

## Article

# Environmental Management Practices: The Mediating Role of Lean Management and the Moderating Role of Environmental Transformational Leadership in Organizational Performance

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## Abstract

Environmental practices are now a strategic necessity as firms face accelerating regulatory, market, and societal pressures to operate sustainably. Yet evidence remains mixed on whether and how these practices translate into superior organizational performance in manufacturing. This study examines how environmental management practices improve organizational performance in the manufacturing sector and clarifies two unresolved issues in prior research: the relationship between environmental management practices (EMPs) and organizational performance (ORP). It further investigates the mediating role of lean management (LM) and the moderating role of environmental transformational leadership (ETL). This study used a quantitative method and cross-sectional data. A self-report questionnaire was used with 260 participating employees from all levels in the manufacturing sector in the Kingdom of Saudi Arabia (KSA). Structural equation modeling (SME) was employed to test the hypothesis. The results of this study showed that environmental management practices have significant and positive effects on organizational performance. In addition, this study revealed that lean management exhibited a significant positive impact on organizational performance and was a crucial element in the developed model. Nevertheless, environmental transformational leadership was not significant and did not support the relationship between environmental management practices and organizational performance. Theoretically, these findings advance the literature by (a) specifying lean management as a central mechanism that connects environmental practices to performance and (b) delineating boundary conditions by showing that environmental transformational leadership may not amplify these effects in this context. Practically, the results suggest that managers seeking performance gains from environmental initiatives should prioritize the systematic integration of lean management routines—such as waste reduction, process standardization, and continuous improvement—alongside environmental programs. Organizations should also evaluate leadership development efforts critically, because general transformational behaviors oriented toward environmental stewardship may be insufficient on their own to enhance the impact of environmental practices on performance.

**Keywords:** environmental management practices; lean management; environmental transformational leadership; organizational performance

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## 1. Introduction

Since the launch of Saudi Vision 2030, the Kingdom of Saudi Arabia has implemented a series of economic and institutional reforms aimed at diversifying the economy, reducing dependence on oil revenues, and strengthening private sector participation [1]. Saudi Arabia is dedicated to complying with the Paris Agreement by becoming environmentally friendly [2]. Following the launch of the 2030 vision, the country introduced the Saudi Green Initiative (SGI) in 2021, which aims to help the country combat climate change, enhance quality of life, and safeguard the planet for future generations.

Organizations around the world face pressure from governments and stakeholders to implement and integrate environmental management practices [3,4]. According to [5], it is crucial for a firm to invest in EMPs to enhance its competitive capability and environmental performance. EMPs refer to the set of strategies and techniques used by firms to control and manage the effects of their operations on the natural environment [6]. Examples include increasing staff awareness, cleaner production, green design, green marketing, investment in environmental protection, and establishing green management goals and environmental management systems such as ISO 14000 and recycling management [7]. According to [8,9], the excellent adoption of EMPs could lead to better organizational performance (ORP) and a better reputation. ORP is a set of financial and non-financial measures, such as operation, marketing, and environmental and supply chains [8,10,11], which provide critical information and results regarding the achieved objectives [12]. Operational and environmental performance measures are currently recognized as critical indicators for evaluating the overall success of the organization [8,12]. The link between a company's reputation and OP, either the financial or the non-financial measures, has been a significant area of research by scholars such as [13,14], who have been exploring how reputation affects OP and vice versa. Unlike the current research, these studies have theoretically evaluated reputation outcomes without empirical evidence. According to [15], a company's reputation is how the key stakeholders see its past actions and future potential that affect its overall appeal compared to competitors. Thus, companies should understand the expectations and the needs of their stakeholders to build a compelling reputation [16]. Although previous studies generally report positive associations between environmental initiatives and organizational outcomes, the magnitude and consistency of these relationships vary across industries, organizational contexts, and performance dimensions, suggesting that the underlying mechanisms remain insufficiently understood [17,18].

The resource-based view (RBV) is theorized in the current research as the pathway explaining the relationship between the EMPs and OP. The RBV explains how valuable resources such as EMPs can create a competitive advantage. EMPs such as waste reduction, green marketing, and cleaner production can be viewed as essential resources for enhancing operational efficiency, reducing costs, and ultimately realizing better OP [19]. Previous studies have used different theories such as stakeholders, legitimacy, and resource dependence [20]. A big issue with applying such theories in identifying environmental issues is that they cannot identify the importance of natural resources within a firm [21]. Thus, the RBV focuses on achieving performance through internal capabilities [22,23]. For the manufacturing industry, a lean management system represents the organization's capability that allows the firm to capture the value potential of its green resources.

The resource-based view (RBV) posits that a firm's ability to achieve a sustained competitive advantage depends on resources that are valuable, rare, inimitable, and organized (VRIO) [19]. In the context of the Saudi manufacturing sector, EMPs serve as a strategic resource that extends beyond mere regulatory compliance. EMPs generate strategic value by optimizing resource expenditures through waste minimization. In addition, the shift to deep environmental practices like cleaner production is still young in many emerging

markets. This scarcity provides a strategic weapon with which for early movers to differentiate themselves and move ahead of competitors. Therefore, the RBV has shaped the hypothesis and provided a robust theoretical foundation for this research.

Organizations today can achieve greater efficiency and greater customer satisfaction by adopting lean management [24]. LM, with its focus on waste minimization and process improvement, somewhat aligns with the goals of EMPs [25]. LM is an integrated model, a complicated management system that extends across the entire organization and requires the involvement and commitment of all employees at every level to continuously improve the company's performance [26]. The main purpose behind using LM is to produce products and provide services without any kind of waste from overproduction, waiting, or low quality [27]. LM is an environmentally focused practice including total quality management (TQM), just-in-time (JIT), total preventive maintenance (TPM), and human resource management [27,28]. LM serves as a catalyst to help the adoption of environmental enhancement [29]. A few previous studies have used lean management (LM) as a mediator, such as [29,30]. Despite the conceptual compatibility between environmental management and lean management, empirical evidence examining lean management as the mediating mechanism through which environmental management practices improve organizational performance remains limited [31,32].

Another important aspect of this study is transformational leadership. Transformational leaders are widely recognized to be more efficient in improving environmental management, making the concept of environmental transformational leadership (ETL) increasingly important [33]. During the past decade, ETL has become the most studied area of all leadership theories since its introduction in 2013 by [34]. ETL is a behavior exhibited by a leader who can motivate subordinates to accomplish environmental goals and inspire them to go beyond the expected levels of environmental performance [35]. In the context of social learning theory [36], green leaders can play an important role in motivating and inspiring subordinates to participate in environmental actions [37]. Although environmental transformational leadership has received growing scholarly attention, empirical evidence concerning its role as a boundary condition remains fragmented and inconclusive, particularly in manufacturing settings and emerging economies [34,38,39].

In light of the limitation observed in the existing literature, this study aimed to expand the current knowledge and contribute to the existing literature in several ways: First, there is a scarcity of research investigating the impact of several factors of EMPs using wide-ranging methodologies across various industrial fields [40]. Additionally, most existing studies have been conducted in developed economies [41]; this study will re-examine and redefine the relationship between EMPs and OP in a developing country such as Saudi Arabia. In addition, previous studies ignore reputation as a sub-variable in the OP; this study proposes that reputation is an important construct in the OP. Second, this research examines the role of LM as an important bridge in this relationship. Additionally, to the best of our knowledge, there is no existing study constructing the ETL as a moderator in this relationship; this research examines the moderating role of ETL as an important factor in this relationship. Recent reviews continue to highlight the need for integrated models that simultaneously examine environmental management practices within developing country contexts, where empirical evidence remains comparatively scarce [42].

The current study aims to examine the relationship between environmental management practices (EMPs) and organizational performance (OP) by investigating the mediating role of lean management (LM) and the moderating role of environmental transformational leadership (ETL). The study contributes to the existing literature by providing empirical evidence on the mechanisms through which environmental management practices influence organizational performance. Moreover, it extends prior research by integrating environmental management, lean management, and environmental leadership within a

unified framework in the context of Saudi Arabia's manufacturing sector, thereby offering theoretical and managerial implications for organizations pursuing sustainable performance. The main research questions are as follows: Q1—What is the impact of environmental management practices on organizational performance? Q2—How does lean management mediate the relationship between environment management practice and organizational performance and reputation? Q3—How does environmental transformational leadership moderate the relationship between environmental management practices and organizational performance and reputation? To provide a clear structure, this paper is organized as follows: Section 2 contains a literature review, Section 3 contains the theoretical framework and hypothesis development, Section 4 presents the study's methodology, Section 5 presents the study's analysis and results, and Section 6 presents a discussion of the results and their implications.

## 2. Literature Review

### 2.1. Environmental Management Practices (EMPs)

Environmental management practices (EMPs) are systematic methods that firms utilize to lessen their environmental impact and function more sustainably; they vary by organization size, industry, and environmental impact and include pollution prevention, energy efficiency, waste reduction, green product design, and environmental compliance [43]. EMPs are used by small and medium-sized businesses to improve their environmental performance; each organization defines and applies EMPs differently, but the essential principles are the same: decrease environmental harm, constantly enhance sustainability performance, and align operations with environmental objectives [44]. EMPs are becoming more essential in business owing to regulations, customer awareness, and global environmental aspirations. Offering EMPs can decrease environmental impact, increase efficiency, and provide long-term value. In addition, EMPs help companies avoid penalties, comply with environmental rules, and maintain reputation. EMPs also play a role in minimizing pollution, resource consumption, and ecological harm in hazardous industries such as manufacturing, chemicals, and oil and gas [45]. Companies that implement EMPs can attract environmentally conscious customers, investors, and partners, and they may also save money and boost performance by promoting sustainable product and process designs [46].

