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ESG Framework and Sustainable Supply Chain Management Competitiveness: A Structural Equation Model

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Resumen

Esta investigación tiene como objetivo desarrollar un modelo conceptual que revise la relación entre practicas medio ambientales, sociales y de governanza corporativa (ESG) y su impacto en la competitividad de la cadena de suministro (SCC). Las practicas como colaboración, innovación, comunicación, agilidad y flexibilidad como constructos mediadores. El marco ESG es la medida más utilizada en la actualidad relacionada con la sustentabilidad pero ha sido poco utilizada en la cadena de suministro. Se diseño un modelo de Ecuaciones Estructurales con el enfoque de Mínimos Cuadrados Parciales (SEM-PLS) como aportación a esta limitante. Los modelos SEM-PLS sin técnicas estadísticas ampliamente utilizadas en ciencias sociales, en ambientes altamente complejos y en investigaciones exploratorias. Los principales hallazgos muestran que la implementación continua de practicas ESG en operaciones de la cadena de suministro influencian la sustentabilidad y mejora la competitividad de la cadena de suministro, beneficiando stakeholders, inversionistas y consumidores precoupados por contingencias medioabientales.

Palabras clave: Sustentabilidad, Competitividad de la Cadena de Suministro, Medio ambiente, Sociedad, Governanza corporativa, Modelos de Ecuaciones Estructurales.

Abstract:

This research aims to develop a conceptual model that reviews the relationship between environmental, societal, and corporate governance (ESG) practices and their impact on supply chain competitiveness (SCC). It uses collaboration, innovation communication, agility, and flexibility operations as mediator constructs. The ESG framework is the most used measure related to sustainability but is still limited in supply chain or operation management research. A Structural Equation Model using Partial Least Squares is developed to fill this gap. SEM-PLS is a statistical method widely used in social sciences, highly complex situations, and exploratory research. The main findings are the continuous improvement of ESG practices in supply chain operations, influencing sustainability and improving supply chain competitiveness, benefiting stakeholders,

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investors, and customers concerned by environmental issues such as greenhouse gases, carbon dioxide emission or pollution, labor conditions, and corporate reputation.

Keywords: Sustainability, Supply Chain Competitiveness, Environment, Society, Corporate Governance, Structural Equation Modeling

Introduction

The environmental, Social, and Governance (ESG) refers to a set of criteria used to evaluate a company's performance in terms of its impact on the environment, society, and corporate governance, becoming essential for investors, customers, and stakeholders interested in sustainable and responsible practices (Stan et al., 2023). Since its adoption by the United Nations in 2006, it has attracted considerable attention. Bloomberg Intelligence (2021) reports that the size of ESG-portfolios is approximately $40 trillion and is expected to reach $53 trillion in 2025.

The ESG framework has been used as the most used measure of a firm's sustainability and social impact. Sustainability is a topic of discussion nowadays, where the primary concern is to meet today's needs without compromising future generations' needs (Rajesh, 2020). The Securities and Exchange Commission in the United States has recommended that all publicly traded companies reveal the material of their ESG information (SEC, 2020).

The influence on ESG has been assessed at the firm level, but in the supply chains, it remains unstudied. However, supply chain partners have been integrating ESG principles into their purchasing and sourcing practices, labor rights, or corporate governance impacts. Integrating ESG standards into supply chain practices has become a key driver to ensure that their supply chain operations are sustainable and responsible for meeting the expectations of stakeholders and customers concerned about the implications for the environment, society, and business (Stan et al., 2023).

Firms integrating ESG standards into their practices are found to have more excellent governance, care more for sustainable development and environment, and have less earnings volatility in financial indicators, but in non-financial terms, have improved consumer satisfaction, market acceptance, and societal perception of the firm. Consequently, the competitive advantage may grow with ESG practices (Mohammad & Wasiuzzaman, 2021).

Given the importance of ESG and its impact on competitiveness and the little research made in this field, this research seeks to address some limitations and missing links between ESG practices and supply chain competitiveness. Therefore, this research aims to develop a conceptual model that

reviews the relationship between environmental, societal, and corporate governance practices and their impact on supply chain competitiveness. It uses collaboration, innovation communication, agility, and flexibility operations as mediator constructs.

