DEVELOPING A CORPORATE SOCIAL RESPONSIBILITY FRAMEWORK FOR SUSTAINABLE CONSTRUCTION USING PARTIAL LEAST SQUARES STRUCTURAL EQUATION MODELING

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Abstract. Sustainable construction is vital for the embodiment of sustainable development, and corporate social responsibility practice is critical for construction firms to realize sustainable construction. However, the link between sustainable construction and corporate social responsibility is still in its infancy, and previous studies have not developed comprehensive methods for evaluating sustainable construction performance. We first established a conceptual corporate social responsibility framework based on the five aspects of sustainable construction: economic, environmental, social, stakeholders, and health and safety. Then, a set of criteria assessing sustainable construction performance was identified through a literature review and interviews with industry practitioners. A questionnaire survey was conducted to collect primary data and identify the significance of the proposed criteria. Furthermore, partial least squares structural equation modeling (PLS-SEM) was used to statistically validate the conceptual model and identify key factors for sustainable construction. The results revealed that health and safety, and environment are the key aspects, while site inspection and audits, providing a healthy and safe working environment, effective emergency management procedures and safety supervision, compliance with environmental laws and regulations, reducing pollution and waste, and corporate environmental management system are critical to achieving sustainable construction. Our study underlines the link between sustainable construction and corporate social responsibility, improves the evaluation accuracy, and provides new guidelines for practical applications.

Keywords: sustainable construction, corporate social responsibility, questionnaire survey, partial least squares structural equation modeling (PLS-SEM).

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Introduction

While the construction industry is one of the major sectors involved in promoting socioeconomic development, it also imposes tremendous environmental burden, consuming >40% of the world's energy, 25% of its water, and 40% of its natural resources, and producing > 45% of global waste (Ibrahim, Roy, Ahmed, & Imtiaz, 2010; Darko & Chan, 2017). This environmental cost conflicts with the very idea of sustainability and the construction industry's vision of sustainable development. Sustainable construction (SC) embodies sustainability as the responsibility of the construction industry while providing its products and services (Kibwami & Tutesigensi, 2016). Thus, over the past two decades, the construction industry has been active in promoting SC globally to reduce environmental pressure (Sfakianaki, 2019). Although the desire for SC has been growing, construction firms need to implement strategies and methods concerning the development of SC.

One effective strategy for SC is corporate social responsibility (CSR), which has attracted increasing attention in the construction industry in recent years (Lu, Ye, Chau, & Flanagan, 2018). The Commission of the European Communities (2002) emphasized that CSR has received increasing attention among firms as a critical part of emerging forms of governance because it helps them to cope with fundamental changes in the competitive business environment. Jones, Comfort, and Hillier (2006) indicated that CSR focuses on integrating social, environmental, and economic factors into business strategy and practice and can bring diverse potential benefits, such as reducing operating costs, increasing the capacity to innovate, and enhancing environmental protection. Similarly, CSR can balance the social, environmental, and economic values inherent in its activities and strategies while advancing the long-term sustainability of society and environment (Maqbool & Zameer, 2018). In addition, Chang and Yeh (2016) stated that practicing strategically chosen CSR could be advantageous for the competitiveness of firms and could create co-benefits for stakeholders. As a result, CSR can lead the construction industry toward SC development.

In this work, we aim to construct a CSR framework and identify key factors for rationalizing SC in the construction industry. Although prior studies have adopted qualitative analysis, literature review, and basic statistical methods to address SC problems (Chang, Soebarto, Zhao, & Zillante, 2016; Kissi, Sadick, & Agyemang, 2018; Sfakianaki, 2019), quantitative methods are still insufficient to evaluate performance and analyze results to help industrial practitioners make decisions in construction firms and require further investigation. Hence, we used an exploratory sequential hybrid method, which combines the qualitative data acquisition and analysis in the first phase with the quantitative data acquisition and structural equation modeling (SEM) in the second phase to assess the SC performance based on a CSR framework. The first phase lays the foundation for this study to conduct an in-depth exploration of CSR criteria and SC aspects, and the second phase offers the opportunity for rigorously testing the conceptual model as well as the hypothetical relationships among criteria packages through SEM.

Thus, this study develops a comprehensive CSR framework and proposes a hybrid method to assist construction firms to evaluate sustainable performance and identify key factors for making decisions. First, the study provides the theoretical basis to establish a CSR framework

for achieving SC. Second, the proposed hybrid methods with increased accuracy of results for decision makers are presented. Third, guidelines for improving sustainable construction performance is discussed.

The paper is outlined as follows: Section 2 provides the literature review related to SC and CSR, research gaps, proposed measures, and the hypothesized model. The hybrid method and its evaluation procedures are illustrated in Section 3. Section 4 presents the analytical results. Section 5 discusses the managerial and theoretical implications of the results. Finally, Section 6 involves the conclusions, contributions, limitations, and potential future implications of the study.

1. Literature review

This section reviews previous studies to explain the background of sustainable construction and corporate social responsibility, the research gaps, proposed measures, and hypothesized model. These discussions offer strong theoretical foundation for the conceptualization and realization of this work.

1.1. Sustainable construction (SC)

Sustainable construction (SC) can be interpreted as the implementation of the principles of sustainability in construction (Kibwami & Tutesigensi, 2016). The concept of SC was proposed in *the First International Conference on Sustainable Construction* in 1994 (Kibert, 1994) by Hill and Bowen (1997): SC is "creating and operating a healthy built environment based on resource efficiency and ecological design." In addition, Dickie and Howard (2000) defined SC as the contribution of the construction industry to sustainable development, which is in accordance with Kibert's statement (2008) that SC should be considered as a subset of sustainable development. These declarations confirmed that SC is critical for the construction industry to adopt sustainability, and construction firms should incorporate it into their operations

SC promotes sustainable development from multiple aspects and perspectives. Previous studies offered comprehensive analyses on three aspects of SC: economic, environment, and society since SC is a comprehensive integration of the three aspects' problems (Abidin, 2010). Several studies pointed out that SC can reduce the environmental burden of a building throughout its entire lifespan, minimize operating and maintenance costs as well as increase innovation and efficiency (Ogunbiyi, Goulding, & Oladapo, 2014). Schröpfer, Tah, and Kurul (2017) indicated that a better action plan and cooperation of various stakeholders play a key role in implementing SC strategy, and these stakeholders must lead the sustainable transformation of the construction industry. Moreover, health and safety is a key aspect affecting SC because workers pay close attention to their working environment and self-safety (Rajendran & Gambatese, 2009).

Prior researches have confirmed the significance of achieving SC to address environmental challenges, improve resource-efficient strategies and create developmental paradigms (Gan, Zuo, Ye, Skitmore, & Xiong, 2015; Yin, Laing, Leon, & Mabon, 2018). Tan, Shen, and

Yao (2011) conducted an overview of SC practices and found that implementing SC could improve construction firms' competitiveness and help them develop sustainable strategies while meeting the rapidly changing demands of the competitive market. Oke and Aigbavboa (2017) combined practices of value management with sustainability to identify the values of SC and acknowledged that SC could assist firms to acquire better economic performance in practice. Yu, Shi, Zuo, and Chen (2018) investigated key factors affecting the adoption of SC and stressed that SC could effectively enhance social and environmental performance of construction projects. It is obvious that these studies explored critical measures for achieving SC from various perspectives. However, few studies have shown how CSR and SC interact in the context of the construction industry. Therefore, this study seeks to establish the link between CSR and SC.

