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Norma Binti Mohter, Yudi Fernando

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Towards conceptualisation of low-carbon supply chain

Norma Binti Mohter

Faculty of Industrial Management,
Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA),
26300, Pahang, Malaysia
Email: norma8689@yahoo.com

Yudi Fernando*

Faculty of Industrial Management,
Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA),
26300, Pahang, Malaysia
Email: yudi@ump.edu.my
and
Faculty of Education and Liberal Studies,
City University of Malaysia,
Petaling Jaya, 46100, Selangor, Malaysia
Email: yudifernando.td@gmail.com
*Corresponding author

Abstract: In this study, we urged manufacturers to practise low-carbon (LC) throughout their supply chain (SC). This paper also highlighted the need for LC practices in the supply chain. A few elements have been discovered to support the necessity for LC practices. For instance, changes in consumer preferences for low-carbon products, low-carbon awareness among customers, stakeholder demand for sustainability practices in the company and government policies are the factors that influence the LC practices in supply chain. However, there are still many manufacturers who need to be educated about this necessity and change their production process due to financial constraints. LC should begin with the supply chain due to supply chain activities contribute significantly to carbon emissions. Low carbon supply chain practices are an effective strategy for manufacturers to reduce their carbon footprint and obtain an advantage over their competitors. Manufacturing can boost revenue, improve company's reputation, and environmentally friendly.

Keywords: low-carbon; carbon emission; supply chain; low-carbon supply chain; stakeholder; firm performance.

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Biographical notes: Norma Binti Mohter is a PhD candidate from the Faculty of Industrial Management, Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA). Recently, she is doing her Doctorate in Supply Chain Management and focusing on low-carbon practices and creating sustainable supply chain. She is currently working with a private college as a Lecturer in the business and management fields.

Yudi Fernando is an Associate Professor at the Faculty of Industrial Management, Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA) and holds a PhD. He is a Visiting Professor at the City University Malaysia. He is the Vice President of the Society of Logisticians, Malaysia/Pertubuhan Pakar Logistik Malaysia (LogM).

1 Introduction

Since the Kyoto Protocol officially came into force in 2005, governments all over the world have been working hard to decrease carbon emissions through a variety of strategies (Abbasi and Choukolaei, 2023). Nonetheless, global greenhouse gas emissions have not decreased. According to current research, human-caused greenhouse gas (GHG) emissions are the primary cause of the fast change in the climate and constitute a serious threat to mankind (Bajan and Mrówczyńska-Kamińska, 2020). A large contributing factor to carbon emissions are a variety of supply chain activities such as material handling, shipping, the manufacturing process, waste product disposal, and product life cycle stage (Jain et al., 2023). The Global Carbon Project (GCP) (2018) reported that the total CO_2 emissions from energy consumption worldwide increased by 1.7% (about 560 million tonnes) in 2018, hitting an all-time high of 33.1 billion tonnes. Between 2030 and 2040, these values are predicted to continue to rise (Sun et al., 2020). In response to climate change, an increasing number of carbon dioxide reduction goals are being devised. As part of this, the United Nations' seventh sustainable development goal (SDG7) seeks to encourage the use of low-cost, reliable, efficient, and clean energy as a means of reducing carbon emissions (CO_2) (United Nations, 2015). Many countries have embraced low-carbon practices, for instance, developing countries like China and India are implementing energy savings and low-carbon efficiency, whilst developed countries in Europe are focusing on carbon capture, carbon effectiveness, and storage. Furthermore, the global carbon capture, utilisation, and storage (CCUS) strategies have carried out several successful projects, including CEMCAPD, CLEANKER, and IEILAC, each of which focuses on the global cement industry (Guo et al., 2024). Aside from that, the US government promotes companies to produce low-carbon products and gives them tax deductions ranging from 10% to 40%. The organisation also actively promotes green marketing, which highlights environmental awareness. With this exposure to respective parties, the major goal of the European countries to achieving zero-carbon emissions by 2050 will be easy to realise.