The research is arranged as follows: Section 2 presents the literature review of supply chain competitiveness and its dimensions, as well as the environmental, society, and governance framework. Section 3 specifies the model construction and describes the method that will be used to analyze the model developed. Section 4 discusses the links between supply chain competitiveness and the ESG frame. Section 5 is the conclusions of the research.

Literature review

Supply chain competitiveness

Several authors have explored supply chain or supply chain management, definitions, concepts, performance, strategies, and frameworks (Verma, 2011), which has created the need to achieve competitiveness through supply chain management (SCM) (Sarker et al., 2022). With the creation of SCM, obtaining a competitive advantage has changed. Factors such as globalization, outsourcing, and nearshoring or disruption of demand or supply disruptions influence the gain or loss of competitive advantage (Azadegan & Dooley, 2021), so supply chain academics and practitioners have to rethink theories and practices to ensure that supply chain competitiveness (SCC) can be maintained (Flynn et al., 2021; Gremyr & Halldorsson, 2021).

Supply chain competitiveness has attracted attention because improving and managing the supply chain is essential. Nowadays, the real competition is among supply chains and not among firms, and organizations will only survive if they are competitive enough in supply chain and customer satisfaction (Verma, 2011).

SCC refers to the advantages of a supply chain (SC) over other supply chains (Febransyah & Camelia Goni, 2022), but the term first appeared in the 1990s (Macbeth, 1990). Since then, several researchers have analyzed the term. For example, Cavinato (1992) developed a total cost/value model to measure SCC based on cooperation between SC partners in production, product innovation, development, and cost advantage. Bhatnagar and Sohal (2005) analyzed quality, responsiveness, flexibility, and inventory factors. In contrast, Anh et al. (1999) used manufacturing capabilities, cost, quality, and delivery as dimensions of the SCC.

Verma and Seth (2011) consider that if supply chains want to compete, they must develop and manage cooperation and collaboration partnerships. In this situation, flexibility and agility are the main factors that help them achieve a competitive advantage.

From the literature review, five dimensions are analyzed to explain supply chain competitiveness: collaboration (Ahn et al., 1999), innovation (Cherrafi et al., 2018), communication (Khompatraporn & Somboonwiwat, 2017), agility (Viardot & Nylund, 2017) and Flexibility (Taplin, 2014)

Collaboration is essential to achieve a competitive advantage, and different ways can influence it: a strategic alliance between retailer and supplier can generate business opportunities, improve service levels, and reduce costs (Kros et al., 2019). Marchi et al. (2016) consider that long-term relationships are necessary to increase supply chain competitiveness, so strategic alliances are a way to achieve this. Finally, collaboration can be improved by knowledge sharing and learning activities such as collaborative problem-solving or developing sharing knowledge networks (Hernández-Espallardo et al., 2010).

Innovation is also relevant for supply chain competitiveness, and this brings the development of new services and goods, processes, and systems (Kiwala et al., 2023). Furthermore, innovation capacity is analyzed as a central factor for SCC and developed by new practices, methods, and systems shared between strategic supply chain partners (Zawislak et al., 2023). Finally, activities such as learning and trust serve as a foundation for long-term partnerships between supply chain members and are critical contributions to SCC (Song & Ranjan Chatterjee, 2010).

The next element for SCC is communication, mainly made of information technologies. Good communication between supply chain partners can result in better product design, logistics, marketing, and sales, increasing collaboration and reducing lead time. Also, to maintain competitiveness in a supply chain, the adoption of information technologies such as Radio Frequency Identification (RFID) or Electronic Data Exchange (EDI) produces better integration in the supply chain (Lagorio et al., 2022).

Agility is the capability to generate the highest value for the customer by producing and marketing various products and services with the lowest cost and lead time but with higher quality (Mukhtar & Azhar, 2020). To compete, organizations have to be capable of responding quickly to demand changes and developing new products (Dubey et al., 2018).

At least, flexibility is conceived as a capability of the firms to shift product mix or production volume rapidly without losing efficiency (Khatri & Srivastava, 2016). Flexibility can be achieved by creating long and short-term agreements with suppliers, developing capabilities to perform changes in product design, introducing new products quickly, and offering broad product lines (Tukamuhabwa et al., 2015)

ESG framework

As a background, Environmental (E), social (S), and governance (G) refers to a set of criteria used to evaluate a company's non-financial value in terms of its impact on the environment, social, and corporate governance. These factors have become essential for investors, stakeholders, and customers (Stan et al., 2023) ESG framework is critical for firms who are looking for sustainable growth in the future (United Nations, 2004) and is a crucial indicator for building trust in firms adding sustainable value created by products and services (Zhou et al., 2022).