1.2. Corporate social responsibility (CSR)

Despite having a long history, CSR is a multifaceted and vague concept since it has different interpretations in different contexts. Therefore, the consensus on the concept of CSR has not been reached to date. A widely acknowledged definition of CSR that is attributed to the Commission of the European Communities (2001) is "a concept whereby companies integrate social and environmental concerns in the business operations and in their interactions with their stakeholders on a voluntary basis." Lichtenstein, Badu, Owusu-Manu, Edwards, and Holt (2013) summarized previous definitions and stated: "CSR is characterized by a deliberate corporate effort to improve society and maintain sustainable business development." These definitions demonstrated that CSR could reduce the negative effects of firms' activities while increasing the positive effects by addressing extensive social and environmental issues and by contributing to the development of local communities and society (Bevan & Yung, 2015).

As a dynamic measure of sustainable development, CSR requires the implementation of various practices and actions. Z. Y. Zhao, X. J. Zhao, Zuo, and Zillante (2016) developed a CSR indicator framework according to the stakeholder theory for construction contractors and highlighted some factors, such as quality and safety of construction, and occupational health and safety as well as the supplier-partner relationship. Yuen, Thai, Wong, and Wang (2018) investigated the interactive impacts of CSR, service quality based on customer satisfaction, job satisfaction as well as financial performance and found that the implementation of CSR is contingent on a firm's motivation and its current service quality. Kudłak, Szőcs, Krumay, and Martinuzzi (2018) examined public CSR politics' role in promoting greater CSR participation among firms and showed that public procurement, subsidies and tax incentives as well as CSR reporting standards would be the most important factors in public CSR politics. Nevertheless, these effective practices and measures were identified in a specific context and for specific industries; hence, a new indicator of the CSR framework should be established and identified for SC.

Barthorpe (2010) provided a general review of CSR and demonstrated how it has been integrated and performed in the UK's construction industry and showed that CSR had now penetrated into business practice as a sound business philosophy that provided an opportunity to acquire strategic competitive advantage. Jiang and Wong [32] explored key CSR's activity areas in the Chinese construction industry to help construction firms strengthen

social welfare and minimize environmental impacts and stated that the fulfillment of CSR should be integrated into the construction process and the uniqueness of Chinese construction practice. Liao, Shih, Wu, Zhang, and Wang (2018) attempted to explore the short-term relationship of corporate social performance and corporate financial performance to verify whether CSR could produce immediate impacts and indicated that international contractors prioritizing CSR problems could minimize financial risks and maximize the future business performance. Nevertheless, prior researches have demonstrated CSR could encourage the development of SC but have not addressed how the two concepts are interrelated.

1.3. The research gaps

Numerous studies have utilized basic statistical methods, survey-based approach, and qualitative methods to analyze SC. Shi, Ye, Lu, and Hu (2014) used the interview and questionnaire survey methods to investigate construction management consultants' competence and knowledge structure to underpin SC in China. Chang et al. (2016) adopted a statistical method to investigate the Chinese policy system and to help promote the transition to SC. Faith, Fagbenle, Amusan, and Adedeji (2018) utilized a structured questionnaire survey to conduct a comparative analysis of SC practices between domestic and foreign construction firms. However, a comprehensive model establishing an analytical framework for SC has not been developed to date.

Furthermore, prior studies have used a wide range of methods to demonstrate CSR advantages. For example, Z. Y. Zhao, X. J. Zhao, Davidson, and Zuo (2012) developed a CSR indicator framework for global construction firms as a tool to measure CSR performance. Ranängen and Lindman (2018) explored whether CSR practices comply with stakeholders' interests through sustainability reports' content analysis together with a stakeholder survey. Avram, Domnanovich, Kronenberg, and Scholz (2018) utilized a systematic literature review to explore ways to integrate CSR into small- and medium-sized enterprises' strategies. All these studies have demonstrated that CSR is a feasible measure for sustainability. Nevertheless, few studies have utilized CSR to explore and promote SC.

This study uses structural equation modeling (SEM) to construct a CSR framework and identify key CSR indicators as well as their intertwined relationships for the development of SC. SEM is a multivariate approach used to explore and test relationships among variables (Belás, Smrcka, Gavurová, & Dvorsky, 2018). It is a robust analytical method that has been globally used by construction management researchers for both simple correlations between structures and more complex analysis of first- and higher-order variables (Hsu, Tsai, & Tzeng, 2018).

1.4. Proposed measures

Previous studies have demonstrated that SC was affected by many aspects, and its implementation needs comprehensive real practices and promotion strategies. Aspects and criteria must reflect the multinational nature of SC and be sufficiently simple to implement. Hence, this study identifies five aspects of SC (covering economic, environment, social, stakeholders, and health and safety), and 35 criteria (8 criteria were used to measure SC directly, and 27 CSR

criteria were implemented under the five aspects). These criteria were independently evaluated by the construction industry practitioners to identify the importance of each criterion based on Likert five-level scale. Likert five-level scale is a metric scale commonly utilized in questionnaire surveys, and it is the most popular method used in survey researches (Vonglao, 2017). Table 1 shows the finalized aspects and criteria. The detailed descriptions of the aspects and criteria are presented as follows:

Due to the ongoing demand for sustainable buildings, SC practices have gained the attention of researchers in the construction industry worldwide (Durdyev, Ismail, Ihtiyar, Bakar, & Darko, 2018). Tan et al. (2011) reported that technology and innovation (SC1) would enhance firms' ability to increase sustainable performance of both the construction process as well as its produced assets; developing measurement and reporting system (SC2) would utilize existing benchmarks to assess firms' social and environmental performance while identifying areas for enhancement. Akadiri and Fadiya (2013) stated that decisions for sustainable practices, other long-run strategic challenges and ultimately action need a firm's top management commitment (SC3), which would accelerate the move in a sustainable direction. To facilitate construction firms' transition to SC, Chang et al. (2016) indicated that government could enact economic incentives policies (SC4), such as offering subsidies and awards as well as innovative financing solutions. In addition, reduce, reuse and recycling (SC5) is an effective measure to minimize the amount of resource usage, improve resource efficiency, and reduce material goods' impact on the environment (Kibwami & Tutesigensi, 2016). Finally, Athapaththu and Karunasena (2018) suggested that a firm should develop its own standards, guidelines, or policies of SC (SC6) to reduce economic, environmental, and social risks related to construction practices and should reorganize and adjust people and organizational structure (SC7) to promote the fulfillment of SC policy and strategy while increasing people's awareness and commitment (SC8) to SC.

After reviewing the SC practices, we propose CSR criteria from five aspects of SC. Numerous studies have verified that the economic aspect (EC) of SC is a co-benefit important to firms (Kissi et al., 2018). Increasing market presence (EC1) means helping firms acquire outstanding CSR achievements in its global logistics and resource supply chains of the construction sector (Lu, M. Ye, Flanagan, & K. Ye, 2016). Sustainable procurement practices (EC2) have positively impacted on the procurement process of firms by achieving value for money over the long run and can reduce misuse of funds in projects (McMurray, Islam, Siwar, & Fien, 2014). Acquiring more efficient technologies (EC3) is applied in firms to increase production efficiency and secure operational benefits, such as minimized costs and cycle periods (Calveras, Ganuza, & Llobet, 2007). Reducing operating costs (EC4) can provide opportunities for firms to implement product price strategies, and products with the same quality and lower prices will gain more market share in the market competition (Jones et al., 2006). Improving financial performance and profitability (EC5) reflects the ability of firms to make profits, enabling firms to stay alive in a rapidly changing market environment (Lin, Hung, Chou, & Lai, 2019). Finally, firms' investment in innovation and development (EC6) involves developing eco-innovative construction materials and methods as well as technologies (Zhao et al., 2012).

