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EVALUATING THE IMPACT OF EMS ON ENVIRONMENTAL PERFORMANCE AND OPERATIONAL EFFICIENCY IN SAUDI ARABIA

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ABSTRACT

Interest in corporate efforts to minimize or eliminate waste generated during the production, use, or disposal of their products has been growing. Earlier research emphasized the importance of such initiatives, while more recent studies aim to identify factors that facilitate or hinder their implementation. The introduction of ISO 14001 has shifted focus towards corporate environmental management systems (EMS), with the premise that such systems are essential for reducing waste and pollution while enhancing overall performance. This study examines that premise using survey data from Saudi Arabia managers, evaluating their perceptions of EMS and ISO 14001. It compares the impacts of having a formal EMS without certification to having a certified EMS. Findings reveal that firms with a formal EMS perceive benefits beyond pollution control, including significant improvements in various operational performance areas. Furthermore, firms with certified EMS experience even greater performance impacts compared to those without certification. Additionally, long-term experience with EMS amplifies the adoption and application of environmental strategies. These findings highlight the importance of further research into EMS, firms' environmental choices, and the relationships between EMS and performance outcomes.

KEYWORDS: Environmental Performance, EMS, Operational Performance, Operational Efficiency Saudi Arabia, ISO 14001.

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1. INTRODUCTION

In Saudi Arabia and throughout the world [1], companies' capacity to control their environmental performance (EP) has emerged as a critical strategic factor. This increased focus results from the understanding that the environment is a vital resource that affects long-term business sustainability as well as regulatory compliance. Businesses are under growing pressure to improve quality, lower prices, increase flexibility, and lessen their environmental impact in this changing environment [2, 3]. The International Organization for Standardization (ISO) responded to these requests by launching the ISO 14000 series in 1996 with the goal of helping businesses integrate environmental issues into their business plans [4]. With its emphasis on Environmental Management Systems (EMS), ISO 14001 stands out among these standards and provides a thorough framework to support environmental improvements across all organizational activities [7]. The cooperative and flexible nature of ISO 14001, in contrast to prescriptive regulatory frameworks, enables businesses to customize environmental objectives to their own operating situations [5, 6]. Many Saudi companies are implementing ISO 14001 to show their commitment to sustainability and to increase their legitimacy as environmental responsibility becomes ingrained in corporate identity, especially in resource-intensive industries [8]. Two major uncertainties still prevent wider implementation in Saudi Arabia, despite its growing significance. First, there is still uncertainty regarding the direct correlation between financial performance and pollution reduction. Second, the practical benefits of ISO 14001 certification, especially when compared to informal environmental initiatives, lack consistent empirical support. These concerns are especially pressing for industries such as oil and gas, where managers must weigh environmental stewardship against operational efficiency. This study addresses these challenges by examining whether ISO 14001 certification leads to measurable improvements in performance among Saudi firms. Historically, environmental initiatives were often viewed as conflicting with core business objectives, with many in academia and industry assuming that such practices incurred costs without delivering corresponding value [9, 10]. Early assumptions suggested that environmental improvements would result in extended lead times, higher production costs, or reduced product quality. However, this perception began to shift following Porter's seminal argument that environmental responsibility could be aligned with competitive advantage [11]. His perspective contributed to a broader re-evaluation of the role of environmental strategy in corporate performance which is a shift that underpins the growing appeal of ISO 14001. In Saudi Arabia, as in other countries with complex industrial landscapes, the implementation of ISO 14001 is particularly challenging for high-impact sectors such as manufacturing, chemicals, mining, and agriculture [12]. Nonetheless, the standard's flexible design allows both large firms and small and medium-sized enterprises (SMEs) to adopt tailored EMS models suited to their resource capabilities [13]. Certification also enables firms to communicate environmental accountability to key stakeholders, including regulators, customers, and investors. Yet skepticism remains, particularly around the cost-effectiveness of certification [14]. This skepticism is more pronounced in emerging economies, where regulatory infrastructures are still developing, and firms often operate under tighter resource constraints. While proponents of ISO 14001 argue that certification enhances environmental and operational efficiency [15], critics question its substantive impact, citing the absence of mandatory performance targets and the potential for superficial compliance [25]. Others note that for firms with pre-existing EMSs, the added value of certification may be limited, especially given the administrative burden associated with implementation [16, 17]. Consequently, it is crucial to empirically examine whether ISO 14001 delivers the promised performance outcomes, particularly in Saudi Arabia where empirical data remain scarce. ISO 14001 standards can be broadly categorized into two dimensions: organizational evaluation and product/process evaluation. The former includes internal audits, EMS structuring, and performance monitoring mechanisms designed to improve environmental governance. The latter focuses on assessing product characteristics, lifecycle impacts, and labelling. By concentrating on organizational-level EMS frameworks, this study evaluates how EMS design and certification affect firm performance in environmental and operational domains. Drawing on field studies, survey data, and engagement with industry practitioners, this research adopts a practical and inclusive definition of EMS as a formalized system comprising procedures, training protocols, monitoring processes, and internal reporting mechanisms [18]. EMSs serve as internal guidelines for incorporating environmental goals into pollution management, process design, and strategic planning. External communication methods

