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Significance of sustainable management practices and policy robustness in achieving carbon neutrality in KSA and UAE

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ABSTRACT

Countries are under significant pressure from climate change due to high levels of carbon emissions, and they are working towards carbon neutrality (CN). This is particularly relevant for Saudi Arabia and the United Arab Emirates, which heavily rely on fossil fuels. Therefore, this study aims to suggest solutions for these countries. Specifically, it examines how sustainable management practices (SMP) impact CN. Additionally, it explores the moderating role of strong policies in the relationship between SMP and CN. To strengthen the study's findings, data were collected from 795 respondents across 244 firms in industries like oil, gas, iron, and copper extraction, selected based on their carbon emissions and potential for adopting sustainable practices. Using ordinary least squares regression, the study found that SMP has a significant positive effect on CN. Moreover, strong policies significantly enhance the relationship between sustainable practices and CN in both countries. Policymakers are encouraged to reinforce environmental regulations and offer incentives for adopting green technologies and practices. Effective policies can ensure the consistent use of SMP, leading to a significant reduction in carbon emissions.

1. Introduction

The biggest problem facing humanity right now is climate change. It's a serious issue because we can see extreme changes in the weather and the environment getting worse, which could be bad for our future (La Sorte et al., 2021). This shows that we must do everything we can to make sure things stay good in the long run, no matter what it costs. The built environment, comprising structures, transportation networks, infrastructure, and other anthropogenic elements in our vicinity, accounts for over 50% of the annual global extraction of materials and constitutes a substantial source of GHG emissions (Pauliuk et al., 2021). In 2015, the emissions of carbon dioxide (CO_2) resulting from the construction and operation of buildings accounted for 38 percent (13.1 gigatons) of the total world energy-related emissions (Saradara et al., 2023). To address climate change and its harmful effects, in December 2015, world leaders at the United Nations Climate Change Conference (COP21) in Paris committed to significantly reducing global greenhouse gas (GHG) emissions. Their goal was to limit the increase in global temperature to 2 °C this century, with efforts to keep the rise below 1.5 °C, and to provide financial support to developing countries for climate change mitigation, resilience strengthening, and adaptation. By 2020, CO_2 emissions in this sector had decreased by about 10 percent, totaling 11.7 gigatons. This reduction was largely due to decreased energy consumption caused by the COVID-19 pandemic, which lowered energy demand. Efforts to reduce carbon emissions in the power sector also contributed. Therefore, it is crucial to rapidly and significantly cut GHG emissions (Rajamani, 2016; Saradara et al., 2023).

The Gulf Cooperation Council (GCC) countries rely heavily on oil and gas exports as their main source of income. According to the British Petroleum Statistical Review of World Energy for 2020, these countries hold approximately 30.5% of the world's proven oil reserves and 19.6% of proven gas reserves. Domestic energy prices in these countries are among the lowest in the world, leading to high levels of energy consumption, which shapes their economic structure and negatively impacts the environment.

Saudi Arabia faces significant environmental challenges due to high carbon emissions, which

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contribute greatly to air pollution and climate change. In 2022, it emitted 608 million standard cubic meters of carbon, which has severe effects such as desertification, loss of biodiversity, and health problems for its population. Therefore, effective measures are urgently needed to address these environmental impacts.

The United Arab Emirates (UAE) faces challenges in its goal to achieve carbon neutrality. Despite its ambitious Net Zero 2050 Strategy, the country's heavy reliance on fossil fuels makes transitioning difficult. Current trends suggest that the UAE may struggle to meet its targets, potentially causing emissions to increase rather than decrease. Climate Action Tracker has rated the UAE's climate change policies as "critically insufficient," indicating the need for stronger measures to achieve the 1.5°C target.

The UAE's new Energy Strategy 2050 aims to achieve 30% clean energy by 2030, but the country still has a significant dependence on fossil fuels. Efforts towards carbon capture and storage (CCS) remain limited, addressing only a small portion of emissions. Although targets have been set for sectors such as electricity to become zero-emitting by 2050, many obstacles exist due to the high current levels of emissions. To move forward, the UAE must diversify its economy away from oil, improve transparency in emission reporting, and significantly increase investments in renewable energy and technologies that reduce or remove emissions.

