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-RESEARCH ARTICLE-

GUIDELINES FOR PREPARING THE INDUSTRIAL BUSINESS SECTOR TOWARDS A GREEN INDUSTRY

Kittima Lumphakdi*

King Mongkut's University of Technology North Bangkok, Thailand,
ORCID: https://orcid.org/0009-0005-6871-0660
Email: kittima.lump@gmail.com

Thanin Silpcharu

Professor in Business, Faculty of Business Administration,
King Mongkut's University of Technology North Bangkok, Thailand.
ORCID: https://orcid.org/0000-0001-9503-2379
Email: thanin.s@fba.kmutnb.ac.th

Sunee Wattanakomol

Associate Professor in Business, Faculty of Business Administration,
King Mongkut's University of Technology North Bangkok, Thailand.
ORCID: https://orcid.org/0000-0001-7518-8229
Email: sunee.w@fba.kmutnb.ac.th

─Abstract─

The green industry is crucial in increasing the competitiveness and sustainability of the industrial sector in Thailand. Therefore, this study's objectives are to examine the preparation guidelines for the transition of the industrial business sector to a Green Industry and to improve a structural equation model using a mixed-methods approach. The qualitative research used in-depth interview techniques with nine experts and a focus group with 11 successful business leaders to evaluate the model. The quantitative section collected data from 500 executives or those responsible for environmental management in industrial businesses certified at Green Industry Level 4 (GI4) and Level 5 (GI5). The data were collected using a questionnaire and analysed through various statistical methods, such as descriptive, inferential, and multivariate analyses. The main

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guidelines of the study identified the four most important elements: 1) Organizational Support (= 4.53), insisting on increasing awareness and training of organizational personnel. 2) Environmental Management (= 4.50), concentrating on pollution reduction through appropriate control measures. 3) Data Insight (= 4.44), showing the importance of creating a central database for flexible information access. 4) Learning and Mind-set Change (= 4.43) was considered a very important aspect, specifically in allowing personnel to participate in product design according to environmentally friendly processes. The hypothesis test showed a significant difference in the overall aspects between various sizes of manufacturing enterprises at the 0.05 level. The analysis after improving the structural equation model showed that it was consistent with the empirical data and meets the evaluation criteria. The model's statistical indicators were as follows: a chi-square probability level of 0.058, a relative chi-square of 1.179, a goodness of fit index of 0.962, and a root mean square error of approximation of 0.0169.

Keywords: Structural Equation Modelling, Green Industry, Industrial Business Sector, Environmental management, guidelines, control measures

INTRODUCTION

The sustainable development movement has reached the industrial sector of Thailand, which in 2020 contributed 33.4% of GDP according to the 2021 World Bank report. The same sector is responsible for considerable environmental impact. An international team of scholars found that Thailand's industrial sector released 23% of the country's greenhouse gases in 2022 (Thailand Greenhouse Gas Management Organization). The change toward sustainable practices in the industrial sector is being driven by multiple directions environmental concerns, regulations, and consumer preferences all pushing the sector toward a "Green Industry". In 2018, the Thai government showed the "Thailand 4.0" policy framework to push for an industry that is increasingly motivated by considerations of sustainability. This aims for the country's industrial sector to take on new business models emphasizing sustainability, with the end goal of moving toward an "Eco-Industrial Society" (UNIDO). However, the good intentions, the progress has been slow. Overall, 32% of the manufacturing in Thailand companies only that have received international environmental management systems standards (Grillitsch & Hansen, 2019). Businesses in Thailand running green practices found many advantages, according to research, including superior access to markets, coordination with stakeholders, and, maybe most importantly, a significant reduction in expenses (Bapat et al., 2024).

However, research indicates that Thailand's small and medium-sized enterprises (SMEs), accounting for 80% of industrial companies in the country, face substantial challenges in transitioning to a Green Industry. These challenges include insufficient

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training, limited technological expertise, and a lack of financial resources the most critical (Wallo et al., 2024). The researchers aim to create detailed supporting materials for guiding the industrial sector in Thailand towards sustainability. This deep into the operation of sustainable practices, analysing trends, governing factors, and policy influence (Hofmann, 2024). The varied geography sectors, and sizes of the industry present both a challenge and an opportunity in Thailand's industry. In addition, it identifies the importance of the adjustment in the green industry practices to the local context. For these practices to be used, they must not only be suitable but also practicable. The study aims to identify key stakeholders within Thailand's diverse geography, sectors, and industry sizes, exploring the perspectives on sustainable practices. The goal is to provide an overall understanding of the transformation process leading to a green industrial revolution in Thailand, along with practical, actionable guidelines to accelerate the achievement of sustainable practices within the country's industrial sector.

The researcher set the objectives to study the factors affecting the industrial business sector's preparation for the green industry. The objectives include studying the general structure and operational characteristics of the green industrial business sector, examining the components involved in preparing the industrial business sector for the green industry, and developing a structural equation model to guide the preparation of the industrial business sector towards the green industry. This study follows a mixed-methods approach, combining qualitative research through in-depth interviews, quantitative analysis, and focus group discussions. The primary goal is to enhance a structural equation model that provides guidelines for preparing the industrial business sector for transitioning to a green industry, while also generating knowledge and best practices for managing these crucial changes. The sample group for this research includes a qualitative phase, involving in-depth interviews with nine experts, and a quantitative phase that utilizes the survey technique to gather data from 500 executives or those responsible for environmental management in industrial organizations certified as Green Industry Level 4 (GI4) and Level 5 (GI5).

