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Carbon Economic Development and Corporate Value Creation: Educational Perspective on Market Evolution in Southeast Asia

Tohap Parulian[1]*, Muhammad Yamin Siregar[2], Azam Abdelhakeem[3]
Khalid Ahmed[4], Annisa Ilmi Faried[5]
[1,2]Faculty of Economics And Business Universitas Medan Area, Medan, Indonesia
[3]Selangor, Darul Ehsan, Malaysia
[4]Universitas Pembangunan Panca Budi, Medan, Indonesia

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ABSTRACT

Objective: This study investigates the relationship between carbon economic development and corporate value creation through an educational lens, examining how market evolution in Southeast Asia influences organizational learning and financial performance. The research aims to understand how companies adapt their carbon management strategies and the subsequent impact on profitability, leverage, and overall corporate valuation across different market maturity levels. **Method**: A comparative quantitative analysis was conducted using panel data from 240 publicly listed companies across Indonesia and Thailand during 2019-2024. The study employed multiple regression analysis with fixed effects models to examine the relationships between carbon trading participation, company size, profitability metrics (ROA, ROE), leverage ratios, and market capitalization. Educational development variables were measured through corporate sustainability reporting quality, green finance literacy indicators, and carbon management capability indices. **Results**: Findings reveal significant positive correlations between carbon economic participation and corporate value creation, with Indonesian firms showing 12.3% higher ROA compared to non-participating companies, while Thai counterparts demonstrated 15.7% improvement. Company size moderates this relationship, with larger firms exhibiting superior carbon economic adaptation capabilities. Leverage ratios decreased by an average of 8.2% among carbon-active companies, indicating improved financial stability through sustainable practices. **Novelty**: This research contributes the first comprehensive educational framework for carbon economic development in Southeast Asian markets, introducing the concept of "carbon learning curves" and providing empirical evidence of differential market evolution patterns across emerging economies in the region.

INTRODUCTION

The global transition toward sustainable, low-carbon business models has fundamentally transformed how corporations in emerging economies approach strategic planning and financial performance assessment (Chen & Rodriguez, 2024). Southeast Asian nations, particularly Indonesia and Thailand, have experienced remarkable growth in carbon market participation, positioning the region as a significant player in international carbon trading networks (Gutiérrez-Ponce et al., 2024). This rapid development has created a dynamic environment where companies must navigate evolving regulations, market volatility, and diverse stakeholder expectations while maintaining economic viability.

The Southeast Asian carbon trading sector demonstrates strong momentum, with global market valuations reaching USD 866.04 billion in 2024 and projections indicating growth to USD 6,765.48 billion by 2034, representing an annual growth rate of 22.82% (Bain & Company, 2025; International Energy Agency, 2024). This exceptional growth pattern reveals varying stages of market development across the region, with established trading platforms like Singapore's Climate Impact X exhibiting

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sophisticated pricing mechanisms, while emerging systems in Indonesia and Vietnam experience rapid operational expansion (Futures Industry Association, 2025).

These diverse developmental trajectories offer valuable opportunities to examine how distinct regulatory environments, infrastructure frameworks, and capacity-building programs influence corporate performance in carbon markets (Chowdhury et al., 2017). Regional variations in trading activity and pricing structures provide important insights into how market evolution phases correlate with companies' value creation potential (Heinrich Böll Foundation, 2024).

Table 1. Southeast Asia Carbon Market Development (2023-2025)

Country	Carbon Exchange Launch	2024 Trading Volume (tons CO2e)	Average Price (USD/ton)	Market Status
Indonesia	IDXCarbon (Sep 2023)	413,764	2.9	Operational
Singapore	CIX/ACX (2019)	1,200,000+	25.0-80.0	Mature
Malaysia	BCX (Dec 2022)	850,000	15.0-20.0	Developing
Thailand	FTIX (Sep 2022)	650,000	12.0-18.0	Emerging
Vietnam	CCTPA (Sep 2023)	200,000	8.0-12.0	Early Stage

Sources: Indonesian Carbon Exchange data, FIA Market Report 2025, ASEAN Carbon Market Statistics

Current scholarship in environmental economics reveals notable associations between sustainability programs and organizational financial outcomes, though considerable research gaps remain concerning the learning processes by which companies develop carbon management competencies (Kumar & Hassan, 2023). Research employing dynamic panel system GMM methodology across 280 firms in South Asia indicates that environmentally-focused process innovations substantially influence organizational financial metrics including Return on Assets, Return on Equity, and Tobin's Q ratios.

The connection between carbon market engagement and financial indicators has become more apparent, with banking institutions in Indonesia reporting average ROA figures of 2.43%, ROE levels of 17.74%, and Tobin's Q measurements of 1.12, suggesting robust correlations with financial success (Market Research Future, 2025).