The main objective of using and developing clean energy is to eventually obtain a cleaner, carbon-free economy. The organisation should change their processes by applying low-carbon practices. The cost from energy systems, carbon emissions, and pollutant emissions can all be decreased with the effective use of clean energy, which can also provide employment possibilities and enhance energy security (Lin and Li, 2022). However, there are still many traditional manufacturing companies that are reluctant to apply low-carbon practices in their supply chain especially high-emission industries (Zhu and Ma, 2023). According to the Green Development Report of China's Private Enterprises, only 53.5% of high-emission industries practice low-carbon strategies in their technologies, production, and policies. Not only that, the supply chain managers also still lack awareness about the importance of applying low-carbon practices in their

supply chain (Jain et al., 2023). Hence, the objective of this paper is to encourage manufacturers to implement low-carbon (LC) practices in their supply chain (SC). The aim is for manufacturers to be able to identify the importance and the positive result from LC practices in the supply chain. Subsequently, the company can implement LC practices in many areas such as production, process, raw materials, suppliers, technologies, etc. The benefits of low-carbon practices apply not only to company financial performance, but also to the company's reputation and environmental impact whereby effects such as clean air and water will also reduce energy loss (Xi et al., 2023).

2 Literature review

2.1 Low-carbon practices

The global temperature rise is caused by the world's population growth, globalised economies, and the industrial revolution. To overcome these issues, an alternative has been proposed called sustainable development. According to Mustaffa et al. (2022), green, sustainable, and low-carbon approaches have been used frequently as indicators of environmental approaches while also driving socioeconomic development. The green ideal is primarily focused on environmental changes. For instance, sustainability is concerned with the three core components that comprise of the economy, environment, and society (Mustaffa et al., 2022). LC practices are activities that will reduce carbon emission. These activities include operation and financing (Shi et al., 2023).

LC practices are the procedures that improve the utilisation of materials or energy, such as leveraging green, innovative manufacturing technologies and improving component distribution systems (Wang et al., 2022b). Moshood et al (2021) divided potential LC activities into four categories. Firstly, product designing that includes packaging design, user term efficiency, waste removal, and product recycling or reuse. Secondly, procurement which includes purchasing, supply chain management, transportation, and waste management. Next, waste management in the output manufacturing process. Finally, the consideration of logistics, which includes consumer shipping, reverse logistics and so on.

2.2 Supply chain management

Fritz (2022) defined supply chain management (SCM) as the process of managing information, finances and physical material flows. This can range from raw material extraction to end product/service delivery to customers in business-to-business exchanges (B2B), or consumers in business-to-customer exchanges, known as business-to-consumer exchanges (B2C). Global SC's goal is to deliver a product/service to customers/consumers while meeting quality, time, and cost objectives. Fritz (2022) also discovered SC stakeholders with sustainability issues by tracing the multiple processes a product/service goes through from the initial components to the end customer (e.g., design, production, distribution). Mentzer et al. (2001, p.18) defined SCM as the systemic, strategic coordination of traditional business functions and strategies across these business functions within a particular company and across businesses throughout the chain with the objective of boosting the long-term performance of the individual companies and the supply chain as a whole. Companies should not focus solely on the

interests of their shareholders, but also on those of other stakeholders, which include organisations or individuals that have an impact or are impacted by the firm's objectives such as the workers, customers, suppliers, local communities, governments, and competitors (Fritz, 2022).

Parashar et al. (2020) define SC as the company's relationships with its suppliers and customers. Companies can become more competitive and reduce cost, which result in profit growth, with the help of their valued chain members. Parashar et al. (2020) also mentioned that organisations cannot operate and execute independently. The SC is an important criterion of competitive advantage. SCM entails working together to exploit a strategic position that focuses on improving operational efficiency and results in downstream advantages for customers. The supply chain is described as the process of transferring resources, information, and resources at several levels including to suppliers, vendors, manufacturers, wholesalers, distributors, retailers, and consumers. SCM includes procurement, production, transportation, and reverse logistics planning, with an emphasis on collaboration, transparency, and cycle time. While Moshood et al. (2021) states that supply chains are comprised of a variety of organisations that work together to fulfil customer needs, including vendors, distributors, logistics and transportation systems, retailers, customers or final user, also governmental regulatory bodies.