The capacity of the environment (EN) determines a stable and lasting development of SC. Sustainable design (EN1) aims to increase building performance by minimizing adverse

impacts on the environment as well as improving the health and comfort of building users (Basta, Lapalme, Paquet, Saint-Louis, & Abu Zwaida, 2018). Reducing pollution and waste (EN2) and efficient use of energy and resources (EN3) are effective measures to mitigate the environmental burden of the use of energy and resources (Zhu, Zhao, & Sarkis, 2011). In addition, Zhao et al. (2012) reported that establishment and improvement of the corporate environmental management system (EN4) provided construction firms a useful and valuable tool to manage each project's impact on the environment. Compliance with environmental laws and regulations (EN5) can help firms mitigate high pressure on the environment and create a space for firms' engagement in environmental innovation (Zhao et al., 2012).

The social aspect (SO) of SC reflects the obligation of construction firms to make choices and take practices to contribute to the society and firms' welfare and interests (Serpell, Kort, & Vera, 2013). Firms provide training and education (SO1) to improve employees' competence can increase commitment to the development of SC (Jiang & Wong, 2016). A close relationship between construction projects and local community exists; thus, creating well-being of the local community (SO2) is specified to create social welfare and contribute to the development of the local community (Jiang & Wong, 2016). Enhancing the image and reputation of firms (SO3) plays an important role in acquiring market share, gaining customers' recognition, and increasing firms' competitiveness (Weber, 2008). Organizational culture (SO4) can develop firms' CSR initiatives and policies by constituting a framework that provides guidance on issues solved, the way people think, and interactive standards (Maon, Lindgreen, & Swaen, 2010). Employment creation and skills development (SO5) involves recruiting the right employee that takes on new responsibilities and positions through developing and training them; thus, it can contribute to the development of society, such as by increasing the number of jobs (Yankson, 2010).

Although stakeholders (ST) have different value system and interests, the development of SC requires their close coordination and cooperation (Brooks & Rich, 2016). Enhance communication with collaborators (ST1) involves disclosing firm-to- collaborators policies and commitments, establishing appropriate safeguards as well as improving collaboration space and efficiency (Jones et al., 2006). No direct contractual relationship between the government and construction firms exist, but the government can regulate industry behavior and guide the direction of the industry by promulgating corresponding rules and regulations (ST2) (Mohammed & Rashid, 2018). Shareholders' decision-making participation (ST3) involves decision-making on firms' activities and income distribution, which can help improve decision efficiency and acquire win-win results (Zhao et al., 2012). Developing a good partner relationship (ST4), such as a good relationship with the local community, may cause constructive community involvement, in turn, offering help and support for the firms' growth (Petrovic-Lazarevic, 2008). Knowledge sharing (ST5) reflects the intensity of exchanging useful knowledge among business partners through partnerships, such as technical skills, product knowledge, and manufacturing processes (Runhaar & Lafferty, 2009).

Health and safety (HS) plays a key role in achieving SC, such as reduced on-site risks and cost, but it is a big challenge for construction firms (Rajendran & Gambatese, 2009). Thus, to reduce risks and avoid accidents occur, firms should conduct site inspection and audits (HS1) to ensure that safety implementation is strictly in accordance with the designed safety plan (Jones et al., 2006). Firms should apply health and safety induction and training

Table 1. Evaluation aspects and criteria for SC

Aspect	Criterion
Sustainable construction (SC)	Technology and innovation (SC1)
	Measurement and reporting system (SC2)
	Top management commitment (SC3)
	Economic incentives policies (SC4)
	Reduce, reuse and recycling (SC5)
	Standards, guidelines or policies (SC6)
	People and organizational structure (SC7)
	Increasing people's awareness and commitment (SC8)
Economic (EC)	Increasing market presence (EC1)
	Sustainable procurement practices (EC2)
	Acquiring more efficient technologies (EC3)
	Reducing operating costs (EC4)
	Improving financial performance and profitability (EC5)
	Investment on innovation and development (EC6)
Environmental (EN)	Sustainable design (EN1)
	Reducing pollution and waste (EN2)
	Efficient use of energy and resources (EN3)
	Establishment and improvement of the corporate environmental management system (EN4)
	Compliance with environmental laws and regulations (EN5)
Social (SO)	Training and education (SO1)
	Creating well-being of the local community (SO2)
	Enhancing the image and reputation of firms (SO3)
	Organizational culture (SO4)
	Employment creation and skills development (SO5)
Stakeholders (ST)	Enhance communication with collaborators (ST1)
	Promulgating corresponding rules and regulations (ST2)
	Shareholders' decision-making participation (ST3)
	Developing a good partner relationship (ST4)
	Knowledge sharing (ST5)
Health and safety (HS)	Site inspection and audits (HS1)
	Health and safety induction and training scheme (HS2)
	Providing healthy and safe working environment (HS3)
	Regular health checks and notification of the results (HS4)
	Effective emergency management procedures and safety supervision (HS5)
	Construction quality and safety (HS6)

scheme (HS2), such as emergency procedures, safe work practices, and preventive actions, to improve employees' health, safety, and skills (Petrovic-Lazarevic, 2008). Zhao et al. (2016) also suggested providing a healthy and safe work environment (HS3); for example, providing construction machinery and equipment, labor protection supplies, and technical measures to prevent accidents and injury can motivate workers and improve their work engagement. Regular health checks and notification of the results (HS4) (Zhao et al., 2012) is an effective measure that reflects the firm's care for employees, reduces their worries, and improves job satisfaction. Effective emergency management procedures and safety supervision (HS5) (Zhao et al., 2016) is a measure that firm can make decisions and provide solutions timely to reduce risks and damages. Finally, construction quality and safety (HS6) is the construction activities' basic requirements, and it reflects construction firms' ability to deliver high-quality products in a safe manner (Jiang & Wong, 2016).