Cost reduction is a major benefit arising from waste reduction, energy efficiency, resource efficiency, and lower operational expenses. Proactive environmental management decreases legal, reputational, and disruption risks [47]. According to the same author, EMPs increase a company's reputation with sustainable consumers, investors, and stakeholders by compelling corporations to change their ways, and they promote eco-friendly products and procedures. In addition, EMPs can help companies obtain environmental certifications, subsidies, and collaborations and enter new markets, especially in green or environmentally sensitive sectors. Despite their usefulness, EMPs have challenges. EMP adoption and integration may require significant investment. Leadership time, money, and commitment are needed to integrate new technologies, reform procedures, and train staff [41]. If changes disrupt workflows or disengage staff, organizational resistance may arise, leading companies to greenwash by adopting EMPs cosmetically to gain public favor without change [48]. To realize EMPs' benefits, firms must plan intelligently, spend resources, and implement them truly and consistently [49].

EMPs include a set of green management goals; educating personnel; and investing in clean production, green design, green marketing, recycling, and ISO 14001 [50] certification. These sub-variables signify the importance of environmental commitments. Green goals promote sustainability and regulation because companies can prioritize environmental initiatives and track progress with stated and monitored targets [51]. Awareness

helps workers realize their environmental responsibilities, and through staff training, engagement, and seminars, companies can boost sustainability, demonstrate long-term commitment by sponsoring clean technology and eco-infrastructure, and implement green design and cleaner production to reduce waste and pollution [52]. Green marketing communicates environmental values through branding, product features, and corporate messaging, where it also improves the company's image and attracts green customers [53]. Recycling and scrap management reuse and redistribute materials, supporting circular economy ideals. Finally, ISO 14001 certification formalizes a company's environmental plan and promotes competitiveness. These strategies provide a full and realistic framework for assessing modern company EMP implementation [41]. These practices are now synthesized into three categories: Strategic Alignment (green management goals and marketing), Operational Integration (design, production, and recycling), and Institutional Culture/Compliance (awareness, investment, and ISO certification).

#### 2.1.1. Strategic Alignment

Green management goals guide an organization's environmental agenda by setting long-term, quantifiable, and achievable environmental goals for an organization. Sustainable resource use, energy efficiency, waste reduction, and emissions reduction are common aims. Such goals promote environmental stewardship and demonstrate a company's commitment to sustainability [54]. These aims can help environmental organizations prioritize resources and labor and organize departmental and staff environmental activities. Green goals with indicators improve environmental performance [55].

Green marketing emphasizes sustainability and environmental benefits. Beyond typical marketing, it emphasizes the company's commitment to recycling, reducing emissions, and supporting environmental causes. Green marketing targets eco-conscious consumers and builds trust with sustainable stakeholders. When conducted successfully, it promotes brand image, client loyalty, and competition. Packaging, commercials, sustainability reports, websites, and labeling can communicate green marketing [47]. Companies must combine marketing, eco-design, greener production, and ISO certification. Environmental regulations that demand labeling or validated claims are met via green marketing [45]. A good green marketing plan can influence purchasing decisions, attract new investors, and enhance staff morale in many organizations, especially those with a large environmental impact [53].

#### 2.1.2. Operational Integration

Green design, sometimes called eco-design or sustainable product design, considers environmental considerations in product and process development. It reduces the environmental impact from raw material extraction to product use and disposal. Green design uses non-toxic, recyclable, or biodegradable materials; maximizes energy efficiency; reduces packaging; and is durable or easy to disassemble. It decreases a product's ecological footprint and helps sustainability by conserving resources and minimizing pollution. Green design companies frequently develop client loyalty as global demand for sustainable products rises [56]. The strategy improves brand image and expands green markets. Energy and material waste are reduced by green design, saving money. Design teams, engineers, and sustainability specialists must work together to balance environmental aims with product functionality and market needs, stimulating creativity and cross-functional collaboration [41].

Environmental management promotes cleaner production by optimizing processes, products, and services through efficient raw material and energy use, improved equipment performance, and operational redesign to minimize waste, reduce pollution, and enhance overall sustainability in manufacturing [57]. The main benefits of cleaner

production are environmental performance and operational and financial efficiency. Minimizing waste and resource use reduces material costs, disposal fees, and productivity. Companies can avoid environmental penalties and sanctions through cleaner production. Cleaner production is needed in high-risk industries such as petrochemicals. Increasing worker safety and reducing environmental impact can help companies preserve their licenses [56].

EMPs include recycling, scrap management, and manufacturing and post-consumption waste disposal. Effective recycling reduces raw material use by recovering useful components from rejected products or production trash [58]. Making these resources part of the production cycle boosts efficiency and circular economy models [59,60]. Structured recycling reduces raw material and waste disposal expenses; clutter reduction, workflow improvement, and environmental compliance improve operational efficiency. Many companies improve scrap management using waste segmentation, recycling audits, and supplier partnerships. Recycling reduces industrial waste and petrochemical environmental impact [51]. Recycling projects have high initial costs but long-term environmental and economic benefits. Sustainable operations require recycling and scrap management, which shows environmental responsibility [61].

### 2.1.3. Institutional Culture/Compliance

Environmental awareness among staff is crucial to EMP success. The firm's sustainability efforts benefit from workers' everyday environmental education and engagement. Environmental awareness includes understanding the company's sustainability goals, how jobs affect the environment, and how to mitigate damage [62]. Awareness training is essential. Examples include structured training, onboarding, posters, newsletters, internal promotions, and sustainability competitions. Such activities raise firm environmental awareness, leading to more constant and proactive behavior [63].

Sustainable business practices require long-term ecological responsibility and financial investments—such as clean technologies, energy-efficient machinery, pollution control, and renewable energy—which, despite high initial costs, deliver significant long-term financial and strategic benefits while protecting the environment [21]. Environmental investments enhance corporate reputation and stakeholder confidence by funding not only physical assets such as clean technologies but also environmental audits, R&D, and employee training; when strategically planned, implemented, and monitored within an environmental management system, these investments help organizations achieve sustainability goals while strengthening long-term resilience and competitiveness [4].

ISO 14001, the most popular environmental management system (EMS) standard, helps companies manage environmental issues successfully. ISO 14001 certification shows that a company has decreased its environmental impact, obeyed laws, and enhanced performance. The guideline encourages companies to assess their environmental impact, set goals, and apply controls to decrease pollution, save resources, and engage stakeholders [64]. Certification is a technical and cultural shift that requires commitment from top management, staff training, internal audits, and environmental activity documentation. ISO 14001 helps high-risk industries including manufacturing, construction, and petrochemicals. Because customers, regulators, and investors value sustainability, firm legitimacy rises upon certification [4]. Certification opens new markets, strengthens relationships with environmental organizations, and qualifies companies for green supply chains and government contracts. ISO 14001 increases resource management, workforce engagement, and environmental liability control, reducing costs and risk [56].

#### 2.1.4. Organization Performance (ORP)

Organization performance includes financial, operational, environmental, and reputational factors, including sustainability. Operations and environmental performance are gradually integrated in the environmental management literature to reduce greenhouse gas emissions, solid waste, energy use, and resource utilization. Corporate performance today depends on reputation, an intangible and subjective measure. This indicates stakeholders' views on a company's ethics, credibility, and sustainability [65]. This holistic view emphasizes that firms currently operate in a complex and highly scrutinized global context where cost-efficiency or profit maximization alone cannot guarantee long-term success [57]. Competitiveness, productivity, sustainability, and stakeholder expectations depend on operational performance. Today's globalized and environmentally conscious company context requires operational, environmental, and public perception excellence. Therefore, operational success today incorporates environmental efficiency, process excellence, and reputational value [57]. Operational performance drives organizational sustainability. Effective resource use, timely production, low defect rates, and cost control help enterprises survive and thrive in competitive marketplaces. Environmental performance assessment helps companies achieve legal requirements, acquire sustainability-linked funding, and become ISO 14001-certified [52]. In addition, adding firm reputation in the performance framework addresses the growing value of intangible assets. A good reputation increases brand value, talent, investor confidence, and customer loyalty. In a world where stakeholders expect openness and responsibility, companies with a well-managed public image—particularly in environmental, ethical, and governance practices—perform better financially and operationally [65].

Practitioners and scholars analyzing organizational efficiency must grasp multidimensional OP pros and cons. Effective OP methods can lead to success and sustainability, but they can also cause issues, especially when they include non-traditional measures such as environmental and reputational performance [66]. Cost reduction is a major benefit of operational excellence; companies can save money by optimizing production, inventory, energy, and waste. Successful product quality, delivery, and service operations boost customer satisfaction, and high operational standards promote customer trust and loyalty in oil and gas, where delays and quality issues are costly. As organizations seek trusted and sustainable providers, strong performance metrics drive collaborations, contracts, and supply chain collaboration [59]. Conversely, benefits include incorporating environmental performance into operational KPIs. Reduced emissions, hazardous waste, and energy and water use demonstrate corporate accountability and environmental compliance [67]. Strategic performance metrics include reputation: a company's reputation impacts investor confidence, consumer loyalty, and employee morale. In crises and competitive upheavals, non-financial assets such as reputation can be leveraged. Companies with strong reputational capital are less influenced by public and regulatory scrutiny in volatile markets [65].

