Circular supply chain management: Performance outcomes and the role of eco-industrial parks in China

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Abstract

A circular economy (CE) is increasingly recognized as a more environmentally sustainable alternative to the dominant linear take-make-dispose economic model. We empirically investigate the effect of circular supply chain management (CSCM) on cost and financial performance in China, which has established the world's largest system of eco-industrial parks (EIPs) to promote CE over the last decade. We combine the Natural Resource-Based View (NRBV), Contingent NRBV and the literature on CSCM to develop a conceptual model and test it using survey data collected from 255 Chinese manufacturing firms. The results show that CSCM, when exercised as a unified strategy, has a significant positive effect on cost and financial performance. Firms located within EIPs adopt CSCM at higher levels as compared to firms located outside EIPs. Nevertheless, the contextual factor of being located within an EIP does not moderate the CSCM practice-performance relationship, suggesting that performance is driven by practices rather than firms' locations. These results were affirmed by post-survey participant validation in three focus group meetings and six face-to-face interviews. Our findings contribute to sustainability literature by offering a new construct and measurement items relevant to CSCM and provide practical insights to guide a transition to a CE.

Keywords: Circular supply chain management; Circular economy; Eco-industrial parks; Practice; Performance

Article Classification: Research paper

1. Introduction

In the long term, the current rate of natural resource consumption around the world will pose challenges for environmental and economic sustainability. According to the UNEP's International Resource Panel (2019) report, in the last 50 years, extraction of natural resources has gone up by over three times, creating an annual resource demand exceeding what the earth can regenerate. The circular economy (CE) can significantly reduce the consumption rate of virgin natural resources (Mathews et al., 2018). CE differs from the traditional "take, make, dispose" economic model as it aims to develop a restorative and regenerative industrial system by design, thus decoupling economic development from resource extraction and environmental impacts (Ellen MacArthur Foundation, 2019; Gartner, 2019). Given its promising vision, countries including China, United States, United Kingdom, and many European Union (EU) nations, have embraced the CE philosophy.

In the last few years, CE has received more attention in the supply chain sustainability literature and practice (Agrawal et al., 2019; Bai et al., 2020; Genovese et al., 2017; Govindan et al., 2020; Nasir et al., 2017; Van Wassenhove, 2019). According to Gartner (2019), leading global companies, such as Coca Cola, Apple, Dell, HP, Cisco Systems, and AkzoNobel, are investing in innovations to increase circularity in their supply chains. For example, Coca Cola invested €13 million to establish plastics recycling plants in the UK and France, outside of its core business model (Ellen MacArthur Foundation, 2021a).

Traditional supply chain sustainability concepts, such as sustainable SCM, green SCM, and closed loop SCM, have been extensively studied in the literature. Circular supply chain management (CSCM), which Farooque et al. (2019b) define as *"the integration of circular thinking into the management of the supply chain and its surrounding industrial and natural ecosystems"* (p. 884), is still at its nascent stage of development. A key difference relative to traditional supply chain sustainability concepts, is that CSCM applies a zero-waste vision (Veleva et al., 2017) and enables value recovery not only within the original supply chains but across different supply chains through collaboration with firms in the same industrial sector and/or other sectors (Genovese et al., 2017; Weetman, 2017). Further, although research shows a positive relationship between supply chain sustainability and firm performance (Govindan et al., 2020), the relationship of CSCM with firm performance, remains largely unexplored in the academic literature (Agrawal et al., 2019). However, the financial benefits of CSCM have been reported in practice (Zhang et al., 2021). For example, HP's CE initiative in Brazil suggests that CE implementation resulted in up to 30% cost reduction, while 97% of the collected materials and components were reincorporated into their supply chain (Ellen MacArthur Foundation, 2021b).

CE is not only implemented at the firm-level but can be used by a collection of firms in industrial parks or at a macro-level by cities, provinces, and regions (Ghisellini et al., 2016; Zhijun and Nailing, 2007). As part of its CE strategy, China transformed some industrial parks into eco-industrial parks (EIPs) to close loops in resource flows and reduce waste over a system of firms (Mathews et al., 2018). However, there is a lack of knowledge on the role of EIPs and their CE practices from supply chain perspective (Bansal and Mcknight, 2009). Moreover, in China, some, but not all, of the traditional industrial parks and export processing parks have been transformed into EIPs. Therefore, many manufacturing firms in China still operate outside EIPs. Thus, firms' location (i.e., inside or outside of EIPs) may be considered as a proxy for CSCM adoption with significant implications for firm performance.

Given these knowledge gaps, this research is set to address the following key question:
"What is the impact of CSCM on firm performance and how does being located in an eco-industrial park (EIP) affect the CSCM to performance relationship?" We empirically examine how CSCM adoption affects firm performance in Chinese manufacturing industries using a large-scale survey study at a supply chain level, followed by post-survey participant validation for data triangulation. This study makes several original contributions. First, drawing upon the firm's Natural Resource-Based View (NRBV) (Hart, 1995; Hart and Dowell, 2011), and a review of the existing literature, this study theorizes and develops a new construct, CSCM, to measure the extent of CE implementation at a firm and supply chain level. We incorporate material circularity in CSCM which is significantly different from the earlier studies of Cheng et al. (2021) and Zhu et al. (2010; 2011), which did not include material

circularity in the measurement items related to CE practices. Second, taking a contingent NRBV perspective, this study examines whether being located in an EIP moderates the CSCM-to-firm performance relationship. Overall, China provides a suitable context for examining CSCM-to-firm performance relationship, considering the Chinese government's stance on promoting CE as a mainstream national policy for about two decades. These contributions differentiate the research from previous studies in the supply chain sustainability domain.

The paper is organized as follows. In section 2, we present the theoretical background followed by hypotheses development in section 3. In section 4, we describe the research methodology. Next, we present the study results in section 5. Discussion on research findings and their implications are presented in section 6. Conclusions, research limitations and future research directions are provided in section 7.

2. Theoretical Background

2.1 CSCM: A new sustainability discourse in SCM

The integration of CE in SCM is not new. According to a recent literature review on CSCM by Farooque et al. (2019b), the term "circular supply chain" first appeared in 2006. Since then, a number of studies (for example, Genovese et al., 2017; Nasir et al., 2017) linked CE with SCM. However, it was not until Farooque et al. (2019b) that a formal definition of CSCM was established as *"the integration of circular thinking into the management of the supply chain and its surrounding industrial and natural ecosystems. It systematically restores technical materials and regenerates biological materials toward a zero-waste vision through system-wide innovation in business models and supply chain functions from product/service design to end-of-life and waste management, involving all stakeholders in a product/service lifecycle including parts/product manufacturers, service providers, consumers, and users"* (p. 884). More recently, a comparative review of academic research and practical implementation cases by Zhang et al. (2021) shows that CSCM encompasses multiple dimensions, including closed-loop SCM, reverse SCM, remanufacturing SCM, recycling SCM, and industrial symbiosis.

The emerging CSCM concept makes three major advancements in the supply chain sustainability domain. Firstly, CSCM involves restorative (for technical materials) and regenerative (for biological materials) cycles designed based on CE philosophy. It represents a paradigm shift in supply chain sustainability research from a linear "cradle-to-grave" to a circular "cradle-to-cradle" approach (Genovese et al., 2017). Secondly, the zero-waste vision of CSCM goes beyond the boundary of sustainable SCM (Paulraj et al., 2017) and green SCM (Li et al., 2019; Liu et al., 2020; Schmidt et al., 2017) by encouraging the use of non-virgin materials through a systematic resource circulation within supply chains (Genovese et al., 2017; Koh et al., 2017). Thirdly, CE offers a broader sustainability perspective as compared to closed-loop supply chains (CLSCs) (Van Wassenhove, 2019). CSCM does not restrict the scope of value recovery from end-of-life (EoL) products to within the producer's supply chain. In a circular supply chain, firms collaborate with other firms within and/or outside the original industry sectors (Weetman, 2017) including secondary supply chain networks and/or involving new auxiliary players for recovering value from EoL products and/or wastes.

Some recent studies based on the traditional supply chain sustainability concepts have recognized the importance of transitioning towards a CE (see, for example, Genovese et al. (2017); Li et al. (2021); Van Wassenhove (2019). However, none of these studies present a unifying CSCM strategy. Similarly, some early works by Zhu et al. (2010; 2011) attempted to conceptualize CE practices at the firm level however, they did not account for circularity in the measurement items related to CE practices. Their CE practices construct was a repositioning of measurement items of green SCM (see, for example, Zhu and Sarkis (2004) for measurement items related to green supply chain practices. Likewise, the CE practices construct adapted in recent studies has been measured using the same measurement items (see, for example, Cheng et al. (2021). Thus, new metrics that reflect the circularity in the relevant practices are needed.

2.1.1 CSCM Practices

We conceptualize four CSCM practices, namely circular product design, circular procurement, cleaner production, and EoL product and waste management. Table 1 compares the CSCM practices with the related constructs from the literature.