Several studies have also investigated potential strategies for decarburization, presenting various approaches for different industries and areas. Rana et al. (2023) and Suberu et al. (2014) detailed the deployment of renewable energy technologies, the need to incorporate solar and wind energy, and the progress in battery storage to enforce the reliability of the grid and decrease emissions of greenhouse gases. Likewise, Jacobson et al. (2017) stated a complete transition to 100% renewable energy by 2050, urging a global shift towards wind, water, and solar energy, stressing their effectiveness and advantages in the global economy. CC technologies are defined by Omoregbe et al. (2020) and present how CCS technology may help to minimize emissions from industrial processes and fossil fuel power plants. They point out that the idea of how to upscale these technologies requires the support of governments and the collaboration of the global community. Concerning the transport sector, Zhang et al. (2021) described the strategy of electrification of transport using electric vehicles and the formulation of SU-Mobility plans, revealing significant emission level reductions when the two strategies are applied jointly. There are also good mitigation opportunities in buildings. In the study of Elnabawi et al. (2024), the possibilities for creating energy-efficient buildings and constructing suggestions about passive solar warmth and cooling and using superior insulation in efficiency are acknowledged. In addition, Hepburn et al. (2020) underscored the chief role of policy support in the advancement of sustainable initiatives by laying down the role of carbon price mechanisms and subsidies in the advancement of technology for achieving carbon neutrality (CN).

However, it is evident that the issue of carbon emissions remains unresolved, particularly in countries reliant on fossil fuels. Moreover, the absence of studies utilizing data from Saudi Arabia and the UAE to understand how management variables can be leveraged to meet CN targets is a significant research gap. Therefore, this study endeavors to address these crucial gaps. The study's primary contributions are as follows: Firstly, it examines the impact of sustainable management practices (SMP) on the CN of Saudi Arabia and the UAE. These practices, including optimizing resource efficiency, adopting renewable energy sources, and implementing circular economy principles, have been shown to significantly enhance CN by reducing greenhouse gas emissions and promoting eco-friendly operations (Geissdoerfer et al., 2020). Effective policy frameworks and organizational commitment are pivotal for achieving these outcomes. Secondly, it investigates how policy robustness (PR) can moderate the relationship between SMP and CN. PR can play a crucial role in this relationship by ensuring consistent regulatory frameworks, incentivizing green innovations, and mitigating risks associated with policy changes (Udeagha and Ngepah, 2023). Effective policies can strengthen firms' commitment to sustainability, thereby amplifying their impact on emission reductions. Thirdly, it compares the impact of SMP on CN in Saudi Arabia and the UAE. This comparative analysis will enable these countries to identify their respective areas of improvement and enhance their policies to achieve CN.

The current study has the following main objectives based on the above discussion. 1) To evaluate the Impact of SMP on CN in Saudi Arabia and UAE. 2) To examine the Moderating Role of PR on the Relationship Between SMP and CN. 3) To compare the Impact of SMP on CN Between Saudi Arabia and UAE.

The structure of this paper is designed to guide the reader through the research process. Section two provides a comprehensive literature review, setting the context for the study. Section three details the data and methodology used, ensuring transparency and reproducibility. In section four, the results are presented and discussed, with comparisons to previous studies and a detailed analysis of the findings. Finally, section five concludes the paper, offering policy recommendations based on the study's findings and acknowledging the limitations of the research.

2. Literature review

2.1. Sustainable management practice and CN

There is extensive literature on how key management concepts and practices are effective in

the fight toward achieving CN. Some are energy and emission saving, application and promotion of renewable power sources, utilization of waste materials, and responsible supply chain management. Energy efficiency is the basis of achieving a modified carbon footprint in numerous businesses and organizations. Global climate goals can be met through enhanced energy efficiency, which also comprises more than 40% of the emission cuts, according to the International Energy Agency. Organizations that adopt energy-efficient systems save energy and operational costs when conducting their business activities; this is both energy and economic (Rosenow and Bayer, 2017). The adoption of renewable energy is another significant factor. Shifting from fossil fuel-based energy systems to wind/solar or hydropower-based energy systems drastically reduces carbon dioxide emissions. According to Mazzucato and Semieniuk (2018), investment in renewable energy has picked up in the recent past, led by policies and technologies. The adoption of renewable energy in organizations leads to the realization of a considerable decrease in carbon footprints, thus playing a central role in CN agendas.

Waste management is also a good practice for the reduction of waste, which is under the sustainable management system. The policies of circular economy, which stress incremental recycling and reusing and thus reduce the disposal of waste or the extraction of raw materials, entail a significant reduction of emissions on waste disposal and raw material extraction. Ghisellini et al. (2016) pointed out that circular economy management can contribute to the effective cutting of industrial carbon emissions, as indicated by the fact that it can cut emissions by 30%. Various practices related to sustainable supply chain management (SSCM) have been considered about CN. The acronym for the strategy is SSCM, which entails using sustainable practices within the supply chain, product acquisition, and distribution. Other research by Seuring and Müller (2008) suggested that SSCM helps decrease environmental effects while at the same time improving the reputation and competitive position of a company. Organizations implementing SSCM best practices have found lower carbon emissions in their operations, which affects other carbon reduction goals (Kumar and Rahman, 2015). In addition, sustainable management strategies require precise monitoring and systematic preparation of carbon outputs. Applicable international standards, including ISO 14001 and the Greenhouse Gas Protocol, are useful in comprehensively identifying and quantifying an organization's emissions, as well as in offering guidelines on how emissions can be controlled or mitigated. These standards include the best practices in disclosure and overcoming the shortfalls related to carbon management in organizations that aspire to CN (Schaltegger et al., 2012).

