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Guidelines for Managing Carbon Credits in the Industrial Sector to Support Carbon Neutrality

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Abstract

Thailand has established greenhouse gas reduction targets under its Nationally Determined Contributions (NDC) to achieve carbon neutrality and Net Zero Greenhouse Gas Emissions by 2065. The industrial business sector is regarded as a major source of greenhouse gas emissions. Therefore, there is a critical need for systematic carbon credit management to drive the industrial business sector toward achieving carbon neutrality and to develop a Structural Equation Model (SEM). In-Depth Interviews are conducted, with nine experts in the field, to create the tools required for a quantitative study section. A Focus group discussion is employed with 11 experts to collect their consensus on the numerical model for the research. The Quantitative section, Surveys are conducted through questionnaires targeting 500 executives specializing in the industrial business sector. Furthermore, Data Analysis using Descriptive, Inferential, and Multivariate statistical methods. The results of this study indicated that, the four most significant factors in order of descending are: 1) Organization Support ($\overline{X}$= 4.35), the allocation of an annual budget for carbon credit management, 2) Innovation ($\overline{X}$ = 4.33), the use of technologies for carbon dioxide collect and storage, 3) Collaboration ($\overline{X}$ = 4.32), the formulation of long-term collaboration plans to achieve Net Zero targets to assess visionary planning cooperatively with government organizations, and 4) Good Governance ($\overline{X}$ = 4.20), the accurate and comprehensive disclosure of greenhouse gas emissions data to ensure credibility and verifiability by stakeholders. Moreover, there is a statistical significance of 0.05, which confirms the alternative hypothesis that the perceived importance when categorized by size of industrial businesses. The analysis of the developed SEM indicated that the evaluation criteria consistent with empirical data. In addition, the findings obtained from the Chi-Square Probability (CMIN–p)) test indicated a value of 0.130, a Relative Chi-Square value (CMIN/DF) of 1.102, with a Goodness of Fit Index (GFI) at 0.957, and a Root Mean Square Error of Approximation (RMSEA) of 0.014.

Keywords: Carbon Credit Management, Industrial Business Sector, Carbon Neutrality

Introduction

Greenhouse Gases (GHGs) are major contributors to Global Warming and Climate Change worldwide. The most significant GHGs are Carbon Dioxide and Methane, which contribute to rising temperatures and climate change. These changes impact widely, intensifying the climate crisis and put serious threats to humans, ecosystems, and the environment (Filonchyk et al., 2024). Therefore, an urgent need for response measures from countries around the world is crucial. The report on average global surface temperature measurements from 1860 to the present, the average global surface temperature has shown a consistent beyond trend since the middle of 19th century (McCulloch et al., 2024). Trends in global greenhouse gas emissions from 1850 to 2024 indicate a continuous long-term increase, especially since the mid-20th century, driven by fast industrial expansion. Therefore, global greenhouse gas emissions have risen from less than 10 billion tons per year in the early 20th century to more than 50 billion tons per year at present (Majeed et al., 2026). Industrial business sectors in Thailand have recognized the need to adapt their production processes to reduce environmental impacts (Uttajarern et al., 2023). Following the ratification of the Manila Declaration (2009) and the Paris Agreement (2015), the Ministry of Industry developed the Green Industry (GI) program to elevate production standards and resource management to a more systematic level (Sharma, 2025 and Garcia, 2023). This initiative is specifically evident among industrial businesses certified at the GI 3 to GI 5 levels, reflecting progress in systematic environmental management and proactive production that takes environmental impacts into account (Bosetti, 2023). Data from the Ministry of Industry indicate a continuous increase in the number of factories certified at the GI 3 to GI 5 levels over the past decade, demonstrating the commitment of the Thai industrial sector to advancing sustainable production and supporting greenhouse gas emission reductions in accordance with GI program standards (Charoenrat et al., 2022; Kamthonkiat, 2025), thereby reflecting alignment with the Sustainable Development Goals (SDGs), particularly SDG 13, SDG 7, SDG 14, and SDG 15 (United Nations, 2025). However, empirical evidence indicates that greenhouse gas emissions in Thailand is continue increasing. From 1962 to 2024 greenhouse gas emissions in Thailand show a clear long-term beyond trend, rising from approximately 229 million tons to more than 458 million tons of carbon dioxide equivalent on average (Li et al., 2026). Data from the Climate Data Explorer via Climate Watch show that in 2022, Thailand's greenhouse gas emissions were highest in the industrial sector, with total emissions of approximately 202.41 million tons of carbon dioxide equivalent. This situation reflects that current measures may be insufficient to effectively reduce overall greenhouse gas emissions. Therefore, there is a need to develop systematic approaches and mechanisms for managing carbon credits to support emission reductions and consistent with the country's long-term carbon neutrality goals (Limmeechokchai et al., 2022; Basu et al., 2025).

The Intergovernmental Panel on Climate Change (IPCC) has identified carbon dioxide as the greenhouse gas that contributes most significantly to global warming in the atmosphere of earth, it also projected to increase more than other greenhouse gases. Thailand uses the Carbon Dioxide Equivalent (CO_2eq) metric as its primary indicator, referencing the Our World in Data database, which was developed using the greenhouse gas emissions dataset together with conversion factors based on the IPCC AR6 guidelines, allowing different gases to be expressed in a single standardized unit (Taweesan et al., 2025). Carbon dioxide is used as the reference gas because it is the most widely exhaled gas from the energy and industrial sectors, it also has a long atmospheric existence, and serves as the diagnostic for calculating the global warming potential of all greenhouse gases under IPCC standards (Sebos, 2022).Scientific evidence indicates that Thailand is facing steadily impacts from climate change. Over the past five decades, carbon dioxide emissions in the country have shown a continuous above trend, leading to higher concentrations of greenhouse gases in the atmosphere and, therefore, global warming (de Oliveira-Júnior et al., 2025). Furthermore, the increasing trend in Thailand's carbon dioxide emissions over the past 40 to 50 years is associated with a rise in the average temperature of the country. Between 2018 and 2024, the average annual temperature increased by approximately 1.6 degrees Celsius (Raihan et al., 2023). If systematic emission reduction measures are not urgently implemented, this could result in a 33.7 to 43.6% decrease in Gross Domestic Product (GDP) by 2048 (Ngoc Xuan et al., 2026; Yang et al., 2023). From the above context, the climate change is an environmental problem, also a structural risk that affects the country's long-term economic stability and competitiveness. Especially, the industrial sector, which is a major driver of the economy and concurrently a significant source of greenhouse gas emissions, must adapt to the goal of carbon neutrality (Champeecharoensuk et al., 2024). Achieving this goal requires an effective, transparent, and verifiable management mechanism. The carbon credit management is therefore crucial policy in supporting greenhouse gas emission reductions in the industrial sector, both by creating economic incentives, enhancing energy efficiency, and promoting innovation and clean technologies (Sutthasil et al., 2023). In addition, the researchers concentrate

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on carbon credit management in the industrial sectors to support carbon neutrality, and expect that this study will contribute to achieving more substantial results in carbon credit management within the industrial sectors and support the accomplishment of Net-Zero greenhouse gas emissions, specifically on carbon neutrality.

Research Objectives

1. To examine the structure and operational characteristics of carbon credit management in the industrial sector in order to support carbon neutrality.
2. To examine the components of carbon credit management approaches in the industrial sector in order to support carbon neutrality.
3. To develop a structural equation model of carbon credit management approaches in the industrial sector to support carbon neutrality.

