
Selective Mediation Pathways: Sustainable Practices and Competitive Advantage in Malaysia's LNG Industry

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Abstract: Sustainable practices are widely assumed to strengthen competitive advantage through the three Triple Bottom Line (TBL) dimensions of economic, environmental, and social performance, which are typically treated as parallel, interchangeable mediators. This study tests that assumption, asking whether the three dimensions mediate uniformly or selectively in a capital-intensive, commodity-export setting. Using partial least squares structural equation modelling (PLS-SEM) on survey data from 252 middle managers in Malaysia's liquefied natural gas (LNG) industry, it tests 15 direct hypotheses and 12 specific indirect (mediation) pathways linking four types of sustainable practices (organisational, technological, supply chain, and business strategy) to competitive advantage. The results, which speak to SDG 9.4 and Malaysia's National Energy Transition Roadmap, show a selective rather than uniform mediation pattern. Environmental performance is the primary mediating channel; social performance mediates only the technological-practices pathway; and economic performance mediates none, with its direct path to competitive advantage non-significant. These associations indicate that, in capital-intensive commodity-export settings, sustainability investments convert into competitive returns mainly through environmental and social channels rather than through economic performance. For practice, LNG operators can concentrate sustainability investment on the channels most likely to yield strategic returns, particularly organisational, technological, and supply chain practices that work through environmental performance. Because the three TBL dimensions are not interchangeable as mediators, disaggregated mediation analysis is warranted in commodity-export contexts.

Keywords: Competitive advantage, LNG industry, Malaysia, mediation, PLS-SEM, sustainable practices, triple bottom line.

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INTRODUCTION

Malaysia's oil and gas industry is estimated to account for around 20 per cent of the national GDP (Ariyon, Sukendi, Putra, Kausarian, & Santika, 2023) and is increasingly being challenged with balancing sustainability with competitiveness in the global energy market (Dadd, Kirou, Velasquez, Kalhori, & Galatro, 2023). Malaysia provides a relevant case study of a major Southeast Asian LNG exporter, with long-term contracts and evolving policy frameworks, to explore the sustainability investment pathway to achieving strategic advantage in a price-taking commodity trade. Malaysia's National Energy Transition Roadmap, SDG 9.4, and buyer-driven carbon penalties are forcing Malaysian LNG companies to pay close attention to sustainable practices that provide tangible competitive returns (Simpa, Solomon, Adenekan, & Obasi, 2024; Stern, 2019). The challenge for operators is identifying what sustainability investments provide a competitive edge and by which performance pathways these returns are achieved. Competitive advantage in the LNG sector, shaped by commodity pricing and long-term contracts, is likely to differ from advantage in differentiated product markets. Market access, legitimacy, and operational resilience are likely more salient than price or market share.

Strategic management theory offers a partial answer through the integration of the Resource-Based View (RBV) and the Triple Bottom Line (TBL) framework. RBV proposes that valuable, rare, inimitable, and non-substitutable resources generate sustained competitive advantage (Barney, 1991; Wernerfelt, 1984). Sustainable practices are conceptualised as strategic resources that can produce such advantages when they yield superior performance outcomes (Mahoney & Pandian, 1992). The TBL framework operationalises performance across three dimensions: economic, environmental, and social outcomes (Elkington, 1998). The conventional integration of RBV and TBL assumes that all three performance dimensions act as mediators between sustainable practices and competitive advantage (Masud, Rashid, Khan, Bae, & Kim, 2019; Mendes, Braga, Correia, & Silva, 2023).

This conventional assumption has received limited empirical scrutiny in capital-intensive industries. Most studies test mediation through a single TBL dimension, typically environmental performance, and assume that economic and social performance behave in similar ways (Afum et al., 2020). Studies that test multiple mediators typically report aggregate mediation effects rather than specific pathways. The result is a knowledge gap regarding which TBL dimensions actually mediate, which do not, and why the patterns might vary across industry contexts.

This study addresses this gap by testing 12 specific mediation pathways from four types of sustainable practices through the three TBL dimensions to competitive advantage in Malaysia's LNG industry. Four practice constructs are examined: organisational practices (OP), technological practices (TP), supply chain practices (SCP), and business strategy practices (BSP). It analyses three aspects of performance: economic performance (EP), environmental performance (EVP), and social performance (SP). The survey data collected from 252 middle managers of the Malaysian LNG ecosystem are analysed with partial least squares structural equation modelling (PLS-SEM).

This study makes three contributions. First, it gives empirical evidence of the non-interchangeability of the three TBL dimensions as mediators. The mediation pattern is selective: competitive advantage is mediated by environmental performance but not by economic performance. Second, the study reveals that the standard assumption of one and the same mediation across the various dimensions of performance does not apply to commodity-export situations, where price-taking behaviour and long-term contractual relationships weaken the degree of mediation of economic performance in competitive differentiation. Third, the study offers practical guidance for LNG operators on which sustainability investments yield competitive returns through which performance pathways. The novelty lies in the context as much as in the method. Most Triple Bottom Line mediation research, including recent work framing the three dimensions as a joint path to sustainability (Gallardo-Vázquez, 2025), draws on manufacturing or developed-country settings in which firms hold pricing discretion and can convert efficiency gains into differentiation. Malaysia's LNG industry inverts those conditions: output is a homogeneous commodity sold on oil-indexed, multi-decade contracts to buyers who

increasingly screen suppliers on carbon intensity. That combination of price-taking economics and buyer-driven environmental criteria is what makes the setting theoretically informative, because it predicts a muted economic channel and an environmental channel that becomes the binding route to competitive advantage. This is a structural prediction that manufacturing-based evidence cannot generate.

The remainder of this paper is organised as follows. The next section reviews the relevant literature and develops the hypotheses. The methodology section describes the research design. The results and discussion section presents the empirical results and provides discussion regarding the selective mediation pattern, theoretical implications and managerial relevance. The conclusion presents a summary of the contribution, limitations and suggestions for further studies.

THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

Sustainable Practices as Strategic Resources

The Resource-Based View represents sustainable practices as strategic resources from which competitive advantages can be obtained if they are valuable, rare, inimitable, and non-substitutable (Barney, 1991). A number of different types of sustainable actions have been distinguished in the literature that represent different investments in sustainability by organisations (Adams, Jeanrenaud, Bessant, Denyer, & Overy, 2016). These cover the operational, technological, logistical, and strategic aspects applicable to capital-intensive industries like LNG (Adekoya, Adefemi, Tula, Nwaobia, & Gidiagba, 2024).

Organisational practices (OP) include internal management systems, sustainability training, cross-functional integration, and risk management. Technological practices (TP) encompass emissions monitoring systems, energy efficiency technologies, digitalisation and process innovations (Ozowe, Ukato, Jambol, & Daramola, 2024). These practices in the supply chain are known as supply chain practices (SCP), green supplier evaluation, sustainable logistics, and circular economy approaches (Khan et al., 2022). Business strategy practices (BSP) involve sustainability-centric strategic planning, stakeholder engagement, and a steadfast dedication to sustainability concepts (Wahyudi, Arisontha, Solihat, & Titiantono, 2025).

For each type of practice, a theory is proposed to suggest that it impacts one or more of the TBL performance dimensions. Empirically, the questions are whether the impact is general or selective, and whether the pattern in commodity sectors with a higher weight on capital differs from the one in manufacturing sectors.