like sustainability reports boost stakeholder confidence and firm transparency. ISO 14001 encourages continual improvement via a structured, process-oriented approach rather than mandating environmental outputs [7]. Policy formulation, legal compliance, resource allocation, training, stakeholder involvement, and periodic review are its core principles [19]. ISO 14001 uses these aspects to improve operational and environmental performance. Theoretically, ISO 14001 has performance benefits, but institutional support and legal frameworks are still evolving. This study adds to knowledge by examining how ISO 14001 certification affects Saudi Arabian enterprise environmental and operational performance. This addresses a knowledge gap and offers statistics to help corporations, lawmakers, and sustainability specialists align environmental management with strategic business goals.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. Principles of EMS

Organizations may identify, monitor, regulate, and constantly improve their environmental performance with the use of an Environmental Management System (EMS), which offers a systematic and organized framework. Ensuring adherence to environmental legislation and cultivating an organizational culture of proactive environmental stewardship are its two main goals [19]. The purpose of compliance-oriented elements of an EMS is to assist businesses in fulfilling their legal and regulatory responsibilities in order to prevent fines, interruptions to business operations, or damage to their reputation. In addition to promoting voluntary and creative environmental practices that seek to lessen ecological consequences through tactics like resource efficiency, waste reduction, emissions management, and cleaner manufacturing processes, EMSs also support regulatory alignment [20]. Even while EMS is becoming more widely used across sectors, there is still a dearth of empirical studies evaluating its efficacy and practical use [21]. While there is currently a dearth of thorough, cross-sectoral data, especially in emerging economies, several research concentrate on theoretical advantages or case-specific results. Although there were EMS principles before official standardization, the 1996 release of ISO 14001 was a turning point since it provided an internationally accepted framework that standardized EMS activities and established a standard for certification and benchmarking. In addition to formalizing EMS standards, the ISO 14001 standard pushed businesses to include environmental goals into strategic decision-making. However, there is still a lack of knowledge on the precise elements that affect EMS effectiveness, including organizational culture, leadership dedication, staff engagement, industry traits, and regulatory settings [22]. Furthermore, further research is required to determine the specific circumstances in which EMSs result in quantifiable enhancements in operational and environmental results. More empirical research is necessary to elucidate the mechanisms through which EMS implementation drives performance and to identify best practices that can be replicated across sectors and regions as environmental pressures increase globally and expectations surrounding corporate sustainability change.

