



# Empirical investigation of extended TOE model on Corporate Environment Sustainability and dimensions of operating performance of SMEs: A high order PLS-ANN approach

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## ABSTRACT

**Aims:** The goal of economic expansion, which ignores social welfare and environmental restrictions, has been supplanted in the business environment. The paper investigates how corporate environmental sustainability affects sundry parts of a company's performance. The study question is dichotomized into two segments. Firstly, examine the effect of selected dimensions, such as Economic, Social, Technological, and Organizational factors, on Corporate Environment Sustainability. Secondly, to validate and prove the mediating effect of CES on firm performance with selected manifests.

**Methods:** A total of 390 respondents from SMEs were analyzed systematically. The synergy of Smart-PLS and Artificial Neural Network determines the impact of environmental sustainability on the various dimensions of a firm's performance that yielding a novel insight that would render vital benefit to stakeholders while drawing the policies related to sustainable development.

**Findings:** The findings reveal that corporate environmental sustainability plays a significant role in shaping the relationships between technological, organizational, environmental, and social factors and SMEs' operating performance.

**Novelty:** The study is the first to empirically validate and evaluate the multimodal framework by extending TOE and TBL theorem. This theoretical nexus can be a pathfinder for policymakers, administrators, and managers to enhance SMEs' performance. Additionally, the validity of this construct in the study has been empirically reinforced statistically.

## 1. Introduction

Organizations are becoming more sensitive to economic, social, and environmental performance (Yeng et al., 2018). Businesses in various industries and sectors have chosen to adopt Industry 4.0, ICTs, automation to augment their value creation through sustainable development due to severe market antagonism and a fast-evolving business environment (Nair and Choudhary, 2016). In the words of (Biswas et al., 2018; Sushil, 2012), sustainable development has numerous dimensions, viz. ecological, economic, moral, social, institutional, cultural, educational, etc. Sustainable development has prompted a new way of thinking about developing, communicating, and offering value to customers and other corporate entities (Alnuaimi, 2021). (Awa et al. 2016) emphasized the need to put the concept of sustainable

advancement into action as the most apparent component of a company's environmental ties and a vital contributor to value creation. According to (Cantelle and Zardini, 2018; Van Kemenade and Hardjono, 2019), developing concepts, ideas, and approaches for SD are critical to be subsumed by every industry worldwide. There is a lot of focus on a company's environmental performance, resulting in optimum production and sustainability (Akanksha Jain, 2014). The enhanced focus among supply chain participants such as clients, suppliers, consumers, government observances, and retaliatory environmental penalties created the need to adopt green manufacturing practices (A. K. Gupta and Gupta, 2020). In this regard, brand equity was also a crucial cause for this seeming sensitivity to environmental issues as a 'green organization' (Ferro et al., 2018). A series of articles (Panchal et al., 2021; Spangenberg et al., 2002) demonstrated the importance of operational

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success and sustainability of manufacturing units. Many studies have been conducted in various disciplines to explore the aspects that contribute to business sustainability, notably in SMEs worldwide.

In this regard (D'Souza et al., 2020) applied institutional theory and a conceptual framework to analyze the impacts and antecedents of sustainability for MNCs in China. The study investigated the long-term viability of MNCs by identifying the motivators for implementing sustainability and detecting performance disparities. The constraints that prevent SMEs from engaging in sustainable engagement vary, but the primary issues are a lack of awareness, financial resources, competition, and government assistance. Recent literary research has also paid greater attention to coping with environmental changes. For example (Morea et al., 2021), used CSR reports of eight blue-chip cosmetics companies to verify how they achieve various environmental, social, and economic issues. They framed various mandatory and non-mandatory statements that identify goals and propagate best practices to achieve the SDGs of UNO. Another sustainable, innovative business model was proposed by (Reficco et al., 2018). The study encompassed different industries ranging from agribusiness, manufacturing, and service sectors and found that sustainable innovation necessitates (social, economic, and environmental) collaborative channels at the BM level (Arbolino et al., 2022). elucidated cross-country comparison of industrial sustainability in 36 OECD countries. This article aims to provide a new perspective on industrial sector performance in sustainability and the circular economy. The findings of this study allow justifying the use of the composite index as a tool for assessing industrial policy in a variety of scenarios, including social, economic, and political factors (Lu et al., 2020). applied Carroll's CSR pyramid to augment the organizational performance of SMEs in Pakistan. The findings confirmed that by incorporating Industry 4.0, a cleaner environment renders a synergistic business opportunity to contribute to SD by improving environmental management, production efficacy, and socially sustainable development for SMEs. In a nutshell, it can be inferred that the selected manifests such as economic, ethical, legal, philanthropic, technological, and economic factors influence organizational performance and postulate a significant relationship with the long-term sustainable growth of SMEs. Sustainable development in SMEs is described as growing and conserving the resources for Next-Gen society. These small, micro and medium-sized firms have been conducting their operations as a responsible charter to fulfil local and global environmental norms (Timans et al., 2016). The description implies a long-term commitment to balancing social, environmental, and economic concerns rather than short-term profits and chaotic practices. Sustainable development is a relatively new subject that has emerged in management literature in the recent past. Still, the study is scarce on SMEs' practices and understanding of the common misunderstandings of sustainable development (G. K. Singh, 2021).

Small and medium-sized businesses play an essential part in all countries' economies by contributing to national economic growth and employment (Bag et al., 2021). Adopting sustainability principles is crucial for SMEs in today's sophisticated, competitive, and untidy business world. However, SMEs and sustainability are inextricably linked to achieving consistent growth. On the other hand, SMEs' growth is impossible without incorporating sustainability themes into their business plan (Priyadarshini and Abhilash, 2020). Moreover, SMEs have a subsumed role in employment generation and overall economic growth. According to the OECD report, strengthening SMEs' shares in a Global and Digitalized Economy has become the need of the hour because they account for over 70% of total employment.<sup>1</sup> They are significant contributors to the value formation of every nation. SMEs render 45% of total work and 33% of GDP in developing nations (Rozados and Tjahjono, 2014). These statistics reveal the vital role of

sustainability in SME development that could be achieved by adopting specific measures (Munerah et al., 2021). Even though SMEs account for a substantial portion of the national and global economies, their participation in sustainability is far from satisfactory. Only a few works have incorporated practical assessment into business strategies (Kowalska, 2020). Further, it is unclear why sustainability is not ingrained in SMEs of India. There might be a few causes for this, which vary in country and industry:

- Lack of awareness among employees on how sustainability might be applied.
- A lack of understanding among business owners about the benefits of sustainability measures.
- There is a lack of inexpensive financial resources.
- Inadequate and insufficient management and skill advancement.
- There is a shortage of information on how to put sustainability into practice.
- Interference of well-intentioned sustainability measures with other industrial goals.

Sustainable development activities should be incorporated into giant corporations' strategies by SMEs. The past studies examined the implementation of SD in large firms, but the researchers observed a clear gap in the comprehensive research of SMEs. Several scholars stress that methods for implementing SD for SMEs have not been thoroughly investigated, leading to the diminished pace of implementation of SD (Kowalska, 2020; S. Kumar and Singh, 2021). Focusing less attention on implementing sustainable solutions in smaller firms may fail to recognize that these organizations can potentially threaten the natural environment (Panchal et al., 2021). Furthermore, the slowness with which SMEs adopt the sustainable development plan may be attributed to a shortage of frequently lesser financial resources to develop novel technologies for society (Sadaf et al., 2021). The observed gap as a lack of wholesome research to apply sustainable tools appears to be studied. Simultaneously, the literature review reveals a lack of research output indicating the country's socio-economic development impact on the execution of sustainable promotion. The decision framework was purposefully picked from a collection of comparable theories to ensure that the study's TOE-TBL hypotheses are theoretically sound. These hypotheses are discussed in greater detail in the following sections. In the present context, the study contributes to the existing literature field on SMEs' sustainability in India. The proposed frame examines the mediating presence of CES between technological, organizational, economic, social factors and the operating performance of SMEs. In fact, the study takes an integrated view by investigating the direct effect of TOES to CES and OP. Thus, more specifically, the research attempts to get the answer to the following precise questions.

RQ.1: Do the dimensions of TOE and TBL influence and motivate SMEs toward corporate environmental sustainability (CES)?

RQ.1: Does CES have a favorable and mediating effect on the operating performance of SMEs?

To reply to the above RQ, responses were obtained through a survey methodology conducted on 390 manufacturing and service industries units in India. The measurement items used for the manifest were identified from previous work and validated by the experts. Afterwards, Structural Equation Modelling (SEM) and ANN were employed. SEM is a multivariate statistical technique for analyzing structural associations. This technique combines CFA and multiple regression analysis, and it is used to analyze the structural relationship between observed manifest and latent constructs. The researcher prefers this method to estimate the multiple and interrelated dependence in a single analysis (Hair et al., 2016). In the recent past, SEM has gained popularity in project management and business research due to precise statistical practice for quantifying the correlations between numerous unobserved manifests that can be derived from measurable constructs. It has been commended for its capacity to quantify complicated effects across various variables

<sup>1</sup> <https://www.oecd.org/industry/C-MIN-2017-8-EN.pdf> (Accessed 2 Oct. 2021).

and successfully handle measurement errors. PLS-SEM allows the researchers to estimate complex models with several constructs, predictor variables, and structural paths without imposing distributional assumptions on the data. It also offers solutions with small sample sizes by computing measurement (Hair et al., 2018). Moreover, the ANN model has also been used to recognize the non-linear relationship to overcome the linear constraints and validate the relative weight of the selected constructs in the model.

The following is a breakdown of the paper. The first portion explores the introduction and background of SMEs. The second section discusses secondary sources of knowledge about the research topic and the formulation of hypotheses. The third section examines the research methodology, survey methods, and sampling design. The fourth part outlines the data analysis, validity of the proposed model, theoretical implication, limitations, conclusion, and a list of references.

## 2. Theoretical Background

The researchers analyze the prose on CES and firms' performance for the last ten years of SMEs of emerging economies.