Triple Bottom Line Performance and Competitive Advantage

Triple Bottom Line considers sustainability performance as a multi-dimensional phenomenon that incorporates economic, environmental and social aspects (Elkington, 1998). The three dimensions are theorised to help develop competitive advantage in different ways. Economic performance can be measured by reduction in cost, increase in productivity and increase in revenue (Alhaddi, 2015; Saha, Talapatra, Belal, & Jackson, 2022). Sapukotanage, Warnakulasuriya, and Yapa (2020) and Stefan and Paul (2008) agree that environmental performance is obtained by compliance with regulations, access to the market, and legitimacy of the actors. Social performance is realised through workforce engagement, community relations and reputational capital (Alhaddi, 2015).

The traditional view of combining RBV and TBL is that its three performance dimensions are more or less equivalent in their contribution to competitive advantage. Many studies group the three dimensions together as a single construct of sustainable performance or consider these as alternative mediators and use a similar mediation logic (Masud et al., 2019; Mendes et al., 2023). Whilst in practice the three dimensions may be interdependent, for the purpose of this study they are considered as separable mediation channels, both to be able to determine the separate contributions to competitive advantage and to address a gap in the literature on the role of the separate dimensions.

The assumption of comparability is unlikely to be true in commodity sectors where capital is a major input, such as LNG, where the mechanisms of advantage creation vary across the three dimensions. Long-term supply

contracts are common in LNG markets, and they contain pricing formulas with a view to 15-25 years (Aboieyeh & Katebi, 2016). Buyer commitments are based on volume guarantees rather than price competition (Shi & Variam, 2017). In this context, it is clear that achieving a marginal improvement in economic performance (e.g., through cost savings or productivity) will not be sufficient to generate a competitive advantage since the price is determined by the contract and commodity producers are price takers in spot markets (Casarin, Lazzarini, & Vassolo, 2020; Stern, 2019). In contrast, environmental performance has become a market access requirement (Frezal & Deuss, 2025). Currently, buyers are demanding carbon-neutral certificates for their products and imposing carbon-intensity penalties on high-emission suppliers (Raynor & Gopalakrishnan, 2025; Simpa et al., 2024). Social performance is supported by means of workforce safety, community relations and operational continuity, particularly in capital-intensive operations where any disruption of operations is expensive (Hopkins et al., 2021).

Hypothesis Development

The hypotheses are operationalized in 12 direct practice-to-performance relationships (H1 – H12) and three performance-to-advantage relationships (H13 – H15). Each direct hypothesis has been based on the RBV logic and the TBL logic and empirical evidence from sustainability research.

Regarding practice-to-economic-performance relationships (H1–H4), prior studies indicate that practices such as organisational, technological, supply chain, and business strategy relate to operational efficiency, productivity, and cost performance (Afum et al., 2020; Tasmin, Muazu, Nor Aziati, & Zohadi, 2020). Relationships between sustainable practices and the environment (H5–H8) are more consistent, with several studies showing environmental benefits across sectors (Mukhtar, Shad, & Lai, 2025; Ozowe et al., 2024). Evidence for practice-to-social-performance relationships (H9–H12) is mixed: some social outcomes are less directly connected to investments in a particular practice (Khan et al., 2022; Wahyudi et al., 2025). Business practices aimed at social benefits, stakeholder engagement, ethical governance, and sustained community involvement can produce positive social effects in theory, but direct causal relationships depend on context.

H13 proposes that economic performance positively affects competitive advantage, following RBV logic that financial outcomes generate strategic resources. H14 proposes that environmental performance positively impacts competitive advantage, as results indicate environmental performance can enhance market access and stakeholder legitimacy in energy markets (Stern, 2019; Wahyudi et al., 2025). H15 suggests that social performance has a positive impact on competitive advantage, with evidence that workforce and community outcomes have a positive influence on operations continuity and a social licence to operate (Hopkins et al., 2021).

The full hypothesis set is summarised below.

- H₁: Organisational Practices (OP) positively influence Economic Performance (EP).*
- H₂: Organisational Practices (OP) positively influence Environmental Performance (EVP).*
- H₃: Organisational Practices (OP) positively influence Social Performance (SP).*
- H₄: Technological Practices (TP) positively influence Economic Performance (EP).*
- H₅: Technological Practices (TP) positively influence Environmental Performance (EVP).*
- H₆: Technological Practices (TP) positively influence Social Performance (SP).*
- H₇: Supply Chain Practices (SCP) positively influence Economic Performance (EP).*
- H₈: Supply Chain Practices (SCP) positively influence Environmental Performance (EVP).*
- H₉: Supply Chain Practices (SCP) positively influence Social Performance (SP).*
- H₁₀: Business Strategy Practices (BSP) positively influence Economic Performance (EP).*
- H₁₁: Business Strategy Practices (BSP) positively influence Environmental Performance (EVP).*
- H₁₂: Business Strategy Practices (BSP) positively influence Social Performance (SP).*
- H₁₃: Economic Performance (EP) positively influences Competitive Advantage (CA).*
- H₁₄: Environmental Performance (EVP) positively influences Competitive Advantage (CA).*
- H₁₅: Social Performance (SP) positively influences Competitive Advantage (CA).*

The mediation hypotheses follow from the combination of the direct hypotheses. Twelve specific indirect effects were tested (four practices $\times$ three performance mediators), each examined through bootstrapped 95% confidence intervals on the product of the relevant a-path and b-path.

Conceptual Model

The conceptual model that combines practice constructs with performance dimensions and competitive advantage outcomes is shown in Figure 1. The model organises the constructs in three layers according to the logic of the theory presented above. The four constructs of sustainable practice that capture the firm-level investments in sustainability are included in the leftmost layer and are based on the specification of strategic resources in the Resource-Based View (Maijanen, 2020). The three dimensions of the TBL are included in the middle layer as they represent the potential mediators between practices and competitive advantage. The rightmost layer contains the strategic outcomes of competitive advantage. The arrows from each practice construct to each performance dimension represent the 12 direct hypotheses (H1 to H12), and the arrows from each performance dimension to competitive advantage represent the three performance-to-advantage hypotheses (H13 to H15).