2.2. Strategic EMS Framework

This study begins with the premise that ISO 14001 certification reflects a systematic approach to environmental management, wherein the adoption of an EMS is essential for improving both environmental performance and operational efficiency. In the context of Saudi Arabia's oil and gas sector an industry that faces heightened environmental scrutiny and operational complexity EMS implementation carries significant strategic implications. The first dimension of this research investigates the influence of EMS on operational performance indicators. Plant-level experts were consulted to evaluate the impact of EMS on key performance metrics, including lead time, product quality, cost efficiency, and customer value factors that collectively contribute to competitive advantage. Additional variables considered in the analysis include corporate reputation, product and service innovation, waste reduction, and the perceived balance between the costs and benefits of environmental initiatives. An EMS enables organizations to monitor, control, and improve environmental performance in accordance with established policies, objectives, and performance targets.

To capture the variation in EMS maturity, **the study categorizes firms into three distinct states:**

1. Firms with no formal EMS.
2. Firms with a formal EMS, but without ISO 14001 certification.
3. Firms with a certified EMS in accordance with ISO 14001 standards.

These three stages reflect a continuum of environmental system development. Progression from informal to formal and ultimately to certified

EMS is expected to yield incremental gains in performance, assuming the benefits of each stage outweigh the associated implementation costs. Certification is particularly anticipated to enhance system standardization, documentation, and overall effectiveness. **Based on this rationale, the following hypothesis is proposed**

H1: Operational performance is lowest in firms without a formal EMS, improves to a moderate level with the adoption of a formal EMS, and is highest in firms with ISO 14001-certified EMS.

The second analytical dimension of the study focuses on environmental strategies adopted by firms to reduce emissions and enhance sustainability. Within the oil and gas industry where environmental risk management is both a regulatory requirement and a strategic imperative managers have access to a wide range of environmental initiatives. These range from simpler end-of-pipe solutions, such as recycling and waste separation, to more advanced options like product or process redesign and forming inter-organizational alliances. The complexity of these strategies varies, with some requiring internal coordination and others demanding cross-boundary collaboration. Drawing on earlier frameworks developed by Cascio and GEMI [22], the study posits that EMS implementation facilitates a more integrated and proactive environmental strategy across all stages of the production lifecycle, including raw material sourcing, operational processes, and product distribution. **Accordingly, the second hypothesis is formulated as follows**

H2: The adoption of environmental strategies is lowest in firms without a formal EMS, increases in firms with a formal EMS, and is highest in firms with ISO 14001-certified EMS.

These two hypotheses serve as the foundation for the empirical investigation, allowing for the evaluation of how varying levels of EMS implementation affect both performance outcomes and the breadth of environmental strategies pursued by oil and gas firms operating in Saudi Arabia.

2.3. Other Key Influencing Elements

While the primary focus of this study is on the relationship between EMS maturity and firm performance, it also accounts for three contextual factors that may influence these outcomes. **These include** (1) the age of the EMS, (2) the availability of organizational resources, and (3) the firm's ownership structure. Each is considered for its potential role in shaping both operational performance and the extent of environmental strategy adoption in Saudi Arabia's oil and gas sector.

The duration an EMS has been in place may affect how deeply environmental practices are embedded within a firm. Mature systems often facilitate the adoption of more advanced initiatives; however, diminishing returns may occur once basic improvements are exhausted. ISO 14001 may further enhance EMS effectiveness by providing structure and formalization, although the interaction between system longevity and certification remains underexplored [23]. Resource availability plays a critical role in EMS implementation and certification. Firms with greater financial and technical capacity are more likely to pursue ISO 14001, adopt a broader range of environmental strategies, and sustain continuous improvement. Certification costs typically higher than ISO 9000 can pose a barrier for resource-constrained firms [24, 25]. Moreover, well-resourced firms often benefit from reputational gains linked to proactive environmental performance [26]. Ownership form public vs. private can influence environmental priorities. Publicly traded firms may face short-term financial pressures, potentially limiting environmental investments. However, recent evidence suggests that strong environmental performance can enhance shareholder value, with market actors increasingly considering sustainability in investment decisions [27, 28]. This study includes ownership structure as a moderating factor in analyzing EMS-related outcomes.