Wei et al. (2022) reviewed policy and management priorities of carbon peaking and neutrality, aiming at multi-stakeholder integrated management priorities. Hou et al. (2022) are concerned with the application of green management for papers, and the results evidence that environmental initiatives are positively associated with carbon results due to decreasing emissions and increasing resource utilization. In the same vein, Liu et al. (2024) examined the aluminum sector in China, stressing that sustainable management policies, for instance, carbon-neutral processes, enhance sustainable performance and correlate industry practices with the CN goals of the country. Koh et al. (2023) extend this discussion and argue that there are many wider considerations of sustainable Supply Chain Management where supply chains have a critical part to play in producing net zero carbon economies. Some scholars advocate that supply chain management, by ensuring that the flows are crafted efficiently and that communication and coordination among the different players in the network is encouraged, forms one of the fundamental building blocks of controlling overall carbon emissions. Altogether, these works stress the necessity of the connection and interdependence of sustainable management within different sectors to achieve carbon-neutral results, thereby proving the fact that the strategies of each certain sector must be included in the general approach to the global carbon reduction problem.

2.2. Moderating role of PR

The combination of sustainability management and the goal of achieving CN is affected by many factors, including the degree to which environmental policies are well-developed and enforced. Because of this, there is a need for policies that are well structured, comprehendible, and firm to boost the prospects of sustainable practices on the route towards CN. Policy consistency or rigidity makes for better policy formulation as they are not only effective but also practical, and this gives stability to policies. Adopting SMP requires a conducive environment, which is provided for by sound policies. According to Delmas and Toffel's (2008) study respondents, higher environmental regulation pressures frequently compel companies to be more innovative and continuous in applying sustainable measures than lower pressures do. It may encompass provisions like reporting requirements, efficiency benchmarks, and even reward structures that seek to influence an organization's efforts toward lowering its environmental impact. An example of the effects of sound policies is the development of renewable energy. As stated by Lüthi and Prässler (2011), countries whose policy for renewable energy is clear and stable have more investment in renewable technology. These policies enable investors to reduce risks down the line, hence embracing more renewable energy projects that are essential for CN.

Policy strength influences the general effectiveness of waste reduction programs.

Governments that implement strict waste management regulations compel companies to adopt circular economy principles. A study by Mathews and Tan (2011) went further to argue that the advanced economies in policies of waste recognized enhanced recycling, hence minimal overall emission of waste. These policies create a way of ensuring that companies maintain good standards in waste management, aiming at the achievement of CN. Secondly, there is an agreement that sound policies are key to efficient SSCM. To modern businesses, there is a need to have SSCM supported by regulation to ensure that everyone in the supply chain is embracing sustainability. Seuring and Müller (2008) stated that "mandatory approaches of policy frameworks to increase sustainability in the supply chain improve the sustainability performance of companies in total." Such policies ensure that suppliers and manufacturers are made accountable for their impact on the environment, hence the support for CN. Another feature is PR, which is equally important in enhancing sustainability practices' transparency and accountability. There is a sound policy that supports emission measurement and reporting with the help of standards like ISO I4001 and the Green House Gas Protocol. They provide assurance on the credibility and legitimacy of companies' reported emissions and their carbon reduction efforts, hence promoting the legitimacy of corporate sustainability (Schaltegger et al., 2012).

In summary, PR significantly moderates the relationship between SMP and CN. Through clear, stringent, and enforceable regulations, robust policies create an environment that encourages and facilitates the adoption of sustainable practices, driving organizations toward achieving CN.

3. Modeling and empirical strategy

3.1. Model

The empirical approach adopts a quantitative methods design. Variables of the study include SMP, PR, CN, and corporate social responsibility. A representative sample from diverse industries and organizational sizes in both regions is selected to capture the heterogeneity of SMP. Based on the above discussion, we have developed the following testable model of the study.

$$CN = f\,(SMP,\ PR,\ SMP \times PR,\ Sector,\ EE,\ CSR) \quad (1)$$

The econometric form of the above model is as follows:

$$CN = \alpha_0 + \alpha_1 SMP + \alpha_2 PR + \alpha_3 (SME * PR) + \alpha_4 Sector + \alpha_5 CSR + \alpha_6 EE + \varepsilon) \quad (2)$$

where, CN is carbon neutrality, SMP is sustainable management practices, PR is policy robustness, CSR is corporate social responsibility, and EE is employee experience.