In the transition to a CE, the design function needs a fundamental change as it greatly influences the entire value chain of the product system. Research identifies the importance of design function in order to minimize products' environmental impacts over their useful life and afterwards (Brezet, 1997; Cai et al., 2022; Zhu et al., 2007b). Circular product design introduces design principles based on circularity and end-of-life thinking (i.e., a cradle-to-cradle approach), which are distinct from previous design concepts reflected in supply chain sustainability research (Burke et al., 2021; Farooque et al., 2019b). The cradle-to-cradle approach emphasizes product design to continuously improve and ultimately achieve the indefinite circulation of resources. Moreover, circular product design strategies mainly focus on slowing and closing resources loops (Bocken et al., 2016) by designing long-life products and extending product-life thereby maintaining product integrity (i.e., preventing and reversing product/component obsolescence (den Hollander et al., 2017). Closing resources loops may be achieved by designing products for technical and biological cycles with simplified disassembly and reassembly.

Green purchasing (Min and Galle, 2001) and environmental purchasing (Carter and Carter, 1998) practices are seen as environmentally-conscious ways of sourcing raw materials but do not integrate CE philosophy in the purchasing function. The principles of CE assume that raw materials used must not have any harmful effects on the environment (Genovese et al., 2017). Therefore, circular procurement strives for the use of natural, non-virgin, renewable, biodegradable/restorable and non-hazardous materials, contributing to closing energy and material loops within supply chains (European Commission, 2020). From a practical viewpoint, circular procurement may create vertical and horizontal collaborations focused on developing circular resource flows, adding new procurement channels and reducing costs through sharing or reuse of resources. For example, companies operating inside Kalundborg Symbiosis, an eco-industrial park in Demark, share and reuse energy, water, and materials saving money and minimizing waste (Ellen MacArthur Foundation, 2021c).

Manufacturing/production-related practices significantly influence environmental impacts (van Berkel et al., 1997) but they are rarely included in empirical supply chain sustainability studies. Cleaner production, which is considered as one of the key firm-level CE practices (Bilitewski, 2012; Ghisellini et al., 2016; Sousa-Zomer et al., 2018), has largely been studied as a standalone practice, for example, see Hicks and Dietmar (2007) and Zeng et al. (2010). Consequently, there is a lack of knowledge on the role of manufacturing/production practices as part of an integrated strategy for sustainability in supply chains (Farooque et al., 2019b; Sousa-Zomer et al., 2018). Thus, there is a need for a systems approach, examining cleaner production as part of CSCM. For example, cleaner production practices contribute to pollution prevention and waste reduction (Su et al., 2013); however, there is a need to continuously improve the related processes to achieve the zero waste goal of CSCM. Similarly, investment in new equipment may be needed for cleaner production practices to improve material/energy conservation and efficiency.

To establish circularity in supply chains, EoL products and waste management activities play a critical role in recirculating and recovering residual value within the product system. This involves a systematic approach towards managing circular resource flows through effective reuse, refurbishing, remanufacturing and recycling strategies for technical materials and compositing, waste-to-energy production and anaerobic digestion for biological materials by means of a supporting collection and treatment system (Farooque et al., 2019b). Unlike the reverse logistics systems and network (as emphasized in the traditional supply chain sustainability concepts), resource recirculation and value recovery in circular supply chains extends beyond the original supply chains (Farooque et al., 2019b). Rather, firms engage in collaborative arrangements within and outside their industrial sectors to maximize the utilization of used and/or EoL products and materials instead of sending them to landfills (Farooque et al., 2019b; Van Wassenhove, 2019). Therefore, the EoL product and waste management activities present a broader scope which is not restricted to managing reverse flows in the original supply chains rather it considers the entire product system for resource recirculation and value recovery purposes.

Table 1: CCSM practices vs SCM sustainability practices

CSCM Practice	Related Construct(s)	Key Differences
Circular product design	**Eco-design** (Bovea and Pérez-Belis, 2012; Brezet, 1997; Luttropp and Lagerstedt, 2006) **Design for environment** (Cucciella et al., 2012; Sarkis, 1998; Sroufe, 2003) **Green design** (Golicic and Smith, 2013; Sonia, 2014; Vachon and Klassen, 2006a; Zhu and Sarkis, 2007) **Sustainable product design** (Chen et al., 2012; Kleindorfer et al., 2005)	Circular product design and competing design concepts differ in terms of principles, strategies and methods (for detailed discussion please see, Bocken et al. (2016); den Hollander et al. (2017)). Circularity and end-of-life thinking are an integral part of circular product design philosophy (Farooque et al., 2019b).
Circular procurement	**Green procurement** (Blome et al., 2014; Carter and Jennings, 2002) **Green purchasing** (Min and Galle, 1997; Sonia, 2014; Zsidisin George, 1998) **Environmental purchasing** (Carter and Carter, 1998; Carter et al., 1998; Carter et al., 2000)	CE principles have remained absent in the extant green and environmental purchasing practices (Farooque et al., 2019b). Circular procurement focuses on the use of non-virgin raw material contributing to the closed loops of energy and material within supply chains (European Commission, 2020).
Cleaner production	**Sustainable manufacturing/production** (Golicic and Smith, 2013; Linton et al., 2007) **Green manufacturing** (Li et al., 2020; Mao and Wang, 2019; Sonia, 2014; Zhu and Sarkis, 2007)	An explicit focus on manufacturing/production practices has been missing in the extant supply chain sustainability research. Cleaner production is considered to play a key role for CE implementation at a firm level (Ghisellini et al., 2016). However, the topic has received more attention as a standalone sustainability practice and has seldom been reflected as part of an integrated strategy for sustainability in supply chains (Farooque et al., 2019b; Sousa-Zomer et al., 2018). Furthermore, there is a need to examine the influence of cleaner production principles and practices on other CSCM practices for achieving the CE goals.

EoL product & waste management	**Reverse logistics** (Carter and Ellram, 1998; Kleindorfer et al., 2005; Van Hoek, 1999) **Green logistics** (Dekker et al., 2012; Lai and Wong, 2012; Murphy Paul, 2003; Sonia, 2014) **Environmental recycling and waste practices** (Pullman et al., 2009; Sroufe, 2003)	Transition from narrowly-focused closed-loop recycling in original supply chains to a systematic approach towards resource recirculation and value recovery at a broader level including collaborative arrangements within and outside of original supply chains and industrial sectors (Farooque et al., 2019b).

2.2 NRBV and CSCM

The NRBV (Hart, 1995; Hart and Dowell, 2011) emerged as an extension to the resource-based view (RBV) of the firm. The RBV explains how firms achieve and sustain competitive advantage by utilizing their unique resources and capabilities. Hart (1995) proposed NRBV by extending RBV to include a relationship between a firm and its natural environment. Overall, NRBV suggests that using proactive environmental strategies can enhance organizational performance (Graham and Potter, 2015; Hart and Dowell, 2011).

The NRBV argues for developing a dynamic capability of proactive environmental strategies including: pollution prevention, product stewardship and sustainable development for sustained competitive advantage (Hart, 1995). *Pollution prevention* focuses on eliminating emissions, effluents and waste, which can reduce costs and lead to a competitive advantage. *Product stewardship* enables firms to minimize the life cycle burden of products by engaging stakeholders to incorporate environmental concerns into product design and development. Finally, *sustainable development* involves closely engaging with external stakeholders to build a shared vision for minimizing a firm's environmental impact, increasing competitiveness in the long term (Hart, 1995).

The NRBV has been a key theoretical lens in supply chain sustainability research (Cucciella et al., 2012; Graham and Potter, 2015; Schmidt et al., 2017). However, most of the empirical research on NRBV focuses on pollution prevention strategies, whereas product stewardship or sustainable development strategies have received much less attention (Hart and Dowell, 2011). In this study, we consider two of the three interconnected strategies of NRBV, namely pollution prevention and product stewardship. The sustainable development strategy is mainly concerned with the industrial level decisions which goes beyond the scope of this research.

The CSCM construct presented in this research relates to the NRBV's pollution prevention and product stewardship strategies. Cleaner production, which represents the environmental efforts of a firm's internal operations, is aimed at preventing pollution at its source in the production process on a continuous improvement basis (Buysse and Verbeke, 2003; Cucciella et al., 2012; Paulraj et al., 2017; Thoumy and Vachon, 2012; Vachon and Klassen, 2006b). Circular product design and circular procurement are proactive stances to minimize a product's environmental impact and are aimed at realizing product stewardship through strong stakeholder engagement (Cucciella et al., 2012; Hart and Dowell, 2011). Moreover, EoL and waste management represent "take-back" strategies for resource recirculation and recovery as part of the broad product stewardship strategy (Hart, 1995).

2.3 Contingent NRBV

Previous research in supply chain sustainability has extensively studied the practice-performance relationship; however, only a few studies have assessed the impact of contingency factors affecting the environmental strategy to competitive advantage linkage (Hartmann and Vachon, 2018; Schmidt et al., 2017). These studies provide empirical support to the contingent NRBV proposition that firms possessing similar capabilities may develop different approaches to environmental management and/or obtain differential levels of competitive advantage with similar environmental strategies (Aragón-Correa and Sharma, 2003). In this regard, identification of the contingencies affecting CSCM-to-firm performance relationship would be of great theoretical and practical significance. We explore whether being located within an EIP affects the CSCM-to-firm performance relationship as a contingency factor.

