



Carbon Management Accounting System and Corporate Environmental Performance: A Conceptual Framework

Hussein H. H. Sharaf-Addin*

Department of Management and Humanities, Universiti Teknologi PETRONAS, Malaysia. *Email: hussein.sharaf@utp.edu.my

Received: 27 October 2023

Accepted: 16 February 2024

DOI: <https://doi.org/10.32479/ijeeep.15595>

ABSTRACT

The growing concern over climate change and the need to address its effects has prompted industries and companies to prioritize reducing carbon emissions. This study proposes an effective Carbon Management Accounting System (CMAS) model that can lead to sustainable Energy Efficiency (ENEFF) and enhance Corporate Environmental Performance (CEP) through sustainable operations. The study extensively reviewed previous research and developed a conceptual framework for the relationship between CMAS, ENEFF, and CEP in the Malaysian Oil and Gas industry. The study also developed two research models extracted from the conceptual framework developed, which are: (1) a carbon management accounting model and (2) a corporate environmental performance model. By using these models, the study directly explores the relationship between CMAS and ENEFF and indirectly explores the relationship between CMAS and CEP through the mediating role of ENEFF. This study provides a foundation for future research to examine both models as an integrated approach to enhance ENEFF and overall CEP in the Oil and Gas industry.

Keywords: Carbon Management Accounting System; Energy Efficiency; Corporate Environmental Performance; Oil and Gas Industry

JEL Classifications: Q52, Q54, Q56

1. INTRODUCTION

The increased awareness of climate change and the urgent need to address its effects have made companies more conscious of the importance of prioritizing the reduction of their carbon emissions. This underscores the extensive impact of carbon emissions on the environment and global business activities. Consequently, companies must swiftly adopt measures to mitigate greenhouse gas (GHG) emissions, calling for comprehensive and sustainable solutions. Conversely, it has been identified that companies' operations are the primary drivers of Carbon Dioxide (CO₂) emissions and the subsequent rise in CO₂ levels (Ong et al., 2022). In this regard, companies can rely on carbon accounting, which helps them manage and control the CO₂ costs of their activities (Ong et al., 2022). This enables companies to align with stakeholder interests and enhance overall regional environmental performance (Linares-Rodríguez et al., 2022).

Previous researchers (e.g., Bhargava et al., 2018; Gupta et al., 2019; Irfan et al., 2023) have highlighted various low-carbon strategies for improving Energy Efficiency (ENEFF). These include implementing carbon taxes and clean development mechanisms to address regional environmental challenges. As indicated by Nemecek et al. (2009), energy efficiency, as a low-cost mitigation strategy, has been a prominent topic in global policy discussions.

Furthermore, Dragomir (2012) reported that Corporate Environmental Performance (CEP) is a multifaceted variable that depends on measures such as recognition, measurement, verification, and reporting of CEP indicators. Scientific research has focused on measuring companies' environmental performance and examining its relationship with other firm-specific variables, such as company size, environmental strategies, disclosure practices, financial performance, and reputation.

However, in our extensive review of previous studies, we found that most studies have concentrated on the relationship between carbon accounting and corporate performance, carbon accounting and corporate environmental performance, and Carbon Management Accounting System (CMAS) and corporate performance. Additionally, Malaysia is poised not only to enhance the energy efficiency of its Oil and Gas industry through strategic management commitment and practices but also to integrate techniques like CMAS with energy efficiency and environmental performance enhancement. This will position Malaysia as a responsible global player in the transition towards a greener energy future.

This study extends previous research by developing a comprehensive conceptual framework that extracts the relationships between CMAS, ENEFF, and CEP. Therefore, the main objective of this research is to investigate the direct and indirect relationships between CMAS and ENEFF, as well as overall CEP. The structure of this study is presented as follows: sections two, three, and four critically review previous studies related to the carbon accounting system, energy efficiency, and corporate environmental performance. Section five reviews related studies on carbon accounting in Malaysia. Section six illustrates the conceptual framework developed in the study, and the theoretical and managerial implications of the framework are discussed in section seven. In section eight, the expected results are outlined, and the study is concluded.