### 2.1. Firm performance

Several articles on the firm performance of SMEs in various locations and circumstances have complied in the recent past (Sabella et al., 2014), analyzed business performance and the ways to conserve resources in heavy industries. Earlier research described CES, CSR, supply chain and OP in industrialized countries like the USA, China, Europe, and Australia (Mendoza-Fong et al., 2019; Rakesh Kumar Birda and Manish Dadhich, 2019). However, there has been a trend of CES awareness in recent decades in growing economies such as the Asian and African continents. Likewise, the published work has focused on a few aspects of firm advancement and ES (Sethi et al., 2020). Nevertheless, the fundamental element of firm performance has also been studied on a limited scale. This paper extends a step further by probing the impact of ES on overall FP, including all elements, and studying the various functional characteristics in-depth (Tjahjadi et al., 2021). created a framework for measuring performance in big and small engineering firms. They divided the measurements into two components. The first component corresponds to the management pyramid developed by (Rasa Dainiene and Lina Dagiliene, 2015) as strategic, technical, and operational processes. Second, analyze how these criteria help the public, businesses, consumers, and individuals. In this regard (Pambreni et al., 2019), studied the various dimensions of organizational performance and developed an environmental protection framework. They highlighted that the firm's performance could be augmented with decreased waste material, waste discharge, and treatment. The firm can also enhance its goodwill by adopting quality assurance practices (Dadhich, 2017). The recently disclosed knowledge was examined to see whether there was a link between sustainability and performance. When considering only one part of the performance, it was with or without moderators and contextual. Thus, the study is likely one of the first to check the mediation effect of environmental sustainability on operational performance while considering other significant performance aspects.

### 2.2. Environmental sustainability

(Karabulut, 2015) evaluated 128 papers based on environmental sustainability (ES) and reviewed potential gaps in sustainability and associated organizational accomplishment. This paper may interest readers who want to realize the likely conceptual frameworks and diagnostic methods employed in ES literature throughout the last decade. (Cantale and Zardini, 2018) examined Italian SME manufacturers and established the relationship between EP and FP, using organizational commitment and business reputation. In this study, buyer

satisfaction and competitive benefit were used as mediators (Seth et al., 2018). conducted a thorough analysis of the CS literature spanning two decades and measured various aspects of CSR, TBL, and environmental policy (Müller and Wulf, 2021). defined CS's internal and external precursors as leadership, image, consumer demands, aspirations, and legality (M. Singh et al., 2020). conducted an in-depth assessment of the literature in their latest work to show the links between operations papers and ES. They said a mounting interest in environmental sustainability among functional academics and policymakers.

Under the dynamic capability concept (Lepore and Spigarelli, 2020), stated that a green business attitude has a favorable impact on the performance of Chinese businesses. The legitimacy might also be viewed as servant and fear of litigation expenses. Authority restrictions have been the key motivators for a portion of business sustainability (Shahzad et al., 2018). As a primary incentive, legitimacy drives the public relations and ICT functions actively to engage in sustainability operations. There is much comprehensive literature on CSR in both advanced and emerging countries, yet the environment is another component that is considered within the CSR umbrella (Nair and Choudhary, 2016). When firms implement environmental steps to improve their functioning, such elements are accounted for using the TBL hypothesis. In our research, we distinguish the ES under CSR and TBL. However, the motivation of this study is the assessment of literature that remains on the CES, which may have a direct effect on the performance of companies and their productivity (Rasa Dainiene and Lina Dagiliene, 2015).

The following is a review of pertinent CS and ES literature. A systematic and detailed examination of sustainability literature (Aykol and Leonidou, 2015; Dadhich, 2017; G. Gupta and Nagpal, 2020) provided a tangible, complete, and multi-dimensional viewpoint on business sustainability (Dadhich et al., 2021a). identified the drivers of strategic ES adoption in a comprehensive literature study. Having studied and complied with around 114 reputable peer-reviewed publications, he stated that the CS and ES field has expanded, but more experimental research is still needed. While scholarly research has developed, commercial sustainability remains low. Therefore, (Rasa Dainiene and Lina Dagiliene, 2015) provided three strategic elements, i.e., process, content, and context, based on TBL to execute commands into the substantial growth of the organization (see Fig. 1).

There is a need to resolve several global and local issues related to a sustainable environment and green practices. The published literature surveys such as those shown in Table 1 have endeavored to investigate the principal enablers of CES in small and medium enterprises. India alone has witnessed a long list of environmental issues such as pollution, erosion of sands, greenhouse gas emissions, climate change, industrial waste disposal, and exploitation of natural resources. Thus, the research details the different dimensions of operating performance and the effect of selected dimensions, such as economic, social, technological, and

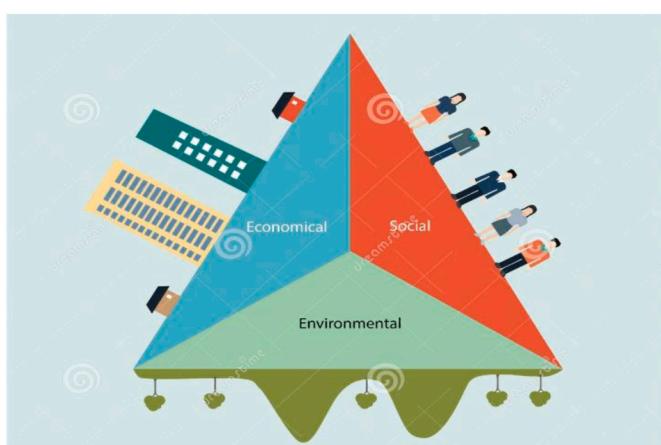


Fig. 1. TBL-framework (Rasa dainiene and lina dagiliene, 2015).

**Table 1**  
Execution measures and sources.

Constructs Codes → Source & Year ↓	1	2	3	4	5	6
D'Souza et al. (2020)				•	•	
Hourneaux et al. (2018)	•	•	•	•	•	•
Gupta and Nagpal (2020)					•	•
Kaswan and Rathi (2020)	•	•	•	•	•	•
Khurana et al. (2019)	•	•	•		•	
Lu et al. (2020)	•			•		•
Mendoza-Fong et al. (2019)			•			
Morea et al. (2021)			•	•	•	
Thakur and Mangla (2019)	•	•	•	•	•	•
Belhadi et al. (2020)	•	•	•		•	•
Imran et al. (2018)	•		•		•	
Dadhich et al. (2021b)	•	•	•	•	•	•

1: Technological Factors; 2: Organizational Factors; 3: Economic Factors; 4: Social Factors; 5: Environmental Factors; 6: Operating Performance.

organizational factors, on CES.

### 2.3. TBL-TOE framework

A single theory usually contains several constraints and cannot be applied to any development. As a result, the combined paradigm of many theories is more helpful in explaining the context. The narrative review included views from previous investigations, and the evidence from these studies was sorted and combined. The suggested framework consists of a wide variety of cruxes. This study combines two influential theories for analyzing corporate environmental sustainability: the TOE framework (Tornatzky and Fleischner, 1990) and the TBL approach (Kingsley, 2013). The TOE framework provides a valuable analytical tool for examining the adoption of various types of innovations. The TOE model is a concrete theoretically basis and empirically coherent with the previous study (Sabella et al., 2014). It has corroborated the antecedent factors that influence CES analytically (Lepore and Spigarelli, 2020). These three factors impact how a company views the need for new technology to search for it and accept it. The dimensions of this theory are still relevant and render the insights to excel even in volatile situations (Sethi et al., 2020). (A. K. Gupta and Gupta, 2020) proposed a TOE-based model for understanding RFID adoption in manufacturing firms that planned to increase supply chain visibility and process efficiency, while (H. Gupta et al., 2021) applied the same framework to investigate the factors that influenced small-and-medium-sized businesses to adopt contemporary green practices.

The TBL is a three-part accounting framework: social, environmental, and financial. Organizations have embraced the TBL framework to evaluate performance. The three factors work together to define a company's performance (Kaswan and Rathi, 2020). Moreover, firm sustainability is best acknowledged as exemplified by the TBL due to its intricacy. According to (Rasa Dainiene and Lina Dagiliene, 2015), the TBL strategy can help a company achieve economic prosperity, environmental excellence, and social justice. The three-pillar method, or TBL, has been generally acknowledged for sustainability by researchers, society, and organizations, despite different definitions and terminology (Akanksha Jain, 2014). Four dimensions were recognized by (Spanenberg et al., 2002), social, economic, environmental, and utilitarian. Further, TBL ideology includes these functional dimensions in the present context. Human capital was defined as being more significant manifest in the social element. The emphasis was on a person's abilities, commitment, experience, and subsequent behavior. According to (Thakur and Mangla, 2019), social sustainability is the least quantifiable component of the triple bottom line paradigm. In the same vein (Hourneaux et al., 2018), and (Lu et al., 2020) believed that social factors could augment the operating performance by establishing cordial affairs with the public and stakeholders. Since the social factor has been given less attention in the current context of the study, the researchers predict that it will have a subsumed effect on CES of SMEs; based on this

justification, the paper incorporated this factor as a part of the theoretical framework. (Khurana et al., 2019) in their empirical work in Indian manufacturing industry have elucidated corporate sustainability can be achieved by incorporating financial performance. From another viewpoint (Belhadi et al., 2020), confirmed the association between CES and economic performance while studying the small manufacturing units of North Africa. Conversely (Imran et al., 2018), presented exciting evidence that an organization that invests in a green supply chain can attain economic stability in the long run. In the Mexican maquila industry context (Mendoza-Fong et al., 2019), assessed the operational, commercial, and economic factors that profoundly affect CES in the short run. They also emphasized the role of CES in achieving firm performance in the long run. The economic factor classifies the financial health of a firm. Thus, based on above justification, the study has integrated the economic factor as prominent part of the conceptual framework. Finally, this research refers to dimensions, interdependencies, and symbiotic effects. Thus, in summary, this study's aims are as follows: (a) to develop a TBL-TOE based decision framework that includes a comprehensive set of choice variables for CES adoption, (b) to evaluate and validate the proposed model to be adopted by SMEs.