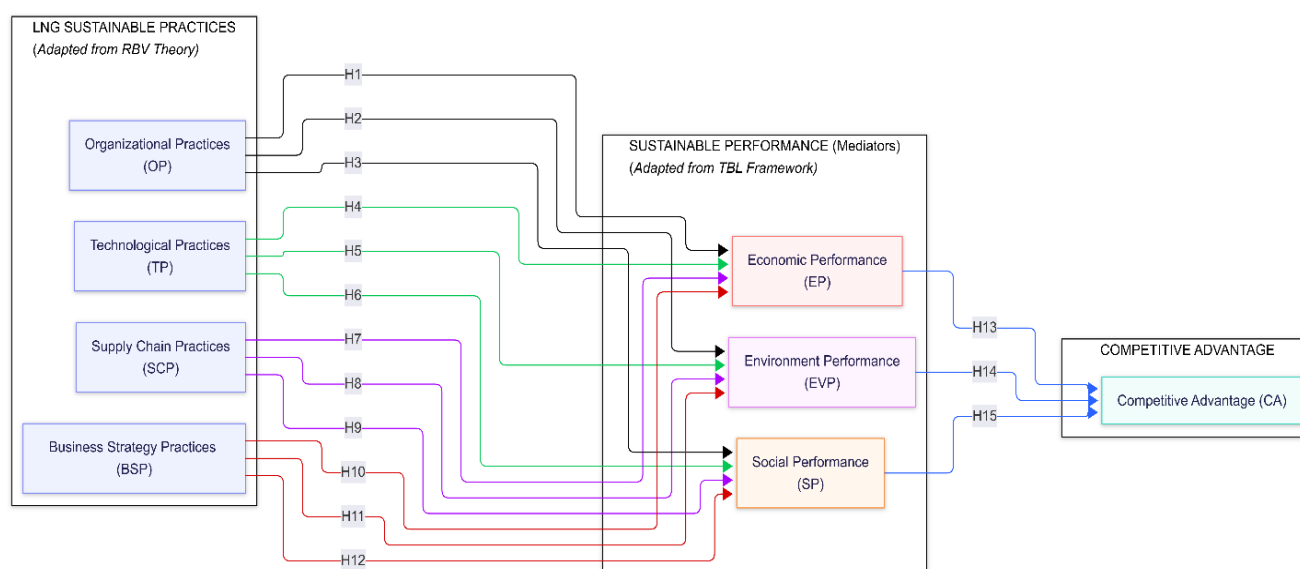


Figure 1: Conceptual model linking sustainable practices to competitive advantage through Triple Bottom Line performance

The model treats the three TBL dimensions as separable mediating channels rather than components of a single aggregate sustainable performance construct. This separation allows the empirical analysis to identify which dimensions actually mediate practice-to-advantage relationships and which do not, addressing the gap in prior research that has typically aggregated the three dimensions or tested mediation through a single dimension (Gallardo-Vázquez, 2025).

The model does not include moderation effects, which are reserved for separate analyses. The mediation analysis derived 12 specific indirect effects from the combination of the practice-to-performance and performance-to-advantage paths, with statistical significance assessed through bootstrapping with 5,000 resamples.

METHODOLOGY

Research Design and Sample

A quantitative cross-sectional survey design was utilised. The middle manager was used as the unit of analysis. Participants were required to be in the Malaysian LNG industry or in the Supply Chain Ecosystem for at least five years and to have firsthand experience in sustainability practices, performance management and/or competitive strategy. No respondents who had less than five years of experience, or who did not have a direct role in sustainability or strategy were included in the study.

The sampling frame was built by listing the different categories of organisations involved in the LNG value chain: upstream gas producers, liquefaction companies, regasification companies, EPC contractors, equipment and technology suppliers, logistics providers, technology providers, financial services providers and regulatory agencies. A purposive sampling method has been used to address the functional and organisational diversity within the frame. Organisations were recruited via professional networks, industry associations and targeted outreach. This can be a problem with selection bias, as managers who are more aware of or more positive about sustainability may have been more likely to respond. To reduce this risk, a wide range of job types and organisation types throughout the value chain were targeted in the recruitment process (see respondent profile). Questionnaires were electronically collected and physically administered during six months of fieldwork. The questionnaire was delivered to qualified managers from LNG operators, as well as their service, engineering and supply-chain partners. Malaysia's oil and gas services and equipment industry consists of approximately 4,000 registered companies, with less than half of them being active (Malaysia Petroleum Resources Corporation, 2025), and the liquefied natural gas (LNG) services segment is a highly concentrated and specialised industry with only a few large operators. 110 registered LNG organisations in Malaysia were first contacted. Of these, 12 organisations (10.9 per cent) agreed to take part in the survey and circulate the survey to their managers. Although the organisational participation rate seems concentrated, these organisations are among the largest employers in the market and resulted in 252 individual managerial responses. The study intentionally targeted middle managers as their roles are the operational conduit between the sustainability strategy from the board level to the plant and asset level and thus, they have direct visibility of the implementation of sustainability practices and its impact on day-to-day competitiveness. The competitive-advantage construct in question, therefore, is the competitive advantage that is perceived at this managerial level and not the financial or market valuations that are evaluated in the boardroom.

The minimum sample size was determined a priori using the inverse square root method (Kock & Hadaya, 2018), which for a structural model with a maximum of seven predictors targeting a minimum significant path coefficient of 0.20 at $\alpha = 0.05$, indicated a minimum sample of 155 respondents. The final sample of 252 valid responses exceeded this threshold by a margin sufficient to provide approximately 0.85 statistical power for detecting the indirect effects of the magnitudes reported in this paper. As a complementary check, an a priori power analysis conducted with G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) for a linear multiple regression with seven predictors (the largest number of antecedents directed at any single endogenous construct), a medium effect size ($f^2 = 0.15$), a significance level of 0.05 and statistical power of 0.80, returned a required minimum of 103 respondents, a threshold the achieved sample of 252 again exceeds comfortably. A total of 252 participants completed the questionnaire, after discarding 35 questionnaires that did not meet the screening criteria (16 due to incomplete answers, 12 due to failure of attention checks and 7 due to experience threshold). Completed-and-retained responses were approximately 88 per cent of questionnaires returned, although there was no closed list sampling frame and effective response rates could not be calculated precisely since the sample was reliant on snowball recruitment. Since the frame was constructed using snowball sampling and purposive sampling methods and not from a closed list, the degree of non-response bias cannot be fully measured. The respondent profile is presented in the results section.

Hypotheses and Endpoint Mapping

The study examines 15 hypotheses that include 12 direct practice-to-performance relationships (H1 to H12) and three performance-to-advantage relationships (H13 to H15). The primary endpoint is the 12 specific indirect

effects operationalized from these direct hypotheses that together summarise the selective mediation pattern that is key in the study. The structural model was estimated using standardised path coefficients, and statistically tested using t-values, p-values and 95% bias-corrected confidence intervals obtained from the bootstrap procedure. There are 15 direct hypotheses (H1–H15), each of which is linked to one estimated path coefficient. Each specific indirect effect corresponds to the product of one a-path and one b-path, and their significance is evaluated using the guidelines for PLS-SEM mediation analysis, that is, by applying bias-corrected bootstrap confidence intervals to the product of the indirect effects.

Measurement Instruments

Reflective scales were used to measure all constructs, which were adapted from existing instruments. Sustainable practice constructs (OP, TP, SCP, BSP) were adapted from the green supply chain management literature (Zhu, Sarkis, & Lai, 2008) and corporate sustainability research (Bansal, 2005). Performance constructs (EP, EVP, SP) were adapted from Triple Bottom Line measurement work (Ahmad, Mazhar, Laedre, Bruland, & Torp, 2022; Masud et al., 2019). Competitive advantage was measured using items that capture differentiation, market position, and strategic outcomes (Huang, Dyerson, Wu, & Harindranath, 2015; Islami, Latkovikj, Drakulevski, & Popovska, 2020; Wang, Lin, & Chu, 2011). The competitive advantage scale included items on the firm's ability to achieve superior market standing, differentiate its offerings, and secure long-term strategic benefits relative to competitors, which distinguishes the construct from operational performance gains. All items were measured on a seven-point Likert scale ranging from strongly disagree to strongly agree.