In addition, the qualitative phase includes focus group discussions with 11 qualified individuals. The quantitative section divides the variables into two categories: independent variables, which include medium and small industrial business establishments and large industrial businesses, and dependent variables, which focus on the general operational characteristics of the green industry sector and guidelines for preparing the industrial business sector for the green industry. These variables are measured using a checklist and rating scale. The observed variables, derived from the data collected on the guidelines for preparing the industrial business sector, form latent variables that are divided into two types: Exogenous Latent Variables, which include the organizational support component, and Endogenous Latent Variables, which encompass the data insight, environmental management, and learning and mind-set

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change components. The qualitative research was conducted by experts approved by the Executive Committee of the Doctor of Business Administration Program in Industrial Business Administration at King Mongkut's University of Technology North Bangkok, Thailand. The quantitative research involved studying 500 entrepreneurs from business sectors and industries certified at Green Industry Levels 4 (GI4) and 5 (GI5).

Data collection was carried out through interviews, mailed questionnaires, and electronic surveys, using cluster sampling and probability random sampling (Lottery Method). The sample included 250 executives or environmental management personnel from medium and small industrial enterprises, and 250 from large industrial enterprises. The period of quantitative data collection was conducted from January to March 2024. The research framework for this study follows an "Inductive Research" approach using a mixed-methodology technique. It consists of three main components: 1) Qualitative research, which involves in-depth interviews to explore and understand key aspects of the subject; 2) Quantitative research, which utilizes survey data collection to gather statistical insights; and 3) Qualitative research through focus group discussions, which is employed to verify and refine the research model. This combination of methods allows for a comprehensive exploration of the factors affecting the industrial business sector's preparation for the green industry.

RESEARCH HYPOTHESIS

The researcher has therefore set the research hypothesis based on the theory, which can be summarized into 6 research hypotheses as follows:

H1: *Organization Support components have a direct influence on Data Insight components.*
H2: *Organization Support components have a direct influence on Environmental Management components.*
H3: *Organization Support components have a direct influence on Learning and Mind-set Change components.*
H4: *Data Insight components have a direct influence on Learning and Mind-set Change components.*
H5: *Data Insight components have a direct influence on Environmental Management components.*
H6: *The structural equation model of the preparation guidelines for the industrial business sector towards green industries, when classified by business size, found that overall is different.*

LITERATURE REVIEW

This study identifies several key independent variables and their impact on the transition

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of businesses to Green Industry practices, culminating in the primary outcome variable, Green Industry Transition. Data Insight is the main independent variable influencing the preparation of businesses for the shift to a Green Industry. As noted by Allan et al. (2021), global policy changes in green sectors, such as stricter environmental regulations and increasing consumer demand for sustainable practices, necessitate this transition. Daniya and Tang (2024) emphasize that organizations with strong data analysis capabilities are better positioned to identify opportunities for environmental improvement and make informed sustainability decisions. Ogiemwonyi et al. (2023) further highlight that data-driven decision-making positively influences Green Innovation Performance, as companies leveraging data insights can enhance eco-friendly products, processes, and overall environmental competitiveness.

Organizational Support is another critical independent variable identified in this study. Arici and Uysal (2022) underline the significant role of leadership in fostering green innovation and preserving creativity, with leadership behaviours influencing employee engagement in green practices. This aligns with social exchange theory, which suggests that employees tend to reflect the positive behaviours of their leaders. Graves et al. (2013) also found that perceived organizational support for environmental initiatives positively influences employee engagement in green behaviours and their commitment to sustainability goals. Kim et al. (2019) further affirmed that organizational support, particularly through green human resource management practices, significantly shapes employees' green behaviour and overall organizational environmental performance.

Learning and Mindset Change is identified as the third independent variable. Zhu et al. (2023) emphasize the importance of a growth mind-set in effective management, highlighting its role in fostering creativity, goal achievement, continuous learning, and openness to new ideas. Dweck and Yeager (2019) found that cultivating a growth mind-set within organizations leads to increased employee engagement, innovation, and adaptability to environmental challenges. Heslin and Keating (2017) found that leaders with a growth mind-set are better equipped to support environmental management systems and promote sustainable practices throughout the organization.

Environmental Management is recognized as the fourth independent variable in this study. Gelderman et al. (2017) found that effective environmental management positively impacts marketing results, customer satisfaction, and corporate reputation. Proactive environmental management strategies enhance operational efficiency, reduce waste, and foster corporate innovation. Li et al. (2020) demonstrated that companies with well-implemented environmental management systems experience better financial outcomes and improved market competitiveness. Green Industry Transition refers to the primary outcome variable in the study, encompassing the shift of businesses toward Green Industry practices. It involves changes in production methods, resource usage, and overall environmental impact. Song et al. (2018) observed that companies

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successfully adopting green practices experience improvements in resource efficiency, reduced environmental impact, and better market positioning. Similarly, Shen et al. (2017) noted that organizations transitioning to green industry practices typically benefit from cost reductions, expanded market presence, and enhanced stakeholder relationships. These variables collectively provide a comprehensive framework for understanding the factors influencing the preparation and transition of businesses to Green Industry practices.