2. CARBON MANAGEMENT ACCOUNTING

2.1. Carbon Accounting

Carbon accounting is a systematic process that entails the measurement, monitoring, and reporting of an organization's greenhouse gas (GHG) emissions. This encompasses both direct emissions from activities such as fuel combustion and indirect emissions from purchased electricity. As such, carbon accounting serves as a tool utilized by both scientists and financial analysts to address and mitigate GHG emissions and their impact on climate change, as a component of environmental accounting (Stechemesser and Guenther, 2012). The precision of carbon accounting is paramount for comprehending the environmental footprint of operations, establishing targets for emissions reduction, and demonstrating transparency to stakeholders. Achieving this necessitates making informed decisions regarding the tracking, tracing, management, and control of carbon performance (Burrill et al., 2011), which can be effectively implemented through a Carbon Management Accounting System (CMAS).

2.2. Carbon Management Accounting

As a sub-part of Carbon Accounting, Carbon Management Accounting (CMA) is a system that comes into play encompassing activities related to formulating strategies and plans, gathering pertinent information, and making informed decisions aimed at effectively reducing carbon emissions (Schaltegger and Csutora, 2012). In essence, Nartey (2018) reported that the organizational strategy, structure, environmental management accounting (EMA), firm size, technology, and perceived environmental uncertainty are found to be positively correlated with CMAS in

Ghana. Moreover, the inter-organizational and intra-organizational arrangements enhanced the GHG emissions performance through CMA procedures in the U.S. (Mahmoudian et al., 2021).

3. ENERGY EFFICIENCY

Energy Efficiency (ENEFF) pertains to the capacity to accomplish tasks or achieve results using less energy, thereby diminishing energy consumption and its associated environmental impacts. Therefore, bolstering ENEFF constitutes a crucial aspect of any sustainability endeavor. It involves identifying opportunities to curtail energy usage while maintaining or even enhancing operational performance. This can be accomplished through various means, including equipment upgrades, the adoption of energy-efficient technologies, and the implementation of optimal energy management practices. As stated by Zublie et al. (2023), enhancing ENEFF represents the most effective approach to reducing the costs associated with carbon dioxide emissions. This encompasses measures aimed at augmenting energy efficiency through the reduction of fossil fuel consumption, ultimately mitigating the impact of greenhouse gases on climate change. According to Irfan et al. (2023), ENEFF stands out as a low-carbon strategy that can be employed to combat the escalating levels of carbon emissions. Additionally, ENEFF denotes a reduction in energy consumption for production, translating to energy savings (Irfan et al., 2023).

Empirically, Saidur et al. (2007) examined disaggregated data for Malaysia spanning from 1995 to 2003 to assess the energy efficiency of land, water, and air transportation. The findings indicate that, on average, road transportation demonstrates the highest level of energy efficiency, followed by air and water transportation. Meanwhile, Oh and Chua (2010) documented the evolution of Malaysian energy policies, highlighting the government's concerted efforts to reduce its carbon footprint through various energy efficiency initiatives. In addition, the study of Zublie et al. (2023) confirms that academic laboratory equipment, lighting, and air conditioning are vital to energy consumption in Malaysia. Liu et al. (2023) found that energy efficiency has both positive and negative effects on CO₂ emissions in the long run in China. They recommended energy efficiency and environmental implications as prioritizing policies that improve energy efficiency. In the meantime, Wang et al. (2020) detected that the CO₂ emissions were found to be closely related to energy consumption in the Chinese water-intensive sector. Recently, energy consumption reduction was found also to be significantly affected by environmental management accounting in innovative activities of 55 Brazilian sectors (da Rosa et al., 2020). This creates further incentive for combining energy efficiency with carbon accounting and environmental performance in the proposed framework.

4. CORPORATE ENVIRONMENTAL PERFORMANCE

4.1. Environmental Performance

Corporate environmental performance pertains to how effectively a company manages and mitigates its impact on the environment.

This encompasses the company’s overall dedication, actions, and outcomes about environmental sustainability. It involves a spectrum of practices and initiatives aimed at minimizing environmental harm and advancing sustainability. This includes efforts to employ efficient technologies, reduce resource consumption, lower emissions, adopt eco-friendly technologies, and implement waste reduction strategies. A high level of corporate environmental performance showcases a company’s dedication to responsible business practices, often resulting in advantages like cost savings, an enhanced reputation, and compliance with regulatory standards. Moreover, it signifies a company’s acknowledgment of its role in broader environmental stewardship and its contribution to a more sustainable future.

However, there is no commonly accepted definition of CEP and applied measures as well. According to Wagner and Schaltegger (2004), CEP should include business performance dimensions to provide a comprehensive view of environmental management’s effects on firms’ economic performance. Burritt et al. (2002) and Bartolomeo et al. (2000) initially developed a comprehensive framework of environmental management accounting in which management information could be split out into physical and monetary dimensions (Figure 1).