3.2. Participants

The study involved an extensive data collection process targeting 795 workers across industries engaged in the extraction of natural resources, such as oil and gas, iron, and copper, in the UAE and Saudi Arabia. The primary focus of the research was on managerial-level staff within these industries, given their strategic roles in decision-making and operational oversight. The data were gathered through structured questionnaires distributed via email, ensuring a broad and representative sample across the targeted industries. The selection of firms for this study was guided by specific criteria aimed at capturing the most relevant and impactful data. Firstly, industries were chosen based on their significant contribution to carbon emissions and their pivotal role in the regional economy. The oil and gas sectors were selected due to their dominance in the UAE and Saudi Arabia's economic landscapes and their substantial environmental impact. These sectors are not only key drivers of economic growth but also major contributors to carbon emissions, making them critical areas of study for understanding the intersection of industrial practices and environmental sustainability.

Similarly, the consideration of the iron and copper industries was based on the high direct use of natural resources and the problems related to it. These industries were chosen to give a broad perspective of resource-demanding industries other than the well-known oil and gas field industries. These sectors were filtered down to firms of different sizes to get a cross-section of the large, medium, and small firms, apart from the fact that they would provide the best practices. Since data collection began in 2022, it was conducted up to 2024 to enable the adoption of a longitudinal research design to enable a time series study. Such a period is beneficial as it results in a rich dataset, with the changes in industry practices and with the effects observed in regions with active sustainability initiatives. The distribution of questionnaires through email was done to increase reach and the likelihood of responses among the target population, with the goal of making the study more reliable.

3.3. Ordinary least square (OLS)

OLS is adopted for statistical analysis of the hypothesis in the empirical setting. OLS is a fundamental class of methods used for estimating the associations between variables in statistically linear-related regression contents. OLS finds the line of best fit by establishing the least mean square residual, that is, the residual sum of squares minimized. This method could assume that the residuals (or errors) are independently distributed and normally distributed and often under the condition of homoscedasticity, meaning that they have equal variance (Montgomery et al., 2021). OLS is frequently used in linear models because of the

estimated efficiency and simplicity of the algorithm necessary to identify the coefficients R2, which is an essential foundation for econometrics and a variety of other sciences (Wooldridge, 2019). However, its accuracy is subject to a bunch of certain assumptions being violated or held constant in the process.

OLS regression relies on several key assumptions for valid and reliable results. These include linearity, where the relationship between the independent and dependent variables is linear; independence, meaning observations are independent of each other; homoscedasticity, where the variance of the errors is constant across all levels of the independent variables; no multicollinearity, implying that independent variables are not perfectly correlated; and normality, where the residuals (errors) are normally distributed. Additionally, the model assumes that there are no omitted variables that could bias the results and that the relationship between variables is correctly specified.

4. Results and discussion

4.1. Demographics

Table 1 presents the demographic information of the respondents. In the UAE and Saudi Arabia, the distribution of firms across the oil and gas, iron, and copper sectors is notably similar, with the majority in oil and gas (37%). Employee experience varies, with Saudi Arabia having a higher proportion of employees with 16 to 20 years of experience (40%) compared to the UAE (23%). This suggests a more experienced workforce in Saudi Arabia's industrial sectors.

Corporate social responsibility (CSR) policy implementation shows a significant portion of firms in both countries engaging in high CSR spending, with 49% in the UAE and 44% in Saudi Arabia, indicating a strong commitment to corporate social responsibility. Average CSR spending is higher in Saudi Arabia (32%) than in the UAE (22%), while low CSR spending is relatively balanced between the two. These results highlight the emphasis both countries place on CSR, albeit with varying degrees of investment, potentially influencing their environmental and social governance strategies.

Fig. 1 and Fig. 2 present the number of selected firms from each industry and the year of experience of the respondents, respectively.

4.2. Confirmatory factor analysis (CFA)

The results of CFA are exhibited below in Table 2. The constructs in the study show solid reliability and convergent validity. SMP and PR both display minimum loadings above the 0.72 threshold, demonstrating adequate indicator reliability. SMP, with a Composite Reliability (CR) of 0.88 and Cronbach's alpha of 0.81, and PR, with CR of 0.91 and Cronbach's alpha of 0.87, indicate high internal consistency. CN achieves the highest Average Variance Extracted (AVE) at 0.73, suggesting good construct validity, though its CR is the lowest at 0.78, indicating slightly lower reliability compared to the other constructs.

Table 1: Data and demographics of firms and employees

	UAE (n=380)		Saudi Arabia (n=415)		Total	
Sector						
Oil and gas	141	37%	155	37%	296	37%
Iron	114	30%	111	27%	225	28%
Copper	125	33%	149	36%	274	34%
Employees experience						
5 to 10 years	114	30%	103	25%	217	27%
11 to 15 years	127	33%	102	25%	229	29%
16 to 20 years	89	23%	166	40%	255	32%
21 years and above	50	13%	44	11%	94	12%
Firms sector						
Oil and gas	134	35%	155	37%	289	36%
Iron	129	34%	135	33%	264	33%
Copper	117	31%	125	30%	242	30%
CSR policy implementing firms						
Low CSR spending	107	28%	103	25%	210	26%
Average CSR spending	85	22%	131	32%	216	27%
High CSR spending	188	49%	181	44%	369	46%