According to Lowe's (2001) most commonly accepted definition, "an eco-industrial park is a community of manufacturing and service businesses located together on a common property. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues” (p.1). In China, the EIP concept was first introduced by the United Nations Environment Programme in 1997 (Shi et al., 2012). The Ministry of Ecology and Environment of China (previous names: ‘Ministry of Environmental Protection’ and ‘State Environmental Protection Administration’) started the promotion of EIPs in the country and established the first national trial EIP in August 2001 (Zhu et al., 2007a). Since then, the Chinese government has instituted laws, policies, and regulations, and provided financial support to develop and promote EIPs for achieving sustainable industrial development and CE goals (Zhu et al., 2015). According to Mathews et al. (2018) and Geng et al. (2019), so far China has strategically developed more than 50 certified EIPs mainly by converting existing industrial parks into EIPs.

Firms operating inside EIPs get involved in buyer-supplier relationships of a highly symbiotic and complex nature, whereby they exchange physical materials, energy and services among themselves (Chertow, 2000). Firms within EIPs can use by-products and waste from others as inputs, thus saving on raw material purchase and waste disposal costs (Mathews et al., 2018). In this regard, EIPs allow firms to obtain resources more easily and better than competitors (i.e., firms outside EIPs). However, at the same time, this presents unique challenges and uncertainties for firms when comparing firms’ operations in an EIP (i.e. industrial symbiosis) with typical supply chain network operations. It is mainly due to the fact that the products exchanged in industrial symbiosis networks are outside the core business of typical manufacturing firms (Herczeg et al., 2018). Moreover, the exchanges are not usually available upon demand, and the quantity and quality vary based on other factors such as production volume and production technologies being used by other firms in the industrial symbiosis network.

3. Hypothesis Development

3.1 CSCM and firm performance

According to the seminal work of Zhu and Sarkis (2004) on green supply chain management, economic performance outcomes include both negative and positive aspects. CE often requires major initial investments such as increased training cost, new equipment or process modifications (Geng et al., 2009) which can increase costs in the short term (Li et al., 2019). Factors such as lower energy costs, savings from using recycled/reused materials, and reduced fees for waste discharge and treatment can reduce costs over the long-run (Mathews and Tan, 2016). Further, some customers may even seek out companies using CE practices potentially increasing their sales. These competing forces sheds light on the contradictory findings related to the economic benefits of CE implementation.

As explained in the preceding section, the NRBV theorizes a positive association between proactive environmental strategies and sustainable competitive advantage (Hart, 1995; Hart and Dowell, 2011). In this research, we do not consider the short-term negative impact of investments for CE and CSCM; rather, we employ the NRBV as a theoretical lens to hypothesize the performance outcomes of CSCM implementation, focusing on long-term performance indicators which are likely to reflect a sustainable competitive advantage. Moreover, for analysis purposes, we divide the broad aspect of economic performance into two dimensions i.e., cost performance and financial performance. Cost performance focuses on costs related to operational efficiency such as materials purchasing cost, energy costs, and fees for waste water discharge and treatment (Pullman et al., 2009; Zhu and Sarkis, 2004). Financial performance focuses on overall profitability indicators such as return ratios, earnings and profit (Flynn et al., 2010; Paulraj et al., 2017) to assess the financial performance outcomes of CSCM. Thus, we hypothesize the following:

H1: Firms having higher levels of adoption of CSCM will demonstrate better cost performance.

H2: Firms having higher levels of adoption of CSCM will demonstrate better financial performance.

3.2 Eco-Industrial Parks and CSCM-to-firm performance relationship

Drawing upon the contingent NRBV, the contextual role of industry and how it affects the adoption of environmental management strategies has been a scholarly interest in the recent years (Hartmann and Vachon, 2018). We argue that the contextual factors, i.e., uncertainty or dynamism, complexity and munificence, identified in the contingent NRBV theory are inherent in an EIP setting. Firstly, firms operating inside EIPs can experience a high degree of dynamism or uncertainty, which makes it difficult for managers to understand or predict the effect of changes in the business environment (Aragón-Correa and Sharma, 2003). For example, the availability, volume and quality of material and/or waste exchange in EIPs is typically more in the control of the waste producers than of the waste users, creating and a potential mismatch of demand and supply. From a contingent NRBV perspective, when faced with dynamism or uncertainty, firms try to develop capabilities and reconfigure their resources that allow them to stay competitive (Aragón-Correa and Sharma, 2003). Secondly, firms inside EIPs become engaged in so-called industrial symbiosis which refers to a complex interaction of "traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products" (Chertow, 2000, p. 313). In this regard, the contingent NRBV perspective argues for managing complexity by introducing incremental changes (Aragón-Correa and Sharma, 2003). Others propose that increased complexity allows firms to leverage and develop their internal capabilities, thus making them more competitive (Mar Fuentes-Fuentes et al., 2004). Lastly, firms operating inside EIPs have a unique advantage over others (i.e., non-EIP firms) where these firms get involved in industrial symbiosis in addition to collaborating with supply chain partners for circularity and sustainability (Klassen and Vachon, 2003; Lee, 2004; Nidumolu et al., 2014). Thus, munificence in the form of availability of sufficient resources for firms operating inside EIPs makes experimentation and innovation more convenient for them (Aragón-Correa and Sharma, 2003) while facilitating better and effective environmental management (Hartmann and Vachon, 2018). Thus, we hypothesize:

H3: Firms located inside EIPs will demonstrate higher levels of CSCM adoption.

Furthermore, contingent NRBV argues that the contextual factors have the potential to moderate the environmental strategy and competitive advantage relationship (Aragón-Correa and Sharma, 2003). Recent research has found empirical support for the moderating role of contextual factors (Hartmann and Vachon, 2018; Schmidt et al., 2017).

We argue that being located in an EIP is a contextual factor, which has the potential to moderate the CSCM-to-firm performance relationship. The industrial symbiosis is seen as a major contributor to supporting this argument. According to Butturi et al. (2019), industrial symbiosis focuses on the "optimization of the materials cycle and fulfils the circular economy principles of reusing, recycling and remanufacturing materials thereby increasing resource efficiency, reducing waste and pollution, and bringing about economic benefits" (p.3). According to reports, the environmental performance (including eco-efficiency) in many EIPs has improved, besides creating huge savings on raw material purchase and waste disposal costs (Mathews et al., 2018). For example, in the Chinese province of Guangxi, a typical EIP saves more than 2 million tonnes of CO_2 emissions annually by reducing energy usage and circulating materials (Sun et al., 2017). Given these arguments, we hypothesize:

H4a: The relationship between CSCM and cost performance will be stronger in firms located inside EIPs as compared to firms operating outside EIPs.

H4b: The relationship between CSCM and financial performance will be stronger in firms located inside EIPs as compared to firms operating outside EIPs.

3.3 Control variables

This study controlled for three variables. Firm size, measured using the number of fulltime employees, was controlled. It is generally observed that large firms often have better access to essential resources. According to the RBV, availability of resources or capabilities greatly influences what the firm can and cannot do because the formulation and implementation of strategies require a commitment of scarce resources (Pullman et al., 2009). Larger firms have relatively more resources and flexibility to adopt CE, which requires significant initial investment (Geng et al., 2009). Therefore, CSCM is likely to be more advanced as compared to smaller firms.

Ownership type or structure affects the implementation of sustainability-related practices especially in China (Li and Zhang, 2010). State-owned enterprises outnumber any other ownership type in China. On one hand, these state-owned enterprises receive a lot of support and assistance to implement CE (Geng et al., 2009) but, at the same time, they face more pressure from the government (Li et al., 2019). However, Zhu and Geng (2013) found that foreign firms are more proactive in implementing supply chain sustainability practices at a higher level, followed by state-owned and private manufacturers in China.

CE implementation and/or adoption varies between industries as some industries may have a comparative advantage over others in lending themselves to more circular initiatives. For example, recirculation of metal scrap is much easier when compared to extracting metal from industrial sludge, which requires chemical treatment (Van Wassenhove, 2019). Moreover, given the high levels of variations in resource recovery procedures and waste management activities in different industries, firms might need distinct supply chain players to collaborate for circular initiatives (Farooque et al., 2019a). A conceptual model of the study is presented in Figure 1.

