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CBAM's Impact on Thai Exporters' Low-Carbon Strategy: The Moderating Role of Green Transformational Leadership

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Abstract: The European Union Carbon Border Adjustment Mechanism (CBAM) introduces new compliance requirements for exporters in carbon-intensive sectors, including firms in emerging economies. This study examines the association between CBAM regulatory pressure (CRP) and low-carbon strategy (LCS) adoption among Thai listed exporting firms and tests whether green transformational leadership (GTL) moderates that association. The study uses a quantitative, cross-sectional documentary design. The auditable profile archive contained 100 numbered records; removal of five duplicate/replacement entries produced a final analytical sample of 95 unique firms. CRP, GTL, and LCS are arithmetic means of documentary items scored on a 1–5 scale. Models control for Firm Size, Export Intensity, and eight sector dummies, with Steel & Metals as the reference category. CRP was positively associated with LCS in Model 2 (standardized β = .872, t = 13.31, p < .001; ΔR^2 = .421). In Model 4, GTL had a positive main effect (β = .766, p < .001), whereas the CRP × GTL interaction was not statistically significant (β = −.034, t = −0.82, p = .415; ΔR^2 < .001). Conditional CRP effects were positive at low, mean, and high GTL, and the Johnson–Neyman transition points lay outside the observed GTL range. H1 was supported, and H2 was not supported. The findings indicate that CBAM regulatory pressure and GTL are both positively associated with low-carbon strategy, but the proposed moderating role of GTL is not supported in this sample.

Keywords: carbon border adjustment mechanism, low-carbon strategy, green transformational leadership, regulatory pressure, Thai exporters

1. Introduction

A necessary element of climate change response at the international level is the inclusion of obligations regarding trade, which has been growing in importance in recent years, and voluntary commitments [1]. A key development is the Carbon Border Adjustment Mechanism (CBAM) of the European Union, which started a transitional period in October 2023 and will be fully implemented in 2026 [2]. In its implementation, CBAM will require importers of carbon-intensive products (steel, cement, aluminum, fertilizers, and electricity) to report on and—during the definitive phase—surrender certificates for the embedded emissions of the products covered by the scheme, thus introducing a carbon price on imports similar to that in the European Union Emissions Trading System (EU ETS) [3]. This mechanism may have an impact on the competitiveness of the export market, and climate policy is not only an environmental issue but also a question of export market access and competitiveness [4]. CBAM is not only a challenge for countries such as Thailand, where manufacturing is a significant part of their economy.

Thailand is directly impacted by CBAM, as it is one of Southeast Asia's biggest manufacturing and exporting economies. Cross-country exposure indices identify iron and steel among Thailand's most exposed CBAM sectors, while studies of Asian trade indicate that firms may face higher reporting and market-access costs even where aggregate national exposure is comparatively low [5, 6]. The low-carbon shift in industrial production is not just an environmental goal but also a strategic imperative, as the country's export-dependent industrial landscape, particularly in the Eastern Economic Corridor, relies heavily on carbon-intensive industries [7–9].

The impact of this regulatory pressure on how Thai companies react could have a wide-ranging influence on the competitiveness of industries, the direction of investments, and Thailand's 2050 carbon-neutrality agenda. The corporate disclosures analyzed in this study reveal that there is a significant difference in approach: some firms have adopted CBAM and have created dedicated sustainability committees and also obtained third-party carbon certifications, while others have limited disclosures and do not appear to be very concerned about carbon emissions. This diversity reflects a non-uniformity in the form of external pressure that is translated into an internal action.

As the outside pressure from CBAM comes to the fore in policy debates, the organizational pathways by which companies internalize the pressure and turn it into action are still not well

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understood. The institutional theory suggests that coercive regulatory pressures can influence the change of any organization [10], and the extent to which this external pressure causes an organization to change its strategy—rather than just paying lip service—is a very important function of internal organizational factors. Leadership is one of them that is very important. According to upper-echelons theory, the nature of an organization's outcomes is a reflection of the values, cognition, and actions of top management [11]. Green transformational leadership (GTL) refers to leaders who encourage, motivate, and empower employees to make environmental sustainability as the core of the work or mission [12]. However, the specific role of GTL in this context has not been tested empirically in the CBAM context, which has significant implications, particularly as CBAM is changing trade flows across Asia [4].

Here, there are three gaps that underlie the study: first, most empirical research on CBAM has focused on macro-level and forecasting of economic impacts (e.g., [2, 4]), and strategic responses of firms have not been studied. Second, despite the linkages between GTL and environmental performance and green innovation [12–15] having been established, GTL has not been studied as a boundary condition on regulatory-pressure effects. Third, literature on institutional decoupling warns that symbolic and not substantive disclosure-based compliance is possible [16], but the internal capacities that are required to make coercive pressures translate into substantive strategic actions are not specified. The present research study fills these gaps as well.

This study addresses two research questions: whether CBAM regulatory pressure is associated with low-carbon strategy adoption among Thai exporting companies and whether GTL moderates that association. The reconciled sample consists of 95 unique listed companies in CBAM-affected and adjacent industries. Documentary sources include corporate websites, sustainability and annual reports, verified executive statements, regulatory filings, and public certifications. The study contributes by testing a firm-level regulatory-pressure model in an emerging-economy setting and by examining GTL as a proposed boundary condition. Because the CRP × GTL interaction is not statistically significant in the final analysis, the theoretical contribution is framed as evidence of a strong GTL main effect rather than a supported moderation mechanism.

2. Literature Review and Hypotheses Development

2.1. Theoretical framework

The study combines two interrelated theories to gain a better understanding of the role of institutional theory and upper-echelons theory in explaining the export responses of Thai exporting firms to the EU's CBAM. These frameworks jointly account for the forces that influence the changes in organizations and the internal leadership mechanisms that shape how the change is interpreted, internalized, and translated into strategic action [17].

