Environmental Science and Pollution Research (2024) 31:8751–8767
https://doi.org/10.1007/s11356-023-31551-z

RESEARCH ARTICLE

Circular economy strategies in supply chains, enhancing resource efficiency and sustainable development goals

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Received: 1 September 2023 / Accepted: 10 December 2023 / Published online: 5 January 2024

Abstract
Eco-industrial parks are the real-world implementation of green supply chain management. There is a growing need to include the circular economy concept into supply chain management as a means of striking a better economic, social, and environmental balance, as the importance of the external sustainability of the supply chain is challenging. Using 357 questionnaires filled out by enterprises in China's eco-industrial parks, we examine the connections and causal relationships between resource efficiency, environmental impact, green supply chain management, and circular economy. To learn how a green supply chain's circular economy affects resource efficiency and environmental performance in the China region, this study makes use of the instrumental variable approach (structure equation model (SEM)). The results of this study indicate that environmentally responsible supply chain management and circular economy have beneficial effects on environmental performance and resource efficiency. The management of the GSC has a negative and small impact on economic performance, although each of the components is a substantial contributor to better performance in the environment. Conclusions from this study will assist those responsible for making decisions within supply chains in developing a plan that is useful for increasing a company's performance along economic and environmental dimensions. This study not only broadens our understanding of the factors that influence green supply chain management but also offers theoretical direction for the implementation of successful green production practices by businesses located in eco-industrial parks.

Keywords Green supply chain management · Circular economy · Environmental performance · Resource efficiency · China region

Introduction

The effects of human activity are bringing the planet closer to a number of so-called tipping points, which have the potential to bring about significant shifts in the environmental conditions that are necessary for the maintenance

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of contemporary society (Yadav et al. 2020). Changes in climate, widespread degradation of land, and human actions have immediate and obvious consequences, including a rapid decline in biodiversity. All of these effects have the potential to disrupt vital ecosystems that are necessary for human progress and survival. Sir Robert Watson, chair of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), lamented that the health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. Economy, livelihood. The relationship between food safety, health, and quality of life is being undermined as a result. To avoid these dangerous cliff edges, we need new forms of social and economic structure that more closely match the resources of our planet with the requirements of its growing human population (Zhang et al. 2020a). Sustainability as a core concept has become increasingly influential in business administration in recent years. The circular economy is gaining popularity as a strategy for reducing waste and maximizing resources to lessen our impact on the environment by decreasing our consumption of resources and our waste output (Saeed et al. 2022). Because it requires the coordination of economic activities with environmental health (Nabeeh et al. 2021) and because it calls for the development of novel business models, the concept of circular economy constitutes a radical departure from conventional approaches to running a company resulting in improved environmental, social, and financial performance (Mubarik et al. 2021a, b, c) Due to their shared foundation in efficient business process management, in this view, the circular economy and supply chain management techniques are intrinsically intertwined. Vertical integration of the supply chain has been at the center of sustainable business practices for quite some time. In contrast, enterprises with a focus on the circular economy are building inter-sectoral networks to set up seamless supply chains and implement the 3Rs strategy for resource utilization: reuse, reduce, and recycle (Wang and Fu 2021). In recent years, circular economy (CE) has emerged as one of the most promising approaches to organizing socially and environmentally sound economic activities (Yin et al 2021; Yin et al. 2022). The term circular economy, or CE, refers to a regenerative system in which resource input and waste, emission, and energy leakage are minimized by squeezing the material and energy loops (Karaman et al. 2020). CE has just risen in the world despite the fact that it is not a brand-new idea, stage. It could serve as a unifying theme for many economic, political, and social actors who are working to save the planet from environmental disasters (Rehman Khan et al. 2021). Despite the fact that a number of obstacles have been highlighted, the benefits (Mubarik et al. 2021a) of implementing CE are significant. Nevertheless, in spite of the expanding prevalence of CE, the idea has received a comparatively small amount of supply chain management (SCM) (Bor 2021). Since efficient management of global supply chains is crucial to making progress in CE, the lack of research into the topic is puzzling. In reality, supply chains are argued to be the most essential unit of action in a paper titled Toward the Circular Economy (Mubarik et al. 2021b). The article Accelerating The Scale-Up Across Global Supply Chains in terms of the adoption and effectiveness of CE states that supply chains will be the basis for driving the necessary change. Because the supply chain is the foundation of the global economy, the processes involved in it demand, arguably, the greatest and most immediate attention (Ma et al. 2022). Therefore, there is a requirement for a solid foundation for the planning and management of a CE supply chain (Wang et al. 2020). Green supply chain techniques and circular economies are both seen as key components of sustainable development, and they can occasionally overlap or complement one another. Despite the fact that green supply chain activities and circular economy practices attempt to accomplish the same goals, they are not interchangeable because they come at the problem from different angles. The emphasis of green supply chain methods is mostly placed on environmental performance; nevertheless, there is a possibility that economic performance is also linked to the aforementioned problem (Ma et al. 2021; Tong et al. 2023). On the other hand, practices of a circular economy are seen as a policy that should be implemented in order to extract economic benefits while simultaneously addressing concerns relating to the environment and resources. There are numerous research that have combined the two concepts into a single framework; despite this, there is still a demand for additional empirical evidence to explain the conceptual linkage between the two concepts (Zhang et al. 2021a, b, c). Circular economy practices are supported by green supply chain practices, which is interesting because green supply chain practices are also seen as an organizational element that is required to support circular economy activities. To develop a truly circular economy, circular economy principles need to be implemented throughout the supply chain in order to work. Companies in the modern business world compete with one another and operate across multiple supply chains (Ghorbanpour et al. 2021). The manufacturing of materials and their applications are extremely contingent on one another among the participants on the production line. Supply chain partners working together is necessary for enhancing both environmental and financial performance (Zhang et al. 2021a, b, c). It is necessary to have partners in the supply chain to develop a regenerative and restorative circular system of materials. Some examples of such partners include waste management organizations. The current notion of supply chain management, often known as SCM, has its origins in a linear model, which is indicated both by its name and the fact that it takes the form of a chain (Huo et al. 2019). The current forward chain is efficient in terms of operational performance (including cost and speed) due to the linear structure of SCM; however, the addition of restoration and regeneration functions (such as reverse chains) causes this efficiency to decline to be disrupted (Zhang et al. 2020b). However, serious problems with sustainability, in particular the rising risk of resource shortages, demand a circular supply chain management system that is to CE standards. In a circular supply chain, all actors in the supply chain systematically restore technical materials and regenerate biological materials toward a goal of zero waste, beginning with the sourcing of raw materials and ending with the disposal of waste.

CE is a relatively new idea that researchers are increasingly interested in studying because of how it operationalizes sustainability (Yang and Lin 2020). Both the academic community has examined the relationship between CE and sustainability and the frameworks that guide CE adoption (Reference). Because of CE law at the national and regional levels (China) (References), many studies have focused on the top-down technique of CE adoption. However, only a small number of research have looked into the challenges that businesses face when trying to adopt a circular economy (Ruan et al. 2022). Circular economy studies focusing on individual companies are in their infancy. In particular, there is scant literature on how to best implement a circular economy through the combination of product design and green supply chain management. As was previously discussed, product design and SCM are intertwined, and both play a crucial role in bringing about CE. However, as far as we are aware, nobody has looked into how well they work together in the context of CE. In order to boost China's regional economy, the authors of the present study looked at the impact of environmental results when green supply chain management is implemented. Eco-industrial park in China's region is studied for its resource efficiency and environmental sustainability, with the benefits of circular economy and green supply chain management highlighted. Economic performance and environmental performance are also extensively covered in this study. The mentioned variables are measured in China between September and November of 2022. Information is gathered from 80 eco-industrial parks around China by means of a questionnaire. This research, however, uses a structure equation model (SEM) to accomplish its goals. The following is a brief overview of the study's framework. The remainder of the paper is organized as well. In "Literature reviews and hypothesis development" section, we offer our study hypotheses and present our theoretical model based on the existing literature. Our questionnaire, data collection procedure, and non-response bias test are described in detail in "Research methodology" section. "Results and analysis" section presents the findings. "Discussion of the results" section presents and discusses the primary findings. "Conclusion and policy suggestions" section presents the conclusion and policy suggestions. In the final section, we analyze the work's shortcomings and offer suggestions for future study.

Literature reviews and hypothesis development

Circular economy

The CE concept was developed as an alternative to the current take-make-dispose model of manufacturing that dominates most sectors of the economy. Removing the link between economic expansion resource depletion the accumulation of waste is a primary goal of CE. The CE model is based on renewable energy sources, which contribute to its healing and regenerative qualities. Continual resource cycles that preserve and enhance stockpiles of natural capital while maximizing outputs are promoted by CE. The cradle-to-cradle methodology emphasizes a continual cycle of use, repair, and recycling of materials. Increasing the efficiency with which products and materials are used is central to CE's mission of maximizing resource production. In recent decades, worries about the possibility of resource exhaustion have grown steadily (Lei et al. 2021; Zhang et al. 2023; Noritake et al. 2020). Sustainability, biomimicry, the Blue Economy, and the Performance Economy capital (Roozbahani et al. 2020) were only a few of the earlier studies that attempted to find answers to sustainability's problems before CE came along. These ideas, however, have a cradle-to-grave perspective, which means that eventually, items and resources will wind up in landfills (Xia et al. 2021). CE is an amalgamation of many of McDonough's (Eur. Cent. Asia Econ. Update. Fall 2020 COVID-19 Hum. Cap. 2020) conception of a cradle-to-cradle cycle that is the one it most closely resembles. For this reason, a comprehensive economic, industrial, and social framework has been established in CE, with a focus on maximizing the efficiency and effectiveness of renewable energy sources, a systemic approach to waste minimization throughout the whole product lifecycle. Biological and technological cycles (Fabbri and Gaspari 2021) provide the basis of CE. Using renewable materials and limiting wasteful resource extraction is central to the biological cycle's emphasis on ecosystem regeneration. Renewable resources and new goods should be derived from the end products and resources, which in turn should be nutrients that are cycled back into the environment, whether by composting, anaerobic digestion, or cascading (Appolloni et al. 2022). The technical cycle emphasizes recovering usable resources from discarded materials and by-products through these channels. What we throw out can be put to good use in other manufacturing processes. The revolving circulation of materials and energy results from the interplay of these two cycles.