To comprehensively evaluate ORP in the context, it is essential to deconstruct it into key sub-variables. This study adopts a multidimensional approach to ORP by focusing on three interrelated sub-variables: environmental performance, operational performance, and firm reputation performance. Each sub-variable captures distinct, yet complementary, dimensions of organizational success and resilience. Together, they reflect the organization's ability to manage internal efficiency, external perception, and environmental impact in a rapidly evolving global landscape.

Environmental performance is an organization's ability to manage and reduce its activities', goods', and services' environmental impact. Energy and water conservation, emissions reduction, solid and hazardous waste reduction, and air and water pollution avoidance are included. Excellent environmental performance demonstrates rule-

following and proactive sustainable development [52]. Environmental performance is becoming a business goal in corporate sustainability. Environmental stewardship impacts long-term profits, risk reduction, and brand reputation. A company's environmental responsibility is measured by carbon footprint, water usage per unit of output, energy intensity, and recycling rates [68]. Strong environmental performance benefits strategy. Energy-efficient technologies, raw material reduction, and renewable energy consumption save organizations money over time. Tax incentives, subsidies, and green finance are more likely for environmental leaders. Vision 2030 in Saudi Arabia promotes clean energy and sustainable industry, making it an excellent policy for green businesses [69].

Operations performance assesses an organization's efficiency, quality, and responsiveness in basic activities. A company's use of labor, technology, time, and money to suit consumer wants and organizational goals is evaluated. Standard operational performance metrics include cost reduction, productivity, cycle time, inventory management, product quality, and delivery reliability [70]. It also involves the firm's ability to innovate, adapt, and support current sustainability efforts [71]. High operational performance boosts competitiveness. Better operational results reduce waste, errors, and delivery times, saving costs and enhancing customer satisfaction. Lean and automated production methods boost throughput and eliminate errors, enhancing profitability and reliability. Petrochemicals and oil and gas are fast-paced, complex sectors that require supply chain precision and risk minimization [72].

Customers, investors, employees, regulators, and the public judge a company by its reputation, an intangible but powerful asset. Reputation drives operational performance, trust, loyalty, market placement, and longevity. A time-based evaluation of a firm's behavior, ethics, and social and environmental responsibility is informative [4]. In today's ethically and ecologically sensitive business world, reputation is crucial. Corporate responsibility, ethics, and transparency typically lead to brand loyalty, premium pricing, improved capital access, and top talent retention [73]. According to stakeholder theory, corporations that actively meet stakeholder expectations improve engagement, advocacy, and support, increasing value [56]. Environmentalism substantially impacts corporate reputation. Customers and investors favor companies that publicly promote sustainability, reduce their ecological footprint, and contribute to climate goals. Company reputations can be damaged by environmental violations, pollution scandals, and unethical behavior, which can result in consumer boycotts, divestments, or government penalties. This study quantifies business reputation using valid criteria, including stakeholder perceptions of the company's environmental commitment, ethics, reporting openness, and community engagement. Based on prior research [74,75], these metrics provide a valid framework for measuring reputation as a sustainability–performance nexus result and performance driver [76].

## 2.2. *Lean Management (LM)*

Lean management is a systematic approach to customer value and waste reduction across all corporate processes. The Toyota Production System (TPS)-based lean management is widely utilized to boost efficiency, save costs, and increase organizational agility. Lean management eliminates “waste” including overproduction, waiting time, transportation inefficiencies, excess inventory, defects, and unused talent [45]. It maximizes client value with fewer resources. Kaizen, standardization, staff involvement, and customer focus do this. Lean organizations improve workflow, transparency, and responses to demand and operational issues. Lean management encourages organizational learning and problem-solving, not just technology installation [77]. Modern lean management has many interconnected “bundles”, such as TQM, JIT, and TPM. All improve process

efficiency, product quality, and equipment reliability. This study assesses lean management utilizing these validated sub-variables from manufacturing [47].

Lean management improves operations and growth in fast-changing firms. Its ability to minimize waste, increase efficiency, and foster innovation makes it vital. In a world of shifting customer expectations and severe competition, lean organizations can quickly adapt, decrease costs, and improve performance [78]. A key benefit of lean management is cost reduction. Eliminating non-value-added tasks streamlines and cuts expenses in lean approaches. Resource optimization cuts production costs, boosts earnings, and boosts competitiveness. Despite high overhead and waste costs, lean approaches help heavy industries such as petrochemicals and manufacturing to stay competitive by making every process step efficient and customer-focused [73]. Besides cost reduction, lean management improves quality and reliability. Processes and continuous improvement reduce product and service failures [79].

LM is promoted internationally for its ability to promote efficiency, waste reduction, and progress. Lean management helps automotive, manufacturing, healthcare, and service companies innovate and enhance efficiency. Lean management has strategic and operational benefits, but organizations must consider its limitations before and during implementation [80]. Waste disposal is a popular lean management cost-cutting advantage. Lean management cuts inventory, shipping, waiting, overproduction, and faults. Operational efficiency and cost reduction can boost revenues without compromising quality or customer satisfaction [45]. Process standardization and quality improvement are essential. Lean total quality management encourages best practices, monitoring, and zero-defects. Refunds, brand reliability, and product homogeneity improve. Petrochemicals require safety and precision; therefore, statistical process control and root-cause analysis may reduce errors and operational failures [81]. Lean management improves service. JIT reduces inventory and increases flexibility by meeting real-time consumer demand. Thus, companies can provide products faster, adjust to market changes, and streamline supply chains. Adapting helps businesses compete in changing environments [82].

To measure lean management comprehensively, this study focuses on three core sub-variables that represent foundational practices within the lean philosophy: total quality management (TQM), just-in-time (JIT), and total productive maintenance (TPM). These practices are interdependent components that support waste minimization, process standardization, and operational reliability. Together, they form an integrated system that enhances productivity and aligns closely with environmental and organizational performance goals.

Continuous improvement enhances quality in all organizational activities with TQM. Customer feedback, quality control tools, and staff participation ensure that products and services meet or exceed expectations. TQM helps lean management standardize products, decrease defects, and reduce rework [45]. Customer focus, leadership commitment, staff involvement, process methodology, and data-driven decision making are TQM requirements. TQM emphasizes these principles to boost performance and customer satisfaction. By fostering employee responsibility, it boosts quality and creativity. This study measured TQM with continuous quality improvement, customer feedback, and statistical process control [83]. TQM reduces risk and maintains regulatory compliance in the petrochemical and industrial industries, where tiny mistakes can have big consequences. It improves efficiency and reliability by integrating quality into design, production, and delivery [80,84].

JIT is a lean method that reduces inventory by receiving things only as needed in production. It reduces waste from overproduction, inventory, and idle resources. JIT streamlines operations and improves customer service [85]. JIT boosts cash flow and reduces storage expenses by reducing inventory. It needs strong supply networks, demand

forecasts, and real-time communication to succeed. This study evaluates JIT using on-demand material availability, well-maintained equipment, JIT supplier relationships, and supplier engagement in product development [86]. JIT increases supply chain efficiency but requires extensive coordination. Flexibility and risk mitigation are crucial in JIT situations because disruptions can significantly impair operations [87].

Preventive maintenance and operator engagement boost equipment productivity and availability in TPM. Traditional maintenance requires technicians, but TPM trains all personnel in routine maintenance. This enhances equipment reliability, downtime, and output [88]. TPM incorporates machine maintenance into work to foster ownership and accountability. Asset-intensive industries where equipment failure could interrupt production or pose safety hazards need it. This study measures TPM utilizing robustness, equipment check frequency, personnel maintenance training, and prompt part replacement. TPM improves safety, sustainability, corporate success, and employee engagement. Maintaining machinery lowers energy, faults, waste, and emissions, helping the environment [80].