3. METHODOLOGY OF THE STUDY

This study employs a quantitative, survey-based research design to investigate the relationship between EMS maturity and firm-level performance within Saudi Arabia's oil and gas sector. The primary aim is to assess how EMS implementation and ISO 14001 certification influence operational outcomes and the adoption of environmental strategies. A structured questionnaire was developed to gather data on environmental practices, EMS characteristics, and organizational factors. The survey instrument consisted of five sections. The first section collected demographic and professional information from respondents, including their roles and involvement in environmental initiatives. The second section captured characteristics of the business unit, such as product type, operational uncertainty, and current quality and environmental certifications. The third section examined the influence of ISO/QS 9000 certification, while the fourth focused on respondents' familiarity with ISO 14001 and the drivers of its adoption. The final section assessed the effectiveness and efficiency of the EMS in place and the range of environmental strategies employed. Data

collection followed the modified Dillman survey methodology [29] and was conducted in three waves. A total of 310 completed responses were obtained, forming the basis of the final sample. Although the response rate was relatively modest, the managerial roles of respondents and the diversity of participating firms support the credibility and relevance of the data. Follow-up communications with non-respondents revealed that survey length was a common deterrent, though no evidence of response bias was found between early and late respondents. Four independent variables were examined.

The first was EMS maturity, categorized into three levels (1) no formal EMS (EMS1), (2) a formal EMS without certification (EMS2), and (3) an EMS certified under ISO 14001 (EMS3). The second variable was EMS age, measured in years (YEARS), indicating how long the EMS had been operational. The third was resource availability, proxied by firm sales (SALES), and categorized into quartiles. The fourth variable was ownership structure (PUBLIC), a binary measure identifying whether a firm was publicly traded (1) or privately held (0). Two sets of dependent variables were used. The first assessed the perceived impact of environmental initiatives on ten aspects of operational performance, such as cost, lead time, product quality, market reputation, and international competitiveness. Responses were recorded on an 11-point Likert scale from 0 ("Strongly Disagree") to 10 ("Strongly Agree"). The second set evaluated the extent to which 16 environmental strategies were considered by the firm, ranging from basic waste reduction to complex initiatives like alliances and product redesign. These were also rated on an 11-point scale from 0 ("Never Considered") to 10 ("Always Considered"). Data analysis was conducted in four steps. First, normality checks were performed on all variables. Second, standard diagnostics confirmed the suitability of the data for Ordinary Least Squares (OLS) regression analysis. Third, analysis of variance (ANOVA) was used to test for significant main effects across EMS categories. Finally, multiple regression models were specified and tested based on the ANOVA results to assess the influence of EMS maturity and contextual variables on both operational performance and environmental strategy adoption.

4. RESULT AND DISCUSSION

To ensure sectoral relevance, the study specifically targeted oil and gas companies operating in Saudi Arabia. Respondents were asked to describe the primary outputs of their facilities, which were categorized according to Standard Industrial Classification (SIC) codes. Of the total 310 valid responses, 276 (89.0%) were drawn from core oil and gas-related SICs, while the remainder were excluded due to their limited alignment with the environmental scope of this study. The final analysis, therefore, focused exclusively on these 276 firms, allowing for precise examination of EMS practices in a sector characterized by significant environmental risk and operational complexity.

4.1. Effects of EMS on Operational Performance

The primary aim of this research was to assess how different stages of EMS maturity ranging from informal systems to ISO 14001 certification affect corporate performance metrics in the Saudi oil and gas sector. A series of full factorial ANOVAs were conducted to explore preliminary differences, followed by regression analysis using a main-effects model for interpretive clarity. As shown in Table 1, the ANOVA results revealed statistically significant effects of EMS status on all ten performance variables. These include operational cost reduction (COST), lead time (LT), product quality (QUAL), market position (POS), and corporate reputation (REP). Notably, higher-order interactions were mostly insignificant, reinforcing the decision to retain only main effects in the final regression models.