## 3. Research model and hypotheses

### 3.1. Technological factors

Technological factors refer to a thorough understanding of a specific technology and experience in dealing with that technology (Sarkar, 2012). AI-ML-DL, Blockchain, Big-data and other technologies are a few prevalent examples of tech-upgraders. Still, most businesses cannot recognize and capitalize on new technology because companies buy technology without thinking about how it would help them run their company (Müller and Wulf, 2021). Firms acquire technology because their immediate competitors have purchased it or because the technology is a hot topic at espousal. According to (Kumar and dadhich, 2015; Liguori and Winkler, 2020), it is not simply technology that will assist enterprises but aligning technology with the most vital strategy for any corporation. Employees must be taught how to use a given technology and think analytically (Sartal et al., 2020). This must be done in unification with technology and related methodology breakthroughs; the desired results can only be realized (Dubey et al., 2015). Advanced development related technology can enhance processes and industrial outputs, which contribute to SD.

Thus, the hypothesis is:

**H1.** Technological factors have a positive, profound, and significant effect on CES.

### 3.2. Organizational factors

Organizational structure is a cornerstone for every firm to perform operational tasks and deliver internal strength. A successful OS enables process standardization, operational flexibility, technology specialization, and workflow formalization (Sushil, 2012). For any firm to balance operational and economic performance, a suitable blending of organizational competencies and resources is required to produce a sustainable status for the organization (Pambreni et al., 2019; N. Sharma and Dadhich, 2014). According to (Hourneaux et al., 2018), operational performance, financial performance, and market performance all have a role in an organization's long-term viability. Industrial revolutions necessitate the progress of technical skills and organizational thought and its associated variables (Kaswan and Rathi, 2020). Together with progressive working practices, organizational constructs can lead to the acquisition of smart and intelligent human resources that can aid in the evolution of a company's technical leadership (Sartal et al., 2020). Administration with high morale can also boost employees towards the transition of the firms. Eventually, the employees' proactive conduct is

considered organizational competency required for the firm's long-term sustainability.

Henceforth, it is postulated that:

**H2.** Organizational factors have a positive and subsumed effect on CES.

### 3.3. Economic factors

The baseline and the circulation of money are the focus of economic variables. As a result, income, expenditures, employment, taxes, corporate environment, and business diversification could be solid motivators for financial actions. Individual earnings, the cost of under-employment, establishing turnover, creating sizes, job creation, job growth, and employment distribution by industry are only a few examples of economic constructs (Tang et al., 2019; Xiao-Wen and Min, 2021). Financial stability is a crucial feature that positively influences the sustainability of blue-chip companies (Timans et al., 2016). According to (Saleh and Ndubisi, 2006), a reliable monetary strategy was seen as having the sharpest impact on operational profit, but finance access is challenging in the present context for small and medium firms. Organizations with sufficient external and internal financial resources can transform to CES and could be more productive in the competitive business environment.

Therefore, the next hypothesis is as follows:

**H3.** The value created by economic factors is positively associated with the CES of SMEs.

### 3.4. Social factors

Social variables refer to the social dimensions of a society region. Education, social resource, quality & access, physical condition, social wellbeing, life excellence, and social capital are principal components of social constructs in the present context. Literacy, unemployment, women's education, female labor, age of demographics, family income, poverty, population, median commute time, and so on are only a few and far examples of possible manifests (Al-Azzam et al., 2020). Expressed quantitative statistics could more easily assess organizational, technological, and economic dimensions, but social sustainability measurement necessitates a balance between quantitative and qualitative indicators (Sethi et al., 2020). Further, the proposed plan includes four dimensions for social sustainability: employee turnover rate, health, and a safe environment that enhances the living quality of the surrounding society with social welfare initiatives. Similarly, the cordial affairs of the firms with the public and stakeholders also boost sustainability.

Hence, the hypothesis is posited as:

**H4.** The worth created by social factors influence the CES of the selected firms.

### 3.5. Environmental measures

Presently, there are massive concerns related to environmental protection and regulation, and thus, there is a need to opt for the appropriate policy to sustain in the long run (Dadhich et al., 2021c). The firms concerned about the environment may benefit from the government, stakeholders, customers, etc. (G. D. Sharma et al., 2020). Hence, specific parameters provide an environmental management system (EMS) and suggest a potential impact on the viability of the firms. Long-term trends for each ecological component, in theory, might aid corporations in determining the benefits of a project in a variety of ways (G. D. Sharma et al., 2020). Controlling greenhouse gases, pollutants, excess nutrients, energy consumption, solid and hazardous waste management, and so on are only a few examples (Priyadarshini and Abhilash, 2020). ES is a deliberate priority to a different magnitude in

organizations that may help business executives to augment performance and corporate excellence (Sartal et al., 2020). In the words of (Foo et al., 2018), a firm's sustainability may create value for competitive advantages, thereby creating a value system for next-generation.

Thus, the researcher theorizes that:

**H5.** CES has a favorable and mediating relationship between TOES and OP of SMEs.

The proposed hybrid models are assumed to extend an improved structure by which the drivers of corporate sustainability can be established (see Fig. 2). The principal focus of this analysis is on the firms' environmental sustainability. This area has received little attention due to a lack of comprehensive studies in recent years. Thus, the study has tended to focus on CES and the performance of SMEs in India.

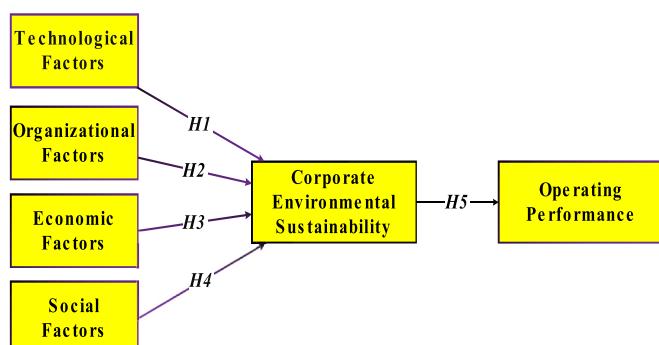
### 3.6. Research gap and novelty

According to a literature assessment, most of the research focuses on large corporations, and it has been observed that SMEs receive hardly any attention in emerging economies. Past studies viz. (G. K. Singh and Dadhich, 2021; Timans et al., 2016) emphasized the importance of a company's scale in defining other long-term promoting strategies. SMEs are one of the most vital drivers of SD in the global market, and they foster value creation, innovation, entrepreneurship, and social well-being in every nation. They are more flexible than large organizations when it comes to change (Chauhan et al., 2021). Many studies have covered sustainability, waste management and firm performance in the Chinese, European, and African continents. Still, CES constructs in any theoretical framework have not been explored in the Indian context. This research meets a knowledge gap in the subject of research by providing an opportunity to expand expertise in the field. In response to the underlined research need, the paper seeks to inform SMEs on how to adopt the notion of CES. Similarly (Biswas et al., 2018; Cantele and Zardini, 2018), observed no direct association between ES and FP in European manufacturing enterprises. Therefore, a precise frame of sustainable issues for SMEs is to be investigated further in their future field of inquiry.

## 4. Research method

### 4.1. Questionnaire and measures

The paper entails a survey instrument by drawing on legitimate and well-defined notions from the literature, specifically ES, and a performance criterion. The operating performance scale was adopted by previous work (Karabulut, 2015) and is established on the balanced scorecard recommended by (Seth et al., 2018). The scale is divided into five aspects to measure firm performance: economic, social, organizational, technological factors and operational performance. The selection of independent manifest and other constructs is based on the TBL and



**Fig. 2.** Conceptual framework.

TOE framework approach, a reliable and relevant corporate sustainability scale created by (Dainiene and Dagiliene, 2015; Tseng et al., 2020). The environmental dimension of TBL was used in the study to evaluate the CES variable. Employees from the selected organizations were requested to complete the questionnaire. The study employed snowball sampling approaches in a non-probabilistic sample (N. Sharma and Dadhich, 2014). For the survey, we used both personal and virtual conversations.

#### 4.2. Sampling design

Literature usually urges the idea of 1:6 sample size, where five samples per manifest are satisfactory for the bootstrapping assessment (Hair et al., 2009; Langevin et al., 2020). According to research (Lepore and Spigarelli, 2020), a sample size of 390 is likewise sufficient for a model with 25 or more manifest. The number of components and levels of commonality of every measure in a model also influence the sample size (Gudergan et al., 2008). proposed sample size of 150 for models with 5 or 7 constructs with communalities greater than 0.6. SEM is benign with a sample size of 200 or more (Gudergan et al., 2008). The study relied on 390 respondents of various units that justified the sample size area and the proposed reserach framework (see Fig. 3).

The constructs of the study were assessed using a five-point Likert scale, with "1" denoting "far below the average" and "5" representing "far above the average".

#### 4.3. Data collection and cleaning

The study is both narrative and quantitative, and it was done with managers of industrial organizations utilizing a survey-type research approach. Further, non-probabilistic sampling can be regarded as a homogenous group with at least one common attribute belonging to the same industry (Imran et al., 2018). Thus, the sample contains 35% lower and 45% middle management and 20% responses from top management. A cluster-sampling method was also applied, with each cluster representing a collection of business organizations. A firm was chosen for judgmental sampling to collect the data needed for the research. Employees of the nominated companies were invited to fill out our

survey. The study encompassed multiple manufacturing and service industries such as IT & software, plastics & rubber, mines & minerals, and automobiles & others. The selection of multiple SMEs allows the generalizability of results and comprehension of the domain-specific manifest. The paper employed a pilot survey of 50 respondents to rectify the questionnaire and make the questions meaningful and comprehensive. The survey was administered using both human interviews and web technology. Out of 500 responses, 110 incomplete and unreturned questionnaires were discarded, and only 390 valid responses were considered for further analysis. The major research interrogation is to analyze the effect of the CES on the performance of firms. The whole performance has four prominent manifests viz. improved quality, trustworthiness in delivery, cost efficiency, productivity & optimum resource utilization. After collecting the data, outliers were removed by applying Mahalanobis distance technique (Mahalanobis, 1936) which is typically used to identify multivariate outliers. The manifest with a  $\sigma$  of less than 0.5 was also removed to ensure the consistency and reliability of the data. PLS-ANN has been employed on the collected sample of 390, which is consistent with the guideline of 1:6 ratio. In addition, this sample unit has exceeded the 50 times thumb rule for using ANN (Khayer et al., 2020). There are six parameters in the neural network; the minimum sample size required would be 300. Thus, the sample size of 390 is appropriate for the ANN analysis.