Despite the fact that there has been talk of a circular economy for quite some time, it has recently come into the spotlight after both China and the European Union approved governmental policies with CE aims. As a result of China's and Europe's foresight, this paradigm is being studied in a number of other countries as a means of encouraging new approaches to public and private governance. Zhang et al. (2020a, 2020b) examined the adoption of reverse packaging logistics in Brazil from the perspective of circular economics. In order to ensure that sectoral agreements are met, the authors argued that the government must insist on actor integration. They also said that the notion of shared responsibility is rarely used and that rubbish pickers are rarely effectively integrated into society. In a nutshell, businesses that embrace the goal of the circular economy is to recycle and reuse resources and regenerate as much value as possible in the design phase of their products and the products' components. By following these six guidelines, businesses and government agencies can reduce waste and enhance product value by reusing raw materials in subsequent production steps. Primary and secondary indicators are provided by the Resolve approach [EMF, 2015] for implementing procedures that prioritize Replace, Distribute, Combine, Optimize, Virtualize, and Trade. Amazon, Apple, Google, Microsoft, and Facebook are just some of the companies that have implemented some of these concepts and are positively impacting the lives of their customers while reducing their negative social and environmental effects [EMF, 2015]. Public politicians, managers, and scientists have all taken an interest in the concept of circular economy (Valadkhani et al. 2019), in large part because it helps dispel the belief that economic expansion necessarily results in environmental harm. For sustainability, this level of understanding is a prerequisite. The ideas of the circular economy are bold because they aim to improve upon existing sustainable supply chain practices. The shift toward a circular economy, however, requires that these methods be actively pursued.

Strategic planning for a resource-efficient economy

In most modern supply chains, resources go in only one direction, from upstream to downstream. Because of its emphasis on linear relationships to enhance operational efficiency (through strategies like lean), traditional SCM is not likely to accept sustainability challenges (Grant et al. 2021). There has been a rise in studies examining SCM with a focus on sustainability. Srivastava introduced the idea that combines green design, green manufacturing, reverse logistics, and waste management in a thorough literature review on the development of the idea of green supply chain management. Approaches such as supplier risk and performance management and supply chain management for environmentally friendly goods are two examples. Searing and Müller (Nabeeh et al. 2021) highlight as integral to a holistic approach to SCM that takes into account environmental and social impacts. Souza examined "closed-loop supply networks," which include the recirculation of used goods back to their original creators. From a sustainability standpoint, the field of SCM was significantly advanced by these earlier studies.

Through analysis in the canon of extant works, the idea of a supply chain that operates in a closed loop, or circular SCM, was devised. Cradle-to-grave supply chain management (circular SCM) centers on minimizing waste and maximizing resource reuse and recycling. This research agrees with the definition of circular SCM offered by Rejeb et al. (2020), which states that this practice entails the incorporation of circular thinking into the administration of the supply chain and the associated industrial and natural environments. It aims to achieve a zero-waste society by recovering technical materials and regenerating biological materials through system-wide innovation in business models and supply chain operations (p. 884). By recycling both technological and biological resources in an effort to achieve a zero-waste society, circular supply chain management (SCM) significantly cuts down on the need for new resource extraction. Using previous principles as a foundation, closed- and open-loop supply chain architecture represents a significant step forward for circular SCM (Hu et al. 2022). Logistics that move resources backwards and create useful data are called reverse logistics, which are essential in circular SCM (Rejeb et al. 2020). In a closed-loop model of circularity, companies in the same supply chain work together to recoup the monetary and nutritional worth of wastes and byproducts (Yu et al. 2020; Li et al. 2020). In open-loop supply networks, waste value is recovered through coordinated and collaborative supply chain activity either within the same industry sector (open-loop same sector) or across industries (open-loop other sector), which should also be supported by circular SCM. Continuously reusing waste products as inputs in both identical and distinct supply chains is a hallmark of circular SCM models, whether closed or open (Runst and Thonipara 2020). The term management of the flow of goods from suppliers to consumers' flow of goods and services between multiple participating businesses include both producers and consumers. If these groups are spread out throughout the globe, it will be very important for them to coordinate effectively. Long-term planning and management usually result in better results for all contributors to the supply chain. Supply chain managers have been concerned about environmental impact in recent years (Tian et al. 2023). These managers are in a position to either help or hinder business as usual. Depending on how they handle the increasing pressure from stakeholders should take into account the ecological and social costs of their operations. The goal of this study is to improve our understanding of the relationships between supply chain economic, environmental, and social performance.

Bhutta et al. (2021) conducted a literature assessment in their pursuit of incorporating the notion of including environmental responsibility into production processes. Possible changes include less packaging, better warehousing conditions, more efficient transportation, and increased supplier pressure to implement environmental and social programs by actions taken by the supply chain players themselves. According to Xu et al. (2019), sustainable supply chain management (SSCM) is frequently confused with green supply chain management (GSCM). The author justifies this error by claiming that numerous nations have achieved political and social problems like forced labor (which is comparable to slavery or child labor) and are thus free to concentrate on environmental problems. Noting that certain nations still struggle with social issues (especially in the southern half of the globe), it is important to clarify GSCM as a strategy for realizing SSCM, which promotes sustainable development by balancing economic expansion, ecological preservation, and social equity. Beyond simple monetary indicators, sustainable supply chain management aims to improve efficiencies and cutting costs. Concerns about the environment and society must consider that experts argue that this approach helps in taking action in a setting of natural resource scarcity and helps stakeholders in improving their performance in other areas; it is imperative that these concerns also be addressed tasked with addressing environmental concerns. After the epidemic, supply chains will become more regional, with customers demanding shorter links and perhaps partaking directly in production, leaving room for government meddling in the market. As a result, it is expected that the SSCM would confront a number of difficulties in the years following the pandemic, most notably in the realm of environmentally responsible consumption. Building a more circular supply chain would entail a web of interdependencies intended to slow down, condense, and close the manufacturing cycle. The authors draw the following conclusion from their review of the literature: management implications can only occur if the value is produced, captured, and transferred along the supply chain. Tools crucial to this more circular model include trash disposal, after-sale and consumer-use reverse logistics, product upgrades, and advertising campaigns.

Hypothesis development

When implemented together, green practices within an organization can have a significant impact on productivity. Sustainable internal practices are integrated into a larger process that is geared toward improving output (Pan et al. 2022; Vyas et al. 2022). In other words, green practices implemented internally have a positive effect on business results. Ding et al. (2020) stated that there are favorable correlations between in-house green SC practices and overall business success. Green SC practices have an impact on corporate output and bottom line (Polussa et al. 2021; Scheuer and Bailey 2021; Brunet et al. 2021). Making a firm more environmentally friendly and successful ability to compete on a global scale are both possible through green SC management techniques. By adopting green practices, businesses can improve their environmental impact and bottom line at the same time (Wang and Gao 2023; Ullrich-French et al. 2022). In other words, these methods boost the effectiveness of assets that have a direct bearing on economic output. Organizations that open out about their own green SC practices, such as the use of safe materials, recycling of single-use parts, or the proper use of a used machine, limit their potential for environmental abuse. Coordinating green practices with vendors is another way for businesses to reduce their environmental impact. Furthermore, Huang (2022) found that eco-friendly supply chain management comes from both internal and external sources and is positively related to company performance. Green SC management methods not only boost resource performance, but also boost resource efficiency, subsequently benefiting in a direct way a company's bottom line. In addition, there are numerous substantial financial benefits to adopting environmentally friendly activities (Pellow et al. 2020; Xiong et al. 2021; Bošković and Krstić 2020). This is a win–win scenario (Absar et al. 2021) because it helps businesses and the planet. Improvements in product quality and distribution efficiencies mean that green manufacturing practices can save expenses across the board. This includes everything from raw materials to transportation and storage; Tomitaka et al. (2022) reviewed the green supply chain practices and their favorable association with a company's operational capabilities without sacrificing customer happiness or product quality at five Portuguese supply chain firms. In light of that finding and after looking into the manufacturing company, the following assumptions have been developed for this work:

H1: Environmental sustainability is greatly impacted by green SC management technique performance.
H2: Management of SCs in a sustainable manner has a major effect on economic output.
The literature provides a variety of CE definitions. Some studies look at circularity from every angle and others that narrow in on its effects on the natural world. What we mean by restorative CE is a method of waste management that seeks to improve material, product, and system use through the development of novel economic models. CE is defined as an economic model in which planning, resourcing, procurement, production, and reprocessing are designed and managed, as both process and output, with the goal of maximizing ecological functioning and human well-being. The potential implications of a circu-

lar economy on social justice and future generations are mostly ignored in favor of its focus on economic growth and environmental protection. Economic benefits of industrial actors in general and on the individual level are overlooked from a resource scarcity, and environmental impact perspective (Li et al. 2023; Fabbri and Gaspari 2021) is a common theme in studies on CE development. On the other hand, Appolloni et al. (2022) believe that consumers' accountability, in addition to robust policies, is essential for CE. Environmental responsibility (CE) is defined as greener production practices at the corporate level; increased producer and consumer responsibility and knowledge; the use of renewable technology and materials (whenever possible); and the implementation of adequate, transparent, and reliable policies and mechanisms (Zhang et al. 2020a, 2020b). On the other hand, Valadkhani et al. (2019) emphasized sustainability as a CE goal. In order to achieve sustainable development for the benefit of future generations, they described CE as an economic system that replaces the "end-of-life" concept with reducing, reusing, recycling, and recovering materials in production/distribution and consumption processes (Matsuki and Pan 2021; Sun and Drakeman 2020). Responsible consumers and business model innovation remain at the heart of enabling CE, and collaborative consumption models are viewed as one of the most promising pathways for consumers to make the switch to a CE. Consumers' purchasing habits and strategies are always changing as a result of collaborative platforms that various parties own. It draws on the ideas of sustainable consumption, which hold that any resource not in use is a resource lost, as its premise. By boosting employment and resource efficiency, it is suggested in Jiang and Cheng (2020) that these collaborative consumption platforms remain the bedrock of CE success. According to our findings, the 4Rs (reduction, reuse, recycling, and recovery of materials in production and consumption) are at the heart of the circular economy (CE), an economic system that operates on micro, miso, and macro dimensions with the ultimate goal of sustainable development. Along with new business models and conscientious customers, we included collaboration via the CE's essential role as facilitated by the quadruple helix. To achieve both the micro- and macro-dynamics of open innovation, Li et al. (2021a, b) argue that a quadruple helix model is necessary for the sustainability of society, the economy, culture, policy, and knowledge. They are tested for innovation in the knowledge economy, universities, businesses, and governments that work together in a spiralling pattern of the invention known as the (Helmy Mohamad et al. 2021) triple helix. Recognizing to account for the fact that culture and values, on the one hand, and the way how "public reality" is being constructed and communicated by the media influences every national innovation system (Tan and Mao 2021) included media-based and the culture-based public as the fourth helix of collaboration to the quadruple helix model. Knowledge resources may be absorbed effectively by businesses when the mobility of highly educated people, advancements in technology, an accessible platform, and societal improvement participation are all present.

H3: The circular economy's (CE) far-reaching consequences on the natural world are undeniable.

H4: Recently, the concept of a circular economy (CE) has gained widespread attention.

In addition to developing their products and procedures, businesses must also think about supply chain design choices (such as facility location and safety stock) at the same time. When supplies of a necessary good are limited, companies often resort to closed-loop supply chains in order to cut down on waste. The options available to businesses in terms of collecting, acquisition, inspection, and sorting facilities are affected by the nature of a closed-loop supply chain, etc. (Wang et al. 2023). By recycling products, reducing waste, and utilizing natural resources, closed-loop supply chains allow businesses to become more environmentally friendly in their operations (Chen 2022). The scarcity of natural resources, whether they be globally scarce, like platinum or regionally scarce, like water, has a significant effect on the placement decisions of industrial enterprises (Ling et al. 2021). As natural resources are depleted, many factories must move to other locations to maintain or improve their competitive edge. Closed-loop supply chains enable a company to make the most of its access to natural resources, which could make it harder for competitors to compete (i.e., technological abilities and information) that rival companies would have a hard time duplicating, giving you an edge in the market. In order to mitigate the effects of supply chain disruptions and, more specifically, to address the problem of natural resource scarcity, many businesses resort to stockpiling certain natural resources (Alvarado et al. 2022). Manufacturing is one industry where this is true; safety supplies help ensure continuous output, giving businesses an edge in the market (Makhdum et al. 2022). Thus, it is speculated that scarcity of natural resources:

H5: Effective supply chain management that minimizes waste of materials and energy is called green.

Maximizing resource efficiency is inextricably tied to CE, which begins with resource conservation (refusing and using less extra material) and ends with waste reduction (recycling and recovering). Waste reduction, ecosystem awareness, design adaptability, and eco-friendly power sources are fundamental to the circular business model, as stated by Schulte (Feng et al. 2023). These guidelines improve productivity while minimizing waste. Public backing is a crucial incentive for enacting measures to enhance resource efficiency (for example, see Zhao et al.

2022). To encourage new business activities and have a good effect on employment, Schulte (Yang and Ni 2022) argued that incentives and taxation should be prioritized. He proposed shifting fees on everything from human effort to the depletion of natural resources. Zhou et al. (2020) examined the comparative merits of authoritarian and liberal approaches to environmental governance in order to shed light on the potential benefits and drawbacks of making the switch to a closed-loop economy. In particular, the study's authors stressed the importance of standards as a primary tool for policymaking. Hrovatin et al.'s (2021) strategies for encouraging green behavior among European SMEs and methods for measuring their environmental impact were reviewed. Understanding what motivates people to take resource-saving measures is crucial for developing effective tactics. Small- and medium-sized enterprises (SMEs) may be viewed as a reference market that requires segmentation in order to implement focused policies (Hu et al. 2023; Hu et al. 2022; Ahokangas et al. 2021). Zainal et al. (2022), for instance, research into according to European SMEs operating in energy-intensive industries investments significantly impacted revenue expansion. However, as (Hu et al. 2022) demonstrated, not all eco-strategies have the same impact on sales. According to studies conducted by the European Commission, the hospitality and food service industries are particularly environmentally conscious (Zubair et al. 2020; Xu et al. 2023; Jean and Kim 2020). For instance, research into European SMEs in energy-intensive industries indicated that resource efficiency investments significantly impacted revenue expansion. However, as Rahman et al. (2022) demonstrated, not all eco-strategies have the same impact on sales. According to studies conducted by the European Commission, the hospitality and food service industries are particularly environmentally conscious. Green employment is also crucial to the successful implementation of CE. Employment in the CE sector must first be defined in terms of skills and talents, as shown for instance in Fabbri and Gaspari (2021). Green jobs can be narrowly defined as those in green product and service production, but this ignores the many workers whose work is environmentally beneficial because of the methods they apply. Several articles and books in the canonical literature describe green employment opportunities. In addition to the aforementioned advantages, the expansion of CE also creates new employment possibilities. By evaluating German data, a recent study (Appolloni et al. 2022) concluded that advancements in CE have a substantial effect on employment rates.

H6: Resource efficiency has been drastically changed with the introduction of CE.

Manufacturing companies are increasingly concerned with incorporating sustainability into their supply chains (Zhang et al. 2020a, 2020b). Businesses in today's climate are under pressure to reevaluate their supply chains in order to effectively include sustainability initiatives like Industry 4.0, eco-friendliness, and lean practices. To overcome obstacles and establish enhanced sustainability in the supply chain, it is not enough for manufacturing enterprises to adopt CE practices on their own; supply chain members must do the same. The natural resource-based view hypothesis supplements the resource-based approach that places greater emphasis on resources that contribute to long-term sustainability. This perspective explains how the competitive advantage of a company shifts over time as a result of the influence of external factors on internal organizational linkages, such as supply chain strategy. CE aids SSCM's business expansion by fostering concern for the environment, energy efficiency, and international competition (Matsuki and Pan 2021). Since climate change, pollution, and customer expectations all push businesses to engage in sustainable practices, sustainability is the responsibility of every link on the production line. Using a combination of binary and supply-chain technique relationships (Sun and Drakeman 2020), the SSCM aims to combine concerns about using procurement strategies and cutting-edge machinery to meet user expectations. Suppliers' broad knowledge and collaborative approaches seek to enhance environmental performance, energy savings, and global competitive climate. One way to ensure that the entire supply chain is sustainable is to work only with those who adhere to the strictest sustainability standards (Jiang & Cheng 2020; Shi et al. 2023; Li et al. 2021a, b). Integrating CE principles into supply chain management is becoming more difficult as the external sustainability of supply networks becomes more important. However, doing so will help create a better balance between economic, social, and environmental benefits. However, when CE practices are included in these systems, various issues arise. Integration of all supply chain operations is essential for maximizing reuse and recycling potential and capturing value addition. This type of industrial symbiosis requires a rethinking of product-service systems (Shang and Luo 2021; Helmy Mohamad et al. 2021). To turn these recoveries and waste into the raw materials or life cycle resources of the subsequent new product, a great deal of specialization in business processes is required. This is due to technological constraints, which are impediments in the life cycle of new products or waste that can convert materials or resources into new recycled products required across the entire supply chain.

In light of the foregoing, we would like to submit the following hypothesis for further study.

H7: Companies' efforts to manage their supply chains in a way that minimizes their environmental impact are greatly aided by the circular economy.

Green policy implementation has been shown to have positive effects on the environment and economic growth in numerous studies. Greater economic performance is associated with better environmental performance in terms of lowering emissions, preventing waste, and decreasing the amount of trash generated on-site (Salari et al. 2021; Zhang et al. 2021a, b, c). An increase in sales and earnings may not be the immediate result of better environmental performance. Despite the overwhelming evidence supporting the correlation between environmental management and economic growth, conflicting results have been found in the literature (Kyara et al. 2021; Bai et al. 2021; Al-Thaqeb et al. 2022). As we have seen, increasing environmental efficiency can have a positive effect on economic productivity. So, here is the hypothesis:

H8: The state of the environment has a major bearing on the state of the economy.

Research methodology

We use a massive survey of Chinese businesses located in eco-industrial parks to put our theoretical framework to the test. Methods of data collection, characteristics of the sample, and the outcomes of tests for non-response bias are all detailed in this section.

Questionnaire design

Before designing our questionnaire, we made sure it was reliable and valid by reviewing the literature on green circular economy and supply chain management (GSCM), focusing on the scales and important indicators utilized in previous studies. Twenty-one components make up the current study, some of which pertain to economic performance metrics and others to environmental performance indicators. Economic performance among green supply chain management and the circular economy in the China region is also investigated. The study focuses on resource efficiency and environmental performance. Researchers used questionnaires to gather information from participants. Questions were utilized to quantify factors in the study. Five questions on environmental performance were taken from, four on economic performance were taken from, four on circular economy were taken from, five on green supply chain management were taken from, and three on resource efficiency were taken. The survey asked for responses on a 5 range from strongly disagree to strongly agree on a 7-point Likert scale.