2.1.1. Institutional theory

DiMaggio and Powell [10], in their institutional theory, suggest that organizations exist in an institutional context that is defined by norms, rules, and cognitive frameworks that influence behavior. The institutional isomorphism theory recognizes three mechanisms: coercive, mimetic, and normative pressures. Coercive pressure, which is the subject of this study, is the kind of pressure imposed by regulatory organizations, government policies, and other influential stakeholders on which organizations rely [18]. Organizations that are subjected to coercive pressures from the regulatory environment take actions and develop practices and structures that meet the expectations of the environment in order to maintain their legitimacy, access resources, and avoid sanctions.

The CBAM is a simple case of institutional pressure of the coercive type. It is a regulatory measure by one of the key trading partners, which gives rise to instant compliance obligations for Thai carbon-intensive exports [17]. The mechanism will include a transitional phase (2023–2025) and a definitive phase (2026). The potential for higher costs and loss of market access could provide a powerful incentive for companies to keep track of, report, and lower carbon emissions [19, 20]. Thus, institutional theory suggests that such coercion will lead to formal carbon-management practices.

However, this institutional theory cannot account for the observed differences in firms' responses to CBAM. While companies in CBAM-impacted industries are all under the same outside pressure, there is a wide range of responses in terms of speed, depth, and strategic nature. Among the companies in this data set, PTT Global Chemical (PTTGC) and Siam Cement Group (SCC) have integrated CBAM into their strategy, established formal targets to reduce carbon and sought third-party certifications, while other companies with similar exposure levels have had limited public involvement. This variation provides a way to explain the extent to which institutional pressure is translated into strategic action, which is partially addressed by upper-echelons theory, and relates to institutional decoupling, in which symbolic reporting is not necessarily the same as substantive action in operations.

2.1.2. Upper-echelons theory

The upper-echelons theory [11] brings the attention of analysis from the level of the organization to that of the top-level strategic decision makers. The theory is that top executives' values, cognitive bases and experiences are reflected in the organizations' outcomes such as strategic decisions and performance. The cognitive frameworks of the managers are the lenses through which they see and interpret information, given bounded rationality. Therefore, the characteristics of the top management affect the process of perception, interpretation, and response to the external pressures. In the environmental field, this has been broadened to look at "green" leadership. GTL is defined by Chen & Chang [12] as "Leadership that inspires and empowers employees to actively pursue environmental issues that go beyond compliance." GTL is made up of 4 dimensions: idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. It is suggested that there is a relationship between GTL and environmental performance [13–15, 21, 22, 23], green innovation, employee pro-environmental behaviour, and related organizational capabilities.

In the context of the CBAM, we hypothesize that firms with executives who possess high environmental values and have transformational-leadership traits are more likely to have strategic responses to CBAM pressures. Instead of symbolic compliance, these types of companies view CBAM as a chance for a competitive advantage by adopting early decarbonization, green product innovation, and supply chain innovation [17]. In contrast, companies without this leadership can reactively respond, ensuring that they are still able to access the market based on the least amount of compliance.

2.1.3. Integrating institutional and upper-echelon perspectives

An institutional theory combined with the upper-echelons theory provides a more comprehensive explanation than either theory alone. According to the institutional theory, external coercive pressure (CBAM) can be considered an independent variable that can elicit an organization's reactions. According to the upper-echelons theory, one internal contingency that is significant in understanding the moderating effect on the pressure is green transformational leadership [17]. The integration is analytically interesting because it states the boundary condition of institutional theory, which remains open: coercive pressure is necessary but insufficient, and top-management interpretation is what is needed to decide between the outcomes of substantive transformation or symbolic compliance. This framework resonates with research in organization studies that seeks to combine macro- and micro-foundational approaches to understanding organizations [16].

2.2. Construct definitions and operationalization

The three constructs are operationally derived through a theoretical approach by using disclosures of the companies, sustainability reports, public certifications, and verified executive statements for the reconciled sample of 95 unique companies. Coding rubrics are available in Table A1 and A2 and will be the same unique-firm identifiers and sector coding used throughout the final analytical dataset.

2.2.1. CBAM regulatory pressure (CRP)

CBAM regulatory pressure (CRP) is operationalized from six documentary items, Q6–Q11, each coded on a 1–5 scale in the retained company-profile instrument. The firm-level CRP score is the arithmetic mean of those six items: CRP = (Q6 + Q7 + Q8 + Q9 + Q10 + Q11) / 6. This specification matches the fractional CRP values in the final analytical dataset and replaces the earlier indicator-count description.

2.2.2. Low-carbon strategy (LCS)

Low-carbon strategy (LCS) is operationalized from seven documentary items, Q19–Q25, each coded on the same 1–5 scale. The firm-level LCS score is the arithmetic mean of the seven items: LCS = (Q19 + Q20 + Q21 + Q22 + Q23 + Q24 + Q25) / 7. The items capture documentary evidence relevant to decarbonization strategy and implementation, as defined in the retained company-profile instrument.

2.2.3. Green transformational leadership (GTL)

GTL is operationalized from seven documentary items, Q12–Q18, each coded on a 1–5 scale. The firm-level GTL score is the arithmetic mean of those seven items: GTL = (Q12 + Q13 + Q14 + Q15 + Q16 + Q17 + Q18) / 7. The items reflect documentary evidence of senior-level environmental leadership, governance, communication, and organizational engagement as specified in the company-profile instrument.

2.3. Hypothesis development

2.3.1. Direct effect of CBAM pressure on low-carbon strategy

Based on institutional theory, we hypothesize that the degree and innovativeness of companies' low-carbon strategies will be influenced by the severity of the CBAM regulatory pressure on the companies. Coercive pressure is exerted in a number of ways. First, the mechanism also carries a direct compliance cost because firms that fail to do monitoring, reporting, and reduction will pay higher certificate costs or will not be able to access the market. Secondly, CBAM creates a normative influence of industry bodies, supply chain partners, and professional networks when companies see other companies making plans for CBAM [20]. Third, it introduces a disadvantage for high-carbon producers in terms of market share in the EU market, incentivizing early adopters to take market share from laggards [2]. This is supported by recent empirical studies that indicate that a stricter regulatory environment will stimulate such swift corporate decarbonization within the sectors that are exposed [17, 24].