The OP scale encompasses formal management systems, sustainability training, cross-functional integration, and environmental risk management. The TP scale incorporates emissions monitoring systems, energy efficiency technologies, digitalisation and process innovations. The SCP scale includes green supplier assessment, sustainable logistics solutions and circular economy solutions. The BSP scale covers sustainability-oriented strategic planning, integration of stakeholders, and long-term engagement with sustainability principles. EP scale is a measure of operating efficiency, profitability and cost performance. EVP scale is used to assess the reduction of emissions, resource efficiency, and pollution prevention. The SP scale assesses workforce safety, community relations, and occupational health outcomes. The CA scale pertains to differentiation, market positioning, and strategic outcomes.

The questionnaire underwent an expert review for content validity prior to pilot testing. The pilot test with 30 respondents informed minor word refinements. The main administration was conducted across the Malaysian LNG ecosystem with both online and in-person distributions.

Data Analysis

Data were analysed using partial least squares structural equation modelling (PLS-SEM) in SmartPLS 4, following the two-step procedure recommended by Hair, Hult, Ringle, and Sarstedt (2022). This survey-based, PLS-SEM approach to modelling the perceptions of Malaysian industry and project practitioners follows prior research in the Malaysian project-management context (Lee & Foo, 2022; Lee, Lee, & Thurasamy, 2020). PLS-SEM was selected as the analytical method for three reasons. First, the study is exploratory and prediction-oriented, disaggregating the Triple Bottom Line into three separate mediators and testing their distinct pathways in the comparatively under-researched LNG setting rather than confirming an established theory, and variance-based modelling is the preferred tool for exploratory, prediction-oriented work of this kind (Hair, Risher, Sarstedt, & Ringle, 2019). Second, the structural model is complex, estimating fifteen direct paths and twelve specific indirect effects through three parallel mediators, which PLS-SEM accommodates more efficiently than covariance-based methods (Ramayah, Cheah, Chuah, Ting, & Memon, 2018). Third, PLS-SEM does not require multivariate normality, which self-reported survey data such as those collected here rarely meet (Hair et al., 2019). The measurement model was assessed for indicator reliability through outer loadings (threshold 0.70), internal consistency through Cronbach's alpha and composite reliability (rho_c, threshold 0.70), convergent validity through average variance extracted (AVE, threshold 0.50), and discriminant validity through the heterotrait-monotrait ratio of correlations (HTMT, threshold 0.85) and the Fornell-Larcker criterion

(Fornell & Larcker, 1981; Henseler, Ringle, & Sarstedt, 2015). Common method bias was assessed through a full collinearity test (Kock, 2015); all factor-level variance inflation factors were below the conservative threshold of 3.3, which indicates that common method bias is not a serious concern in these data. The data-security and anonymisation rules imposed by the participating LNG-sector organisations meant that temporal data, such as submission timestamps and batch identifiers, were not retained. A formal early-versus-late wave analysis (Armstrong & Overton, 1977) therefore could not be carried out. The findings should accordingly be read with the caveat that the sample may over-represent managers who are more engaged with sustainability.

The structural model was assessed using path coefficients with bootstrapped t-values, p-values, and 95% confidence intervals, explanatory power (R^2) and effect sizes (f^2). Bootstrap resampling was performed using 5,000 subsamples and the bias-corrected and accelerated (BCa) procedure. All significance tests were two-tailed at $\alpha = 0.05$. P-values reported below 0.001 are denoted as " < 0.001 "; all other p-values are reported to three decimal places.

The mediation analysis followed the recommendations of Hair et al. (2022) for PLS-SEM. Specific indirect effects were computed as the product of the relevant a-path and b-path, with bootstrap-derived t-values, two-tailed p-values, and 95% bias-corrected confidence intervals computed for each of the 12 specific indirect effects. An indirect effect was treated as statistically significant when its 95% bootstrap confidence interval excluded zero, in line with the BCa-bootstrap inference procedure (Preacher & Hayes, 2008). The total indirect effects, aggregated across the three mediators for each practice construct, were computed in the same way and are reported in Table 6.

No covariates or control variables were included in the structural models. This choice prioritized model parsimony and focused on the theoretical relationships among the latent constructs at the industry level rather than on individual firm- or manager-level effects. Demographic variables (age group, education, gender, and organizational tenure) were not entered as controls because the theoretical model concerns relationships among latent constructs at the firm level rather than person-level effects, and because the structural model already produces a large number of estimated paths relative to the sample size. Uncontrolled confounding remains a possibility in this cross-sectional design and is treated as a limitation later in the paper. The 15 direct hypotheses and the 12 specific indirect effects did not follow a formal multiple-testing correction due to their structured nature and because they were not exploratory comparisons a priori. However, the family-wise Type I error rate is inflated by testing 27 coefficients, and the individual p-values must be read in the context of this. As a sensitivity test, the results were compared with a conservative alpha value based on Bonferroni correction (15 direct paths, $\alpha = 0.05/15 = 0.0033$; 12 indirect effects, $\alpha = 0.05/12 = 0.0042$). Under this stringent criterion, the environmental and social a-paths (H2, H5, H6, H8), the supply-chain-to-economic path (H7), and both supported performance-to-advantage paths (H14, H15) remain significant, whereas the two weaker economic-to-performance paths that are significant at $\alpha = 0.05$ (H1 and H10, both $p = 0.015$) do not. None of the four supported specific indirect effects (smallest $p = 0.021$) survives the Bonferroni threshold for the mediation family. Because Bonferroni is conservative when tests are correlated, as they are here, it likely overstates the loss of significance; even so, the mediation findings are best interpreted as a suggestive, selective pattern rather than as confirmatory effects, a caution reinforced by the small magnitudes of the indirect effects reported below.

Data Availability

The complete questionnaire, item wordings, scale anchors, and SmartPLS model file used to generate the results reported in this paper are available from the corresponding author on reasonable request, subject to data-protection conditions agreed with participating organisations. Participants were assured of organisational and individual anonymity, and some organisations have commercial confidentiality agreements that prevent public deposit of the respondent-level dataset. An anonymised summary file with descriptive statistics and the primary structural and mediation model coefficients will be provided to facilitate independent verification of the reported analyses.

RESULTS AND DISCUSSION

Sample Profile

The 252 respondents had a variety of functional/organisational backgrounds. Sixty-two per cent ($n = 157$) of the respondents were males and 37.7 per cent ($n = 95$) females. The largest age group was 35-44 years (75.0 per cent, $n = 189$), indicating a sample of relatively mature professionals with significant industry experience. Education was high, with 93.3 per cent having at least a bachelor's degree (bachelor's 63.5 per cent, master's 27.8 per cent, professional certification 6.7 per cent, and doctoral 2.0 per cent).

The top functional areas were Operations and Production (29.8 per cent), Sustainability and Environmental Management (11.9 per cent), Engineering and Technical Services (9.5 per cent), Maintenance and Asset Management (9.5 per cent) and Quality Assurance and Quality Control (9.5 per cent). The other respondents were spread across Health, Safety and Environment (7.5 per cent), Supply Chain (7.5 per cent), Project Management (7.1 per cent), Business Development (6.3 per cent) and R&D (1.2 per cent).

Organisation type shows the largest share (20.6 per cent) were Equipment and Technology Suppliers, followed by EPC Contractors (17.9 per cent), Logistics and Transportation Providers (13.5 per cent), Service Providers (13.5 per cent) and Technology Providers (13.1 per cent). The medium-sized organisations (50-250 employees) made up 45.2 per cent of the sample, the very large organisations (more than 1000 employees) 27.4 per cent and the large organisations (251-1000) 21.0 per cent. The respondents' experience had demonstrated that 80.6 per cent had 11 or more years in the LNG industry, giving credibility to the responses on the strategic and operational aspects. The respondent profile is summarised in Table 1.