To better comprehend ESG, it is necessary to understand the concept of Corporate Social Responsibility (CSR), the precursor of ESG. CSR has become popular since the 1950s when Bowen (1953) published a set of principles for corporations to fulfill their responsibilities. Since then, CSR has been one of the main elements of management studied by academics. One of the significant issues regarding CSR is the difficulty of defining and measuring it (Khojastehpour & Shams, 2020).

With new findings regarding CSR, the concept of ESG has been used as an alternative in many studies, so CSR and ESG are often defined as the same concept. However, ESG is more detailed in terms of definition and evaluation, and the main difference is that CSR is used more in terms of accountability. At the same time, ESG involves the company's evaluation of environmental, social, and governance roles (Park et al., 2022).

For this research, the ESG concept is defined as the activities of the firms associated with the relationship between the organization and its ecological surroundings, its interaction with human organisms and other populations, and its corporate systems of internal control and procedures to manage all the affair of the organization to serve the interest of the stakeholders (Whitelock, 2019).

With the rising focus on sustainability issues, firms must validate their commitment to environmental sustainability and social responsibility to meet the expectations of customers, investors, and regulators, and this issue needs to be addressed urgently not only by the firms alone but all the supply chain partners (Meng, 2024).

ESG issues influence supply chain operations, and supply chain operations affect ESG performance. Some topics reviewed include greenhouse gas emissions, worker safety, transparency, and responsible procurement in United States companies. Also, companies are responsible for identifying, preventing, and addressing social and environmental issues throughout their supply chain networks (Dai & Tang, 2022).

The influence of ESG in SC is of great importance and continues to expand (Stan et al., 2023). Firms are incorporating ESG principles into supply chain activities such as purchasing and sourcing, looking for sustainable, socially responsible, and ethical supply chains. This involves

various concerns, such as human rights, labor standards, environmental impacts, and corruption (Ferriani & Natoli, 2021).

By incorporating ESG concerns into SC practices, firms can reduce risk exposure, improve their reputation, and stimulate sustainable and responsible supply chains. Some of the benefits of ESG and SC are improved relationships with suppliers and customers, increased efficiency, reduced costs, and access to new markets (Stan et al., 2023).

The environmental (E) component pertains to the firm's effects and risk mitigation approaches. In this research, environmental factors are viewed as the combination of capabilities of the firm to reduce the overall carbon footprints of products, greenhouse gas discharges, and the responsible use of natural resources by the supply chain partners (Lam & Lai, 2015).

The social (S) component is related to a firm's associations with its stakeholders. It is evaluated by human capital management, equitable remuneration, employee involvement, and the firm's influences on the communities it serves. This pillar, or ESG, is paying more attention to the stakeholders (Yawar & Seuring, 2017).

Governance (G) involves the management and leadership of the organizations. ESG seeks to gain deeper insight into leadership's incentives, stakeholders' expectations, and the nature of the designed internal controls. The notion of governance encompasses a set of guidelines and procedures such as the company's purpose, the role, the shareholder's rights, or the codes of conduct of the director boards (Stan et al., 2023).

Method

Structural Equation Modelling (SEM) based on Partial Least Squares (PLS) has become one of the most widely used approaches to analyzing data and defining complex models in various research contexts (Ciavolino et al., 2022). First-generation multivariate analysis techniques, such as multiple regression, logistic regression, or analysis of variance, have three significant limitations: (1) the postulation of a simple model structure, (2) all the variables have to be observable, and (3) the assumption that all variables can be considered without error (Haenlein & Kaplan, 2004).

To overcome these limitations, academics have increased the use of second-generation techniques, mainly Structural Equation Modelling (SEM). These models enable researchers to model and estimate complex problems simultaneously with multiple dependent and independent variables (Cole & Preacher, 2014). Since SEM works with multiple related equations, it offers several advantages over other statistical techniques, such as flexibility in how the equations are presented and developing graphical language so complex relationships can be presented powerfully (Monecke & Leisch, 2012).

Two popular methods dominate the SEM in practice: covariance-based (CB-SEM) and partial least squares (PLS-SEM), whereas CB-SEM is primarily used to confirm or reject theories and their hypothesis, determining how closely a proposed model can reproduce the covariance matrix for an observed sample dataset. In contrast, PLS is introduced as a causal-predictive approach that explains the variance in the model's dependent variables (Chin et al., 2020).