For example, in the coded data set, a few companies indicated that they have joined the TGO's CBAM Phase-3 preparation declaration, launched the "SSI GREEN" label and established Net Zero 2050 targets (Sahaviriya Steel Industries (SSI)), mentioned CBAM in their climate strategy and have an internal carbon-pricing mechanism, and explicitly referred to CBAM as a material risk and have Carbon Footprint of Product (CFoP) certification (Thai Oil (TOP)). Based on the previous empirical and theoretical studies, the first hypothesis is:

H1: CBAM regulatory pressure is positively associated with low-carbon strategy adoption among Thai exporting firms.

2.3.2. Moderating role of green transformational leadership

While pressure from CBAM can drive companies to low-carbon business, the level, speed, and direction of the adoption should rely on top-management leadership. An executive's interpretation and response to pressure are shaped by its level of GTL, an executive attribute that is relatively stable, and thus we theorize GTL as a moderator rather than a mediator because the former is a stable executive attribute that conditions the effect of external pressure, whereas the latter is a state created by the pressure [25].

Upper-echelon theory suggests that companies that have a high environmental top management commitment will perceive pressure from CBAM—not only a compliance obligation but also a strategic differentiation opportunity. GTL enhances the conversion of outside pressure to inside action in a number of ways. First, leaders can shape a powerful environmental narrative, which can reshape CBAM from a "threat" to an "opportunity" for innovation and deploy organizational resources to decarbonization. Second, GTL facilitates organizational learning and capability-building, equipping companies with the technical and managerial capabilities needed for good carbon management. Thirdly, leaders who demonstrate their commitment to the environment indicate that sustainability is a guiding principle, which permeates decisions on carbon. Fourth, GTL facilitates the use of economic, human, and technological resources for the implementation of emissions reduction projects [14, 15].

This moderating logic also can account for the variability in response to the same CBAM exposure. For instance, SCC and Indorama Ventures (IVL) have both high CBAM exposures and high GTL indicators, sustainability executives, board-level committees, DJSI recognition, and public CEO commitments and have a correspondingly high LCS adoption. However, other companies like Siam Steel Service Center (SSSC) with similar exposure (steel is a Phase 1 covered good) have a modest share of adoption of LCS. This trend reinforces the hypothesis of the CBAM pressure effect on GTL. Thus, the second hypothesis is:

H2: Green transformational leadership positively moderates the relationship between CBAM regulatory pressure and low-carbon

strategy adoption: that is, the positive relationship between CBAM pressure and low-carbon strategy will be stronger for firms with a higher level of green transformational leadership. The conceptual framework is shown in Figure 1.

Figure 1
Conceptual framework of the hypothesized relationships



The conceptual framework, grounded in institutional theory and upper-echelons theory, depicts the direct effect of external regulatory pressure (CBAM) on the adoption of a low-carbon strategy, with green transformational leadership moderating that path. As shown, the moderator's dashed arrow terminates on the CRP→LCS path (not on the Low-Carbon Strategy box), denoting an interaction effect rather than a direct effect.

3. Methodology

3.1. Research design

The research design is cross-sectional, document-based, and quantitative, examining associations among CBAM regulatory pressure, green transformational leadership, and low-carbon strategy adoption among Thai listed exporting companies. The analysis represents strategic intent and readiness during the 2024–2025 CBAM transition period rather than long-term adaptation. A single cross-section holds the regulatory phase constant while allowing comparison of cross-firm heterogeneity. Causal claims are therefore avoided, and results are interpreted as associations.

An analysis of document-based evidence is useful for analyzing the reaction of firms on regulatory change since the evidence is verifiable and not based on self-reported perceptions. To ensure evidence was accurate and minimize single-source bias, evidence was triangulated, with information from sustainability reports, regulatory filings, official websites, and independent certifications.

3.2. Sample and sampling procedure

The sample frame comprises Stock Exchange of Thailand (SET)-listed companies in CBAM-affected or adjacent industries. Purposive criterion sampling required: (i) SET listing with relevant 2024–2025 disclosures; (ii) operations in a CBAM-covered or adjacent sector; and (iii) sufficient documentary information to score CRP, GTL, and LCS. The auditable archive contained 100 numbered records. Five duplicate/replacement entries were consolidated, leaving 95 unique firms for analysis. The earlier manuscript reported N = 104; however, no complete 104-record register was available in the supplied materials, so that figure cannot be independently reconciled. The auditable analysis is therefore limited to the supplied final dataset of 95 unique firms.

Eighty-one unique firms were represented by supplied company-profile documents. Fourteen additional unique firms in the reconciled archive were reconstructed from public 2024–2025 disclosures using the same documentary scoring rules, producing one complete analytical dataset of N = 95. The five duplicate/replacement pairs in the 100-record archive were #21/#71 (DCC), #23/#69 (SCGD), #25/#68 (BGC), #37/#59 (KTIS), and #39/#96 (UVAN); one observation per firm was retained. The final mutually exclusive sector inventory is: Steel & Metals (n = 14), Cement & Construction (n = 13), Chemicals & Petrochemicals (n = 10), Energy (n = 16), Agro & Food (n = 14), Packaging & Paper (n = 8), Automotive Parts (n = 10), Shipping & Logistics (n = 7), and Other Sectors (n = 3). Steel & Metals is the reference sector.

3.3. Data sources

Publicly available data was used to gather data for the transitional period of the CBAM (2024–2025). The primary sources of information were (i) company sustainability reports, which included information on environmental management, carbon-reduction programs, and climate strategy; (ii) annual reports (Form 56-1 One Report) submitted to the SET, including executive statements and governance disclosures, verified financial, and operational information; (iii) the company's official websites containing information on the organizational structure, leadership, and sustainability commitments; (iv) SET ESG ratings; (v) TGO certifications—Carbon Footprint for Organization, Carbon Footprint for Product, and Carbon Footprint Reduction labels; (vi) press releases and investor-relations materials; and (vii) third-party assessments—DJSI membership, FTSE4Good inclusion, MSCI ESG ratings, and Sustainalytics scores. To ensure accuracy and completeness of the profile, multiple verifiable sources have been used to create each firm profile.