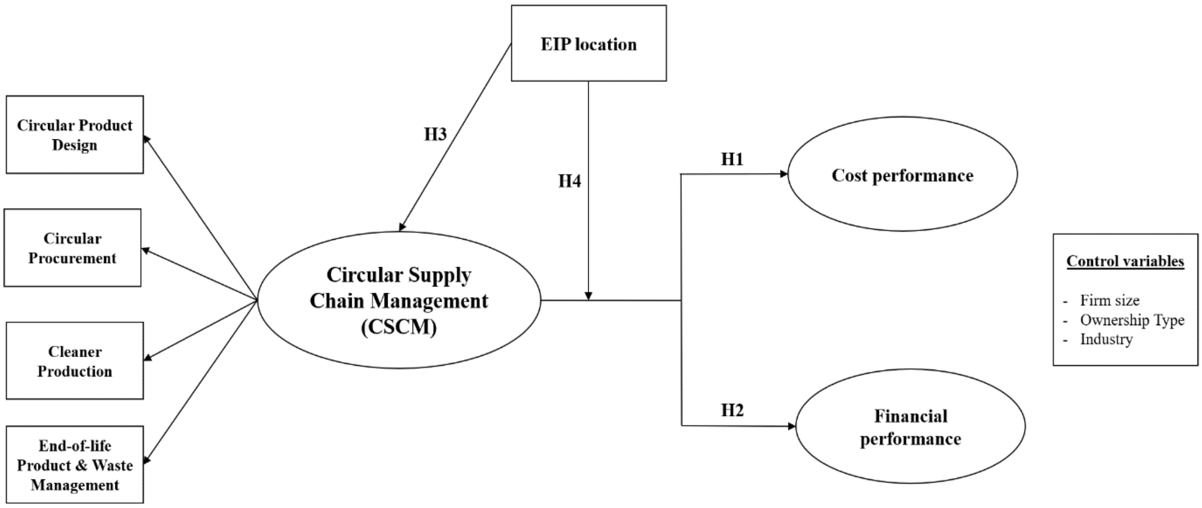

Figure 1: Conceptual model

4. Methodology

4.1 Sample and data collection

Data for this study were collected during mid-2019 as part of a larger study focused on CE/CSCM adoption in the Chinese manufacturing sector. The survey employed a convenience sampling approach, which is appropriate when the population has little variation (Saunders et al., 2019). The approach is justifiable for this study because business cultures in the multiple regions in China are relatively homogeneous. The Chinese central government has tight controls over the making and the implementation of the laws, including the Circular Economy Promotion Law. Individual provinces in China have very limited legislation power. A top-down approach is also the norm for the implementation of business and economic development policies. Our survey methodology is contextually appropriate and in line with previous studies (Zhu et al., 2011; Zhu and Sarkis, 2004) where authors have used non-random sampling methods due to difficulties in obtaining data for organizational practices in the Chinese manufacturing industry.

To obtain a large sample size, the questionnaires were distributed using multiple channels. Firstly, researchers used their own professional network (one of the co-authors works as the Secretary General of a regional Logistics Management Club in Northern China). Secondly, a team of postgraduate and MBA/EMBA students at a large state university were hired to provide some additional support in data collection. Thirdly, officials working in local government agencies in northern China also provided help to collect data from respondents within their network. An effort was made to collect data from two respondents (i.e., matched response) per organization: one for the independent variables and one for the dependent variables. For this reason, the survey questionnaire was comprised of two parts. Part 1 included questions on dependent variables and required response from a senior executive working in the department of administration, strategy, finance, or performance, or someone who was familiar with the overall performance of the firm. Similarly, part 2 included questions on independent variables and required response from a senior executive working in the department of operations, supply chain or someone who was familiar with overall operational activities of the firm. Respondents were asked to consider a same business unit while responding to survey items in both parts.

Out of 930 questionnaires distributed via all channels to various manufacturing firms, a total of 360 was returned (response rate = 38.7%). Around 110 individual respondents raised queries and wrote some additional comments about their companies' CSCM practices. Our survey sample covered all of the six greater administrative areas of China. All the questionnaires were scrutinized, and a large proportion of responses (nearly 30% of collected responses) were rejected based on their response to screening items (i.e., attentiveness to scale variations), response patterns and missing data (Edwards, 2019). Overall, these efforts ensured the rigor of the data collection process for obtaining quality data. A final sample of 255 responses meeting the assumptions related to normality, constant variance and outliers, was considered appropriate to be used for analysis purposes. Table 2 provides a summary of sample distribution. Demographic details are presented in Appendix A.

A data triangulation process was employed to ensure the rigor of the research results. After the survey, three focus group meetings and six face-to-face interviews were organized with selected participants to discuss the survey results. In order to meet the anonymity and ethical requirements of the survey process, the focus group and interview participants were selected among those who consented to participate in post-survey meetings. Preference was given to senior managers in large and medium-sized enterprises who possessed good knowledge of the industry. To allow in-depth discussions, each focus group meeting involved only three participants besides the researcher. Each meeting lasted about one and a half hours. Similarly, the face-to-face interviews involved senior level participants including three officials from the local government and three representatives from the industry. In general, the participants were asked to comment on the validity of the survey results, and to discuss their organizations' CE practices and their implications for cost and financial performance. This qualitative process provided valuable insights into the validity and robustness of the survey results as well as their interpretations.

Table 2: Sample characteristics

Variable	Inside EIP	Percentage (Inside EIP)	Outside EIP	Percentage (Outside EIP)	Total	Percentage (Total)
Firm Size (No. of employees in 2018)						
< 100	22	44.0%	28	56.0%	50	19.6%
101-500	37	45.1%	45	54.9%	82	32.2%
501-1000	16	41.0%	23	59.0%	39	15.3%
1001-3000	13	35.1%	24	64.9%	37	14.5%
3001-8000	7	31.8%	15	68.2%	22	8.6%
> 8001	8	32.0%	17	68.0%	25	9.8%
Ownership Type						
Private	61	48.4%	65	51.6%	126	49.4%
State-owned	20	30.3%	46	69.7%	66	25.9%
Joint venture	15	41.7%	21	58.3%	36	14.1%
Foreign owned	7	33.3%	14	66.7%	21	8.2%
Collective	0	0.0%	5	100.0%	5	2.0%
Others	0	0.0%	1	100.0%	1	0.4%
Industry						
Basic metals/Metal product/Machinery/Equipment	32	43.8%	41	56.2%	73	28.6%
Metallurgy	7	30.4%	16	69.6%	23	9.0%
Chemicals	9	45.0%	11	55.0%	20	7.8%
Automotive/Transport equipment/Vehicle	5	26.3%	14	73.7%	19	7.5%
Electrical appliances/Household appliances	12	63.2%	7	36.8%	19	7.5%
Pharmaceutical/Treatment	11	73.3%	4	26.7%	15	5.9%
Food/Beverage/Wine/Tobacco	4	30.8%	9	69.2%	13	5.1%
Building material/ Building & decorative	2	18.2%	9	81.8%	11	4.3%
Coke/Petroleum	1	10.0%	9	90.0%	10	3.9%
Electronics/Communication	6	66.7%	3	33.3%	9	3.5%
Textile/Apparel/Leather	2	33.3%	4	66.7%	6	2.4%
Rubber/Plastics	2	33.3%	4	66.7%	6	2.4%
Paper/Printing/Publishing	0	0.0%	2	100.0%	2	0.8%
Wood/Furniture	1	100.0%	0	0.0%	1	0.4%
Others	9	32.1%	19	67.9%	28	11.0%
Total	103	40.0%	152	60.0	255	100.0%

4.2 Constructs development and measurement items

An extensive review of related literature was done to develop the measurement items for constructs related to CSCM and firm performance. All the measurement items were adapted or modified from scales established in the literature as presented in Table 3. We used perceptual measures for all variables, including firm performance following Singh et al.'s (2011) supportive argument in favor of using perceptual measures as opposed to limited collections of incomplete objective data.

We modeled CSCM as a second-order construct reflected by four first-order constructs, namely, circular product design, circular procurement, cleaner production, and EoL product and waste management, to capture a holistic view of CSCM adoption and implementation. A five-point Likert scale was used for items measuring CSCM. The respondents were asked to evaluate the extent of CSCM practices implementation in their respective organizations in the last year on the scale of 1 (not at all) to 5 (to full extent).

Similarly, the economic performance-related variables consist of cost and financial performance. The participants were asked to evaluate their firm's economic performance in the current year against each item in comparison with the main competitor in the industry. Thus, the data provide a time lag of one year between the implementation of practices and outcomes, thereby reducing potential bias (Dobrzykowski et al., 2016). For the items measuring firm performance, a seven-point Likert scale anchored by 1 = significantly lower and 7 = significantly higher was used as it is considered better for identifying social desirability bias issues (Stöber et al., 2002).

The measurement items originally adapted from English-language literature were first translated into Chinese and subsequently translated back into English by two experienced translators. Both versions were checked for inconsistencies during the translation process to ensure conceptual equivalence with the original English sources (Paulraj et al., 2017). Prior to administering the survey, two rounds of pilot tests and face-to-face discussions involving seven senior executives in each round from large-scale Chinese manufacturers were conducted. The feedback and suggestions, which were mainly related to inclusion/deletion of items or wording, were incorporated while finalizing the questionnaire. This qualitative assessment of the measurement items helped us improve the survey instrument by ensuring clarity and content validity and reducing the likelihood of misinterpretations before its distribution to a larger sample.