Research Scope

1. This research employs a mixed-methods approach, incorporating qualitative research through in-depth interviews, quantitative research through surveys, and qualitative research through focus group discussions. The aim is to examine and develop a structural equation model for carbon credit management in the industrial sector to support carbon neutrality, thereby generating knowledge on effective carbon credit management approaches for achieving carbon neutrality in the industrial sector.
2. Variables used in the quantitative research component of the study, including: Independent
Variables which are: small and medium-sized industrial businesses with total revenue not exceeding 500 million baht, and large industrial businesses with total revenue exceeding 500 million baht, and Dependent Variable which refers to the structure and operational characteristics of industrial businesses that manage carbon credits.
3. The qantitative data collection for this research was conducted between **October and November 2025.**

Research Hypothesis

H1: Organization support has a direct influence on collaboration.
H2: Organization support has a direct influence on the good governance component.
H3: The organization support component has a direct influence on the innovation component.
H4: The collaboration component has a direct influence on the innovation component.
H5: The innovation component has a direct influence on the good governance component.
H6: The level of importance assigned to carbon credit management elements in the industrial sectors to support overall carbon neutrality varies according to the size of the business or industry.

Conceptual Framework of the Research

This research is inductive research employed using a mixed methodology approach, comprising three components: qualitative research through in-depth interviews, quantitative research through survey data collection, and qualitative research through focus group discussions to validate the research model.

Population and Sample Used in this Study.

1) Qualitative Research: In-depth interviews were conducted with nine key experts. Purposive sampling was used in accordance with the expert qualification criteria established by **the Doctor of Business Administration Program in Industrial Business Administration, Faculty of Business Administration, King Mongkut's University of Technology North Bangkok**. The experts were categorized into three groups which are: three executives from industrial organizations, three academics, and three representatives from government and related agencies.

2) Quantitative Research: Survey research techniques were conducted, the population for this section consisted of executives from business and industrial organizations certified under the GI criteria at Level 3 and above. These organizations were classified as small- and medium-sized industrial businesses with total revenue not exceeding 500 million baht, and large-sized industrial businesses with total revenue exceeding 500 million baht, totaling 1,522 organizations. The sample size was determined based on criteria from factor analysis or SEM research, which suggest that a sample size of 500 is considered very appropriated (Thanin, 2024). A multi-stage sampling method was used, beginning with Cluster Sampling. Moreover, organizations were divided into two groups which are: small- and medium-sized industrial businesses with total revenue not exceeding 500 million baht, and large industrial businesses sized with total revenue exceeding 500 million baht that were registered as GI Level 3 or higher. Therefore, probability sampling using the lottery method was applied to collect data from the selected sample groups.

3) Qualitative Research: A focus group discussion technique was conducted to validate the model. The key informants were qualified experts, specifically executives from the industrial business sectors. Purposive sampling was used to select 11 experts based on the qualification criteria established by the **Doctor of Business Administration Program in Industrial Business Administration, Faculty of Business Administration, King Mongkut's University of Technology North Bangkok.** These experts were different from those who participated in the qualitative research conducted through in-depth interviews.

Research Tools

1) In-Depth Interview: The researchers structured interview guide comprising four components which are: Organization Support, Innovation, Collaboration, and Good Governance.
2) Survey Research: The researchers divided a questionnaire into four parts, as follows:

Part 1: General Status of the Organization. The questionnaire consists of four checklist items and one open-ended question.

Part 2: Structure and operational characteristics of industrial businesses that manage carbon credits. The questionnaire is in the form of a checklist and consists of 20 items.

Part 3: Guidelines for Carbon Credit Management in the Industrial Sector to Support Carbon Neutrality. The questionnaire is a five-point Likert scale rating instrument, based on Thanin (2024), and consists of 100 items.

Part 4: Comments and suggestions, the questionnaire consists of five open-ended questions.

3) Focus Group Discussion: The research tool used was a focus group discussion record form.

Research Methodology

1. In-Depth Interviews: The procedures of this part were conducted and establish interview guidelines and topics. After that the researchers contact experts to request their assistance and cooperation in providing information. Then conduct interviews with the experts according to the established structure. During the interviews, the researcher recorded all relevant information and transcribe the in-depth interviews verbatim to categorize the content into themes, and interpret the meanings. Then analyze the data by subtopics, considering their relevance to the research questions.
2. Quantitative Research: The researchers arrange a list and addresses of 500 registered GI businesses. After that contact the sample group to request their participation in completing the questionnaire. The researcher then coordinated with the participants for interviews, if private meetings are not convenient, the questionnaires will be distributed and collected via postal mail or electronic options, and to verify the accuracy and completeness of the returned questionnaires, the data will then process for statistical analysis.

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3. Focus Group Discussion: This will process with a moderator introducing the discussion topics to encourage participants, generate ideas and express their opinions on the issues or proposed approaches in a comprehensive, detailed, and insightful. The researchers began with contact experts to request their assistance and cooperation in providing information after prepared a draft of the discussion topics and present them to the experts for review before contribution procedure. Then conduct the focus group discussion on the agreed date, time, and location, which during the discussion, the researcher will continuously record the data, and then organize the data obtained for further analysis.

Statistics Used in Data Analysis.

1. In-Depth Interviews: This section used content analysis to summarized, and categorized by component.
2. Quantitative Research: The general data were analyzed using descriptive, inferential, and multivariate statistical methods, using the SPSS (Statistical Package for the Social Sciences) and AMOS (Analysis of Moment Structures) software programs
3. Focus Group Discussion: Conducted content analysis to summarize the opinions and suggestions obtained from the group discussion.

Results

1. Results of the qualitative research using in-depth interview techniques.

The study found that the comprises of four core components as follows:

1) Innovation Components, including 1) Promoting the use of clean technologies in production processes to reduce carbon dioxide emissions, 2) Using infinite energy in production processes to reduce reliance on fossil fuels, 3) Applying appropriate technologies to remove contaminants and reduce carbon dioxide emissions, 4) Using low-carbon materials, which are generate lower carbon dioxide emissions than conventional materials, and 5) Eliminating unnecessary production steps and adopting automation.

2) Good Governance Components, including 1) Establishing clear and concrete policies for reducing greenhouse gas emissions and communicating these policies to relevant stakeholders, 2) Disclosing accurate and complete greenhouse gas emission data to build credibility and enable verification by stakeholders, 3) Conducting internal audits of greenhouse gas emission management, 4) Strictly compliant with environmental laws and regulations to sustain the rule of law, and 5) Reporting and publishing annual carbon dioxide reduction performance to ensure continuity and transparency in reporting.

3) Organization Support Components, including 1) Allocating an annual budget for carbon credit management, 2) Developing continuous short, medium, or long-term investment plans for carbon credit management, 3) Providing regular training and skill development for employees in managing carbon dioxide emission reductions, 4) Assigning a dedicated team responsible for carbon dioxide emission reduction, and 5) Supporting personnel development to become Corporate Carbon Footprint (CFO) and Carbon Footprint of Products (CFP) observers, enabling them to serve as internal observers in preparation for the future carbon credit market.

4) Collaboration Component, including 1) Establishing collaboration with government organizations on carbon dioxide reduction projects to measure the level of cooperation between the public and private sectors, 2) Collaborating with other business organizations to develop carbon dioxide reduction guidelines to assess inter-organizational cooperation within the industry, 3) Providing platforms for the business sector to participate in policymaking through respective collaboration to measure the level of stakeholder engagement, and 4) Participating in meetings, listening to policy proposals, or providing information to support the development of the national strategic plan for greenhouse gas reduction.

2. Analysis results on the general status of the organization.

The study found that medium and small-sized business organizations with total revenue not exceeding 500 million baht accounted for 50.00% of the sample, while large sized businesses with total revenue exceeding 500 million baht also accounted for 50.00%. Regarding the duration of business operations, the majority of industrial businesses had been operating for more than 15 years, accounting for 75.20%, followed by those operating for less than 15 years, at 24.80%. The most prevalent industry type was petrochemicals and chemicals, representing 19.80% of the sample. This was followed by consumer goods and services, accounting for 12.80%. The most obvious environmental and energy standards were CFO and CFP certifications ISO 14067, representing 26.80%, followed by the GHGs standard with ISO 14064 at 26.40%. In addition, environmentally friendly business operations with GI Certification, the majority of organizations were certified at GI Level 3, accounting for 54.40%, followed by GI Level 4 at 36.80%.