3.4. Coding and measurement

For each firm, CRP, GTL, and LCS were calculated as arithmetic means of the documentary item scores used in the company-profile instrument: CRP = mean(Q6–Q11; six items), GTL = mean(Q12–Q18; seven items), and LCS = mean(Q19–Q25; seven items). Each item uses a 1–5 scale, so all construct scores remain on the 1–5 metric while retaining fractional means. The final master dataset contains 95 rows, one per unique ticker. Firm Size is coded 1 for 500 or more employees and 0 otherwise. Export Intensity is coded ordinally as 1 = <25%, 2 = 25–49%, 3 = 50–74%, and 4 = >75% of export/international-revenue exposure. The sector is represented by eight dummy variables, with Steel & Metals omitted as the reference category. Independent second-coder records were not available for the complete reconciled N = 95 dataset; accordingly, no inter-rater reliability statistic is claimed for this final analysis.

3.5. Analytical approach

The analysis was done in three phases. Descriptive statistics were then calculated for each construct by sector to describe the distribution of CRP, LCS, and GTL. Secondly, bivariate correlation analysis was performed between the independent variable (CRP), dependent variable (LCS), moderator variable (GTL), and control variables at 0.05, 0.01, and 0.001 alpha levels. Third, following common practices in interaction analysis Hayes (2022), Reference [25], moderated hierarchical regression was performed to test the two hypotheses. Equation (1) represents the regression

specification developed for this study. The regression model used was:

$$LCS = \beta_0 + \beta_1(CRP) + \beta_2(GTL) + \beta_3(CRP \times GTL) + \beta_4(Controls) + \varepsilon \quad (1)$$

The continuous focal predictors were mean-centered before forming the CRP × GTL interaction term. The hierarchical model included Firm Size, Export Intensity, and eight sector dummies as controls, with Steel & Metals as the reference category. The moderation specification corresponds to PROCESS Model 1. Conditional unstandardized effects were evaluated at GTL = M − 1 SD, M and M + 1 SD, and Johnson–Neyman transition points were calculated on the original 1–5 GTL metric. Standardized β values reported in Tables 1 and 2 are from the hierarchical regressions; the PROCESS-style interaction and conditional-effect coefficients are reported as unstandardized B values.

Model 1 contained Firm Size, Export Intensity, and eight sector dummies (10 predictors; $F(10, 84)$); Model 2 added CRP (11 predictors; $F(11, 83)$); Model 3 added GTL (12 predictors; $F(12, 82)$); and Model 4 added CRP × GTL (13 predictors; $F(13, 81)$). Below are the standardized β, t, exact two-tailed p-values, R^2, ΔR^2, and F statistics. The unstandardized interaction coefficient, standard error, 95% confidence interval, conditional effects, and Johnson-Neyman region are also presented.

4. Results

4.1. Descriptive statistics and sectoral overview

The final sample of companies for analysis includes 95 different firms. The mutually exclusive distribution of sectors and completed CRP, LCS, and GTL means are reported in Table 3. In the entire sample, the mean of CRP, LCS, and GTL was 4.16, 4.30, and 4.30, respectively. Within sector groups, Energy firms had the highest mean LCS (M = 4.79), Agro & Food had the highest mean GTL (M = 4.63), and Chemicals & Petrochemicals had the highest mean CRP (M = 4.53). Other Sectors had the lowest means for each of the three constructs.

The sector distribution consists of mainly Energy (n = 16), Steel & Metals (n = 14), Agro & Food (n = 14), Cement & Construction (n = 13), Chemicals & Petrochemicals (n = 10), and Automotive Parts (n = 10) sectors, along with small numbers in Packaging & Paper (n = 8), Shipping & Logistics (n = 7), and Other Sectors (n = 3). Show high variation in documentary low-carbon maturity between samples.

Using the N = 95 dataset, the prespecified maturity rules were used to categorize 62 firms as Leaders, 26 as Moderate, and 7 as Laggards, as presented in Table 4. Leaders had mean scores of CRP = 4.46, LCS = 4.72, and GTL = 4.70; Moderate firms averaged CRP = 3.72, LCS = 3.85, and GTL = 3.87; Laggards averaged CRP = 3.05, LCS = 2.35, and GTL = 2.33. These values are plotted in Figure 2.

4.2. Hypothesis testing

4.2.1. Preliminary checks and correlation analysis

Pearson correlations for the final N = 95 dataset are shown in Table 5. CRP was strongly correlated with LCS (r = .800, p < .001) and GTL (r = .732, p < .001), while LCS and GTL were very strongly correlated (r = .953, p < .001). Export Intensity was positively but moderately associated with CRP (r = .209, p = .043) and not associated with LCS or GTL. There was no significant correlation between Firm Size and the three constructs of focus. Under the conventional threshold (VIF>5), no severe multicollinearity was found, as all the variance-inflation factors were below 5 (maximum VIF = 4.89) in the full moderation

Table 1
Regression Results for Direct Effect (Hypothesis 1), N = 95

Variable	Model 1 β	Model 1 t (p)	Model 2 β	Model 2 t (p)
Firm Size	.138	1.51 (.135)	–.027	–0.50 (.616)
Sector (Cement & Construction)	.155	1.39 (.167)	.192	3.03 (.003)
Sector (Chemicals & Petrochemicals)	.194	1.82 (.073)	.160	2.63 (.010)
Sector (Energy)	.398	3.25 (.002)	.390	5.61 (< .001)
Sector (Agro & Food)	.261	2.26 (.026)	.340	5.17 (< .001)
Sector (Packaging & Paper)	.015	0.14 (.890)	.311	4.82 (< .001)
Sector (Automotive Parts)	.053	0.49 (.627)	.334	5.13 (< .001)
Sector (Shipping & Logistics)	–.071	–0.67 (.502)	.142	2.30 (.024)
Sector (Other Sectors)	–.381	–4.04 (< .001)	.055	0.88 (.380)
Export Intensity	.106	1.06 (.291)	–.103	–1.76 (.081)
CBAM Regulatory Pressure (CRP)	—	—	.872	13.31 (< .001)
R^2	0.382	—	0.803	—
ΔR^2	—	—	0.421	$\Delta F(1, 83)$ = 177.28 (< .001)
F	5.20	$F(10, 84)$ (< .001)	30.77	$F(11, 83)$ (< .001)

Note: Standardized β coefficients are shown. The reference sector is Steel & Metals. Model 1: R^2 = .382, $F(10, 84)$ = 5.20, p < .001. Model 2: R^2 = .803, $F(11, 83)$ = 30.77, and p < .001. Adding CRP produced ΔR^2 = .421, $\Delta F(1, 83)$ = 177.28, p < .001. Exact p-values are reported, with the exception of p-values less than .001. After the inclusion of Firm Size, Export Intensity, and sector in Model 2, CRP was a significant positive predictor of LCS (standardized β = .872, t = 13.31, p < .001). Therefore, H1 is supported in the N = 95 analysis.