Table 3: Constructs and their measurement items

Constructs	Reference	Items
Circular Product Design	Brezet (1997); Zhu et al. (2011); den Hollander et al. (2017)	Design of products for re-contextualizing, re-purposing, repair, refurbishing, remanufacturing Design of products for recycling Design of products for ease of disassembly Design of products to use recycled materials
Circular Procurement	Carter and Carter (1998); Zhu et al. (2011); Zhu et al. (2013)	Require your main suppliers to use materials that are used (non-virgin), repaired, refurbished, remanufactured or recycled Require your main suppliers to use environmentally-friendly packaging (e.g., non-hazardous and recycled, etc.) Prefer renewable energy sources when selecting energy providers Consider water and energy savings in product use when purchasing products Consider the amount of waste production in product use when purchasing products Consider the impact of transportation emissions when selecting suppliers
Cleaner Production	Sousa-Zomer et al. (2018); Zeng et al. (2010)	Improve employee environmental consciousness through training and evaluation Improve processes to reduce/eliminate waste Improve processes to increase energy efficiency through the use of clean technologies Increase investment in equipment for environmental protection Environmental issues are considered in the processes of production planning and technology innovation
EoL Product and Waste Management*	Carter and Ellram (1998); Hsu et al. (2013)	Collect expired/unsold products from distribution network Collect used/end-of-life products from customers Return products to suppliers Require your main suppliers to collect their packaging materials from your firm (i.e., packaging materials of supplied materials or components) Collect packaging from customers
Cost Performance	Zhu and Sarkis (2004)	Cost of purchased materials Operational cost Energy consumption cost Waste treatment fee Waste discharge/disposal fee
Financial Performance	Flynn et al. (2010)	Growth in sales revenue Return on sales Growth in profit Net Profit Margin Return on investment (ROI) Growth in market share

* For possible reuse, refurbishing, remanufacturing or recycling

4.3 Data analysis procedure

Structural equation modelling (SEM) was used to test the CSCM-to-firm performance effects as hypothesized in H1 and H2. For H3, a nonparametric Kruskal–Wallis H test was applied to find out the differences among groups of the independent variable (i.e., measured as yes/no to ask whether a firm was located in an EIP) on a dependent variable (i.e., measured on a Likert-scale for CSCM adoption).

For H4, a chi-square difference test and multigroup analysis (MGA) were used to assess the moderating role of being located in an EIP on the CSCM-to-firm performance relationship. Given its superior quality path diagrams, we used the IBM® SPSS® Amos 25 software package for data analysis purposes (Raut et al., 2021).

4.4 Bias assessment

a) Non-response bias

The full-scale survey was administered during June-September 2019. Using a t-test, we compared early and late responses on all variables (30 responses each) but found no significant differences among them. Therefore, non-response bias was not considered to be a concern.

b) Response type and firm location

Given that a survey involving a matched response in SCM research is quite challenging, we allowed a single respondent to fill in the questionnaire if a matched response was not possible. In such cases, a greater attention to respondent selection criteria was followed as recommended by Montabon et al. (2018) to select single best respondent with the requisite knowledge. As a result, we ended up receiving a mix of matched responses (n=75) and a single respondent (n=180) based questionnaires. Similarly, the survey was distributed equally among firms located inside and/or outside an EIP. The final sample included responses from firms located inside (n= 103) and outside (n= 152) an EIP. Hence, to ensure an unbiased sample for this study, initially we performed a t-test comparing both response types and firm's location and found no significant statistical difference.

To further validate this claim, we conducted a chi-square difference test. The CFA was subjected to a two-stage multigroup analysis (MGA) (Bollen, 2014; Jöreskog, 1998) run separately for both the grouping variables (i.e., response type and firm's location). In the first stage, all the parameters were estimated freely in their respective groups, whereas, the second stage involved constraining the parameters to be equal across the groups. Applying the conventional cut-off value of 0.05, the MGA results indicate similar patterns of measurement relationships among the groups. Thus, our analysis did not suggest any significant difference or moderating effect.

c) Common method bias

Several approaches were adopted during the research design stage to reduce the likelihood and effect of common method bias (CMB) as recommended by Podsakoff et al. (2003); Podsakoff et al. (2012). Firstly, the survey was anonymous and self-administered. The respondents were ensured that no answers would be identifiable by individuals or organizations. Secondly, we separated the measurements related to the dependent and independent variables into two different parts, also known as "split survey method", requiring a response from two different respondents within the same organization (Dubey et al., 2015). However, due to the anticipated challenges in getting matched responses from manufacturing firms, a single respondent was also allowed to respond to the whole questionnaire in case a matched response was not possible. Thirdly, we used different variations at the construct and measurement scale levels to help mitigate the CMB concerns including social desirability. At the construct level, we used organization rather than the individual as a proxy subject when referring to CSCM practices (Nederhof, 1985) following Pullman et al. (2009)'s example. Similarly, at the measurement scale level, we used different measurement scales in the questionnaire to eliminate the impact of consistency in the response patterns. For example, the scale used for cost performance variables implied response in terms of lower cost as a means to achieve better performance, whereas the same scale implied response in terms of increased use of renewable energy, restored (non-virgin) materials and higher profits, as an indication of better performance.

Overall, these variations also allowed us to measure respondents' engagement in the process and helped us filter unengaged responses. Such a questionnaire design was proved to be effective as it filtered nearly 30% of collected response due to their lack of attentiveness to scale variations, similarities in response patterns and missing data, as mentioned earlier.

As the majority of data (approx. 70%) for this study was obtained from a single source (i.e., one respondent from each participating firm) using a self-report questionnaire, CMB may be a concern (Guide and Ketokivi, 2015). Based on the MGA, the results from the single respondent group were not statistically different from the matched response group; therefore, a major concern related to CMB was not indicated. However, to detect the presence and severity of CMB, we performed three tests: firstly, we conducted Harman's (1976) single-factor test in which we performed an un-rotated factor analysis with eigenvalues greater than 1. The test results showed the presence of six different factors, whereas the first factor explained only a fraction of the variance (26.9%) in the data. Secondly, we performed a common latent factor test by introducing a latent factor to the original measurement model (Podsakoff et al., 2003); Podsakoff et al. (2012). The results showed that the fit for the original measurement model (i.e., $\chi 2/df = 1.58$, CFI = 0.95, and RMESA = 0.05) was similar to the fit for the model including the common latent factor (i.e., $\chi 2/df = 1.45$, CFI = 0.96, and RMESA = 0.04). We conducted a third test as recommended by Widaman (1985). We tested two latent variable models – a measurement model with traits only and another with an addition of a method factor along with the traits. Using the CFI change cutoff criterion of 0.01 (Cheung and Rensvold, 2002), the model fit indices do not show significant improvement. Also, the path coefficients and their significance were indifferent between the two models, suggesting that they were robust despite including a methods factor. Based on this we conclude that CMB is unlikely to influence the validity of results presented in this study.

4.5 Measurement Model: validity and reliability

Both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used to assess convergent validity. EFA loadings (all above 0.50) as presented in Table 4 suggest that our measurement items show an adequate level convergent validity (Hair et al., 2006). In CFA, we used two different measurement models for measuring the independent and dependent factors, as different scale anchors were used for independent and dependent indicators (Paulraj et al., 2017). A high level of average variance extracted (AVE) as shown in Table 5, exhibits the adequacy of convergent validity (Fornell and Larcker, 1981).

Discriminant validity was assessed by comparing the AVE to the squared correlation between two constructs. The AVE values (all above 0.5) as presented in Table 5 were found to be greater than inter-construct correlations, suggesting no concerns related to discriminant validity (Fornell and Larcker, 1981). Finally, reliability was measured using composite reliability (CR) as well as Cronbach's alpha (α). All values above 0.7 show adequate level of reliability for newly-developed constructs (Hair et al., 2006).

We examined common fit indices to assess the goodness-of-fit of our proposed model with the dataset. These fit indices are as follows: $\chi 2/df = 1.58$; CFI = 0.95; RMSEA = 0.05. Based on the conventional cutoffs for model fit suggested by Hu and Bentler (1999), our model fit is considered excellent. However, the assessment of goodness-of-fit is not as straightforward (Singh et al., 2011). Scholars, for example Guide and Ketokivi (2015), encourage authors to use inferential procedures (such as chi-square test) as opposed to non-inferential thumb rules to support their claims on good model fit. However, it is well established that the chi-square test is sensitive to sample size and model complexity; therefore, studies with large sample size (>200) rarely report non-significant chi-square (Tabachnick et al., 2007). In such cases, authors disregard the significant chi-square statistic, see for example Singh et al. (2011). Based on this discussion, for our study with a relatively large sample size, we believe we have obtained an adequate level of fit to perform subsequent analysis using the current model.

