evidence to implicate the early and late responses, suggesting the absence of non-response bias in the dataset.

Prior to conducting the SEM analysis, the assessment of the missing data, normality, outliers, and multi-collinearity had been conducted to screen the dataset. In this case there were six items with missing data that have been replaced with value estimated using expectation–maximization method in SPSS. In addition, the distribution of data was deemed within the normal range; thus, the data transformation procedures were not required. Moreover, all data were within the range of 1–5; therefore, there are no outliers in the dataset. Lastly, the results of the collinearity test to measure the level of covariance between the independent variables and dependent variable in the regression model indicated the non-existence of multi-collinearity in the dataset. Hence, the data screening has shown satisfactory results and provided evidence of the dataset competency to continue with the covariance SEM analysis.

The study undertook univariate normality, a normality test in the statistical application of the Lisrel. The results shown in Table 3 indicated the p-value of the skewness and kurtosis for all of the variables are insignificant (p-value > 0.05). Hence, it is evidenced that no violation of the normality assumption has been detected in the dataset.

2.11 Results

In this study, a two-step approach of SEM is utilized to separate the evaluation between measurement and structural model to measure the psychometric properties of the items for each individual variable and determine the relationships that exist between both exogenous and endogenous variables (Anderson & Gerbing, 1988; Byrne, 1998) in the same model.

2.12 Assessment of measurement model

The reliability of the measurement models has been assessed to determine whether the indicators for each construct achieve the internal stability and consistency. The results of reliability analysis results are presented in Table 3. The Cronbach's α value for the constructs ranges from 0.845 to 0.893, thus signifying the scales are strongly reliable (Bollen, 1989). In addition, the CR statistics range from 0.840 to 0.895, above than the threshold value of 0.60 and the AVE value above than the threshold value of 0.50, suggesting that all constructs are appropriately reliable (Fornell & Larcker, 1981). The unidimensionality of each construct has been tested through the measurement convergent and discriminant validity. From Table 4, the CFA is above 0.60 and signified the support of convergent validity since all the indicators were significantly loaded on the expected construct. Moreover, the AVE value greater than 0.50 also indicates excellent convergent validity.

The final iterations for the measurement models for Recovery Capabilities, Integration Capabilities, Manufacturing Capabilities, CLSCO, and CE performance in Table 5 reveal that the entire GOF tests have shown a well-fitting model to the data. The discriminant validity was further evaluated through inter-construct correlations, as illustrated in Table 6. By referring to Table 5, the diagonal matrix and the square root of AVE indicate that correlation between the variables is less than the square roots of AVE measures. The result implies that the measurement models have sufficient discriminant validity for all the constructs. From Table 6 also, the nomological validity also has been achieved from the evident of the significant correlations among the latent variables. As such, from numerous compliances of convergent and discriminant validity, the measurement models were reliable and fit for further evaluation of the structural model.

2.13 Structural equation model

Table 7 shows the fit indices for the structural model and supports the excellent model fit with $\times 2/df = 1.3782$ (<5.0), goodness of fit index (GFI) = 0.81 (>0.80), comparative fit index (CFI) = 0.97 (>0.90), non-normed fit index (NNFI) = 0.97 (>0.90), parsimonious normed fit index (PNFI) = 0.82 (>0.50), root-mean-square error of approximation (RMSEA) = 0.05 (<0.08), and standard root mean residual (SRMR) = 0.078 (<0.08). Hence, the final structural model is sufficiently achieved the construct validity as well as adequately reproduces the population covariance matrices.

Based on the results of structural model in Fig. 2, hypothesis H_1 was not supported as the statistical analysis found insignificant relationship of β coefficient = −0.0067 and z value = −0.061. This result signified that the recovery capabilities have no direct effect on the CLSCO. Hypothesis H_2 was supported with a positive relationship between integration capabilities and the CLSCO and statistically significant at $p<0.01$ (β coefficient = 0.45^{***}, significant at z value = 4.44). Hypothesis H3 was supported with a positive relationship between manufacturing capabilities and the CLSCO and statistically significant at $p<0.05$ (β coefficient = 0.36^{**}, significant at z value = 1.96). Lastly, hypothesis H4 was supported with a positive significant effect between the CLSCO and the CE performance and statistically significant at $p<0.01$ (β coefficient = $0.43.^{***}$, significant at z value = 4.99). Hence, hypotheses H_2, H_3, and H_4 were supported (Table 8). Figure 3