3. Analysis results of the structure and operational characteristics.

The most regular objective for organizations managing carbon credits was to improve resource efficiency and cost-effectiveness accounted for 23.80%, followed by building a positive image and enhancing the organization's environmental credibility accounted for 22.60%. The department most frequently responsible for managing greenhouse gas emission reduction measures was led by the Sustainability Manager accounted for 23.00%. The Sustainable Development Committee (Executive Level) and the Climate Change Risk Management Committee, both accounting for 22.00%. The most regular carbon dioxide emission reduction target was to reduce emissions by more than 30% per year, accounting for 30.00%. Following by an approach which was having no specific emission reduction target, representing 28.80%. The most frequently used method for defining the scope of carbon dioxide emission reporting was the ESG Reporting guidelines of the Stock Exchange of Thailand, accounting for 22.20%. Moreover, calculating greenhouse gas emissions from various organizational activities, with the CFO accounting for 21.20%. The most regular used tool for managing carbon dioxide reduction was the adoption of low-carbon vehicles or transportation, such as electric vehicles (EVs), at 26.00%, followed by the implementation of waste management technologies. The most regular method for developing personnel in carbon credit management was participation in training programs organized by government organizations, educational institutions, or related organizations, accounting for 37.00%. This was followed by internal training conducted by in-house trainers, representing 25.80%.

4. Analysis results of the structure and operational characteristics classified by the size of the industrial business.

It result shown that SMEs most frequently cited objective was to build a positive image and enhance the organization's environmental credibility accounted for 25.20%, followed by compliance with international laws and standards accounted for 24.80%. For large businesses, the principal objective was to improve resource efficiency accounted for 27.60%, followed by compliance with the agreements or conditions of domestic and international business partners accounted for 22.40%.

The organization responsible for managing greenhouse gas emission reduction measures varies significantly according to the size of the industrial business. For SMEs, the organization most frequently responsible is the Sustainability Manager accounted for 27.60%, followed by the Corporate Governance and Sustainability Committee at the company board level, accounted for 25.60%. For large businesses, the principal responsible intuition is the Climate Change Risk Management Committee accounted for 34.40%, followed by the Sustainability Committee at the management level, accounted for 22.00%.

Carbon dioxide emission reduction targets vary significantly according to the size of the industrial business. SMEs mostly regular target was to reduce emissions by less than 10% per year accounted for 35.20%, followed by a reduction of 10–30% per year accounted for 26.40%. For large businesses mostly approach was to have no specific emission reduction target accounted for 42.00%, followed by a target of reducing emissions by more than 30% per year accounted for 37.20%.

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The tools used to reduce carbon dioxide emissions vary significantly according to the size of the business or industry. For SMEs mostly used tool was the implementation of clean energy policies accounted for 29.60%, followed by the adoption of digital technologies and AI or the IoT to monitor and control CO_2 emissions accounted for 18.40%. For large businesses, the most frequently used tool was the adoption of low-carbon vehicles or transportation, such as EVs accounted for 33.60%, followed by the implementation of waste management technologies in production processes accounted for 28.40%.

5. Analysis results of the importance level.

An analysis revealed that, overall, were rated at a high level, with a mean score of 4.30. When considered individually, the components are ranked as follows:

1) Organization Support was at highly important, with a mean score of 4.35. The mean scores of individual items ranged from 4.43 to 4.26, including: 1) Allocating an annual budget for carbon credit management ($\bar{X}$ = 4.43, S.D. = 0.74), 2) Regularly providing training or development programs for employees on managing carbon dioxide emission reduction ($\bar{X}$ = 4.43, S.D. = 0.77), and 3) Encouraging an organizational culture that emphasizes awareness and responsibility for reducing greenhouse gas emissions ($\bar{X}$= 4.38, S.D. = 0.75).

2) Innovation was also as a high important level, with a mean score of 4.33. The mean scores of individual items were from 4.38 to 4.27, including 1) Using technology to collect and store carbon dioxide ($\bar{X}$= 4.38, S.D. = 0.78), 2) Using renewable energy in production processes to reduce reliance on fossil fuels ($\bar{X}$ = 4.38, S.D. = 0.81), and 3) Applying technologies, such as IoT or AI to monitor and control carbon dioxide emissions before their release into the atmosphere ($\bar{X}$ = 4.36, S.D. = 0.79).

3) Collaboration was also at a high level of important, with a mean score of 4.32. The mean scores of individual items were from 4.40 to 4.26, including 1) Establishing a long-term collaboration plan to achieve the Net Zero goal in cooperation with government organizations ($\bar{X}$ = 4.40), 2) Participating in voluntary T-VER projects or engaging in carbon credit trading ($\bar{X}$ = 4.39), and 3) Collaborating with expert groups in clean technologies to develop new tools and innovations ($\bar{X}$ = 4.37).

4) Good Governance was at a high level of important, with a mean score of 4.20. The mean scores of individual items were from 4.30 to 4.04, including 1) Disclosing accurate and complete greenhouse gas emissions data to enhance credibility and ensure verifiability among stakeholders ($\bar{X}$= 4.30), 2) Establishing formal carbon reduction targets to demonstrate strategic commitment ($\bar{X}$ = 4.29), and 3) Reporting carbon data in accordance with international standards, such as the GHG Protocol, to ensure compliance with global standards ($\bar{X}$= 4.28).

6. Analysis results of the importance level classified by business and industrial size.

verall SMEs, components were revealed rated as highly important, with a mean score of 4.24.

1) Organization Support was at high importance level with mean score of 4.28.
2) Innovation was at a high importance level with mean score of 4.27.
3) Collaboration also was at a high importance level with mean score of 4.26, and
4) Good Governance was at a high importance level with mean score of 4.13.

Large businesses were also found to rated the components as highly important level in overall, with a mean score of 4.37.

1) Organization Support was at a high importance level with a mean score of 4.42.
2) Innovation was at a high importance level with a mean score of 4.39.
3) Collaboration also was a t a high importance level with a mean score of 4.38, and
4) Good Governance was at a high importance level with a mean score of 4.27.

7. Comparison of differences in the importance level classified by business and industrial size.

The study found that the level of importance designated differently significantly by industrial size, which the large businesses were significantly higher importance on all components which are Organization Support, Innovation, Collaboration, and Good Governance than SMEs. Furthermore, statistically significant differences were found for each individual aspect.

8. Results of hypothesis testing on the differences in the importance categorized by business and industrial size.

The hypothesis testing results of **H6** indicate that **H6** is supported with overall p-value of 0.02, which the large businesses appointing higher importance to all components which are Organization Support, Innovation, Collaboration, and Good Governance than SMEs.

9. Analysis results of opinions and suggestions.

1) The government should implement tax incentives to encourage investment in carbon reduction, accelerating investment decisions and positively influencing the private sector.
2) As international trading partners place increasing emphasis on climate change, Thai organizations should elevate carbon management to a strategic business agenda.
3) Organizations should enhance knowledge and understanding of carbon credits across all departments and among all personnel.
4) Allocating investment budgets, adopting appropriate technologies, and establishing clear strategic directions to drive carbon reduction.
5) Setting short, medium, and long-term goals, implementing a monitoring system, and precisely applying the PDCA (Plan–Do–Check–Act) cycle.
6) Promoting sustainable energy use as a standard operating practice within the organization.
7) Organizations required to establish clear and actionable carbon reduction plans.
8) Increased operating costs due to compliance with environmental requirements, and
9) Greater operational complexity, requiring higher budget allocations.

10. Analysis results of the SEM before model improvement.

The results of the SEM analysis presented in both unstandardized and standardized estimate modes before the model improvement, are shown in Figures 2 and 3.