Table 1: Respondent Profile (N = 252)

Characteristic	Category	% of sample
Gender	Male	62.3% ($n = 157$)
	Female	37.7% ($n = 95$)
Age group	35-44 years	75.0% ($n = 189$)
	Other age groups†	25.0% ($n = 63$)
Highest education	Bachelor's degree	63.5%
	Master's degree	27.8%
	Professional certification	6.7%
	Doctoral degree	2.0%
Functional area	Operations & Production	29.8%
	Sustainability & Environmental Management	11.9%
	Engineering & Technical Services	9.5%
	Maintenance & Asset Management	9.5%
	Quality Assurance & Quality Control	9.5%
	Health, Safety & Environment	7.5%
	Supply Chain	7.5%
	Project Management	7.1%
	Business Development	6.3%
	Research & Development	1.2%
Organisation type	Equipment & Technology Suppliers	20.6%
	EPC Contractors	17.9%
	Logistics & Transportation Providers	13.5%
	Service Providers	13.5%
	Technology Providers	13.1%
Organisation size	Other organisation types†	21.4%
	Medium (50-250 employees)	45.2%
	Very large (>1,000 employees)	27.4%
	Large (251-1,000 employees)	21.0%
Industry experience	Small (<50 employees)†	6.4%
	11 years or more	80.6%
	5-10 years†	19.4%

Note: N = 252. Figures were drawn from the respondent characteristics mentioned in the text. Counts (n) are provided when they have been reported in the source. Categories marked with a † are derived as the complement of the categories reported (i.e., age groups other than 35-44; organisation types not one of the 5 largest; smallest size band of organisations; and lower band of experience implied by the 5-year criterion). Percentages may not sum to 100 because of rounding.

Measurement Model Assessment

All constructs satisfied the established reliability and validity criteria. Outer loadings ranged from 0.835 to 0.899 for first-order indicators, exceeding the 0.70 threshold. Internal consistency reliability was strong, with Cronbach's alpha values ranging from 0.886 to 0.922 and composite reliability (ρ_c) ranging from 0.920 to 0.944. Convergent validity was satisfied for all constructs, with AVE values ranging from 0.697 (TP) to 0.809 (OP). Table 2 summarises the results of the measurement model.

Table 2: Measurement Model Assessment

Constructs	Cronbach's α	ρ_c	AVE	Loadings range
Business Strategy Practices (BSP)	0.886	0.921	0.745	0.852–0.874
Competitive Advantage (CA)	0.898	0.929	0.765	0.857–0.890
Economic Performance (EP)	0.899	0.929	0.767	0.866–0.886
Environmental Performance (EVP)	0.895	0.927	0.761	0.857–0.890
Organisational Practices (OP)	0.922	0.944	0.809	0.886–0.911
Supply Chain Practices (SCP)	0.899	0.929	0.767	0.866–0.890
Social Performance (SP)	0.912	0.938	0.790	0.872–0.911
Technological Practices (TP)	0.891	0.920	0.697	0.804–0.866

Note: Sample size $n = 252$. α = Cronbach's alpha; ρ_c = composite reliability; AVE = average variance extracted. All values exceeded the recommended thresholds ($\alpha \geq 0.70$, $\rho_c \geq 0.70$, AVE ≥ 0.50 , loadings ≥ 0.70).

Discriminant validity was assessed using the heterotrait-monotrait (HTMT) ratio and the Fornell-Larcker criterion. All HTMT values were below the 0.85 threshold. The Fornell-Larcker criterion was satisfied, with the square root of each construct's AVE exceeding its inter-construct correlations. Common method bias was assessed through full collinearity, with all inner model VIF values below 1.1, well within the 3.3 threshold.

Direct Effects

The structural model results for the direct effects are summarised in Table 3. Of the 12 practice-to-performance hypotheses (H1–H12), seven were supported. Of the three performance-to-advantage hypotheses (H13–H15), two were supported. The pattern was selective rather than uniform.

Table 3: Direct Effects Results (H1–H15)

Hypothesis	Path	β	t-value	p-value	95% CI	Decision
H1	OP $\rightarrow$ EP	0.130	2.330	0.015	[0.021, 0.239]	Supported
H2	OP $\rightarrow$ EVP	0.191	3.294	0.001	[0.077, 0.305]	Supported
H3	OP $\rightarrow$ SP	0.126	1.847	0.065	[−0.008, 0.260]	Not Supported
H4	TP $\rightarrow$ EP	0.073	1.148	0.251	[−0.052, 0.198]	Not Supported
H5	TP $\rightarrow$ EVP	0.202	3.557	< 0.001	[0.091, 0.313]	Supported
H6	TP $\rightarrow$ SP	0.182	3.113	0.002	[0.067, 0.297]	Supported
H7	SCP $\rightarrow$ EP	0.220	3.747	< 0.001	[0.105, 0.335]	Supported
H8	SCP $\rightarrow$ EVP	0.215	3.693	< 0.001	[0.101, 0.329]	Supported
H9	SCP $\rightarrow$ SP	0.124	1.804	0.071	[−0.011, 0.259]	Not Supported
H10	BSP $\rightarrow$ EP	0.159	2.433	0.015	[0.031, 0.287]	Supported
H11	BSP $\rightarrow$ EVP	0.076	1.202	0.229	[−0.048, 0.200]	Not Supported
H12	BSP $\rightarrow$ SP	0.065	1.007	0.314	[−0.062, 0.192]	Not Supported
H13	EP $\rightarrow$ CA	−0.043	0.653	0.514	[−0.172, 0.086]	Not Supported
H14	EVP $\rightarrow$ CA	0.193	3.125	0.002	[0.072, 0.314]	Supported
H15	SP $\rightarrow$ CA	0.226	3.766	< 0.001	[0.108, 0.344]	Supported

Note: Sample size $n = 252$. β = standardised path coefficient. Bootstrapping with 5,000 resamples and BCa procedure. P-values are two-tailed. 95% CI = 95% bootstrap confidence interval. Construct abbreviations: BSP = business strategy practices; CA = Competitive advantage; EP = Economic performance; EVP = Environmental performance; OP = Organisational practices; SCP = Supply chain practices; SP = Social performance; TP = Technological practices. Hypothesis decisions were based on the conventional $\alpha = 0.05$ threshold.

Environmental performance was the most consistently influenced of the three constructs. Three of the four practice constructs significantly influenced EVP (OP, TP, SCP), with effect sizes (f^2) ranging from 0.041 to 0.051 (small). Economic performance was influenced by three practices (OP, SCP, BSP), with the strongest effect from SCP ($\beta = 0.220$, $f^2 = 0.052$). Social performance was significantly influenced only by TP ($\beta = 0.182$, $f^2 = 0.035$). For performance-to-advantage relationships, EVP ($\beta = 0.193$, $p = 0.002$) and SP ($\beta = 0.226$, $p < 0.001$) significantly influenced competitive advantage, whereas EP ($\beta = -0.043$, $p = 0.514$) did not.