Table 1: ANOVA Results for Performance Variables.

Performance Variable	F-statistic	Significant Interactions
COST	6.45**	0
LT	3.95**	0
QUAL	5.80**	0
POS	7.20**	0
REP	14.50**	0
PRODS	5.75**	0
WPROD	8.50**	0
WEQIP	6.90**	0
BENE	8.30**	0
INTER	9.05**	0
**significant at <0.01 level		

To explore these effects more precisely, we specified regression models incorporating EMS state, resource levels, ownership structure, and EMS age as independent variables. As summarized in Table 2, both EMS2 (formal EMS without certification) and EMS3 (certified EMS) were statistically significant predictors across all ten performance indicators. The average impact coefficient was 1.29 for EMS2 and 2.44 for EMS3, indicating a substantial improvement in performance when transitioning from informal systems to certified EMS frameworks.

Table 2: Regression Results for Performance Variables (N = 276).

Factor	COST	LT	QUAL	POS	REP	PRODS	WPROD	WEQIP	BENE	INTER
EMS2	1.30**	0.80**	0.85**	1.10**	2.15**	0.85**	1.85**	1.30**	1.60**	1.30**
EMS3	2.50**	1.90**	0.95**	1.20**	3.95**	1.25**	2.90**	2.80**	2.80**	3.55**
SALES4	n.s.	n.s.	n.s.	n.s.	0.55*	n.s.	n.s.	n.s.	n.s.	n.s.
PUBLIC	0.45**	0.40**	0.55**	0.35*	0.60**	n.s.	n.s.	0.45**	0.40**	0.25**
YEARS	n.s.	n.s.	n.s.	n.s.	0.30	n.s.	n.s.	n.s.	0.30	n.s.
Note: ***p < 0.01, **p < 0.05; n.s.= not significant.										

The findings provide strong support for Hypothesis 1, suggesting that firms with a certified EMS experience superior operational performance across a wide range of metrics. These outcomes affirm the EMS's role as a strategic resource, particularly in sectors like oil and gas where regulatory scrutiny and operational efficiency are critical.

4.2 Effects of EMS on Environmental Strategy Adoption

The second objective of the study was to evaluate how EMS maturity influences the range and frequency of environmental options adopted by firms. As shown in Table 3, ANOVA results confirmed that EMS state significantly influenced all 16 environmental strategy variables.

Table 3: ANOVA Results for Environmental Options

Environmental Option	F-statistic	Significant Interactions
PROD	6.50**	0
PROC	11.30**	0
DIS	5.75**	1
SUB	8.80**	0
REDUC	10.75**	0
RECYC	4.00**	0
REBLD	4.50**	0
REMAN	3.75**	0
CONSM	4.90**	1
ROLN	3.80**	0
RECPK	5.20**	0
SPRED	3.20**	0
CREAT	5.75**	0
SEG	7.80**	0
RELOC	6.00**	0
ALL	10.50**	0

While EMS maturity significantly influenced environmental strategy adoption overall, the distinction between EMS2 and EMS3 was statistically significant in only six of the 16 options. These were primarily reactive strategies such as waste segregation (SEG), remanufacturing (REMAN), and creating markets for waste (CREAT). This suggests that ISO 14001 certification may be particularly effective in raising awareness and improving documentation and handling of waste streams, but less influential in prompting proactive innovations such as product redesign (PROD) or process substitution (SUB). Interestingly, EMS age (YEARS) was a more consistent predictor of strategy adoption, significantly influencing ten out of the sixteen environmental options. This finding supports the view that sustained engagement with EMS practices allows firms to move beyond compliance and explore a wider range of sustainability initiatives. Hence, while certification may enhance performance, it is EMS longevity that appears to deepen the scope of environmental commitment.