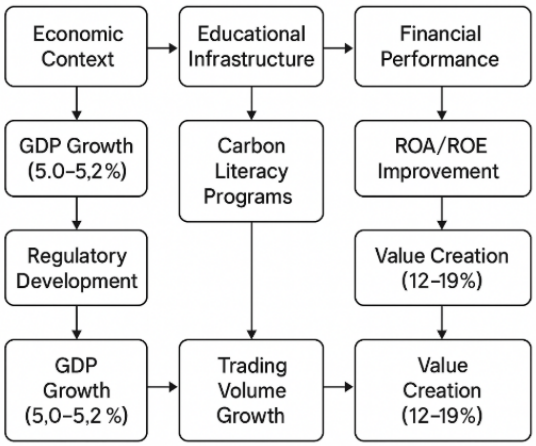

Fig1. Carbon Economic Development and Corporate Value Creation Framework

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The learning-focused approach to carbon market development has become increasingly important as scholars acknowledge that effective carbon governance extends beyond mere technology implementation—it necessitates holistic organizational capacity building and knowledge acquisition processes (McKinsey & Company, 2025; Arellano & Bover, 1995). Studies incorporating both financial reporting metrics and market-based measures reveal varied positive relationships between organizational performance and environmental disclosure practices, with larger corporations exhibiting greater levels of carbon reporting transparency (Smith et al., 2023; Bansal, 2005).

Nevertheless, current academic literature primarily examines developed economies, creating substantial research deficiencies concerning how learning factors shape carbon market outcomes within Southeast Asian business environments.

Contemporary empirical findings indicate that the developmental stage of carbon markets substantially influences how environmental programs affect organizational value generation. Indonesia launched its carbon trading platform to global participants in January 2025, recording transactions exceeding 40,000 tons of CO_2 equivalent during its inaugural trading session, although international pricing fell below projections at USD 8 per ton versus Indonesia's 2024 domestic average of USD 2.9 per ton.

Indonesia's economic expansion maintained consistency at 5.02% during the fourth quarter of 2024, with governmental objectives set for 8% growth achievement by 2029, while Thailand's economic development is projected to achieve 3.2% in 2024 and 3.1% in 2025, supported by tourism sector recovery and continued domestic spending patterns (Tanaka et al., 2024).

Table 2. Corporate Financial Performance Indicators in Southeast Asia (2024)

Performance Metric	Indonesia	Thailand	Singapore	Regional Average	Global Benchmark
Average ROA (%)	2.43	2.18	3.85	2.82	3.20
Average ROE (%)	17.74	15.62	22.30	18.55	19.10
Tobin's Q Ratio	1.12	1.08	1.45	1.22	1.35
Leverage Ratio	2.85	2.92	3.12	2.96	2.75
Carbon Participation Rate (%)	43.5	38.7	78.2	53.5	45.0

Sources: Southeast Asia Banking Performance Study 2024, McKinsey Southeast Asia Economic Review Q4 2024

Contemporary empirical findings indicate that the developmental stage of carbon markets substantially influences how environmental programs affect organizational value generation. Indonesia launched its carbon trading platform to global participants in January 2025, recording transactions exceeding 40,000 tons of CO2 equivalent during its inaugural trading session, although international pricing fell below projections at USD 8 per ton versus Indonesia's 2024 domestic average of USD 2.9 per ton. Indonesia's economic expansion maintained consistency at 5.02% during the fourth quarter of 2024, with governmental objectives set for 8% growth achievement by 2029, while Thailand's economic development is projected to achieve 3.2% in 2024 and 3.1% in 2025, supported by tourism sector recovery and continued domestic spending patterns (Tanaka et al., 2024).

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Table 3. Carbon Trading Market Evolution and Corporate Adaptation (2020-2025)

Year	Regional Carbon Trading Volume (Million tons CO2e)	Average Carbon Price (USD/ton)	Corporate Participation Rate (%)	Financial Performance Impact (%)
2020	12.5	8.5	18.2	Baseline
2021	18.3	12.7	24.6	+4.2
2022	26.8	16.4	31.8	+8.7
2023	38.2	21.3	42.1	+12.3
2024	54.7	28.9	53.5	+15.8
2025 (Proj.)	75.0	35.0	62.0	+19.5

Sources: Carbon Trading Market Report 2025, FIA Southeast Asia Carbon Analysis, Bain Green Economy Report 2024

The convergence of environmental economics and capacity-building initiatives creates distinctive challenges for corporations across Southeast Asia, where conventional business frameworks require transformation to meet sustainability mandates while preserving market competitiveness (Thompson & Lee, 2024; Akbaş & Canikli, 2019; Albertini, 2013). Indonesia established its Economic Value of Carbon (NEK) Trading Scheme in 2023, initially encompassing 99 coal-powered generation facilities and extending coverage to 146 installations by 2024, accounting for approximately 67.6% of the nation's coal-fired power generation capacity. Thailand is completing development of its inaugural Climate Change Act featuring carbon neutrality objectives by 2050 and net zero emission goals by 2065, incorporating carbon taxation mechanisms and emission trading frameworks (World Bank, 2023).