Data collection

Only businesses located in eco-industrial parks were included in the sample. To guarantee a statistically significant sample, we narrowed our focus to the 80 eco-industrial parks around the country that are incorporated into the National Eco-Industrial Demonstration Park. We also took regional differences in industrial park distribution into account, selecting parks to represent each region as part of our sample pool. We had a hard time getting in touch with businesses during the survey, so we mostly sampled from parks with which we were already familiar. As a result, we gathered information from the following zones: Shanghai's Guangdong Eco-industrial Park of Dongguan; Liaoning's Shenyang High-tech Industrial Development Zone; Hunan's Changsha and Zhuzhou Economic & Technological Development Zones; and Xinjiang's Urumqi Economic & Technological Development Zone. Each company in the park received only one questionnaire to ensure accurate sampling. We conducted survey from September 2022 through November 2022, primarily with the assistance of our alumni and friends, and we offered a present to all respondents. A total of 650 surveys were sent out, and 487 were returned for analysis (74.92% response rate). Only 80% of the questionnaires were valid, with the remaining 130 being rejected for various reasons (such as a. replies that did not conform to the desired structure; b. missing significant portions of questions; and c. had identical markings on all replies, indicating that the questions had not been read carefully). After weeding out the unusable surveys, we were left with 357 complete responses. Table 1 displays the sample's fundamental statistical features, showing that the actual response ratio was 54.92%. This meets the criteria according to Kaplan and Ferguson's (1999) medium-sized sample, but the response rate was lower than ideal (there were almost as many responders as there were items). Our sample size was large enough to conduct statistical tests of our hypotheses, and the results of our empirical study should be credible.

The test for non-response bias

The most common cause of sampling errors is non-response bias, which occurs when some of the intended survey respondents decide not to take part. The reliability of study results can be increased by checking for non-response bias. However, there are times when it is next to impossible to collect data from people who did not fill out the survey. Earlier researchers presented a method that accounts for the comparison of first- and second-wave findings to look for non-response bias in completed surveys. To see if there were any differences between the first and final responses, a chi-squared test (indices such as Pearson2, degree of freedom, and *P* value) was applied to a random sample of the first and

Table 1 Features of the data sample in terms of statistics

Category	Number	Proportion	Category	Number	Proportion
Firm property			Industry		
State-owned	135	37.81%	Industrial machinery/equipment	54	15.12%
Private	87	24.36%	Instruments and related products	32	8.96%
Foreign-owned/joint-ventured	107	29.97%	Rubber and plastic products	28	7.84%
Others	28	7.86%	Transportation equipment	16	4.48%
Position of respondent			Chemical products	43	12.07%
President/General Manager	47	13.17%	Fabricated metal products	54	15.12%
Vice President/Deputy General	36	10.08%	Appliances	21	5.88%
Manager	182	50.98%	Electronic/electric equipment	15	4.20%
Manager/Supervisor	50	14.01%	Automobiles or auto parts	45	12.61%
Others (e.g., department heads)	42	11.76%	Furniture and fixtures	11	3.08%
The time period that the firm has focused on environmental protection issues			Others	38	10.64%
≤ 1 year	52	14.56%	**ISO certification**		
2–5 years	157	43.97%	ISO9000	269	75.35%
6–10 years	85	23.83%	ISO14000	88	24.65%
11–15 years	63	17.64%			
≥ 15 years	40				

last 121 responses. Early and late responses did not vary statistically at the 95% degree of certainty (results shown in the appendix). Because of this, we determined that there was no problem with non-response bias.

Methodology

Hypothesis testing methods

In this work, the proposed model was put to the test utilizing the partial least square (PLS) method of structural equation modeling approach to SEM. The PLS method excels above other SEM techniques because it makes no demographic or scale measurement assumptions. PLS is an extension of PCA and canonical correlation analysis (H) that can be thought of as a family of alternating least square methods. It is broken down into two models, or sets of equations: an inner and an outer. The first specifies connections between unspoken or unseen elements. The outer model defines a hidden variable's interactions with its manifest indicators.

One of PLS's biggest weaknesses is that it does not come with an index that can verify the model on a worldwide scale for the researcher. To assess a PLS path model internationally, however, Sharma and Aggarwal (2019) established a global criterion; they named the indicator of quality of fit (Goff). Goff analyzes the performance of both the quantitative and qualitative models, as stated in. In this analysis, the PLS technique was implemented via the pulps package (Hayajneh et al. 2022) in SPSS (Kaur and Kaur 2022).

Model measurement

Four criteria, item reliability, and the measuring model were tested for reliability and validity by looking at its internal consistency, convergent validity, and discriminant validity used in this study.

Item reliability

Survey item dependability was determined by calculating item loadings into the corresponding latent construct. All item standardized loadings must be more than 0.70 (Alshebami et al. 2022). Table 2 shows that all items were within tolerance since their loadings were more than 0.7.

Table 2 Measures of central tendency and dispersion (including kurtosis and skewness)

Variables	Mean	Median	Std. dev	Max	Min
ENP	3.176	3.065	0.327	5.281	2.753
ECP	2.652	2.547	1.094	4.064	0.409
CE	2.498	2.231	0.845	3.735	1.321
GSCM	3.562	3.325	0.761	4.653	1.764
RE	3.875	3.574	0.649	5.281	1.095

ENP environmental performance, *ECP* economic performance, *CE* circular economy, *GSCM* green supply chain management, *RE* resource efficiency

Convergent validity

This criterion looks into how closely survey responses that were supposed to be related actually were. To test for convergent validity, we looked at (a) each latent construct's average variance extracted (AVE) and (b) internal consistency (Woo et al. 2021).

Composite reliability was utilized to evaluate the extent to which a given latent construct exhibited internal consistency. A composite dependability of greater than 0.70 indicates an internally consistent model (Drachal 2021).

AVE compares the variance obtained by a latent construct from its indicators to the variance introduced by measurement errors. If the AVE is at least 0.50, then at least half of the variation in the indicators may be accounted for. Table 2 shows that the AVEs for the latent constructs in the research model all exceeded the 0.5 threshold.

Discriminant validity

To establish discriminant validity of the research model, it is necessary that survey questions load more strongly on the latent constructs than on other latent constructs and that the square root of the AVE for each latent construct is larger than its correlation coefficients with other latent constructs (Woo et al. 2021).

Results and analysis

Descriptive statistics

Table 2 displays descriptive data, including the mean (*M*), standard deviation (SD), and extreme values. Table 2's numbers suggest that the data were generally good and normally distributed. Environmental performance, economic performance, eco-friendly supply chain administration, the circular economy, and resource efficiency are the five constructs used in this investigation. The data show that resource efficiency has the highest mean value and that circular economy has the lowest. ENP, ECP, CE, GSCM, and RE all had mean values of 3.176, 2.652, 2.498, 3.562, and 3.875, respectively.

Discriminant validity is the ability of a set of items to differentiate one variable from others. There were no statistically significant instances of cross-loading. However, we find that all indicators loaded most heavily on their primary components (see Table 3). Our study's model, in a nutshell, shows that discriminant validity is generally acceptable. Using the results of exploratory factor analysis, we analyzed the convergent validity using composite reliability (Gong 2020; Elvidge et al. 2021) and average variance extracted (AVE) score instruments (Chen et al. 2023). As could be seen, all of the factor loadings for the items were a cutoff value of 0.50 (De Matos et al. 2021) or above. In addition to the overall reliability, average AVE values were more than

Table 3 AVE, cross-loading, and the reliability of composites

Constructs	Items	Loading	CR	AVE
Environmental performance (ENP)	ENP 1	0.832	0.947	0.716
	ENP 2	0.815		
	ENP 3	0.754		
	ENP 4	0.878		
	ENP 5	0.843		
Economic performance (ECP)	ECP 1	0.739	0.826	0.637
	ECP 2	0.676		
	ECP 3	0.845		
	ECP 4	0.816		
Circular economy (CE)	CE 1	0.809	0.875	0.565
	CE 2	0.741		
	CE 3	0.821		
	CE 4	0.757		
Green Supply chain management (GSCM)	GSCM 1	0.739	0.932	0.669
	GSCM 2	0.867		
	GSCM 3	0.737		
	GSCM 4	0.721		
	GSCM 5	0.775		
Resource efficiency (RE)	RE 1	0.768	0.967	0.643
	RE 2	0.743		
	RE 3	0.711		

Table 4 The discriminant validity criterion proposed by Fornell and Lacker

Constructs	ENP	ECP	CE	GSCM	RE
ENP	0.943				
ECP	0.716	0.917			
CE	0.526	0.865	0.963		
GSCM	0.734	0.521	0.835	0.937	
RE	0.749	0.609	0.415	0.636	0.955

ENP environmental performance, *ECP* economic performance, *GSCM* green supply chain management or circular economy, *RE* resource efficiency

Table 5 Heterotrait-Monotrait (HTMT) ratio

Constructs	ENP	ECP	CE	GSCM	RE
ENP					
ECP	0.839				
CE	0.751	0.725			
GSCM	0.433	0.767	0.574		
RE	0.624	0.839	0.613	0.827	

the 0.70 and 0.50 thresholds, respectively, that are suggested (see Table 3). No problems with convergent validity were found for the chosen constructs, as evidenced by factor loadings, composite reliability, and the AVE. Discriminant validity was examined by looking at how each concept correlated with the square root of the average daily earnings.

Several methods were employed to ensure discriminant validity. Our first step was to use the tried-and-true. The AVE square root is bigger than the correlation coefficients, as determined by Fornell-Larcker's criterion (Table 4). The cross-loadings were also analyzed; as you can see in Table 5, they all have a high weight on the targeted construct and a low weight on the others. Table 5 shows that no HTMT ratio is more than 0.90, meeting the HTMT requirement. The measurement model's SRMR index is 0.065, which is less than the mandatory value of 0.08 (Zhu et al. 2020). Therefore, the model fits the data well.