5. THEORETICAL AND PRACTICAL IMPLICATIONS

This study provides meaningful contributions to both theory and practice within the field of environmental management. From a theoretical standpoint, the findings support and extend the resource-based view (RBV) of the firm by positioning EMS particularly ISO 14001-certified systems as strategic assets that enhance operational and environmental performance. The results affirm that EMS maturity not only reflects internal capability but also fosters continuous improvement, coordination, and learning across organizational functions. Moreover, the positive influence of EMS age on the adoption of environmental strategies underscores the importance of institutional learning and path

dependency in shaping sustainability practices over time. Additionally, this research contributes to the evolving literature on EMS effectiveness by differentiating between the impacts of informal, formal, and certified systems. By doing so, it challenges the notion that ISO 14001 certification is merely symbolic, instead demonstrating its substantial operational value. The distinction between EMS levels adds depth to our understanding of environmental governance and opens avenues for refining performance-based environmental theories. On a practical level, the study offers evidence-based insights for corporate decision-makers in the oil and gas sector. The results highlight the performance-enhancing value of ISO 14001 certification, particularly in areas such as cost reduction, waste minimization, lead time efficiency, and product quality. For practitioners, these findings suggest that investment in formalizing and certifying EMS can yield both environmental and economic benefits. Moreover, the study emphasizes that while certification provides structure and legitimacy, long-term experience with EMS is essential for cultivating broader environmental practices. Policymakers and industry regulators may also benefit from this research, as it underscores the role of EMS in aligning corporate behaviour with environmental standards and national sustainability goals, especially in environmentally sensitive sectors like oil and gas.

6. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Despite its contributions, this study is subject to several limitations. First, the data was collected through self-reported measures, which, while useful for capturing managerial insights, may introduce perceptual bias or subjectivity. Although experts were targeted to improve the validity of responses, future studies should consider incorporating objective environmental performance indicators such as emissions data, energy consumption, or waste treatment records. Second, the sample is limited to 310 oil and gas firms in Saudi Arabia. While this provides a focused sectoral lens, it may constrain the generalizability of findings to other industries or regions. Future research could adopt a comparative approach by examining how EMS performance relationships vary across sectors with different regulatory pressures or environmental exposures.

Third, the study employed traditional regression and ANOVA-based techniques to assess relationships. Although appropriate for the research questions, more advanced statistical methods such as structural equation modelling (SEM) or robust path analysis could uncover deeper causal relationships and interdependencies among variables. These methods may also help in modelling mediating or moderating effects more accurately. In terms of future research opportunities, several directions emerge. First, further studies could explore how external factors such as regulatory environment, market orientation, and supply chain collaboration influence the relationship between EMS and firm performance. Second, given the dynamic nature of ISO 14001 adoption, longitudinal studies could assess how these relationships evolve over time. Third, researchers should examine whether ISO 14001 adequately captures all critical dimensions of an effective EMS or whether alternative standards or internal frameworks better reflect environmental best practices. Finally, future work could investigate how organizational culture, leadership commitment, and employee engagement interact with EMS maturity to influence environmental strategy adoption and performance outcomes.

7. CONCLUSION

This study set out to examine the operational and strategic implications of adopting formal and certified EMS in Saudi Arabia's oil and gas sector. The findings confirm that EMS maturity especially ISO 14001 certification has a significant and positive impact on both operational performance and the adoption of environmental strategies. Firms with certified EMS reported improvements in cost control, product quality, waste reduction, and lead time efficiency. Certification was also associated with a broader, though largely reactive, set of environmental practices. Importantly, the study reveals that EMS age, reflecting the depth of system experience, plays a critical role in driving proactive and diverse environmental initiatives. These insights emphasize that while ISO 14001 certification provides valuable structure, the real benefits of EMS come from long-term integration into corporate operations and strategy. The study reinforces the view that EMS is not merely a compliance mechanism, but a strategic resource that supports organizational sustainability and competitiveness in environmentally sensitive industries. As such, it offers a compelling case for firms particularly in the oil and gas sector to invest in the development, formalization, and continual refinement of their environmental management systems.