The ESG in the supply chain among corporate leaders is unequivocal, but the interplay between ESG and SC remains understudied. Research by Dai and Tang (2022) identified 15 papers published during the last five years focusing on ESG measures and supply chain operations issues. With this idea, a PLS-SEM model is designed to increase understanding of the relationship between ESG pillars and supply chain competitiveness. One of the main characteristics of SEM-PLS is that it is precious for exploratory purposes (Hair et al., 2014), so this technique fits well with the objective of this research.

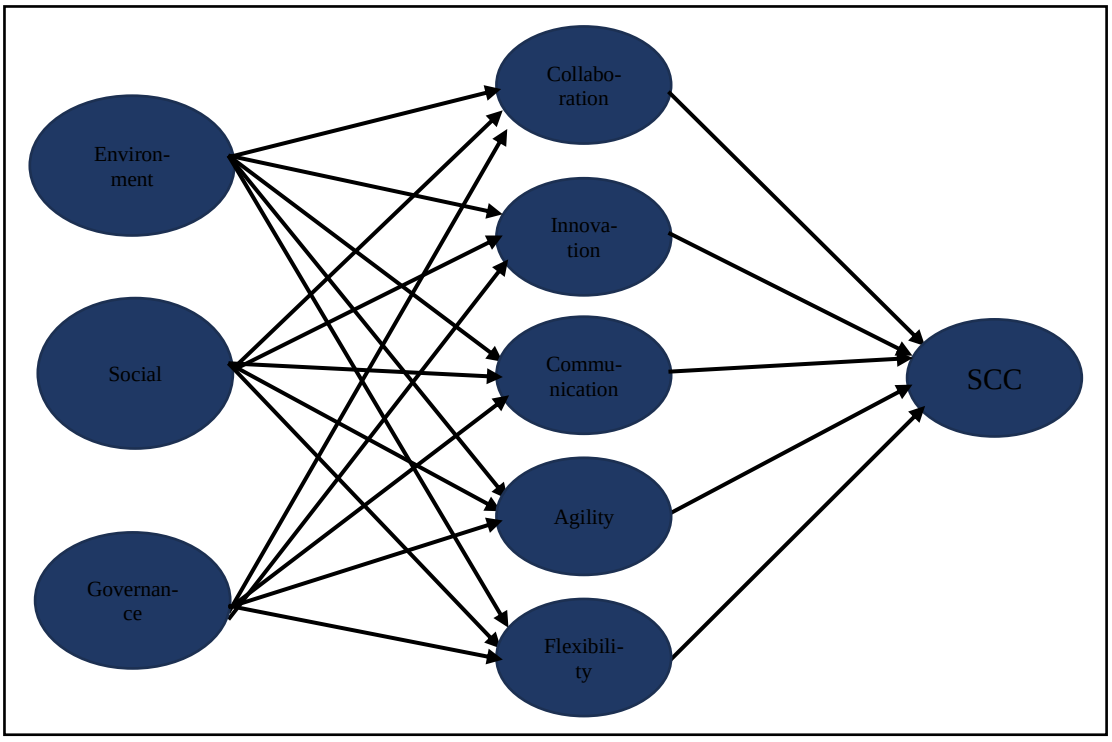
When an SEM-PLS is applied, researchers need to follow the following processes: (1) the path model specification, (2) outer model evaluation, and (3) inner model evaluation (Hair et al., 2014). Path models visually display the hypothesis and variable relationships examined when SEM is applied. The path model has two elements: constructs that are not directly measured and are represented in the model as circles or ovals, and indicators, also called items or manifest variables, are directly measured and contain raw data (Hair et al., 2021).

The inner and outer model evaluation displays the relationship between the evaluated constructs. The outer model, or measurement model, assesses the relationships between the indicator variables and their corresponding construct. The inner model shows the relationship between the constructs, and the researcher establishes the hypothesis of the research.

The model proposes that Environment positively influences supply chain competitiveness (H1) but is mediated by collaboration (H1a), innovation (H1b), communication (H1c), Agility (H1d), and Flexibility (H1e). Also, social positively influences supply chain competitiveness (H2) and is mediated by collaboration (H2a), innovation (H2b), communication (H2c), Agility (H2d), and Flexibility (H2e). Finally, the third hypothesis proposed is that corporate governance positively influences supply chain competitiveness (H3) and is mediated by collaboration (H3a), innovation (H3b), communication (H3c), Agility (H3d), and Flexibility (H3e). The path model presented in Figure 1 only shows the inner model.