In the framework, the time frame of decision making including past, present, and future is outlined. In addition, environmental accounting could be recognized at the firm’s organizational, plant, regional, and national scales.

4.2. Environmental Performance Measures

There are several measures of corporate environmental performance. Some researchers used measures, including financial and non-financial measures, related to environmental competitiveness, such as corporate image, product image, sales, market share, new market opportunities, short-term profit, long-term profit, cost savings, and productivity (e.g. Rahman and Islam, 2023; Wagner and Schaltegger, 2004). Other researchers used emissions and waste reduction, water abstraction, natural resource use, and raw materials extraction as measures of environmental performance (e.g. Dawkins and Fraas, 2011; Delmas et al., 2015; Delmas et al., 2015). However, some measures related to the

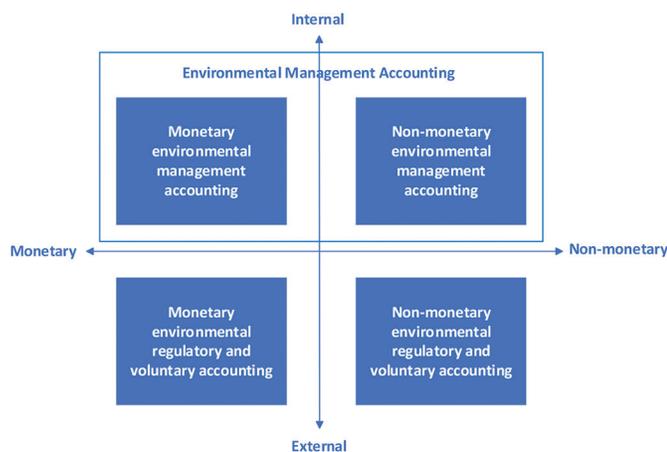
study topic include carbon footprint, energy consumption, waste generation and reduction, and water usage measures.

5. STUDIES ON CARBON ACCOUNTING IN MALAYSIA

The Oil and Gas industry plays a crucial role in the economy of countries, serving as a major contributor to government revenue and a significant source of employment. In Malaysia, for instance, as early as the 1990s, commendable strides were made in integrating sustainable practices within the Oil and Gas sector through a robust carbon strategy framework. This sector served as the primary energy source in the base year, and in both the 2025 scenarios, there is an anticipated increase in the use of Renewable Energy (RE) by about 4.5 times (Ho et al., 2013). One example of this integration is the implementation of a low-carbon city strategy, which employs sustainable development principles to achieve a high level of energy efficiency using low-carbon energy sources and production technologies (Ho et al., 2013). These technologies, often referred to as clean coal technologies (Siong et al., 2022), are instrumental in advancing environmental sustainability within the industry. Moreover, Gan et al. (2013) studied the low-carbon society outlook for Malaysia to 2035. Their findings detected an unsustainable development given an increase in spending on fossil fuels energy imports for coal and oil and gas. Their study suggested an extensive use of renewable energy sources and promoted energy efficiency across all sectors which could effectively address an overreliance on fossil fuels and then reduce CO₂ emissions. This supports the argument that energy consumption in Malaysia is predominantly reliant on fossil fuels, which constituted 95.4% in 2016, as reported by the BP Statistical Review of World Energy in 2017 (Siong et al., 2022).

The government, in collaboration with industry stakeholders, has implemented a range of initiatives aimed at reducing carbon emissions and mitigating environmental impacts. These efforts encompass investments in research and development of cleaner technologies, the adoption of renewable energy sources, and the promotion of energy efficiency measures. Moreover, both energy audit and energy efficiency emerge as pivotal factors in the drive to curtail carbon emissions. The awareness, knowledge, and commitment to energy conservation also play a significant role in achieving energy efficiency (Fernando and Hor, 2017). Additionally, Malaysia has actively engaged in international partnerships and commitments to uphold its environmental responsibilities in the face of climate change. This includes its involvement in agreements such as the Kyoto Protocol and its participation in the efforts of the Intergovernmental Panel on Climate Change (IPCC), which entail a commitment to reducing greenhouse gas emissions (Fernando and Hor, 2017). These collaborative endeavors further demonstrate Malaysia’s dedication to addressing global environmental challenges.