The R^2 values for the endogenous constructs were as follows: SP ($R^2 = 0.081$), EP ($R^2 = 0.116$), CA ($R^2 = 0.131$), and EVP ($R^2 = 0.149$). The relatively low R^2 for Social Performance (0.081) suggests that while included practices contribute to its variance, other factors not captured in this model also play a significant role. The R^2 for CA indicates that the three performance dimensions together explain 13.1 per cent of the variance in competitive advantage. These values are reported in Table 4. Equivalently, close to 87 per cent of the variance in competitive advantage lies outside the present model and is attributable to determinants the three Triple Bottom Line dimensions do not capture. This is a modest level of explanatory power: Performance across the three Triple Bottom Line dimensions accounts for only a small share of the variance in competitive advantage in this setting. The remaining variance is likely attributable to determinants the model does not capture, such as market structure and buyer concentration, the regulatory and policy environment, the composition and tenor of an operator's long-term contract portfolio, firm scale and asset configuration, and upstream resource endowment. In a price-taking commodity industry, such structural factors plausibly weigh more heavily than sustainability-related performance in shaping competitive position. Read this way, the low coefficient reflects a substantive feature of the market rather than a deficiency of the model. In a capital-intensive, price-taking commodity industry such as LNG, firm-level sustainability actions can be expected to account for only a limited share of competitive advantage, because the dominant determinants are macro-structural rather than firm-controlled: the multi-decade, oil-indexed pricing formulas and contractual lock-ins that fix much of an operator's revenue largely independently of its own sustainability profile. On this reading, the 13.1 per cent is an industry-specific finding rather than a sign of a weak model; it marks the boundary within which sustainability strategy can shift competitive position in this setting. The low value therefore bounds the strength of the inferences drawn here, is consistent with the small effect sizes reported above, and indicates that future models should incorporate market- and firm-structural covariates.

Table 4: Coefficient of Determination (R^2) for the Endogenous Constructs

Endogenous construct	R^2	Variance explained
Social Performance (SP)	0.081	8.1%
Economic Performance (EP)	0.116	11.6%
Competitive Advantage (CA)	0.131	13.1%
Environmental Performance (EVP)	0.149	14.9%

Note: R^2 is the proportion of variance in each endogenous construct explained by its antecedents in the structural model; the final column expresses the same quantity as a percentage. All values are modest in magnitude, as discussed in the text. Construct abbreviations are defined in Table 3.

Mediation Analysis

The mediation analysis examined 12 specific indirect effects from each practice construct to competitive advantage through each performance dimension. The results are shown in Table 5.

Table 5: Specific Indirect Effects (Mediation Pathways)

Specific Indirect Path	Indirect Effect	t-value	p-value	95% CI	Decision
OP $\rightarrow$ EVP $\rightarrow$ CA	0.037	2.153	0.031	[0.003, 0.071]	Supported
TP $\rightarrow$ EVP $\rightarrow$ CA	0.039	2.215	0.027	[0.004, 0.074]	Supported
SCP $\rightarrow$ EVP $\rightarrow$ CA	0.042	2.309	0.021	[0.006, 0.078]	Supported
BSP $\rightarrow$ EVP $\rightarrow$ CA	0.015	1.062	0.288	[-0.013, 0.043]	Not Supported

Specific Indirect Path	Indirect Effect	t-value	p-value	95% CI	Decision
OP → SP → CA	0.029	1.549	0.122	[-0.008, 0.066]	Not Supported
TP → SP → CA	0.041	2.226	0.026	[0.005, 0.077]	Supported
SCP → SP → CA	0.028	1.600	0.110	[-0.006, 0.062]	Not Supported
BSP → SP → CA	0.015	0.934	0.350	[-0.016, 0.046]	Not Supported
OP → EP → CA	-0.006	0.586	0.558	[-0.026, 0.014]	Not Supported
TP → EP → CA	-0.003	0.430	0.668	[-0.017, 0.011]	Not Supported
SCP → EP → CA	-0.009	0.619	0.536	[-0.037, 0.019]	Not Supported
BSP → EP → CA	-0.007	0.604	0.546	[-0.030, 0.016]	Not Supported

Note: Sample size $n = 252$. Indirect effect = Product of a-path $\times$ b-path. Bootstrapping with 5,000 resamples and BCa procedure. P-values are two-tailed. 95% CI = 95% bias-corrected bootstrap confidence interval; significance corresponds to confidence intervals excluding zero. Construct abbreviations as shown in Table 3.

Four of the 12 specific indirect effects were statistically significant. Environmental performance mediates the effects of three practice constructs on competitive advantage (OP → EVP → CA, TP → EVP → CA, SCP → EVP → CA). Social performance only mediated the technological practices pathway (TP → SP → CA). Economic performance did not mediate any practice-to-advantage relationship; all four EP-mediated indirect effects were negative and non-significant. The consistent negative direction of these non-significant EP-mediated indirect effects, while not statistically conclusive, is a notable pattern that warrants further conceptual exploration. Although the four supported indirect effects are statistically significant, their magnitudes are small in absolute terms. They range from 0.037 to 0.042 (for example, OP → EVP → CA = 0.037, $p = 0.031$), meaning that a one-standard-deviation increase in a practice construct is associated with roughly 0.04 of a standard-deviation change in competitive advantage through the relevant mediator. The effects of this magnitude are not likely to be of decisive effect alone, and the statistical significance here indicates a detectable, though not strong, relationship between the variables. In practical terms, this effect is about 0.04 of an SD, too small to be interpreted as a clearly decisive source of strategic advantage by itself and on the other hand, the fact that three of the four practice constructs had an effect on the environmental channel suggests that it is a genuine (albeit incremental) mechanism rather than statistical noise. This reading is consistent with the conservative multiple-testing sensitivity check reported in the methodology, under which these indirect effects do not survive a Bonferroni-adjusted threshold. The pattern is therefore best understood as identifying which channels operate, and in which direction, rather than as quantifying the return managers could expect from a given investment.

The total indirect effects aggregated across the three mediators are presented in Table 6. Three of the four practice constructs produced statistically significant total indirect effects on competitive advantage. The largest point estimate among the supported total indirect effects was for the technological practice's pathway (IE = 0.077, $p = 0.004$).

Table 6: Total Indirect Effects on Competitive Advantage

Path	Indirect Effect	t-value	p-value	95% CI	Decision
TP → CA	0.077	2.904	0.004	[0.025, 0.129]	Supported
OP → CA	0.060	2.254	0.024	[0.008, 0.112]	Supported
SCP → CA	0.060	2.081	0.037	[0.003, 0.117]	Supported
BSP → CA	0.022	0.948	0.343	[-0.023, 0.067]	Not Supported

Note: Sample size $n = 252$. The total indirect effect = the sum of the three specific indirect effects through EP, EVP, and SP. Bootstrapping was performed with 5,000 resamples using the BCa procedure. The p-values are two-tailed. 95% CI = 95% bias-corrected bootstrap confidence interval. Construct abbreviations are defined in Table 3.

Environmental performance accounted for three of the four significant specific indirect effects. Social performance produced a significant indirect effect only via the technological practices pathway. None of the four EP-mediated indirect effects reached statistical significance, and all four point estimates were negative.