#### 4.4. Common method bias

It refers to the degree of illegitimate covariance shared among manifests. It happens due to employing a standard procedure to collect data from the same area of research (Abuhammad, 2020; Jordan, 2020). (Podsakoff et al., 2003) found that CMB can create artificial covariance between measurements, impacting the outcome. Hence, its presence evokes spurious support for the tested ideas. In behavior and social science research, the effect of CMB/CMV is a crucial validity issue (Hair et al., 2016). Process and statistical control are two methods presented by (Gudergan et al., 2008) to test and reduce CMB. To combat CMB through process control, the researchers clarified to the respondents that their responses would be unnamed and personal. The researchers put the dependent and independent variables in various parts of the questionnaire to reduce CMB using statistical tests. The researchers also made sure that the statements in the items were clear, concise, and unambiguous. The reliability of the CMV single factor approach has been questioned by (Kenny and Baron, 1986). As a result, the study utilized a different way to check CMB. The Common Latent Factor (CLF) in the SEM model was used to test CMB. The researcher also calculated the values of standardized regression weights with and without a common least factor; the CLF is significant if the difference between the two values is more than 0.2 (Jordan, 2020).

### 5. Data analysis and interpretation

The central research question is divided into two stages. Firstly, to test the effect of selected dimensions, viz. technological factors (4 signifies), organizational factors (4 signifies), economic factors (4 signifies), social factors (4 signifies) on CES along with five statements. Secondly, to validate and prove the mediating effect of CES on operating performance along with four manifests. The study found that measuring scales were used for each of the six sustainable tools (see appendix A).

The above Table 2 enunciates that the sample comprised 68.50% male and 31.50% female, 51.20% of the units have existed below five years, and 48.80% were above five years in the market—almost equal category of service and manufacturing segment. Eventually, most actors were from the junior management level, i.e., 47.90%, middle management scored 30.70%, and the share of top management was 21.40%. Nearly 48.80% of the respondents hold work experience of less than four years, 33.40% were between five to ten years, and 17.80% possessed industrial experience above ten years. Further, business activities of

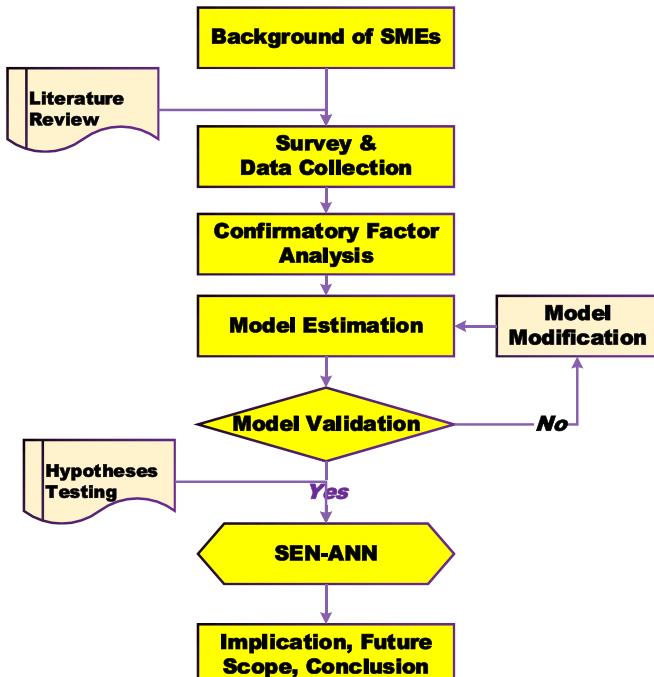


Fig. 3. Research framework.

**Table 2**  
Demographic profile

Particular	Classification	Freq.	%
Gender	Male	267	68.50
	Female	123	31.50
Age of unit	Below 5 Yrs.	200	51.20
	Above 5 Yrs.	190	48.80
Firm category	Service	210	53.80
	Mfg.	180	46.20
		390	100
Managing Level	Junior Mgmt.	187	47.90
	Middle Mgmt.	120	30.70
	Top Mgmt.	083	21.40
Work Experience		390	100
	0-4 Yrs.	190	48.80
	5-10 Yrs.	130	33.40
Domain of SMEs	Above 10 Yrs.	070	17.80
		390	100
	IT & Software	75	19.20
Domain of SMEs	Plastics & Rubber	95	24.30
	Mines & Minerals	105	26.90
	Automobiles & Others	115	29.60
		390	100

SMEs are IT & software 19.20%, plastics & rubber 24.30%, mines & minerals 26.90%, and 29.60% of units from automobiles & others.

### 5.1. Measurement model

It links the standardized measured manifests to their latent manifests. At the outset, the validity and reliability of the manifests and latent variables were examined by virtue of factor loading between the items. Manifests loadings  $\geq 0.5$  are considered for EFA, followed by structural equation modeling (see Fig. 4). According to (Hair et al., 2011), the reliability of all latent variables is subsumed by composite reliability ( $CR \geq 0.75$ ) and convergent validity ( $AVE \geq 0.50$ ). SQRT of AVE tests discriminant validity with the associating inter-factor correlation (see Table 3). If the AVE is greater than the inter correlational values of factors, DV is acceptable, and it validates the progression of research in the concluding direction (Hair et al., 2016). Further, DV is also confirmed by analyzing the higher factor cross-loading of the selected items (see Table 4).

Prima facie, the research aims to test the reliability of selected sub-

**Table 3**  
Reliability and convergent validity of the constructs.

Scale	Ch. $\alpha$	rho_A	CR	AVE	MSV
Corporate Environmental Sustainability	0.815	0.812	0.758	0.622	0.585
Economic Factors	0.835	0.836	0.822	0.564	0.496
Operating Performance	0.930	0.953	0.931	0.814	0.692
Organizational Factors	0.889	0.913	0.895	0.694	0.926
Social Factors	0.875	0.865	0.858	0.724	0.495
Technological Factors	0.853	0.889	0.861	0.680	0.455

**Table 4**  
Fornell-larcker criterion.

Constructs	CES	ECF	OP	ORF	SCF	TCF
Corporate Environmental Sustainability	0.652					
Economic Factors	0.312	0.754				
Operating Performance	0.639	0.233	0.896			
Organizational Factors	0.304	0.229	0.219	0.815		
Social Factors	0.477	0.247	0.237	0.362	0.791	
Technological Factors	0.564	0.292	0.231	0.342	0.620	0.762

stances that have already been discussed; Cronbach's Alpha expressed a score above 0.815 that abridged that the observed variables were reliable enough for confirmatory statistical analysis. In addition, the values rho\_A CR were above 0.70, and the values of AVE, MSV exceeded 0.50, which indicates good construct reliability (A. K. Gupta and Gupta, 2020; Hair et al., 2009). IBM SPSS 23.0 and Smart-PLS software were used to conduct a series of tests on how well the data perform concerning each other.

$$\text{Cronbach Alpha } (\alpha) = \frac{(n - 1)}{n} X \left( 1 - \frac{\sum \sigma_i^2}{\sigma_j^2} \right)$$

$$\text{Composite Reliability (CR)} = \frac{(\sum_{i=1}^n \lambda_i)^2}{(\sum_{i=1}^n \lambda_i)^2 + (\sum_{i=1}^n \delta_i)}$$

$$\text{Average Variance Extracted (AVE)} = \frac{\sum \lambda_i^2}{\sum \lambda_i^2 + \sum (1 - \lambda_i^2)}$$

The Cronbach alpha based on standardized manifests employs the correlations among items and does not depend on the items' shape or

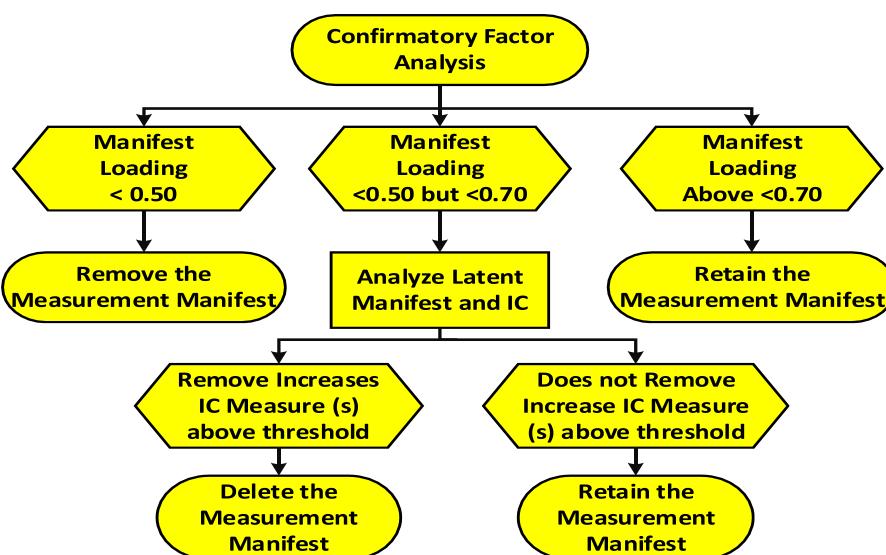


Fig. 4. Decision-making process of measurement variables.

size. CR is computed from the sum of factor loadings ( $\lambda_i$ ), squared for each construct and the sum of the error variance terms for a construct ( $\delta_i$ ). AVE estimates each factor with the squared inter-construct correlations (SIC) associated with that factor.

Fornell-Larcker criterion is also gratified with suggested values (Kingsley, 2013; Munerah et al., 2021; Sushil, 2012). Thus, the model estimate meets the requirements of reliability, substance, and discriminant validity. Further, it was succeeded by the testing of the PLS model. Hence, the testing of the PLS model was corroborated.