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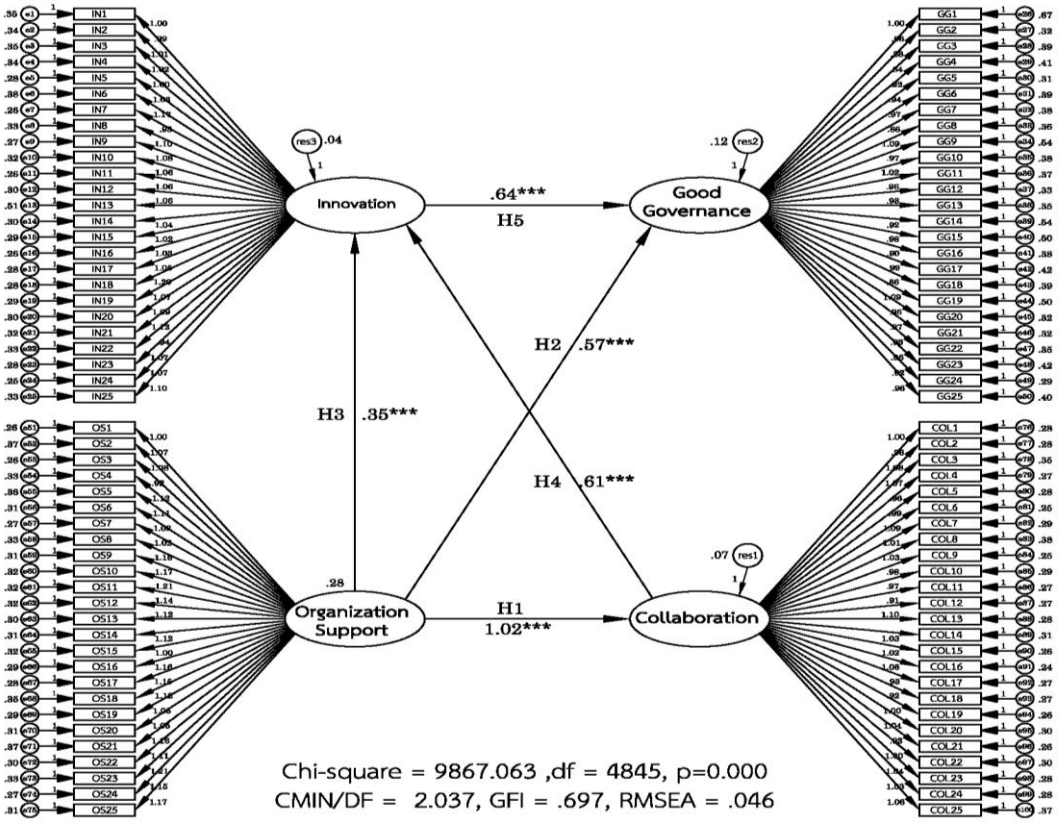

Figure 2: The SEM in Unstandardized Estimate Mode, before model improvements.

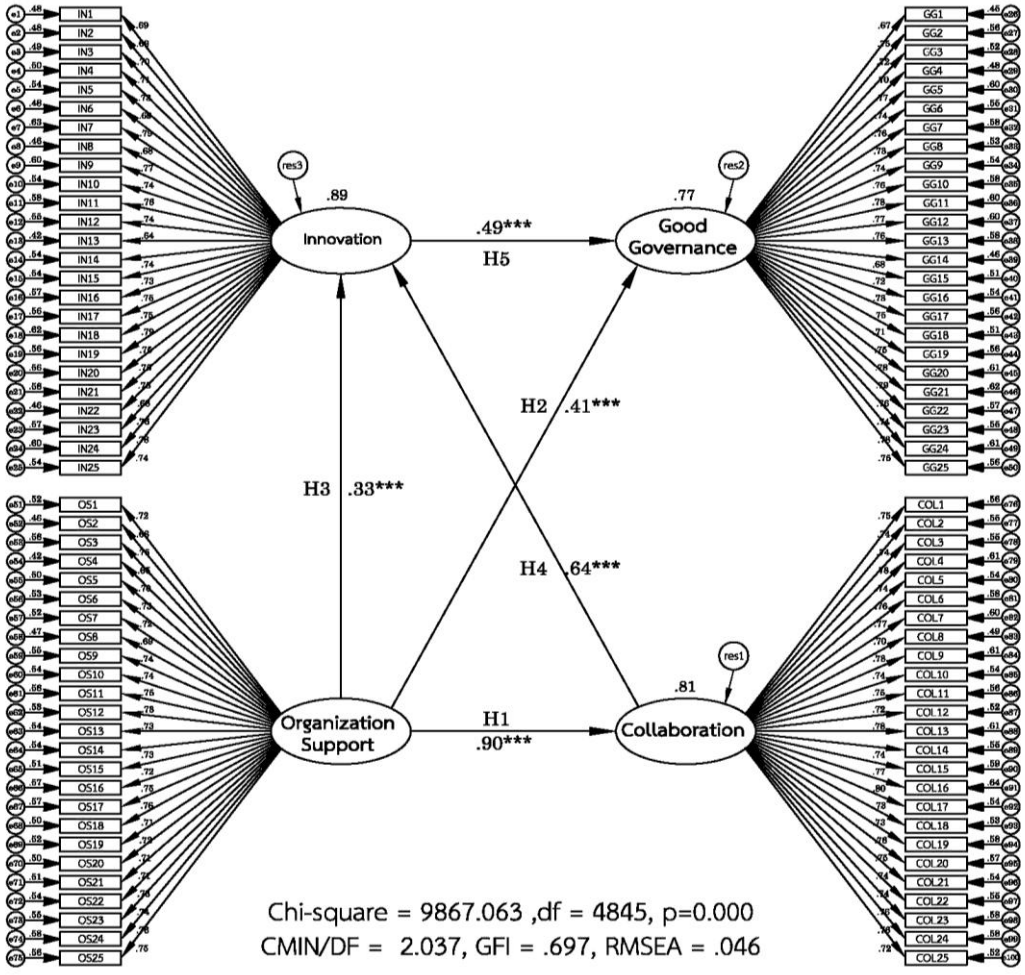

Figure 3: The SEM in Standardized Estimate Mode, before model improvements.

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11. Analysis results of the SEM after model improvement.

The results of the SEM analysis of presented in both unstandardized and standardized estimate modes after model improvement, are shown in Figures 4 and 5.

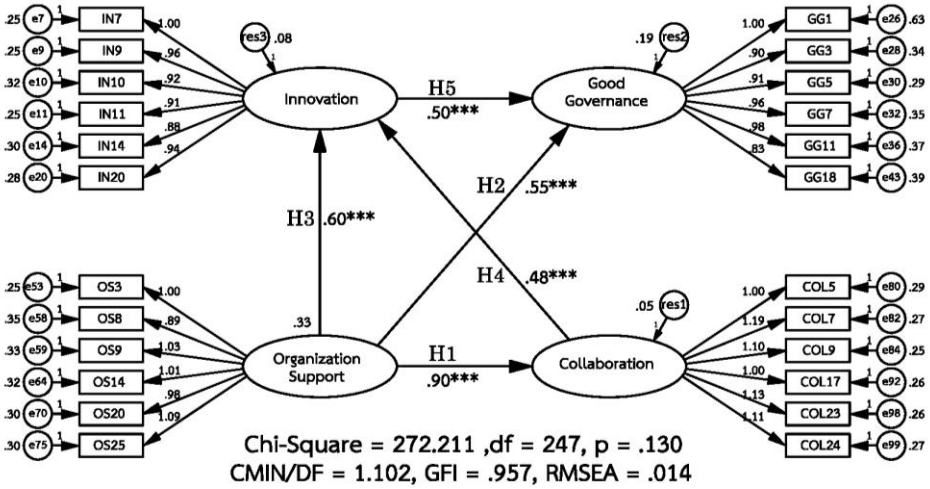

Figure 4: The SEM in Unstandardized Estimate Mode, after model improvements.