The Selective Mediation Pattern

The selective mediation pattern described above challenges the conventional assumption that the three Triple Bottom Line dimensions function as interchangeable mediators between sustainable practices and competitive advantage. The empirical pattern indicates the three dimensions are not equivalent in their mediating roles. This finding contrasts with studies that aggregate the TBL dimensions and highlights the need for disaggregated analysis of the pathways from practices to competitive advantage. Environmental performance is the primary channel; social performance mediates selectively, while economic performance does not mediate at all in this sample.

This pattern affects how researchers conceptualize the practice–performance–advantage relationship in capital-intensive commodity industries. Studies that aggregate the three TBL dimensions into a single sustainable performance construct may overlook the selective mediation pattern described here. Research testing mediation through a single dimension may miss the relative importance of alternative pathways. Empirical evidence supports a disaggregated approach in which each TBL dimension is evaluated as a distinct mediator.

Environmental Performance as the Primary Mediating Channel

Environmental performance was the most consistent mediating channel, transmitting the effects of three practice constructs (OP, TP, and SCP) to competitive advantage. Two factors plausibly explain this pattern of results.

The first is buyer expectations. Asian LNG buyers (Japan, South Korea, China, and now India) have begun to differentiate suppliers based on carbon intensity, methane emissions, and environmental performance certificates (Simpa et al., 2024; Stern, 2019). Therefore, environmental performance is a market access requirement rather than a discretionary attribute. Sustainable practices that improve environmental outcomes generate competitive advantages through their effects on buyer access and pricing, whereas practices that improve other dimensions may not produce equivalent strategic effects.

The second is regulatory alignment. The National Energy Transition Roadmap (NETR) of Malaysia provides emissions reduction targets, which, combined with overall commitments to Sustainable Development Goals, can be seen as compliance requirements for LNG operators (Oehler-Şincai, 2024; Rahman & Wahid, 2024). Investments in environmental performance hence fit well with considerations of regulation and also build the long-term legitimacy of the operations. Environmental performance is especially relevant as a mediator in the context of LNG as it is underpinned by the European Commission's Energy Efficiency Action Plan and the European Strategy for the Energy System.

The non-significant BSP → EVP path ($\beta = 0.076$, $p = 0.229$) warrants further discussion. In this sample, business strategy practices such as strategic planning and stakeholder involvement for sustainability did not significantly affect environmental performance. While strategic intent is a significant element, its direct impact on environmental outcomes may be less likely without the complementary operational investments via OP, TP, or SCP. This means that BSP can function as an 'umbrella' policy that guides other practices and not as a practice itself to directly improve environmental performance.

The Selective Role of Social Performance

The technological practices pathway (TP → SP → CA) had an indirect effect of 0.041 ($p = 0.026$), which was mediated by social performance. The other three practice-to-SP-to-CA pathways were not significant. This selective mediation pattern is in line with their direct effect results as shown in Table 3, which revealed TP as the sole practice construct to significantly predict social performance ($\beta = 0.182$, $p = 0.002$).

This pattern indicates that technological investments for social performance improvements are more closely linked to social performance in the LNG context than to the organisational, supply chain, and strategic interventions. Technological developments in capital-intensive industries impact its operation, safety, health and well-being of the surrounding community by better controls, lower emissions and more robust

infrastructure. Technologies used at LNG facilities affect workforce safety, the occupational health of workers and the impact on communities more than organisational training programs or supply chain commitments.

The implication for practice is that LNG operators aiming to improve their social performance and make it a competitive advantage should focus on technology investments. Operators relying on organisational or strategic interventions alone may not achieve the social performance improvements that drive competitive advantages in this context.

The Failure of Economic Performance to Mediate

The most striking finding is the failure of economic performance to mediate any practice-to-advantage relationship. All four EP-mediated indirect effects were negative, although none reached statistical significance. Mediation failure traces to the non-significant EP → CA structural path ($\beta = -0.043$, $p = 0.514$).

This finding contradicts the conventional RBV expectation that economic performance, as the immediate financial outcome of strategic resources, should directly translate into competitive advantage (Newbert, 2008). Two contextual factors explain the deviation from this expectation.

The first is the commodity nature of the LNG markets. LNG is a homogeneous commodity sold through long-term supply agreements with pricing formulas indexed to oil prices or regional gas indices (Aboieyeh & Katebi, 2016; Stern, 2019). Operators are price-takers in spot markets and pricing formula adherents in contract markets. Marginal improvements in economic performance, such as cost reduction or productivity gains, accrue to firm profitability but do not translate into pricing power or market share gains, both of which are conventional indicators of competitive advantage.

The second is the long-term contract structures. LNG supply contracts typically span 15 to 25 years with fixed-price formulas and volume commitments (Aboieyeh & Katebi, 2016). Even substantial economic performance improvements over the contract period do not enable the operator to capture additional value from existing buyers because pricing terms are contractually fixed. Improvements in economic performance, therefore, protect the operator's margin but do not generate competitive differentiation.

These two factors jointly explain the non-significant EP→CA path in this study. The implication for theory is that economic performance did not mediate the practice-to-advantage relationships in this price-taking, contract-bound setting. Within the limits of a cross-sectional design, the data show no evidence of such mediation rather than positive evidence that it cannot occur. The finding extends the TBL literature by identifying a context in which one of the three dimensions does not appear to convert into competitive advantage through the conventional mechanism.

CONCLUSION

This study examined indirect pathways through which four types of sustainable practices influence competitive advantage in Malaysia's LNG industry, using PLS-SEM analysis of data from 252 middle managers. Findings indicate a selective mediation pattern: environmental performance is the primary mediating channel; social performance mediates only the technological practices pathway; and economic performance does not mediate any practice-to-advantage relationship.

The contribution to theory is the empirical demonstration that the three Triple Bottom Line dimensions are not interchangeable as mediators in capital-intensive commodity industries. The contribution to practice is the identification of which sustainability investments can provide competitive returns and the pathways to those returns. Based on the selective mediation pattern reported here, a more disaggregated approach to conducting TBL research in capital-intensive industries is warranted. Combining economic, environmental, and social performance into a single entity, or examining mediation through only one dimension, can obscure strategic insight regarding sustainability investments in commodity exports. Disaggregated analysis reveals which pathway(s) are active, which are not, and why pathway structures differ by industry.

The methodological implication is that future research on sustainability and competitive advantage in capital-intensive industries should use disaggregated mediation analysis rather than aggregate analysis, and should test all plausible mediators instead of focusing on a single dimension based solely on theoretical

arguments. The key takeaway is that identifying which performance aspects matter for strategic decision-making is valuable in these sectors. Operators can then prioritize sustainability investments toward practices and performance dimensions most likely to yield strategic returns given their specific industry conditions.

Theoretical Implications

The selective mediation pattern contributes to the literature on the triple bottom line (TBL) and the resource-based view (RBV) in three ways. First, it provides empirical evidence that the three TBL dimensions do not act as substitutes when mediating sustainable practices and competitive advantage; studies testing a single mediator across performance dimensions may misidentify causal relationships. Second, the pattern shows that the relative importance of TBL dimensions varies by industry characteristics, such as commodity pricing, long-term contract structures, and price-taker status. Third, empirical findings indicate that economic performance is not always the mediating link between practices and advantage, challenging the assumption that economic effects automatically translate into competitive advantage.