Table 2
Regression Results for Moderation Effect (Hypothesis 2), *N* = 95

Variable	Model 3 β	Model 3 t (exact *p*)	Model 4 β	Model 4 t (exact *p*)
Firm Size	–.025	–0.86 (.393)	–.021	–0.70 (.485)
Export Intensity	–.018	–0.57 (.573)	–.018	–0.57 (.568)
Sector (Cement & Construction)	–.052	–1.35 (.180)	–.048	–1.24 (.220)
Sector (Chemicals & Petrochemicals)	–.062	–1.70 (.094)	–.056	–1.51 (.136)
Sector (Energy)	.033	0.74 (.461)	.039	0.86 (.394)
Sector (Agro & Food)	–.002	–0.04 (.970)	.005	0.11 (.915)
Sector (Packaging & Paper)	–.039	–0.91 (.365)	–.036	–0.83 (.407)
Sector (Automotive Parts)	.035	0.87 (.388)	.036	0.88 (.379)
Sector (Shipping & Logistics)	–.025	–0.72 (.471)	–.019	–0.51 (.611)
Sector (Other Sectors)	–.007	–0.20 (.844)	.010	0.24 (.810)
CBAM Regulatory Pressure (CRP)	.239	4.22 (< .001)	.238	4.19 (< .001)
Green Transformational Leadership (GTL)	.782	14.28 (< .001)	.766	13.19 (< .001)
CRP × GTL	—	—	–.034	–0.82 (.415)
R^2	0.944	—	0.944	—
ΔR^2	—	—	< .001	$\Delta F(1, 81) = 0.67$ (.415)
F	114.16	$F(12, 82)$ (< .001)	105.01	$F(13, 81)$ (< .001)

Note: Standardized β coefficients are displayed, based on the reference sector Steel & Metals. Adding CRP × GTL produced $\Delta R^2 < .001$, $\Delta F(1, 81) = 0.67$, and $p = .415$. The standardized interaction was $\beta = –.034$, $t = –0.82$, $p = .415$. The corresponding unstandardized interaction coefficient was $B = –0.0401$, SE = 0.0489, 95% CI [–0.1373, 0.0572]. Exact *p*-values are reported except when $p < .001$. The CRP × GTL interaction was not statistically significant, and its confidence interval contained zero. Therefore, H2 is not supported. GTL is strongly related to LCS as a main effect, though $N = 95$ data do not support the relationship between GTL and strengthening the CRP-LCS relationship.

Table 3
Mean Scores by Sector (*N* = 95)

Sector	*n*	CRP Mean	LCS Mean	GTL Mean
Steel & Metals	14	4.37	3.99	3.79
Cement & Construction	13	4.28	4.34	4.40
Chemicals & Petrochemicals	10	4.53	4.54	4.61
Energy	16	4.31	4.79	4.71
Agro & Food	14	4.29	4.63	4.63
Packaging & Paper	8	3.62	4.07	4.30
Automotive Parts	10	3.85	4.23	4.19
Shipping & Logistics	7	4.02	3.94	3.98
Other Sectors	3	2.67	2.38	2.48
Total	95	4.16	4.30	4.30

Note: LCS = low-carbon strategy, GTL = green transformational leadership, CRP = CBAM regulatory pressure. The scores are in the range of 1 to 5. All *n* values are obtained by summing the values, and all means are computed from the full firm-level documentary data set on which the correlation and regression analyses are performed.

Table 4
Classification of Firms by Overall Sustainability Maturity (*N* = 95)

Category	Criteria	*n*	Representative Firms
Leaders	CRP ≥ 4.0, LCS ≥ 4.0, GTL ≥ 4.0	62	SSI, TSTH, SCC, PTTGC, IVL, SAT, ACE, BCPG, TEGH, SCGP, WICE, SJWD (examples)
Moderate	2.5 ≤ scores < 4.0	26	GSTEL, GJS, MILL, ALUCON, TCAN, RCI, SMM, YUASA, TRU, SUPER, TSE, HTC, ICHI, RCL (examples)
Laggards	Score < 2.5 on at least one key construct	7	WACOAL, SPC, TOG, SSSC, THAI, KKC, SWI

Table 5
Correlation Matrix (N = 95)

Variable	1	2	3	4	5
1. CRP	—	—	—	—	—
2. LCS	.800***	—	—	—	—
3. GTL	.732***	.953***	—	—	—
4. Firm Size	.115	.149	.182	—	—
5. Export Intensity	.209*	–.002	–.018	.156	—

Note: LCS = low-carbon strategy, GTL = green transformational leadership, CRP = CBAM regulatory pressure. Firm Size is the large-firm indicator, and Export Intensity is the four-category ordinal control. * $p < .05$; ** $p < .01$; *** $p < .001$ (two-tailed). The correlation pattern is used to give initial support to H1 at the bivariate level, and the decision about the hypothesis is made based on the regression results of the controlled hierarchical regression. Because of the high LCS-GTL correlation, it is important to look at the interaction test and multicollinearity diagnostics when interpreting H2.

model, though the LCS-GTL correlation is high, which should be interpreted with care.

