Importance of Sustainability Indicators in Construction SSCM

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Abstract. For ongoing review in the strategic planning of the construction industry, numerous complex categories such as ecological, social, and economic are necessary. The present research and analysis look at sustainable supply chain management (SSCM) in the construction industry from a holistic viewpoint, focusing on the construction company's long-term sustainable decision-making tools rather than only SCM for building projects. This article specifies a number of sustainability measures for assessing supplier networks of construction companies. By analyzing their use in prior literature and agreeing to the explanation, those indicators were grouped and assigned to the categories which better reflect the SSCM principle of their application in the construction sphere. For sustainable policymakers and construction business managers, the use of indicators can aid in the development of policies for the construction sector.
Key words: *Supply Chain, Construction, Sustainability Indicators, SCM, Sustainable Construction.*

Introduction

Relevance of the article

The implementation of SSCM in building projects decreases environmental impact, lowers the chance of failure and boosts the corporation's competitiveness. According to researchers studying supply chains and their management (Mentzner et al., 2001), the performance of supply networks (local and holistic) can be improved if conjunctural connections and processes between enterprises are actively controlled. The importance of management is sometimes underestimated, which also determines the added value of construction projects.

Level of problem investigation

In the building industry, innovations are adopted slowly. The SC is considered as a series of events that cannot be monitored at a single point or stage and it must be viewed as a network (Li et al., 2006). Finance, information, and material links connect all entities in the construction SC, but not all of them are required in every point of the chain (Fliedner, 2003). A contractor can receive components from several sources at the same time and distribute his finished product to a number of distributors and wholesalers. The structure of the construction SC is determined by the customers' needs and the actions of the company. Regardless of the peculiarities of construction organizations, the majority of existing sustainable SSCM methodologies and techniques are being integrated to construction with no further examination.

Scientific problem

The existing academic literature demonstrates that integrating sustainability indicators into construction SCM has several benefits and obstacles (Salami, Isah, & Muhammad, 2021). Better traceability, general efficiency, logistic management, authentication and certification systems are among the former. Modern technology helps to achieve important supply chain quality criteria like traceability and certification (RezaHoseini, Noori, & Ghannadpour, 2021), as well as green consumption and waste reduction in the construction industry. This necessitates politicians having a thorough understanding of the underlying technology and how it impacts and produces current value networks. The limitations of technology, especially consumers' reluctance to adapt, must be better understood. The current legislation does not adequately account for the unique characteristics of artificial intelligence solutions. These are some of the key elements for legislators to create regulations that collectively account for advanced technology's functionality in construction (Banihashemi, Fei, & Chen, 2019).

Object of the article is SSCM indicators in the construction sector and their application, implementation and development in the supply chain.

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Aim of the article is to compile a list of sustainability indicators to be used in analyzing construction companies' supply chains.
***Objectives of the article*:** 1. To analyze SSCM in construction sector. 2. To extract main sustainability indicators. 3. To find the most important sustainability indicators which have the most power for the construction projects in SC. 4. To make recommendations for future research and conclusions.
Methods of the article
This research is based on exhaustive literature review, empirical research, statistical data review, legislative documents and questionnaire of the experts of SSCM. The results are shown in the tables.

1. A brief theoretical introduction

SSCM promotes a broader variety of actions for SC executives and businesses. This necessitates the creation and implementation of policies to improve partners' ecological, financial and social governance. The SSCM can be divided into four sections: (1) data, production, and money planning; (2) economic and social factor management; (3) inventions and software product development; and (4) stakeholders' accountability (Rajesh, 2020). Consumers are required to determine the arrangement of the construction SC as a result of the entity's activities. The supply chain is viewed as a series of operations, and it must be considered a system. SSCM highlights a broader array of activities for SC managers and businesses, as that necessitates the development and implementation of plans to improve partners' social, ecological and financial management (Goel, Ganesh, & Kaur, 2020). To meet the expanding demands of clients and contractors, some steps must be done to optimize operations and the construction processes as the present systems and technologies are unproductive, insecure and unstable.

2. Sustainability indicators in SSCM

Despite the increasing prevalence of sustainable logistics and SCM in construction, SSCM's possibilities, obstacles, and limitations still remain. Additional research is needed and the topic's potential has yet to be realized (Prasad, Pradhan, & Gaurav, 2018). Several issues of the SSCM in construction have been recognized, including environmental, economic, and social patterns (Schulz, & Flanigan, 2017), which are typically known as a Triple Bottom Line.

Numerous publications highlight the importance of transitioning to a more sustainable methodology, particularly in the construction industry. Shen, Tam, & Ji (2010) explains that through competitive activities the sustainability level could be increased in the construction management strategy. SSCM incorporates the construction company's management, external stakeholders, suppliers and consumers' sustainability goals and regulations. All participants in the building supply chain must accomplish certain goals in order for the SC to be sustainable (Fritz, 2019). Product life-cycle analysis, which allows the identification of an item's environmental impact throughout its life cycle from the stage of the product design to the stage of product or building utilization could be used as an example (Stanitsas, Kirytopoulos, & Loepoulos, 2021). Construction businesses must wisely choose suppliers of building supplies based on a various types of criteria, such as environmental, social and economic, which they must specify with the organizational plans, regulations and legislative norms (Schöggl, Baumgartner, & Hofer, 2017).