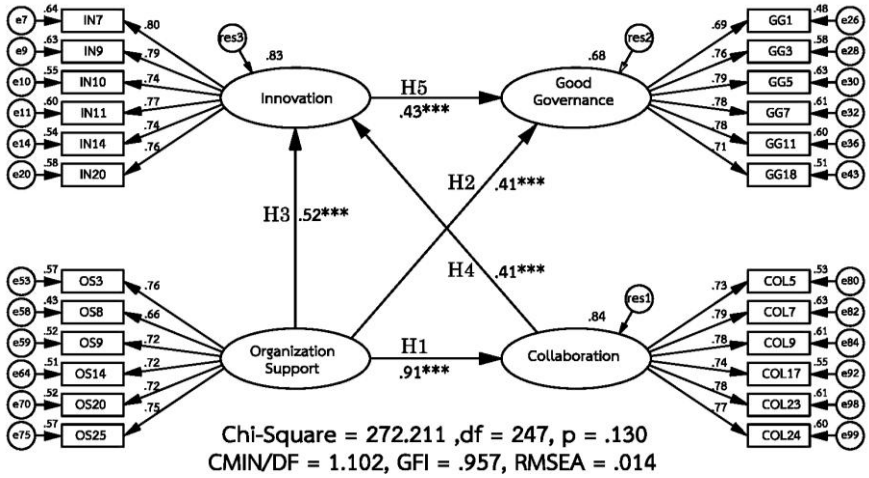

Figure 5: The SEM in Standardized Estimate Mode, after model improvements.

The SEM after model improvements, was found to comprise four latent variables: one exogenous latent variable, namely Organization Support, and three endogenous latent variables, namely Collaboration, Good Governance, and Innovation. The Organization Support component was found to have a direct influence on the Collaboration component, with a specified path coefficient. The Innovation component also demonstrated a direct influence on the Good Governance component. The Organization Support component comprises six observed variables. The Collaboration component comprises six observed variables. The Good Governance component comprises six observed variables. The Innovation component comprises six observed variables.

12. Results of the Consistency Assessment of the SEM before and after model improvements.

Table 1: Statistical values assessing the consistency of the SEM comparison of the model before and after improvement.

Statistics	Criteria	Before Improvements	After Improvements
CMIN–ρ (Chi-square probability level)	> 0.05	0.000	0.130
CMIN/DF (Relative Chi-Square Value)	< 2.00	2.037	1.102
GFI (Goodness of Fit Index)	> 0.90	0.697	0.957
RMSEA (Root Mean Square Error Estimation Index)	< 0.08	0.046	0.014

Table 1, after model improvement, the chi-square probability (CMIN– ρ) was 0.130 (greater than 0.05), the relative chi-square (CMIN/DF) was 1.102 (less than 2), the Goodness-of-Fit Index (GFI) was 0.957 (greater than 0.90), and the Root Mean Square Error of Approximation (RMSEA) was 0.014 (less than 0.08). All four statistical indicators met the established evaluation criteria. Therefore, the refined structural equation model for carbon credit management in the industrial sector to support carbon neutrality demonstrates a good fit with the empirical data.

13. Results of hypothesis testing to analyze the causal relationships among latent variables in the SEM.

H1: Organization support directly influences collaboration. The hypothesis testing results supported this relationship (p = 0.001), with a standardized regression weight of 0.91.

H2: Organization support directly influences good governance. The hypothesis testing results supported this relationship (p = 0.001), with a standardized regression weight of 0.41.

H3: The Organization Support component has a direct influence on the Innovation component. The results of the hypothesis testing revealed that the research hypothesis is supported (p = 0.001), with a standardized regression weight of 0.52.

H4: The Collaboration component has a direct influence on the Innovation component. The results of the hypothesis testing confirmed that this hypothesis is supported (p = 0.001), with a standardized regression weight of 0.41.

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H5: The Innovation component has a direct influence on the Good Governance component. The results of the hypothesis testing revealed that this hypothesis is supported (p = 0.001), with a standardized regression weight of 0.43.

14. Overall analysis results both direct and indirect influences of the SEM based on standardized estimates after model improvement.

The study found that the component with the greatest overall influence was the Organization Support component, which exerted a strong overall influence on the Collaboration component, with a standardized regression weight of 0.91. This finding is consistent with the direct influence identified between these two components.

15. Analysis of the relationships among variables after model improvement.

The study found that after model optimization, there were 276 pairs of relationships among variables in the structural equation model of carbon credit management approaches in the industrial sector to support carbon neutrality. All relationships were statistically significant (p = 0.001). The researchers ranked the five strongest pairs of relationships, from highest to lowest, as follows:

1. The relationship between the variables of organizing collaborative activities among the government, private sector, and community to reduce carbon dioxide emissions (COL7) and the formulating collaborative policies with businesses in the same industry group to declare a common stance (COL9) has a value of 0.644.
2. The relationship between the variables of organizing collaborative activities among the government, private sector, and community to reduce carbon dioxide emissions (COL7) and participating in cooperated research projects with universities and government organizations to develop clean technologies that reduce greenhouse gas emissions (COL23) has a value of 0.637.
3. The relationship between the variable of using leftover raw materials from production as inputs in another production process to reduce end-product waste (IN7) and the use of ISO 50001 standards as a criterion for improving production processes and enhancing energy efficiency (IN9) has a value of 0.6342.
4. The relationship between variables of establishing collaborative policies with businesses in the same industry group to declare a common stance (COL9) and the participating in cooperated research projects with universities and government organizations to develop clean technologies that reduce greenhouse gas emissions (COL23) has a value of 0.6336.
5. The relationship between the variable of using leftover raw materials from production as inputs for another product in the production process to reduce end-product waste (IN7) and the establishing a research and development (R&D) unit to create innovations to reduce carbon dioxide emissions (IN20) has a value of 0.6284.

16. Feedback from experts in the focus group discussion.

1. Policy from the Organizational Leadership Level (Tone at the Top): Organizations should establish carbon credit management policies at the leadership level to clearly reflect top management's commitment. Strong carbon leadership helps create a shared direction within the organization and reduces ambiguity in implementation.
2. Organizations should establish clear greenhouse gas emission reduction targets in terms of both quantity and timeframe, and develop a roadmap to achieve carbon neutrality or net-zero carbon emissions.
3. Organizations should clearly and systematically define greenhouse gas emission management guidelines that cover all emission scopes which are: Scope 1, Scope 2, and Scope 3. This approach helps fully reflect the organization's total greenhouse gas emissions.
4. Managing Scope 3 Emissions: Indirect emissions under Scope 3 should receive special attention because they encompass activities throughout the supply chain, from upstream to downstream. Scope 3 emissions are complex and difficult to control, however, they account for a significant proportion of total emissions across many industries.
5. Carbon management should be continuously integrated into an organization's medium- and long-term investment plans so that greenhouse gas emission reduction becomes an integral part of business decision-making. Linking carbon considerations to investment decisions enables organizations to comprehensively assess long-term costs and returns.

Discussion

Climate change has become a global challenge impacting the economy, environment, and competitiveness of countries, particularly the industrial sector, a major source of greenhouse gas emissions. Therefore, systematic carbon credit management plays a crucial role in driving industrial organizations to achieve carbon neutrality and net-zero greenhouse gas emissions (Pimpa, 2024; Jatuporn et al., 2023). Based on this research, the researchers identified five key issues for discussion:

1. The research findings indicate that organization support is the most critical component of carbon credit management in the industrial sector. This is because it directly determines the organization's direction, policies, and operational guidelines, encompassing resource allocation, management, and the systematic development of infrastructure related to carbon dioxide emission reduction. Such support may take the form of budget allocation, technical assistance, personnel skill development, and the design of internal support systems to promote the sustainable achievement of carbon dioxide emission reduction targets. This finding is consistent with the Resource-Based View (Purba et al., 2023; Bogale et al., 2025), which posits that resources are the primary determinants of organizational performance, based on the fundamental premise that an organization is a collection of valuable, unique, and difficult-to-imitate resources.

This enables organizations to sustain a long-term strategic advantage, consistent with the study by Awashreh, (2025), which indicates that individual involvement in driving organizations toward net-zero carbon goals can be enhanced through the design of behavioral measures and internal policy systems, This aligns with Wantanakomol (2020), who emphasized that workforce skills development and technological advancement are crucial to organizational sustainability, as well as Lertsinsongserm (2022), who highlighted the importance of developing knowledge in clean energy for human resource development. Furthermore, Mesquita et al. (2025) state that the use of Big Data Analytics (BDA) in conjunction with Lean practices and environmental practices can stimulate green innovation in the manufacturing sector, leading to improved competitive advantage and enhanced long-term sustainability outcomes.