Figure 1: Environmental management accounting



Source: (Bartolomeo et al., 2000; Burritt et al., 2002)

6. CONCEPTUAL FRAMEWORK

The presence of a comprehensive framework for a Carbon Management Accounting System (CMAS) to support carbon

management and control initiatives and activities is largely lacking. Therefore, this study seeks to address the ambiguity observed in previous research. The theoretical framework established in this study establishes a link between CMAS and Energy Efficiency (ENEFF) as the main determinants of Corporate Environmental Performance (CEP). Building on assumptions derived from related previous studies, it is posited that the integrated principles of these factors contribute to a sustainable, growth-oriented, and consistently maintained CEP. Figure 2 visually outlines the developed theoretical framework.

As depicted in Figure 2, the framework highlights the intricate relationship between the Carbon Management Accounting System (CMAS), Energy Efficiency (ENEFF), and Greenhouse Gas (GHG) emissions, presenting an integrated approach towards enhancing Corporate Environmental Performance (CEP). When effectively integrated, these components synergize to form a sustainable and resilient corporate performance model, striking a balance between economic prosperity and environmental stewardship. The framework is primarily constructed based on the findings of previous studies.

However, prior research primarily focused on specific relationships within this framework. For instance, some studies delved into the significant connection between carbon strategy management and ENEFF (e.g., Chen et al., 2021; Rahman and Islam, 2023). Others examined the associations between GHG emissions and firm performance (e.g., Al Kurdi et al., 2023; Bhargava et al., 2018; Linares-Rodríguez et al., 2022; Oh and Chua, 2010), or

between carbon emissions and firm performance (e.g., Das, 2023; Irfan et al., 2023; Khatib et al., 2023; Ong et al., 2022). Notably, the study by Irfan et al. (2023) is the sole one that specifically addresses the relationship between carbon emissions and energy efficiency.

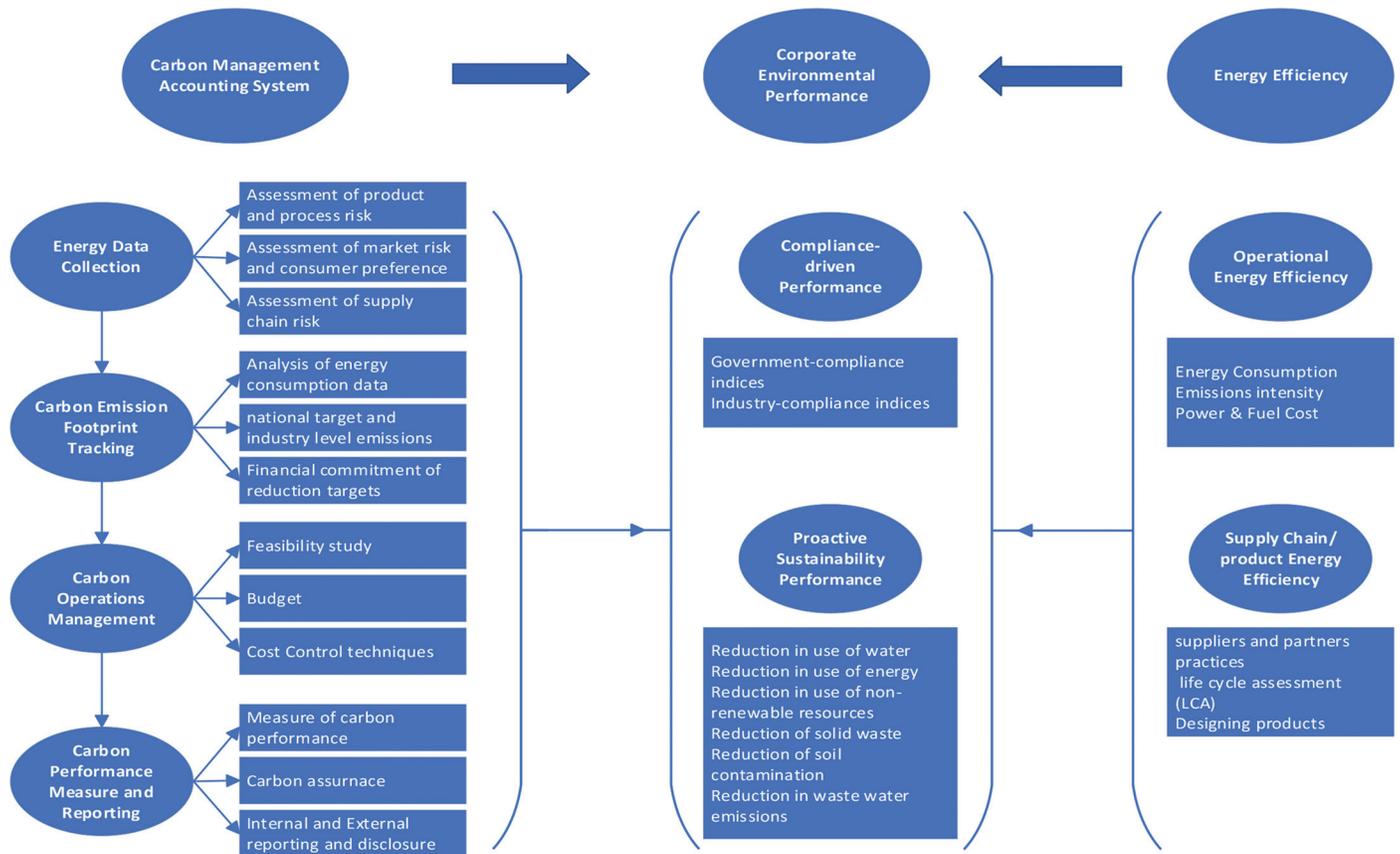
Meanwhile, a study highly relevant to our research is the one conducted by Ong et al. (2022), which explores the mediating effect of carbon accounting on the relationship between carbon risk management and the carbon performance of Malaysian companies. However, our perspective suggests that the study may overlook the pivotal role of energy efficiency as a primary determinant of companies' performance when effectively managing carbon emissions through the adoption of carbon accounting techniques.