The majority of SSCM research focuses on the three fundamental pillars of sustainability which are sometimes referred to as the Triple Bottom Line. Few scientists explored these pillars for the SSCM, and they supplied the most generally referenced definitions of the SSCM. Nonetheless, there are presently insufficient techniques available to assess a construction company's sustainability using the Triple Bottom Line. Not all markers are equally precise and quantifiable, according to Moldan, & Dahl (2012). According to Stanitsas, Kirytopoulos, & Loepoulos (2021), it is important to separate sustainability indicators to various categories before evaluating construction business' supply chains.

Categorization of Sustainability Indicators in Construction Sector
Research methods.

Aim of the research is to find the most important sustainability indicators which have the most power for the construction projects in supply chain.

Objectives of the research: 1. Conclude an exhaustive literature review; 2. conduct a survey with the professionals of sustainable construction businesses; 3. using the formula of the categorization of importance (1) find the most important indicators and 4. summarize the results.

Research methods: literature review, development of a new system of sustainability indicators, comprehensive analysis of survey results, categorization of indicators according to their importance.

The research data analysis and the discussion of the results

In order for the results to be achieved, once sustainability indicators have been developed, the significance of the indicators needs to be determined. The importance of sustainability indicators varies in terms of the construction SCM (Boone et al., 2019). Therefore, one of the most important parts of the analysis is to determine the importance of the indicators. Determining the weights of indicators affects the weight of certain indicators in the construction supply chain process, so it can be applied to all multi-criteria assessment tasks. All the indicators listed above can be categorized in a number of different ways, one way being according to their importance, by dividing them into five groups (Table 1):

Categorization of indicators according to their importance

Table 1

IMPORTANCE	SIGNIFICANCE COEFICCIENT	COLOR CODE
LOW	0	
MEDIUM	0,25	
HIGH	0,5	
VERY HIGH	0,75	
MORE THAN VERY HIGH	1	

Source: created by the author.

The evaluation of the hierarchy and the breakdown of the problem separation allow to describe the problem of reference weighting of indicators. The aim of the proposed model is to achieve a more accurate solution.

The ratio scale (intensity) is as follows:

Green - low importance; yellow - a little more important; orange - high importance; red - very high importance; black - absolutely high importance (Tamošaitienė et al., 2017). These indicators contribute to and influence the ethics of sustainable TGV practices.

After the finishing the survey, the Average counting formula (1) to find the most important indicators was applied:

$$M(x) = (x_1+x_2+x_3)/3 \qquad \text{Formula 1}$$

The research data analysis and the discussion of the results

In the period of time of December 2021 three groups of construction experts from large construction companies that use supply chain technologies were asked via email to select the key sustainability indicators. They were grouped according to the similarities of the construction companies that they represented. Out of 70 listed indicators they reduced this number to 38 key indicators. Also they were asked to evaluate these indicators according to their importance by dividing them into five groups (Popovic et al., 2018) according to color value (Table 1). Three groups of experts arranged sustainability indicators in construction SC into five groups according to color code and importance. Following the responses from the three groups of experts, a weighting factor (1) was calculated and is also provided in the tables below with the optimized list of sustainability economic indicators (Table 2).

The final list of sustainable economic indicators

Table 2

Group	Theme	Indicator	Color code			Significance coef.	Importance nr.
			1	2	3		
ECO 1	Work performance and final results	Successful financial and economic performance of work; Ability to pay and affordability; Emphasis on project results				0,917	**1 – 2**
ECO 2	Stability	Economic and political stability				0,167	**13**
ECO 3	Stakeholders	Stakeholder involvement; Supply chain collaboration; Customer relations management, access to contacts				0,833	**3 – 4**
ECO 4	Innovations	Innovation management, new product development				0,583	**6**
ECO 5	Profit	Targeted marketing and benefits Economic and environmental accounting				0,250	**9 – 10 – 11 – 12**
ECO 6	Efficiency	Effective project control; Effective risk management plan; Scope management control				0,917	**1 -2**
ECO 7	Strategy	Best practice strategy				0,250	**9 – 10 – 11 – 12**
ECO 8	Recourses	Efficient allocation of resources; Cost management plan; Resource planning				0,833	**3 – 4**
ECO 9	International ity	Internationalization				0,250	**9 – 10 – 11 – 12**
ECO 10	Bureaucracy	Bureaucratic rationalization				0,417	**7**
ECO 11	Ethics	Business ethics; Organizational culture				0,250	**9 – 10 – 11 – 12**
ECO 12	Improvements	AI management technologies and general improvements				0,333	**8**
ECO 13	Incentives	Targeted incentives				0,083	**14**
ECO 14	Money planning	Effective strategic planning; A project management plan for construction activities is being developed; Implementing a change management strategy; Efficient data processing for decision-making practices				0,750	**5**

Source: created by the author.