### 2.3. *Environmental Transformational Leadership (ETL)*

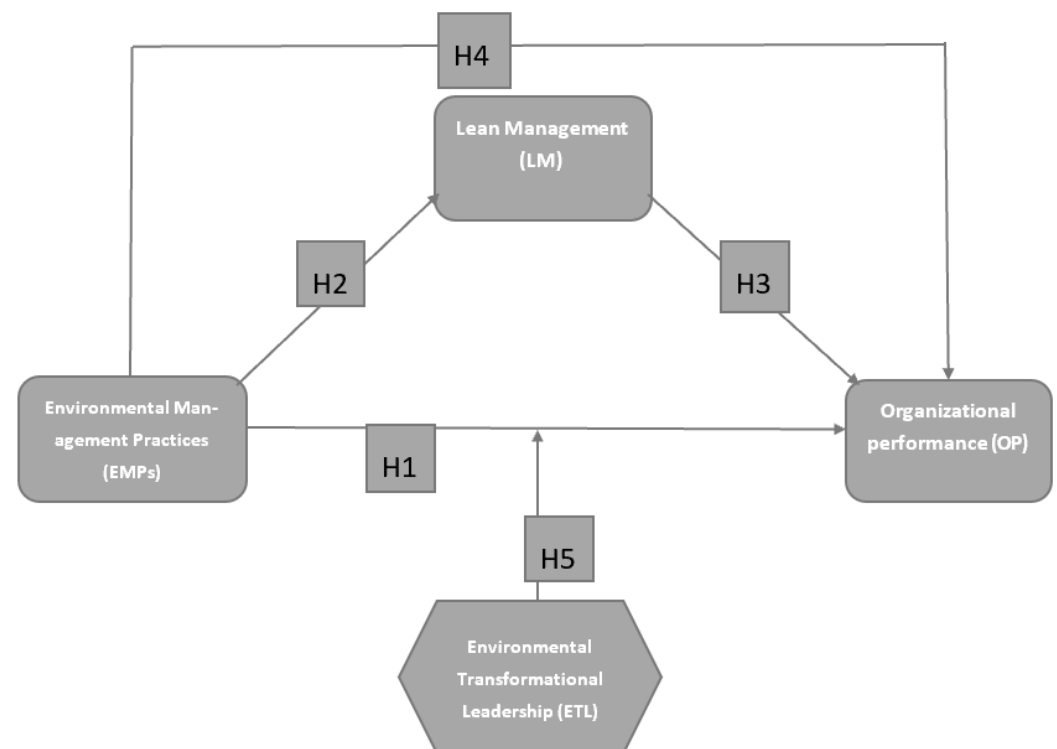
ETL applies transformational leadership to the environment, where a leader may inspire, encourage, and persuade individuals to exceed environmental standards by tying their actions to sustainability goals and ideals [89]. ETL is part of a green leadership change needed for organizational transformation, where corporations must lead in sustainability, offer green solutions, and be accountable to stakeholders to address global environmental concerns to link strategic goals to environmental integrity [90]. ETL is becoming more significant in business sustainability, prompting businesses to take a proactive and inventive approach to embedding sustainability into company strategy and culture as firms worldwide face rising environmental challenges, including stronger regulatory frameworks and changing consumer expectations; it motivates people, leads to the implementation of environmental goals, and changes companies [91]. ETL's ability to foster enterprise-wide environmental ideals is vital because it inspires, empowers, and influences voluntary environmental behavior, unlike traditional environmental leadership, where leaders make environmental protection a corporate mission, not a practice. Value-based leadership fosters continuous innovation and change across departments and hierarchies [92]. ETL is also essential for organizational culture sustainability, where it is incentivizing environmental problem-solving, modeling ethical environmental behavior, honoring green initiatives, reducing change resistance, and aligning staff's actions with sustainability goals [93].

Environmental transformational leadership (ETL) boosts organizational sustainability by inspiring, motivating, and engaging employees to improve environmental, employee, and business performance [34,94]. Every leadership style has downsides, even ETL; organizations may optimize ETL's potential and limit implementation risks by understanding its merits and cons [90]. Environmental innovation and performance are important benefits of ETL as transformational leaders encourage staff to think creatively and critically about the environment [91]. Intellectual stimulation improves environmental results and long-term sustainability by encouraging eco-friendly products, cleaner production, and resource efficiency [34]. ETL also significantly impacts staff involvement and environmental commitment by providing a clear environmental vision and team motivation to exceed objectives [95]. Employees are more inclined to support sustainability and green initiatives. Engaged people volunteer to recycle, minimize energy use, and enhance the environment [96]. Environmental transformational leadership (ETL) is a multidimensional construct composed of distinct yet interrelated behaviors that collectively empower organizations to pursue and sustain environmentally responsible practices. In this study,

ETL is measured through five key sub-variables, directly adapted from validated survey instruments [37,97]. These sub-variables capture leadership behaviors that influence employee motivation, environmental goal clarity, collaboration, and innovation: Inspiring Environmental Vision, Providing Clarity of Environmental Goals, Promoting Team Collaboration for Environmental Goals, Encouraging High Environmental Achievement, and Stimulating Creative Thinking About Green Ideas.

### 3. Theoretical Framework and Hypothesis Development

After discussing the theoretical background and the literature on environmental management practices, lean management, environmental transformational leadership, and organizational performance, this paper offers a comprehensive model by using EMPs as an independent variable that is expected to influence organizational performance, which represents the dependent variable. This study also expected that lean management would influence the relationship between EMPs and OP as a mediator. In addition, this study used environmental transformational leadership as a moderator between the EMPs and OP. See Figure 1.



**Figure 1.** comprehensive model. Created by the author.

#### 3.1. EMPs and ORP

The implementation of EMPs plays a significant role in the success of the OP. The relationship between EMPs and OP has been extensively studied in previous studies, with the assumption that well-established EMPs lead to better OP [3,98]. Many studies found a positive link between EMPs and multiple measures of OP, including environmental, operational, and financial performance [6,45,99–101]. It is also noted that, in order to improve environmental performance, a firm needs to decrease greenhouse emissions, ensure environmental protection, and improve and develop plans to reduce the impact of their activities on the environment. In addition, refs. [102,103] found a positive relationship between the EMPs and operational performance, with higher operational productivity, innovation, and product quality. Moreover, according to [104,105], EMP can enhance a

company's reputation among its stakeholders, including customers, suppliers, regulators, etc., which can be interpreted as better competitive advantages and better performance. According to the resource-based view (RBV), environmental capabilities represent strategic resources that enable firms to develop sustainable competitive advantages and achieve superior organizational performance. Recent empirical evidence generally supports this relationship. For example, ref. [17] found that environmental management practices significantly improve firms' environmental performance by enhancing organizational capabilities.

Nevertheless, some scholars [106,107] have argued that the relationship between EMPs and OP is intricate and subject to various factors, such as the practices that have been implemented, the industry in which the study was conducted, and the period of analysis. Additionally, some scholars suggest that the adoption of EMPs may incur a significant increase in operational costs and operational interruption, which may negatively affect short-range performance [25,108,109]. Prior researchers such as [3,17,98,101,110] found a positive relationship between EMPs and OP. Based on the theoretical arguments and empirical evidence, the following hypothesis is proposed:

**H1.** *EMPs have a positive impact on ORP.*

### 3.2. EMPs and LM

Environmental practices and lean management converge on shared objectives such as waste elimination and enhanced resource efficiency. Environmental practice prioritizes a reduction in ecological waste and the advancement of sustainability, whereas lean management targets the removal of non-value-adding activities to elevate operational performance. As a result, organizations that implement environmental practice measures frequently integrate lean principles to streamline production processes and mitigate environmental impacts. Recent studies corroborate this link; for example, ref. [110] shows that combining sustainability initiatives and lean management adoption fosters continuous improvement and resource optimization. Moreover, refs. [58,111] report that combining environmental and lean practices yields superior operational efficiency compared with either approach alone. In general, environmental initiatives create conditions via waste reduction that enable effective lean implementation.

Several past studies present mixed evidence on the relationship between EMPs and LM; most of them suggest a positive relationship. Many scholars argue that EMPs improve LM implementation by identifying waste management [25] and promoting collaboration for continuous improvement [112–114]. A positive relationship between EMPs and LM has been documented, where pollution prevention activities lead to more efficient processes. According to [115], an environmental management system provides a structural approach for lean implementation. Despite the significant benefits, there are some challenges; one issue is that LM focuses on cutting costs and working faster, while EMPs require spending money in advance as part of the environment protection requirement, such as buying energy-efficient equipment or training staff [116]. Another issue is that some LM techniques such as JIT delivery might affect the environment; for example, more frequent shipment may lead to higher consumption of fuel and pollution [117]. Further empirical research is required to clarify the nature of this relationship and provide a more comprehensive understanding of how environmental management practices facilitate lean management implementation. Therefore, the following hypothesis is proposed:

**H2.** *EMPs have a positive impact on LM.*

### 3.3. LM and ORP

Several studies have explored the impact of lean management on organizational performance [58,113,118]. LM has resulted in considerable cost reductions, increased worker productivity, and improved quality [119]. Several studies show that LM can improve OP by reducing costs and increasing efficiency [58,120]. According to [26], LM improves product quality, which can enhance the company's reputation. In addition, companies with strong LM tend to maintain better relationships with stakeholders and boost their market reputation [121]. However, there is some evidence that poorly implemented LM can lead to worker tension, damaging both performance and reputation [122]. Additionally, some researchers have found a strong relationship between LM and overall organizational performance [123,124]. It is also found that lean management practices (such as JIT, TQM, and TPM) could significantly improve operational efficiency, cost-competitiveness, quality, and overall performance [58]. Based on the theoretical arguments and empirical evidence, the researcher hypothesizes the following:

**H3.** *LM have a positive impact on ORP.*

### 3.4. LM Mediates the Relationship Between EMPs and ORP

EMPs have recently been used by companies to meet government requirements and enhance firm reputation [125]. However, the direct impact of EMPs and OP is sometimes debated because these practices may incur upfront costs and operational difficulties [126]. LM, with its focus on cost reduction, may help bridge this gap [116]. LM improves the effectiveness of the EMPs by reducing resource disposal and improving the cost-efficiency [42,127]. According to [32], firms that use LM with EMPs regularly experience improved operational performance such as lower production costs, higher quality products, and better compliance with environmental principles. Additionally, LM may lead to competitive advantages, including an improvement in the company's reputation [128]. It is also found that the shared effects of LM practices are connected to improved operational performance [120]. However, according to [58,129], previous studies on the relationship between LM and OP have produced inconsistent findings, possibly because they did not consider non-financial measures of OP. According to [25], overemphasizing LM may lead to tradeoffs between efficiency and sustainability. For example, a strong focus on waste reduction could discourage investment in green tools that require higher preliminary expenditures [117]. In addition, lean practices for managing goods can also clash with environmental goals; for example, maintaining a low inventory to save money means more delivery trips, which may create more pollution [130]. These findings suggest that lean management functions as an important mechanism linking environmental management practices with organizational performance.