7. THEORETICAL AND MANAGERIAL IMPLICATIONS

7.1. Theoretical Implications

Upon reviewing previous studies, it has been consistently reported that an effective Carbon Management Accounting System (CMAS) leads to greater control over Greenhouse Gas (GHG) emissions (e.g., Chen et al., 2021; Pichancourt et al., 2018). However, none of the reviewed studies have extended the assessment of CMAS effectiveness to its impact on Energy Efficiency (ENEFF). In our study's assumption, companies with a more robust and precise CMAS are likely to demonstrate higher levels of ENEFF. This suggests that accurate tracking and reporting of carbon-related data

Figure 2: A Conceptual framework of CMAS, ENEFF, and CEP



may play a pivotal role in enhancing energy efficiency. Therefore, we hypothesize that the effectiveness and efficiency of a company's CMAS are linked to its level of ENEFF.

Furthermore, previous studies have consistently affirmed that companies with effective CMAS tend to achieve higher levels of corporate performance (Stechemesser and Guenther, 2012). However, the metrics used to gauge corporate performance encompass both financial and non-financial aspects. Notably, the measurement of corporate environmental performance remains somewhat ambiguous in related previous research, especially when focusing on CMAS. In this study, we posit that the effectiveness and accuracy of a company's CMAS are intrinsically connected to its overall Corporate Environmental Performance (CEP).

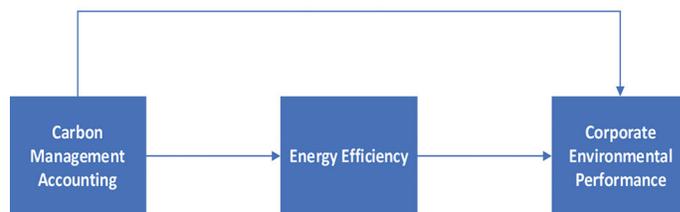
However, the relationship between ENEFF and CEP is a critical area of study from the perspective of sustainability and business practices. ENEFF refers to the ability to use less energy to perform the same tasks or achieve the same results, thereby reducing energy consumption and associated environmental impacts. Corporate environmental performance, on the other hand, encompasses a company's overall commitment, actions, and outcomes about environmental sustainability. Based on the findings of Rahman and Islam (2023), ENEFF had a significant effect on environmental performance. However, the measures of environmental performance investigated were ambiguous while in the current study, the focus of environmental performance is in tandem with carbon issues including carbon savings and emissions intensity. While previous studies examined the effect of different factors (carbon risk management, carbon accounting, carbon emissions) on CEP, studies investigating the direct effect of CMAS on CEP are almost nonexistent.