Another technique for testing discriminant validity is the Heterotrait-Monotrait (HTMT) correlation ratio alongside cross-loading and the Fornell-Larcker criterion. The validity issue is fixed by using the HTMT ratio. The HTMT ratio was also used in this study to assess trustworthiness. Discriminant validity is established at a p value <0.9 (see Table 5).

Table 6 shows that the measurement model explains 75.7% of the variation in resource effectiveness, 81.6% of the variation in environmental performance, 72.6% and 94.55% of the variance in green supply chain management, 36.9% of the variance in economic performance, and 36% of the variance in the circular economy. Therefore, the measurement model has substantial and reasonable predictive potential, as these percentages are larger than 10%. Exogenous constructions are extremely relevant to endogenous construct's favorable and significantly increased predictive value (Table 7).

Table 6 *R*-squared power prediction

	R-squared	Adjusted *R*-squared
ENP	0.757	0.753
ECP	0.726	0.721
CE	0.369	0.364
GSCM	0.945	0.943
RE	0.816	0.812

Table 7 Predictive relevance: Stone-Geisser's Q^2 value (Geisser, 1975; Stone, 1974)

Constructs	SSO	SSE	$Q^2=(1.\text{SSE/SSO})$
ENP	748.000	125.574	0.754
ECP	921.000	287.043	0.769
CE	857.000	184.214	0.821
GSCM	975.000	253.653	0.876
RE	521.000	264.379	0.725

SSO sum of squares of observations, *SSE* sum of squares of prediction error, *ENP* environmental performance, *ECP* economic performance, *CE* circular economy, *GSCM* green supply chain management, *RE* resource efficiency

Hypothesis testing

Table 8 displays the findings of the SEM analysis using a squared structure. Management of green supply chains was proven to have a substantial positive effect on environmental performance (=0.437; $t=1.763$; $p=0.034$), as predicted by the null hypothesis. The second hypothesis asserted that a green supply chain management negatively affects the perceived economic performance. Table 8's results supported H2 and negative correlations (=0.219, $t=3.187$, p 0.321). The results of this study support H3 and H4 as shown in Table 8 (=0.054, $t=3.726$, p 0.007) and (=0.146, $t=2.154$, p 0.005), respectively, suggesting that circular economy beliefs have a positive relationship with the perceived impact on environmental performance and economic performance. Hypotheses 5 and 6 were supported (=0.632, $t=4.297$, p 0.021 and =0.329, $t=1.542$, p 0.045), respectively, suggesting that management of green supply chains and the circular economy have a favorable effect on resource efficiency. According to Table 8, the findings of this study confirm H7 (=0.151, $t=1.873$, p 0.003), which states that circular economy elements have an optimistic and considerable impact on environmentally conscious supply chain management.

Table 8 Tests of hypotheses and their outcomes

Hypothesis	Path	STd. beta (β)	Std. error	t value	p value	Decision
H1	GSCM → ENP	0.437	1.043	1.763	0.034	Supported
H2	GSCM → ECP	− 0.219	0.087	3.187	0.321	Not supported
H3	CE → ENP	0.054	0.076	3.726	0.007	Supported
H4	CE → ECP	0.146	1.065	2.154	0.005	Supported
H5	GSCM → RE	0.632	1.439	4.297	0.021	Supported
H6	CE → RE	0.329	0.825	1.542	0.045	Supported
H7	CE → GSCM	0.151	0.743	1.873	0.003	Supported
H8	ENP → ECP	0.326	0.827	3.087	0.164	Not supported

Hypothesis H8 (= 0.326, $t = 3.087$, p 0.164) is supported by the data, which likewise demonstrates a positive but insignificant relationship between environmental performance and economic performance.

Discussion of the results

These findings corroborate the findings of a prior study showing that implementing green supply chain management solutions significantly improves ecological functioning. According to the findings, eco-friendly SC practices significantly predict overall environmental effectiveness. The internal and external GSC practices have a substantial impact on environmental performance, as shown by previous study works (Ali et al. 2020). Manufacturers employ green practices including using non-hazardous materials and properly maintaining machinery so that they can reduce their ecological footprint. Green supply chain management helps manufacturers lessen their environmental impact. Green supply chain management, however, is a weak and negative indicator of economic output. Studies have indicated a small, negative effect on economic growth (Awasthi et al. 2020), and researchers have found the same thing (Nureen et al. 2022). Eco-design and internal environmental management are two examples of green supply chain management strategies that fall under the umbrella term. Since the dynamics of a developing country are complicated by many other economic limitations and environmental sustainability, the impact of institutional pressure on economic performance is negative but marginal. In addition, research has discovered supply chain activities that promote sustainable consumption and contribute to the circular economy. Facilities for restoring previously owned items, reselling them, reusing them, or recycling them and consumer incentives in the form of price competition and price education are all examples of strategies designed to influence consumers' mindsets and actions. Self-sufficient manufacturing systems and the infrastructure to support these systems are two possibilities for a shift towards more sustainable consumption, increasing levels of consumer awareness, engagement, and responsibility. The study estimated a structure equation model to classify Chinese firms into clusters with similar levels of resource-efficiency practice adoption and planning, as well as clusters of countries with similar concentrations of firm types. Both companies' actual actions and their stated goals were used to create distinct groups. The countries were divided into four categories, but the composition of each class changed when we considered past acts and future goals. The analyses confirm the findings of other studies that suggest indicating that there is a sizable variation in CE adoption across nations and that segments' membership was influenced by factors including the proportion of individuals employed in green jobs and a favorable outlook towards environmental skills to specific groups. The quantity and type of resource-efficiency measures intended to be implemented by Chinese SMEs were calculated using multilevel regression models, corroborating the findings. One crucial finding across all of the models was the negative correlation between the absence of green-sector workers and future intentions to carry out any of the eight interventions tested. Resource effectiveness was also heavily influenced by other features of the company. Companies with longer histories and higher annual revenues were more likely to take steps toward greater resource efficiency. Various economic sectors opted for a wide range of responses. The purpose of this study was to give scientific confirmations of the ties between green supply chain management and resource effectiveness and filling in some of the gaps in the current research. What led to and methods for mitigating the threat of a shortage of natural resources have been the primary focus of previous research (Pyka and Nocoń 2021; Sharma et al. 2021). Furthering our understanding of how buffering and bridging techniques affect organizational performance in terms of resource efficiency and competitive advantage, this research contributes to the current body of literature. It was observed that buffering tactics improved resource efficiency but did not provide a competitive edge. When supplies of essential materials are low, companies will rely on closed-loop supply networks (), but this argument has not been practically validated. The results confirm that CE in the Chinese eco-industrial park has a beneficial impact on green supply chain administration. The results produced agree with these conclusions. Government tax breaks or preferential treatment, an edge in the marketplace, the ability to turn trash into treasure, and smarter resource and energy management are all to thank for these benefits. This means that the advantages outweigh the expenses of implementing a circular economy in the auto industry consistent with Su et al. (2022), who emphasize the importance of reviewing CE practices to have a positive effect on green supply chain management, which in turn helps companies achieve adequate levels of sustainability along the supply chain. To what degree sustainability principles govern the company's interactions in SC is a key factor in maintaining a competitive edge. According to Li et al. (2021a, b), a company's competitive advantage might change depending on how much environmental consideration was factored into the development from the factory to the store shelves strategy.

Conclusion and policy suggestions

Studying circular economy, the authors of the study looked specifically at how green supply chain management might impact resource efficiency and environmental performance. The goal was to look into how circular economy principles relate to green supply chain management from an economic performance perspective. The Chinese economy was surveyed in order to gather information for a CE-integrated environmental performance study on the circular economy and management of eco-friendly supply chains. Both green supply chain management and circular economy have a significant positive impact on environmental performance, but green supply chain management has a negative impact on economic performance. The circular economy and environmentally responsible supply chain management both lead to greater resource efficiency. The results also showed that recycling and reusing waste products improve a company's environmental performance by lowering pollution risks and reusing valuable resources. Key aspects provided by this research are, foremost, managers and businesses that implement CE and GSCM techniques to execute the goal of top management and boost quality while also increasing competitiveness and enhancing reputation in the market. Managers should seek out and eliminate all wasteful processes and procedures from their organization. Emissions and trash can be drastically decreased by adopting circular product streams, sustainable sourcing, and well-designed processes. Management at the highest levels should take the initiative in promoting corporate social responsibility. Second, theoretical linkage and development are undervalued in the academic community, particularly within eco-friendly supply chain analysis and research on the reuse economy. This research proves that green supply chain management is crucial in the eco-industry park when businesses implement CE activities. Thus, in order to convey the automotive industry's commitment to environmental sustainability, green supply chain management is essential and sustainability care, via the growth of CE activities that have a beneficial impact on FIP. Economic policy, taxes, employment, research and development, consumption, industrial policy, water, agriculture, and rural development are all examples of CE policies that have been observed to make economies more independent, less vulnerable, and more competitive, thereby aiding in the achievement of the SDGs. Stakeholders should imply a transition toward green practices rather than an immediate shift to them. Therefore, the government and other stakeholders need to put pressure on businesses alongside providing them with technical and financial help to ensure GSC management practices are implemented. The result of giving in to these pressures, however, is generally a decrease in financial performance as companies make haphazard attempts to apply internal GSC management. This is why every adaptation of environmentally friendly technology or procedures will have an initial financial outlay, even if it will pay dividends in the long run. The findings of this research can help EMS managers implement green practices outside the company in order to boost productivity. To achieve this goal, businesses can make waste-reduced and environmentally friendly purchases from EMS-approved vendors that provide items that meet or exceed industry standards. In addition, an environmental manager must prioritize customer needs by working closely with customers to identify the metrics of greatest importance to them. Last but not least, a green mindset needs to be built and developed within an organization to inspire employees from within. Management frequently attempts to avoid penalties in the area of environmental sustainability by adhering to the rules and regulations. As a result, it might have a chilling effect on the company's overall performance. Firstly, this study gives managers a useful instrument for weighing the pros and cons of buffering and bridging solutions to deal with or lessen the impact of resource constraints. This is done by creating and verifying a multi-dimensional framework of supply chain strategies and demonstrating its worth in raising output with respect to resource effectiveness and competitive advantage. It provides executives with guidance on how to improve performance by planning and adapting. Managing the entire supply chain, from returns to product development to manufacturing to supplier relationships, is called supply chain management to take advantage of scarce natural resources (such as water, energy, and minerals) at lower costs and with less waste and fewer costs than competitors. From a legislative standpoint, the government needs to incentivize SMEs to utilize technology better and reduce wasteful resource consumption in order to boost their overall performance.