3 Current concept

Low-carbon practices have been implemented in many areas such as low-carbon law (Chen, 2023), low-carbon energy (Tian et al., 2022), low-carbon product design (Das, 2021), low-carbon taxation (Yu et al., 2022a), low-carbon food (Yang et al., 2021), and also LC cities (Liu et al., 2022). This LC implementation changes the supply chain process which not only focuses on financial performance, but also environmental and stakeholder benefits. LC initiatives must include the entire process, from the beginning until the end, and use LC materials. This is important for manufacturers to gain competitive advantage from an economical, environmental and social standpoint (Yadegaridehkordi et al., 2023). Insistence from stakeholders about awareness of LC practices must be taken into consideration to avoid a reduced demand for a product that does not meet the customer's expectations. LC practices are needed in SC because of the increasing awareness of the need for sustainable products from the user. According to Olatunji et al. (2019), a few researchers have investigated various factors that affect the application of LC strategies such as customer awareness, supply chain collaboration, rising energy prices, the power position of the primary manufacturing business, and cost reduction. The rising energy prices are because of climate change, which will encourage the company to find an energy substitute.

According to Liao et al. (2022), consumers are now beginning to think about utilising green and LC products to reduce their environmental impact. Customers' increasing preference for LC products is a major driving force for firms to minimise carbon emissions. As indicated by Liu et al. (2021), rising customer awareness of the importance of environmental conservation is driving firms to develop and offer LC products. People's purchasing habits are changing as they become more aware of GHG emissions, particularly in developed nations. Customers are increasingly interested in purchasing LC items because customers are more concerned about the environmental impact of the things they purchase. According to the Bemporad Baranowski Marketing Group's

(BBMG) Conscious Consumer Report (Bemporad and Baranowski, 2007), 90% of Americans prefer environmentally friendly goods and are pleased to pay more for those products. As reported by Qin et al. (2021), from 2011 to 2015, the number of consumers choosing green items on online retailers such as Alibaba climbed nearly 14-fold. Additionally, in the first half of 2017, the renowned shopping platform JD.com saw a 62% year-on-year increase in green consumers, with total sales of green consumption-related goods expanding 18% faster than the platform's overall growth in 2019.

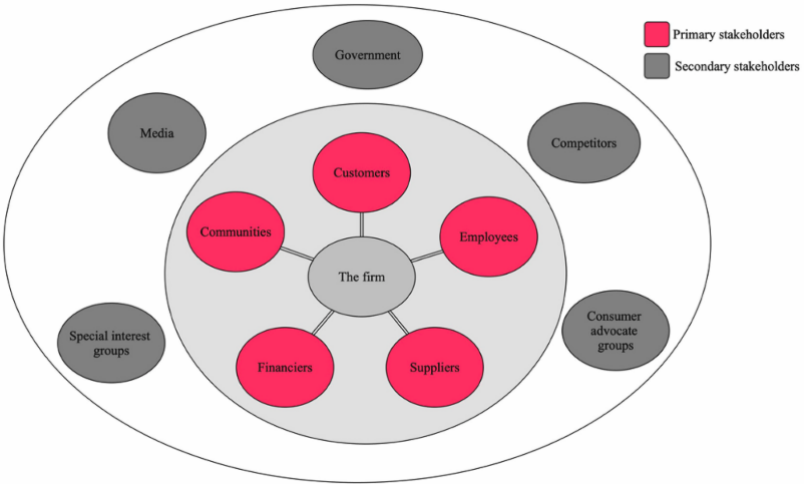
The consumers' preference for LC products along with increased sustainability awareness, price sensitivity and attitudes have resulted in carbon reduction and firm profits. These factors have a positive impact on firm performance. According to Zou et al. (2023), customers often pay attention to environmental attributes when purchasing a product or service. For example, to attract customers' attention, McDonald's has introduced strawless lids to do away with plastic straws. The display of carbon usage on labelling also reduces the negative effects of information asymmetry. Consumers can distinguish if they are consuming low-carbon or high-carbon products and force companies to consider reducing carbon emission on their products. Companies can practice carbon reduction as part of their SCM, which falls into three phases: first, physical distribution management, which focuses on the distribution of the end product; second, logistics management, which focuses on optimising internal operations; and third, the supply chain network, which focuses on integration across organisational boundaries. In China, companies have been forced by the government to participate in research and development of emission reduction technologies to promote carbon reduction policies. This enforcement could aim to encourage consumers to consume environmentally friendly products and services product (Yu et al., 2022a).