4.2.2. Direct effect (Hypothesis 1)

Hierarchical regression was done for H1. Model 1 was based on Firm Size, Export Intensity, and eight sector dummies. Model 2 added CRP. Model 1 explained 38.2% of the variance in LCS, R^2 = .382, $F(10, 84)$ = 5.20, $p < .001$. Adding CRP increased explained variance by ΔR^2 = .421, $\Delta F(1, 83)$ = 177.28, $p < .001$, producing Model 2 R^2 = .803, $F(11, 83)$ = 30.77, $p < .001$.

4.2.3. Moderation effect (Hypothesis 2)

H2 was tested by adding GTL and then the mean-centered CRP × GTL interaction. Model 3 explained 94.4% of the variance in LCS, R^2 = .944, $F(12, 82)$ = 114.16, and $p < .001$. GTL was strongly and positively associated with LCS (standardized β = .782, t = 14.28, $p < .001$), while CRP remained significant (β = .239, t = 4.22, $p < .001$). Model 4 also explained 94.4% of the variance, R^2 = .944, $F(13, 81)$ = 105.01, $p < .001$.

4.2.4. Visualization of the moderation effect

Figure 3 shows the conditional CRP → LCS relationship for low, mean, and high GTL, with Model 4 and holding the covariates at their sample means, and Steel & Metals as the reference sector. The almost parallel lines are in line with the lack of significance for the interaction (β = −.034, p = .415).

GTL had M = 4.296 and SD = 0.749. The conditional unstandardized effect of CRP on LCS was B = 0.327, SE = 0.079, t = 4.14, $p < .001$, 95% CI [0.170, 0.484] at low GTL (M − 1 SD = 3.547); B = 0.297, SE = 0.071, t = 4.19, $p < .001$, 95% CI [0.156, 0.438] at mean GTL; and B = 0.267, SE = 0.081, t = 3.31, p = .001, 95% CI [0.107, 0.427] at M + 1 SD = 5.045. The value 5.045 is the arithmetic M + 1 SD conditioning point and lies slightly above the instrument maximum; it is therefore an extrapolated probe rather than an observed GTL score. At the observed maximum GTL = 5.000, the conditional CRP effect remains positive and significant (B = 0.269, SE = 0.080, t = 3.38, p = .001, 95% CI [0.111, 0.427]). Johnson–Neyman transition points occur at approximately −0.596 and 6.076 on the original GTL metric, both outside the observed range of 2.0–5.0. Thus, the CRP effect is positive and significant throughout the observed GTL range, but the CRP × GTL interaction itself is not significant; H2 is not supported.

Figure 2
Sustainability metrics by maturity category (N = 95; bars = means; error bars = ±1 SD)

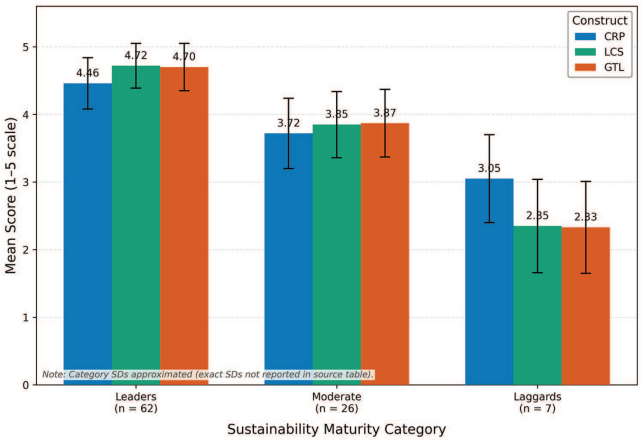
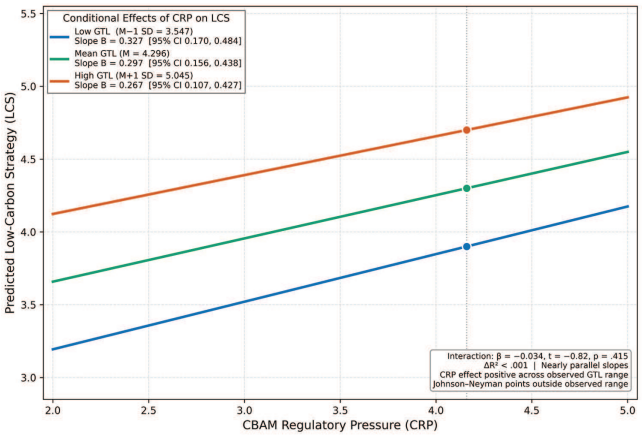


Figure 3
Simple-slope diagnostic for the CRP-LCS relationship at low, mean, and high levels of green transformational leadership (N = 95)



5. Discussion

5.1. Key findings and integration with prior literature

The relationship between CBAM regulatory pressure and low-carbon strategy adoption was examined in 95 unique listed

companies in Thailand, with GTL tested as a moderator. CRP remained strongly and positively associated with LCS after controlling for Firm Size, Export Intensity, and sector, supporting H1. H2 was not supported: although GTL had a large positive main effect on LCS (Model 4 β = .766, p < .001), the CRP × GTL interaction was small and non-significant (β = −.034, p = .415). Conditional CRP effects were positive across the observed GTL range, but the slope did not significantly vary as a function of GTL. The H1 finding is consistent with an institutional-theory interpretation in which coercive regulatory pressure from a major trading partner is associated with formal carbon-management and low-carbon strategic responses. Because the design is cross-sectional and documentary, the result is interpreted as an association rather than a causal effect. The non-significant interaction qualifies the proposed upper-echelons moderation argument: GTL is an important organizational correlate of low-carbon strategy, but the data do not demonstrate that GTL significantly amplifies the CRP–LCS association.

5.2. Theoretical implications

The robust controlled CRP-LCS relationship lends support to the institutional-theory contribution. There is a strong correlation between the level of external regulatory pressure and the level of low-carbon strategic adoption among the sampled companies. However, this cross-level conditioning mechanism, hypothesized, was not confirmed: it did not show a significant increase with the increase of GTL. This separation allows a more nuanced understanding of the theoretical model, between a leadership main effect and a moderation effect. However, looking from a higher level, GTL is still a matter of substance due to its strong linkage with LCS, even after taking into account the regulatory pressure and controls. The results indicate that environmental leadership is directly associated with low-carbon strategic maturity. Further testing in multi-country or longitudinal studies is needed before any causal or cross-level mechanism is inferred.