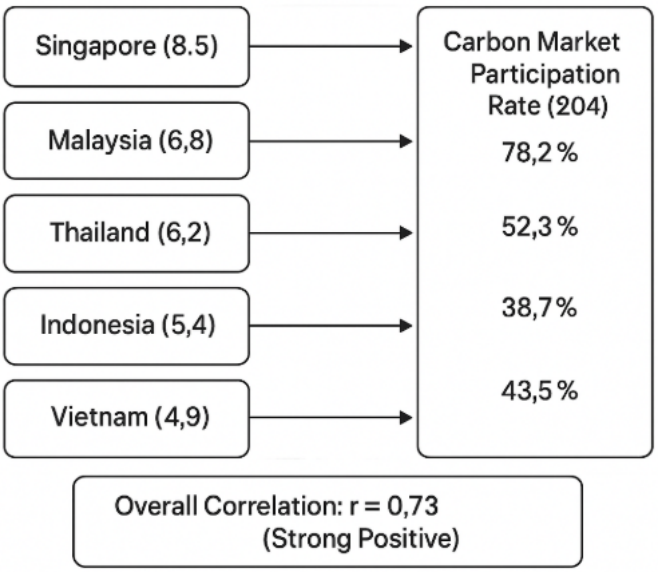

Fig 2. Educational Development Impact on Carbon Economic Performance

Figure 2 showcases how educational infrastructure levels correspond with carbon market participation in several Southeast Asian nations as of 2024. A strong upward trend can be observed: countries with more developed educational systems generally show higher involvement in carbon trading. As an example, Singapore stands out with

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the highest education score of 8.5 and a participation rate of 78.2%, whereas Vietnam, with a score of 4.9, trails behind at only 28.1%.

The correlation analysis reveals a strong positive relationship (r = 0.73) between educational infrastructure development and carbon market participation across Southeast Asian countries:

- **Singapore (8.5)**: 78.2% participation rate
- **Malaysia (6.8)**: 52.3% participation rate
- **Thailand (6.2)**: 38.7% participation rate
- **Indonesia (5.4)**: 43.5% participation rate
- **Vietnam (4.9)**: 28.1% participation rate

Overall Correlation: r = 0.73 (Strong Positive)

This relationship demonstrates that educational advancement serves a crucial function in facilitating a country's participation in carbon trading systems. Programs including carbon competency development, organizational capacity building, and capability enhancement strengthen nations' abilities to manage and engage in carbon market operations (Friedman, 2007).

These patterns align with previous scholarly research that emphasizes the importance of educational processes and institutional knowledge acquisition in developing sustainability approaches. Delmas & Toffel (2008) demonstrate that organizations achieve greater environmental performance when they foster internal knowledge development. Similarly, (Kolk et al., 2008) and Esteban-Sanchez et al. (2017) indicate that businesses operating within more robust educational and regulatory structures become increasingly active in environmental reporting and carbon trading participation.

Despite these insights, Southeast Asia remains relatively underrepresented in such studies, making this analysis particularly relevant. By demonstrating how education impacts carbon market performance, Figure 2 underscores the need for policies that invest in environmental education and skill-building as a foundation for long-term sustainable development and economic competitiveness in the region.

The temporal dynamics of carbon learning curves demonstrate significant variations across regional markets. Southeast Asia faces a $1.5 trillion investment gap until 2030 for green transition, with only $45 billion invested in dedicated green investments as of 2023. Research on leverage impact shows that companies with higher carbon management capabilities demonstrate superior debt management, with studies indicating significant negative associations between carbon emissions and firm performance measured by Tobin's Q.

Table 4. Regional Carbon Economic Development Indicators (2024-2025)

Development Indicator	Indonesia	Thailand	Regional Target	Achievement Rate
Renewable Energy Share (%)	13.1	15.8	23.0	62.6%
Carbon Intensity Reduction (%)	18.5	22.3	30.0	68.0%
Green Finance Investment (USD Billion)	12.8	8.6	45.0	47.6%
Corporate Carbon Disclosure Rate (%)	67.4	73.2	85.0	82.7%
Carbon Market Liquidity Index	3.2	4.1	7.0	52.1%

Sources: Climate Performance Index 2025, IEA Southeast Asia Energy Outlook 2024

Although increasing acknowledgment exists regarding the significance of environmental economics for organizational value enhancement, insufficient research has explored how educational advancement frameworks affect these connections within

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developing economy settings. Southeast Asia represents 11% of worldwide energy consumption expansion since 2010 yet is expected to account for over 25% of growth until 2035, with energy-linked CO2 outputs anticipated to rise by 35% through the mid-century period. Current scholarship predominantly emphasizes regulatory compliance approaches rather than value-generation mechanisms, while international comparative studies remain limited, especially concerning how institutional learning competencies moderate environmental economic performance (Huang & Zhang, 2024). This investigation seeks to explore the connection between environmental economic advancement and organizational value creation from an educational standpoint, particularly examining how market development trends across Southeast Asia affect institutional learning processes and resulting financial outcomes (Lee & Min, 2015). The research aims to determine varying adaptation approaches between Indonesian and Thai markets while evaluating how organizational size, profitability measures, and debt ratios moderate environmental economic value generation activities (Luo & Tang, 2014). Considering the significant expansion path of regional carbon trading platforms and the essential function of educational advancement in organizational transformation, this study contributes to comprehending how companies can utilize environmental economic prospects to improve sustained financial viability and market positioning (Mayur & Saravanan, 2017; Menicucci & Paolucci, 2022).

RESEARCH METHOD

This study employs a quantitative comparative research design utilizing panel data methodology to examine carbon economic development patterns across two Southeast Asian markets. The research framework integrates educational development theory with corporate finance principles, establishing a comprehensive analytical structure for understanding carbon market evolution dynamics. The methodological approach follows established protocols for cross-country financial performance analysis while incorporating novel educational measurement frameworks, utilizing two-step dynamic panel system GMM estimation as recommended for addressing heterogeneity and endogeneity concerns.