A further reason to implement LC practices in SCM is to meet stakeholder demands. A company's stakeholders are described as a group and/or individuals who are affected by the company's decisions or activities. By featuring both primary stakeholders (employees, suppliers, financiers, communities and customers) and secondary stakeholders (media, government, competitors, consumer advocate groups and special interest groups), the company can develop a general strategy to focus on and satisfy the needs of stakeholders (see Figure 1), (Fritz, 2022). Stakeholder engagement and competition strategies drive low-carbon supply chain (LCSC) practices (Luo et al., 2022). Various scholars have interrogated the strategies used by stakeholders in LCSC using the evolutionary game method. As an example, Yuan et al. (2019) studied the basis of the interaction of operational strategies between stakeholders in an LCSC. Furthermore, the competitive and pricing tactics of the supply chain's upstream and downstream actors push firms to continuously compete in the market and promote carbon emission reduction. Seeing as the firm intends to make investments in new technologies and be transparent with consumers, the firm's knowledge of low-carbon and corporate culture has turned into an important factor in supporting the successful operation of LCSCs. This will naturally boost consumer trust and revenues (Esmat et al., 2021).

As a result of this raised consciousness, businesses are inclined to spend more in emerging technologies such as blockchain, big data analysis, and cloud computing to improve supply chain traceability and transparency, raise consumer trust, and foster a balance between financial performance and emission reduction (Luo et al., 2022). Stakeholder pressure, according to Singh et al. (2022), is a motivator for organisations to

implement green initiatives and utilise sustainable resources. This has moved organisations to develop more ecologically friendly products. This pressure enables organisations to shift their basic disciplines, especially marketing, management, and operations from traditional to sustainable practices. Fritz (2022) reported that investors require companies to prove their sustainability performance through indicators such as investor carbon disclosure project. This study was useful for investors to identify the positive and negative impact from their investment towards the environment and society. Companies that do not practice any sustainable program or only focus on profitability, may be unable to satisfy other stakeholder expectations such as customers. Other than that, another reason why LC practices should be applied in the SC is to promote LC cities that are in line with increased environmental awareness and government regulation (Luo et al., 2022). For instance, since 2010, China has been experimenting with creating LC cities. The low-carbon city pilot programme emphasises reducing carbon emissions in urban production and life, which calls for modernising and transforming energy technology, energy efficiency, industrial structures, consumption habits, and even living style. The raw materials that are used should reduce carbon emissions and be sustainable. The development or construction must utilise low-carbon materials in their project.

Figure 1 The firm-centred stakeholder (see online version for colours)



Source: Fritz (2022)

Several LC policies have been implemented by governments around the world to encourage businesses to reduce their emissions. For instance, China's Government proposed to reduce CO_2 emission per unit of gross domestic product (GDP) by 40–45% by 2020. As China is aware that they are the country with the highest released carbon emissions, China's Government enforced the implementation of LC activities such as the development of low-carbon cities (Du et al., 2023), low-carbon development (Chen et al., 2023) and low-carbon supply chain (Yu et al., 2020).

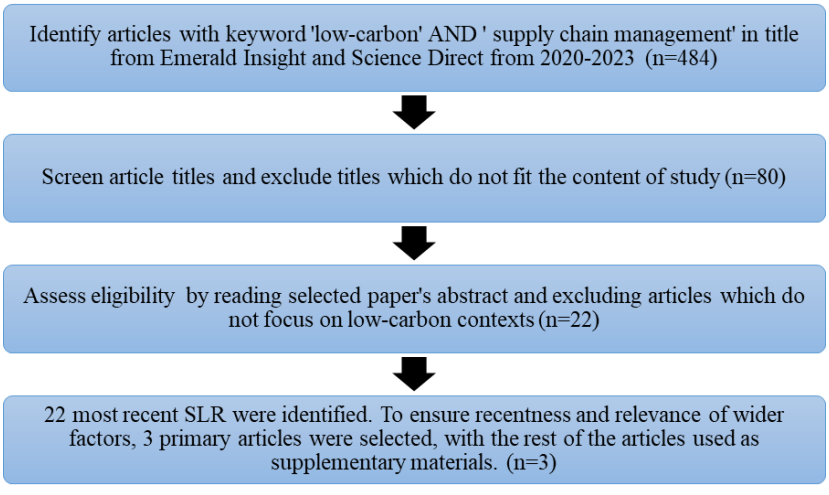
Other than that, to help lessen the damaging effects of carbon emissions on climate change, Luo et al. (2022) states that carbon emissions are used to determine whether a firm's production process is carbon intensive. Carbon emissions are mainly caused by using fossil fuels, agriculture, deforestation, manufacturing processes (e.g., cement