2.14 Discussions

The study discovers that there is a positive significant effect between integration capabilities and the CLSCO, indicating that integration capabilities are the valid indicator of the CLSCO towards the CE performance among manufacturing firms in Malaysia. Results from the earlier studies have indicated the importance of functional and departmental integration capabilities to support the reverse logistics operations (Mollenkopf et al., 2007). Apart from reverse supply chains, functional and departmental integration skills are critical

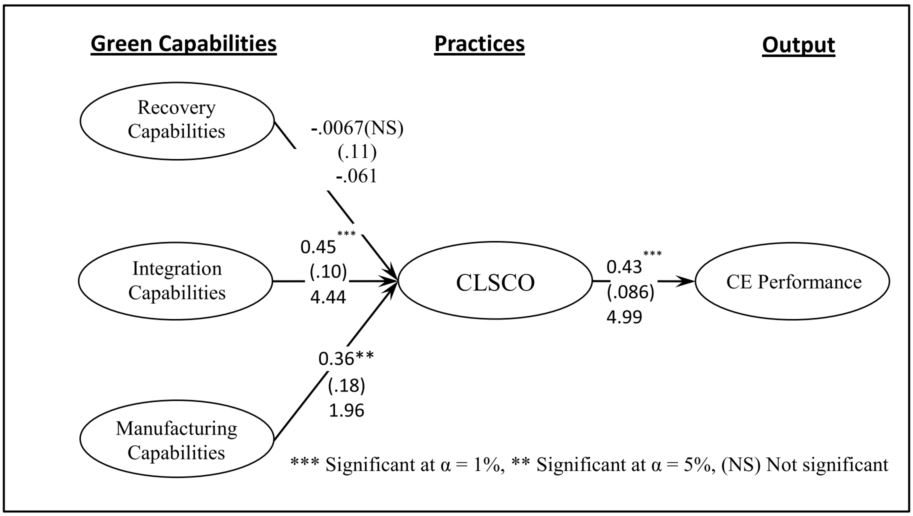

Fig. 3 Structural Model

Table 1 Summary of Green Capabilities

No	Reference	EN	PU	DN	MF	RC	IN	OC	RB	I S	ST	FC	MK	IV
1	Liu et al., 2020		√											
2	Quintana-García et al. 2020	√												
3	Qiu et al., 2020	√					√		√					
4	Yang et al., 2019													√
5	Mao et al., 2019				√									
6	Foo et., 2019		√											
7	Albertini, 2019						√	√						√
8	Joo et al., 2018													√
9	Rathore et al., 2018													√
10	Yook et al., 2018		√											
11	Bae, 2017	√												
12	Hazen et al. 2015									√				
13	Gmelin & Seuring 2014						√							
14	Lai et al 2014						√							
15	Chen & Chang 2013								√					
16	Rizzi et al., 2013						√							
17	Saavedra et al. 2013						√							
18	Bell & Mollenkopf 2013						√		√	√				
19	Jayant et al. 2012					√								
20	Hassini et al., 2012				√	√								
21	Shi et al., 2012									√				
22	Hofer et al. 2012							√						
23	Wu et al.,(2012)							√			√			√
24	Abu Seman et al. 2012							√	√				√	
25	Huo, 2012						√							
26	Mondragon et al.,2011						√							
27	Wen-hui et al., 2011					√	√							
28	Xu 2011					√								
29	Zarandi et al., 2011						√							
30	Zhang et al. 2011					√								

Table 1 (continued)

No	Reference	EN	PU	DN	MF	RC	IN	OC	RB	I S	ST	FC	MK	IV
31	Hazen et al. 2011					√								
32	Sarkis et al., 2011						√		√				√	
33	Luthra et al. 2011													√
34	Murillo-Luna et al. 2011							√			√	√		
35	Diabat & Govindan 2011						√							
36	Seuring 2011						√							
37	Lee & Kim 2011				√		√							
38	Tate et al., 2011							√						
40	Cheung & Rowlinson 2011							√	√					
41	Arimura et al. 2011							√						
42	Pati et al., (2010)									√				
43	Sarkis et al				√									
44	Erol et al. 2010				√		√							
45	Hsiao 2010				√		√		√					
46	Jack et al., 2010									√				
47	Massoud et al. 2010											√		
48	Zhu & Geng 2010							√						
49	Gold et al. 2010						√		√					
50	Thun & Muller 2010						√							
51	Shang et al., 2010			√	√		√	√					√	
52	Akçalı et al. 2009					√								
53	Defee et al. 2009						√							
54	Lau & Wang 2009			√	√	√	√							
55	Jolley 2009							√						
56	Zhu et al., 2008								√					
57	Lashkari & Zhang 2008					√								
58	Srivastava					√								
59	Darnall et al., 2008				√		√	√	√	√				