CSR: Corporate social responsibility

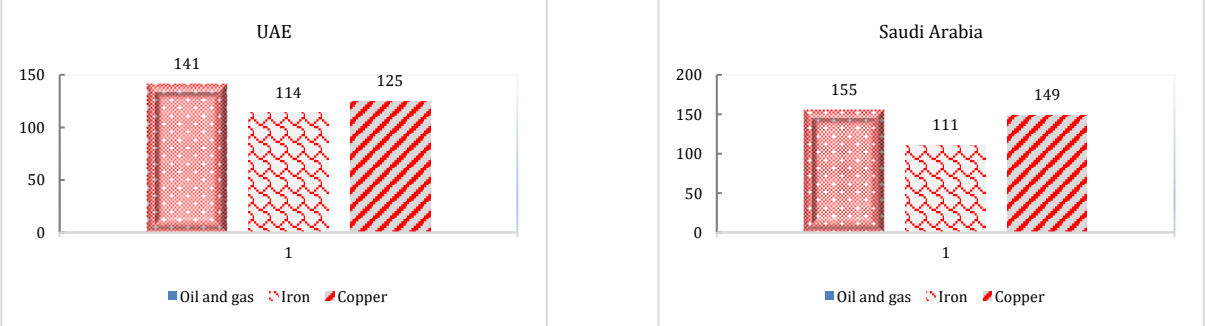

Fig. 1: Number of respondents from each sector

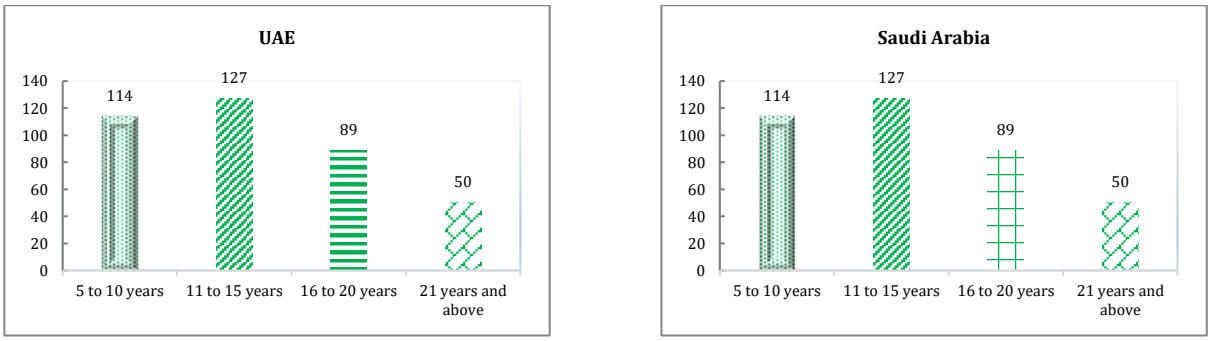

Fig. 2: Employee experience

Table 2: Confirmatory factor analysis

	Min loadings	AVE	CR	Cronbach's alpha
SMP	0.72	0.54	0.88	0.81
PR	0.69	0.55	0.91	0.87
CN	0.66	0.73	0.78	0.82

Min loadings: Minimum loadings; AVE: Average variance extracted; CR: Composite reliability; SMP: Sustainable management practices; PR: Policy robustness; CN: Carbon neutrality

4.3. Correlation analysis

The results of the correlation analysis are outlined in Table 3. Table 3 reveals significant relationships among the variables. CN is positively correlated with SMP (0.481) and PR (0.588), indicating that enhancing these factors can significantly impact CN. PR shows strong correlations with both SMP (0.566) and CSR (0.533), highlighting its central role in driving sustainability initiatives. The Sector (S) variable exhibits weaker correlations with CN (0.213) and SMP (0.201), suggesting sector-specific factors may influence sustainability outcomes. Employee Experience (EE) has notable correlations with CN (0.417), SMP (0.399), and PR (0.491), indicating that experienced employees play a crucial role in achieving sustainability targets. The positive correlation between CSR and other variables, especially PR (0.533) and EE (0.431), underscores the importance of CSR activities in fostering an environment conducive to sustainable practices. These correlations suggest a multifaceted approach is necessary to enhance CN effectively.

4.4. Multicollinearity and heterogeneity analysis

Before the regression analysis, we must examine the characteristics of the data by examining the multicollinearity and heterogeneity. The findings of both the analyses are reported in Table 4. The findings of variance inflation factor (VIF) confirm the non-presence of multicollinearity in the predictors. Moreover, the heteroskedasticity test has $p > 0.05$, mentioning the presence of homogeneity in the studied model.