METHODOLOGY

Population and Sample Groups

The qualitative section of this study employed in-depth interview techniques. Nine experts were selected through purposive sampling, based on the expert qualifications defined by the Doctor of Business Administration Program in Industrial Business Administration, Faculty of Business Administration, King Mongkut's University of Technology North Bangkok, Thailand. The experts were categorized into three groups: three entrepreneurs or executives from industrial business organizations, three representatives from government sectors and related organizations, and three academics. For the quantitative research, the survey technique was used.

The population in this study consisted of executives or those responsible for environmental management at industrial business establishments certified as Green Industry Level 4 (GI4) and Level 5 (GI5). The sample size was determined using criteria for factor analysis or structural equation modeling, resulting in a recommended sample size of 500, which is sufficient for obtaining reliable statistical results. The multi-stage sampling method was employed, with cluster sampling steps that categorized industrial businesses into two sizes: medium and small-sized establishments, and large industrial businesses. Probability sampling was applied through the lottery method, with data collected from the sample group as shown in Figure 1.

Qualitative research was also conducted using the focus group discussion technique to validate the research model. The participants for this phase were experts in the industrial business sector, selected through purposive sampling based on the qualifications specified by the Doctor of Business Administration Program in Industrial Business Administration, Faculty of Business Administration, King Mongkut's University of Technology North Bangkok, Thailand. The focus group consisted of 11 individuals, who were distinct from those involved in the in-depth interviews.

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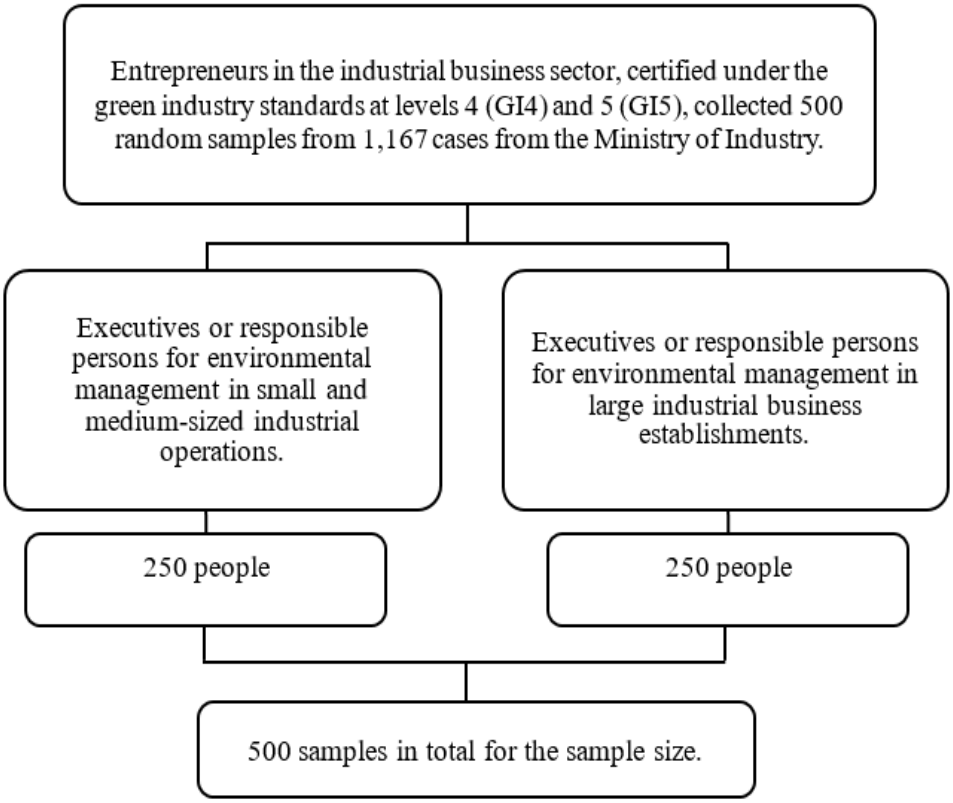

Figure 1: Determining the Sample Size for the Research

Research Tools

The research employs three distinct methodologies: qualitative research using in-depth interviews, quantitative research using surveys, and qualitative research through focus group discussions. In the qualitative phase, in-depth interviews are conducted using a structured interview format. The researcher has developed interview guidelines that focus on four key areas: Data Insight, Organizational Support, Learning and Mindset Change, and Environmental Management. For the quantitative research, a survey method is employed with a questionnaire divided into four sections. Section 1 addresses the general status of industrial businesses, including five items, with a checklist of three items and two open-ended questions. Section 2 explores the general structure and operational characteristics of industrial businesses, comprising a checklist with 20 items. Section 3 outlines guidelines for preparing the industrial sector for the green industry, consisting of 100 items on a Likert scale, which is suitable for assessing opinions and levels of agreement. Section 4 gathers comments and suggestions regarding the guidelines for preparing the industrial business sector for the green industry, consisting of five open-ended items. In the qualitative phase using focus group discussions, the research tool is a conversation record to capture insights and feedback

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from participants.