Table 1 (continued)

No	Reference	EN	PU	DN	MF	RC	IN	OC	RB	I S	ST	FC	MK	IV
60	Talbot et al., 2007			√	√									
61	Kumar & Craig 2007					√								
62	Álvarez-Gil et al. 2007											√		
63	Biehl et al., 2007				√	√								
64	Jayaraman & Luo, 2007				√		√		√					
65	French, & Laforge 2006					√								
66	Jayaraman, 2006					√								
67	Kumar & Malegeant, 2006						√							
68	Prahinski & Kocabasoglu, 2006					√								
69	Daugherty et al., 2005					√								
70	Preuss 2005				√									
71	Richey et al., 2005													√
72	Schultmann et al. 2003					√								
73	Guide Jr. et al. 2003					√								
	Total	3	3	3	**13**	**18**	**25**	12	11	6	2	3	3	7
	Percentage	2.8	2.8	2.8	**12.0**	**16.5**	**22.9**	11.0	10.1	5.5	1.8	2.8	2.8	6.4

"√" indicates the study found specific capabilities of green environmental actions. Type of capabilities: *EN* Environmental Capabilities; *PU* Purchasing Capabilities; *DN* Design Capabilities; *MF* Manufacturing Capabilities; *RC* Recovery Capabilities; *CO* Cooperation Capabilities; *OC* Organizational Capabilities; *RB* Resource-based Capabilities; *In* Integration Capabilities; *IS* Information-Related Capabilities; *ST* Strategic Capabilities; *FC* Financial Capabilities; *MK* Capability to Market; *IV* Innovative Capabilities

The bold figure denotes the top three green capabilities discussed in the past study

Table 2 The Results of Principal Component Factor Analysis

	Total	% of Variance	Cumulative %
Extraction Sums of Squared Loadings	11.638	25.862	25.862

Table 3 Summary of Normality Test Results

Variable	Mean	St. Dev	Skewness *p*-value	Kurtosis *p*-value
Recovery Capabilities	3.58	0.755	0.660	0.771
Integration Capabilities	3.04	0.793	0.857	0.618
Manufacturing Capabilities	3.56	0.739	0.734	0.628
CLSCO	3.05	0.812	0.567	0.636
CE performance	3.49	0.757	0.738	0.700

CLSCO Closed-loop Supply Chain Orientation, *CE performance* Circular Economy Performance

for assuring the forward supply networks' performance. Cross-functional integration is built during the product invention process, and capabilities are developed through resource knowledge sharing (Qiu et al., 2020). It becomes evident that a high degree of product returns to support the CLSCO can be realized only the internal functional areas and departments cooperate with each other in an integrated manner, work seamlessly, and solve the departments' boundary's issue. This demonstrates that the benefit of strengthening cross-functional integration (internal integration) to businesses outweighs the benefits of external integration initiatives (Rizzi et al., 2013). This is mostly because firms' capacity to adapt and develop ways to influence the impact of external integration on product returns is conditional on the success of internal integration. As a result, organisations with stronger integration skills can manage variations in the amount, timing, type, and quality of product returns, which may have an effect on the CLSCO.

Concerning this, the latest study reviewed by Simonetto et al. (2022) advanced the understanding by concentrating on the CLSC's mitigation risks by enhancing the capabilities of Industry 4.0 technology in operations. The study discovered that by enhancing the integration of Industry 4.0 capabilities, it was possible to improve logistics systems, overcome stock issues and excess supply problems, achieve higher-quality assurance of products and processes, and increase sustainability in production and transportation, thus contributing to mitigating various kinds of risks.