4.5. Regression analysis

Additionally, the regression results obtained from 244 firms, comprising 795 employees, are presented in Table 5. The findings display the influence of sustainability management practices (SMP), PR, the moderating effect of PR, and other variables on the CN of firms within the oil and gas, iron, and copper sectors. Regarding sustainable management, the data from Saudi Arabia revealed a significant positive impact of sustainable management on a firm's CN ($\beta = 0.407$, $p < 0.05$). This study's results also showed a positive and significant relationship between SMP and the CN of a firm in the UAE context. This means that in the case of both Saudi Arabia and UAE, it is apparent that firms that have SMP are highly motivated to attain CN. This result similarly supports the findings of Zhao et al. (2022). These results signify significant evidence for the assumption that firms with effective SMP are likely to achieve the status of CN, underscoring the significance of sustainable management in improving the company's environmental performance and minimizing carbon emissions.

Table 3: Correlations analysis

	CN	SMP	PR	S	CSR	EE
CN	1					
SMP	0.481	1				
PR	0.588	0.566	1			
S	0.213	0.201	0.421	1		
CSR	0.322	0.308	0.533	0.420	1	
EE	0.417	0.399	0.491	0.488	0.431	1

CN: Carbon neutrality; SMP: Sustainable management practices; PR: Policy robustness; S: Sector; CSR: Corporate social responsibility; EE: Employee experience

Saudi Arabia has also engaged in the following measures which are in a bid to enhance sustainable development: availability and sustainable management of water and sanitation; affordable, reliable, sustainable and modern energy; making cities and human settlements safe, inclusive and

sustainable; sustainable consumption and production, protection, restoration, and sustainable use of ecosystems, sustainable management of forests, combating desertification, halting land degradation and losing biodiversity, strengthening the means of implementation and enhancing the global Partnership for Sustainable Development (Zaidan et al., 2019).

Table 4: Multicollinearity and heterogeneity test

Multicollinearity test	VIF
SMP	2.351
PR	3.674
S	5.102
CSR	1.139
EE	7.031
Mean VIF	3.859
Heteroskedasticity test: Breusch-Pagan-Godfrey	F-statistics
	1.148
	Prob. (0.362)

VIF: Variance inflation factor; SMP: Sustainable management practices; PR: Policy robustness; S: Sector; CSR: Corporate social responsibility; EE: Employee experience; Prob.: probability value

The results regarding the direct influence of PR support its substantial and positive impact on CN in both Saudi Arabia and UAE, as evident from Table 4. Notably, the results remained stable across the entire sample size. Interestingly, there was no variation in terms of both sign and significance when the data was analyzed by sector or country. These consistent results clearly demonstrate that PR directly correlates with CN in both countries. This implies that companies with strong, well-formulated policies have significantly higher prospects of achieving CN. Existing literature further corroborates this, emphasizing the critical role of robust policies in fostering sustainable practices within organizations (Ahmad et al., 2023; Etzion et al., 2017). An effective policy framework can provide regulations and incentives that encourage firms to adopt environmentally friendly practices, thereby reducing their carbon emissions.

Examining SMP as an independent variable in the prediction of CN and moderating the role of PR in this relationship gave insightful results. This interaction with the case of UAE came out to be positive and significant in terms of contributing to carbon neutralization. However, regarding the UAE, the moderating impact of interacting policy strength is not quite explicit, but it carries a positive sign. This partially supports the tested hypothesis because the overall direct and indirect influences of sustainable management approaches and practices combined with well-developed policies are more influential in improving quantitative CN than the simple aggregate of the noted variables. It puts the best face on the matter, for there is either a synergistic effect to point towards when it comes to sustainable management on the one hand and strongly—if not sustainably—constructed policies on the other. This approach is highly important for improving the capacity of a firm to realize sustainability objectives and, better still, the CN goal.

Detailed empirical research of the UAE and KSA revealed different findings in terms of SMP, policies, sectors, and facets of CSR. Concerning Sustainable Management, the assessments based on figures showed increasing concerns and management of sustainability factors within organizations' plans. The status of development in both countries reveals the transition of the countries' industries to embrace sustainability and environmentally friendly technologies and practices to reduce the adverse effects on the environment. As for policy stability, the study also focused on the significance of the regulation for the development of environmental management frameworks in the sphere of the oil and gas industry. In their approach, both countries have proved commitment to policy development, but they fail in terms of uniform implementation of policies and the rate at which they adopt regulatory changes to suit the existing environmental conditions. The current policy environment requires reinforcement for stability if there is to be consistency and proactivity on the part of sustainable development. In general, the practices within the oil and gas industry sectors were characterized by divergent approaches to handling environmental impacts. Some organizations demonstrated proactive measures, such as investing in renewable energy projects and implementing carbon reduction strategies. However, the sector faces challenges related to the varying pace of technology adoption and the need for alignment with robust policies to ensure a cohesive and effective transition towards sustainable practices. In the realm of CSR, the study identified a growing recognition of the role that businesses play in contributing to societal and environmental well-being. Both countries showcased instances of CSR initiatives aimed at community development, environmental conservation, and social impact. These initiatives align with global trends where corporations increasingly view CSR as an integral part of their business strategy, contributing positively to the communities and environments in which they operate.