Data Collection

The qualitative research was conducted through in-depth interviews following a structured process. This process included obtaining an introduction letter from King Mongkut's University of Technology North Bangkok, Thailand, and contacting experts to request their cooperation. Interviews were scheduled at predetermined times and locations, and the researcher carefully recorded and transcribed each interview. The collected data was thoroughly reviewed, and information was categorized into meaningful groups. The categorized data was then analysed for consistency with the research objectives, and the findings were used to inform the development of questions for the subsequent quantitative research. For the quantitative research, the study focused on selecting 500 executives or personnel responsible for environmental management in industrial businesses registered with the Ministry of Industry, using the Lottery Method. An introduction letter was also obtained from the Faculty of Business Administration at King Mongkut's University of Technology North Bangkok, Thailand. The researcher reached out to participants in Bangkok, metropolitan areas, and other provinces, requesting their cooperation in completing the questionnaire. In cases where in-person collection was not feasible, questionnaires were distributed via post and electronic media. Once the completed questionnaires were received, they were coded and recorded for statistical analysis. For the qualitative research using the "Focus Group Discussion" technique, conversations were recorded while a moderator facilitated the group discussions to generate ideas and opinions on specific issues. The process began with obtaining an introduction letter from the Doctor of Business Administration Program at King Mongkut's University of Technology North Bangkok, Thailand, followed by contacting experts for their participation. A draft conversation guide was prepared and reviewed by a qualified individual. The group discussions took place on the scheduled date, with researchers recording the data thoroughly. The information collected from these discussions was then organized and formulated for further analysis.

Data Analysis

The qualitative research in this study used in-depth interview methods combined with content analysis to develop guidelines for preparing the industrial business sector for the green industry. This approach allowed the researcher to gain insights from experts and analyze the data in a structured manner to generate actionable guidelines. In the quantitative research phase, survey methods were employed to analyze basic general data, utilizing descriptive statistics, inferential statistics, and advanced statistical techniques. These analyses were conducted using SPSS and AMOS software programs. These methods were selected to provide a comprehensive understanding of the data, allowing for both summary statistics and the examination of complex models to address the research objectives. For the qualitative research using focus group discussion

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techniques, content analysis was applied to compile feedback and suggestions gathered during the group discussions. This allowed the researcher to organize the input from the participants and derive meaningful insights for further analysis and development of the research model.

RESULTS

Phase 1 Quantitative Results

The analysis of the industrial sector's preparedness for transitioning to a green industry identified four key components: Data Insight, Organizational Support, Learning and Mind-set Change, and Environmental management. The empirical data showed a significant consistent with these components, as evidenced by the following statistical measures: p-value = 0.058, CMIN/DF = 1.179, GFI (Goodness of Fit Index) = 0.962, RMSEA (Root Mean Square Error of Approximation) = 0.019. These results were statistically significant at the 0.001 level. in line with both the literature review and empirical data, fulfilling the criteria conducted by Arbuckle (IBM SPSS Amos 24 user's guide. IBM Corp. Vol. 20 (53, 601, 604, 614). The results of this study are presented in both "Unstandardized Estimate", and "Standardized Estimate" modes, shown in Figures 2 and 3 after the model improvement.