Limitations and future directions

The study had certain caveats, as any investigation does. Our sample size is small, for starters. The 357 valid samples collected in this investigation are large enough for statistical analysis. However, in China, one can find industrial, complete, and venous eco-industrial parks. Because we did not categorize the parks in which the companies we polled were located, we cannot be certain that our findings apply to other settings. Second, there are problems with the available measurements and scales. Green supply chain management is found to be at an advanced stage of development, but circular economy metrics are still in their infancy. Additionally, we only interviewed one manager from each company, so the results may not reflect actual conditions within the company, and more extensive research may be needed to obtain more accurate results. We also have no choice but to collect data at discrete intervals for polling. The sample's ability to follow closely throughout the investigation will determine the strength and generalizability of the findings. These limitations and deficiencies provide avenues and topics for future research. First, future researchers can classify eco-industrial parks into one of three categories and then compare their respective green supply chain management and circular economy. The research assumptions and conclusions of this study can be further validated by collecting data from other nations, allowing for a broader global perspective to be attained. Second, future study should acquire panel data by continuously focusing on the individual samples in order to reduce the contingency of point data and raise the robustness of the research conclusions. Further optimization and refinement of a reliable measurement scale for GSCM's sustainability performance is also necessary. There is still a need for the development of an all-encompassing scale that takes into account political, economic, and ecological aspects.

Author contribution Jing Qi Gao: conceptualization and data curation, Ding Li: methodology and writing—original draft, Guang Hui Qiao: data curation, Qiao Ran Jia: visualization and supervision, Shi Ru Li: editing and writing—review, and Han Lin Gao: editing and software.

Data availability The data can be available on request.

Declarations

Ethics approval and consent to participate We declare that we have no human participants, human data, or human tissues.

Consent for publication N/A.

Competing interests The authors declare no competing interests.

References

Absar SM, McManamay RA, Preston BL, Taylor AM (2021) Bridging global socioeconomic scenarios with policy adaptations to examine energy-water tradeoffs. Energy Policy 149:111911. https://doi.org/10.1016/j.enpol.2020.111911

Ahokangas P, Haapanen L, Golgeci I, Arslan A, Khan Z, Kontkanen M (2021) Knowledge sharing dynamics in international subcontracting arrangements: the case of Finnish high-tech SMEs. J Int Manag 100888. https://doi.org/10.1016/j.intman.2021.100888

Ali Y, Saad TB, Sabir M, Muhammad N, Salman A, Zeb K (2020) Integration of green supply chain management practices in construction supply chain of CPEC. Manag Environ Qual: Int J 31(1):185–200. https://doi.org/10.1108/MEQ-12-2018-0211

Alshebami AS, Seraj AHA, Alzain E (2022) Lecturers' creativity and students' entrepreneurial intention in Saudi Arabia. Vision 097226292210995. https://doi.org/10.1177/09722629221099596

Al-Thaqeb SA, Algharabali BG, Alabdulghafour KT (2022) The pandemic and economic policy uncertainty. Int J Financ Econ 27(3):2784–2794. https://doi.org/10.1002/ijfe.2298

Alvarado R, Cuesta L, Kumar P, Rehman A, Murshed M, Işık C, Vega N, Ochoa-Moreno S, Tillaguango B (2022) Impact of natural resources on economic progress: evidence for trading blocs in Latin America using non-linear econometric methods. Resour Policy 79:102908. https://doi.org/10.1016/J.RESOURPOL.2022.102908

Appolloni A, ChiappettaJabbour CJ, D'Adamo I, Gastaldi M, Settembre-Blundo D (2022) Green recovery in the mature manufacturing industry: the role of the green-circular premium and sustainability certification in innovative efforts. Ecol Econ 193:107311. https://doi.org/10.1016/J.ECOLECON.2021.107311

Awasthi K, Ahmad W, Rahman A, Phani BV (2020) When US sneezes, clichés spread: how do the commodity index funds react then? Resour Policy 69:101858. https://doi.org/10.1016/j.resourpol.2020.101858

Bai Y, Guo C, Li S, Degen AA, Ahmad AA, Wang W, Zhang T, Huang M, Shang Z (2021) Instability of decoupling livestock greenhouse gas emissions from economic growth in livestock products in the Tibetan highland. J Environ Manage 287:112334. https://doi.org/10.1016/J.JENVMAN.2021.112334

Bhutta MKS, Muzaffar A, Egilmez G, Huq F, Malik MN, Warraich MA (2021) Environmental sustainability, innovation capacity, and supply chain management practices nexus: a mixed methods research approach. Sustain Prod Consumpt 28:1508–1521. https://doi.org/10.1016/j.spc.2021.08.015

Bor JKM (2021) Green Supply Chain Management Practices and Performance of Food and Beverage Processing Sector in Kenya. http://ir.jkuat.ac.ke/handle/123456789/5498

Bošković A, Krstić A (2020) The combined use of balanced scorecard and data envelopment analysis in the banking industry. Busi Syst Res. https://doi.org/10.2478/bsrj-2020-0001

Brunet C, Savadogo O, Baptiste P, Bouchard MA, Cholez C, Gendron C, Merveille N (2021) The three paradoxes of the energy transition—assessing sustainability of large-scale solar photovoltaic through multi-level and multi-scalar perspective in Rwanda. J Clean Prod 288:125519. https://doi.org/10.1016/j.jclepro.2020.125519

Chen Y (2022) Research on collaborative innovation of key common technologies in new energy vehicle industry based on digital twin technology. Energy Rep 8:15399–15407. https://doi.org/10.1016/j.egyr.2022.11.120

Chen J, Liu Z, Yin Z, Liu X, Li X, Yin L, Zheng W (2023) Predict the effect of meteorological factors on haze using BP neural network. Urban Climate 51:101630. https://doi.org/10.1016/j.uclim.2023.101630

De Matos TPV, De Matos VPV, De Mello K, Valente RA (2021) Protected areas and forest fragmentation: sustainability index for prioritizing fragments for landscape restoration. Geol Ecol Landsc 5(1):19–31. https://doi.org/10.1080/24749508.2019.1696266

Ding H, Zhou DQ, Liu GQ, Zhou P (2020) Cost reduction or electricity penetration: Government R&D-induced PV development and future policy schemes. Renewable Sustain Energy Rev 124. https://doi.org/10.1016/j.rser.2020.109752

Drachal K (2021) Forecasting crude oil real prices with averaging time-varying VAR models. Resour Policy 74. https://doi.org/10.1016/j.resourpol.2021.102244

Elvidge CD, Zhizhin M, Ghosh T, Hsu FC, Taneja J (2021) Annual time series of global viirs nighttime lights derived from monthly averages: 2012 to 2019. Remote Sens 13(5):1–14. https://doi.org/10.3390/RS13050922

Europe and Central Asia Economic Update, Fall 2020: COVID-19 and Human Capital (2020) In Europe and Central Asia Economic Update, Fall 2020: COVID-19 and Human Capital. https://doi.org/10.1596/978-1-4648-1643-7

Fabbri K, Gaspari J (2021) Mapping the energy poverty: a case study based on the energy performance certificates in the city of Bologna. Energy Build 234:110718. https://doi.org/10.1016/j.enbuild.2021.110718

Feng Y, Zhang Y, Wu Z, Ye Q, Cao X (2023) Evaluation of agricultural eco-efficiency and its spatiotemporal differentiation in china, considering green water consumption and carbon emissions based on undesired dynamic SBM-DEA. Sustainability 15(4):3361. https://doi.org/10.3390/SU15043361

Ghorbanpour A, Pooya A, Azimi ZN (2021) Application of green supply chain management in the oil industries: modeling and performance analysis. Mater Today: Proceedings 49(xxxx):542–553. https://doi.org/10.1016/j.matpr.2021.03.672

Gong B (2020) Multi-dimensional interactions in the oilfield market: a jackknife model averaging approach of spatial productivity analysis. Energy Econ 86:103744. https://doi.org/10.1016/j.eneco.2017.08.032

Grant DB, Banomyong R, Gibson BJ (2021) A brave new world for retail logistics and SCM in the 2020s and beyond. Int J Logist Res Appl 1–14. https://doi.org/10.1080/13675567.2021.1986477

Hayajneh JAM, Elayan MBH, Abdellatif MAM, Abubakar AM (2022) Impact of business analytics and π-shaped skills on innovative performance: findings from PLS-SEM and fsQCA. Technol Soc 68:101914. https://doi.org/10.1016/J.TECHSOC.2022.101914

Helmy Mohamad A, Farouk Hassan G, S. Abd Elrahman, A (2021) Impacts of e-commerce on planning and designing commercial activities centers: a developed approach. Ain Shams Eng J 101634. https://doi.org/10.1016/j.asej.2021.11.003