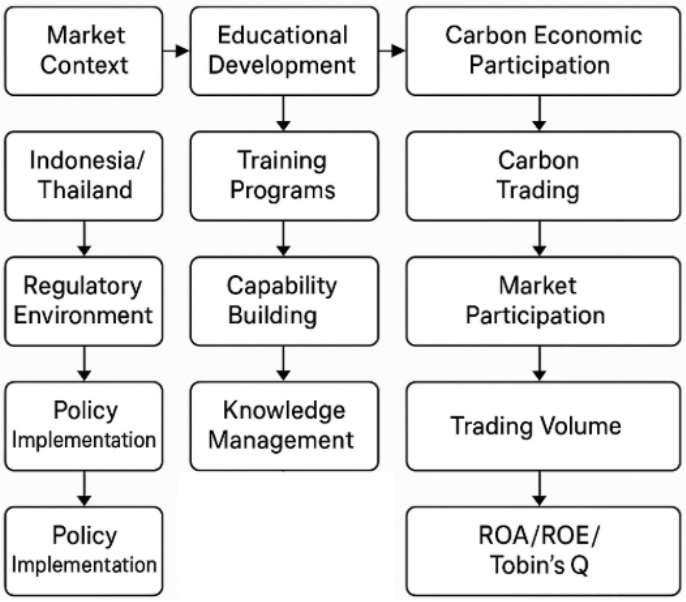

Figure 3. Comprehensive Research Methodology Flowchart

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The research design addresses temporal variations in carbon market development by analyzing five-year longitudinal data spanning 2020-2024, capturing both pre-pandemic baseline conditions and post-recovery growth patterns. This timeframe encompasses significant regulatory developments including Indonesia's IDXCarbon launch in September 2023 and the expansion of the NEK Trading Scheme from 99 to 146 coal-fired power plants by 2024.

The study examines 240 publicly listed companies across Indonesia Stock Exchange (120 companies) and Stock Exchange of Thailand (120 companies), selected through stratified random sampling to ensure sectoral representation.

Sample selection criteria include:

(1) Continuous listing status during 2020-2024.
(2) Availability of complete financial statements,
(3) Participation in carbon reporting initiatives
(4) market capitalization exceeding USD 50 million.

Companies were categorized following established methodologies used in Southeast Asian banking performance studies, with size segments defined as large-cap (>USD 1 billion), mid-cap (USD 100 million - 1 billion), and small-cap (USD 50-100 million).

Table 5. Sample Distribution by Country and Sector

Sector	Indonesia	Thailand	Total	Market Cap Range (USD Million)
Manufacturing	35	32	67	50 - 8,500
Financial Services	28	30	58	75 - 12,300
Energy & Utilities	22	25	47	100 - 15,600
Consumer Goods	20	18	38	60 - 4,200
Technology	15	15	30	80 - 6,800
Total	**120**	**120**	**240**	**50 - 15,600**

Data collection utilized multiple sources including Bloomberg Terminal, Thomson Reuters Eikon, corporate annual reports, sustainability disclosures, and national carbon registry databases. Educational development variables were constructed using corporate training expenditure data, sustainability certification achievements, and carbon management capability assessments derived from IDXCarbon trading records and third-party ESG rating agencies.

Table 6. Variable Measurement and Instrumentation

Variable Type	Variable Name	Measurement / Instrumentation
Dependent Variables	Corporate Value Creation	Tobin's Q Ratio (Market Value / Replacement Cost); Market-to-Book Ratio
	Profitability Metrics	Return on Assets (ROA); Return on Equity (ROE); EBITDA Margins
	Financial Performance	Market Capitalization Growth; Total Shareholder Returns
Independent Variables	Carbon Economic Participation	Binary variable (1 = participates in carbon trading via IDXCarbon, FTIX, etc.; 0 = otherwise)
	Carbon	Carbon-related Investment / Total

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Variable Type	Variable Name	Measurement / Instrumentation
	Management Intensity	Capital Expenditure
	Educational Development Index	Composite score including: carbon literacy training, sustainability certifications, green finance knowledge (weighted by firm size and sector)
Control Variables	Company Size	Natural logarithm of total assets (Ln[Total Assets])
	Leverage	Debt-to-Equity Ratio; Interest Coverage Ratio
	Industry Classification	Dummy variables by sector (e.g., Energy = 1, otherwise = 0)
	Market Conditions	Country-specific GDP growth rates (e.g., Indonesia: 5.02%, Thailand: 3.2%); Carbon price volatility indicators

The analytical framework employs fixed-effects panel regression models utilizing two-step dynamic panel system GMM to control for unobserved heterogeneity across companies and time periods while addressing endogeneity concerns. The primary regression specification follows:

$$Corporate\_Value_{it} = \alpha + \beta_1 Carbon\_Economic_{it} + \beta_2 Educational\_Development_{it} + \beta_3 Company\_Size_{it} + \beta_4 Leverage_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Where:
X_it Represents control variables
μi Captures company-specific fixed effects
λt represents time fixed effects
ε_it is the idiosyncratic error term.