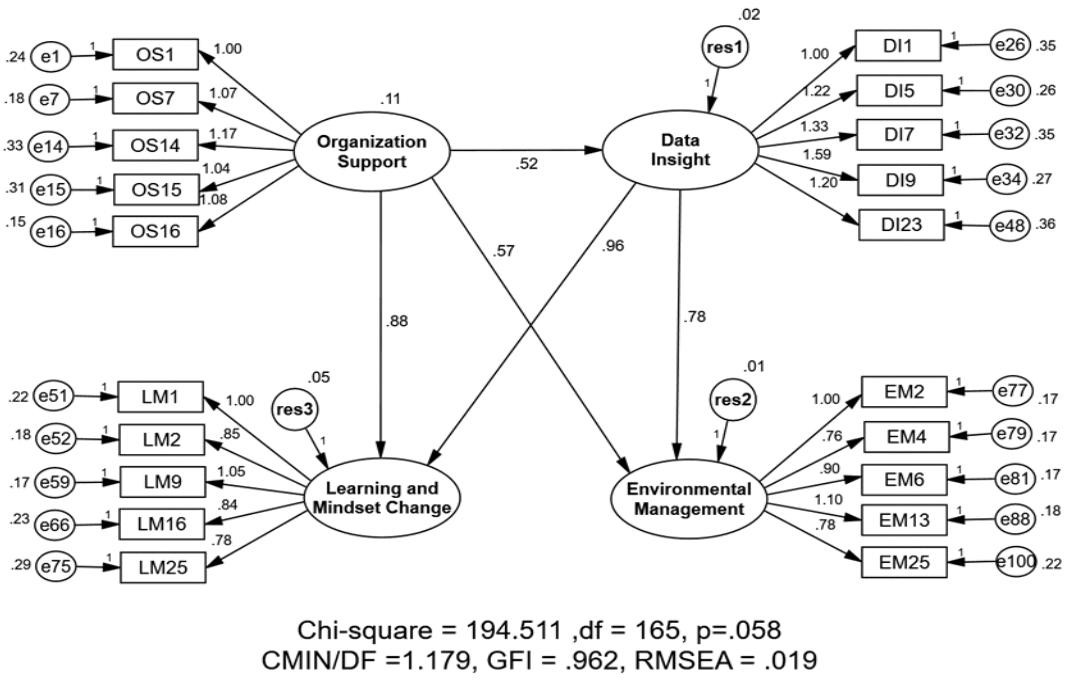

Figure 2: The results of the structural equation modelling analysis were presented in Unstandardized Estimate mode after the model improvement

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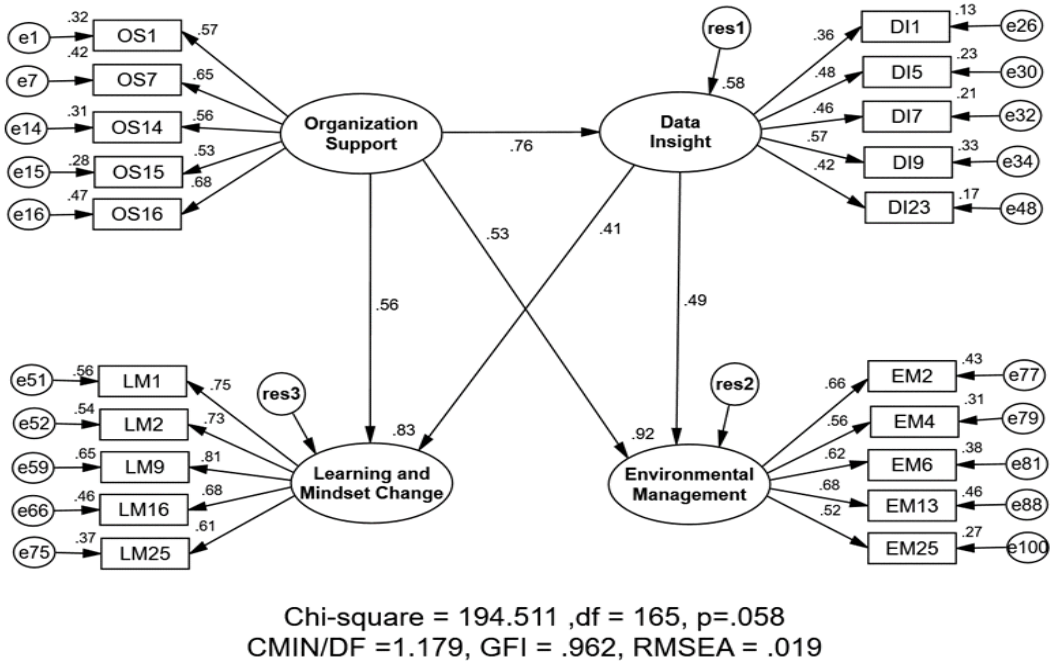

Figure 3: The results of the structural equation modelling analysis were presented in Standardized Estimate mode after the model improvement

The structural equation model identified 4 important components which are: Data Insight, Organizational Support, Learning and Mind-set Change, and Environmental Management, essentially for the industrial sector and its transition to a Green Industry. The study examined 5 hypotheses (Table 1) to find the causal relationships between these components, all of which were found to be supported. The findings showed that Organizational Support significantly influences Data Insight ($\beta = 0.76$, $p < 0.001$), Environmental Management ($\beta = 0.53$, $p < 0.001$), and Learning and Mind-set Change ($\beta = 0.56$, $p < 0.001$). In addition, Data Insight was found to directly influence both Learning and Mind-set Change ($\beta = 0.41$, $p < 0.001$) and Environmental Management ($\beta = 0.49$, $p < 0.001$).

Table 1: Hypothesis Testing Results

Hypothesis	Relationship	Standardized Regression Weight	p-value
H1	Organization Support → Data Insight	0.76	<0.001
H2	Organization Support → Environmental Management	0.53	<0.001
H3	Organization Support → Learning and Mind-set Change	0.56	<0.001
H4	Data Insight → Learning and Mind-set Change	0.41	<0.001
H5	Data Insight → Environmental Management	0.49	<0.001

The analysis findings confirmed all 5 hypothesized relationships and statistically

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significant direct influences between the variables. The strongest relationship observed was between Organizational Support and Data Insight ($\beta = 0.76$, $p < 0.001$), showing the key role of organizational support in accommodating the collection and effective operation of data for the Green Industry transition. Significant relationships were also found between Organizational Support and both Environmental Management ($\beta = 0.53$, $p < 0.001$) and Learning and Mind-set Change ($\beta = 0.56$, $p < 0.001$), presenting the importance of organizational commitment in helping in environmental efforts and encouraging a culture of long-term learning and application. In addition, Data Insight was found to influence both Learning and Mind-set Change significantly ($\beta = 0.41$, $p < 0.001$) and Environmental Management ($\beta = 0.49$, $p < 0.001$), ensuring the value of Data-Driven Decision-Making in increasing organizational learning and environmental practices. The perceived importance of each component in the green industry transition was assessed, with detailed findings shown in Table 2.