5.3. Practical implications

CBAM is a strategic planning question, as well as a compliance question, for managers. The strong association between CRP and LCS indicates that firms with higher regulatory-pressure scores also tend to have higher LCS scores. Leadership capability is still relevant as GTL is closely linked to LCS, but the findings should not be interpreted as showing that higher GTL strengthens the effect of CBAM pressure. It is therefore important to consider regulatory readiness and internal sustainability leadership as related but empirically different aspects of management initiatives. The results indicate that, apart from advocating for technical decarbonization, policymakers need to think about promoting leadership capability. There is a need for programs for executives beyond general technical training, such as sustainability-leadership training grants, board-level climate-governance toolkits, and other agency-specific programs like the Thailand Greenhouse Gas Management Organization (TGO) and Federation of Thai Industries that help SMEs to move beyond reactive compliance to strategic response to support Thailand's 2050 carbon-neutrality target. Sustainability executives, public CEO climate commitments, board-level sustainability committees, and external ESG recognition continue to be good descriptive indicators of sustainability governance. In this analysis, they are in line with the strong GTL main effect but should not be interpreted as evidence that leadership acts as a moderator of the regulatory-pressure effect.

5.4. Illustrative examples from the dataset

Section 5 presents illustrative cases, like PTTGC, IVL, SCC, BGRIM, ACE, BCPG, SAT, and TEGH, which exhibit a higher degree of co-occurrence between stronger documentary evidence of carbon management, governance, and low-carbon investment and higher CRP, LCS, and GTL scores. These cases show the overall quantitative trend but cannot be used alone to demonstrate causality or moderation. Companies with direct or indirect CBAM exposure but comparatively weaker disclosed leadership or sustainability-governance indicators offer useful descriptive comparisons. Their profiles illustrate heterogeneity in low-carbon maturity; however, these descriptive contrasts do not demonstrate that lower GTL weakens the CRP–LCS relationship. Similarly, companies not directly affected by CBAM but displaying strong leadership and decarbonization efforts illustrate the close association between GTL and LCS. This pattern is consistent with the finding of no support for H2, and it supports the discussion of organizational heterogeneity.

6. Conclusion

This study investigated the association between CBAM regulatory pressure, low-carbon strategy adoption, and green transformational leadership in a reconciled sample of 95 unique listed companies in Thailand. H1 was supported: CRP was strongly and positively associated with LCS after controlling for Firm Size, Export Intensity, and sector (β = .872, p < .001). GTL was also a strong positive predictor of LCS, but the CRP × GTL interaction was not statistically significant (β = −.034, p = .415), so H2 was not supported. Conditional CRP effects remained positive throughout the observed GTL range, and the Johnson–Neyman transition points were outside that range. Several limitations should be noted. First, the study relies on publicly disclosed documentary evidence and therefore captures observable practices and strategic signals. Second, the cross-sectional design limits causal interpretation. Third, 14 profiles were reconstructed from public 2024–2025 disclosures because the corresponding local profile documents were not available in the supplied archive. Fourth, independent second-coder records were unavailable for the complete reconciled N = 95 dataset, so no inter-rater kappa is reported. Fifth, the very high LCS–GTL correlation indicates substantial overlap in documentary maturity and requires caution, although final-model VIFs remained below 5. Finally, the single-country design limits generalization to other emerging economies.

Future research directions. Longitudinal studies of these same companies as CBAM's definitive financial obligations begin in 2026 would help to provide answers to these questions. Generalisability would be assessed through cross-country comparisons (e.g., Vietnam, Malaysia, and India). Additional moderators may be recognized in qualitative case studies of outliers (e.g., SSSC, PCSGH, HTC, and ICHI), including technological capability, ownership structure, and stakeholder pressure. Lastly, more robust connections between CBAM readiness and financial results—export growth, access to the EU market, and valuations from investors—will reinforce the business case for CBAM readiness and leadership development.

Ethical Statement

No human participants, animals, data collection, or intervention was involved in this study, which analyzed publicly available corporate and institutional documents. Thus, institutional ethics approval and informed consent were not necessary.

Conflicts of Interest

The author states that there is no conflicts of interest.

Data Availability Statement

Data are available from the corresponding author upon reasonable request.

Author Contribution Statement

Rapeerat Thanyawatpornkul: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing–original draft, Writing–review and editing, Visualization, and Project administration.

References

[1] Bellora, C., & Fontagné, L. (2023). EU in search of a carbon border adjustment mechanism. *Energy Economics*, *123*, 106673. https://doi.org/10.1016/j.eneco.2023.106673

[2] Magacho, G., Espagne, E., & Godin, A. (2024). Impacts of the CBAM on EU trade partners: Consequences for developing countries. *Climate Policy*, *24*(2), 243–259. https://doi.org/10.1080/14693062.2023.2200758

[3] European Commission, Directorate-General for Taxation and Customs Union. (2023). *Carbon border adjustment mechanism*. Retrieved from: https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en

[4] Zhong, J., & Pei, J. (2024). Carbon border adjustment mechanism: A systematic literature review of the latest developments. *Climate Policy*, *24*(2), 228–242. https://doi.org/10.1080/14693062.2023.2190074

[5] Lim, B., Hong, K., Yoon, J., Chang, J. I., & Cheong, I. (2021). Pitfalls of the EU's carbon border adjustment mechanism. *Energies*, *14*(21), 7303. https://doi.org/10.3390/en14217303

[6] Maliszewska, M., Fischer, C., Jung, E., & Chepeliev, M. (2025). *Carbon border adjustment mechanism (CBAM) exposure indices methodological note*. World Bank Group. https://doi.org/10.1596/43614

[7] Eicke, L., Weko, S., Apergi, M., & Marian, A. (2021). Pulling up the carbon ladder? Decarbonization, dependence, and third-country risks from the European carbon border adjustment mechanism. *Energy Research & Social Science*, *80*, 102240. https://doi.org/10.1016/j.erss.2021.102240