Another component that had a strong correlation with the CLSCO was manufacturing capabilities. The findings reveal that manufacturing capabilities have a significant role in determining the degree of CLSCO among Malaysian enterprises. Without a doubt, the capacity to include many production tasks has an effect on the degree of CLSCO. The incorporation of the industrial ecology system demonstrates why firms must develop manufacturing capabilities to deal with the CLSCO, ensuring that energy and materials are used efficiently in manufacturing products and that waste is kept to a minimum, if not eliminated entirely from the production ecosystem (Sarkis, 2001). This is contingent upon the production system's capacity to convert returns or waste into outputs that may be utilised by other components of the ecosystem (Sarkis, 2001). In addition to having the capability to recycle, manufacturers also need to be able to use recovered materials in the creation of

Table 4 The Results of Measurement Model Evaluation

Constructs	Measured Items	Factor loadings	SC	CR	AVE
Recovery capabilities	Reconstruct a product using recycled components	.79	0.845	0.841	0.514
	Introduce technology that facilitate product recovery	.70			
	Construct recovery procedures throughout time	.69			
	Repair or rework quality	.72			
	Rework or repair timeliness	.68			
Integration capabilities	Obtain information from vendors	.72	.869	.867	.522
	Collaborate with suppliers to achieve cleaner processes	.76			
	Collaborate with suppliers to swap materials	.77			
	Receive data from customers	.68			
	Replace materials with customers	.67			
	Management collaborates effectively on all significant recovery decisions	.73			
Manufacturing capabilities	Develop techniques that decrease resource usage	.61	.849	.842	.518
	Substitution of harmful and dangerous materials	.75			
	The emphasis is on minimising waste and maximising resources use	.83			
	Components derived from sustainable sources	.68			
	Process design that reduces energy and natural resource use in operations	.71			
CLSCO	Acquisition of used and discarded components and materials	.79	.859	.889	.535
	Examine the condition and packing of returned items	.85			
	Examining, sorting, and storing used objects	.68			
	Recycle or reuse resources from used items and components	.65			
	Recondition items to prolong their useful life	.76			
	Marketing and sales of reusable products	.70			
	Acquisition of old and discarded components and materials	.67			

Table 4 (continued)

Constructs	Measured Items	Factor loadings	SC	CR	AVE
CE performance	Reduce scrap rate	.71	.871	.873	.534
	Offers operational cost reductions	.72			
	Increase in profits from after-sale services	.74			
	Reduction in the cost of procuring materials	.68			
	The quantity of waste for disposal is reduced	.78			
	Environmental management practise enhancement	.75			

CLSCO Closed-loop Supply Chain Orientation; *CE performance* Circular Economy Performance; *SC* Standardised Cronbach's; *CR* Composite Reliability; *AVE* Average Variance Extracted

Table 5 The Results of Goodness-of-Fit Tests for the Measurement Models

Goodness of fit statistic	Acceptable Levels	RC	IC	MC	CL	CE
χ^2/df	$\chi^2/df \le 5.0$	1.063	0.963	1.100	1.657	1.637
p-values for χ^2	$P > 0.05$	0.373	0.468	0.355	0.084	0.099
RMSEA	RMSEA ≤ 0.08	0.020	0.010	0.026	0.066	0.065
Goodness of Fit Index (GFI)	GFI ≥ 0.80	0.99	0.98	0.99	0.97	0.97
Root-Mean-Square Residual (RMR)	RMR ≤ 0.05	0.011	0.021	0.016	0.024	0.022
Standard Root Mean Residual (SRMR)	SRMR ≤ 0.08	0.019	0.025	0.026	0.033	0.034
Comparative Fit Index (CFI)	CFI ≥ 0.90	1.00	1.00	1.00	0.99	0.99
Tucker-Lewis Index or Non-Normed Fit Index (TLI or NNFI)	NNFI/TLI ≥ 0.90	1.00	1.00	1.00	0.98	0.98
Normed Fit Index (NFI)	NFI > 0.90	0.99	0.99	0.99	0.98	0.97
Incremental index of Fit (IFI)	IFI ≥ 0.90	1.00	1.00	1.00	0.99	0.99
Relative Fit Index (RFI)	RFI ≥ 0.90	0.97	0.98	0.97	0.96	0.96
Adjusted Goodness of Fit (AGFI)	AGFI ≥ 0.90	0.96	0.96	0.96	0.91	0.93

RC Recovery Capabilities, *IC* Integration Capabilities, *MC* Manufacturing Capabilities, *CLSCO* Closed-loop Supply Chain Orientation; *CE performance* Circular Economy Performance