Table 2: Perceived Importance of Green Industry Transition Components

Component	Mean	Standard Deviation	Importance Level
Organizational Support	4.53	0.32	Highest
Environmental Management	4.50	0.31	Highest
Data Insight	4.44	0.38	High
Learning and Mind-set Change	4.43	0.30	High
Overall	4.47	0.29	High

The results presented that all components were considered highly important in the transition to green industry practices, with the mean from 4.43 to 4.53 on a 5-point Likert scale. Organizational Support performed as the most important component ($M = 4.53$, $SD = 0.32$), followed by Environmental Management ($M = 4.50$, $SD = 0.30$) respectively. Data Insight ($M = 4.44$, $SD = 0.37$) and Learning and Mind-set Change ($M = 4.43$, $SD = 0.31$) were also found to be highly important, a bit less than the Organizational Support and Environmental Management. The overall mean score of 4.47 ($SD = 0.29$) defined respondent's all aspects of Green Industry transition preparation are important. The study compared the importance ratings between small and medium-sized enterprises (SMEs) and large enterprises to further study potential differences in perceptions based on organizational characteristics. The results of this comparison are detailed in Table 3. The analysis showed statistically significant differences between SMEs and large enterprises in all components, including overall importance ($p < 0.001$ for all comparisons). SMEs consistently in each component as more important than large enterprises, with the greatest difference found in Organizational Support ($t = 7.53$, $p < 0.001$) and the smallest in Learning and Mind-set Change ($t = 5.07$, $p < 0.001$). These findings suggest that SMEs perceive a higher necessity in preparing for the green industry transition, possibly regarding to differences in resource availability, regulatory pressures, or market positioning strategies compared to large enterprises.

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Table 3: Comparison of Importance Ratings by Enterprise Size

Component	SMEs		Large Enterprises		t-value	p-value
	Mean	SD	Mean	SD		
Overall	4.58	0.22	4.41	0.35	6.52	<0.001
Organizational Support	4.63	0.25	4.42	0.35	7.53	<0.001
Environmental Management	4.58	0.22	4.41	0.35	6.52	<0.001
Learning and Mind-set Change	4.49	0.24	4.36	0.34	5.07	<0.001
Data Insight	4.54	0.35	4.34	0.38	6.11	<0.001

Phase 2 Qualitative Results:

The qualitative phase of this study presented detailed insights into how industrial businesses are preparing for the transition to a green industry. Over two months, semi-structured interviews were conducted with nine experts representing industry, government, and academicians, with each interview lasting between 60 and 90 minutes. The analysis uncovered key subjects that are consistent with the components identified in the structural equation model which are: Data Insight, Organizational Support, Learning and Mind-set Change, and Environmental Management.

Data Insight, was identified as a key element in achieving successful green industry transitions it is included:

1) Data Instructure which refers to the importance of refined data collection systems was commented by participants. Investing in "IoT" sensors and real-time monitoring systems has been essential for tracking and optimizing resource consumption, the industry executive shared.
2) The capacity to analyse environmental data was recognized as an important skill. It's not just about collecting data but it's about possessing the tools and expertise to summarize practical insights from that data this was pointed out by an academic expert.
3) The practice of integrating environmental data into strategic decision-making was determined as a best practice. A government official has observed the greatest success in organizations that have accepted sustainability metrics into their main "KPIs" and decision-making processes.

Organizational Support is exposed as a crucial factor in achieving successful green industry transitions. The key subjects identified as follows:

1) The important role of Leadership Commitment was collectively insisted on. An industry executive mentioned the move toward sustainability must begin at the leadership level. When the CEO prioritized it as a strategic goal noticed a significant growth in engagement throughout the organization.
2) Effective transitions often demand considerable investments in new technologies,

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training, and process redesigns, this refers to Resource Allocation. Organizations that perceive sustainability as solely a cost rather than a strategic investment often find it challenging to make substantial progress stated to an academic expert.

3) Cultivating a culture of sustainability within the organization was recognized as essential. A government official remarked that having policies and procedures is not sufficient. There needs to be a cultural transformation where every employee feels responsible for and empowered to contribute to the organization's sustainability objectives.

Learning and Mind-set Change, are essential to make the convenience and maintaining green industry transitions. The key interesting are as follows:

1) Continuous Education and Training are necessary for ongoing educational initiatives, it was recommended by the participants. An industry executive stated the introduced all-inclusive sustainability training program for all employees, from the foundry to the boardroom. This has been important in supporting a shared understanding and commitment to our green initiatives.
2) Innovation and a willingness to innovate were recognized as a critical factor for successful experimentation. An academic expert observed an organization that cultivates a culture of innovation and accepts the idea of mistyping fast and learning quickly often leading the way in green industry practices.
3) A broad range of stakeholder engagement was identified as crucial. A government official notified the most successful organizations encountered are those who actively search for input and collaborate with various stakeholders throughout their long-term procedures.