## 5.2. Structural Model

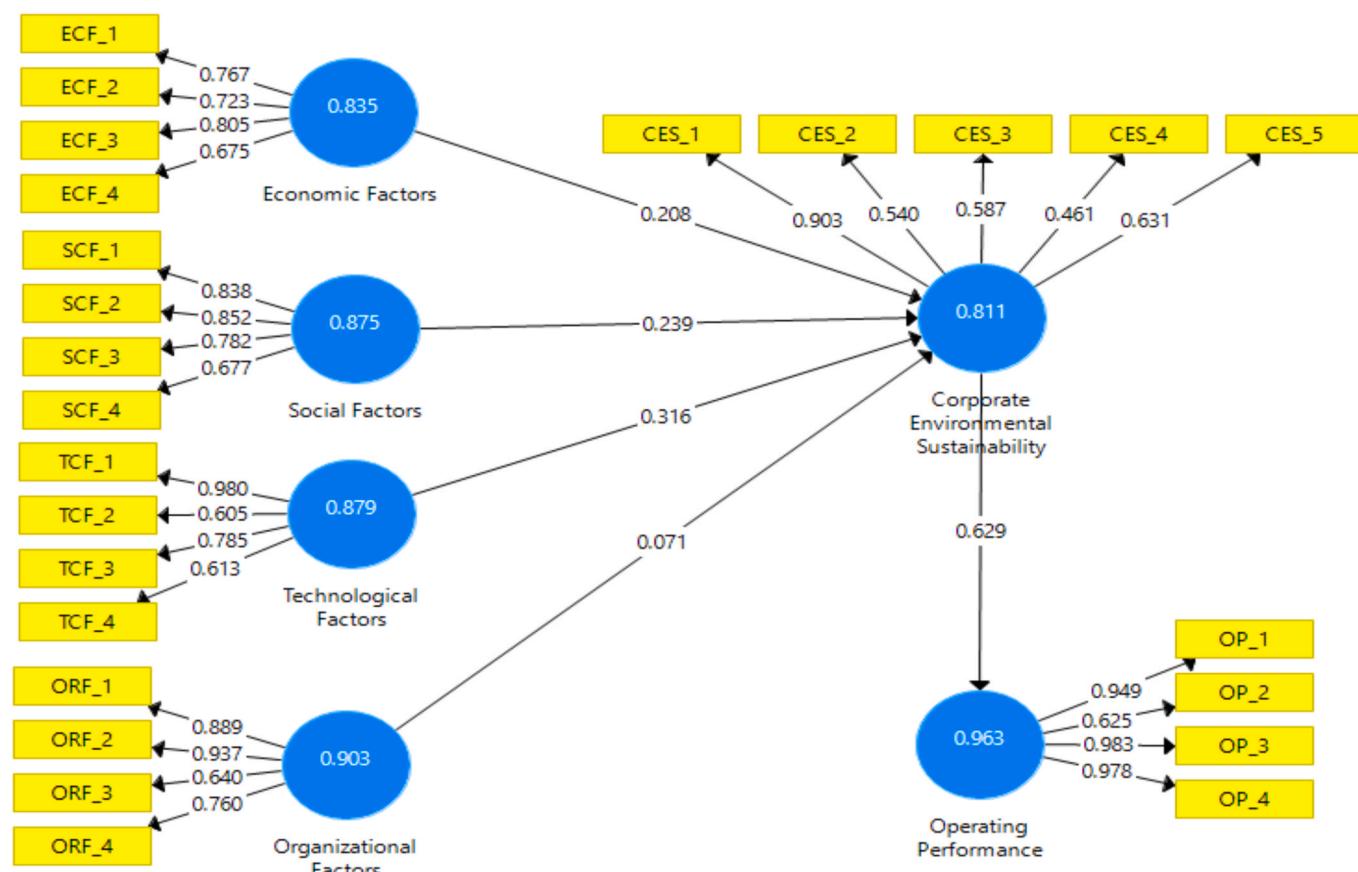
The study also examined the presence of any multi-collinearity (MC) concerns in the model. All the VIF were less than five, which eliminated the problem of MC (Hair et al., 2011).  $F^2$  denotes the effect size conducive to analyzing predictor variables' influence on dependent variables (Fornell and Larcker, 1981). Similarly, (Ringle et al., 2015) also illustrated that a smaller value of  $F^2$  is vital to subsume the dependent variables in many ways. The present value of this parameter is more than 0.02, which is considered an acceptable range. Besides, the proposed framework outlines significant and positive momentum of explanatory value as evident from the value of  $R^2$ , which scored from 35% to 62%. The study tested the mediation of critical factors CES between TOES and operational performance by employing the recommended method (Kenny and Baron, 1986). TOES is positively related to CES, whereas CES has a favorable and mediating relationship with the operating performance of SMEs in India (see Fig. 5).

Discriminant validity is also certified by using cross-loadings and HTMT, which delineates that items load higher on the proposed factors (Ringle et al., 2015). The bootstrapping of the mediation model and the path analysis demonstrate that four paths are essential to explain CES,

which further proves its significance for describing the operating performance of the selected units (see Table 5 and 6). The researcher employed t-statistics and 95% confidence intervals to determine the relevance of the association. If the bottom and higher limits of the 95% confidence interval do not contain a zero, the association is significant

**Table 5**  
Cross loading of manifests.

Manifests	CES	ECF	OP	ORF	SCF	TCF
CES_1	<b>0.903</b>	0.145	0.902	0.061	0.107	0.143
CES_2	<b>0.540</b>	0.163	0.233	0.129	0.388	0.403
CES_3	<b>0.587</b>	0.179	0.241	0.183	0.426	0.448
CES_4	<b>0.461</b>	0.227	0.129	0.112	0.374	0.402
CES_5	<b>0.631</b>	0.306	0.246	0.216	0.438	0.451
ECF_1	0.231	<b>0.767</b>	0.126	-0.026	0.075	0.163
ECF_2	0.218	<b>0.723</b>	0.065	-0.067	0.152	0.118
ECF_3	0.243	<b>0.805</b>	0.123	0.020	0.113	0.143
ECF_4	0.204	<b>0.675</b>	0.078	-0.020	0.099	0.148
OP_1	0.597	0.142	<b>0.949</b>	0.125	0.133	0.134
OP_2	0.393	0.024	<b>0.625</b>	0.099	0.081	0.043
OP_3	0.618	0.144	<b>0.983</b>	0.094	0.137	0.138
OP_4	0.615	0.141	<b>0.978</b>	0.112	0.131	0.136
ORF_1	0.181	-0.014	0.097	<b>0.889</b>	0.239	0.192
ORF_2	0.191	-0.021	0.134	<b>0.937</b>	0.214	0.183
ORF_3	0.130	-0.057	0.059	<b>0.640</b>	0.194	0.191
ORF_4	0.155	-0.013	0.085	<b>0.760</b>	0.210	0.234
SCF_1	0.409	0.156	0.110	0.152	<b>0.838</b>	0.473
SCF_2	0.415	0.112	0.121	0.187	<b>0.852</b>	0.507
SCF_3	0.381	0.120	0.122	0.244	<b>0.782</b>	0.502
SCF_4	0.330	0.068	0.075	0.262	<b>0.677</b>	0.522
TCF_1	0.513	0.129	0.142	0.309	0.565	<b>0.980</b>
TCF_2	0.317	0.138	0.096	0.214	0.513	<b>0.605</b>
TCF_3	0.411	0.147	0.097	0.201	0.508	<b>0.785</b>
TCF_4	0.321	0.195	0.050	-0.047	0.324	<b>0.613</b>



**Fig. 5.** Mediation effect of CES structural model.

**Table 6**  
Heterotrait - monotrait ratio (HTMT).

Particular	CES	ECF	OP	ORF	SCF	TCF
Corporate Environmental Sustainability	0.642					
Economic Factors	0.302	0.744				
Operating Performance	0.629	0.133	0.896			
Organizational Factors	0.204	0.029	0.119	0.815		
Social Factors	0.487	0.147	0.137	0.262	0.790	
Technological Factors	0.524	0.192	0.131	0.242	0.630	0.761

(Alnuaimi, 2021; Karabulut, 2015; Seth, 2016).

### 5.3. Major findings and discussion

This study empirically outlines the mediating effect of CES between the proposed constructs (technological, organizational, economic, social) and operating performance (see Table 7). Further, Fig. 6 delineated the features of path coefficient of the proposed constructs.

#### 5.3.1. Discussion of hypothesis 1

State of the art technological facets have a striking effect on CES ( $t=5.812$ ,  $p=0.040$ ) because it has several benefits that may boost the organization to excel and gain a competitive advantage in post-pandemic scenarios. The finding reveals that technological factors (popularly known as Industry 5.0) are the most crucial internal variable to assist the firm's smooth transformation into a sustainable model. The results corroborate with the study of (Lakmali, 2020), who empathized that maintenance of capital equipment during the manufacturing process can upgrade techno-development. Moreover, the findings of this work are again aligned with the previous work of (Biswas et al., 2018; Cantele and Zardini, 2018), who proposed the TOE model for technology adoption in SMEs. It is concluded that enhancing the computational reviewing reduces the response time in scheduling so that SMEs can leverage advanced technologies through AI-ML-DL.

#### 5.3.2. Discussion of hypothesis 2

Likewise, a series of positive associations of organization manifests on CES ( $t=1.717$ ,  $p=0.041$ ) because a firm cannot successfully adopt sustainability due to economic or social factors. According to (Gutierrez et al., 2015; Tornatzky and Fleischner, 1990), an organization's readiness to embrace the new technology is vital to achieving long-term goals. Further, executive management & stakeholders' assistance and optimum resource allocation have become the need of an hour in the present chaotic scenario. The ability to detect the problem and proactive management approach may also help the firm grow sustainably, and this finding is consistent (Yang et al., 2015). Suppose stakeholders, managers, and policymakers have vigilant, aware, and proactive. In that case, they can motivate and counsel the employees to overcome human-centred problems and bring radical changes in industrial sustainability (Lin et al., 2017).

#### 5.3.3. Discussion of hypothesis 3

It is observed that economic factors positively stimulate CES ( $t=5.546$ ,  $p=0.021$ ) with  $F^2$  as 0.08. Hence, the null hypothesis is rejected,

and the consequences were consistent with the previous studies (Sethi et al., 2020; G. K. Singh and Dadhich, 2021; Tjahjadi et al., 2021) a profound effect of economic factors on the sustainability of the industry. This result is consistent with those of (Dadhich, 2016), who studied and confirmed that the firm could leverage monetary factors for achieving CES. Such association was also evident in Chinese SMEs (Wen et al., 2020; Bag et al., 2021). also established the economic factors as a benchmark in the TOE model, which became the base for SD. The study contributes to the literature by rendering empirical evidence of the market's enhanced share, revenues from new product sales, return on investment, and profitability augments CES in the long term.