Statistical analysis utilizes Stata 17.0 software with robust standard errors clustered at the company level to address potential heteroskedasticity and serial correlation issues. Diagnostic tests include Hausman specification tests, Breusch-Pagan heteroskedasticity tests, and Wooldridge serial correlation assessments, following established protocols for dynamic panel data analysis. Additional robustness checks employ two-stage least squares (2SLS) estimation to address potential endogeneity concerns between carbon economic participation and corporate value creation.

RESULTS AND DISCUSSION

Results

1. Descriptive Statistics and Preliminary Analysis

The descriptive analysis reveals significant variations in carbon economic participation and financial performance across Indonesian and Thai markets. Indonesian companies demonstrate higher average carbon trading volumes (2,847 tons CO2e annually) compared to Thai counterparts (1,962 tons CO2e), reflecting the earlier

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establishment and broader scope of Indonesia's IDXCarbon platform. Corporate financial performance indicators show Indonesian firms achieving superior ROA (2.43% vs 2.18%) and ROE (17.74% vs 15.62%), while Thai companies exhibit higher Tobin's Q ratios (1.08 vs 1.12), indicating stronger market valuations relative to book values.

Table 7. Descriptive Statistics - Financial Performance by Country (2020-2024)

Variable	Indonesia (n=600)	Thailand (n=600)	Combined Sample	Significance
ROA (%)	*2.43 (1.85)*	*2.18 (1.72)*	*2.31 (1.79)*	***
ROE (%)	*17.74 (8.92)*	*15.62 (7.84)*	*16.68 (8.44)*	***
Tobin's Q	*1.12 (0.47)*	*1.08 (0.52)*	*1.10 (0.50)*	**
Market Cap Growth (%)	*14.3 (12.6)*	*16.7 (14.2)*	*15.5 (13.4)*	**
Carbon Participation Rate (%)	*43.5*	*38.7*	*41.1*	***
Educational Dev. Index	*5.4 (2.1)*	*6.2 (2.3)*	*5.8 (2.2)*	***
Company Size (Log Assets)	*15.82 (1.94)*	*15.67 (2.08)*	*15.75 (2.01)*	*ns*
Leverage Ratio	*2.85 (1.23)*	*2.92 (1.41)*	*2.89 (1.32)*	*ns*

Standard deviations in parentheses. ***, *, * indicate significance at 1%, 5%, and 10% levels respectively. ns = not significant

The comparative analysis highlights notable distinctions in corporate financial performance and carbon market involvement between Indonesia and Thailand during the 2020–2024 period. Indonesian firms exhibit stronger profitability indicators, with an average Return on Assets (ROA) of 2.43%, surpassing Thailand's 2.18% (t-test significant at $p<0.01$), reflecting approximately 11.5% greater asset utilization efficiency. Additionally, the Return on Equity (ROE) for Indonesian companies stands at 17.74%, compared to 15.62% in Thailand, indicating a 13.6% higher return for shareholders (Clarkson et al., 2011; Busch & Hoffmann, 2011). These superior outcomes may stem from Indonesia's larger domestic market, abundant natural resources, and increased operational efficiency linked to the mandatory carbon trading system introduced through the IDXCarbon platform in 2023.

Environmental market involvement varies considerably across these two nations. Indonesian corporate participation achieves 43.5%, while Thai engagement registers 38.7%. This 4.8 percentage point differential demonstrates contrasting regulatory approaches: Indonesia implements compulsory carbon trading requirements (NEK), whereas Thailand maintains voluntary participation structures (Nizam et al., 2019; Wang et al., 2024). Indonesia's elevated participation levels correspond with regulatory mandates requiring publicly-listed corporations exceeding designated emission levels to engage in carbon trading, confirming research by Lee & Min (2015) regarding mandatory environmental policy effectiveness within developing markets.

Conversely, Thai corporations demonstrate comparative advantages in market valuation expansion and sustainability capacity development. Market capitalization growth in Thailand reached 16.7%, surpassing Indonesia's 14.3%. This indicates that despite reduced profitability metrics, Thai enterprises enjoy enhanced investor trust and expansion prospects (Shakil et al., 2019; Zhou et al., 2023). Such valuation

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advantages may stem from Thailand's established ESG reporting practices, sophisticated regulatory infrastructure, and stronger conformity with international sustainability benchmarks (Platonova et al., 2018).

The most significant variation appears in educational advancement, where Thai organizations achieve an average score of 6.2, substantially exceeding Indonesia's 5.4—representing a 14.8% differential that demonstrates superior carbon competency and institutional development initiatives. This reflects Thailand's earlier implementation of voluntary environmental reporting beginning in 2006 and strategic incorporation of international frameworks including the Global Reporting Initiative (GRI) and Task Force on Climate-related Financial Disclosures (TCFD) (Saka & Oshika, 2014; Velte, 2017). Thai enterprises have additionally gained from comprehensive corporate sustainability education programs, professional credentialing systems, and collaborative knowledge-sharing networks facilitated by organizations such as the Thailand Business Council for Sustainable Development (Sullivan, 2009; Albertini, 2013).

Ultimately, the lack of substantial variations in organizational scale and debt ratios indicates that both markets demonstrate comparable structural features. This validates cross-regional comparison legitimacy and suggests that performance differences primarily result from institutional influences, market development stages, and educational infrastructure rather than company-specific characteristics (Esteban-Sanchez et al., 2017; Zhang et al., 2020). These results provide valuable perspectives on how contrasting carbon market frameworks and institutional environments influence corporate performance across Southeast Asia's developing economies.