According to the resource-based view (RBV), environmental management practices create valuable organizational resources, but superior performance depends on firms' ability to effectively leverage these resources. Lean management represents a complementary capability that enhances resource utilization and operational efficiency, thereby translating environmental management practices into improved organizational performance. In this study, lean management, as a mediator, represents the 'organization' component of the RBV. Lean management is an organizational routine and system that allows the firm to capture the value potential of its green practices.

**H4.** *Lean management mediates the relationship between EMP and ORP.*

## 4. Materials and Methods

### 4.1. Research Context and Data Collection

This research aimed to examine the relationship between EMPs and OP through the mediating role of LM and the moderating role of ETL in the context of the manufacturing sector in Saudi Arabia, particularly in the Eastern Province, which is the largest region in the Kingdom. In conducting this research, a quantitative approach was deemed suitable for the objectives to answer the research questions. All data were carefully collected from all-level workers in the manufacturing sectors in the petrochemical field as well as oil and gas. A primary reason for selecting all workers in this field is that safety and the environment are top priorities and crucial for conducting day-to-day activities. In addition, all manufacturing companies should work in alignment with the requirements of the Ministry of Energy. The data were collected over a period of almost five weeks through an online questionnaire, which was created specifically for this study using Google Forms, from 6 March to 9 April 2025. Data were collected from 260 participants with an effective response rate of 92%. The survey questions were carefully designed to maintain confidentiality for all participants. Moreover, the survey clarity and length were controlled to maintain participants' engagement. The distribution techniques employed for data collection were social networking platforms such as WhatsApp, Telegram, and email applications. A cleared consent statement for participation in the study was identified. In addition, an introduction about the subject was crafted in the survey to provide information about the study in place prior to answering the survey questions (see the Questionnaire for more details). Ethical approval for this research was obtained with reference no. CAFS-202510-003.

The final dataset included 239 valid responses. To verify that this sample size provides sufficient statistical power to detect the proposed effects, an a priori power analysis for structural equation modeling was conducted following [131]. For a model structure with 5 latent variables and 39 observed indicators, assuming a medium anticipated effect size of 0.15, an alpha level of 0.05, and a target power of 0.80, the minimum required sample size was determined to be 156. Thus, the final sample of 239 is statistically adequate and yields a ratio of approximately 6.13 cases per measured variable, satisfying the minimum 5:1 parameter-to-sample threshold recommended for stable estimation in covariance-based SEM [132,133].

### 4.2. Operationalization and Measurement of Variables

Constructs were measured using specific behavioral and operational items adapted directly from relevant and established literature to ensure content validity, indicator-level significance, and structural coherence. All items were presented in English, which is the standard language of business communication within the targeted industrial sector in Saudi Arabia. The questionnaire comprises 39 individual indicators capturing eight distinct first-order constructs and two second-order constructs, ensuring that every manifest variable was directly mapped to its empirically validated scale block in the previous literature, please refer to Appendix A for further details. A five-point Likert scale was used across all variables, with scaling interpretations provided as follows:

For environmental management practices (EMP): 1 = "No consideration" to 5 = "Implemented successfully". For all other constructs: 1 = "Strongly disagree" to 5 = "Strongly agree".

As structured in Table 1 (Measures and Confirmatory Factor Analysis), environmental management practices (EMPs) were captured via eight individual indicators (EMP1–EMP8) adapted from [7]. Organizational performance (OP) was assessed as a second-order construct using five item indicators per sub-dimension for environmental

performance (EP1–EP5), operational performance (OP1–OP5), and reputational performance (RP1–RP5), following [65,134]. Lean management (LM) was operationalized through its individual multi-indicator dimensions adapted from [58]: total quality management (TQM1–TQM3), just-in-time (JIT1–JIT4), and total preventive maintenance (TPM1–TPM4). Lastly, environmental transformational leadership was targeted through five discrete indicators (ETL1–ETL5) adapted from [37,97]. Demographic profile in Table 2.

**Table 1.** Measures and confirmatory factor analysis.

| Variables                                              | Reference | Cronbach's $\alpha$ | CR   | AVE  | Std. Factor Loading |
|--------------------------------------------------------|-----------|---------------------|------|------|---------------------|
| Environmental Management Practices<br>EMP1–EMP8        | [7]       | 0.90                | 0.92 | 0.59 | 0.69–0.81           |
| Organizational Performance                             |           |                     |      |      |                     |
| Environmental Performance<br>EP1–EP5                   |           | 0.94                | 0.91 | 0.67 | 0.78–0.85           |
| Operational Performance<br>OP1–OP5                     | [65,134]  |                     | 0.85 | 0.54 | 0.66–0.80           |
| Reputational Performance<br>RP1–RP5                    |           |                     | 0.90 | 0.64 | 0.78–0.84           |
| Lean Management                                        |           |                     |      |      |                     |
| Total Quality Management<br>TQM1–TQM3                  |           |                     | 0.84 | 0.63 | 0.77–0.82           |
| Just-in-Time<br>JIT1–JIT4                              | [58]      | 0.92                | 0.85 | 0.58 | 0.69–0.79           |
| Total Preventive Maintenance<br>TPM1–TPM4              |           |                     | 0.87 | 0.63 | 0.75–0.82           |
| Environmental Transformational Leadership<br>ETL1–ETL5 | [37,97]   | 0.92                | 0.93 | 0.73 | 0.83–0.86           |

**Table 2.** Demographic profile.

| 30.               | Category          | Frequency (n) | Percentage (%) |
|-------------------|-------------------|---------------|----------------|
| <b>Age</b>        | <30 years         | 102           | 42.7           |
|                   | 30–39 years       | 108           | 45.2           |
|                   | 40–49 years       | 25            | 10.5           |
|                   | 50+ years         | 4             | 1.7            |
| <b>Education</b>  | Undergraduate     | 212           | 88.7           |
|                   | Master's          | 27            | 11.3           |
| <b>Gender</b>     | Male              | 222           | 92.9           |
|                   | Female            | 17            | 7.1            |
| <b>Experience</b> | 1–5 years         | 88            | 36.8           |
|                   | 6–10 years        | 72            | 30.1           |
|                   | 11–15 years       | 48            | 20.1           |
|                   | 15+ years         | 31            | 13             |
| <b>Position</b>   | Lower management  | 118           | 49.4           |
|                   | Middle management | 98            | 41             |
|                   | High management   | 23            | 9.6            |

## 5. Analysis and Results

In this section of the study, we investigate descriptive statistics and evaluate the reliability of the constructs using Cronbach's alpha. The relationship between the four main

variables in this study and the five hypotheses is examined and evaluated using well-known statistical analysis techniques such as structural equation modeling (SEM) and confirmatory factor analysis (CFA) using IBM Amos (v.29).

Table 1 below provides a detailed breakdown of the constructs, sources, reliability metrics, and factor loadings. Environmental management practices (EMPs) were measured using eight items. Cronbach's  $\alpha = 0.90$ , CR = 0.92, and AVE = 0.59, with standardized loadings between 0.69 and 0.81.

Organizational performance (ORP) was assessed as a second-order construct comprising the following: (1) Environmental Performance (EP): five items (CR = 0.91, AVE = 0.67, loadings: 0.78–0.85). (2) Operational Performance (OP): five items (CR = 0.85, AVE = 0.54, loadings: 0.66–0.80). Reputational Performance (RP): five items (CR = 0.90, AVE = 0.64, loadings: 0.78–0.84).

Lean management (LM) was operationalized through three sub-constructs: (1) Total Quality Management (TQM): three items (CR = 0.84, AVE = 0.63, loadings: 0.77–0.82). (2) Just-in-Time (JIT): four items (CR = 0.85, AVE = 0.58, loadings: 0.69–0.79). (3) Total Preventive Maintenance (TPM): four items (CR = 0.87, AVE = 0.63, loadings: 0.75–0.82).

Environmental transformational leadership (ETL) was measured using five items (CR = 0.93, AVE = 0.73, loadings: 0.83–0.86).

All constructs demonstrated strong internal reliability (Cronbach's  $\alpha > 0.84$ ) and met or exceeded the recommended psychometric thresholds outlined by [135,136].

While the aggregate Cronbach's alpha values for the second-order constructs of organizational performance ( $\alpha = 0.94$ ) and lean management ( $\alpha = 0.92$ ) are high, these values are a known mathematical reflection of the large multi-item pools (15 and 11 items, respectively) used to capture these multidimensional phenomena [137,138]. Post hoc deletions of items to artificially lower alpha values were avoided to prevent data-driven overfitting and specification bias, which can compromise the generalizability of the structural paths. Because the underlying first-order dimensions display robust convergent validity (AVEs ranging from 0.54 to 0.67), retaining the full, established item sets ensures the preservation of content validity as intended by the original scale developers.