The results indicated that the transformation of strategic resources into competitive advantage has to do with the performance dimension through which resources function, for the RBV literature. Sustainable practices can be strategic resources (Guimarães, Severo, & Vasconcelos, 2017), but this competitiveness will rely on how they contribute to enhancing the appropriate performance dimension for the industry context. In LNG, it is the environmental and social dimensions that are the pathways. It is possible that operative pathways are different in other industries.

The results also speak to the general discussion about the competitive level of returns of sustainable investments versus competitive costs (Grewal, Serafeim, & Yoon, 2016; Pástor, Stambaugh, & Taylor, 2021). In the selective mediation pattern, there is some reconciliation between the different perspectives. Here, sustainability investments generate competitive returns, albeit on the basis of certain dimensions of performance and practice types. Studies finding no effect of sustainability on competitive advantage might have combined dimensions in ways that could have hidden patterns of selection. Research with consistent positive results could have been with the best cases, where more than one mechanism was in place. The disaggregated method employed in this paper provides a methodological model for addressing the empirical heterogeneity in the literature.

The results support the Triple Bottom Line theory and shed light on the relationship between the triple dimensions as separable as well as additive components of sustainable performance. The TBL framework was designed to give a holistic perspective of sustainability results, and it is assumed that all three dimensions will be applied together to create good sustainability performance (Kappo-Abidemi & Kanayo, 2020). As reported in the evidence here, the three dimensions can act independently as mediators, and there are significant differences in how they translate practices into competitive advantage. The separable formulation also allows for further theoretical analysis of the ways sustainability converts into strategic results.

Managerial Implications

The findings have direct implications for the sustainability strategies of LNG operators. These are associations, not causal prescriptions. The recommendations below identify which channels co-vary with competitive advantage; they do not establish outcomes from altering an operator's investments. Each implication is tied to a specific empirical pattern that supports it. The implications are presented as plausible managerial inferences from cross-sectional associations rather than as causal directives.

First, the EVP-mediated indirect effects from organisational, technological, and supply chain practices ($IE = 0.037, 0.039, \text{ and } 0.042$, respectively, all $p < 0.05$; see Table 5) are consistent with the proposition that environmental performance is the primary mediating channel between sustainable practices and competitive advantage in this context. Operators may therefore consider prioritising these three practice categories when allocating sustainability investments aimed at competitive returns through environmental performance. The cross-sectional design does not, however, establish that such reallocation would in fact produce the predicted improvements.

Second, the total indirect effect of technological practices on competitive advantage ($IE = 0.077$, $p = 0.004$; see Table 6) is the largest among the four practice constructs and is the only construct that operates through two significant mediating channels: EVP ($IE = 0.039$, $p = 0.027$) and SP ($IE = 0.041$, $p = 0.026$), respectively. This pattern fits the inference that technological practices may carry particular weight in capital-intensive LNG settings, although the magnitude of the total indirect effect remains modest in absolute terms.

Third, the non-significant $EP \rightarrow CA$ path ($\beta = -0.043$, $p = 0.514$; see Table 3) and the four non-significant EP-mediated indirect effects (all point estimates negative; see Table 5) fit the inference that sustainability investments aimed primarily at economic performance gains may not, in this context, translate into competitive differentiation. This inference is supported by the data but is not firmly concluded because it is a cross-sectional design.

These implications are most relevant for ageing LNG facilities like the Bintulu liquefaction plant, where retrofit expenditures need to be prioritized in times of capital shortage. The empirical patterns indicate that investments that focus on environmental outcomes (methane fugitive emissions reduction, flaring elimination and energy efficiency) have a better chance of delivering measurable competitive returns than investments whose sole objective is to improve economic performance. The strength of this inference is bounded by the limitations of the study.

Directions for Future Research and Study Limitations

The selective mediation pattern documented in this study reflects the structural conditions of the LNG industry in Malaysia. Three boundary conditions warrant consideration when generalising the findings. The first is commodity pricing: the non-significant economic-performance mediation is plausibly attributable to the commodity nature of LNG markets, where pricing is contractually fixed in long-term agreements, and operators are price takers in spot markets. Different patterns may be found in industries where pricing is more flexible. The second is asset specificity: the LNG industry in Malaysia involves very specific capital, very long asset lifecycles, and low reconfigurability, while the salience of environmental performance is related to buyer pressures and regulatory requirements, which are particularly strong in capital-intensive sectors. The third is the regulatory environment: LNG operators are operating in an environment that emphasizes environmental performance, as seen in the National Energy Transition Roadmap (Rahman & Wahid, 2024), SDG 9.4 commitments (Beier, Niehoff, & Hoffmann, 2021), and Asian buyer-side carbon performance criteria (Ul Deen & Farooq, 2023).

Beyond these boundary conditions, four classes of limitations warrant explicit acknowledgement. First, the cross-sectional survey design supports tests of associations among latent constructs but cannot establish causal directions. The same data pattern would also be consistent with alternative causal orderings, including reverse causation or common-cause structures. Second, the single-country, single-industry sample restricts the findings' inferential reach. The structural conditions characteristic of Malaysia's LNG sector are not uniformly present in other LNG-producing nations or in other capital-intensive industries, and generalisation requires comparative empirical evidence. Third, all constructs were measured through self-reported responses from middle managers, who may have partial visibility of organisational sustainability outcomes and competitive positioning. Common-source bias was assessed through full-collinearity VIF testing and was not flagged as a concern; however, post-hoc analytical checks cannot fully rule out common-source effects. Fourth, recruitment relied on purposive and snowball sampling rather than a closed sampling frame, which raises the possibility of selection and non-response bias; managers more engaged with sustainability may have been over-represented, and the direction of any resulting bias cannot be established from the data at hand. Comparative sampling from a defined frame would allow this to be assessed directly.

The R^2 for Competitive Advantage is low at 0.131, meaning that the included TBL dimensions account for 13.1 per cent of the total variance. In capital-intensive commodity markets like LNG, firm-level sustainability practices play a secondary role to macro-structural forces, long-term contractual pricing formulas, and broader geopolitical market dynamics, which govern the remaining 86.9 per cent of the variance.

Furthermore, while the primary environmental indirect effect is statistically significant, its magnitude is small ($\beta = 0.037$). In multi-billion-dollar energy markets, even an effect of this small magnitude can have practical significance, because it can govern commercial market access and help operators avoid carbon-intensity penalties. Nonetheless, because these findings rely on cross-sectional data, these are associations, not causal prescriptions.

These limitations imply a sequenced research programme. The first priority is longitudinal replication: a multi-wave panel methodology that examines sustainable practices at time 1, TBL performance dimensions at time 2, and competitive advantage indicators at time 3 would be helpful for stronger causal inferences to be drawn about the mediation pathways. The second priority is comparative, cross-national research across LNG-producing jurisdictions with different contractual and regulatory environments, including Australia, Qatar, the United States, and emerging exporters such as Mozambique, to test whether the selective mediation pattern is obtained in other LNG settings. A multi-group PLS-SEM analysis with country as the grouping variable would allow systematic comparison. The third priority is comparative cross-industry research extending the empirical model to refining, petrochemicals, electricity generation, and primary metals. The fourth priority is methodological triangulation, combining survey data with archival environmental performance data (emissions registries, methane intensity disclosures, sustainability assurance reports) and financial data (operating margins, return on capital employed) to test whether the selective mediation pattern obtained from self-reported measures replicates when objective indicators are used.

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TRANSPARENCY: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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