1.5. Hypothesized model

SC is regarded as a direction for the construction firms to pour their efforts and resources to achieve sustainable development and aims at improving firms' sustainable performance and efficient use of resources (Abidin, 2010). However, measures or practices that can guide construction firms toward SC are lacking. Hence, we used CSR practice to offer precise guidelines for construction firms to achieve SC. Furthermore, based on the descriptions above, many studies have identified the common aspects for improvement of SC as economic, environment, social, stakeholders, and health and safety. Table 1 shows the five aspects and their respective CSR criteria, as well as the eight criteria used to measure SC. Figure 1 shows the hypothesized relationships proposed in this study.
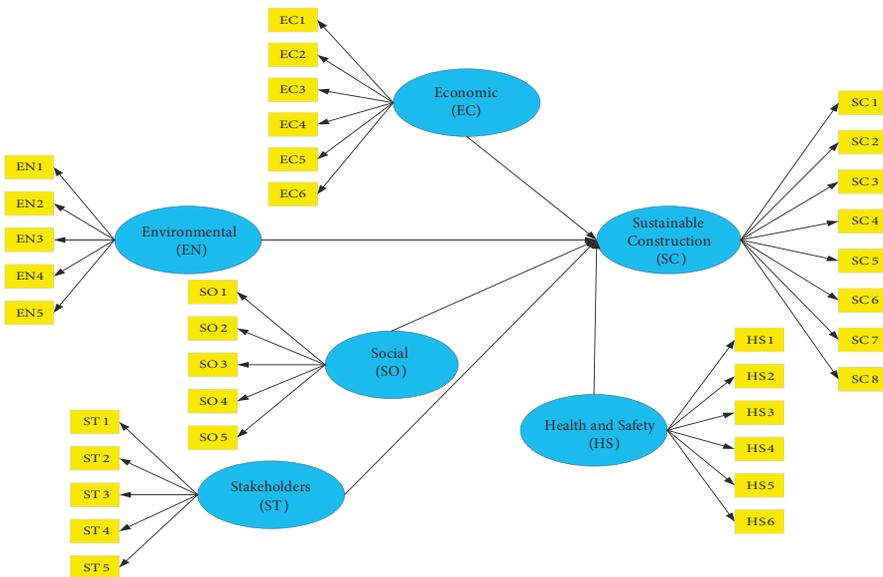

Figure 1. The hypothesized research model for developing CSR framework for SC

2. Research methodology

To realize the research objectives, we performed the study in three steps. First, a systematic literature review was conducted to determine critical factors concerning CSR and SC. Second, a questionnaire survey was carried out to collect relevant data. Finally, SEM analysis was utilized to explore and verify the relationship between CSR and SC. The research methodology is presented in Figure 2.

2.1. Obtaining the relevant factors of CSR and SC

Based on the previous studies, this study sorts out the core factors related to CSR and SC through a relatively comprehensive literature review and theoretical analysis and collects the verified scales in the published literature and preliminarily determined indicators that can measure CSR and SC. Then, interviews with experienced experts were conducted to improve and verify the availability of the initial factors of CSR and SC.
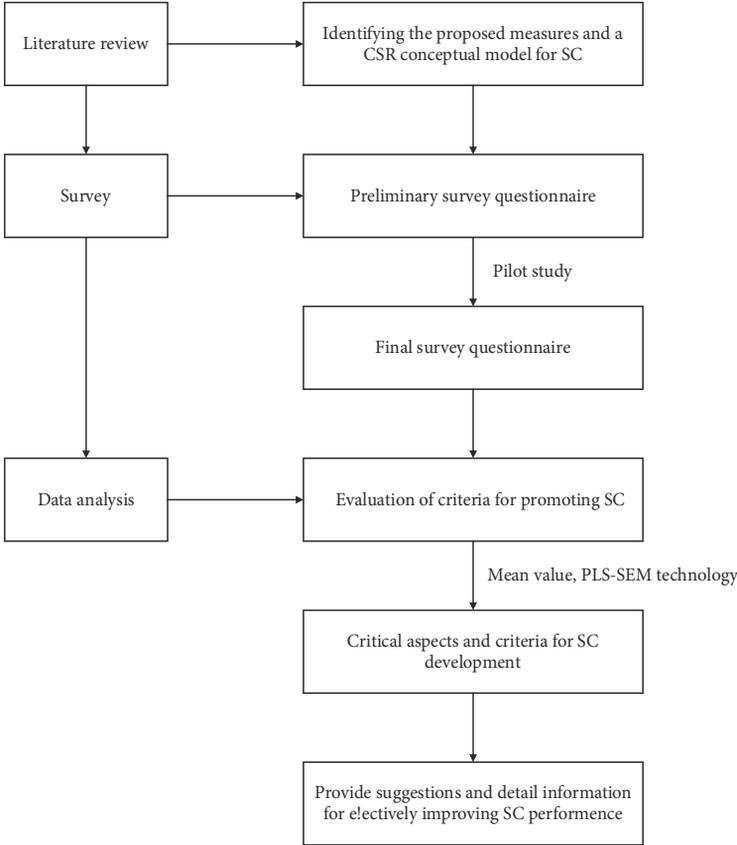
Figure 2. The flow chart of the research methodology

2.2. Questionnaire survey for data collection

A questionnaire is a commonly used standardized data collection method with internal coherence and excellent consistency, providing a large number of reliable sample data for experimental research (Durdyev et al., 2018). Therefore, this study designed a structured questionnaire to investigate the views of stakeholders on the impact of CSR on SC in the construction industry. The questionnaire consisted of two parts: The first part was utilized to collect the personal background information. The second part was used to identify the important behaviors (factors) that could enhance CSR from the five aspects of SC and promote SC directly. In addition, the second part used the Likert five-level scale (1-not critical to 5-very critical) to measure the importance of factors.

After the completion of the questionnaire design, senior experts and project managers of SC projects were invited to make evaluations, and relevant issues were modified and improved to make the description of measurement items more understandable and applicable to the engineering practice. The questionnaire survey was divided into the pre-survey and formal survey, and the respondents were chosen from the stakeholders engaged in SC in the construction industry. The pre-survey was utilized to check whether the questionnaire could meet the needs of post-scientific research and to modify the problems found to determine the final questionnaire. In the pre-survey stage, questionnaires were sent, and 51 valid questionnaires were collected. The Cronbach's alpha of the questionnaire was 0.945, the Cronbach's alpha of the CSR scale was 0.926, and the Cronbach's alpha of the SC scale was 0.862 > 0.6, meaning the questionnaire has good reliability (Chen & Yao, 2016). Then, the questionnaires were sent and filled online, and sample data were collected in the formal stage.

2.3. Data analysis tools

SEM is a statistical method utilized in sustainable researches to test assessment systems and explore variables' relationships (Yuan, Li, Zheng, & Skibniewski, 2018). Currently, SEM is mainly solved by two estimation techniques. The first technique is the covariance structure analysis based on maximum likelihood estimation, and the second technique is the variance analysis method based on partial least squares. Since SEM theory involves more complicated mathematical equations and formulas; the operation of the SEM is mainly completed by the SEM software designed and developed based on these two techniques. The representative software has AMOS (based on maximum likelihood estimation) and SmartPLS (based on partial least squares) software. Compared with AMOS, SmartPLS software has less demand for the number of samples and does not require sample data to be consistent with the normal distribution (Khaksar, Abbasnejad, Esmaeili, & Tamošaitienė, 2016). Moreover, the purpose of this study is to focus on exploration and explanatory analysis, while the importance of theoretical knowledge is relatively small. The use of SmartPLS software to construct and run the SEM is more conducive to the verification of the conceptual model and the realization of the experimental purpose. Hence, SmartPLS 3.0 was used to run the PLS-SEM analysis.