Figure 1.

Proposed path model



Source: Own elaboration.

To test this hypothesis, it is necessary to assess the SEM-PLS. The first step is to examine the measurement model or outer model, which could be made with formative or reflective constructs, depending on how the item is redacted. If the construct of the measurement model is reflective, some rules of thumb are required (Hair et al., 2019):

- First step: indicator loadings. Loadings above 0.708 are recommended since they indicate that the constructs explain more than 50 percent of the indicator variance;
- The second step is the internal consistency reliability. This evaluation includes Cronbach's Alpha and Composite reliability. For exploratory purposes, reliability values above 0.70 to 0.90 are considered satisfactory (Diamantopoulos et al., 2012). The third is to calculate the convergent validity of each construct, which is the extent to which a construct converges to explain the variance of its items. The metric is called AVE (Average Variance Extracted), and the minimum accepted AVE is 0.50 or higher. AVE indicates that the constructs explain 50 percent or more of the variance of the items that make up the Fourthep: is to assess the discriminant validity, which is the extent to which a construct is empirically distinct from other constructs in the structural model. The criterion for evaluating

discriminant validity is the Heterotrait-Monotrait Ratio (HTMT). The limit value is 0.90, and values above this limit indicate that discriminant validity is not present in the construct (Henseler et al., 2015).

If the construct is made with formative items. In that case, the measurement model is evaluated by three criteria: (1) convergent validity, (2) indicator collinearity, and (3) statistical significance and relevance of the indicator weights (Hair et al., 2017).

- Convergent validity (1) is measured by the construct's Average Variance Extracted (AVE).
- Indicator collinearity (2) uses the variance inflation factor (VIF). When the values of VIF are higher, the levels of collinearity are higher. VIF values of 5 or above indicate collinearity issues among the constructs. Ideally, VIF values should be close to 3.
- The indicator weights (3) are measured by a BCa bootstrapping procedure and with an outer loading weight. A loading weight of 0.50 or below suggests we should consider removing the indicator. Also, if the confidence interval of the indicator weight is zero, it indicates that the weight is not statistically significant.

In both cases, when the model measurement is adequate, the next step is to evaluate the inner model or structural model. The assessment of the SEM-PLS includes collinearity, the statistical significance and relevance of the path coefficients, the coefficient of determination (R^2), f^2 effect size, and the out-of-sample predictive power of the model (PLSpredict) (Hair et al., 2019).

The structural model coefficients are derived from estimating a series of regression equations, so collinearity must be examined before assessing the structural relationships. VIF values are used to test collinearity. Similarly, in formative measurement models, VIF values must be five or below.

If collinearity is not an issue, the next step is examining the path coefficients. These show the hypothesized relationships between constructs. The path coefficient has values between -1 and +1; the values closest to +1 indicate a strong relationship, and vice versa for negative values.

A bootstrapping procedure obtains the statistical significance of the coefficients; the researcher has to establish the *t*-value and the *p*-value for all the path coefficients. The most used critical values are for the two-tail test: 1.65, 1.96, and 2.57 for a significance level of 10%, 5%, and 1%, respectively. Usually, a significance level of 5% is accepted in almost all disciplines (Hair et al., 2017).

The next step in evaluating a structural model is the R^2 coefficient. R^2 measures the variance explained in each of the endogenous constructs and measures the explanatory power of the structural model. R^2 is an interval that ranges from 0 to 1, and R^2 closest to 1 indicates greater explanatory power. Acceptable R^2 is based on the context and the field of study.

Also, it is necessary to examine how removing a specific construct affects the R^2 value of an endogenous construct. This is what the f^2 effect makes. More precisely, the rank order of the predictor constructs is relevant in explaining a dependent construct in a structural equation model. As a rule of thumb, values higher than 0.02, 0.15, and 0.35 indicate small, medium, and large f^2 effect sizes (Cohen, 2013).

Finally, the SEM-PLS evaluation finishes with the PLSpredict procedure. Shmueli et al. (2019) developed this procedure as an alternative to Stone-Geisser Q^2. PLSpredict is a holdout-sample-based procedure that generates case-level predictions on an item or constructs to evaluate the model predictive power assessment.