Table 5: Model analysis

	UAE		Saudi Arabia		Total	
Variable	CN	Sig.	CN	Sig.	CN	Sig.
SMP	0.429	0.000	0.407	0.000	0.521	0.000
PR	0.581	0.000	0.374	0.003	0.444	0.002
SMP×PR	0.376	0.000	0.182	0.019	0.198	0.067
S	0.102	0.209	0.091	0.277	0.099	0.161
CSR	0.271	0.000	0.301	0.063	0.261	0.076
EE	0.429	0.000	0.222	0.039	0.410	0.053
Adjusted R^2	0.881		0.753		0.833	

CN: Carbon neutrality; SMP: Sustainable management practices; PR: Policy robustness; S: Sector; CSR: Corporate social responsibility; EE: Employee experience; VIF: Variance inflation factor; Sig.: Significance value

4.6. Robustness of empirical results

To assess how the results varied by country, the researchers examined the data, and the outcomes are presented in Table 6. The analysis revealed that there were no significant differences in the results' significance, size, or direction across countries, except for the category of "Sustainable Management Practices." Specifically, there was a noticeable difference between the results from Saudi Arabia and UAE. However, it's crucial to note that this difference doesn't challenge or undermine the main findings of the study.

Table 6: Multi-group analysis

	Diff (C-I)	Sig.	Findings
SMP	0.294	0.000	Difference exists
PR	0.200	0.098	No difference exists
SMP×PR	0.418	0.281	No difference exists
S	0.108	0.109	No difference exists
CSR	0.031	0.529	No difference exists
EE	0.372	0.981	No difference exists

Diff (C-I): Difference in coefficients-interval; Sig.: Significance value; SMP: Sustainable management practices; PR: Policy robustness; S: Sector; CSR: Corporate social responsibility; EE: Employee experience

4.7. Discussion

The first research objective of the study is to evaluate the Impact of SMP on CN in Saudi Arabia and UAE. The research findings indicate a highly statistically significant relationship between SMP and CN in both Saudi Arabia and the UAE, aligning with the growing body of evidence highlighting the critical role of sustainability initiatives in mitigating carbon emissions. This significant correlation supports previous research emphasizing the necessity of integrating sustainable frameworks within institutions to achieve meaningful reductions in carbon footprints. For instance, the work by Sen et al. (2021) underscored that institutions adopting robust sustainability strategies are better positioned to reduce their carbon emissions, thereby contributing substantially to the goal of CN. Similarly, Gennitsaris et al. (2023) elucidated the relationship between green investments and enhanced energy efficiency, emphasizing the critical role these elements play in achieving CO_2 reductions, further validating the efficacy of SMP.

Moreover, the integration of sustainability strategies, such as green supply chain management, has been shown to yield substantial environmental benefits. Ahmad et al. (2022) argued that the implementation of these strategies not only enhances environmental outcomes but also improves the overall sustainability performance of organizations. This notion is further supported by studies indicating that the effective deployment of green supply chains can result in significant reductions in greenhouse gas emissions, thereby reinforcing the positive impact of SMP on CN (Xu et al., 2020).

The second research objective focused on the moderating role of PR in the relationship between SMP and CN. The findings suggest that PR significantly enhances the effectiveness of SMPs in both Saudi Arabia and the UAE, a conclusion that resonates with existing literature on environmental policy and regulation. Saqib and Dincă (2024) highlighted that robust environmental policies create a conducive environment for the implementation of sustainability initiatives, which in turn facilitates more effective carbon reduction strategies. This is echoed by Liu et al. (2019), who emphasize the importance of clear and consistent policies in promoting sustainable practices, noting that such policies provide the necessary framework for organizations to implement and sustain SMPs. The higher impact of PR in the UAE compared to Saudi Arabia may be attributed to the UAE's more stringent environmental regulations, which have been well-implemented and enforced. This observation is consistent with findings by Ashford and Hall (2011), who asserted that the effectiveness of sustainability initiatives is often contingent upon the presence of robust regulatory frameworks. Haque and Ntim (2018) further supported this by illustrating how effective regulations can drive the adoption of sustainable practices, thereby enhancing environmental outcomes.

In comparing the impact of SMP on CN between Saudi Arabia and the UAE, the research reveals that while both countries benefit, the UAE exhibits a marginally higher coefficient. This discrepancy may be explained by differences in policy formulation and compliance, with the UAE demonstrating a more strategic and integrated approach to sustainable development. Ben Belgacem et al. (2023) highlighted the UAE's commitment to promoting green investments and renewable energy, which has significantly bolstered the effectiveness of its SMPs. Furthermore, the UAE's emphasis on sustainable infrastructure and green finance has provided a strong foundation for achieving CN, as Aziz et al. (2024) asserted the importance of these factors.