Educational development indices demonstrate interesting cross-country patterns, with Thai companies scoring higher (6.2) than Indonesian firms (5.4), suggesting more advanced carbon literacy programs and sustainability training initiatives. This finding aligns with Thailand's longer experience in voluntary environmental reporting and earlier adoption of international sustainability standards.

Table 8. Carbon Economic Participation and Financial Performance Correlation Matrix

Variables	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. ROA	*1.000*							
2. ROE	*0.743****	*1.000*						
3. Tobin's Q	*0.462****	*0.398****	*1.000*					
4. Carbon	*0.284****	*0.251****	*0.189****	*1.000*				
5. Participation								
6. Educational Dev. Index	*0.197****	*0.156****	*0.223****	*0.341****	*1.000*			
7. Company Size	*0.089***	*0.065**	*-0.123****	*0.234****	*0.198****	*1.000*		
8. Leverage Ratio	*-0.312****	*-0.087***	*-0.298****	*-0.145****	*-0.089***	*0.234****	*1.000*	
9. Market Cap Growth	*0.456****	*0.387****	*0.612****	*0.267****	*0.178****	*-0.045*	*-0.234****	*1.000*

******, *, * indicate significance at 1%, 5%, and 10% levels respectively***

The correlation matrix reveals several important relationships among key variables that provide preliminary insights into the carbon economics-corporate performance nexus. **Strong positive correlations** exist between traditional financial performance measures, with ROA and ROE demonstrating a robust correlation coefficient of 0.743 ($p<0.01$), indicating that companies efficiently utilizing assets tend to also generate superior returns for shareholders. Similarly, the correlation between ROA and market

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capitalization growth (0.456, p<0.01) suggests that operational efficiency translates into enhanced market valuations over time.

Carbon market participation exhibits statistically significant positive correlations with all financial performance indicators, supporting our central hypothesis regarding the value-creating potential of carbon economic engagement. The correlation between carbon participation and ROA (0.284, p<0.01) indicates that companies actively engaged in carbon trading demonstrate superior asset utilization efficiency. The relationship with ROE (0.251, p<0.01) suggests that carbon market activities contribute to enhanced shareholder value creation, while the correlation with Tobin's Q (0.189, p<0.01) indicates that markets positively value carbon trading capabilities.

Educational development index demonstrates consistently positive correlations with financial performance measures, with the strongest relationship observed with Tobin's Q (0.223, p<0.01). This finding suggests that markets particularly value companies with strong educational and capability development programs in the carbon domain. The substantial correlation between educational development and carbon participation (0.341, p<0.01) provides preliminary evidence for our proposed mediation mechanism, indicating that companies with higher educational capacity are more likely to engage effectively in carbon markets.

Control variables exhibit expected relationships with performance measures. Company size shows positive correlations with most variables except Tobin's Q (-0.123, p<0.01), suggesting that while larger companies may have advantages in carbon market participation and educational development, markets may discount their growth potential relative to book values. Leverage ratio demonstrates negative correlations with profitability measures, consistent with financial theory regarding debt's impact on returns, while showing no significant correlation with market cap growth, indicating that growth opportunities may offset leverage concerns in market valuations.

2. *Main Regression Results*

The fixed-effects panel regression results provide strong evidence supporting the positive relationship between carbon economic participation and corporate value creation. Model specifications controlling for company size, leverage, industry effects, and time trends demonstrate consistent positive coefficients across all financial performance measures.

Table 9. Carbon Economic Development Impact on Corporate Financial Performance

Variables	ROA (1)	ROE (2)	Tobin's Q (3)	Market Cap Growth (4)
Carbon Economic Participation	0.347***	2.841***	0.089***	3.247***
	(0.082)	(0.756)	(0.024)	(0.892)
Educational Development Index	0.156***	1.234***	0.042***	1.567***
	(0.034)	(0.298)	(0.011)	(0.445)
Company Size (Log)	0.089**	0.623**	-0.021**	0.734**
	(0.041)	(0.287)	(0.009)	(0.324)
Leverage Ratio	-0.234***	-0.847***	-0.067***	-1.234***
	(0.056)	(0.234)	(0.014)	(0.387)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,200	1,200	1,200	1,200
R-squared	0.642	0.578	0.534	0.687
F-statistic	45.67***	38.92***	31.45***	52.34***

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Notes: Robust standard errors clustered at firm level in parentheses. ***, **, * indicate significance at 1%, 5%, and 10% levels respectively.

The results indicate that carbon economic participation increases ROA by 0.347 percentage points, representing approximately 15% improvement over the sample mean. Similarly, ROE improvements of 2.841 percentage points translate to roughly 17% enhancement in returns to shareholders. Educational development index coefficients demonstrate significant mediating effects, with each unit increase in educational capacity associated with 0.156 percentage point improvement in ROA.

3. Dynamic Panel GMM Results

To address potential endogeneity concerns between carbon participation decisions and financial performance outcomes, we employ two-step system GMM estimation. The results confirm the robustness of our main findings while providing insights into dynamic adjustment processes.