3. Data analysis and results

3.1. Respondents' information

From January to April 2019, a total of 274 questionnaires were gathered, 216 of which were valid questionnaires with an effective rate of 78.83%. Figure 3 shows the proportion of background information of the survey respondents. With regard to work roles, owners, constructors, designers, supervisors, surveyors, and researchers constituted for 33.3%, 25%, 6.5%, 1.9%, 0.5%, and 32.8% of participants, respectively. In terms of working experience, 34.7%
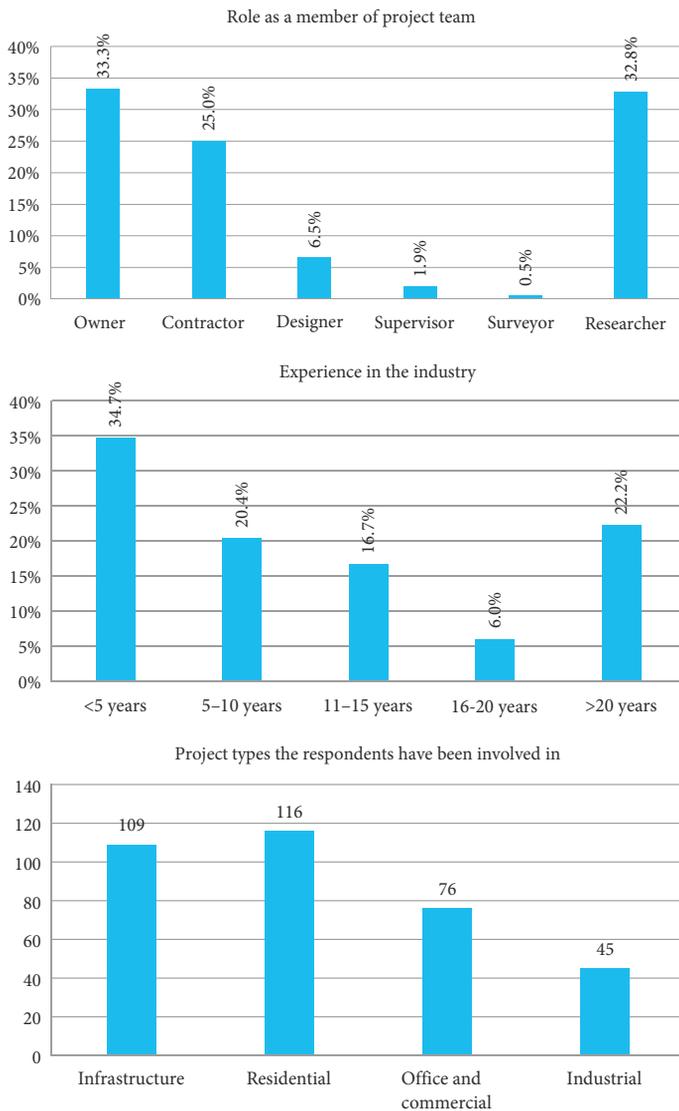

Figure 3. Respondents' profile based on their role, experience, and expertise

and 20.4% of participants had less than 5 and 5–10 years of industry experience; 16.7% and 6.0% of participants had 11–15 and 16–20 years of industry experience, and 22.2% had >20 years of work experience. Therefore, 65.3% of the survey respondents had >5 years of work experience, while 44.9% had more than 10 years of work experience. As for the project types, 109 of survey respondents had experience in infrastructure projects, while 116 of them had residential experience, and 76 and 45 of the participants had commercial office experience and industrial experience, respectively. Hence, most respondents participated in various types of projects had a deep understanding of the questionnaire items.

3.2. Ranking of factors of CSR and SC

Table 2 shows the mean values of all factors ranging from 3.85 (ST3) to 4.65 (HS6). Except for ST3, the mean of the factors was greater than 4, which is between critical and very critical on the five-point scale. To be specific, the mean value of CSR scale factors ranged from 3.85 (ST3) to 4.65 (HS6), and among the 27 indicators, the mean value of 26 indicators was greater than 4, which is between critical and very critical. Although the mean value of ST3 was 3.85, it is also close to 4, indicating that it is important to monitor all of these factors to improve CSR. These factors correspond to the five aspects of SC, and the mean value of each aspect is 4.24, 4.52, 4.30, 4.16, and 4.45, respectively. The results show that the EN and HS aspects have the highest impact on SC. In addition, the mean value of each factor in the SC scale is between 4.17 (SC2 and SC3) and 4.54 (SC1), and the mean value of all is greater than 4, indicating that these indicators are of great importance to promoting SC.

Furthermore, after the calculation of the mean values of all factors, the total ranking of CSR and SC can be acquired. Based on the mean values, the top five factors are construction quality and safety (HS6, 4.65), compliance with environmental laws and regulations (EN5, 4.58), effective emergency management procedures and safety supervision (HS5, 4.54), reducing pollution and waste (EN2, 4.54), and corporate environmental management system (EN4, 4.53). These factors are all included in the Environmental and Health and safety aspects and confirm the conclusion that the two aspects are vital to the development of SC.

3.3. Results of the final structural equation model

SEM is mainly expressed by measurement model (MM) and structural model (SM) (Durdyev et al., 2018). The MM is utilized to describe the correlation between latent variables and observed variables, while the SM is used to verify the causal correlation between endogenous and exogenous latent variables (Park & Rainey, 2008). To validate the significance of SM, we first tested the reliability and validity of MM.

For assessment of reliability, three reliability subtypes are usually examined: factor loadings (FL), Composite Reliability (CR), and Cronbach's alpha (Cα). Table 3 shows the factor loadings ranged from 0.616 to 0.903 ≥0.5 based on Melli et al., 2015), indicating that the observed variables corresponding to each latent variable have a high correlation. CR was between 0.853 and 0.929 (≥0.7 (Ali, Rasoolimanesh, Sarstedt, Ringle, & Ryu, 2018)) and shows the consistency between the observed variables of the latent variable is significant. Cronbach's alpha was between 0.785 and 0.907 (≥0.5 (Chen & Yao, 2016)), indicating the reliability level

Table 2. Mean values and ranking of factors of CSR and SC

CSR and SC		Mean Value	SD	Skewness	Kurtosis	Ranking within the Aspect	Ranking
CSR	EC	4.24					4
	EC1	4.03	1.104	−1.040	0.343	6	26
	EC2	4.13	0.918	−0.962	0.668	5	25
	EC3	4.37	0.891	−1.530	2.169	2	13
	EC4	4.15	1.011	−0.992	0.265	4	24
	EC5	4.26	0.939	−1.289	1.405	3	18
	EC6	4.48	0.771	−1.564	2.725	1	7
	EN	4.52					1
	EN1	4.42	0.832	−1.413	1.774	5	11
	EN2	4.54	0.733	−1.895	4.529	2	3
	EN3	4.52	0.740	−1.884	4.534	4	6
	EN4	4.53	0.740	−1.832	4.195	3	5
	EN5	4.58	0.723	−2.304	7.102	1	2
	SO	4.30					3
	SO1	4.38	0.809	−1.171	0.907	2	12
	SO2	4.24	0.861	−1.104	1.308	3	19
	SO3	4.46	0.782	−1.595	2.930	1	9
	SO4	4.21	0.856	−1.133	1.547	5	21
	SO5	4.23	0.808	−1.087	1.570	4	20
	ST	4.16					5
	ST1	4.29	0.859	−1.446	2.635	2	17
	ST2	4.19	0.862	−1.046	1.030	3	22
	ST3	3.85	0.945	−0.391	−0.336	5	27
	ST4	4.30	0.805	−1.139	1.256	1	15
	ST5	4.19	0.831	−0.849	0.424	3	22
	HS	4.45					2
	HS1	4.46	0.806	−1.613	2.731	4	9
	HS2	4.31	0.801	−1.047	0.901	5	14
	HS3	4.47	0.727	−1.496	2.746	3	8
	HS4	4.27	0.860	−1.135	1.113	6	16
	HS5	4.54	0.674	−1.791	4.647	2	3
	HS6	4.65	0.630	−1.929	3.800	1	1
SC	SC1	4.51	0.702	−1.434	2.260	1	
	SC2	4.17	0.809	−0.961	1.297	7	
	SC3	4.17	0.974	−1.072	0.679	7	
	SC4	4.38	0.780	−1.254	1.876	4	
	SC5	4.33	0.777	−1.188	1.932	6	
	SC6	4.40	0.765	−1.384	2.562	3	
	SC7	4.35	0.750	−1.202	2.253	5	
	SC8	4.44	0.712	−1.172	1.553	2	