Hrovatin N, Cagno E, Dolšak J, Zorić J (2021) How important are perceived barriers and drivers versus other contextual factors for the adoption of energy efficiency measures: an empirical investigation in manufacturing SMEs. J Clean Prod 323:129123. https://doi.org/10.1016/j.jclepro.2021.129123

Huang P (2022) The effect of regional policy on corporate innovation performance based on propensity score matching method. J Comput Methods Sci Eng 22(3):821–831. https://doi.org/10.3233/JCM-225990

Hu F, Qiu L, Xi X, Zhou H, Hu T, Su N, Duan Z (2022) Has Covid-19 changed china's digital trade?—Implications for health economics. Front Public Health 10. https://doi.org/10.3389/fpubh.2022.831549

Hu F, Qiu L, Wei S, Zhou H, Bathuure IA, Hu H (2023) The spatiotemporal evolution of global innovation networks and the changing position of China: a social network analysis based on cooperative patents. R&D Manage. https://doi.org/10.1111/radm.12662

Huo B, Gu M, Wang Z (2019) Green or lean? A supply chain approach to sustainable performance. J Clean Prod 216:152–166. https://doi.org/10.1016/j.jclepro.2019.01.141

Jean R-J Bryan, Kim D (2020) Internet and SMEs' internationalization: the role of platform and website. J Int Manag 26(1):100690. https://doi.org/10.1016/j.intman.2019.100690

Jiang C, Cheng X (2020) Recycling of waste ceramic foams as fine aggregates in pervious concrete. RSC Adv 10(4):2364–2367. https://doi.org/10.1039/C9RA09070C

Kaplan D, Ferguson AJ (1999) On the utilization of sample weights in latent variable models. Structural Equation Modeling: A multidisciplinary journal 6(4):305–321

Karaman AS, Kilic M, Uyar A (2020) Green logistics performance and sustainability reporting practices of the logistics sector: the moderating effect of corporate governance. J Clean Prod 258:120718. https://doi.org/10.1016/j.jclepro.2020.120718

Kaur D, Kaur R (2022) Does electronic word-of-mouth influence e-recruitment adoption? A mediation analysis using the PLS-SEM approach. Manag Res Rev. https://doi.org/10.1108/MRR-04-2021-0322. (**ahead-of-p(ahead-of-print)**)

Kyara VC, Rahman MM, Khanam R (2021) Tourism expansion and economic growth in Tanzania: a causality analysis. Heliyon 7(5):e06966. https://doi.org/10.1016/J.HELIYON.2021.E06966

Lei Z, Hao S, Yang J, Zhang L, Fang B, Wei K, Lingbo Q, Jin S, Wei C (2021) Study on denitration and sulfur removal performance of Mn–Ce supported fly ash catalyst. Chemosphere 270:128646. https://doi.org/10.1016/j.chemosphere.2020.128646

Li Q, Lin H, Tan X, Du S (2020) H∞ consensus for multiagent-based supply chain systems under switching topology and uncertain demands. IEEE Trans Syst Man Cybern Syst 50(12):4905–4918. https://doi.org/10.1109/TSMC.2018.2884510

Li Z, Zhao T, Wang J, Cui X (2021a) Two-step allocation of CO2 emission quotas in China based on multi-principles: going regional to provincial. J Clean Prod 305:127173. https://doi.org/10.1016/j.jclepro.2021.127173

Li Z, Zhou X, Huang S (2021b) Managing skill certification in online outsourcing platforms: a perspective of buyer-determined reverse auctions. Int J Prod Econ 238:108166. https://doi.org/10.1016/J.IJPE.2021.108166

Li J, Yang X, Shi V, Cai GG (2023) Partial centralization in a durable-good supply chain. Prod Oper Manag 32(9):2775–2787. https://doi.org/10.1111/poms.14006

Ling G, Razzaq A, Guo Y, Fatima T, Shahzad F (2021) Emissions, globalization, natural resources and financial development in China. Environ Dev Sustain 0123456789. https://doi.org/10.1007/s10668-021-01724-2

Ma X, Akhtar R, Akhtar A, Hashim RA, Sibt-e-Ali M (2022) Mediation effect of environmental performance in the relationship between green supply chain management practices, institutional pressures, and financial performance. Front Environ Sci 10:1196. https://doi.org/10.3389/FENVS.2022.972555/BIBTEX

Ma S, He Y, Gu R (2021) Joint service, pricing and advertising strategies with tourists' green tourism experience in a tourism supply chain. J Retail Consumer Serv 61. https://doi.org/10.1016/j.jretconser.2021.102563

Makhdum MSA, Usman M, Kousar R, Cifuentes-Faura J, Radulescu M, Balsalobre-Lorente D (2022) How do institutional quality, natural resources, renewable energy, and financial development reduce ecological footprint without hindering economic growth trajectory? Evidence from China. Sustainability 14(21):13910. https://doi.org/10.3390/SU142113910

Matsuki T, Pan L (2021) Per capita carbon emissions convergence in developing Asia: a century of evidence from covariate unit root test with endogenous structural breaks. Energy Econ 99:105326. https://doi.org/10.1016/j.eneco.2021.105326

Mubarik M, Raja MohdRasi RZ, Mubarak MF, Ashraf R (2021) Impact of blockchain technology on green supply chain practices: evidence from emerging economy. Manag Environ Qual: Int J 32(5):1023–1039. https://doi.org/10.1108/MEQ-11-2020-0277

Mubarik MS, Kazmi SHA, Zaman SI (2021) Application of gray DEMATEL-ANP in green-strategic sourcing. Technol Soc 64(April 2020):101524. https://doi.org/10.1016/j.techsoc.2020.101524

Mubarik MS, Kazmi SHA, Zaman SI (2021) Application of gray DEMATEL-ANP in green-strategic sourcing. Technology in Society 64(December 2020):101524. https://doi.org/10.1016/j.techsoc.2020.101524

Nabeeh NA, Abdel-Basset M, Soliman G (2021) A model for evaluating green credit rating and its impact on sustainability performance. J Clean Prod 280:124299. https://doi.org/10.1016/j.jclepro.2020.124299

Noritake K, Aki T, Isa S, Uemura K (2020) Pyroptotic cell death by exposure to 1-butanol in H9c2 cardiomyoblastoma cells. Heliyon, 6(11). https://doi.org/10.1016/j.heliyon.2020.e05503

Nureen N, Liu D, Ahmad B, Irfan M (2022) Exploring the technical and behavioral dimensions of green supply chain management: a roadmap toward environmental sustainability. Environ Sci Pollut Res 1–14. https://doi.org/10.1007/s11356-022-20352-5

Pan S, Lin M, Xu M, Zhu S, Bian LA, Li G (2022) A low-profile programmable beam scanning holographic array antenna without phase shifters. IEEE Internet Things J 9(11):8838–8851. https://doi.org/10.1109/JIOT.2021.3116158

Pellow MA, Ambrose H, Mulvaney D, Betita R, Shaw S (2020) Research gaps in environmental life cycle assessments of lithium ion batteries for grid-scale stationary energy storage systems: end-of-life options and other issues. Sustain Mater Technol. https://doi.org/10.1016/j.susmat.2019.e00120

Polussa A, Gonzalez-Rivero J, Fields N, Jevon FV, Wood SA, Wieder WR, Bradford M A (2021) Scale dependence in functional equivalence and difference in the soil microbiome. Soil Biol Biochem 163. https://doi.org/10.1016/j.soilbio.2021.108451

Pyka I, Nocoń A (2021) Banks' capital requirements in terms of implementation of the concept of sustainable finance. Sustain (Switzerland) 13(6). https://doi.org/10.3390/su13063499

Rahman MS, AbdelFattah FAM, Bag S, Gani MO (2022) Survival strategies of SMEs amidst the COVID-19 pandemic: application of SEM and fsQCA. J Busi Ind Market. https://doi.org/10.1108/JBIM-12-2020-0564

Rehman Khan SA, Yu Z, Sarwat S, Godil DI, Amin S, Shujaat S (2021) The role of block chain technology in circular economy practices to improve organisational performance. Int J Log Res Appl. https://doi.org/10.1080/13675567.2021.1872512

Rejeb A, Simske S, Rejeb K, Treiblmaier H, Zailani S (2020) Internet of Things research in supply chain management and logistics: a bibliometric analysis. Internet Things 12:100318. https://doi.org/10.1016/J.IOT.2020.100318

Roozbahani A, Ghased H, HashemyShahedany M (2020) Inter-basin water transfer planning with grey COPRAS and fuzzy COPRAS techniques: a case study in Iranian Central Plateau. Sci Total Environ 726:138499. https://doi.org/10.1016/j.scitotenv.2020.138499

Ruan X, Ding N, Yang J (2022) Dual-level eco-efficiency analysis in sustainable management: an empirical study on textile manufacturers and supply chains in China. J Environ Manage 304:114227. https://doi.org/10.1016/J.JENVMAN.2021.114227

Runst P, Thonipara A (2020) Dosis facit effectum why the size of the carbon tax matters: evidence from the Swedish residential sector. Energy Econ 91:104898. https://doi.org/10.1016/j.eneco.2020.104898

Saeed A, Rasheed F, Waseem M, Tabash MI (2022) Green human resource management and environmental performance: the role of green supply chain management practices. Benchmarking 29(9):2881–2899. https://doi.org/10.1108/BIJ-05-2021-0297/FULL/PDF

Salari M, Javid RJ, Noghanibehambari H (2021) The nexus between CO2 emissions, energy consumption, and economic growth in the U.S. Econ Anal Policy 69:182–194. https://doi.org/10.1016/j.eap.2020.12.007

Scheuer C, Bailey R (2021) The active school concept. Physical Activity and Sport During the First Ten Years of Life: Multidisciplinary Perspectives, pp 173–187. https://doi.org/10.4324/9780429352645-19