The reduced list of sustainability environmental indicators (Table 3).

The final list of sustainable environmental indicators

Table 3

Group	Theme	Indicator	Color code			Significance coef.	Importance nr.
			1	2	3		
ENV 1	Education	Environmental education				0,167	**11**
ENV 2	Stakeholders	Sustainable project implementation by managing construction project stakeholders; Environmental responsibility				0,667	**5**
ENV 3	Environmental impact	Life cycle of products and services to reduce environmental impact; Environmental Impact Assessment Project Report				0,917	**1 – 2 – 3**
ENV 4	Sustainable materials	Use of sustainable building materials; Appropriate and flexible environmental design details and specifications				0,917	**1 – 2 – 3**
ENV 5	Environmental management	Environmental management plan				0,250	**8 – 9 – 10**
ENV 6	Biodiversity	Project biodiversity				0,250	**8 – 9 – 10**
ENV 7	Load on nature	Consistent and predictable load				0,333	**6 – 7**
ENV 8	Risk management	Adaptation to climate change, disaster risk management				0,833	**4**
ENV 9	Politics	The importance of environmental management systems and policies				0,250	**8 – 9 – 10**
ENV 10	Sustainable use of resources	Ecological efficiency; Energy efficiency Renewable energy sources usable, reduction of fossil fuels; Sustainable use of natural resources; Construction water quality impact				0,917	**1 – 2 – 3**
ENV 11	New technologies	The latest environmental construction technologies and methods				0,333	**6 – 7**

Source: created by the author.

Optimized list of sustainability social indicators (Table 4).

The final list of sustainable social indicators

Table 4

Group	Theme	Indicator	Color code			Significance coef.	Importance nr.
			1	2	3		
SOC 1	Holistic approach	Social responsibility; A holistic approach to benefits				0,250	**11 – 12**
SOC 2	Charity and social activities	Financing of social actions, concepts of social justice				0,333	**9 – 10**
SOC 3	Sustainable work practices	Sustainability and organizational culture of construction companies; Work practice				0,750	**2**

SOC 4	Employee accountability	Employee commitment in the workplace; Accountability culture				0,417	**6 – 7 – 8**
SOC 5	Workers' rights	Human rights; Sustainable employment				0,500	**5**
SOC 6	Society	Community relations and involvement; Public acceptance of the project				0,250	**11 – 12**
SOC 7	Stakeholders	Stakeholder involvement and management; Contractor - supplier relationship				0,667	**3**
SOC 8	Policy	Independence of political factors from the construction project; Transparent and competitive procurement processes				0,333	**9 – 10**
SOC 9	Quality	Implementation of quality management system; High quality work is emphasized				0,583	**4**
SOC 10	Documentation	Detailed contract documentation; Management of intangible assets				0,167	**13**
SOC 11	Competition	Promotion of competition; Adaptation to the project environment				0,417	**6 – 7 – 8**
SOC 12	Reports	Social impact reports; The scope of the construction project and the constraints of the project are well defined				0,417	**6 – 7 – 8**
SOC 13	Applications of systems	Tracking of construction project management stages / processes; Product - service systems				0,833	**1**

Source: created by the author.

The most important sustainability indicators identified by experts that have an impact on the analysis of construction supply chains (Table 4).

The most important indicators from all three sustainability groups

Table 4

Importance	Indicator	Coef. of Importance
1.	Work performance and final results (ECO 1)	0,917
2.	Efficiency (ECO 6)	0,917
3.	Environmental impact (ENV 3)	0,917
4.	Sustainable materials (ENV 4)	0,917
5.	Sustainable use of resources (ENV 10)	0,917
6.	Applications of systems (SOC 13)	0,833
7.	Stakeholders (ECO 3)	0,833
8.	Risk management (ENV 8)	0,833
9.	Recourses (ECO 8)	0,833
10.	Money planning (ECO 14)	0,750

Source: created by the author.

Conclusions

1. The parameters of sustainability were classified into three categories: social (governing), economic, and environmental. As an outcome of the research, construction project managers will be able to more effectively plan current, innovative sustainable solutions in terms of achieving sustainability accomplishments in research programs, taking into consideration the 38 attributes identified. The most important indicators were work performance and final results, efficiency

(economical), environmental impact, sustainable materials and sustainable use of recourses (environmental) and applications of systems (social).

2. The in-depth examination of the indicators according to the SCM sustainability scenario provides a foundation for construction professionals and scholars to further examine and research the indicators of construction engineering projects. In a practical situation, use of such indicators could assist environmental legislators and building company management in developing policies for the construction sector. This method could be applied to construction businesses' life-cycle optimization models, software approaches and etc. For continued study, a factor analysis method can also be used to identify the underlying correlation between the defined sustainability criteria.

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