2. The study found that the most significant factor is the allocation of an annual budget for managing carbon credits. This reflects support from senior management, as organizations will not allocate budgets unless they perceive a strategic necessity. It also demonstrates that organizations are willing to bear the costs of reducing carbon dioxide emissions and are prepared to compete in the voluntary carbon market. These findings are consistent with the concept of the Balanced Scorecard (BSC), it is a strategic management tool that enables companies to change from a narrow, niche-focused perspective to a more comprehensive and integrated approach (Tawse et al., 2023).

3.The analysis of the SEM revealed that the Organization Support component has both direct and total effects on the Collaboration component, with the highest (Standardized Regression Weight). This finding indicates that organizations with strong support structures have greater potential to collaborate with external agencies and various sectors to drive systematic and sustainable greenhouse gas emission reductions (Prokopenko et al., 2023), it is consistent with the World Economic Forum report, which states that achieving net-zero greenhouse gas emissions requires strong institutional cooperation between industry and government, particularly during periods of energy volatility, high energy and material prices, and the risk of persistent supply shortages that affect the industrial value chain down to end consumers (Satola et al., 2022). Also consistent with Su'ait et al. (2026) explains that Malaysia's national energy policy and strategy assign a significant role to renewable energy in

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electricity generation under the SREP project. However, the initiative faces several obstacles and challenges that reflect a lack of effective support mechanisms from the government and financial institutions, thereby limiting cooperation among relevant agencies (Friday et al., 2022).

4. Analysis of the relationship between variables in the SEM after model improvement, revealed that collaborative activities between the government, private sector, and communities on the issue of reducing carbon dioxide emissions (COL7) and the variable of formulating collaborative policies with businesses in the same industry group to declare a common stance (COL9) had a value of 0.644.

The highest correlation was found between pairwise relationships. This correlation reflects that practical collaboration among stakeholders is a crucial foundation for developing policy cooperation and driving concrete carbon neutrality goals. Stakeholder analysis theory explains that allowing diverse stakeholders to participate from the early stages of the governance process enhances decision-making quality by leveraging diverse knowledge and experience, reduces the risk of future conflicts, and facilitates consensus building, resulting in higher efficiency and lower costs in practical implementation. Consistent with Bao, et al. (2024) pointing out, as low-carbon technologies advance to higher levels, retailers play the most effective leadership role in driving low-carbon practices in supply chains. Due to their strategic flexibility and financial incentives, flexible policy setting coupled with carbon pricing mechanisms is more effective than rigid cap controls. Fostering policy collaboration among industry stakeholders to jointly determine pricing can drive systemic and sustainable greenhouse gas emission reductions. Yu et al. (2025) found that collaboration between governments and businesses has a significant impact on carbon reduction behavior, particularly the “willingness to initiate” of stakeholders, which significantly influences the speed of environmental behavior change. This reflects the fact that effective implementation of greenhouse gas emission reduction measures requires policy collaboration and the participation of stakeholders across all sectors.

In addition, Xu et al. (2024) emphasized that cooperation in pollution management is more effective when appropriate incentives and cost structures are designed, with both economic incentives and policy measures playing a crucial role in stimulating stakeholder participation. However, if the cost of reducing emissions is too high, it may reduce the incentive to participate. Consistent with Ritter et al. (2024), who pointed out that interdisciplinary collaboration and multi-stakeholder engagement play a crucial role in driving the circular economy, the integration of knowledge, incentives, and collaborative action among government, the private sector, academia, and civil society is a key mechanism for driving systemic and sustainable change. Similarly, Bowser et al. (2024) noted that building cross-sectoral collaborative networks also plays a role in bridging academic knowledge with practical contexts, fostering innovation, and developing relationships between industry and communities. Despite limitations in trust and coordination across sectors, such collaboration can serve as a vital catalyst for capacity building and driving society towards sustainability. At the same time, Coleman et al. (2023) showed that intersectoral collaboration plays a crucial role in developing innovations to address the limitations of the voluntary carbon market, particularly in the reliable measurement, assessment, and scaling of carbon sequestration potential. Such collaboration facilitates the integration of knowledge, technology, and market mechanisms, resulting in innovations that support efficient and sustainable greenhouse gas emission reduction.

5. Based on the hypothesis testing results, the components of carbon credit planning and management in the industrial sector to support carbon neutrality, when categorized by industrial size, indicate that large enterprises place greater importance on these components than medium and small enterprises. This may be attributed to Thailand’s national targets of achieving carbon neutrality by 2050, reaching GHG emissions by 2065, and reducing emissions by up to 40% under its NDC by 2030 (Pongthanaisawan et al., 2023). Large enterprises are well prepared to establish targets through the development of net-zero strategic plans, the utilization of renewable energy, the improvement of production processes to reduce greenhouse gas emissions, and the adoption of digital technologies to measure and monitor carbon footprints. This is consistent with Thailand’s responsibilities under the United Nations Framework Convention on Climate Change (UNFCCC), with large enterprises taking the lead in driving this transition, the number of companies adopting the Balanced Scorecard (BSC) for strategic planning and management is steadily increasing, with more than 35% of adopters being large and extra-large enterprises (Chankrajang et al., 2022).

Furthermore, SMEs still lack formal environmental and carbon management systems due to limitations in capital, personnel, and information resources, as well as the diversity of business characteristics and their shorter operating lifespans compared to larger organizations (Joy-Camacho et al., 2024). However, raising awareness of the importance of carbon credits should begin at the strategic level (Thapmanee et al., 2025). The Thailand Greenhouse Gas Management Organization (Public Organization), in collaboration with agencies under the Ministry of Natural Resources and Environment, should work together to promote greenhouse gas emission reductions across all sectors and encourage greater emphasis on carbon credits. This is because Thailand’s carbon market currently operates as a voluntary market, which limits trading volume primarily to large enterprises operating under Business-To-Business (B2B) models (Tangchua et al., 2025).

Conclusion

An overview of the structure and guidelines for managing carbon credits in the industrial sector to support carbon neutrality in conclusions presented as follows:

1. An analysis of qualitative research techniques through in-depth interviews with experts, revealed four key components which are: organization support, collaboration, good governance, and innovation. These components comprised a total of 100 items, with 25 variables in each component.

2. General organizational status in this study found that medium and small-sized business organizations with total revenue not exceeding 500 million baht, accounted for the same proportion as large-sized business organizations with total revenue exceeding 500 million baht, each representing 50.00%. The duration of industrial business operations was more than 15 years accounted for 75.20%. The majority of industries were in the petrochemical and chemical sectors accounted for 19.80%. The most important environmental and energy standards were the Corporate Carbon Footprint (CFO) and Carbon Footprint Certification (CFP) (ISO 14067) standards accounted for 26.80%, and the most environmentally friendly business operations (GI) were classified as level 3 GI accounted for 54.40%.

3. The findings of structure and operational characteristics revealed that:

1) The key objective of carbon credit management in most organizations is to enhance the efficiency and cost-effectiveness of resource usage accounted for 23.80%.

2) The department key responsible for managing greenhouse gas emission reduction measures is led by the Sustainability Manager accounted for 23.00%.

3) The main carbon dioxide emission reduction target is to reduce carbon dioxide emissions by more than 30% per year accounted for 30.00%.

4) The most common method for measuring the scope of carbon dioxide emission reporting is based on the ESG reporting guidelines of the Stock Exchange of Thailand accounted for 22.20%.

5) The most typically used tool for managing carbon dioxide emission reduction is waste management technology in the production process accounted for 22.40%.

6) The most influential factor affecting investment decisions in technologies to reduce carbon dioxide emissions is the creation of an environmentally friendly corporate brand to attract investment accounted for 25.60%.