Table 6 The Results of Inter-Construct Correlations

Indicator	RC	IN	MC	CL	CE
Recovery Capabilities	**0.717**				
Integration Capabilities	.315**	**0.723**			
Manufacturing Capabilities	.497**	.581**	**0.719**		
CLSCO	.328**	.558**	.509**	**0.731**	
CE performance	.394**	.348**	.363**	.454**	**0.730**

CLSCO Closed-loop Supply Chain Orientation; *CE performance* Circular Economy Performance

**Correlation is significant at the 0.01 level (2-tailed), bolded figures denote square root of AVE, non-bolded denote inter-construct correlations

Table 7 Goodness-of-Fit Tests Results

Structural Equation Model	χ2	df	χ2/df	GFI	CFI	TLI/NNFI	PNFI	RMSEA	SRMR
	501.68	364	1.3782	0.81	0.97	0.97	0.82	0.05	0.078

new products. In 2014, Dell was one of the pioneering companies to use at least 10% post-consumer recycled plastic in one of their computer lines. To protect the environment and feed its closed-loop supply chain, Dell continues to provide take-back programmes to their customers (Brooke, 2022).

Additionally, various ideas in the manufacturing phase are associated with manufacturers' attempts to decrease waste and pollution, including cleaner production, green design, remanufacturing, and lean manufacturing. Cleaner production is a manufacturing technique

Table 8 Path Coefficient and Hypothesis Testing Results

Hypotheses	Path relationship	Path Coefficient	Std	*t*-Value	Decision
H1	Recovery Capabilities CLSCO	$-0.067^{(NS)}$	0.11	−0.061	Not supported
H2	Integration Capabilities CLSCO	0.45^{***}	0.10	4.44	Supported
H3	Manufacturing Capabilities CLSCO	0.36^{**}	0.18	1.96	Supported
H4	CE performance	0.43^{***}	0.086	4.99	Supported

CLSCO Closed-loop Supply Chain Orientation; *CE performance* Circular Economy Performance

***Significant at $\alpha = 1\%$, **Significant at $\alpha = 5\%$, (NS) Not significant

that focuses on material conservation, energy efficiency, waste reduction, and zero pollution throughout the manufacturing process. Material eco-efficiency is prioritised in this idea by boosting material savings and full exploitation of by-products to increase total resource productivity. Additionally, green manufacturing skills promote safety and maximise the efficiency of the manufacturing process (Mao et al., 2019). On the other side, green design refers to the steps that have been included into a product to minimise its environmental effect throughout its lifespan, from manufacture to disposal, without compromising the product's cost or performance (Zailani et al., 2012).

Nonetheless, no correlation was seen between recovery capabilities and adoption of the CLSCO. This conclusion contradicted the current research, which claimed that recovery capabilities are critical in the CLSCO, since they constitute one of the primary activities in the CLSCO. In this situation, various causes for organizations' inability to fully exploit their recovery skills in the CLSCO have been identified in the literature. Malaysia, for example, is still lagging behind in terms of waste management rules and product recovery operations, resulting in a lack of concern for investment recovery systems such as reuse and recycle activities in CLSCO. For instance, according to a report by World Bank, Malaysia recycled just 24% of major plastic resins in 2019, falling short of the 40% goal of the National Solid Waste Management Department set for 2025. Consequently, 1.07 million tonnes of major plastic resins is thrown rather than recycled into useful materials, resulting in a loss of around 81% of the material value, or about US$1.1 billion annually (World Bank, 2021). The country's recycling rate remains low in comparison with the quantity of waste generated daily (Sobri, 2021).

To enable a seamless transition to the CLSCO recovery system, businesses in developing nations must alter their attitude and implement a recovery plan throughout their supply chains. Miemczyk (2008) asserts that organisations' recovery skills are primarily required to meet their competitive objectives and regulatory compliance. It is well-known that the take-back legislation has not been fully implemented in Malaysia, and the obligations for product recovery apply exclusively to enterprises exporting to European nations and other countries with comparable enforcement. As a result, the demand for manufacturers in Malaysia to build recovery capabilities is still relatively low and constrained, prompting many firms to focus on particular reverse logistics operations as a part of the CLSCO initiatives.