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REFERENCES

A. C. Brouwer and C. S. A. (Kris) van Koppen, "The soul of the machine: continual improvement in ISO 14001," J Clean Prod, vol. 16, no. 4, pp. 450–457, Mar. 2008, doi: 10.1016/J.JCLEPRO.2006.08.022.

A. Camilleri, "The rationale for ISO 14001 certification: A systematic review and a cost–benefit analysis," Corp Soc Responsib Environ Manag, vol. 29, no. 4, pp. 1067–1083, 2022.

Arocena, R. Orcos, and F. Zouaghi, "The impact of ISO 14001 on firm environmental and economic performance: The moderating role of size and environmental awareness," Bus Strategy Environ, vol. 30, no. 2, pp. 955–967, 2021.

Aldrighetti, D. Battini, A. Das, and M. Simonetto, "The performance impact of Industry 4.0 technologies on closed-loop supply chains: insights from an Italy based survey," Int J Prod Res, vol. 61, no. 9, pp. 3004–3029, 2023.

Alrashoud and K. Tokimatsu, "An exploratory study of the public's views on residential solar photovoltaic systems in oil-rich Saudi Arabia," Environ Dev, vol. 35, p. 100526, 2020.

A. Melnyk, R. P. Sroufe, and R. Calantone, "Assessing the impact of environmental management systems on corporate and environmental performance," Journal of operations management, vol. 21, no. 3, pp. 329–351, 2003.

C. Esty and A. Winston, Green to gold: How smart companies use environmental strategy to innovate, create value, and build competitive advantage. John Wiley & Sons, 2009.

Clendenning, D. R. Field, and D. Jensen, "A survey of seasonal and permanent landowners in Wisconsin's northwoods: following Dillman and then some," Soc Nat Resour, vol. 17, no. 5, pp. 431–442, 2004.

Dietz, L. Biber-Freudenberger, L. Deal, and J. Börner, "Is private sustainability governance a myth? Evaluating major sustainability certifications in primary production: A mixed methods meta-study," Ecological Economics, vol. 201, p. 107546, 2022.

D. López-Gamero, J. F. Molina-Azorín, and E. Claver-Cortés, "The whole relationship between environmental variables and firm performance: Competitive advantage and firm resources as mediator variables," J Environ Manage, vol. 90, no. 10, pp. 3110–3121, 2009.

El-Gayar and B. D. Fritz, "Environmental management information systems (EMIS) for sustainable development: a conceptual overview," Communications of the Association for Information Systems, vol. 17, no. 1, p. 34, 2006.

E. Rees, "Achieving sustainability: reform or transformation?" in The Earthscan reader in sustainable cities, Routledge, 2021, pp. 22–52.

F. Waxin, S. L. Knuteson, and A. Bartholomew, "Outcomes and key factors of success for ISO 14001 certification: Evidence from an emerging Arab Gulf Country," Sustainability, vol. 12, no. 1, p. 258, 2019.

Forza, "Survey research in operations management: a process□based perspective," International journal of operations & production management, vol. 22, no. 2, pp. 152–194, 2002.

G. M. Yang, P. Hong, and S. B. Modi, "Impact of lean manufacturing and environmental management on business performance: An empirical study of manufacturing firms," Int J Prod Econ, vol. 129, no. 2, pp. 251–261, 2011.

G. M. Yang, P. Hong, and S. B. Modi, "Impact of lean manufacturing and environmental management on business performance: An empirical study of manufacturing firms," Int J Prod Econ, vol. 129, no. 2, pp. 251–261, 2011.

Hristov, A. Appolloni, A. Chirico, and W. Cheng, "The role of the environmental dimension in the performance management system: A systematic review and conceptual framework," J Clean Prod, vol. 293, p. 126075, 2021.

Javaid, A. Haleem, R. P. Singh, R. Suman, and E. S. Gonzalez, "Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability," Sustainable Operations and Computers, vol. 3, pp. 203–217, 2022.