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7) The most typically form of human resource development in carbon credit management is participation in training programs organized by government organizations, educational institutions, or related organizations accounted for 37.00%.
8) The most common method of disseminating information on carbon credit management is organizing meetings and seminars to provide insight information to investors, partners, and employees accounted for 34.20%.
9) Mostly allocation of investment funds for carbon dioxide emission reduction activities is the installation of solar panels on factory or office building rooftops accounted for 31.60%.
10) The majority of greenhouse gas emission reduction projects are voluntary projects under Thailand's standards, specifically the Thailand Voluntary Emission Reduction Program (T-VER) accounted for 25.20%.
11) The majority of average carbon dioxide emissions range between 50,001 and 100,000 tons of carbon dioxide equivalent per year accounted for 29.00%.
12) Most renewable energy targets for reducing carbon dioxide emissions are currently under probability study accounted for 34.20%.
13) The core factors contributing to the success of carbon credit management relate to the clarity of the organization's vision, mission, and goals accounted for 27.20%.
14) The majority of carbon dioxide reduction projects involve the implementation of automation in energy production and consumption control systems, as well as Smart Energy Management accounted for 33.40%.
15) The most common internal monitoring and evaluation method is external auditing and certification accounted for 29.80%.
16) The most common improvement in production processes to enhance the efficiency of carbon credit management is converting production waste into energy accounted for 24.80%.
17) The most common method of communicating and publicizing carbon credit management activities is the preparation of a Sustainability Report for stakeholders accounted for 23.60%.
18) The most common method for analyzing the financial impact of carbon dioxide emissions is the application of a carbon tax accounted for 39.00%.
19) The regular model for supporting personnel knowledge in carbon credits is collaboration among departments and internal units, such as production and management accounted for 31.00%.
20) The ordinary budget allocation for reducing carbon dioxide emissions exceeds 1,000,000 baht accounted for 48.40%.

4. Importance level of the components of carbon credit management approaches in the business sector.

The overall importance was found to be high, with an average score of 4.30. The components when considered by each aspect, found that Organization Support was at a high importance level with an average score of 4.35, Innovation also was at a high importance level with average score of 4.33, Collaboration was at a high importance level with an average score of 4.32, and Good Governance also was at a high importance level with an average score of 4.20.

When analyzed at the individual aspect level, the three priority aspects with the highest levels of importance were:

1) Organization Support including allocating an annual budget for carbon credit management ($\bar{X}$ = 4.43, S.D. = 0.74), regularly providing training or developing employees with their skills in managing carbon dioxide emission reduction ($\bar{X}$ = 4.43, S.D. = 0.77), and creating an organizational culture that emphasizes awareness of and responsibility for reducing greenhouse gas emissions ($\bar{X}$ = 4.38, S.D. = 0.75), respectively.

2) Innovation Components, including using technology to collect and store carbon dioxide ($\bar{X}$ = 4.38, S.D. = 0.78), using renewable energy in production processes to reduce reliance on fossil fuels ($\bar{X}$ = 4.38, S.D. = 0.81), and applying technologies, such as IoT or AI to control carbon dioxide emissions before their release into the atmosphere ($\bar{X}$ = 4.36, S.D. = 0.79), respectively.

3) Collaboration Components, including establishing a long-term collaboration plan to achieve the Net Zero goal and to assess strategic planning in coordination with government organizations ($\bar{X}$ = 4.40), participating in voluntary T-VER projects or engaging in carbon credit trading ($\bar{X}$ = 4.39), and collaborating with expert groups in clean technologies to develop new tools ($\bar{X}$ = 4.37), respectively.

4) Good Governance Components, including disclosing precise and complete greenhouse gas emission data to build credibility and ensure verifiability for stakeholders ($\bar{X}$ = 4.30), forming formal carbon reduction targets to measure strategic commitment ($\bar{X}$ = 4.29), and reporting carbon data in accordance with international standards, such as the GHG Protocol, to demonstrate compliance with international standards ($\bar{X}$ = 4.28).

5. A comparison of the importance levels, categorized by business size and analyzed using an independent t-test to examine differences between the means of the two groups, revealed that the overall importance levels differed significantly at the 0.05 level of statistical significance. Large businesses were greater importance on carbon credit management approach components to support carbon neutrality than medium and small-sized businesses.

In the organization support aspect, innovation, collaboration, and good governance were found to be statistically significant differences at the 0.05 level. Large businesses greater importance on all components of carbon credit management approaches for achieving carbon neutrality than medium and small-sized businesses.

For each item comparisons, statistically significant differences at the 0.05 level were found in 39 items, which are: Organization Support 12 items, Innovation 10 items, Collaboration 7 items, and Good Governance 10 items. All 39 items indicated that large businesses significantly greater importance on carbon credit management approaches in the industrial sector to support carbon neutrality than medium and small-sized businesses, at the 0.05 level of statistical significance.

6. The results of the SEM analysis indicated that the CMIN/DF was 2.037 and the RMSEA was 0.046, meeting the criteria for a consistency with the empirical data. However, the CMIN–p was 0.000 and the GFI was 0.697, which did not meet the criteria for a consistency with the empirical data. Therefore, the researchers improved the model by considering the Modification Indices in accordance with Arbuckle's recommendations. After the model improvement was completed, the results showed that the CMIN–p was 0.130, which is greater than 0.05, the CMIN/DF was 1.102, which is less than 2, the GFI was 0.957, which is greater than 0.90, and the RMSEA was 0.014, which is less than 0.08. Overall, four statistical values met the evaluation criteria. Therefore, the modified SEM of carbon credit management in the industrial sector to support carbon neutrality is consistent with the empirical data.

7. The results of hypothesis testing to examine the causal relationships among latent variables in the SEM based on five hypotheses. It was found that all five hypotheses were supported, as follows:

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H1: The organization support component has a direct and significant influence on the collaboration component at the 0.001 level of statistical significance.

H2: The organization support component has a direct and significant influence on the good governance component at the 0.001 level of statistical significance.

H3: The Organization Support component has a statistically significant direct influence on the Innovation component at the 0.001 level of statistical significance.

H4: The Collaboration component has a statistically significant direct influence on the Innovation component at the 0.001 level of statistical significance.

H5: The Innovation component has a statistically significant direct influence on the Good Governance component at the 0.001 level of statistical significance.

8. Overall influence analysis of latent variables within the SEM.

The analysis after model improvement, revealed that the highest overall influence was found in the Organization Support component, which exerted a significant overall influence on the Collaboration component. The standardized regression weight was 0.91, derived from the direct effect of the Organization Support component on the Collaboration component, also with a value of 0.91.

9. Analysis of the relationships among variables in the SEM revealed that, after model improvement, there were 276 pairs of relationships, all of which were statistically significant at the 0.001 level.

10. Qualitative research using focus group discussion techniques was conducted with 11 experts who reviewed and supported the model for managing carbon credits in the industrial sector to support carbon neutrality. The meeting collectively approved the model with important suggestions and consensus were reached among the participants regarding various aspects of the industrial sector, as follows:

1) Organization Support Components: Budget allocation to support carbon credit management is a crucial mechanism for achieving tangible and continuous implementation. This should be accompanied by the systematic establishment of targets and the development of short, medium, and long-term plans. Management should cover Scope 1, Scope 2, and Scope 3 emissions and be integrated into strategic investment plans. Key performance indicators (KPIs/OKRs) for carbon management should be clearly defined to drive effective action. Furthermore, promoting participation at all organizational levels and utilizing small-group activities can foster a sense of ownership and cultivate an environmentally conscious corporate culture. Therefore, organization support should encompass three main dimensions: budget allocation, management systems, and corporate culture, in order to drive sustainable long-term carbon neutrality.

2) Good Governance Components: Transparent, verifiable, and accountable governance should begin with leadership-level policies that reflect strategic commitment through the systematic establishment of greenhouse gas emission reduction targets. Organizations should develop a carbon governance framework with clearly defined roles and responsibilities, and internal audit units should continuously assess the effectiveness of internal control systems. Information disclosure must be accurate, complete, and aligned with international standards. In addition, a traceable carbon credit registry system will enhance credibility and build trust among stakeholders, forming a crucial foundation for advancing toward sustainable carbon neutrality.