#### 5.3.4. Discussion of hypothesis 4

The value created by social factors is positively related to the long term sustainability of SMEs ( $t=4.101$ ,  $p=0.005$ ), and the findings resonate with (Akanksha Jain, 2014; Biswas et al., 2018), who found that socio responses toward society have a profound effect on the performance of the firms. According to (Leong et al., 2020) welfare of the society and enhancing the living quality of the surrounding community boost the goodwill of the companies, which is further conducive to achieving sustainable profit. From the employee point of a lower employee turnover rate, the health and safety environment also benefit the firm's sustainability. The findings also corroborated previous work viz. (Kowalska, 2020; Oesterreich & Teuteberg, 2019), which proposed the TOE model and urged that the firm with cordial affairs with the public and stakeholders would lead to sustainability.

#### 5.3.5. Discussion of hypothesis 5

Ultimately, the researcher observed that CES positively influences the firm performance of the selected units ( $t=13.167$ ,  $p=0.010$ ) and is represented as a mediator. Mediation of critical factors on the relationship between TOES and operational performance uses the technique initiated by (Kenny and Baron, 1986). These findings are again unswerving with previous studies viz. (Ferro et al., 2018; H. Gupta et al., 2021), who endorsed the mediating effect of corporate sustainability on the operating profit of SMEs in advanced countries, i.e. higher the sustainability, the higher would be profit for the organization. Further, the firm's sustainability can also assist in achieving several other milestones that encompass compliance with the government, going green, tax holidays, and subsidies (Dadhich et al., 2021a; Kumar Birda and Dadhich, 2019). It is vital to discuss that CES diminishes waste output, provides customized, innovative, and eco-friendly products to customers enhance responsiveness, etc.

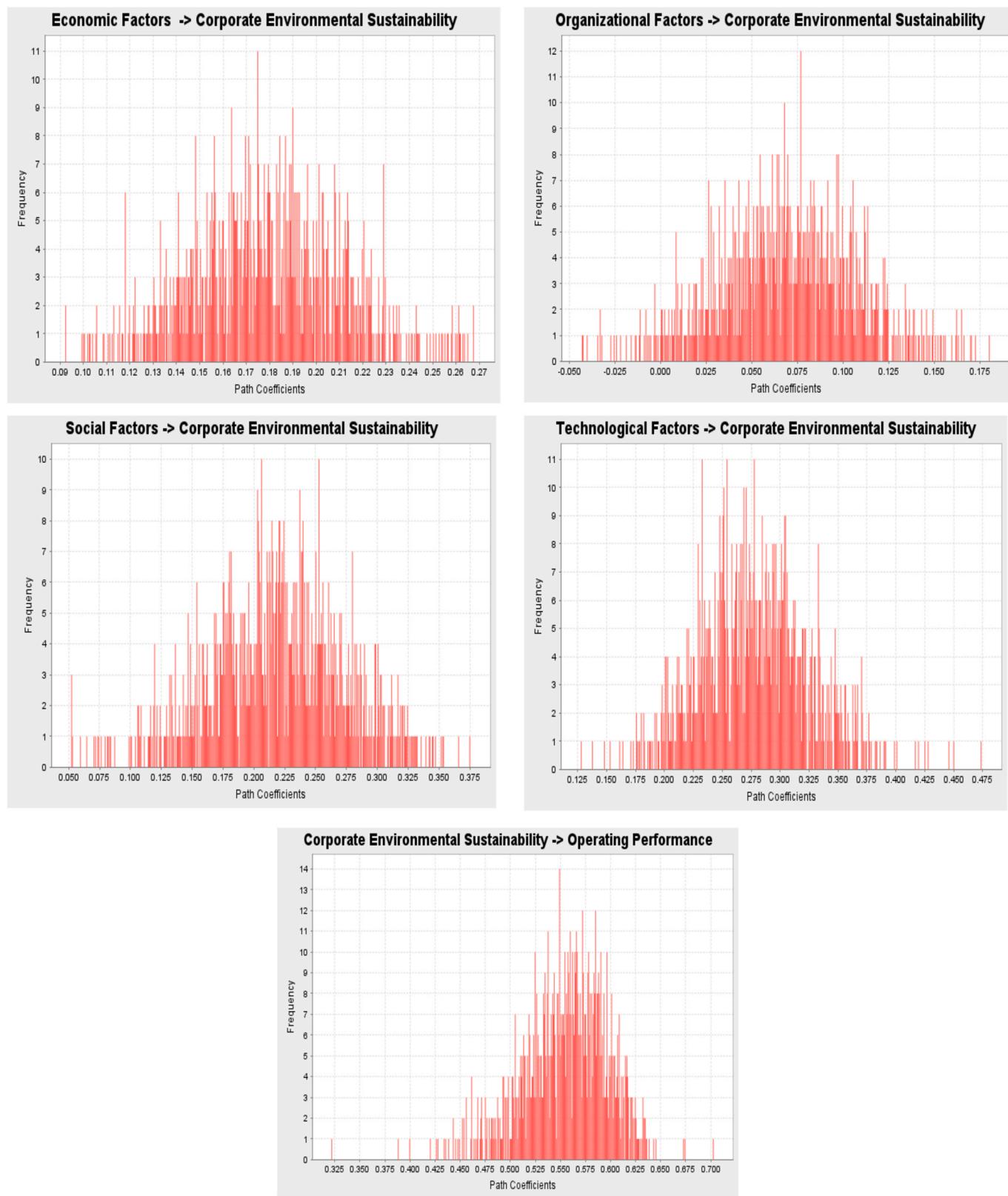
### 5.4. Analysis of ANN

This paper adopts a multi-analytical strategy by integrating PLS with ANN. PLS and Multiple Regression Analysis are linear statistical approaches that can only uncover linear associations and make complex decision-making processes easier (Khayer et al., 2020). An ANN model that can recognize non-linear correlations is proposed to overcome the linear constraints. This frame uses because the neural network model can learn multifaceted linear and non-linear correlations between predictors and adoption choices (Langevin et al., 2020). In addition, ANNs are more robust and proficient in higher prediction accuracy than linear

**Table 7**  
Testing of hypotheses.

SN	Structural Path	Original Sample	Sample Mean	95% Conf. Interval (LB, UB)	T Stat.	Sig.	F <sup>2</sup>
H1	Technological Constructs → CES	0.277	0.279	(0.192, 0.372)	5.812	0.040*	0.181
H2	Organizational Constructs → CES	0.068	0.070	(0.004, 0.143)	1.717	0.041*	0.124
H3	Economic Constructs → CES	0.178	0.180	(0.119, 0.245)	5.546	0.021*	0.080
H4	Social Constructs → CES	0.219	0.220	(0.108, 0.324)	4.101	0.005*	0.241
H5	CES → Operating Performance	0.556	0.557	(0.462, 0.626)	13.167	0.020*	0.256

Note: \* $p < 0.05$ , LB-lower boundary, UB-upper boundary.



**Fig. 6.** Features of path coefficient of constructs.

models, and they may thump conventional statistical techniques such as MRA. Due to their black-box character, neural networks are inappropriate for hypothesis testing and assessing causal linkages (Leong et al., 2020).

As a result, a two-stage method is used in this work to identify the

most significant predictors of CES and firm performance. SEM is utilized in the first step to evaluate the hypotheses and identify significant hypothesized predictors, which are then fed into the neural network model in the second stage to determine the relative relevance of each predictor manifest (Sansana et al., 2021). ANN learns new information and stores

it in synaptic weights, which are interneuron connection strengths similar to those found in the human brain. A concept for defining the number of hidden neurons in one hidden layer and one output is proposed based on the research for this study and earlier work on technology adoption. Each neuron calculates the weighted total of the input signals, which is then translated by the activation function into the generally limited output signal. Although there are many different activation functions, only a few are helpful (Yoon et al., 2020). Step and sign activation functions are the most basic (hard-limit functions). However, they are used in arrangement and pattern appreciation tasks, so they are unsuitable for this study. The sigmoid function is widely used in feed-forward networks as an activation function. However, identity and hyperbolic tangent were also evaluated and compared in this study for simulation (Khayer et al., 2020; N. Kumar and Dadhich, 2014). The activation function equations are as follows:

$$\text{Distinctiveness (Linear)}(x) = x$$

$$\text{Hyperbolic Tangent } \tanh(x) f_x = \frac{2}{1 + e^{-2x}} - 1$$

$$\text{Sigmoid factor } f_x = \frac{2}{1 + e^{-x}}$$

The researcher utilizes a feed-forward back-propagation multilayer perceptron (Kalini, 2017), one of the most common and well-known neural networks. A typical neural network has numerous hierarchical levels, including one input, one or more hidden layers, and one output layer. The difficulty in this process is examining the number of concealed layers. One hidden layer can represent any continuous function. On the other hand, discontinuous functions need the expression of two hidden layers. Only one hidden layer is typically employed in technology acceptance neural network models. Each layer comprises neurons that communicate with neurons in the next layer, and a variable synaptic weight represents each link (Omar et al., 2015).

Signals are sent onward through the network from the input layer to the output in feed-forward networks. MLP is a supervised ANN learning that denotes the knowledge stored in the network by repeatedly exposing it to known input and output patterns. The difference between expected and actual output is computed and supplied back oppositely to adjust synaptic weights and reduce estimate error in ANN. Despite its significance, there is no general rule for determining the optimal number of buried neurons. It is worth noting that all these rules of thumb must be checked before using them in the final application in some circumstances. The network with the fewest hidden neurons that perform best on the testing set should be chosen in most cases. The number of hidden neurons selected could be influenced by various parameters, including the number of hidden layers, sample size, neural network design, activation function complexity, training technique, and so on (G. Gupta and Nagpal, 2020; Raut et al., 2018).