### 5.1. Data Validity and Reliability

Confirmatory factor analysis (CFA) was conducted using AMOS v.29, following the two-step approach recommended by [139]. All standardized factor loadings exceeded the minimum threshold of 0.50, and the construct reliability (CR > 0.70) and average variance extracted (AVE ~0.50) values supported convergent validity. The fit indices from the structural model indicated an overall acceptable fit (see Table 3). Specifically, RMSEA = 0.063 and RMR = 0.051 suggested a good approximation of the model to the data. The CFI (0.916) and TLI (0.908) exceeded the commonly accepted cutoff of 0.90, demonstrating a strong incremental fit. While the goodness-of-fit index (GFI = 0.800) fell slightly below the conventional 0.90 threshold, it remained within the range observed in models with high complexity and moderate sample sizes. This observation aligns with findings by [140], who caution against overgeneralizing GFI cutoffs in the context of complex models with multiple latent variables.

**Table 3.** Goodness-of-fit index of the model.

| GOFI  | GOFI Criteria | Results | Interpretation |
|-------|---------------|---------|----------------|
| RMSEA | $\leq 0.08$   | 0.063   | Good fit       |
| TLI   | $\geq 0.90$   | 0.908   | Good fit       |
| CFI   | $\geq 0.90$   | 0.916   | Good fit       |
| GFI   | $\geq 0.90$   | 0.800   | Marginal fit   |
| RMR   | $\leq 0.08$   | 0.051   | Good fit       |

Discriminant validity was formally assessed using the Fornell–Larcker criterion [136], which dictates that the square root of a construct’s average variance extracted (AVE) should exceed its correlations with any other latent variable. As shown in the discriminant validity matrix table (Table 4), environmental management practices (EMPs) demonstrate excellent statistical distinctiveness. However, the downstream latent variables—lean management (LM), organizational performance (ORP), and environmental transformational leadership (ETL)—exhibit elevated multi-collinearity. This strong shared variance is conceptually consistent with modern sustainability literature, which notes that advanced operational capabilities (lean) and specific leadership paradigms (ETL) often co-evolve alongside multidimensional performance tracking in the industrial sectors. All of these often-nested constructs and their numerous sub-constructs (featuring 39 distinct item indicators, 8 first-order constructs, and 2 s-order constructs) increase the complexity of the model [140]. Item-level discriminant performance was further verified by checking the AMOS modification indices and standardized regression weights. No major cross-loading collinearities were flagged, and each indicator displayed strong and statistically significant standard factor loadings ( $p < 0.001$ ) within reasonable boundaries (0.66 to 0.86), which completely satisfies the standard conservative thresholds for parameter retention and confirms the absence of weak loadings.

**Table 4.** Discriminant validity matrix (Fornell–Larcker criterion).

| Construct | 1. EMP       | 2. ETL       | 3. LM       | 4. ORP       |
|-----------|--------------|--------------|-------------|--------------|
| 1. EMP    | <b>0.768</b> |              |             |              |
| 2. ETL    | 0.584        | <b>0.854</b> |             |              |
| 3. LM     | 0.585        | 0.769        | <b>0.75</b> |              |
| 4. ORP    | 0.617        | 0.751        | 0.86        | <b>0.775</b> |

### 5.2. Model Fit Justification

Although the goodness-of-fit index (GFI) was recorded at 0.800—slightly below the commonly accepted threshold of 0.90—the overall model fit is considered acceptable within the context of complex structural models. Notably, the root mean square error of approximation (RMSEA = 0.063) and root mean square residual (RMR = 0.051) both fall within the range indicative of good model fit. Furthermore, the comparative fit index (CFI = 0.916) and Tucker–Lewis’s index (TLI = 0.908) exceeded the critical benchmark of 0.90, demonstrating a robust incremental fit of the model to the observed data. The chi-square statistic divided by degrees of freedom (CMIN/DF = 2.02) further supports the model’s adequacy, because values below 3 are generally deemed acceptable for structural equation models [141]. These findings are consistent with the recommendations of [133], who emphasizes that no single fit index should be interpreted in isolation. Instead, a holistic view—taking into account multiple fit indices and the theoretical grounding of the model—is advocated. As such, despite the slightly lower GFI, the overall structural model can be considered statistically valid and conceptually well-specified. This interpretation aligns with [140], who suggest that models with high parameterization and multiple latent constructs often experience marginal reductions in GFI without compromising overall model integrity.

### 5.3. Common Method Bias

Given the cross-sectional, single-informant nature of the survey design, the study systematically evaluated the potential threat of common method bias (CMB). A Harman’s single-factor test was initially performed using an unrotated principal axis factoring solution applied to all 39 manifest variables. The first factor accounted for 42.42% of the total variance, sitting safely below the conventional 50% threshold indicative of problematic

method variance. To further validate these metrics beyond the baseline Harman test, the structural path outcomes were evaluated for signs of systematic inflation. Methodological literature dictates that severe common method contamination forces uniform inflation across all latent correlations, which would artificially render all hypothesized paths significant. However, our structural results display highly divergent path behaviors, ranging from an exceptionally strong direct effect (lean management  $\rightarrow$  ORP:  $\beta = 0.914$ ,  $p = 0.010$ ) to a marginal direct effect (EMP  $\rightarrow$  ORP:  $\beta = 0.082$ ,  $p = 0.047$ ) and a completely non-significant interaction path ( $\beta = 0.031$ ,  $p = 0.522$ ). This stark variation in both parameter magnitudes and significance levels provides robust empirical evidence that common method variance is negligible within this dataset and does not compromise structural path estimation [142,143].

#### 5.4. Direct, Mediating, and Moderating Path Coefficients

The path analysis reveals distinct behaviors across the direct structural paths:

**Direct Effects:** The direct path from environmental management practices (EMPs) to organizational performance (ORP) is positive but notably small and only marginally significant ( $\beta = 0.082$ ,  $p = 0.047$ ). In sharp contrast, environmental management practices exert a strong, highly significant positive drive on lean management ( $\beta = 0.500$ ,  $p = 0.010$ ). Furthermore, lean management demonstrates a dominant, substantial direct impact on organizational performance ( $\beta = 0.914$ ,  $p = 0.010$ ), identifying it as the primary performance determinant within the structural framework.

**Mediating Effects:** The bootstrap structural assessment confirmed a highly significant indirect effect of environmental management practices on organizational performance via the mediating mechanism of lean management ( $\beta = 0.457$ ,  $p = 0.010$ ). Because both the direct path (EMP  $\rightarrow$  OP) and the indirect path (EMP  $\rightarrow$  LM  $\rightarrow$  ORP) remain statistically significant and point in the same positive direction, the structural architecture demonstrates complementary partial mediation [144].

**Moderating Effects:** Regarding the interaction term, the structural path evaluating the moderating influence of environmental transformational leadership (ETL) on the relationship between environmental management practices and organizational performance was found to be statistically non-significant ( $\beta = 0.031$ ,  $p = 0.522$ ).

#### 5.5. Results

Structural equation modeling (SEM) was conducted using 5000 bootstrap samples with a 95% confidence interval to assess the hypothesized relationships (see appropriate table). Findings from the structural model (see appropriate figure) are summarized as follows in Table 5:

- Hypothesis 1. Environmental management practices were found to have a positive, yet exceptionally small and marginally significant, direct effect on organizational performance (standardized coefficient  $\beta = 0.082$ ,  $p = 0.047$ ). While this statistically supports the notion that standalone environmental initiatives contribute to performance outcomes across operational, environmental, and reputational domains, the low magnitude highlights its limited capability to drive performance transformations in isolation.
- Hypothesis 2. A strong and statistically significant relationship was observed between environmental management practices and lean management ( $\beta = 0.500$ ,  $p = 0.010$ ). This suggests that organizations prioritizing environmental practices are also highly likely to adopt and implement lean principles.
- Hypothesis 3. Lean management exhibited a significant, substantial, and dominant positive impact on organizational performance ( $\beta = 0.914$ ,  $p = 0.010$ ), indicating that

lean strategies are the primary critical driver of performance improvement in this framework.

- Hypothesis 4. The indirect effect of environmental management practices on organizational performance, mediated through lean management, was highly significant ( $\beta = 0.457, p = 0.010$ ). Because both the direct effect ( $\beta = 0.082, p = 0.047$ ) and indirect path remain significant, this layout establishes a framework of complementary partial mediation [144]. This confirms that lean practices serve as the necessary intermediate engine that captures and channels the vast majority of environmental variance into tangible performance outcomes.
- Hypothesis 5. The moderating effect of environmental transformational leadership on the relationship between environmental management practices and organizational performance was not supported ( $\beta = 0.031, p = 0.522$ ). This implies that, in this context, leadership style does not significantly alter the impact of environmental practices on performance.

**Table 5.** Path estimates.

| Observed Variables                                 | Direct Effect | Indirect Effect | Moderated | <i>p</i> |
|----------------------------------------------------|---------------|-----------------|-----------|----------|
| EMP → Organizational Performance                   | 0.082         | -               | -         | 0.047    |
| Lean Management → Organizational Performance       | 0.914         | -               | -         | 0.010    |
| EMP → Lean Management                              | 0.581         | -               | -         | 0.010    |
| EMP → Lean Management → Organizational Performance | -             | 0.457           | -         | 0.010    |
| EMP × ETL → Organizational Performance             | -             | -               | 0.031     | 0.522    |

The findings of this study underscore the pivotal role that environmental management practices (EMPs) play in enhancing organizational performance, though this relationship requires careful interpretation. Crucially, the direct pathway from EMP to performance is notably weak on its own ( $\beta = 0.082$ ) but becomes vastly more pronounced and structurally optimized when lean management (LM) is introduced as an indirect, bridging mechanism ( $\beta = 0.457$ ). As illustrated in Figure 2, organizations that actively implement lean strategies—such as total quality management, just-in-time production, and total preventive maintenance—experience substantial improvements in their environmental, operational, and reputational performance. The strong direct effect of LM on performance ( $\beta = 0.914$ ), alongside its partial mediating role, proves that lean initiatives are not merely compatible with sustainability goals but are strictly essential for translating raw green choices into substantive business outcomes. However, the anticipated moderating influence of environmental transformational leadership (ETL) was not statistically significant, indicating that leadership style alone may not be sufficient to amplify the benefits of environmental initiatives in this context. Overall, the results highlight the importance of embedding lean practices within environmental strategies to drive comprehensive and sustained performance improvements in the industrial sector.