manufacturing), and the use of refrigerant gases. Carbon emissions are classified as direct or indirect emissions depending on the operations and economic activities of enterprises, according to the GHG protocol. LC practices are needed in supply chain management to achieve sustainable development and reduce energy consumption and pollution throughout the supply chain (Luo et al., 2022). For instance, by practicing LCSCs, organisations will be able to achieve better carbon emission standards, gain competitive advantage, be environmentally friendly, and increase social welfare. The entire process in SCs must comply with low-carbon in entire process, practices, and development. Each member in the supply chain must be monitoring and tracking their carbon emissions to ensure that all parties fulfil all the standards that have been specified by the company. For instance, Singapore intends to further reduce its power sector's carbon footprint by importing approximately 30% of its electricity from low-carbon sources such as renewable energy plants by 2035. Singapore has imported 100 megawatt (WT) from YTL PowerSeraya Pte Ltd and PacificLight Power Pte Ltd. from Peninsula Malaysia and Indonesia respectively. These collaborations can function because these companies have the same goal to nurture sustainability and strengthen cross-border energy.

4 Methods

A critical assessment of extant literature on LC processes and SCM is focusing on systematic literature reviews (SLR) assessment publications. The SLR is limited to the most current papers published in Science Direct and Emerald Insight from 2020 to 2023. Following the initial search, 484 papers were found. The screening procedure was then carried out manually to choose titles related to low-carbon practices and supply chains. The screening method decreased the number of relevant papers to 80. Identified papers were subsequently filtered for content eligibility using abstracts to eliminate studies that did not fall inside the intended context. There were a total of 22 publications examined for analysis. Three of the 22 papers were the most current, published in 2023.

Figure 2 The research process



There were three papers covering the topic of low-carbon practices and supply chain management. Liu et al. (2021), Luo et al. (2022) and Yadegaridehkordi et al. (2023) are the major references for this study because of their relevance and timeliness.

In addition, other publications are used as supplementary elements. Table 1 shows the final count of articles chosen for analysis in this study.

Table 1 Summary of papers considered for analysis on this study

Literature context	*Author and year*
Low-carbon supply chain	Zheng et al. (2023), Tong et al. (2022), Luo et al. (2022) and Fritz (2022)
Stakeholder pressure for low-carbon	Singh et al. (2022) and van Vliet et al. (2020)
Consumers' low-carbon preferences	Das (2023), Cheng et al. (2022), Liu et al. (2021) and Sun et al. (2020)
Green and low-carbon practices in supply chain	Du et al. (2023), Yu et al. (2022a), Wang et al. (2022b) and Moshood et al. (2021)
Low-carbon effects on organisation performance	Yadegaridehkordi et al. (2023) and Yu et al. (2022b)
Low-carbon drivers on organisation	Chen et al. (2023) and Mustaffa et al. (2022)
Low-carbon information sharing in green supply chain	Wang et al. (2022a)
Low-carbon development	Lin and Li (2022)
Low-carbon transition	Tian et al. (2022)
Low-carbon law	Chen (2023)

Source: Author

5 Ideal vs. current practices

This section summarises the need for low-carbon practices in supply chains from the three primary reference SLR papers. The time frame of these SLR was relevant as they were from 2021, making these papers the most recent SLR on the said related topics. The SLR by Liu et al. (2021), Luo et al. (2022) and Yadegaridehkordi et al. (2023) are the study's key consideration to derive the proposed conceptual framework. These scholars have synthesised the body of knowledge and identified the need for low-carbon practices in supply chains.