[8] Perdana, S., & Vielle, M. (2022). Making the EU carbon border adjustment mechanism acceptable and climate friendly for least developed countries. *Energy Policy*, *170*, 113245. https://doi.org/10.1016/j.enpol.2022.113245

[9] Zhang, W., & Sovacool, B. K. (2025). The "triple burden" effect and "pressure-opportunity paradox" of net-zero transitions: Exploring the political economy of carbon border adjustment mechanism (CBAM) implementation in the Global South. *Energy Strategy Reviews*, *62*, 101913. https://doi.org/10.1016/j.esr.2025.101913

[10] DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, *48*(2), 147–160. https://doi.org/10.2307/2095101

[11] Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, *9*(2), 193–206. https://doi.org/10.5465/amr.1984.4277628

[12] Chen, Y. S., & Chang, C. H. (2013). The determinants of green product development performance: Green dynamic capabilities, green transformational leadership, and green creativity. *Journal of Business Ethics*, *116*(1), 107–119. https://doi.org/10.1007/s10551-012-1452-x

[13] Singh, S. K., Del Giudice, M., Chierici, R., & Graziano, D. (2020). Green innovation and environmental performance: The role of green transformational leadership and green human resource management. *Technological Forecasting and Social Change*, *150*, 119762. https://doi.org/10.1016/j.techfore.2019.119762

[14] Farrukh, M., Ansari, N., Raza, A., Wu, Y., & Wang, H. (2022). Fostering employee's pro-environmental behavior through green transformational leadership, green human resource management and environmental knowledge. *Technological Forecasting and Social Change*, *179*, 121643. https://doi.org/10.1016/j.techfore.2022.121643

[15] Tu, Y., Li, Y., & Zuo, W. (2023). Arousing employee pro-environmental behavior: A synergy effect of environmentally specific transformational leadership and green human resource management. *Human Resource Management*, *62*(2), 159–179. https://doi.org/10.1002/hrm.22138

[16] Powell, W. W., & Colyvas, J. A. (2008). Microfoundations of institutional theory. In R. Greenwood, C. Oliver, K. Sahlin, & R. Suddaby (Eds.), *The SAGE handbook of organizational institutionalism* (pp. 276–298). SAGE.

[17] Olasehinde-Williams, G., & Akadiri, S. S. (2025). Environmental policy stringency and carbon leakages: A case for carbon border adjustment mechanism in the European Union. *Environment, Development and Sustainability*, *27*(12), 30817–30838. https://doi.org/10.1007/s10668-024-04941-7

[18] Powell, W. W., & DiMaggio, P. J. (2023). The iron cage redux: Looking back and forward. *Organization Theory*, *4*(4), 26317877231221550. https://doi.org/10.1177/26317877231221550

[19] Dobranschi, M., Nerudová, D., Solilová, V., & Stadler, K. (2024). Carbon border adjustment mechanism challenges and implications: The case of Visegrád countries. *Heliyon*, *10*(10), e30976. https://doi.org/10.1016/j.heliyon.2024.e30976

[20] Erdogdu, E. (2025). The carbon border adjustment mechanism: Opportunities and challenges for non-EU countries. *Wiley Interdisciplinary Reviews: Energy and Environment*, *14*(1), e70000. https://doi.org/10.1002/wene.70000

[21] Omarova, L., & Jo, S. J. (2022). Employee pro-environmental behavior: The impact of environmental transformational leadership and GHRM. *Sustainability*, *14*(4), 2046. https://doi.org/10.3390/su14042046

[22] Sobaih, A. E. E., Hasanein, A., Gharbi, H., & Abu Elnasr, A. E. (2022). Going green together: Effects of green transformational leadership on employee green behaviour and environmental performance in the Saudi food industry. *Agriculture*, *12*(8), 1100. https://doi.org/10.3390/agriculture12081100

[23] Phuong, T. M. T., Thanh, T. B., & Dang-Van, T. (2025). Green transformational leadership and firm ESG performance in a transitional economy: The serial mediating roles of green training and green involvement. *Business Strategy & Development*, *8*(3), e70225. https://doi.org/10.1002/bsd2.70225

[24] Li, W., Liu, X., Yuan, X., & Lu, C. (2024). Impact of CBAM on carbon emission reduction in global steel foreign trade: Projections based on the embodied carbon emission intensity of major countries. *Energy Sources, Part B: Economics, Planning, and Policy*, *19*(1), 2360443. https://doi.org/10.1080/15567249.2024.2360443

[25] Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (3rd ed.). USA: Guilford Press.

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Appendix. Construct Coding Rubric and Indicator–Text Mapping

This appendix reports the scoring structure used in the final analytical dataset. CRP is the arithmetic mean of six documentary items (Q6–Q11), GTL is the arithmetic mean of seven items (Q12–Q18), and LCS is the arithmetic mean of seven items (Q19–Q25). Each item is coded on a 1–5 documentary scale, and construct means remain on the 1–5 metric. Fractional values are retained rather than rounded before analysis.

Table A1
Scoring anchors (applied to all three constructs)

Component	Final scoring rule
CRP	Arithmetic mean of Q6–Q11 (6 items)
GTL	Arithmetic mean of Q12–Q18 (7 items)
LCS	Arithmetic mean of Q19–Q25 (7 items)
Item metric	Each item coded on a 1–5 documentary scale
Construct metric	Arithmetic mean retained on the 1–5 scale; fractional values preserved

Table A2
Indicators and text evidence by construct

Construct	Profile items	Computation
CRP	Q6–Q11	(Q6 + Q7 + Q8 + Q9 + Q10 + Q11) / 6
GTL	Q12–Q18	(Q12 + Q13 + Q14 + Q15 + Q16 + Q17 + Q18) / 7
LCS	Q19–Q25	(Q19 + Q20 + Q21 + Q22 + Q23 + Q24 + Q25) / 7

Note: The final $N = 95$ analysis does not claim inter-rater reliability because independent second-coder records for the complete reconciled sample were not available. The item-level documentary evidence and provenance should be retained with the audit materials so that each construct score can be traced to the underlying profile coding.