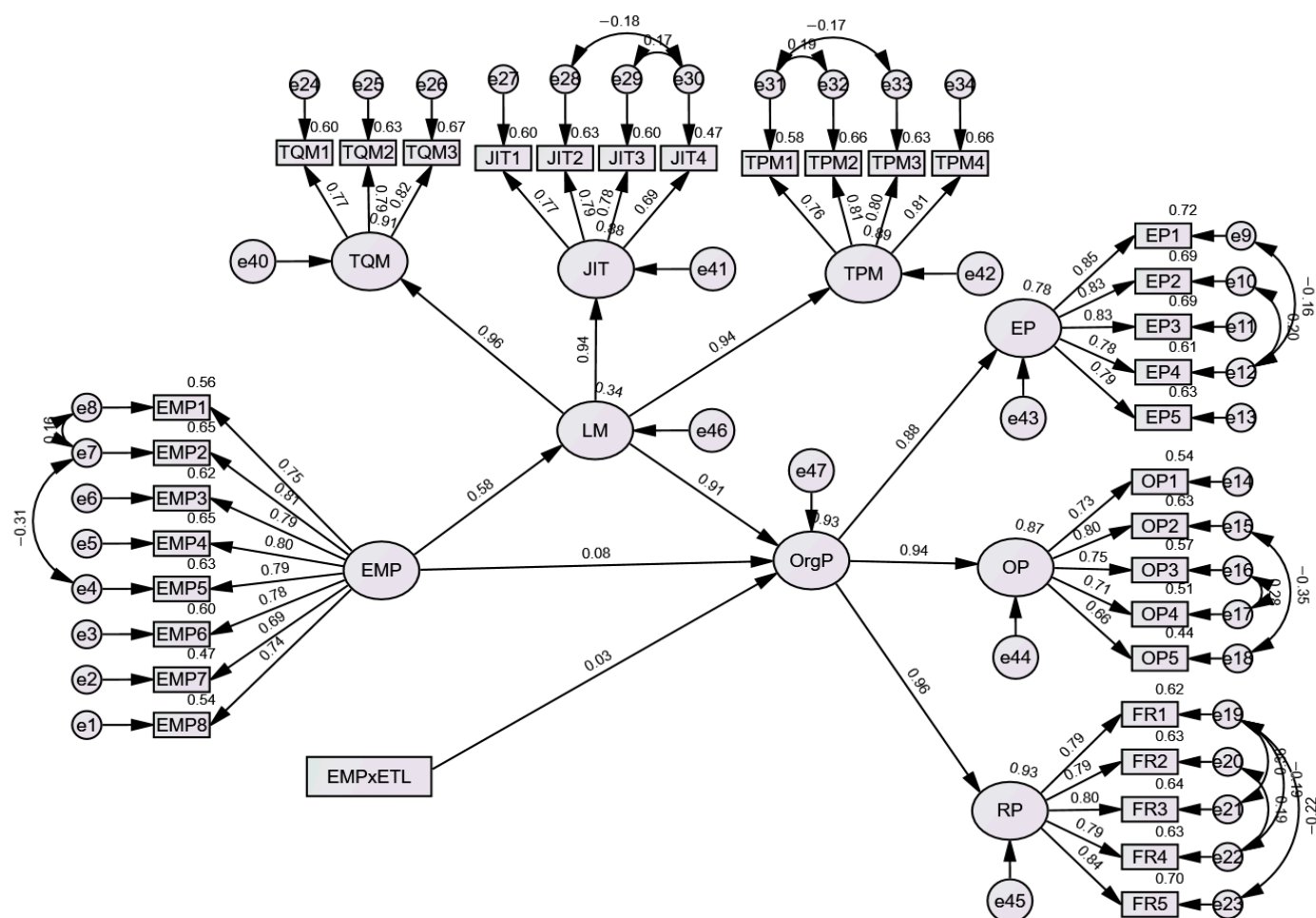


Figure 2. Structural paths.

## 6. Discussion and Conclusions

This study examined the relationship between environmental management practices (EMPs) and organizational performance (OP) with the mediation of lean management (LM) and the moderating effect of environmental transformational leadership (ETL) in the manufacturing sector in the Kingdom of Saudi Arabia.

The outcome of the structural equation modeling revealed that EMPs have a significant influence on the OP. EMPs are positively associated with OP, which supports Hypothesis 1. According to this result, which has been supported by previous research [6,45,56,145–147], environmental initiatives such as establishing green management objectives, green design, recycling management, and ISO14001 certification contribute to performance outcomes across operational, environmental, and reputational domains. However, a critical observation in this empirical finding is that this direct linkage is noticeably weak and only marginally significant ( $\beta = 0.082$ ,  $p = 0.047$ ). This indicates that standalone green initiatives offer limited immediate impact on overall firm returns within the Saudi manufacturing context. The extent of this positive correlation between EMPs and OP varies across industries such as manufacturing more than others [148], and these benefits emerge gradually, requiring strategic implementation and long-term commitment [149]. A primary reason for the weak standalone direct path is the high parameterization of production lines in the petrochemical sector; environmental updates incur heavy initial overheads, meaning that simple green alignment does not translate directly into high operational or reputational value without systemic capacity shifts.

Moreover, the significant positive influence of EMPs on LM is also revealed from this study ( $\beta = 0.500$ ,  $p = 0.010$ ). The results of this research accord with previous empirical studies such as [116,146,150], which found that environmental management practices significantly correlate with lean management, supporting Hypothesis 2. According to [151], companies that are ISO14001-certified adopt lean management to achieve continual improvement. In addition, ref. [152] found that the recycling process should be designed and managed in accordance with lean management principles in order to decrease recycling waste. This indicates that companies prioritizing environmental practices are highly likely to adopt and implement lean management principles to capture administrative and structural efficiencies.

The study further reveals a powerful association between LM and OP ( $\beta = 0.914$ ,  $p = 0.010$ ). It observed that lean management exhibited a substantial and dominant positive impact on organizational performance. Previous research by [58,116,120] found a similar result: applying LM techniques such as total quality management (TQM), just-in-time (JIT), and total preventive maintenance (TPM) directly improves overall performance, which supports Hypothesis 3. LM contributes to waste reduction, process improvement, higher productivity, and cost reduction. In addition, LM fosters continual improvement, which enables companies to adapt quickly to macro-level industrial changes and preserve long-term operational excellence [69,120]. Environmentally, lean practices align with green goals by reducing resource consumption and emissions [116]. For instance, ref. [130] found that companies adapting LM significantly reduce their carbon footprint while maintaining rigid cost-efficiency. Finally, companies experiencing LM see positive shifts in client satisfaction and corporate social responsibility, which enhances the reputation of the organization [153]. Thus, the integration of lean management serves as an essential strategic requirement for securing high-magnitude organizational performance.

The structural assessment of the mediation path yields a vital contribution to our understanding of these dynamics. Rather than full mediation, our results show that lean management serves as a complementary partial mediator (indirect effect) between EMPs and organizational performance ( $\beta = 0.457$ ,  $p = 0.010$ ). This specific characterization following [144] highlights that, while EMPs maintain a residual direct effect, their primary performance-enhancing capacity is channeled indirectly through the structural systems of lean management. This relationship becomes significantly stronger when LM acts as the structural vehicle. Organizations that actively implement lean strategies such as TQM, JIT, and TPM experience substantial rapid gains in their environmental, operational, and reputational performance. Previous studies, e.g., ref. [146], have highlighted the mediating influence of lean management on the association between EMPs and operational outputs. According to [154], firms are advised to implement LM complemented with EMPs to ensure the protection of the natural environment as well as to improve profit-making capability. The critical discrepancy between the weak direct path ( $\beta = 0.082$ ) and the heavy indirect path ( $\beta = 0.457$ ) indicates that lean management acts as the operational bridge required to turn green intentions into systematic business successes. Therefore, this research redefines traditional assumptions regarding the EMP-OP linkage by revealing the hidden, capability-dependent patterns in this dynamic relationship.

Finally, the findings of this study indicate that environmental transformational leadership (ETL) does not support or influence the relationship between EMPs and OP, meaning that Hypothesis 5 is not supported ( $\beta = 0.031$ ,  $p = 0.522$ ). This means that, even if leaders inspire and motivate employees to be greener, it does not automatically make raw EMPs more effective at harvesting immediate short-term performance gains. However, this does not deny the underlying value of ETL in fostering organizational health [34]. ETL remains vital for shaping a pro-environmental culture and inspiring employee engagement in broader sustainability initiatives. Alternatively, the influence of ETL may

manifest in long-term sustainability outcomes and employee satisfaction rather than immediate economic or operational advantages.