Environmental Management was recognized as a vital operational component of the green industry transition. The key subjects identified included:

1) The importance of conducting thorough Lifecycle Assessments was concentrated. An academic expert remarked, "Organizations that consider their environmental impact holistically, from raw material accession to End-Of-Life product management, are in a stronger position to operate meaningful improvements.
2) The application of the circular economy principles usage was recognized as transformative. An industry executive mentioned, "Transitioning from a linear to a circular model has exposed new opportunities for resource efficiency and waste reduction that hadn't previously been explored.
3) The significance of advanced technologies in improving environmental management was recommended as Technology Integration. A government official has observed significant progress in organizations that have incorporated AI and machine learning into their environmental management systems, especially in areas like predictive maintenance and resource optimization.

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Cross-cutting Themes, referring to concepts from the qualitative analysis were found as follows:

1) The impact of government policies and regulations environments frequently occurred, with prominence on finding a balance between regulatory measures and motivations.
2) The role of changing consumer preferences and investor expectations was shown as a key driver of green industry transitions in the Market Dynamics aspect.
3) The importance of integrating new technologies and their adoption happened as a consistent concept across all aspects of the green industry transition.
4) Participants of partnerships harmoniously show the necessity of collaboration in sectors, acknowledging the complex and connected nature of sustainability challenges.

Phase 3 Integration and Synthesis

This phase combined results from both the quantitative and qualitative methods, giving an intensive understanding of how industrial businesses are preparing for the green industry transition. The integration process used a triangulation method, increasing quantitative results with qualitative insights. This synthesis found the main concepts consistently shown in both research phases, which were separated into 4 aspects which are: Data Insight, Organizational Support, Learning and Mind-set Change, and Environmental Management, as indicated in the structural equation model (Table 4). In addition, Cross-cutting concepts served a wider understanding of the Green Industry transition, giving valuable context for the study.

Table 4: Integration of Quantitative and Qualitative Findings.

Component	Quantitative Findings	Qualitative Insights	Integrated Understanding
Data Insight	Strong positive relationship with Environmental Management ($\beta = 0.49$, $p < 0.001$)	Emphasized the importance of data infrastructure and analytics capabilities	Data-driven decision-making is crucial for effective environmental management
Organizational Support	Highest perceived importance ($M = 4.53$, $SD = 0.32$)	Leadership commitment and resource allocation are identified as critical factors	Organizational backing is foundational for a successful green industry transition
Learning and Mind-set Change	Positive relationship with Data Insight ($\beta = 0.41$, $p < 0.001$)	Continuous education and stakeholder engagement are highlighted as key strategies	A culture of continuous learning facilitates the effective use of sustainability data
Environmental Management	Second-highest perceived importance ($M = 4.50$, $SD = 0.30$)	Lifecycle assessment and circular economy principles emphasized	Systematic approaches to environmental management are essential for sustainable practices

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Main Important Findings

For the quantitative analysis, Data Insight showed a positive relationship with Environmental Management ($\beta = 0.49$, $p < 0.001$), a result encouraged by qualitative data insights that focus on the importance of strong structures and advanced analytics capabilities of the data. This integration emphasizes that data-driven decision-making is important for effective environmental management in industrial operations. In addition, Organizational Support appeared as a fundamental element in both research phases. The quantitative received the highest perceived importance rating ($M = 4.53$, $SD = 0.32$), while qualitative insights show the key roles of leadership commitment and resource distribution. This confirmed the key essential of organizational support in convenience and successful green industry transitions. Quantitative findings for Learning and Mind-set Change showed a positive association with Data Insight ($\beta = 0.41$, $p < 0.001$). Qualitative insights elaborated on the importance of continuous education and stakeholder engagement. The integration recommended that encouraging a culture of ongoing learning is important for effectively using sustainability data and applying it to changing environmental challenges. The quantitative rate for Environmental Management was the second most important factor ($M = 4.50$, $SD = 0.30$), it was upgraded by qualitative insights on lifecycle assessment and circular economy principles. Therefore, systematic and integrated methods of environmental management throughout the entire product lifecycle are needed.

Cross-cutting Themes

Policy and Market Dynamics in both phases demonstrated the considerable impact of external factors on the green industry transition. The quantitative analysis stated differences in perceptions between SMEs and large enterprises, which were inspected by qualitative insights into how policies and market pressures affect organizations of different sizes. This recommended the importance of developing refined policy strategies and support mechanisms. Technology as a Catalyst is not explicitly quantified, therefore technology consistently appeared as a key subject in the qualitative interviews. The integration indicated that technology is essential in all components of the green industry transition, stimulating the need for organizations to keep pace with technological advancements. The inclusive strategy to sustainability and its integration demonstrated the coherence of various elements within the Green Industry transition. Meanwhile, the quantitative model provided structured relationships, qualitative insights showed the significance of accepting an inclusive strategy that considers these elements as integral parts of all systems.