of measurement items of each latent variable is relatively high. Thus, the SEM has good reliability. In addition, for evaluation of validity, the convergent validity and the discriminant validity are usually examined. AVE between 0.518 and 0.712 ($\geq$0.5 (Durdyev et al., 2018)) suggested sufficient convergent validity, indicating that a latent variable can explain over half of the total variances of its factors on average. Latent variable correlations can be acquired by taking the square root of AVE (Table 4), all of which are greater than correlation coefficient between latent variables, and each factor obtained the highest cross-loadings (Table 5) on the corresponding construct, revealing that the model has good discriminant validity. Therefore, the reliability and validity of the MM can be tested, and further research can be carried out to determine the correlation between latent variables.

While verifying the SM, SmartPLS 3.0 can calculate the path coefficient of the conceptual model hypothesis path to analyze the correlation between the latent variables. Under the PLS technique, the bootstrapping method is generally used to test the significance level of the path coefficient. The significance level of the model is judged by checking the T-test results. When the significance level is $p < 0.05$, the t value is > 1.96; when $p < 0.01$, the t value is > 2.58. The general significance level was chosen to be $p < 0.05$. From the calculation results in Table 6, all the hypothetical paths in the conceptual model passed the significance test (t value is greater than 1.96). The results showed each aspect has a significant positive impact on SC. From the results of the path analysis (as shown in Figure 4), the path coefficient of EC→SC is 0.173; the path coefficient of EN→SC is 0.242; the path coefficient of HS→SC is 0.298; The path coefficient of SO→SC is 0.163, and the path coefficient of ST→SC is 0.159, indicating HS has the greatest influence on SC, while EN is the second influential, and ST has the least influence on SC.

Table 3. The measurement model assessment (Quality Criteria)

Construct	Indicator	FL	AVE	CR	Xa
EC	EC1	0.672	0.518	0.865	0.812
	EC2	0.679			
	EC3	0.796			
	EC4	0.738			
	EC5	0.788			
	EC6	0.632			
EN	EN1	0.711	0.538	0.853	0.785
	EN2	0.735			
	EN3	0.702			
	EN4	0.750			
	EN5	0.766			
HS	HS1	0.864	0.688	0.929	0.907
	HS2	0.858			
	HS3	0.893			
	HS4	0.824			
	HS5	0.863			
	HS6	0.650			

End of Table 3

Construct	Indicator	FL	AVE	CR	Xa
SC	SC1	0.732	0.570	0.913	0.891
	SC2	0.775			
	SC3	0.616			
	SC4	0.774			
	SC5	0.749			
	SC6	0.813			
	SC7	0.799			
	SC8	0.763			
SO	SO1	0.842	0.712	0.925	0.898
	SO2	0.903			
	SO3	0.865			
	SO4	0.801			
	SO5	0.803			
ST	ST1	0.794	0.623	0.892	0.848
	ST2	0.824			
	ST3	0.736			
	ST4	0.853			
	ST5	0.732			

Table 4. Discriminant validity

	EC	EN	HS	SC	SO	ST
EC	**0.720**					
EN	0.600	**0.733**				
HS	0.461	0.546	**0.829**			
SC	0.647	0.728	0.686	**0.755**		
SO	0.616	0.660	0.468	0.638	**0.844**	
ST	0.576	0.707	0.628	0.687	0.433	**0.789**

Table 5. Cross Loadings

	EC	EN	HS	SC	SO	ST
EC1	**0.672**	0.410	0.329	0.447	0.258	0.489
EC2	**0.679**	0.351	0.269	0.382	0.324	0.349
EC3	**0.796**	0.477	0.392	0.498	0.518	0.453
EC4	**0.738**	0.406	0.325	0.416	0.341	0.449
EC5	**0.788**	0.396	0.309	0.458	0.393	0.460
EC6	**0.632**	0.505	0.341	0.545	0.723	0.290
EN1	0.475	**0.711**	0.491	0.514	0.623	0.441

End of Table 5

	EC	EN	HS	SC	SO	ST
EN2	0.342	**0.735**	0.271	0.515	0.534	0.439
EN3	0.531	**0.702**	0.394	0.572	0.488	0.453
EN4	0.385	**0.750**	0.407	0.536	0.327	0.581
EN5	0.455	**0.766**	0.435	0.525	0.454	0.677
HS1	0.428	0.501	**0.864**	0.608	0.443	0.575
HS2	0.362	0.470	**0.858**	0.594	0.327	0.574
HS3	0.383	0.441	**0.893**	0.614	0.423	0.501
HS4	0.351	0.404	**0.824**	0.559	0.319	0.510
HS5	0.387	0.502	**0.863**	0.593	0.419	0.540
HS6	0.402	0.393	**0.650**	0.418	0.412	0.411
SC1	0.465	0.543	0.505	**0.732**	0.451	0.521
SC2	0.478	0.546	0.592	**0.775**	0.507	0.528
SC3	0.430	0.459	0.444	**0.616**	0.419	0.428
SC4	0.513	0.594	0.557	**0.774**	0.468	0.514
SC5	0.516	0.582	0.444	**0.749**	0.478	0.560
SC6	0.480	0.564	0.553	**0.813**	0.527	0.506
SC7	0.502	0.539	0.560	**0.799**	0.489	0.555
SC8	0.518	0.559	0.471	**0.763**	0.505	0.529
SO1	0.537	0.524	0.380	0.526	**0.842**	0.301
SO2	0.535	0.567	0.382	0.528	**0.903**	0.316
SO3	0.507	0.558	0.378	0.571	**0.865**	0.333
SO4	0.485	0.523	0.433	0.552	**0.801**	0.403
SO5	0.536	0.616	0.399	0.505	**0.803**	0.477
ST1	0.539	0.640	0.437	0.504	0.369	**0.794**
ST2	0.442	0.567	0.557	0.608	0.367	**0.824**
ST3	0.423	0.468	0.460	0.529	0.261	**0.736**
ST4	0.516	0.603	0.526	0.558	0.404	**0.853**
ST5	0.352	0.513	0.486	0.500	0.301	**0.732**