The non-significant moderating effect of ETL in this study presents an interesting departure from established theory. While a vast body of leadership literature confirms that green transformational leadership generally enhances organizational performance, the findings suggest that this influence is contingent upon specific contextual boundaries. In the Saudi context, organizational culture is deeply influenced by high power distance and a preference for top-down directives [155]. In this regard, ref. [156] proposed key mindset shifts in agile leadership: focusing less on the work and more on the culture, and decentralizing decision making. However, the traditional Saudi management mode often prioritizes formal authority; therefore, transformational leaders may fail to institutionalize green practices if environmental stewardship is not yet embedded in the local organizational culture. Additionally, in the manufacturing industry, lean tools like just-in-time might be more important than the influence of a transformational leader. Moreover, the majority of the participants were male (92%), and according to [155], a high degree of inequality will increase the power distance. In this context where inequality reinforces high power distance, the resulting rigid organizational structures and authoritative cultures may dampen the effectiveness of visionary leadership styles.

#### *Theoretical and Managerial Implications*

This study contributes to the literature on EMPs and ORP in several ways. The research developed and analyzed the conceptual model between EMPs' implementation, lean management, environmental transformational leadership, and organizational performance. Furthermore, very few studies are available in the literature that focus on lean management's mediating effect between EMPs and ORP. Moreover, the current research is the first to integrate all these variables within a unified model. Another noteworthy point is that most previous empirical research has evaluated the performance impact only using financial environmental or operational standalone metrics, while the current study provides a combination of operational, environmental, and reputation-related performance indicators. In addition, very few studies have used the eight environmental management practices in developing countries such as Saudi Arabia.

Theoretically, the management literature heavily argues that lean management is not an isolated practice but a bundled, multidimensional socio-technical system [120]. Similarly, organizational performance under the resource-based view (RBV) cannot be captured solely through financial metrics; it must encompass a balanced dashboard of operational, environmental, and reputational outcomes [65]. The finding of this study offers several important perceptions for managers looking to improve ORP through EMPs. The mediating role of LM suggests that a company's managers should integrate EMPs with LM to eliminate waste and deliver sustainable performance. Managers should also invest in training programs to consistently insert LM into environmental initiatives. In addition, the moderating effect of ETL, despite its negligible influence in this study, can be an important factor for improving organizational performance through EMPs' adaption. Organizations should establish leadership development programs that align with sustainability goals. Empirically, the confirmatory factor analysis (CFA) output in AMOS strongly justifies this higher-order structure. The second-order standardized factor loadings for the sub-dimensions are exceptionally high and uniform: total quality management ( $\beta = 0.960$ ), just-in-time ( $\beta = 0.940$ ), and total preventive maintenance ( $\beta = 0.938$ ) load cleanly onto lean management, while environmental performance ( $\beta = 0.882$ ), operational performance ( $\beta = 0.931$ ), and reputational performance ( $\beta = 0.966$ ) load onto organizational performance. These strong higher-order coefficients mathematically validate that the first-order sub-

constructs are observable manifestations of their respective overarching second-order latent variables.

## 7. Limitations and Future Research Directions

While this study offers valuable empirical and practical insights within the framework of Saudi Arabia's Vision 2030, several limitations must be acknowledged to guide future research paths. First, the empirical data collection was geographically constrained to manufacturing organizations operating within a single nation (the Kingdom of Saudi Arabia), specifically targeting the petrochemical hub in the Eastern Province. Consequently, the generalizability of these structural path estimates across different regional regulatory climates or diverse global manufacturing sectors may be limited. Future studies should deploy comparative cross-national structures to test whether these structural linkages are stable across varying national environmental signaling regimes.

Second, the current sampling framework was primarily heavily weighted toward large-scale industrial firms, meaning that small and medium-sized enterprises (SMEs) were underrepresented. Given that SMEs frequently operate under tighter financial and resource boundaries, their strategic ability to simultaneously adopt environmental management practices (EMPs) alongside resource-intensive lean management architectures might show distinct behavior. Future investigations should specifically evaluate dedicated SME cohorts to uncover context-specific operational capability limits.

Third, from a methodological perspective, the final dataset yielded a usable sample size of  $n = 239$  cases. While our a priori power analysis explicitly confirmed that this sample size provides adequate statistical power to execute covariance-based structural equation modeling [131,132], it represents a relatively moderate statistical baseline for highly complex, multi-layered second-order constructs. Future researchers are encouraged to capture larger sample fields to further stabilize the parameter estimation of complex interaction paths.

Fourth, although our statistical defenses rigorously demonstrated that the wild-ranging disparities in our structural path magnitudes ( $\beta = 0.914$  down to  $\beta = 0.031$ ) rule out severe common method variance, the cross-sectional, single-informant nature of our survey design remains a standard constraint. Future studies could achieve higher internal validity by collecting multi-informant data or utilizing a longitudinal data structure to completely eliminate method variance risks. The sample was indeed drawn from the petrochemical and oil and gas sub-sector in the Eastern Province, with a predominantly male composition (92.9%); future research should replicate this across other manufacturing sub-sectors and regions in Saudi Arabia, with a more balanced gender representation.

Finally, our findings revealed that environmental transformational leadership (ETL) did not mathematically moderate the direct path between environmental practices and overall performance outputs. Because this indicates that leadership influence may manifest along alternative organizational channels, future tracking could explore different transactional, green servant, or authentic leadership paradigms in distinct corporate or service environments to map out the boundary conditions of managerial stewardship.

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**Informed Consent Statement:** Informed consent for participation was obtained from all subjects involved in the study.

**Data Availability Statement:** Data are contained within the article.

**Conflicts of Interest:** The author declares no conflict of interest.

## Appendix A. The Research Measurements

| Sections                                  | Variable                                                                                                                 | Source   |
|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|----------|
| Environmental Management Practices (EMPs) | EMP1—Establish green management objectives.                                                                              | [7]      |
|                                           | EMP2—Increase environmental awareness among staff.                                                                       |          |
|                                           | EMP3—Increase investment in environmental protection.                                                                    |          |
|                                           | EMP4—Cleaner production.                                                                                                 |          |
|                                           | EMP5—Green design.                                                                                                       |          |
|                                           | EMP6—Green marketing.                                                                                                    |          |
|                                           | EMP7—Product scrap and recycling management.                                                                             |          |
|                                           | EMP8—ISO14001 certification.                                                                                             |          |
| Organizational Performance (ORP)          | A. Environmental Performance                                                                                             | [65,134] |
|                                           | EP1—Our firm has reduced consumption of hazardous/toxic material compared to competitors.                                |          |
|                                           | EP2—Our firm has reduced air emissions compared to competitors.                                                          |          |
|                                           | EP3—Our firm has reduced effluent wastes compared to competitors.                                                        |          |
|                                           | EP4—Our firm has reduced energy consumption compared to competitors.                                                     |          |
|                                           | EP5—Our firm has reduced solid wastes compared to competitors.                                                           |          |
|                                           | B. Operational Performance                                                                                               |          |
|                                           | OP1—Our company has achieved operational cost savings compared to competitors.                                           |          |
|                                           | OP2—Our company has improved product quality compared to competitors.                                                    |          |
|                                           | OP3—Our company has improved the on-time delivery rate compared to competitors.                                          |          |
|                                           | OP4—Our company has developed a flexible system for rapid responses to changes in orders/demand compared to competitors. |          |
|                                           | OP5—Our company has decreased inventory levels compared to competitors.                                                  |          |
|                                           | C. Firm Reputation                                                                                                       |          |
|                                           | FR1—Stakeholders have a good feeling about the company.                                                                  |          |
|                                           | FR2—Improved reputation due to responsiveness, research, and disclosure of environmental issues.                         |          |
|                                           | FR3—Stakeholders admire and respect the company.                                                                         |          |
|                                           | FR4—Improved reputation due to the provision of sensitive environmental education.                                       |          |
|                                           | FR5—Improved reputation for maintaining a high environmental standard.                                                   |          |
| Lean Management (LM)                      | A. Total Quality Management                                                                                              | [58]     |
|                                           | TQM1—Our company strives to continually improve the quality of its processes rather than taking a static approach.       |          |
|                                           | TQM2—Feedback received from customers is continuously used to improve the work.                                          |          |
|                                           | TQM3—Company processes are being monitored using statistical process control.                                            |          |
|                                           | B. Just-In-Time                                                                                                          |          |
|                                           | JIT1—Materials for company readily available as and when needed and without overstocking.                                |          |
|                                           | JIT2—Equipment and tools at the workplace were properly maintained and in good condition.                                |          |
|                                           | JIT3—Key suppliers delivering on JIT basis.                                                                              |          |
|                                           | JIT4—Suppliers are directly involved in the new product development process.                                             |          |
|                                           | C. Total Preventive Maintenance                                                                                          |          |
|                                           | TPM1—Company maintenance system is fundamental.                                                                          |          |
|                                           | TPM2—Maintenance team regularly checks equipment and supplies to make sure they meet the operating requirements.         |          |

TPM3—Employees are trained to perform daily maintenance and necessary calibration for the equipment in their work site.

TPM4—Company immediately replaces defective parts of equipment.

ETL1—The leader inspires the organization members with the environmental plans.

ETL2—The leader provides a clear environmental vision for the members to follow.

Environmental Transformational Leadership (ETL) ETL3—The leader gets the organization members to work together for the same environmental goals. [37,97]

ETL4—The leader encourages the organization members to achieve the environmental goals.

ETL5—The leader stimulates the organization members to think about green ideas.

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