3) Innovation Component: The development of technologies and production processes to concretely reduce greenhouse gas emissions should begin with a transition to renewable energy in production processes, combined with the application of carbon capture and storage (CCS) technologies in industries where reducing greenhouse gas emissions is challenging. Furthermore, the use of digital technologies such as IoT, artificial intelligence, and automation can enhance the efficiency and precision of energy monitoring and control. At the same time, promoting Kaizen practices and small-scale team activities can facilitate the continuous reduction of losses at the organizational level. From a strategic perspective, integrating carbon management into brand and product value creation can enhance competitiveness within a sustainable low-carbon economy.

4) Collaboration Components: Managing Scope three emissions requires special attention because they encompass the entire supply chain. Effective implementation can mitigate trade risks and enhance competitiveness. This requires collaboration among the public sector, the private sector, and SMEs, along with incentive measures to reduce costs and stimulate investment in carbon reduction technologies. Key mechanisms for systematic and sustainable organizational progress toward Net Zero goals include active personnel involvement, participation in voluntary programs such as T-VER and carbon credit trading markets, and collaboration with clean technology experts.

Suggestions

1. Suggestions from the research results.

At the policy level, the Ministry of Natural Resources and Environment should play a proactive role in supporting and promoting the development of a carbon credit strategic framework for the industrial sector. This framework should utilize the mechanisms of the Thailand Greenhouse Gas Management Organization (Public Organization) to integrate carbon credit management approaches aligned with the national targets of achieving carbon neutrality by 2050 and net-zero greenhouse gas (GHG) emissions by 2065. This includes the development of sector-specific roadmaps to enable businesses to formulate appropriate adaptation strategies and implement carbon credit operations in alignment with Thailand's Nationally Determined Contribution (NDC) target of reducing greenhouse gas emissions by 40% by 2030 in a practical and measurable manner.

2. Suggestions at the policy level.

1) The Thailand Greenhouse Gas Management Organization (Public Organization), under the Ministry of Natural Resources and Environment, should enhance Thailand's carbon credit system by developing sector-specific T-VER guidelines, preparing manuals, and organizing workshops to enable entrepreneurs to implement and register their projects effectively. Furthermore, the organization should develop an online carbon reporting platform (MRV Platform) to increase transparency and reduce costs, establish a one-stop service center to provide consultation, and create a central database to integrate monitoring and reporting systems at the national level.

2) The Fiscal Policy Office, Ministry of Finance, should strengthen its collaboration with the Revenue Department, state financial institutions, and the Bank of Thailand in developing carbon pricing mechanisms and economic incentives, such as tax benefits. This should involve linking support for T-VER projects with tax reductions or greenhouse gas emission offsets, and expanding the carbon market from a voluntary to a semi-mandatory system in order to increase the volume of carbon credit trading.

3) The Department of Skill Development, Ministry of Labour, should develop curricula and skill standards for workers in carbon credit management, digital technology (Digital MRV), artificial intelligence (AI), the Internet of Things (IoT), and energy management systems to support the transition to a low-carbon economy. Promoting the reskilling and upskilling of personnel to enable them to effectively measure, report, and develop greenhouse gas emission reduction projects will enhance organizations' capacity for systematic carbon management.

4) The Department of Industrial Works, Ministry of Industry, should promote measures to support small and medium-sized enterprises (SMEs) in managing carbon credits. This should include providing technical assistance, supporting investment in clean technologies, and offering digital tools appropriate to the business context. The objective is to strengthen the capacity of SMEs to initiate and implement carbon credit management in a systematic and structured manner.

5) The National Innovation Agency, under the Ministry of Higher Education, Science, Research and Innovation, should promote the development of curricula and innovations in carbon credit management. This should involve integrating knowledge of climate change, digital technology, and energy management systems in collaboration with higher education institutions and industry to develop human resources and practical innovations. This approach will concretely drive the country toward the goals of carbon neutrality and net-zero greenhouse gas emissions.

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3. Suggestions at the operational level.

Organization Support should be promoted as follows:

1) Allocate a clear and sufficient annual budget for carbon credit management and greenhouse gas emission reduction activities to ensure that all units can continuously and systematically implement projects.

2) Provide training and skill development programs for personnel in greenhouse gas emission reduction to enhance their knowledge, awareness, and ability to comply with environmental standards.

3) Foster a corporate culture driven by responsibility for greenhouse gas emission reduction by establishing internal policies, campaigns, and consistent communication to encourage participation and raise awareness of the importance of the Net Zero goal among employees at all levels.

Innovation should be promoted as follows:

1) Reuse waste materials as raw materials in the production process. Promote in-house recycling systems by returning waste to the production process in order to reduce the consumption of new resources, minimize end-of-process waste, and decrease overall greenhouse gas emissions.

2) Use carbon capture and storage technology. Develop and apply technologies to capture CO_2 from factory smokestacks for storage or further utilization (CCU/CCS), thereby reducing its release into the atmosphere.

3) Promote the innovative use of renewable energy in the production process. Utilize renewable energy sources, such as solar power, biomass steam, or waste heat, to replace fossil fuels, thereby reducing carbon emissions throughout the production chain.

Collaboration should be promoted as follows:

1) Strengthen cooperation with government agencies by participating in national greenhouse gas reduction initiatives, such as the T-VER support program, and collaborating in assessments conducted by government authorities to build confidence in carbon reduction efforts.

2) Collaborate with other business organizations and industry associations to establish networks for developing joint greenhouse gas emission reduction strategies, including the exchange of information, technologies, and best practices to achieve effective carbon reduction in the industrial sector.

3) Partner with academics and researchers by providing funding for collaborative research with universities to develop clean technologies, carbon data analysis systems

Good Governance should be promoted as follows:

1) Disclose accurate and verifiable greenhouse gas emissions data. Establish a digital carbon data collection system, allow external agencies to audit the information, and publish reports on the organization's website and in a Sustainability Report to enhance transparency for investors, business partners, and the public.

2) Establish long-term targets for carbon neutrality and net-zero emissions that are aligned with the organization's vision and strategic direction, and systematically integrate them into annual action plans and the sustainability strategic framework.

3) Conduct carbon reporting in accordance with international standards, including the GHG Protocol, ISO 14064, and T-VER, by developing personnel's skills in measurement and reporting and obtaining certification from external experts.

4) Industrial business organizations should establish carbon credit management policies at the leadership level to demonstrate strong leadership commitment and clearly define the strategic direction of the organization's carbon management.

5) Industrial businesses should elevate carbon management from mere legal compliance to a strategic approach for creating added value for their brands and products. Implementing robust carbon management practices will enhance the organization's image in terms of sustainability and social responsibility, expand market opportunities, and meet the expectations of consumers and investors.

6) Industrial business organizations should promote the participation of operational-level personnel through small-group activities to encourage brainstorming and process improvement at the departmental level. This approach leads to increased resource efficiency, reduced waste, and enhanced teamwork within the organization.

7) Business and industrial organizations should prepare to comply with the European Union's Carbon Border Adjustment Mechanism (CBAM) by developing accurate, transparent, and traceable systems for reporting and verifying greenhouse gas emissions in order to maintain their export competitiveness.

8) Industrial business organizations should strengthen collaboration between the public and private sectors to support SMEs by promoting access to knowledge, tools, and infrastructure in carbon management. This will enhance the competitiveness of SMEs within supply chains in the context of a low-carbon economy.

4. Suggestions for future research.

1) The service sector, characterized by different operational structures, energy consumption patterns, and greenhouse gas emission profiles compared to the industrial sector in this study, still lacks in-depth studies on the systematic application of such models. Therefore, future research should focus on developing approaches to enhance the efficiency of carbon credit management in the service sector in order to support carbon neutrality.

2) Environmental economic instruments, especially carbon taxes, continue to play a significant role in shaping the cost structure, investment decisions, and competitiveness of the industrial sector, this study remains insufficiently explored in depth. Therefore, future research should focus on strategies to prepare industrial businesses to contend with the impacts of carbon taxes.

3) Future research should emphasize the development and application of green innovations to enhance the efficiency of greenhouse gas emission reduction while simultaneously creating added economic value for organizations.

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