Lastly, the study advances knowledge of the major influence of CLSCO on CE performance. Effective CLSCO could meet the high influence requirements of stakeholders, including customers, employees, and the government, to survive and succeed in the sustainable performance of the CE. For instance, adopting sustainable packaging in CLSCO can influence sustainable CE performance in the supply chain (Zailani et al., 2015). It could also provide excellent after-sales service to customers, comply with the exporting countries' strict WEEE regulations, and comply with the exporting countries' requirements. The circular economy may be effectively implemented by incorporating CLSCO in both forward and reverse supply chains, facilitated by the recovery process and resale or remarketing of used goods in the market. Each practice helps promote product circularity within the sustainable ecosystem by reducing waste and improving supply chain cost savings (Shaharudin et al., 2022).

2.15 Theoretical contribution

Empirical evidence demonstrates that it is impossible to reduce emissions without sacrificing economic growth, as reducing CO2 emissions may lead to a decline in output (Alcalde-Calonge et al, 2022). This is the theoretical reason for the difficulty in achieving climate agreements. Therefore, on the one hand, developing countries such as China or India would have to limit their economic growth ambitions in order to curb emissions, as they cannot afford cleaner technologies. Developed countries, such as the USA, who are responsible for a substantially bigger proportion of the global annual CO2 emission, may be required to consent to a reduction in their existing income levels if they are to drastically lower their current emission levels. Therefore, it is necessary for the study to examine the state of the art in CLSCO over a forward and reverse SC that involves the remarketing of remanufactured products as perfect substitutes in the original market is an ideal case for achieving the circular economy performance.

As a result, this study adds to the theoretical knowledge of how the CLSCO level affects the benefits to CE performance for manufacturers. There is a dearth of evidence that combines the green capability features and CE performance under a single study, despite the fact that the CLSCO has been the subject of numerous studies (e.g. Shaharudin et al., 2015; Bhatia et al., 2020). Researchers have found that companies that use CLSCO see an increase in their "CE performance", which is measured by how well the company does financially (Shaharudin et al., 2017). This research seeks to identify the most relevant green competencies, with a focus on Malaysia, as they relate to the effectiveness of strategy implementation and internal activities within a corporation. This research presents a novel framework for simultaneously assessing the effect of the CLSCO on CE performance and determining the significance of the green capability's part in achieving that effect. The results demonstrated that CLSCO's recovery capability remains negligible, while integration and manufacturing capabilities play a crucial role. This research is one of only few that has focused on identifying the eco-friendly factors behind the CLSCO's success. While it is true that a holistic view of CLSCO's green capabilities may be useful, the idea that recovery capability is unimportant is false. One possible interpretation of the negative indications on the connections is that they are a representation of the likelihood that the recovery capacity is a product of the CLSCO. When a company adopts CLSCO, it boosts its ability to recover from disaster.

In addition, this study improves upon the performance indicators previously used to assess CLSCO. Three primary parts of performance metrics, the reverse supply chain element in CLSCO, and the integration that impacted the firm's performance were proposed by Mondragon et al., (2011) in their study in proposing a set of measurements for the CLSCO. They established performance measurements for auditing forward and reverse supply chains and then tested them using a case study methodology from a major European mobile phone network operator. The findings uncovered the existence of the integration level across supply chains channel that may affect the CE performance and highlighted the significance of having the set of measurements for CLSCO auditing purposes. Therefore, it is crucial to evaluate the CLSCO's efficiency in order to gauge how well the company as a whole is doing at producing the desired outcome. Feedback on the firm's primary concern for quality attainment and customer happiness can be gained through analysis of the impact environmental practises have on operations (Azevedo et al., 2011).

A comprehensive method of performance evaluation is essential for achieving desirable outcomes from CLSCO deployment (Olugu et al (2010). Measuring the efficacy of operations can give management valuable information about performance, progress, problem analysis, and clarity across supply chains, all of which can aid in making decisions that help businesses accomplish their objectives and goals (Neely et al., 2005). This research demonstrates that the success of the CLSCO is reliant not just on the procedure, but also on the established metrics that are suited to bring the adoption to tremendous success. By implementing CLSCO and other sustainable supply chain methods, the sustainability movement in production may improve both quality and productivity. A rise in brand value, sales, and prices may result from this phenomenon as well (Mefford, 2011). Increased income and profitability for businesses is a key factor that attracts investors and, in turn, drives up their stock price. However, the primary difficulty that businesses have is getting the correct assessment with improved measurement that can help them achieve their CLSCO goals.