The integration process provided a key context for interpreting the quantitative results. For example, the strong relationship between Organizational Support and Data Insight was clarified by qualitative insights into leadership initiatives focused on creating data structure and analytics capabilities. In addition, the higher perceived importance of

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Green Industry components among SMEs was shown by qualitative insights into their unique challenges and opportunities. The synthesis also identified future research aspects, such as examining the sustainable evolution of organizations and their sustainability strategies in response to changing external conditions. Overall, the integration and synthesis phases give an overview of the complex interactions in sustainability transitions. It concentrated on the necessity for organizations to operate systemic strategies that know the interdependence of data usage, organizational support, continuous learning, and environmental management (Table 5). Moreover, it focused on the role of external factors, such as policy frameworks, market dynamics, and technological advancements, in defining effective Green Industry transition strategies. These integrated insights give valuable guidance for organizations, policymakers, and researchers in advancing sustainable industrial practices and supporting wider sustainability achievements.

Table 5: Cross-cutting Themes and Their Implications

Theme	Quantitative Evidence	Qualitative Evidence	Implications for Practice
Policy and Market Dynamics	Significant differences between SMEs and large enterprises in the perceived importance of components	Varied impacts of regulations and market pressures on different-sized organizations	Need for tailored policy approaches and support mechanisms for organizations of different sizes
Technology as an Enabler	Not explicitly measured	A recurring theme across all components of the green industry transition	Importance of strategic technology adoption and integration in sustainability initiatives
Holistic Approach to Sustainability	Interconnected relationships between model components	Emphasis on systemic thinking and integrated strategies	Need for balanced development across all components of the green industry transition

LIMITATIONS

The data collection process encountered several limitations. One challenge was the availability of experts for interviews, which may have impacted the range and depth of insights gathered. Additionally, potential participant bias and difficulties in ensuring a representative sample during the quantitative research phase could affect the generalizability of the findings. Issues such as lower response rates from postal and electronic surveys, technical difficulties, and time constraints also hindered the collection and verification of data. In the qualitative research phase, the influence of cultural sensitivity on participant responses was another limitation. This could have affected how participants expressed their views, potentially introducing bias. Moreover, the role of the moderator in focus group discussions could have influenced the responses, leading to potential biases in the data. Finally, the subjective nature of qualitative data analysis posed a challenge in interpreting and synthesizing participant views, which could result in inconsistencies in the findings.

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DISCUSSION

This study's results are consistent with enlarged previous research on sustainable business practices, such as studies on data-driven sustainability which found the importance of data insight corroborating (Etzion & Aragon-Correa, 2016; George et al., 2021; Mikalef et al., 2020). Research on leadership in sustainable urban development that its significance of organizational support is reflected (Mu et al., 2024), and resource management for Eco-Innovation. The intensity of learning and mindset change highlight the important role of organizational learning in sustainability transitions. Operational sustainability, including lifecycle assessment, circular economy principles, and a focus on environmental management, is supported in the existing literature (Kravchenko et al., 2019; Lamesawan et al., 2023), and Industry 4.0 (Beltrami et al., 2021). The observed differences between SMEs and large enterprises contribute to the continuing debate on company size and sustainability practices and challenges, in line with (Dey et al., 2020). The strategies for sustainability reflect the increasing adoption of systems thinking (Dacre et al., 2024; Williams et al., 2021). In addition, the impact of external factors on green industry transitions supports a case of the role of contextual factors in corporate sustainability (Engelmann et al., 2019; Rungrotkankul et al., 2023).

CONCLUSION

This overall mixed-methods study integrates quantitative structural equation modelling with qualitative data from expert interviews and identifies four important components for a successful green industry transition, these are Data Insight, Organizational Support, Learning and Mind-set Change, and Environmental Management. The structural equation model demonstrated strong connections within these components, with Organizational Support originating as an important factor influencing the others. Qualitative results strengthened this, insisting on the significance of leadership commitment and resource management in advancing sustainable practices. Data Insight in increasing Environmental Management and encouraging a culture of Learning and Mind-set Change. However, the research found significant differences between SMEs and large enterprises in how they perceive the importance of these components in the transition to a green industry. SMEs consistently rated each component as more important than large enterprises did, indicating a higher awareness or perceived value in sustainability transitions among smaller organizations. The combination of quantitative and qualitative results concentrated on the elaborate and varied nature of the green industry transition, focusing on the importance of an overall inclusion that accounts for the connections between organizational, technological, and environmental factors. Furthermore, the study stated the importance of external factors such as policy environments, market dynamics, and technological advancements in shaping organizations' sustainability strategies.

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SUGGESTIONS

Further studies should explore how the interaction between different industries and firm sizes impacts the integrated model of green industry transition. Additionally, examining the long-term effects of data analytics on sustainability practices would provide valuable insights. Another important area for future research is investigating the role of organizational culture in shaping and supporting effective environmental management practices. At the operational level, it is recommended to develop leadership programs focused on sustainability and green industry practices. Enhancing data analytics capabilities, particularly in smaller enterprises, would help them better navigate the transition to greener practices. Additionally, fostering continuous education and training for employees to adopt and apply new environmental practices is essential for ensuring long-term success in the green industry. At the policy level, creating support programs tailored to various enterprise sizes would be beneficial in encouraging wider adoption of green industry practices. Promoting digital literacy and the use of advanced technologies through incentives would also support businesses in becoming more sustainable. Furthermore, developing integrated policies that align environmental goals with economic incentives would help drive the widespread implementation of sustainable industry practices.

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