Table 4: Factor loadings and reliability

Construct	Variable(s)	Measurement Items	EFA	CFA	α
CSCM	**KMO = 0.88, Cumulative % of Variance = 66.59**				
	Circular Product Design	Design of products for re-contextualizing, re-purposing, repair, refurbishing, remanufacturing	0.85	0.82	0.86
		Design of products for recycling	0.83	0.90	
		Design of products for ease of disassembly	0.83	0.75	
		Design of products to use recycled materials	0.71	0.67	
	Circular Procurement	Require your main suppliers to use materials that are used (non-virgin), repaired, refurbished, remanufactured or recycled	0.54	0.57	0.83
		Require your main suppliers to use environmentally-friendly packaging (e.g., non-hazardous and recycled, etc.)	0.60	0.68	
		Prefer renewable energy sources when selecting energy providers	0.69	0.68	
		Consider water and energy savings in product use when purchasing products	0.74	0.64	
		Consider the amount of waste production in product use when purchasing products	0.75	0.65	
		Consider the impact of transportation emissions when selecting suppliers	0.71	0.70	
	Cleaner Production	Improve employee environmental consciousness through training and evaluation	0.77	0.73	0.91
		Improve processes to reduce/eliminate waste	0.86	0.83	
		Improve processes to increase energy efficiency through the use of clean technologies	0.82	0.87	
		Increase investment in equipment for environmental protection	0.80	0.78	
		Environmental issues are considered in the processes of production planning and technology innovation	0.79	0.82	
	EoL Product and Waste Management*	Collect expired/unsold products from distribution network	0.83	0.68	0.88
		Collect used/end-of-life products from customers	0.83	0.68	
		Return products to suppliers	0.69	0.69	
		Require your main suppliers to collect their packaging materials from your firm (i.e., packaging materials of supplied materials or components)	0.79	0.87	
		Collect packaging from customers	0.76	0.82	
Firm Performance	**KMO = 0.87, Cumulative % of Variance = 66.49**				
	Cost Performance	Cost of purchased materials	0.76	0.82	0.86
		Operational cost	0.80	0.89	
		Energy consumption cost	0.80	0.78	
		Waste treatment fee	0.81	0.55	
		Waste discharge/disposal fee	0.79	0.51	
	Financial Performance	Growth in sales revenue	0.84	0.77	0.95
		Return on sales	0.91	0.92	
		Growth in profit	0.93	0.96	
		Net Profit Margin	0.92	0.96	
		Return on investment (ROI)	0.88	0.89	
		Growth in market share	0.73	0.65	

* For possible reuse, refurbishing, remanufacturing or recycling

Table 5: Model validity measures

Constructs	M	SD	CR	AVE	1	2	3
1. Cost Performance	4.37	0.76	0.84	0.53	**0.73**		
2. Financial Performance	4.28	1.17	0.95	0.75	0.41**	**0.86**	
3. Circular Supply Chain Management	3.27	0.72	0.80	0.51	0.17*	0.29**	**0.72**

* $p < 0.05$
** $p < 0.01$
Note: value on the diagonal is the square root of AVE.

5. Results

5.1 Survey results

5.1.1 Hypotheses H1 and H2 SEM results

The structural model also produced acceptable statistics: $\chi 2$ = 1573.98 (df = 1040, $\chi 2$ /df = 1.51, $p < 0.00$), CFI = 0.93 and RMSEA = 0.04. As shown in Table 6 (model 1), H1 and H2 for direct effects of CSCM on cost and financial performance were supported ($p < 0.05$). It is also very interesting that path loading of financial performance indicates a much greater and significant effect as compared to cost performance. The R^2 values of 0.17 and 0.22 are generally acceptable since our objective was to identify the relationship between variables, and the p-values of the correlations show significant relationship. Moreover, our R^2 values are comparable to seminal work of Zhu and Sarkis (2004) on green SCM in China. Overall, we believe to have obtained an adequate level of goodness-of-fit suggesting that explanatory power of the theoretical model is acceptable.

5.1.2 Hypothesis H3 Kruskal-Wallis H Test results

The results suggest that there are significant differences ($p < 0.05$) in the adoption of CSCM depending on the firms' location inside or outside EIPs. As shown in Table 6, firms located inside EIP show higher levels of CSCM adoption as compared to firms located outside EIPs. Hence, we found significant support for H3.

5.1.3 Hypothesis H4 MGA and interaction effects

As argued earlier, the chi-square difference test (at the measurement model) suggested no categorical moderation role of being located in an EIP. We performed another chi-square difference test at the structural model. The test result (p-value 0.085) does not suggest a categorical moderation effect at $p < 0.05$. For more in-depth analysis, we performed a path analysis; however, none of the paths were found to be significantly different. Moreover, to exclude the potential bias in the MGA results, we ran an interaction model with control variables using PROCESS macro for SPSS designed by Hayes (version

3.5) to test the moderating role of firm location in the CSCM-to-firm performance relationship. However, hypothesis H4 was not supported. The test results are summarized in Table 6 (model 2).

Table 6: Hypothesis testing

Variables	Model 1 (H1-H2) Cost Performance	Model 1 (H1-H2) Financial Performance	Model 2 (H4) Cost Performance	Model 2 (H4) Financial Performance
Controls				
Ownership Type Dummy[a]				
1. State owned	-1.23	-0.43	-1.27	-0.83
2. Collective	-1.47	-0.35	-1.63	-0.62
3. Private	-1.05	-0.33	-1.30	-0.61
4. Foreign owned	-1.35	-0.26	-1.45	-0.60
5. Joint venture	-1.14	-0.32	-1.42	-0.66
Firm Size Dummy[b]				
1. Less than 100	-0.06	0.02	-0.03	-0.13
2. 101–500	0.11	0.16	0.05	0.03
3. 501-1000	0.13	-0.06	0.10	-0.22
4. 1001-3000	-0.13	-0.13	-0.11	-0.12
5. 3001-8000	0.07	0.32	0.06	0.22
Industry Dummy[c]				
1. Food/beverage/wine/tobacco	-0.18	0.16	-0.03	0.17
2. Metallurgy	0.07	0.03	0.11	-0.13
3. Basic metals/metal product/machinery/equipment	-0.18	0.19	-0.03	0.11
4. Textile/apparel/leather	-0.02	0.25	0.02	0.19
5. Electronics/communication	-0.01	0.92*	-0.06	1.02*
6. Building material/building and decorative	-0.20	0.09	-0.15	0.01
7. Transport equipment/vehicle	-0.28	-0.12	-0.21	-0.17
8. Electrical appliances/household appliances	-0.33	-0.06	-0.23	-0.14
9. Rubber/plastics	-0.59	-0.50	-0.49	-0.61
10. Coke/petroleum	-0.07	0.84*	-0.03	0.82
11. Chemical	0.05	0.57*	0.05	0.39
12. Pharmaceutical/treatment	0.58*	0.85**	0.60*	0.84*
Main variable(s)				
CSCM	0.18*	0.33**	0.11	0.37**
EIP Location	--	--	-0.15	-0.20
CSCM* EIP Location	--	--	-0.11	0.28
R^2	0.17	0.22	0.13	0.19

Kruskal-Wallis H test (H3)	Categorical Variables (Mean Rank): EIP Location (Yes)	EIP Location (No)	χ^2 (df)	Sig
	142.94	117.88	7.09 (1)	0.01

* $p < 0.05$; ** $p < 0.01$; [a] the baseline for ownership dummy variable is the "others" category; [b] the baseline for firm size dummy is the category with more than 8000 employees; [c] the baseline for industry dummy is the "others" category.

5.2 Robustness check

In order to ensure the robustness of our study results, we performed post-hoc robustness and endogeneity tests followed by three post-survey focus group meetings and face-to-face interviews.

5.2.1 Post-hoc robustness tests

To check the robustness of our results relating to hypotheses H1 and H2, we reran the SEM model taking the individual CSCM practice as a standalone latent variable. Circular product design, circular procurement and EoL product and waste management show a statistically significant relationship with financial performance (β=0.21,0.57,0.20 respectively at $p<0.05$) while their relationship with cost performance remains statistically insignificant. Similarly, cleaner production does not show a statistically significant relationship with any of the performance variables. Overall, these results suggest that our original model with CSCM as a second-order construct is more suitable and robust.

5.2.2 Endogeneity

Given the possibility that firms demonstrating higher levels of CSCM adoption may be endogenously influenced by firms' better cost and financial performance, we conducted endogeneity tests- a two-stage least square (2SLS) regression analysis with instrumental variable followed by Durbin–Wu–Hausman postestimation test of endogeneity- as recommended by Lu et al. (2018). According to Deaton (2010); Rossi (2014), a good instrumental variable ideally should have a strong correlation with the suspected explanatory variables but not with the disturbance term. In the large survey data set, we identified coercive isomorphism, a sub-variable of institutional isomorphism (DiMaggio and Powell, 1983) to be used as an instrumental variable in endogeneity tests. Institutional theory seeks to explain how the influence of external, social, political and economic pressures affect organizational strategies, decisions and actions (DiMaggio and Powell, 1983). It identifies three mechanisms through which institutional isomorphic changes occur, namely, coercive isomorphism, mimetic isomorphism, and normative isomorphism. In the Chinese context, coercive isomorphism plays an influential role in CSCM adoption and implementation in the form of stringent laws and regulations imposed by the Chinese government. We performed correlation analysis to confirm that coercive isomorphism was only correlated to CSCM ($R=0.31$ at $p<0.01$) and did not significantly correlate with cost and financial performance. Thus, validating its place as an instrumental variable.