Johnstone, "The means to substantive performance improvements–environmental management control systems in ISO 14001–certified SMEs," Sustainability Accounting, Management and Policy Journal, vol. 13, no. 5, pp. 1082–1108, 2022.

K. Farlow, Promotion to Fire Officer: EMS is an Essential Component of Promotional Testing. Walden University, 2023.

Knekta, C. Runyon, and S. Eddy, "One size doesn't fit all: Using factor analysis to gather validity evidence when using surveys in your research," CBE—Life Sciences Education, vol. 18, no. 1, p. rm1, 2019.

M. Granly and T. Welo, "EMS and sustainability: experiences with ISO 14001 and Eco-Lighthouse in Norwegian metal processing SMEs," J Clean Prod, vol. 64, pp. 194–204, 2014.

M. Erceg-Hurn and V. M. Mirosevich, "Modern robust statistical methods: an easy way to maximize the accuracy and power of your research.," American Psychologist, vol. 63, no. 7, p. 591, 2008.

M. Erceg-Hurn and V. M. Mirosevich, "Modern robust statistical methods: an easy way to maximize the accuracy and power of your research.," American Psychologist, vol. 63, no. 7, p. 591, 2008.

M. Bradburn, S. Sudman, and B. Wansink, Asking questions: the definitive guide to questionnaire design--for market research, political polls, and social and health questionnaires. John Wiley & Sons, 2004.

Maksimovic and G. Phillips, "The market for corporate assets: Who engages in mergers and asset sales and are there efficiency gains?" J Finance, vol. 56, no. 6, pp. 2019–2065, 2001.

Poksinska, J. Jörn Dahlgaard, and J. A. E. Eklund, "Implementing ISO 14000 in Sweden: motives, benefits and comparisons with ISO 9000," International Journal of Quality & Reliability Management, vol. 20, no. 5, pp. 585–606, 2003.

Pezzoli, "Environmental management systems (EMSs) and regulatory innovation," Cal. WL Rev., vol. 36, p. 335, 1999.

Porter, "America's green strategy", Scientific American, April, p. 168," 1991.

Rondinelli and G. Vastag, "Panacea, common sense, or just a label? The value of ISO 14001 environmental management systems," European Management Journal, vol. 18, no. 5, pp. 499–510, 2000.

S. Kristensen, M. A. Mosgaard, and A. Remmen, "Integrating circular principles in environmental management systems," J Clean Prod, vol. 286, p. 125485, 2021.

Salim and S. F. Ismail, "ISO Certifications and Sustainable Fashion Practices in Malaysia: A Legal Perspective," IIUMLJ, vol. 32, 2024.

Sharma and H. Vredenburg, "Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities," Strategic management journal, vol. 19, no. 8, pp. 729–753, 1998.

S. Ong, A. S. Lee, B. Latif, R. Sroufe, A. Sharif, and B. Heng Teh, "Enabling green shared vision: linking environmental strategic focus and environmental performance through ISO 14001 and technological capabilities," Environmental Science and Pollution Research, vol. 30, no. 11, pp. 31711–31726, 2023.

U. Ojiako, H. Bashir, H. H. B. Almansoori, E. J. H. AlRaeesi, and H. A. Al Zarooni, "Using ISO 14001 certification to signal sustainability equivalence: an examination of the critical success factors," Production Planning & Control, pp. 1–28, 2024.

Wang, X. Jiang, and M. B. Khaskheli, "The Role of Technology in the Digital Economy's Sustainable Development of Hainan Free Trade Port and Genetic Testing: Cloud Computing and Digital Law," Sustainability, vol. 16, no. 14, p. 6025, 2024.

Vittinghoff, D. V Glidden, S. C. Shiboski, and C. E. McCulloch, Regression methods in biostatistics: linear, logistic, survival, and repeated measures models. Springer Science & Business Media, 2012.

Zutshi and A. Sohal, "A study of the environmental management system (EMS) adoption process within Australasian organisations—2. Role of stakeholders," Technovation, vol. 24, no. 5, pp. 371–386, 2004.