Liu et al. (2021) investigate the theoretical framework that discusses the influence of consumer preferences for low-carbon products on supply chain performance. They had found that many supply chain enterprises change to low-carbon supply chain practices because of changes in consumer behaviour. Customers are increasingly eager to buy low-carbon items. Consumers are becoming more concerned with the quality and environmental impact of the things they are purchasing. The organisations believe that in the foreseeable future, low-carbon products will increase competitiveness. The demand for low-carbon products is increasing and growing day by day because consumer preferences are shifting to low-carbon products. This is also due government carbon emission restrictions whereby supply chain businesses are under pressure to minimise their carbon emission. Therefore, supply chain companies are looking for better

approaches to reduce carbon emissions. With customer tastes shifting towards low-carbon products, lowering emissions can increase supply chain enterprises' competitiveness. In accordance with their findings, consumers prefer low-carbon items and ready to pay greater money for them. This can encourage all supply chain participants to adhere to government laws and market expectations in order to apply low-carbon practices.

According to Luo et al. (2022), supply chain management and carbon emissions have a substantially positive relationship. Many scholars are interested in low-carbon supply chain management procedures. The researchers separated the low-carbon practises supply chain into five clusters. The first cluster is LC in logistics management. The mode of transportation, vehicle selection, and new logistics modalities are all general elements that contribute to carbon emissions in logistics management. Air, water channels, highways, and train are the primary modes of transportation, each of which emits a distinct quantity of CO_2. Light-duty transportation accounts for over 58% of total emissions. Medium and heavy-duty vehicles, such as trucks, contribute around 24% of CO_2 emissions, whereas freight routes comprise of only 10%. As a result, vehicle selection, particularly electric vehicles and vehicles that use substitute fuels, for example, biomass fuels, play a critical role in carbon reduction. Traditional logistical practises only focus on decreased transportation costs and customer demand satisfaction, which relates to the quick arrival of the product. However, in order to become a green city or country, the organisations must restructure its facility and transportation issues to adhere to low-carbon practices.

The second cluster is carbon accounting in SCM. With rising consumer environmental awareness and low-carbon selections, there has been an increase in the optional disclosure of environmental information such as a company's annual reports and management reports to maintain customer loyalty and market competitiveness. With this disclosed, it helps firms to make decisions about which fields should be improved by allocating more carbon emission efforts. The SCM pattern and structure has been drawn-out to a new field where it is introducing information disclosure such climate change data, carbon labels and carbon footprint recognition.

The third cluster is driving forces of LCSC such as the government policies, consumer's demand for green and low-carbon products, stakeholder collaboration and competition strategies. These factors initially encourage firms to be aware of the need of low-carbon practices. The firm can benefit from these practices by promoting the positive effects of low-carbon practices and profits in supply chains. At the same time, these low-carbon practices may also be part of corporate social responsibility for the firm.

The fourth cluster is sustainability management in SCM. Luo et al. (2022) divided this cluster into three dimensions which are purchase strategy, innovation management and coordination. When the firm chooses green suppliers, the firm can save cost, maintain quality and reduce lead time where the firm can easily change to low-carbon practices because the suppliers can fulfil their needs. Other than that, with innovation in SCM, the firm can identify new technologies that are relevant to their production. Lastly, SCM collaboration with carbon economy has significantly increased. The enforcement of government's policies, consumer low-carbon preferences and supply chain member's openness force firms to adopt this collaboration.

The fifth cluster is barriers to apply low-carbon practices in SCM. The last cluster discusses obstacles that exist for firms to implement low-carbon practices, such as not

receiving financial support such as capital or resources, a scarcity of data or knowledge sharing among firms, shortfall of collaboration among supply chain members, and some uncertainties (suppliers' capacity, storage capacities, and yield uncertainty).