2.16 Practical implication

From a managerial perspective, the findings of this study on the determining capabilities of CLSCO among manufacturing firms in Malaysia have several significant important implications for the managers. First, the findings provide a deeper understanding for the crucial role played by the integration and manufacturing capabilities in determining the CLSCO. Although there are extensive discussions relating capabilities and adoption, a study that focuses on the different sets of capabilities and CLSCO as well as CE performance is still scarcity. Second, the recovery capabilities were found to be incompetent to influence the CLSCO. This new finding may be contrary to the expectations in practice; however, several probable practical reasons may play a role on this surprising finding. Therefore, managers should carefully interpret this finding as there are compelling probable reasons, such as: firms' inferiority in managing waste policies and recovery activities, particularly in developing countries like Malaysia; the lack of interest to invest in the recovery system; limited focus with the main intention to provide after-sales service only; the absence of take-back regulations; and dearth in the reverse logistics infrastructure.

In addition, the study demonstrates the most important green capabilities strategies concerning CLSCO. As a result, it can help factory managers and other practitioners in the logistics sector better comprehend new concepts in CLSCO for suitable steps to nurture strategic green capabilities in meeting Malaysia's upcoming sustainable take-back policy. Original equipment manufacturers (OEMs) are required by this policy to bear complete liability for their products at every stage of the forward and reverse flow chains.

This study aims to give managers useful information by identifying which green capabilities greatly impact the firms' CLSCO. The findings have demonstrated that integration and manufacturing capabilities affected the extent of CLSCO. Understanding these interactions is essential since it informs managers of the relationships' overall influence on achieving the effectiveness of CLSCO, which boosts the firms' performance. Notwithstanding, managers can understand and develop their knowledge in the quest for good future planning and better routine decision-making that might increase the efficacy of the implementation and achieve the competitive advantage of their firms. However, managers must be aware that CLSCO and the general complexity and challenges associated with controlling the reverse flow chains can affect the precision of planning and decision-making.

2.17 Limitation and future direction

Like other empirical studies, some limitation of this study may impact the generalizations of the results. First, the sample population is limited to the manufacturing firms in Malaysia, which may differ in terms of the sizes, capabilities, resources, and supply chain outreach. For example, the sizes are a controlling factor of firm capabilities, resources, and supply chain design. Future study tests this study in different sample such as small and medium size enterprise as well as local and multi-national enterprises. Second, this study is focusing on the Malaysia firm. Second, the ecosystem and maturity of the CLSCO in developing countries like Malaysia is still at embryonic stage in relative to other developed countries. Further study is required to test this study conceptual framework different settings, such as developed countries. Specifically, further study can shed more insights to the recovery capabilities relationship with CLSCO. Third, the design of this study was tested using questionnaire survey limiting the ability to demonstrate the variables' relationship causality. As the CLSCO is dynamic and growing in nature, a longitudinal study is needed by including other impact of green capabilities that might be crucial to increase the CLSCO and eventually raise the CE performance. Among the green capabilities, such as organizational and resource-based capabilities, innovative capabilities, financial-based capabilities, and information-related capabilities.

3 Conclusion

The findings of this study indicate that green capabilities play a crucial part in the CLSCO, which may result in the CE performance. Thus, it is equally obvious that businesses' strength in these competences is critical for the CLSCO's facilitation. The conclusion of this study demonstrates the study's relevance to the industrial ecology system in the circular supply chain as a means of resolving the manufacturing environment's sustainability issue. This has shed light on the CLSCO field, paving the way for future research and practise.

The primary contribution of this study is its demonstration of the impacts of RBV and NRBV on CLSCO adoption. This impact implies that enterprises are implementing CLSCO using the RBV and NRBV theories. Thus, greater emphasis should be placed on the underlying RBV and NRBV philosophies for the effective implementation of CLSCO among Malaysian manufacturing enterprises. Similarly, based on the basic concepts of RBV and NRBV, a firm's success in deploying a collection of resources capable of cultivating green capabilities may facilitate the degree of CLSCO and achievement of CE performance. Additionally, the underlying notion of dynamic capabilities facilitates comprehension of the capability shifts that enterprises may encounter as a result of implementing product circularity in CLSCO. Thus, this scenario means that businesses' capacity to implement CLSCO is contingent on the green capabilities within their control, and that firms must manage the CLSCO implementation efficiently and effectively in order to improve their CE performance.

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