When interpreting PLSpredict results, a $Q^2_{predict}$ coefficient is generated. The model shows no predictive power if this value equals zero or less. If this coefficient is positive, the researcher must verify the prediction errors using root mean squared error (RMSE) or mean absolute error (MAE), depending on the symmetry of the prediction error. After that, the researcher benchmarks the $Q^2_{predict}$ with the RMSE or MAE. If the $Q^2_{predict}$ < RMSE or MAE in all the indicators, the model has high predictive power, it is for the majority of the indicators have medium predictive power, and it is for a minority has low predictive power (Shmueli et al., 2016).

Discussion

The proposed conceptual model seeks to explore the relationship between the ESG framework and supply chain competitiveness to contribute to a better understanding and create new ways of measuring both concepts. Sustainability is a significant topic for firms integrating environmental, social, and economic goals across supply chain activities (Koberg & Longoni, 2019).

The supply chain systems that adopted sustainable principles gave birth to the concept of sustainable supply chains (Rajeev et al., 2017). Scientific literature has followed the growing interest of practitioners in sustainable supply chains. According to the literature reviewed, sustainability can enhance firms' competitive advantages (Rajesh, 2020).

Amid sustainable supply chain literature, the ESG pillars have gained global prominence, posing a set of goals for companies to strive for and for socially conscious investors to ponder their investment decisions upon. ESG scores and standards have progressively become a widely accepted measure for companies to determine and monitor their sustainability performance (Dai & Tang, 2022).

As an example of the impact that ESG has nowadays, since its introduction in 2006 by the United Nations report, the size of the ESG portfolios is approximately $40 trillion in 2021. It is expected to reach $53 trillion by 2025, and most Fortune 250 firms have established various ESG goals.

Additionally, the Corporate Sustainability Reporting Directive (CSRD) will require large European firms to regularly unveil information about their social and environmental impact, promoting transparency in ESG matters and countering greenwashing (Chen & Dagestani, 2023).

Regarding environmental standards, firms should actively develop renewable energy sources, promote sustainable manufacturing practices, improve ecological efficiency, increase green production, and actively implement management to protect the environment (Gawusu et al., 2022). Also, product lifecycle impact assessment can measure the potential impacts on these resources, air quality level, water usage release, and water effluents and pollutants to assess clean and safe water availability. Direct or indirect impacts on land resources can be monitored to reduce the effects on soil and bio-diversities (Rajesh, 2020).

Regarding the social dimension, the S pillar is related to human resources, such as employment stability, employment practices, health and safety, and capacity development. These dimensions can be extended to supply chain partners and evaluate how employment stability impacts work opportunities, human rights, equity of labor, and gender equality. Another dimension includes health and safety practices, which are assessed for preventive measures to handle health and safety incidents (Badri Ahmadi et al., 2017).

The pillar of Governance (G) is related to the operational performance of the firms. It pays attention to the firm's management, increasing the sense of responsibility, providing regular training, improving their employment working skills, and motivating employees to work better (Yang, 2023).

Implementing ESG standards in the supply chain, actively producing low-carbon goods, strengthening environmental protection, fulfilling social responsibilities, and improving corporate governance can attract more consumers with sustainable interests. This generates a better reputation and will also improve the supply chain competitiveness. At the same time, better ESG performance can attract more investors (Rajeev et al., 2017).

Finally, the model developed seeks to explore the relationships between ESG and supply chain competitiveness, addressing that strong ESG practices cultivate a favorable reputation among customers increasing sales and shareholder value of the firm (Stan et al., 2023).

Conclusions

With the evolution and importance of sustainability practices, ESG practices have attracted more attention from academics and practitioners and are becoming a significant strategy to obtain competitive advantages. In supply chain management, ESG is still a developing topic and has recently started to be used.

The ESG framework integrates how the firms manage their operations, including environmental issues such as greenhouse gases, water management, pollution, and carbon emissions. The Social standards regarding how the firm accomplishes its human resources and gives stability and good labor conditions to their workers with capacitation programs,

This conceptual model seeks to contribute to expanding the use of ESG standards in supply chain management practices with the use of a Structural Equation Model with Partial Least Squares, a statistical technique used mainly in exploratory research, and a method applied with frequency in operations management, supply chain, and sustainability research problems.

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