Table 6. The structural model assessment

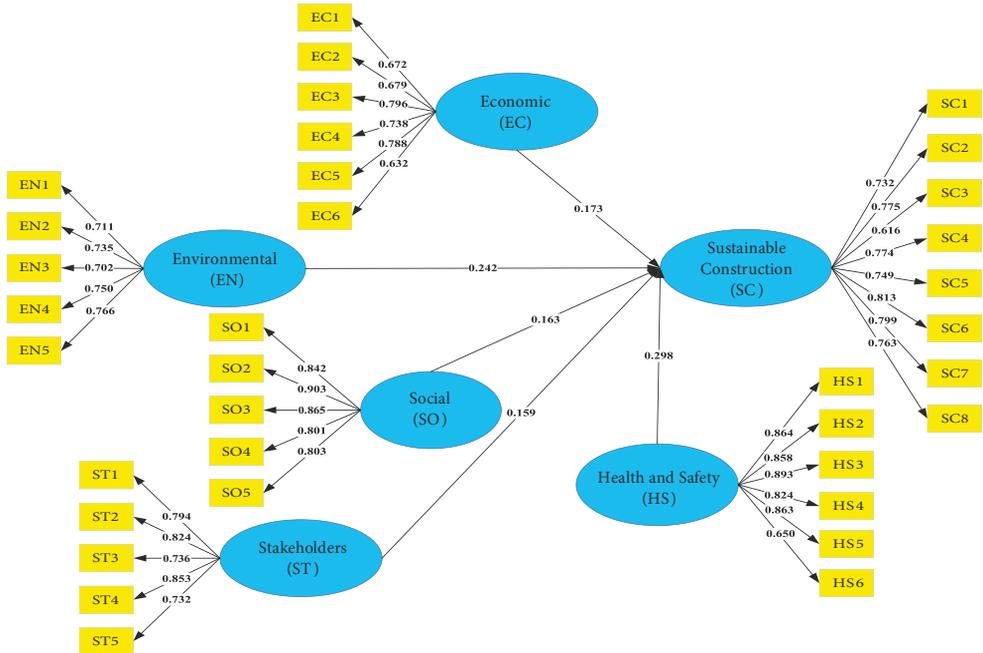| Effect	Coefficient	T Statistics ($|O/STERR|$)	Significance
EC -> SC	0.173	2.800	***
EN -> SC	0.242	3.390	***
HS -> SC	0.298	3.608	***
SO -> SC	0.163	2.359	**
ST -> SC	0.159	2.540	**

Note: ***$p < 0.01$, **$p < 0.05$.

Figure 4. The path analysis results of SC

3.4. Identification of key factors for promoting SC

Identifying key factors can assist construction firms to make decisions toward SC effectively. In previous studies, the mean value was used to select key factors (Tan, Shen, Craig, Lu, & Michael, 2014), while in other papers, factor loading was also used to determine key factors (Durdyev et al., 2018). Nevertheless, a factor with a high mean value does not mean it has a high factor loading (Yuan et al., 2018), such as HS6. Therefore, identifying key factors by using mean value or factor loading, respectively, may not be comprehensive. Yuan et al. (2018) combined the two methods to evaluate the significance of factors, taking the mean value as the horizontal axis and factor loading as the vertical axis. The comprehensive results calculated by the two-dimensional analysis approach are shown in Figure 3. Factors with both mean values and factor loadings higher than the average fall into the first quadrant and are deemed as "more critical." Conversely, factors with both mean values and factor loadings lower than the average fall into the third quadrant and are regarded as "less critical." If the mean values or the factor loadings are greater than the average, factors are considered as "critical."

Figure 5 shows most numbers of factors play an important role in prompting SC. Therefore, ten factors located in the first quadrant, HS1, HS3, HS5, SO3, SC1, SC6, SC8, EN2, EN4, and EN5, are more critical factors for improving SC performance. In addition, the results revealed that health and safety and environmental aspects are the most important aspects for the construction firms to implement SC. Site inspection and audits (HS1), providing a healthy and safe working environment (HS3), and effective emergency management procedures and safety supervision (HS5) are more critical factors under health and safety aspect. Reducing
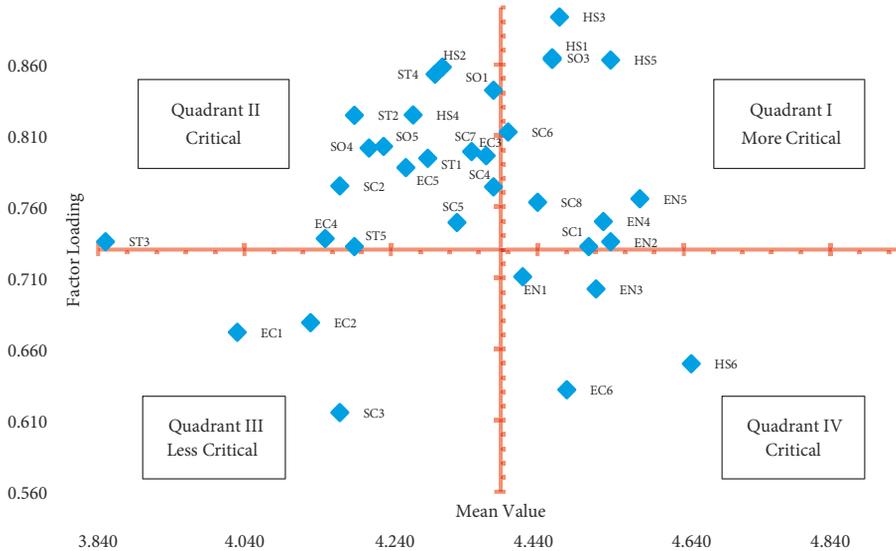
Figure 5. Significance analysis of criteria studied in this work

pollution and waste (EN2), establishment and improvement of the corporate environmental management system (EN4), and compliance with environmental laws and regulations (EN5) are more critical under the environmental aspect. The capital and resources of construction firms are limited. Hence, we suggest firms should allocate energy and resources to enhance these six factors as a viable strategy that can help firms rationalize SC effectively and quickly. Moreover, this study also provides the ranking within the aspects and the factors related to SC directly. If firms have specific advantages in other aspects or the SC factors in Quadrant I, they can also adopt the suggested practices in this paper to improve SC performance.

4. Discussion and implications

4.1. Theoretical implications

The research contributes to the literature by generating several theoretical implications. First, this study utilizes CSR practices to explore SC to achieve sustainability in the construction industry, provides a strong theoretical foundation, and establishes a link between CSR and SC. Second, the findings demonstrate that CSR is an effective strategy for construction firms to pursue SC, and in accordance with prior studies, contributes to the development of sustainability, health, and well-being of society (Moon, 2007). Finally, the study uses SEM to construct a CSR model and identify key aspects of SC and key criteria of CSR, which can promote the development of SC.

Moreover, two key aspects of SC should be discussed. The results revealed the health and safety (HS) has the greatest impact on SC and agree with previous studies that stressed health and safety issues are the major concern in the construction projects and crucial to improving SC (Athapaththu & Karunasena, 2018). Improvement of health and safety would help

minimize accidents, produce a conducive working environment, and enhance the satisfaction of stakeholders (Ogunbiyi et al., 2014). Therefore, construction firms should pay more attention to this issue while launching a viable SC strategy. However, most construction firms perform poorly in this area. The results suggest that construction firms should prioritize site inspection and audits, providing a healthy and safe working environment, and effective emergency management procedures and safety supervision, to help improve the health and safety conditions, in turn, promoting SC.