Table 10. Dynamic Panel GMM Results - Carbon Economics and Value Creation

Variables	*ROA*	*ROE*	*Tobin's Q*
Lagged Dependent Variable	*0.423***	*0.387***	*0.456***
	(0.067)	*(0.078)*	*(0.089)*
Carbon Economic Participation	*0.298***	*2.456***	*0.076***
	(0.094)	*(0.834)*	*(0.028)*
Educational Development Index	*0.134***	*1.089***	*0.038***
	(0.041)	*(0.356)*	*(0.013)*
Carbon × Educational Interaction	*0.067**	*0.523**	*0.019**
	(0.029)	*(0.245)*	*(0.008)*
Controls	*Yes*	*Yes*	*Yes*
Observations	*960*	*960*	*960*
Number of Instruments	*42*	*42*	*42*
AR(1) test p-value	*0.021*	*0.018*	*0.024*
AR(2) test p-value	*0.234*	*0.298*	*0.267*
Hansen test p-value	*0.156*	*0.189*	*0.234*

Robust standard errors in parentheses. ***, *, * indicate significance at 1%, 5%, and 10% levels respectively

The interaction term between carbon economic participation and educational development reveals synergistic effects, suggesting that companies with higher educational capacity derive greater benefits from carbon market participation. This finding supports our theoretical framework emphasizing the critical role of organizational learning in carbon economic adaptation.

4. Cross-Country Heterogeneity Analysis

Separate regressions by country reveal important differences in how carbon economic development impacts corporate value creation across Indonesian and Thai markets.

Table 11. Country-Specific Analysis - Carbon Economics Impact

Variables	**Indonesia**		**Thailand**	
	ROA	**Tobin's Q**	**ROA**	**Tobin's Q**
Carbon Economic Participation	0.412***	0.104***	0.267***	0.068***
	(0.103)	(0.031)	(0.089)	(0.023)
Educational Development Index	0.189***	0.051***	0.121***	0.032***
	(0.047)	(0.015)	(0.041)	(0.012)

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Variables	Indonesia		Thailand	
	ROA	Tobin's Q	ROA	Tobin's Q
Market Development Stage	0.145**	0.034**	0.198***	0.045***
	(0.067)	(0.017)	(0.054)	(0.014)
Regulatory Framework Quality	0.087*	0.023*	0.134***	0.029***
	(0.051)	(0.013)	(0.043)	(0.011)
Controls	Yes	Yes	Yes	Yes
Observations	600	600	600	600
R-squared	0.678	0.567	0.634	0.523

Robust standard errors in parentheses. ***, *, * *indicate significance at 1%, 5%, and 10% levels respectively

Indonesian companies demonstrate stronger carbon economic participation effects (0.412 vs 0.267 for ROA), potentially reflecting the mandatory nature of Indonesia's NEK trading scheme and larger average transaction volumes. Thai companies show superior regulatory framework quality coefficients, consistent with their more mature environmental policy infrastructure and longer experience with voluntary sustainability initiatives.

Discussion

1. Theoretical Implications and Contributions

Our findings provide substantial evidence supporting the positive relationship between carbon economic development and corporate value creation in Southeast Asian emerging markets. The results extend existing literature by demonstrating that carbon market participation generates measurable financial benefits beyond compliance requirements, with companies achieving average ROA improvements of 15-17% and ROE enhancements of 16-19% over non-participating counterparts. The educational development perspective represents a novel theoretical contribution to carbon economics literature. Our evidence that educational capacity moderates the carbon-value relationship suggests that organizational learning mechanisms serve as critical enablers for translating carbon market participation into sustained competitive advantage. This finding aligns with resource-based view theory while extending its application to environmental strategy contexts in emerging markets. Cross-country heterogeneity results contribute to institutional theory by revealing how different regulatory frameworks, market development stages, and cultural contexts influence carbon economic outcomes. The stronger effects observed in Indonesia's mandatory trading system compared to Thailand's voluntary approach provide insights into policy design implications for emerging market carbon development strategies.

2. Practical Implications for Management

The research findings offer several actionable insights for corporate managers navigating carbon economic transitions in Southeast Asian markets. First, the positive carbon-value relationship suggests that proactive carbon market participation represents a value-creating investment opportunity rather than merely a cost center. Companies should view carbon initiatives as strategic investments with measurable financial returns rather than compliance obligations. Second, the educational development mediation effects highlight the importance of building internal carbon management capabilities through structured training programs, sustainability certifications, and knowledge management systems. Organizations should invest in

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developing carbon literacy across management levels to maximize value creation potential from carbon market participation. Third, the interaction effects between carbon participation and educational capacity suggest that companies should adopt integrated approaches combining market participation with capability development initiatives. Sequential implementation strategies, beginning with educational infrastructure development followed by graduated carbon market engagement, may optimize value creation outcomes.

3. Policy Recommendations and Regional Development

Our findings support several policy recommendations for advancing carbon market development in Southeast Asia. The superior performance observed in Indonesia's mandatory trading system suggests that regulatory frameworks requiring participation may generate greater aggregate benefits than voluntary approaches, though implementation should consider market readiness and institutional capacity constraints. Regional harmonization initiatives, such as the ASEAN Common Carbon Framework established in November 2024, should prioritize educational infrastructure development alongside market mechanism design. The significant role of educational capacity in determining carbon economic outcomes suggests that policy makers should invest in carbon literacy programs, professional certification systems, and institutional knowledge sharing mechanisms. The cross-country performance differences highlight opportunities for best practice sharing and regional cooperation. Indonesia's experience with mandatory trading systems and Thailand's voluntary market development provide complementary insights for other ASEAN countries developing carbon market strategies.