The study conducted by Rahman and Islam (2023) found that green accounting has a significant positive impact on both energy efficiency and environmental performance. In essence, the study affirmed that the ENEFF significantly and partially mediates the relationship between green accounting and environmental performance, especially with environmental practices that have the highest impact. Meanwhile, another study conducted by Al Kurdi et al. (2023) found that companies contributing to low carbon emissions are more willing to improve their environmental, social, and governance performance. They also found that carbon emissions significantly mediate the relationship between the board's attributes and environmental, social, and governance performance. However, none of the previous studies were found concerning the mediation role of both CMAS and ENEFF in studying the relationship between carbon emissions and environmental performance. Hence, the following conceptual model is supposed:

Based on the debates raised above, the following conceptual research model was developed:

Future research can employ a comprehensive set of tools designed to empirically investigate the relationship between the Carbon Management Accounting System (CMAS), Energy Efficiency (ENEFF), and Corporate Environmental Performance (CEP) (Figure 3). This instrument involves a multi-faceted approach,

Figure 3: Conceptual research model



integrating an extensive review of previous studies and archival data analysis conducted through structured assessments. A critical examination of previous studies forms a robust foundation for future research, facilitated by the development of the theoretical framework and the subsequent conceptual research model.

Archival data analysis will entail thorough scrutiny of historical records, financial reports, and sustainability disclosures to extract quantitative indicators of carbon performance. This process primarily entails the collection and analysis of secondary data sourced exclusively from annual reports. It places significant emphasis on a meticulous examination of historical records, financial reports, and sustainability disclosures, with a specific focus on quantitative indicators of carbon performance.

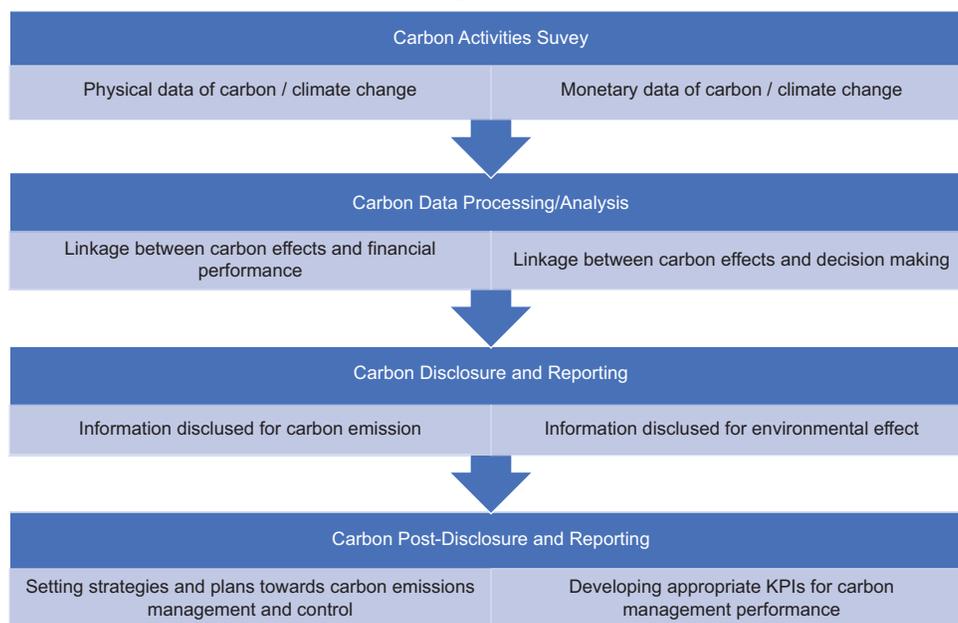
By drawing upon this comprehensive dataset, future research can provide valuable insights into the role of CMAS within Oil and Gas companies in Malaysia. This approach will illuminate the intricate dynamics between CMAS, ENEFF, and CEP, contributing to a deeper understanding of their interrelationships.

7.2. Managerial Implications

Based on the developed conceptual research framework, companies have the opportunity to implement efficient strategies for managing their carbon-related initiatives, particularly by enhancing energy efficiency, to ensure effective Corporate Environmental Performance (CEP). These initiatives are closely tied to the utilization of Carbon Management Accounting System (CMAS) techniques and tools, such as strategic planning, financial and non-financial performance indicators, and financial reporting. Surprisingly, these aspects have not been adequately addressed in the existing literature.

It would be intriguing to empirically test this relationship before delving into the investigation of the mediating role of CMAS in such a relationship. The assumption here is that changes in CMAS practices are associated with corresponding changes in Energy Efficiency (ENEFF). This implies that companies that prioritize and effectively implement carbon strategies tend to also exhibit higher levels of energy efficiency and, consequently, superior overall corporate environmental performance. Consequently, this study underscores the critical importance of utilizing archival data to gain valuable insights into sustainable business practices, as illustrated in Figure 3 below.

Through the processes illustrated in Figure 4, the management of the non-monetary and monetary carbon and the monitoring of carbon emissions on all levels of the value chain are recognized in a single cycle. The study's contribution is to shed light on the

Figure 4: Managerial implications of CMAS framework

role of CMAS tools and techniques associated with the external supply chain and stakeholders. In brief, the framework developed provides information gathered both internally and externally to help companies recognize and evaluate carbon emissions reduction strategies and initiatives.