Next, a 2SLS estimation procedure was adopted. In the first stage, a linear regression was performed using coercive isomorphism as independent variable and CSCM as a dependent variable. The result presented in Appendix B (1) shows that coercive isomorphism has a significant effect on CSCM (β=0.29 at $p<0.01$). In the second stage, predicted values from the first stage were included as independent variable to estimate its effect on cost and financial performance. Appendix B (2) and (3) shows the results of the second stage regression. Both models (2) and (3) show statistically insignificant results (p-values greater than 0.10). We then performed Durbin–Wu–Hausman test of endogeneity, which adds the error terms from the first stage regression model and separately tests whether these error terms are correlated with the error terms in the original model (Cameron and Trivedi, 2009). The Durbin–Wu–Hausman test (p=0.99) also suggest that our study results have no serious endogeneity problem.

5.2.3 Post-survey validation

As mentioned in section 4, focus group meetings were held for validating survey results and to aid researchers' interpretations of the results. Based on the findings, firms can be categorized as either reactive or proactive in CE implementation. To comply with CE related regulations, most reactive firms invested in facilities that treat emissions and waste irrespective of firms' location inside or outside EIPs. Such facilities often required big investments and thus increased business costs in short term. This explains why some firms found CE implementation economically challenging, as identified by Genovese et al. (2017) and Nasir et al. (2017). However, the incurred short-term costs did not necessarily make an implementing firm less cost competitive, because its domestic competitors were subject to the same regulatory requirements and had to incur similar costs. Therefore, we infer that while CE implementation did incur a substantial upfront cost, it undermined a firm's cost competitiveness only when its competitors were located where there are less stringent environmental regulations. Over long term, implementing firms observed economic benefits in reduced energy cost and waste treatment fees. However, the level of CE implementation by these reactive firms is usually not at an advanced stage as their motivation was mere regulatory compliance.

Relatively few reactive firms chose a different path to meet CE regulations. They addressed environmental concerns at source including raw materials, processes, technologies, and management. They used alternative materials that are more environmentally friendly, implement cleaner production technologies, and streamline processes to reduce emissions and waste discharge. They often incurred lower cost than those invested in emissions and waste treatment facilities for meeting environmental regulations. At the same time, they improved raw material utilization, reduced energy consumption, emissions and waste discharge. Therefore, they achieved an advantage in both cost and financial performance. However, only the firms that had enough innovation and dynamic capabilities were able to succeed following this path. Those who did, were usually at a relatively advanced stage of CE implementation.

Proactive firms were the firms that took their own initiatives to optimize their production and supply chain operations. Their CE implementation was not driven by regulatory pressures as their reactive counterparts. In contrast, they actively listened to the voice of the market, sought to improve environmental as well as cost and financial performance to stay ahead of their competitors. They often had a designated organizational unit and a team of specialists to drive and coordinate improvement initiatives. They proactively sought for cost savings opportunities in CSCM practices. They found innovative ways to remanufacture products and components, to reuse parts and raw materials, and to design packaging that is easier for return, reuse and recycling. They invested in smart enabling technologies, for example, QR code for tracing. They designed positive and negative incentives to encourage the reuse and recycling of parts, raw materials and packaging to improve profit margins. There were usually at the most advanced state of CE implementation and had the best cost and financial performance in the industry.

Furthermore, the competitive dynamics in the Chinese manufacturing industries was found to be a key factor that caused the effect of CE implementation on financial performance to be much greater and significant than on cost performance. Most Chinese manufacturers mainly competed on price and they faced stiff competition in both domestic and international markets. A slight cost advantage can lead to considerable price competitiveness, which results in much greater sales opportunities and profits. This means the impact of improved cost performance is disproportionally high on financial performance, and the effect is shown clearly in the survey study results.

Moreover, we conducted face-to-face interviews with some of the survey participants for addressing the endogeneity concerns in addition to the statistical tests mentioned. The interview participants also confirmed the validity of study results (especially H1 and H2) that the main effect is from CSCM to economic performance, not the other way round. Though, it is true that firms having better economic performance are likely to have more financial resources to invest in new initiatives, such firms would normally choose to invest in the most profitable initiatives so not necessarily CSCM practices. Furthermore, the Circular Economy Promotion Law in China is believed to be the most importance driver of CSCM implementation, not other factors including better financial performance.

Overall, the post survey focus group meetings and face-to-face interviews affirmed the validity of all the hypothesis testing results. Hence, the validity and robustness of the results is further established by this data triangulation process.

6. Discussion

The survey results presented in Table 6 show that CSCM has a significant effect on cost performance (β=0.18, $p<0.05$) and financial performance (β=0.33, $p<0.01$), as hypothesized in H1 and H2 respectively. This provides empirical evidence supporting the economic viability of CE practices. Our results are in agreement with several studies (Agrawal et al., 2019; Mathews et al., 2018; Van Wassenhove, 2019; Zhu et al., 2010, 2011) that found that firms adopting CE/CSCM can achieve lower costs and increased profitability. Furthermore, CE/CSCM implementation leads to a significantly greater effect on financial performance as compared to on cost performance among Chinese manufacturers.

These results, further supported by post-survey analysis, are in agreement with the proponents of CE, including the Ellen MacArthur Foundation, that CSCM (built on CE building blocks), when exercised as a uniform strategy, can improve firm performance. Although the results suggest that Chinese manufacturers have adopted CSCM to some extent (mean value of above 3 indicates reasonable adoption), it is still not at a high level. This is understandable given that CE implementation has predominantly been considered at macro (i.e., national/regional/city) and meso levels (i.e., EIPs) (Ghisellini et al., 2016), whereas, the implementation of CE at a micro level (i.e., firm or supply chain) remains unclear (Farooque et al., 2019b). This research provides a comprehensive and holistic view of CE implementation at a firm and supply chain level; the CSCM construct and practices within could be considered as a starting point towards further development of circular supply chains leading to better economic performance.

For H3 (sig < 0.05), our results show significant support (see Table 6). This outcome provides empirical evidence that firms inside EIPs have adopted CSCM at higher levels when compared to those outside EIPs. This result confirms Mathews et al.'s (2018) viewpoint on the role of EIPs in fostering CE implementation at the firm and supply chain level. However, we did not find any difference in the CSCM-to-firm performance relationship based on location inside or outside of an EIP (see Table 6). This suggests that performance is mainly driven by practices. However, underlying differences between firm' operations in an industrial symbiosis network and a typical supply chain network may contribute to the lack of moderation, as evidenced in H4. Industrial symbiosis network partners are not necessarily firms' core supply chain partners; therefore, material exchange between industrial symbiosis partners may not be as effective as other important factors related to supply, such as its availability when needed in the right volume and with the right quality. Moreover, firms operating inside EIPs need to integrate the park administrative authorities' requirements into their supply chain activities (Zhu et al., 2015). However, firms operating outside the EIPs do not need to adhere to additional requirements of EIPs and can focus on strengthening relationships with their supply chain partners, focusing on material recovery and circularity; and, enjoy more freedom to adopt CSCM based on their strategic needs.

6.1 Implications for theory

This study contributes to theory by developing CSCM as a new construct which integrates four operational practices: 1) circular product design, 2) circular procurement, 3) cleaner production, and 4) EoL product and waste management. Furthermore, this research attempts to fill the research gap by providing an empirical evidence to support CSCM-to-firm performance relationship which remained absent in the extant literature.

Studies have used the NRBV framework to link SCM sustainability practices with firm performance (Golicic and Smith, 2013; Govindan et al., 2020; Graham et al., 2018). Similarly, we link CSCM with the NRBV framework to develop a conceptual model focusing on the NRBV's pollution prevention and product stewardship strategies. In doing so, our study contributes to further development of the NRBV framework in three ways. Firstly, it is among the first to link the CSCM perspective, with the NRBV framework. Secondly, our survey results provide empirical support for the NRVB's hypothesis on the relationship between pollution prevention, product stewardship, and competitive advantage. Our finding is in line with previous supply chain sustainability works, for example, Colicchia et al. (2013), which also used two interconnected NRBV strategies (pollution prevention and product stewardship) to develop a conceptual model. Lastly, our study confirms the robustness of the NRBV framework and its applicability in the wider supply chain sustainability domain, including the newly established CSCM concept.

Moreover, the research findings contribute to the contingent NRBV (Aragón-Correa and Sharma, 2003) discourse with the inclusion of the contextual role of being located inside an EIP as a proxy for firms' ability to develop and adopt higher levels of CSCM capabilities. In this regard, our study results are not only consistent with previous studies supporting the contingency view of supply chain sustainability and performance linkage (Hartmann and Vachon, 2018; Schmidt et al., 2017). They make an original contribution by establishing the role of EIP development and industrial symbiosis practices from a supply chain perspective, which has been lacking in the literature (Herczeg et al., 2018).

6.2 Implications for practice

Our study offers several practical implications. Firstly, managers should view CSCM at a firm and supply chain level as an integrated system rather than a set of standalone practices. In circular supply chains, the products are intentionally designed for circularity throughout their life cycle. This means the materials used in products are not meant to be scrapped at the end of their life cycle, thus creating no waste. Further, material resources needed for circular products are mainly sourced from EoL materials that would otherwise be discarded. In this way, the two functional ends of circular supply chains (i.e., circular product design and EoL product and waste management activities) are the most critical functions of SCM to establish circularity. Purchasing practices of firms (circular procurement) in circular supply chains should focus on sourcing to form closed loops of energy and material with minimal or no waste creation and/or negative environment impacts. Production practices (cleaner production) must ensure material efficiency, energy conservation, waste, and emissions reduction at the highest level.