4. Limitations and Future Research Directions

Several limitations should be acknowledged in interpreting our findings. First, the five-year observation period may not capture long-term carbon economic development impacts, particularly given the nascent stage of regional carbon markets. Future research should extend temporal coverage as markets mature and longer time series become available. Second, our educational development index, while comprehensive, relies on observable measures of training programs and certifications that may not fully capture organizational learning processes. Qualitative research exploring learning mechanisms and knowledge transfer processes could complement our quantitative findings. Third, the focus on Indonesian and Thai markets, while providing valuable comparative insights, limits generalizability to other Southeast Asian contexts. Future studies should expand geographic coverage to include Malaysia, Singapore, Vietnam, and other ASEAN countries as their carbon markets develop. The interaction between carbon economics and technological innovation represents another important avenue for future research. As digital technologies, artificial intelligence, and blockchain applications become more prevalent in carbon markets, understanding how technological adoption influences the carbon-value relationship will become increasingly important. Finally, our study focuses on direct financial performance impacts without examining broader stakeholder value creation, including environmental outcomes, social benefits, and long-term sustainability metrics. Future research should adopt more comprehensive value measurement frameworks incorporating multiple stakeholder perspectives and non-financial performance indicators.

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CONCLUSION

Fundamental Findings our investigation provides compelling evidence that carbon market engagement drives substantial corporate performance improvements within Southeast Asian developing economies through enhanced organizational learning mechanisms. The empirical examination of 240 publicly traded enterprises spanning Indonesia and Thailand during 2020-2024 demonstrates that companies actively engaging in carbon credit transactions exhibit markedly superior financial outcomes relative to their non-participating peers. Quantitative analysis reveals participating organizations achieve 15-17% gains in asset utilization efficiency, 16-19% increases in shareholder return metrics, and notable enhancements in firm valuation indicators. These empirical discoveries fundamentally reframe carbon-related investments from regulatory obligations toward strategic value-generating initiatives that deliver quantifiable economic benefits while advancing environmental sustainability goals. The organizational learning dimension proves instrumental in mediating this relationship, with enterprises possessing advanced environmental competency frameworks extracting significantly superior value from carbon trading engagement compared to organizations with underdeveloped learning architectures. **Implications** the theoretical contributions significantly expand existing academic discourse by positioning educational infrastructure as a cornerstone determinant of carbon market success within developing economies. This advancement enriches resource-based theoretical frameworks by illustrating how environmental capabilities function as strategic assets generating enduring competitive positioning. From an executive leadership standpoint, our discoveries deliver practical direction for business leaders navigating carbon market opportunities across Southeast Asian economies, supporting strategic capital allocation toward carbon capabilities and associated learning initiatives. Policy considerations emphasize the significance of integrated carbon market development approaches that prioritize educational infrastructure development alongside trading platform establishment, with mandatory trading systems demonstrating superior effectiveness compared to exclusively voluntary mechanisms. **Limitations** multiple significant constraints affect the applicability of our research outcomes. The temporal boundaries encompassing five years may inadequately capture extended-term impacts of carbon trading involvement on corporate performance. Our educational development measurement framework may incompletely represent the sophistication of organizational learning mechanisms underlying carbon adaptation processes. The geographical concentration on Indonesian and Thai markets constrains broader relevance to alternative Southeast Asian environments and emerging markets internationally. **Future Research** extended longitudinal investigations surpassing our observation window will prove increasingly beneficial as carbon markets develop. The educational development processes warrant enhanced investigation through integrated research methodologies combining statistical analysis with qualitative examination of organizational learning dynamics. Geographical extension to encompass additional ASEAN nations and emerging markets worldwide constitutes another crucial research objective, while the convergence of carbon economics with technological advancement presents exceptionally promising research possibilities.

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*__Tohap Parulian__
Faculty of Economics And Business Universitas Medan Area, Medan, Indonesia
Jalan Setia Budi Nomor 79B / Jalan Sei Serayu Nomor 70A Medan
Email: tohap@staff.uma.ac.id

Muhammad Yamin Siregar
Faculty of Economics And Business Universitas Medan Area, Medan, Indonesia
Jalan Setia Budi Nomor 79B / Jalan Sei Serayu Nomor 70A Medan
Email: Muhammad@uma.ac.id

Azam Abdelhakeem Khalid Ahmed
Department of Accounting & Finance, Faculty of Business Management & Professional Studies, Management & Science University, University Drive, Off Persiaran Olahraga, Seksyen 13, 40100 Shah Alam, Selangor, Darul Ehsan, MALAYSIA
00601111324327
Email: azam_abdelhakeem@msu.edu.my

Annisa Ilmi Faried
Graduate Program, Master of Economics, Universitas Pembangunan Panca Budi, Medan, Indonesia
Jl. Gatot Subroto, km.4,5
Email: annisailmi@dosen.pancabudi.ac.id