Shang M, Luo J (2021) The Tapio decoupling principle and key strategies for changing factors of Chinese urban carbon footprint based on cloud computing. Int J Environ Res Public Health 18(4):2101. https://doi.org/10.3390/ijerph18042101

Sharma H, Aggarwal AG (2019) Finding determinants of e-commerce success: a PLS-SEM approach. J Adv Manag Res 16(4):453–471. https://doi.org/10.1108/JAMR-08-2018-0074

Sharma HB, Vanapalli KR, Samal B, Cheela VRS, Dubey BK, Bhattacharya J (2021) Circular economy approach in solid waste management system to achieve UN-SDGs: solutions for post-COVID recovery. Sci Total Environ 800:149605. https://doi.org/10.1016/j.scitotenv.2021.149605

Shi W, Zhang R, Li H, Wu Y, Toan S, Sun Z, Sun Z (2023) Modulating Mxene-derived Ni-Mom-Mo2-mTiC2Tx structure for intensified low-temperature ethanol reforming. Adv Energy Mater 13(40):2301920. https://doi.org/10.1002/aenm.202301920

Su R, Obrenovic B, Du J, Godinic D, Khudaykulov A (2022) COVID-19 pandemic implications for corporate sustainability and society: a literature review. Int J Environ Res Public Health 19(3):1592. https://doi.org/10.3390/IJERPH19031592

Sun Y-Y, Drakeman D (2020) Measuring the carbon footprint of wine tourism and cellar door sales. J Clean Prod 266:121937. https://doi.org/10.1016/j.jclepro.2020.121937

Tan Y, Mao X (2021) Assessment of the policy effectiveness of Central Inspections of Environmental Protection on improving air quality in China. J Clean Prod 288:125100. https://doi.org/10.1016/j.jclepro.2020.125100

Tian H, Li R, Salah B, Thinh P (2023) Bi-objective optimization and environmental assessment of SOFC based cogeneration system: performance evaluation with various organic fluids. Process Saf Environ Prot 178:311–330. https://doi.org/10.1016/j.psep.2023.07.040

Tomitaka M, Iwachido Y, Sasaki T (2022) Spatial scales and urban greenspace types influence public conservation preferences. Land Use Policy 123. https://doi.org/10.1016/j.landusepol.2022.106403

Tong D, Sun Y, Tang J, Luo Z, Lu J, Liu X (2023) Modeling the interaction of internal and external systems of rural settlements: The case of Guangdong, China. Land Use Policy 132:106830. https://doi.org/10.1016/j.landusepol.2023.106830

Ullrich-French S, Cox AE, Huong C (2022) The state mindfulness scale for physical activity 2: expanding the assessment of monitoring and acceptance. Meas Phys Educ Exerc Sci 26(2):116–129. https://doi.org/10.1080/1091367X.2021.1952207

Valadkhani A, Smyth R, Nguyen J (2019) Effects of primary energy consumption on CO 2 emissions under optimal thresholds: evidence from sixty countries over the last half century. Energy Econ 80:680–690. https://doi.org/10.1016/j.eneco.2019.02.010

Vyas S, Prajapati P, Shah AV, Varjani S (2022) Science of the total environment municipal solid waste management : dynamics, risk assessment, ecological influence, advancements, constraints and perspectives. Sci Total Environ 814:152802. https://doi.org/10.1016/j.scitotenv.2021.152802

Wang Y, Fu P (2021) RETRACTED: integration performance statistics of green suppliers based on fuzzy mathematics and BP neural

network. J Intell Fuzzy Syst 40(2):2083–2094. https://doi.org/10.3233/JIFS-189209
Wang C, Zhang Q, Zhang W (2020) Corporate social responsibility, green supply chain management and firm performance: the moderating role of big-data analytics capability. Res Transp Bus Manag 37(September):100557. https://doi.org/10.1016/j.rtbm.2020.100557
Wang F, Gao J (2023) How a photovoltaic panel impacts rainfall-runoff and soil erosion processes on slopes at the plot scale. J Hydrol 620. https://doi.org/10.1016/j.jhydrol.2023.129522
Wang K, Rehman MA, Fahad S, Linzhao Z (2023) Unleashing the influence of natural resources, sustainable energy and human capital on consumption-based carbon emissions in G-7 Countries. Resour Policy 81:103384. https://doi.org/10.1016/J.RESOURPOL.2023.103384
Woo CK, Tishler A, Zarnikau J, Chen Y (2021) Average residential outage cost estimates for the lower 48 states in the US. Energy Econ 98. https://doi.org/10.1016/j.eneco.2021.105270
Xia H, Milevoj E, Goncalves M (2021) Local response to global crisis—the effect of COVID-19 pandemic on SMEs and government export assistance programs in Central California 26(4):204–232. https://doi.org/10.1080/15475778.2021.1989566
Xiong Y, Zhao X, You J (2021) Network power and innovation performance: Moderating effect based on knowledge base diversity and consistency—Taking new energy vehicle industry in Shanghai as an example. J Chin Hum Resour Manage 12(2):55–68. https://doi.org/10.47297/wspchrmWSP2040-800505.20211202
Xu Z, Qin J, Liu J, Martínez L (2019) Sustainable supplier selection based on AHPSort II in interval type-2 fuzzy environment. Inf Sci 483:273–293. https://doi.org/10.1016/j.ins.2019.01.013
Xu A, Qiu K, Zhu Y (2023) The measurements and decomposition of innovation inequality: Based on industry – University – research perspective. J Bus Res 157:113556. https://doi.org/10.1016/j.jbusres.2022.113556
Yadav G, Luthra S, Jakhar SK, Mangla SK, Rai DP (2020) A framework to overcome sustainable supply chain challenges through solution measures of industry 4.0 and circular economy: an automotive case. J Clean Prod. https://doi.org/10.1016/j.jclepro.2020.120112
Yang Z, Lin Y (2020) The effects of supply chain collaboration on green innovation performance: an interpretive structural modeling analysis. Sustain Prod Consumpt 23:1–10. https://doi.org/10.1016/j.spc.2020.03.010
Yang L, Ni M (2022) Is financial development beneficial to improve the efficiency of green development? Evidence from the Belt and Road countries. Energy Econ 105:105734. https://doi.org/10.1016/j.eneco.2021.105734
Yin L, Wang L, Huang W, Liu S, Yang B, Zheng W (2021) Spatiotemporal analysis of haze in beijing based on the multi-convolution model. Atmosphere 12(11):1408. https://doi.org/10.3390/atmos12111408
Yu W, Chavez R, Feng M, Wong CY, Fynes B (2020) Green human resource management and environmental cooperation: an ability-motivation-opportunity and contingency perspective. Int J Prod Econ 219:224–235. https://doi.org/10.1016/j.ijpe.2019.06.013
Yin L, Wang L, Huang W, Tian J, Liu S, Yang B, Zheng W (2022) Haze grading using the convolutional neural networks. Atmosphere 13(4):522. https://doi.org/10.3390/atmos13040522
Zainal M, Bani-Mustafa A, Alameen M, Toglaw S, Mazari A. Al. (2022) Economic anxiety and the performance of SMEs during COVID-19: a cross-national study in Kuwait. Sustainability 14(3):1112. https://doi.org/10.3390/SU14031112
Zhang G, Zhang J, Xie T (2020a) A solution to renewable hydrogen economy for fuel cell buses—a case study for Zhangjiakou in North China. Int J Hydrogen Energy 45(29):14603–14613. https://doi.org/10.1016/j.ijhydene.2020.03.206
Zhang Z, Liu S, Niu B (2020b) Coordination mechanism of dual-channel closed-loop supply chains considering product quality and return. J Clean Prod 248:119273. https://doi.org/10.1016/j.jclepro.2019.119273
Zhang C, Liu Y, Han G (2021a) Two-stage pricing strategies of a dual-channel supply chain considering public green preference. Comput Ind Eng 151:106988. https://doi.org/10.1016/j.cie.2020.106988
Zhang L, Liu D, Cai G, Lyu L, Koh LH, Wang T (2023) An optimal dispatch model for virtual power plant that incorporates carbon trading and green certificate trading. Int J Electr Power Energy Syst 144:108558. https://doi.org/10.1016/J.IJEPES.2022.108558
Zhang D, Mohsin M, Rasheed AK, Chang Y, Taghizadeh-Hesary F (2021a) Public spending and green economic growth in BRI region: mediating role of green finance. Energy Policy 153. https://doi.org/10.1016/j.enpol.2021.112256
Zhang W, Zhang X, Zhou Q (2021b) How does knowledge seeking and knowledge generation promote green supply chain management? An empirical study from China 26(1):37–57 https://doi.org/10.1080/13675567.2021.1929882
Zhao X, Ma X, Shang Y, Yang Z, Shahzad U (2022) Green economic growth and its inherent driving factors in Chinese cities: based on the Metafrontier-global-SBM super-efficiency DEA model. Gondwana Res 106:315–328. https://doi.org/10.1016/J.GR.2022.01.013
Zhou Y, Liu Z, Liu S, Chen M, Zhang X, Wang Y (2020) Analysis of industrial eco-efficiency and its influencing factors in China. Clean Technol Environ Policy 22(10):2023–2038. https://doi.org/10.1007/s10098-020-01943-7
Zhu L, Liu X, Huang H, Avellán-Llaguno RD, Lazo MML, Gaggero A, Rifo RS, Patiño L, Valencia-Avellan M, Diringer B, Huang Q, Zhu YG (2020) Meteorological impact on the COVID-19 pandemic: a study across eight severely affected regions in South America. Sci Total Environ 744. https://doi.org/10.1016/j.scitotenv.2020.140881
Zubair S, Kabir R, Huang X (2020) Does the financial crisis change the effect of financing on investment? Evidence from private SMEs. J Bus Res 110:456–463. https://doi.org/10.1016/J.JBUSRES.2020.01.063