8. CONCLUSION

This study explores the intersection of the Carbon Management Accounting System (CMAS) and Energy Efficiency (ENEFF) in relation to Corporate Environmental Performance (CEP). It aims to provide valuable insights into the complex dynamics within this field by conducting a thorough review of relevant literature. By offering theoretical insights into carbon management accounting strategies and their environmental outcomes, this study contributes significantly to the discussion of sustainable business practices. To accomplish this, a comprehensive research framework has been developed that has potential implications for both theoretical and managerial perspectives.

From a theoretical standpoint, the conceptual framework provides a basis for future researchers to empirically investigate CMAS techniques and their effects on corporate ENEFF and CEP outcomes. From a managerial perspective, this framework directs the attention of Oil and Gas companies in Malaysia towards carbon data from both internal and external sources. This aids in the development of strategies and initiatives that aim to reduce carbon emissions and promote environmental performance in the corporate realm.

REFERENCES

Al Kurdi, A., Al Amosh, H., Khatib, S.F.A. (2023), The mediating role of carbon emissions in the relationship between the board attributes and ESG performance: European evidence. *EuroMed Journal of Business*, <https://doi.org/10.1108/EMJB-08-2022-0144>.

- Bartolomeo, M., Bennett, M., Bouma, J.J., Heydkamp, P., James, P., Wolters, T. (2000), Environmental management accounting in Europe: Current practice and future potential. *European Accounting Review*, 9(1), 31-52.
- Bhargava, N., Gurjar, B.R., Mor, S., Ravindra, K. (2018), Assessment of GHG mitigation and CDM technology in the urban transport sector of Chandigarh, India. *Environmental Science and Pollution Research*, 25(1), 363-374.
- Burritt, R.L., Hahn, T., Schaltegger, S. (2002), Towards a comprehensive framework for environmental management accounting-links between business actors and environmental management accounting tools. *Australian Accounting Review*, 12(27), 39-50.
- Burritt, R.L., Schaltegger, S., Zvezdov, D. (2011), Carbon management accounting: Explaining practice in leading German companies. *Australian Accounting Review*, 21(1), 80-98.
- Chen, Z., Song, P., Wang, B. (2021), Carbon emissions trading scheme, energy efficiency, and rebound effect-evidence from China's provincial data. *Energy Policy*, 157, 112507.
- Da Rosa, F.S., Lunkes, R.J., Mendes, A.C. (2020), Environmental management accounting and innovation in water and energy reduction. *Environmental Monitoring and Assessment*, 192(10), 621.
- Das, C. (2023), Analysing the effect of low carbon product design on firm performance. *International Journal of Productivity and Performance Management*, 72(1), 180-199.
- Dawkins, C., Fraas, J.W. (2011), Coming clean: The impact of environmental performance and visibility on corporate climate change disclosure. *Journal of Business Ethics*, 100(2), 303-322.
- Delmas, M.A., Lim, J., Nairn-Birch, N. (2015), UCLA Recent Work Title Corporate Environmental Performance and Lobbying. Available from: <https://escholarship.org/uc/item/0d50g6w4> P
- Delmas, M.A., Nairn-Birch, N., Lim, J. (2015), Dynamics of environmental and financial performance: The case of greenhouse gas emissions. *Organization and Environment*, 28(4), 374-393.
- Dragomir, V.D. (2012), The disclosure of industrial greenhouse gas emissions: A critical assessment of corporate sustainability reports. *Journal of Cleaner Production*, 29, 222-237.
- Fernando, Y., Hor, W.L. (2017), Impacts of energy management practices on energy efficiency and carbon emissions reduction: A survey of Malaysian manufacturing firms. *Resources, Conservation and*