Yadegaridehkordi et al. (2023) study reported the determinants of a firm being sustainable are from the stakeholder pressure and market orientation. In this study, they identified five factors that determine the need for low-carbon practices in supply chains. However, only two factors are taken into consideration as the reason for the need of low-carbon practices. Firstly, stakeholder pressure has a positive impact on low-carbon practices. Due to increasing environmental awareness, firms are under pressure to change their processes to fulfil stakeholder demands. Internal and external stakeholders such as customers, the government, suppliers and business owners themselves are demanding for ecological products. This has forced firms to incorporate sustainability into their corporate culture. If the firm is not able to fulfil this, the firm will lose its competitive advantage. On the other hand, Yadegaridehkordi et al. (2023) also identified that market orientation is also one of the driving factors as to why low-carbon practices are needed in the supply chain. They mentioned that the demand for sustainable products from customers has increased to support environmental awareness.

The manufacturing should change the whole SC process to be LCSC, not only focus on few processes. This will be beneficial to manufacturing as it will improve efficiency of a firm (Wang et al., 2022a), increase their effectiveness, cause them to gain a competitive advantage and profit growth. The goal of knowledge management is to achieve knowledge re-creation by sharing, transferring, absorbing, utilising, and integrating knowledge across disciplines, so completing the collaborative innovation process. An outcome of this will be that suppliers and manufacturers can communicate with one another and exchange information. Many investigations concentrate on the impact of LC practices on supply, but few investigate the necessity for LC in SC. For example, Bai et al. (2019) explore the consequences of carbon emissions on the supply chain but provide little explanation about government and customer pressure. Several factors should influence the transition from open loop to closed loop.

Current practices do not investigate all stakeholders such as the media's role to spread LC practices, lack of support from the organisations due to high cost when organisations implement low-carbon practices. According to Lu and Sun (2021), manufacturers choose to continue using regular production modes to save cost. This is because it was found that the cost of low-carbon technologies is high.

6 Proposed framework

For data collection, the distribution of questionnaires and the use of PLS-SEM are an effective tool that allows researchers to simultaneously assess the relationships between multiple constructs and measures, which are impossible with multiple regression method and proper respondents (Al-Omoush et al., 2023). The questionnaire method is suitable for quantitative studies where the right respondents who meet the criteria can be interviewed. The self-assessment questionnaire and the framework indicator were proposed to help companies to position themselves on their stance on LC practices (Konash and Nasr, 2022). An email and postal technique are conducted to obtain feedback from the respective respondents. In addition to friendly reminders through the online portal, the research team called the target respondents and politely asked them to

complete the questionnaires. SmartPLS software and the PLS-SEM approach were used to discover the significant determinants of outcomes. PLS-SEM was a measurement model estimation technique that used the PLS algorithm to confirm the reliability and validity of the questionnaire instrument (Yadegaridehkordi et al., 2023). This method's output could have an impact on environmental, social and financial performance.

The results show that low-carbon products significantly improve the competitiveness and economic performance of the company, and that a proactive environmental strategy significantly affects the relationship between low-carbon product design and the competitiveness of the company. The objective of sustainable operations is to enhance companies by reducing the external environmental impacts caused by production. If the company produces products that have fewer environmental impacts during their life cycle, the firm can improve their energy efficiency through the use of green technologies and by reducing solid waste and emissions through the right technology. Previous studies have shown that green operations positively improve a company's performance, for instance in terms of their environmental impact (Karaman et al., 2020, Das, 2021). The results of the study show that low-carbon operations significantly improve the economic performance and competitiveness of companies and this encourages them to apply similar practices in the future (Das, 2021). The typical supply chain model was analysed in terms of the impact of energy consumption and greenhouse gas emissions. This analysis shows the importance of minimising carbon emissions (Karthick and Uthayakumar, 2022). Companies use a range of ways to reduce carbon emissions and energy consumption at different stages of the process. Manufacturing practices that may be used to minimise carbon emissions include carbon efficient sourcing and delivery, carbon efficient manufacturing, carbon efficient warehousing, carbon efficient logistics, and carbon efficient customer service (Olatunji et al., 2019).