Conversely, while Saudi Arabia is making significant strides in sustainable development, challenges related to policy stability and economic diversification may hinder the full realization of SMP benefits. This is corroborated by Misleh et al. (2024), who identified policy instability as a potential barrier to the effective implementation of sustainability initiatives. Additionally, the need for further advancement in economic diversification measures is crucial for enhancing the efficiency of SMPs in Saudi Arabia, as suggested by Alkhathlan and Javid (2013). This comparison highlights the critical role of supportive policies and strategic

investments in maximizing the impact of SMP across different national contexts.

The implications of these findings extend to the broader discourse on environmental sustainability, particularly in the context of emerging economies. The positive correlation between SMP and CN underscores the importance of integrating sustainability into the core strategies of organizations and governments alike. This research contributes to the growing consensus that sustainable practices are not only beneficial for environmental outcomes but are also crucial for long-term economic resilience. The role of PR as a moderating factor further emphasizes the need for coherent and consistent policy frameworks to support the effective implementation of SMPs. As such, these findings offer valuable insights for policymakers and practitioners seeking to enhance sustainability outcomes in various regional contexts.

5. Conclusion and policy recommendations

The study reveals that SMP and PR are crucial factors in realizing the CN strategy in Saudi Arabia and the UAE. This study establishes that SMPs greatly enhance CN and states that the UAE contributes somewhat more to CN than Saudi Arabia. This contrast underlines the efficiency of the UAE's overall sustainable initiatives and research, as well as investments in those sectors for renewable power and construction. In the analysis, PR comes as a critical mediator that enhances the relationship between SMPs' influence on CN. This proves the hypothesis that countries with better and more consistent policies that are implemented and enforced have better results; this demonstrates the high effectiveness of PR in the UAE. This will imply that favorable conditions should be nurtured on the regulatory front to benefit from sustainable practices. These differences between Saudi Arabia and the UAE also highlight the necessity for differential strategies to integrate sustainability concepts based on the countries' differences in economic and political environment and policies. The number of endeavors and commitment toward sustainability policy in the UAE can be considered somewhat exemplary, while Saudi Arabia's ongoing policy has a lot of potential for policy improvement.

5.1. Policy recommendations

Based on the study's findings, policymakers in Saudi Arabia and the UAE should prioritize the development and enforcement of robust, clear, and consistent environmental policies that support SMP to achieve CN. Specifically, Saudi Arabia could enhance the effectiveness of its SMP by focusing on policy stability and the rigorous implementation of sustainability regulations, ensuring that these policies are consistently enforced across all sectors. The UAE, while already advanced in this area, should continue to strengthen its policy frameworks, particularly in promoting green investments and renewable energy projects. Both countries could benefit from adopting more integrated approaches that link SMP with economic diversification strategies, ensuring that sustainability is embedded within the broader economic and development agenda. Additionally, there should be continuous evaluation and adjustment of policies to keep pace with technological advancements and global best practices, enabling both nations to lead the region in CN efforts.

5.2. Limitations

Some limitations of this study need to be pointed out. First, the generalization of the findings of the analysis may be limited by the availability and quality of data coming from the natural resource industry within Saudi Arabia and UAE. Secondly, generalizing the findings of the study to other regions of the world with different characteristics regarding economic growth, social structures, and environment is hampered because the study compared the performance of only two countries. Thirdly, the study also looks at the aspect of PR but does not consider the impact that may emanate from informal institutions and culture on SMP. Finally, the study mostly uses a quantitative approach, which may be really limiting when explaining the qualitative characteristics of sustainability and policy interactions. Finally, due to the dynamic nature of environmental policies as well as advancement in technologies in relation to the research, the study may pose some limitations, such as the results may be outdated, thus calling for regular updates of the research framework.

5.3. Future research directions

Further studies should build on this by extending the geographical area of study so as to encompass more countries and compare the SMP and the impacts of policies in different economic classes and environmental settings. Furthermore, examining the impact of informal institutions and culture and the engagement of local stakeholders in the adoption of sustainability practices can genuinely produce further insights. Secondly, melding qualitative procedures with quantitative analysis will assist the research design in identifying the interactions between the policies and practices, which is not seen by the quantitative approach alone. Future research should also consider the fact that environmental policies are constantly evolving and the slow pace at which technology in the use of sustainable materials is evolving, thus analyzing the effects of longer periods on sustainable outcomes. Approaching the analysis on the company level and looking at the strategies that were used cross-sector but focusing on the differences that exist in the specific sub-sector of the natural resources industry will help add detail to the picture. Thus, longitudinal studies identify changes in the development of SMP, and their performance offers utility. Finally, analyzing how the

measures introduced by global sustainability programs and the requirements of national legislation can complement each other may reveal ways to bring local activities closer to the international climate goals.

Compliance with ethical standards

Ethical considerations

All participants provided informed consent, and data was anonymized to ensure confidentiality.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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