- Recycling, 126, 62-73.
- Gan, P.Y., Komiyama, R., Li, Z. (2013), A low carbon society outlook for Malaysia to 2035. *Renewable and Sustainable Energy Reviews*, 21, 432-443.
- Gupta, M., Bandyopadhyay, K.R., Singh, S.K. (2019), Measuring effectiveness of carbon tax on Indian road passenger transport: A system dynamics approach. *Energy Economics*, 81, 341-354.
- Ho, C.S., Matsuoka, Y., Simson, J., Gomi, K. (2013), Low carbon urban development strategy in Malaysia-the case of Iskandar Malaysia development corridor. *Habitat International*, 37, 43-51.
- Irfan, M., Mahapatra, B., Shahbaz, M. (2023), Energy efficiency in the Indian transportation sector: Effect on carbon emissions. *Environment, Development and Sustainability*, 1-24, <https://doi.org/10.1007/s10668-023-02981-z>.
- Khatib, S.F.A., Ismail, I.H.M., Salameh, N., Abbas, A.F., Bazhair, A.H., Sulimany, H.G.H. (2023), Carbon emission and firm performance: The moderating role of management environmental training. *Sustainability (Switzerland)*, 15(13), 1-19.
- Linares-Rodriguez, M.C., Gambetta, N., García-Benau, M.A. (2022), Carbon management strategy effects on the disclosure and efficiency of carbon emissions: A study of Colombian companies' context and inherent characteristics. *Journal of Cleaner Production*, 365, 132850.
- Liu, Z., Ul Islam, M., Alarifi, G.A., Cong, P.T., Khudoykulov, K., Quynh, L.N., Hossain, M.S. (2023), Does energy efficiency mediate a green economic recovery? Evidence from China. *Economic Analysis and Policy*, 78, 802-815.
- Mahmoudian, F., Lu, J., Yu, D., Nazari, J.A., Herremans, I.M. (2021), Inter-and intra-organizational stakeholder arrangements in carbon management accounting. *British Accounting Review*, 53(1), 100933.
- Nartey, E. (2018), Determinants of carbon management accounting adoption in Ghanaian firms. *Meditari Accountancy Research*, 26(1), 88-121.
- Nemecek, T., Roches, A., Ayadi, F., Colak, I., Garip, I., Bulbul, H.I. (2009), Renewable Energy and Developing Countries: Energy Efficiency in Contributions to Reducing Global Emissions. In: 9th International Conference on Renewable Energy Research and Applications, ICRERA 2009.
- Oh, T.H., Chua, S.C. (2010), Energy efficiency and carbon trading potential in Malaysia. *Renewable and Sustainable Energy Reviews*, 14(7), 2095-2103.
- Ong, T.S., Kasbun, N.F., Rahman, A.A.A., Meero, A., Teh, B.H. (2022), The mediation effect of carbon accounting in relation to carbon risk management and carbon performance of Malaysian companies. *International Journal of Energy Economics and Policy*, 12(2), 290-298.
- Pichancourt, J.B., Manso, R., Ningre, F., Fortin, M. (2018), A carbon accounting tool for complex and uncertain greenhouse gas emission life cycles. *Environmental Modelling and Software*, 107, 158-174.
- Rahman, M.M., Islam, M.E. (2023), The impact of green accounting on environmental performance: Mediating effects of energy efficiency. *Environmental Science and Pollution Research*, 30(26), 69431-69452.
- Saidur, R., Sattar, M.A., Masjuki, H.H., Ahmed, S., Hashim, U. (2007), An estimation of the energy and exergy efficiencies for the energy resources consumption in the transportation sector in Malaysia. *Energy Policy*, 35(8), 4018-4026.
- Schaltegger, S., Csutora, M. (2012), Carbon accounting for sustainability and management. Status quo and challenges. *Journal of Cleaner Production*, 36, 1-16.
- Siong, T.C., Kogid, M., Alin, J.M. (2022), Asymmetric modeling of fuel consumption in Malaysia. *Energy*, 239, 121905.
- Stechemesser, K., Guenther, E. (2012), Carbon accounting: A systematic literature review. *Journal of Cleaner Production*, 36, 17-38.
- Wagner, M., Schaltegger, S. (2004), The effect of corporate environmental strategy choice and environmental performance on competitiveness and economic performance: An empirical study of EU manufacturing. *European Management Journal*, 22(5), 557-572.
- Wang, X.C., Klemeš, J.J., Wang, Y., Dong, X., Wei, H., Xu, Z., Varbanov, P.S. (2020), Water-energy-carbon emissions nexus analysis of China: An environmental input-output model-based approach. *Applied Energy*, 261, 114431.
- Zublie, M.F.M., Hasanuzzaman, M., Rahim, N.A. (2023), Energy efficiency and feasibility analysis of solar power generation using hybrid system of an educational institution in Malaysia. *International Journal of Photoenergy*, 2023, 8-10.

ACKNOWLEDGEMENT

The authors would like to acknowledge Universiti Teknologi PETRONAS (UTP) Short Term Internal Research Funding (STIRF) for funding this research under Cost Center: 015LA0-058, which was an important support to conduct this research..