Another finding from Yang et al. (2021), in food industries is customer preferences for high carbon footprint (CF) food and low-carbon footprint food. Customers' preferences for carbon labels and health carbon labels were also examined. Customers want to know how many percent that the company had reduced or used on production. Labelling on packaged goods is one strategy for communicating information to customers in order to improve sustainable food consumption. Healthy labels, for example, provide people with nutrient information to assist consumers in making healthier choices, whereas carbon labels reflect a product's accreditation. Carbon tagging has received a lot of attention recently since reducing GHG emissions has been a topic of interest for researchers, governments, and organisations. Some studies have found that customers favour carbon labelling on a variety of commodities, including meat, yoghurt, and vegetables. Carbon labelling has a significant impact on consumers' propensity to acquire low-carbon items as well as to enhance consumers' views regarding low-carbon products. They also mentioned the positive significant relationship between low-carbon products and consumers preferences. Stakeholder pressure also has positive significance in relation to competitive advantages (Singh et al., 2022; Baah et al., 2021). When the organisation finds the right supplier that is able to provide LC material, they can fulfil the stakeholders' need for low-carbon products (Zheng et al., 2021), food (Parashar et al., 2020), cities (Du et al., 2023) and logistics (Liang et al., 2022).

7 Discussion

The findings indicate that lowering carbon emissions boosts a company's economic performance (Kannan et al., 2022). By engaging in low-carbon operations, businesses can minimise waste, increase efficiency in managing resources and improve product quality. As a result, by designing low-carbon products, firms can enhance their profitability. Similarly, the outcomes of the study suggest that a firm that produces low-carbon products can boost a company's competitiveness. The previous study has demonstrated by using green design strategies, that firms can have better corporate image and reputation, which will eventually attract customer interest and promote company advantages. Mitra and Datta (2014) state that supportive collaboration with suppliers is able to contribute to enhanced innovation also boosting the company's competitiveness. By implementing low-carbon design strategies such as designing products with lower environmental impacts, conducting life cycle assessments for their products, and using less hazardous materials, manufacturers can develop a more positive image, expand market share, enhance cost efficiency, and improve product quality. The study also demonstrates that an aggressive environmental approach is able to alter the relationship between low-carbon product design and competitiveness positively. For example, previous findings support the link between environmental policy and corporate competitiveness (Das, 2023). This means that industrial enterprises can conduct proactive environmental actions such as participating in environmental development and innovation with other supply chain members.

8 Conclusions

Yu et al. (2022a) stated that collaboration among supply chain members will be beneficial to each other especially as it will increase competitive advantage as well as profits. Organisations should apply this strategy to increase their performance especially consumer awareness about their responsibility and implementation of SDGs programs. With these practices, organisations will ably fulfil the needs of stakeholders and generate profit. Other than that, the implementation of LCSC has been widely practiced in some countries such as China, Australia, the UK and the USA (Bose and Khan, 2022). This LCSC is practical for organisations to be sustainable. It does not only cover the materials and production but also can be applied to technology, logistics, information and finance.

The role of LC practices in manufacturing is important because of the driving factors from customers, stakeholders, and the awareness of lessening the impact to the environment. Especially after during COVID-19 pandemic, many consumers are now demanding hygienic and sustainable products as one of their alternatives to keep the environment clean. Other than in logistics systems, less transportation movement will reduce air pollution. The global drop in carbon emissions during the lockdown was driven by a decrease in transportation activities due to restrictions. The USA had the greatest reduction in carbon emissions, at 12%, followed by the European Union, at 11%. India reduced emissions by 9%, whereas China reduced emissions by 1.7% (CNBC, 2022). Due to this, many manufacturers now produce sustainable products or have sustainable processes to make sure that this percentage keeps dropping. Hence, it is important for organisations to integrate LC practices in their supply chain in order to gain a myriad of benefits.

9 Limitations and future research

The limitation in this study is many organisations widely discuss their reasons being a sustainable organisation in supply chain process either upstream or downstream. The organisation must not only be concerned about their profit but must consider the benefits gained by their employees as one of the primary stakeholders. Many researchers focus on consumer preferences, shareholder objectives and government policies as proving the need for LC practices, but less discussion is had from an employee's perspective. The employees are also resources in SC that will contribute to low-carbon practices. For future study, the researchers must take into consideration driving factors from all types of stakeholders such as pressure from media, special groups of interest and consumer advocate groups. This is important to identify the relationship between other stakeholders in the SC. Also, it is worth studying the implication of LCSC in organisation. This research will help organisations to identify benefits of applying LCSC in their organisation. This research also can encourage organisations to apply a low-carbon supply chain in their organisation.

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