However, there are several challenges in managing the closed-loop material flows and material circularity. Recent advancement in digital technologies such as blockchain and big data analytics (BDA) may help with managing and monitoring the circulation of materials in the supply chains (Choi et al., 2018; Wang and Sarkis, 2021). Blockchain technology can help to improve the product returns and EoL products and waste management activities in reverse supply chains by effective tracing of materials (Dutta et al., 2020) thereby promoting material recovery and circularity which is at the heart of CSCM. Supply chain managers may use BDA to gather and analyze data collected across materials and products lifecycles and make data-driven decisions as part of CSCM (Cheng et al., 2021).

Secondly, the CSCM-to-firm performance relationship is confirmed supporting the view expressed by Van Wassenhove (2019) that businesses cannot trade-off lower economic performance for improved social or environmental outcomes. In this regard, our results demonstrate practical relevance as firms implementing CSCM benefit economically as well as environmentally. The results provide empirical evidence to dispel contradictory findings with regard to the economic viability of CE at a firm and supply chain level (Genovese et al., 2017; Zhu et al., 2011). With this clarity, supply chain leaders can confidently develop strategies and adopt CSCM practices to further enhance firm performance (Chen et al., 2021; Liu et al., 2021). The strategic considerations may also include business model innovations such as product-service systems where businesses shift their tenets from the delivery of physical products only to providing integrated product-service offerings in the form of leasing or renting (Wang et al., 2020).

Thirdly, despite the potential benefits of CE implementation most firms and supply chains cannot fully realize these benefits because of challenges in resource recirculation, restoration and recovery within their supply chain structures. EIPs' are a potential solution for these challenges. Although being located in an EIP does not directly affect firm performance, it encourages the adoption and implementation of CSCM practices because location proximity makes it easier for EIP firms to collaborate in resource exchanges. However, the Chinese model of EIP system and development has its own shortcomings (Huang et al., 2019) and there is a further need to improve resource circularity performance. Our results do not support a moderating role of EIP location in the CSCM-to-performance relationship. A possible explanation may be the lack of exclusive incentives in the current Chinese EIP management system for the EIPs and the firms operating inside them (Huang et al., 2019). The central and local governments in China offer several policy incentives such as tax reductions and subsidies for all firms irrespective of their locations to promote CE implementation. Many Chinese EIPs offer incentives to attract new firms to join in, but such incentives are available for a short period only. Li et al. (2020b) found that economic incentives have greatly influenced the promotion and uptake of various policies/initiatives such as electric vehicles adoption in China. Therefore, it is likely that more and exclusive economic incentives, if offered for EIPs and participating firms, can further enhance the CSCM adoption and performance outcomes.

Lastly, CE is a multifaceted domain and its implementation requires coordinated efforts from various stakeholders, including governments at different levels, industries, local businesses, non-governmental organizations, and customers, to cooperate in stewarding valuable resources for the best outcomes. Given the robustness of practice-performance relationship in supply chains, firms need to develop systemic sustainability collaborations for circularity, focusing both on the business processes and the outcomes (Nidumolu et al., 2014). For example, firms can systemically collaborate with carefully selected stakeholders (e.g., municipal waste management authorities or retailers) with an explicit focus on improving processes (i.e., EoL product and waste management) or an outcome (i.e., resource consumption) to tackle complex challenges. Firms operating inside EIPs have a unique advantage as the industrial symbiosis environment provides a natural form of collaboration required for circularity. However, our recommendation to develop systemic collaboration is generally relevant at a firm and supply chain level, irrespective of the firm's location. Again, digital technologies such as BDA and blockchain are seen to play a role in developing information-driven collaborations among the different supply chain stakeholders for CE and CSCM implementation (Gupta et al., 2019; Saberi et al., 2019).

7. Conclusions

Businesses across the globe are exploring CE for improving environmental performance. This study analyzed the CSCM-to-firm performance relationship and the role of EIPs in the Chinese manufacturing industry. The results provide empirical evidence of a significant direct relationship between CE and cost and financial performance. EIPs have a pivotal role in CE development, and firms inside EIPs display higher levels of CE adoption in their supply chain practices.

This research offers several contributions. Firstly, this study provides a comprehensive integrated view of CSCM at a firm and supply chain level, including new construct development and its validation. This comprehensive view of CSCM provides guidelines on how individual firms can make a transition to CE and gain performance benefits. Secondly, our study results provide empirical evidence to support how CSCM adoption is positively related to cost and financial performance. Thirdly, our study increases the understanding of an EIP's role from a firm and supply chain perspective. Firms operating inside EIPs adopt CSCM at a higher level due to engagement in industrial symbiosis network relationships. However, the CSCM-to-firm performance relationship is not affected by the EIP location factor. These results reveal that, although EIP infrastructure helps firms in CSCM adoption, there is an equal opportunity for all firms (located inside or outside EIPs) to gain performance benefits associated with CSCM. This lies in developing systemic collaboration for circularity with all supply chain stakeholders. Digital technologies such as BDA and blockchain are seen to play a supporting role in the development and implementation of CSCM.

This study has some limitations but also suggests opportunities for future research. Firstly, this study mainly focused on the cost and financial performance outcomes of CSCM, and future research should include environmental and social outcomes. Secondly, our sample comprises Chinese manufacturing firms across various industries. We chose the Chinese context given the country's progress in CE implementation. Similarly, other countries and regions such as Europe have taken promising initiatives in CE implementation. We suggest that future research study the CSCM implementation in the European context to strengthen the validity and generalizability of CSCM-to-firm performance relationship presented in this research. Thirdly, although we controlled for industry, the CSCM-to-firm performance relationship appears to be stronger in certain industries, which suggests an advancement of circular initiatives in those industries as compared to others. Therefore, future research should focus on a specific industry or group of related industries to take a closer look at industrial influences.

Fourthly, in this study, one contingency factor, being located in an EIP, was considered in the CSCM-to-firm performance relationship. Other important factors such as supply chain leadership have been reported to affect firm performance positively. We suggest that future researchers explore the role of supply chain leadership in the CSCM-to-firm performance relationship. Finally, due to data collection challenges, most of our sample contains data collected from single respondents. Also, perceptual measures were used for all variables including firm performance. Although we did not find any evidence of CMB affecting our study results, future research may consider the possibility of using secondary data and/or objective data to gain new insights.

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Appendix

Appendix A: Demographic characteristics of the sample.

Variable	Sample size	Percentage
Type of firm		
Raw-material supplier	34	13.3%
Component supplier	37	14.5%
OEM	159	62.4%
Contract manufacturer	25	9.8%
Firm sales		
< 1 million RMB	2	0.8%
1-4.9 million RMB	7	2.7%
5-9.9 million RMB	11	4.3%
10-49.9 million RMB	38	14.9%
50-99.9 million RMB	15	5.9%
100-499.9 million RMB	64	25.1%
500-999.9 million RMB	31	12.2%
1-4.9 billion RMB	40	15.7%
5-9.9 billion RMB	18	7.1%
> 10 billion RMB	29	11.4%
Designation (Management Level)		
Top Management (i.e., CEO, COO etc.)	44	17.3%
Middle Management (i.e., Director, Dept Head etc.)	161	63.1%
Lower Management (i.e., Supervisor, Accountant etc.)	50	19.6%
Total	**255**	**100.0%**

Appendix B: 2SLS regression model for endogeneity test

Variables	(1) CSCM	(2) Cost Performance	(3) Financial Performance
Controls			
Ownership Type Dummy[a]			
1. State owned	0.20	-1.24	-0.76
2. Collective	0.07	-1.64	-0.66
3. Private	0.45	-1.27	-0.56
4. Foreign owned	0.14	-1.42	-0.53
5. Joint venture	0.33	-1.39	-0.63
Firm Size Dummy[b]			
1. Less than 100	-0.10	-0.01	-0.07
2. 101–500	-0.31	0.09	0.06
3. 501-1000	-0.17	0.13	-0.15
4. 1001-3000	0.01	-0.13	-0.07
5. 3001-8000	0.08	0.04	0.29
Industry Dummy[c]			
1. Food/beverage/wine/tobacco	-0.09	-0.02	0.23
2. Metallurgy	-0.11	0.09	-0.07
3. Basic metals/metal product/machinery/equipment	-0.19	-0.01	0.18
4. Textile/apparel/leather	-0.49	0.12	0.18
5. Electronics/communication	-0.34	0.01	1.13*
6. Building material/building and decorative	-0.10	-0.19	0.04
7. Transport equipment/vehicle	-0.11	-0.21	-0.14
8. Electrical appliances/household appliances	0.03	-0.19	-0.03
9. Rubber/plastics	-0.53	-0.46	-0.55
10. Coke/petroleum	-0.41	-0.02	0.84
11. Chemical	-0.46*	0.10	0.49
12. Pharmaceutical/treatment	0.03	0.67**	0.97*
Main variable			
CSCM	--	0.07	0.13
Coercive Isomorphism	0.29**	--	--
R^2	0.20	0.11	0.12