### 5.5. Results of neural network modeling

The neural network approach was evaluated using Python and SPSS. The statistically significant features from the SEM analysis were incorporated into the model. Based on the structural equation's findings, four hypotheses have been highlighted as critical for further exploration. A cross-validation technique was used to solve the model's over-fitting problem (Yoon et al., 2020). All inputs and outputs were standardized to improve training efficacy and provide shorter training times and improved performance [0,1].

The code used for in-built ANN algorithm in SPSS:

Input: # Data Preprocessing of the indicators viz. Technological Factors: TCF, Organizational Factors: ORF, Economic Factors: ECF, Social Factors: SCF.

- Import the Libraries
- Load the Dataset

- Split Dataset into X and Y
- Encode Categorical Data
- Split the X and Y Dataset into the Training set and Test set
- Build ANN Model
- Initialize the ANN
- Add the input layer and the first hidden layer
- Train and compile the ANN
- Fit the ANN to the Training setting

Output: # Predict the Test Set of Corporate Environmental Sustainability (CES)

Pre-processed dataset from SEM was again used as an input variable for ANN and transformed into a numerical representation for analyzing the mediating role of CES to achieve operating performance (see appendix B).

Ten-fold cross-validation was performed to avoid overfitting, with 90% of the data used for network training and 10% for testing or determining the trained network's prediction accuracy (Dadhich, 2016; Foo et al., 2018). The RMSE of training, testing data, mean and standard deviation are processed to determine the model's prediction accuracy (see Fig. 8). The ANN model comprises four constructs as input neurons in variables, followed by one output- CES (see Fig. 7). Table 8 portrays the mean RMSE values for the training and the testing model as 1.128 and 1.08, respectively. In contrast, the  $\sigma$  of training data is 0.03 and 0.12 for testing data indicating a precise prediction (Tella et al., 2020).

The importance of each independent manifest reveals how much the predicted value of the network model differs from the changing values of the independent variable (Dadhich et al., 2021d). The normalized and sensitivity assessments for each predictor are outlined in appendix-B. The normalized importance is the ratio of each predictor's relevance to the maximum value. The findings of the ANN demonstrate the importance of each input variable in determining the value anticipated by the neural network with various valves of independent components. It is evident from the appendix-B that TCF\_1 (65%), TF\_2 (77%), TF\_3 (88%), and TF\_4 (100%) are the highest explanatory items in CES. Organizational construct is explained by ORF\_1 (70%), ORF\_2 (72%), ORF\_3 (85%) ORF\_4 (61%) that influence firm sustainability. Similarly, Economic factors consist of ECF\_1 (69%) and ECF\_4 (81%) that were vital enough to adopt CES practices. Eventually, SCF\_1 (65%), SCF\_2 (61%), SCF (73%), and SCF (85%) items scored highest to act as significant predictors of corporate sustainability in SMEs of India.

### 6. Managerial Implications

The study is the first to empirically validate and evaluate the model fit of constructs introduced in prior studies. This study proposed a multimodal framework by extending TOE and TBL theorem. The extension was carried out due to a comprehensive model (A. K. Gupta and Gupta, 2020; S. Kumar and Singh, 2021) to include the economic and social factors for putting up the study at an advanced level. Secondly, with the inclusion of ROI, profitability and revenues from the new product will undoubtedly improve further understanding of their effect on CES. In the same vein (Mendoza-Fong et al., 2019), emphasized the incorporation of employee health & safety, attrition rate, social welfare initiatives, and cordial affairs with the public and stakeholders also influence CES of SMEs in the long run. This theoretical nexus can be used as a pathfinder for policymakers, administrators, and managers to enhance SMEs' performance. Thirdly, the proposed model has strengthened and established an extended model in India's SME domain. Additionally, the validity of this construct in the study has been empirically reinforced statistically. Fourthly, the study enunciates the CES moderates on the rapport between selected constructs and operating performance in manufacturing SMEs of India. The significance of CES is confirmed in the paper, which augments the sustainability of SMEs from a managerial viewpoint. Fifthly, the study provides factual data that supports the inferences of numerous previous studies that

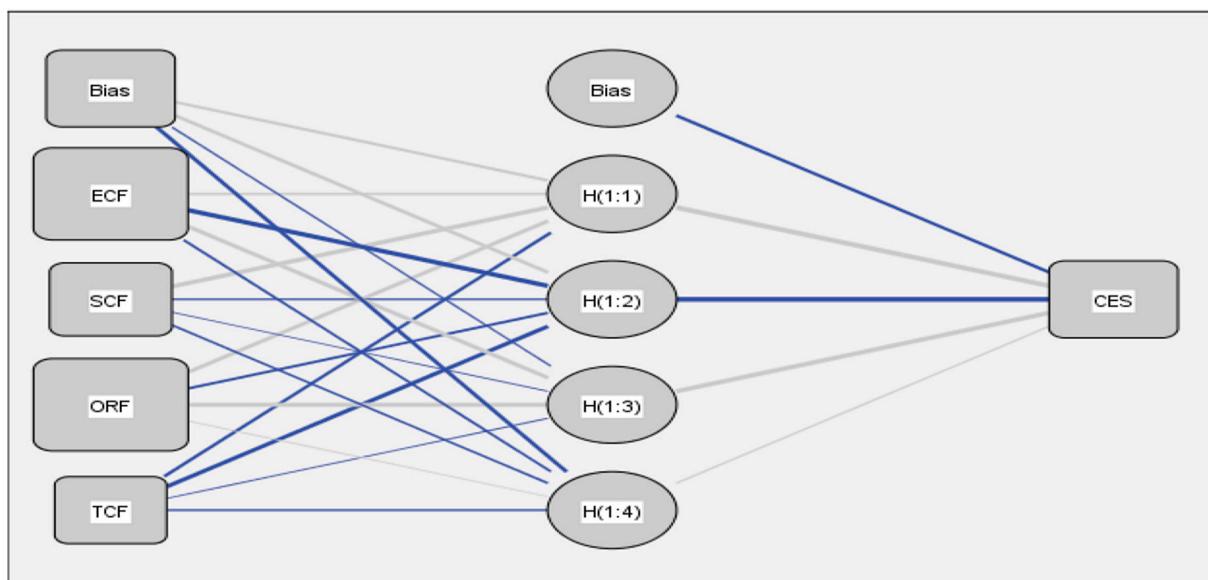


Fig. 7. Ann model for CES

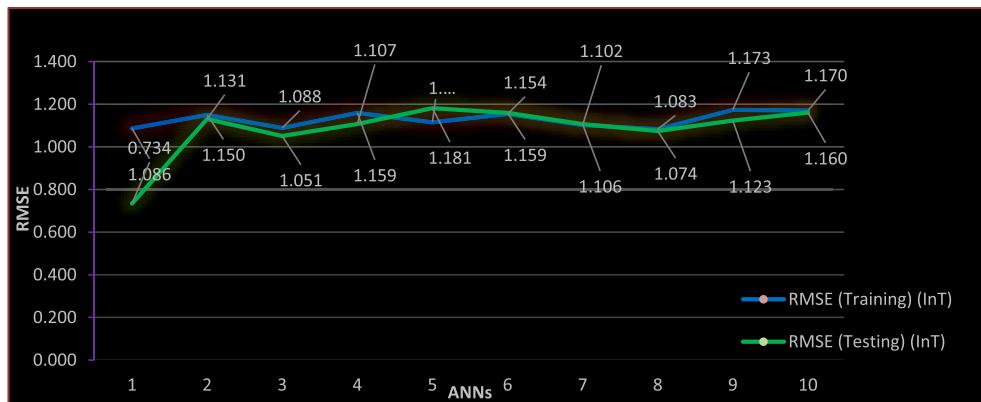


Fig. 8. Rmse statistics of training and testing.

**Table 8**  
RMSE for training and testing data.

Sample size (Tr.)	SSE	RMSE	Sample size (Ttg.)	SSE	RMSE	RMSE (Tr)- (Ttg.)
350	401.256	1.086	40	21.534	0.734	0.353
349	448.115	1.150	41	52.401	1.131	0.019
346	398.057	1.088	44	48.596	1.051	0.038
341	444.804	1.159	49	60.026	1.107	0.052
354	427.559	1.115	36	50.234	1.181	0.066
348	449.862	1.154	42	56.431	1.159	0.005
353	416.594	1.102	37	45.283	1.106	0.004
344	391.535	1.083	46	53.077	1.074	0.009
352	470.728	1.173	38	47.932	1.123	0.050
349	463.897	1.170	41	55.193	1.160	0.010
Mean	431.24	1.12	58	49.07	1.08	0.06
$\sigma$	28.37	0.03	$\sigma$	10.61	0.12	0.10

focused on the logical relationship among ECF, ORF, SCF, TCF and CES that lead to the operational performance of the firms. The paper validates the impact of technological, organizational, and socio-economic factors on the sustainability and profitability of the firms. Most of the

former research has mentioned the positive effect of CES on a firm's performance (A. K. Gupta and Gupta, 2020; Majláth et al., 2019). However, particular novel work (Gandhi et al., 2018; Muñoz-Pascual et al., 2019) was based on the qualitative analysis that excluded the socio-economic factors and emphasized the domain of techno and organizational perspectives. Sixthly, the proposed good fit model advises many benefits that may help SMEs survive, sustain, and gain a competitive edge in the current chaotic environment. The past study (Aykol and Leonidou, 2015), based on conceptual discussion, also elucidated the necessity of corporate sustainability & green initiatives for sustaining and promoting the business in the national and international market. The study is a path ahead to resolve challenging paradigms that evoke the necessity of adopting CES to ensure sustainable profit in the SME domain. Thus, the work contributes to the body of knowledge in the extent of literature on sustainability by integrating TOE-TBL frameworks. Practically, the paper has contributed to the limitation of PLS-SEM, which is a linear model, by supplementing it with the usage of non-linear and non-compensatory ANN models using MLPs and neural networks. Therefore, the study outlines the operational contribution in terms of statistical analysis from the perspective of CES, which can be the archetype of future research methodology. This study

also demands managerial attention to the necessity for more incredible research on the positioning of sustainability in the corporate sector.