Environment aspect, which has a close relationship with the objective of sustainable development, is demonstrated to have a huge impact on SC. Previous studies suggested that construction activities are the main contributor to environmental issues (Darko & Chan, 2017). Hence, construction firms should take action to protect the environment. However, the practices are still insufficient because firms are profit oriented and neglect environmental problems. The results indicated firms could implement practices in compliance with environmental laws and regulations, reducing pollution and waste while establishing and improving protect the environment, thereby achieving sustainable practices in the construction industry.

4.2. Practical implications

Effective management of site inspection and audits (HS1), which has a close link with construction safety, is key to ensure the successful implementation of SC. This practice serves to minimize injury and accidents rates, meet customers and workers' expectations, reduce waste frequency and severity. Although most construction firms ascribe extreme importance to this practice, accidents occur due to various factors. Hence, over the long term, firms must strictly obey the safety plans, laws, and regulations, and form an effective safety inspection system (such as daily safety review, inspection of equipment and facilities). In addition, strengthening safety management by training personnel and workers helps to increase awareness and ability to deal with complex issues. The implementation mechanism with clear responsibility and division of labor also plays a key role in promoting the management of site inspection and audits.

The working environment has a strong impact on employees' motivation, efficiency, and safety, thereby having a direct influence on SC. Providing healthy and safe working environment (HS3) can help reduce personnel casualties and accidents, improve economic efficiency, and labor productivity. Thus, construction firms should establish an occupational health management system and make detailed occupational health and safety management plan; engineers and technicians should conduct on-site investigations to identify potential risk factors, and formulate risk control measures based on the assessment results, such as the formulation of prevention of industrial accidents, occupational diseases, and the formulation of special safety construction plans for risky sub-projects. Meanwhile, firms should also strengthen the inspection and maintenance of on-site equipment, various protective facilities, and labor insurance products to prevent the failure of protective facilities. Moreover, firms should be concerned about the mental health of employees and help them cope with work pressure.

Effective emergency management procedures and safety supervision (HS5) enable construction firms to figure out how to alleviate and avoid the effects of accidents and emergencies to ensure the smooth progress of the project and secure a sustainable and resilient future

for the construction industry. This measure not only allows firms to handle accidents in an orderly manner but also reduces losses. However, firms tend to ignore it or implement it as a formality. Therefore, firms should formulate detailed emergency and safety plans for various emergencies and accidents, such as preventive measures against falling from high places as well as fire and explosion prevention measures and understand how to implement these plans effectively and quickly. Relevant managers and workers should clearly know their responsibilities and what they should do prior to accidents or emergencies happen. In addition, firms also can establish a self-regulatory safety management system, conduct a mandatory safety training program, and site safety check to avoid accidents.

Compliance with environmental laws and regulations (EN5) is a core principle for construction firms to adjust and manage their production and operation activities toward SC. Governments' environmental laws and regulations aim at increasing firms' environmental performance, minimizing the pressure of the environment and promoting sustainable development of the industry, and require firms to incorporate environmental responsibility and good environmental practices into their activities. Hence, before developing strategies and plans, firms need to carefully study the terms of environmental laws and regulations and adjust their strategies and plans based on these terms. Establishing an environmental responsibility system while raising awareness of compliance with laws and regulations among employees is necessary. In addition, firms should also abandon older technologies and equipment, implement clean production, and pay environmental protection taxes according to laws.

Reducing pollution and waste (EN2) is an effective measure to save energy, lower the damage to the environment, and reduce costs for SC. It also can improve efficiency in design, materials procurement and usage as well as service delivery systems. Nevertheless, generating a great deal of pollution and waste has become commonplace in construction activities, and construction firms have a few measures to address it. Therefore, firms should promote innovative and recycling technologies or adopt other practices to minimize noise, dust, wastewater, and solid waste pollution. Implementing masonry wall before construction and installing noise safety fence in advance to strengthen noise pollution control, covering earthwork stacked on site and powder yards that may generate dust, and increasing the recycling of solid waste and construction wastewater after treatment are a few examples. In addition, based on the pollution phenomenon, adjusting or abandoning older production plans over time also can reflect the ability of firms to reduce pollution and waste.

Establishment and improvement of the corporate environmental management system (EN4) is a fundamental tool to support and guide firms to develop and implement sustainable business strategies. It assists firms to enhance the efficiency of operations, increase competitiveness by acquiring customers' recognition, and establish a strong CSR image. However, its practice is still rare among construction firms. To date, ISO-4001 has been utilized as an international standard to provide a format to develop and maintain an effective corporate environmental management system. It defines a comprehensive list of requirements and advice that firms can utilize to manage environmental performance with their specific context. Hence, construction firms could adjust their production and construction activities and establish their own system based on the requirements of ISO-4001 and then gain its certification, which could help increase market share and sustainable competitive advantage.

The results provide a reliable guideline for construction firms to adopt the CSR strategy for SC. The criteria discussed above should be prioritized to implement SC strategy. Under limited resources and funds, these practices indicate clear paths and insights for construction firms to improve their performance and allocate resources to maximize efficiency in the process of attaining SC.

Conclusions

Construction firms strive to pursue sustainability practices to meet the government's requirements and long-term corporate development, while SC is the embodiment of these efforts. Effective measures to implement a sustainable strategy is lacking in the construction industry. This study used CSR practice, which has a close relationship with sustainability, to identify strategies for SC. Therefore, a pool of criteria as driving factors was successfully determined under five aspects of SC through a relatively extensive literature review and practitioners' recommendations. And these criteria and aspects were examined as a hypothesized model to verify if they could contribute to SC performance or not. Structural equation model (SEM) methods were further used to evaluate and validate the hypothesized model according to the perceptions of experienced professionals in the construction industry.

The study provides three main contributions to the scientific literature. For the theoretical contribution, the study establishes a reliable and valid framework using CSR, strengthens the understanding of SC, and develops a link between CSR and SC. For the practical contribution, the results offer precise guidelines for construction firms by assisting them to concentrate on the most critical criteria for SC, thereby helping firms to invest in efforts and allocate resources effectively. For the methodological contribution, the study utilizes SEM technology to assess the hypothesized model accuracy and analyze key driving factors to SC, thereby improving the stability and accuracy of the results and simplifying the decision-making processes.

The results revealed that CSR practices provide fundamental support to SC and implied that health and safety and the environment are the top two aspects influencing sustainable performance in the process of SC. Hence, firms should allocate their resources and efforts to solve health and safety and environmental issues. Efforts on the health and safety aspect should focus on-site inspection and audits, providing healthy and safe working environment as well as establishing effective emergency management procedures and safety supervision, whereas for the environmental aspect, compliance with environmental laws and regulations, reducing pollution and waste, and establishment and improvement of the corporate environmental management system should be the primary concerns. These six criteria should be prioritized for the implementation of a viable SC strategy.

Although the objectives of the study have been met, the study may have the following limitations: First, criteria and aspects were selected through a relatively extensive literature review and practitioners' recommendations, but the set of criteria and aspects may not be comprehensive. Thus, future research should investigate other criteria and aspects that are beyond the scope of this study. Second, the study is limited to data gathered from Chinese

construction practitioners and thus may not be generalizable. Future research involving a wide range of industries and opinions of experts from various countries can be expected. Finally, the number of samples in the study is by no means exhaustive, and expanding the volume of samples could be further studied to test the accuracy and stability of the results through SEM technology.

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Author contributions

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Disclosure statement

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