## 7. Limitations and future research

The findings of this research can be used as a reference point for further investigation. Firstly, the study is delimited in the sense that it was carried out in a south Asian nation, i.e., India, and hence the results may not be generalized and applied to other countries. Secondly, the research was limited to a few factors incorporated concerning SMEs in India, so general acceptance in other nations may differ significantly. Thirdly the study's limitations allowed it to emphasize the industry-specificity of SMEs, but its conclusions could be unfavorable to other industries., fourthly because these investigations are declarative, they are prone to human error. Fifthly, the study used cross-sectional data, observing direct effects on CES and operating activity; thus, an interesting future research topic would perform a longitudinal study to identify changes in SD adoption among SMEs with specific needs. Besides, other constructs, environmental regulation, and compliances may be vital in this subject matter but were not incorporated in this study. More research in this area could aid in the development of a comprehensive understanding of the CES challenges during the previous two decades. This study can be expanded to look at the impact of different control groups, such as firm type, firm size, government regulations, economic system, etc. The study can be expanded to include other emerging economies, such as those in South Asia and South America. Further, future research can remove the insignificant constructs and methodology from this work and incorporate innovative factors into their conceptual model. Thus, future work can consider integrating moderating manifest to get inside of precise findings and propose a new theoretical model to be studied by academicians and policymakers. Moreover, research should investigate the mediation effect of culture and Total Quality Management (TQM) on performance sustainability. Similarly, more study is needed to observe the impact of additional facets such as knowledge management, HRM analytics, and convergence of numerous other theories, including the TBL and TOE theories, on CES and dimensions of firm performance. This study calls attention to the prerequisite for more compressive research on the role of sustainability in corporate success among academics, practitioners, and officials. As a result, this may serve as a novel foundation for encouraging practitioners to emphasize the environmental dimension as a measure of sustainability.

## 8. Conclusion

Theoretically, this research provides a novel empirical perspective on CES adoption in Indian SMEs by merging previously distinct strands of TBL into a TOE framework. The article's focus is on the issue of environmental sustainability in the functional domains of SMEs. According to the findings, CES has a robust & positive link with all performance areas. The results also depict that middle to upper-middle management executives in emerging economies positively influence environmental sustainability perception. A sustainable economy and corporate realize the necessity and importance of growth, using and reusing the resources by virtue of modifications in SMEs promotion. This segment can be the backbone of both domestic and global sustainability agendas. Small and medium-sized businesses must recognize the new potential and value of adopting sustainable principles and practices into

their corporate culture. However, the SD message and narrative have not reached SMEs in many cases, and these firms are usually uninformed of previous ambitious sustainability projects.

Lots of studies explored the concept of CES and operational efficiency in developed nations (D'Souza et al., 2020; Lu et al., 2020; Mendoza-Fong et al., 2019; Muñoz-Pascual et al., 2019), whereas the same notion has been studied in emerging nations (Belhadi et al., 2020; G. Gupta and Nagpal, 2020; Reficco et al., 2018; Yacob et al., 2019) but provided limited insights. Actually, the earlier studies have analyzed the individual and combined effects of TOE on CES. Still, these studies have not considered the changing paradigms of social and economic variables in the conceptual model. In this context, the present study contributes to the existing scope of literature investigating CES's mediating role between TOES and OP of SMEs in India. Further, Structural equation modelling is applied to the proposed constructs to analyze confirmatory factors based on the previous theories. The computed p-value of all four estimated hypotheses was ECF (0.021), ORF (0.041), SCF (0.005), and TCF (0.04) were momentous as  $p < 0.000$ . Further, CES has positively influenced the operating performance, viz., improved quality, trustworthiness in delivery, cost efficiency, and optimum resource utilization of the selected units ( $t = 13.167$ ,  $p=0.010$ ). These constructs are again considered inputs to the neural network version to determine the relative importance of each predictor in a second stage. The results of the ANN outline the importance of every input variable to predict how the value is expected by the neural network with the different values of independent items. The study highlights further outstanding research on sustainability for corporate sectors, academics, practitioners, and policymakers. As a result, this may serve as a novel base for encouraging practitioners to emphasize the environmental dimension as a measure of sustainability. This study adds to the body of expertise about the company's long-term survival. TBL frameworks and the TOE approach are used as part of corporate sustainability. The study elucidated the impact of CES on SME performance and emphasized the importance of long-term viability in these businesses. The paper's findings could be employed to connect regulatory and administering agencies, environmentalists, consultants, business practitioners, and academics to build a long-term institutional paradigm. Environmental practices are already being institutionalized, and the findings of this study might apply to a broad spectrum of developing economies.

## CRediT authorship contribution statement

**Manish Dadhich:** Introduction, Theoretical Background, Research hypotheses, Research method, Formal analysis, and, Interpretation, Discussion, Writing, Reviewing, and Editing. **Kamal Kant Hiran:** Managerial Implication, Limitation, Future scope, Conclusion.

## Declaration of competing interest

The authors declare that they have no tangible and intangible interest or personal relationship that could influence this paper's content.

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## Appendix: A. Manifests of questionnaire and factor loadings

Latent Constructs	Manifests and Codes	Loading
Corporate Environmental Sustainability	CES_1: Our company engages in recycling and waste management practices.	0.903
	CES_2: We are concerned about our company's water and electricity consumption levels.	0.540
	CES_3: Adhere to environmental compliance certifications.	0.587
	CES_4: Company also serves its other customers under environmental standards.	0.461
	CES_5: Company prefers to sell eco-friendly goods.	0.631
Economic Factors	ECF_1: Enhance share of the market.	0.767
	ECF_2: Revenues from new product sales.	0.723
	ECF_3: Better ROI.	0.805
	ECF_4: Profitability	0.675
Social Factors	SCF_1: Employee turnover rate.	0.838
	SCF_2: Employee health and safety have improved.	0.852
	SCF_3: Enhance the living quality of surrounding society with social welfare initiatives.	0.782
Technological Factors	TCF_4: The firm has cordial affairs with the public and stakeholders.	0.677
	TCF_1: The capability of computers to be used in reviewing to reduce the response time in scheduling.	0.980
	TCF_2: Controlling the maintenance of capital equipment during the manufacturing process.	0.605
	TCF_3: The capacity to leverage advanced technologies/automation to complete several tasks.	0.785
Organizational Factors	TCF_4: To carry out a manufacturing process using software and machines controlled by a computer.	0.613
	ORF_1: Organization's readiness to embrace the new technology.	0.889
	TCF_2: Assistance from executive management and stakeholders.	0.937
	TCF_3: Optimum resource allocation mechanism.	0.640
Operating Performance	TCF_4: Ability to detect shifts accurately and rapidly in marketplace demand.	0.760
	OP_1: Improved Quality	0.949
	OP_2: Trustworthiness in terms of delivery	0.625
	OP_3: Cost efficiency	0.983
	OP_4: Productivity & optimum resource utilization	0.978

## Appendix: B. Normalized and Sensitivity Analysis

Neural Network	TCF_1	TCF_2	TCF_3	TCF_4	ORF_1	ORF_2	ORF_3	ORF_4	ECF_1	ECF_2	ECF_3	ECF_4	SCF_1	SCF_2	SCF_3	SCF_4
NI (i)	38.8%	79.0%	64.0%	100.0%	61.5%	86.9%	69.1%	33.2%	71.1%	45.4%	56.4%	82.7%	55.0%	92.5%	49.8%	49.3%
NI (ii)	88.8%	67.4%	61.6%	77.9%	59.2%	87.1%	95.7%	35.5%	20.0%	62.5%	35.8%	91.6%	60.0%	43.1%	84.4%	100.0%
NI (iii)	69.7%	57.9%	100.0%	93.0%	43.4%	43.7%	50.0%	60.4%	57.3%	47.8%	41.7%	33.9%	70.6%	44.0%	72.8%	79.0%
NI (iv)	57.0%	62.8%	100.0%	73.2%	73.8%	32.6%	59.4%	34.7%	56.7%	37.4%	31.5%	63.3%	33.3%	92.6%	48.4%	44.2%
NI (v)	41.0%	41.3%	59.5%	100.0%	69.4%	53.8%	93.7%	45.1%	76.0%	40.6%	29.5%	48.9%	46.0%	21.5%	45.1%	68.6%
NI (vi)	37.8%	71.9%	75.3%	85.5%	43.5%	86.6%	52.4%	65.3%	46.5%	55.3%	56.6%	63.5%	70.6%	21.0%	53.2%	100.0%
NI (vii)	59.9%	73.4%	100.0%	86.2%	48.6%	59.3%	76.3%	60.0%	67.7%	47.4%	58.2%	75.2%	73.6%	56.9%	86.7%	69.0%
NI (viii)	46.3%	68.4%	100.0%	83.4%	43.5%	80.7%	81.7%	91.0%	54.5%	48.9%	55.5%	73.5%	71.2%	28.5%	86.1%	84.0%
NI (ix)	74.1%	79.9%	61.8%	68.4%	100.0%	28.5%	91.1%	55.7%	98.9%	54.1%	41.0%	75.4%	34.5%	81.3%	73.7%	95.6%
NI (x)	51.6%	68.1%	46.0%	100.0%	69.3%	70.2%	72.7%	56.1%	50.5%	59.0%	53.6%	94.3%	55.8%	55.6%	40.5%	48.9%
Average	56.5%	67.0%	76.8%	86.8%	61.2%	62.9%	74.2%	53.7%	59.9%	49.9%	46.0%	70.2%	57.1%	53.7%	64.1%	73.9%
Normalized Val.	65.1%	77.2%	88.5%	100.0%	70.6%	72.6%	85.5%	61.9%	69.1%	57.5%	53.0%	81.0%	65.8%	61.9%	73.8%	85.2%

## Appendix: C. List of Abbreviation

TBL	Triple Bottom Line
TOE	Technological, Organization and Environmental
SD	Sustainable Development
CES	Corporate Environment Sustainability
CSR	Corporate Social Responsibility
ES	Environment Sustainability
ED	Economic Development
SCM	Supply Chain Management
PLS	Partial Least Square
SEM	Structural Equation Model
ANN	Artificial Neural Network
DV	Discriminant Validity
CR	Construct Reliability
AVE	Average Variance Extracted
MSV	Mean Square Variance
OP	Operating Performance
VIF	Variance Inflation Factors
SME	Small & Medium Enterprises
RMSE	Root-mean-square Error
OP	Operating Performance

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