

Green Industrial Downstreaming, ESG Governance, and Regional Economic Resilience: A Comparative Analysis of Indonesia's Nickel Industrialization and Thailand's Bio-Circular-Green Economic Model

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Abstract (English)

This article examines how institutional governance structures shape sustainable industrial transformation, regional competitiveness, and socio-economic resilience through a comparative analysis of Indonesia's nickel downstreaming strategy and Thailand's Bio-Circular-Green (BCG) economic model. The study argues that industrial transformation in emerging economies is determined not solely by resource endowment or technological upgrading, but by the interaction between institutional coordination, ESG-oriented governance, innovation ecosystems, industrial policy coherence, and sustainability integration. Drawing upon institutional economics, comparative business systems theory, and sustainability-transition frameworks, the article investigates how state capacity, industrial governance, green investment coordination, and technological adaptation influence economic performance and long-term developmental resilience.

Using comparative institutional-economic analysis supported by data from BPS Statistics Indonesia, Bank Indonesia, OECD, IMF, ASEAN datasets, World Bank reports, ESG governance indicators, and industrial competitiveness statistics, the findings reveal significant institutional divergence between Indonesia and Thailand. Indonesia demonstrates strong industrial expansion through mineral downstreaming, export restructuring, and investment inflows linked to nickel-based electric vehicle ecosystems, yet faces governance fragmentation, environmental pressures, and uneven regional development. Thailand exhibits more integrated sustainability-oriented governance through the BCG framework, enabling stronger green-industrial coordination and

innovation alignment, although industrial dependency on external demand and technological concentration remain structural vulnerabilities.

This article contributes to the literature by integrating industrial downstreaming, ESG governance, and comparative business systems analysis within the Southeast Asian context. The study proposes a conceptual model linking institutional coherence, sustainability governance, industrial adaptability, and economic resilience. The findings indicate that sustainable industrial transformation requires coordinated governance systems capable of integrating industrial upgrading, environmental sustainability, social inclusion, and innovation-driven competitiveness within emerging-market economies.

Keywords: *industrial downstreaming; ESG governance; green economy; nickel industrialization; sustainability; comparative business systems; economic resilience; Indonesia; Thailand; industrial policy*

Abstrak (Indonesia)

Artikel ini mengkaji bagaimana struktur tata kelola kelembagaan membentuk transformasi industri berkelanjutan, daya saing regional, dan ketahanan sosial-ekonomi melalui analisis komparatif strategi hilir nikel Indonesia dan model ekonomi Bio-Circular-Green (BCG) Thailand. Studi ini berpendapat bahwa transformasi industri di negara berkembang tidak hanya ditentukan oleh ketersediaan sumber daya atau peningkatan teknologi, tetapi juga oleh interaksi antara koordinasi kelembagaan, tata kelola berorientasi ESG, ekosistem inovasi, koherensi kebijakan industri, dan integrasi keberlanjutan. Dengan mengacu pada ekonomi kelembagaan, teori sistem bisnis komparatif, dan kerangka kerja transisi keberlanjutan, artikel ini menyelidiki bagaimana kapasitas negara, tata kelola industri, koordinasi investasi hijau, dan adaptasi teknologi memengaruhi kinerja ekonomi dan ketahanan pembangunan jangka panjang.

Menggunakan analisis ekonomi kelembagaan komparatif yang didukung oleh data dari Badan Statistik Indonesia (BPS), Bank Indonesia, OECD, IMF, dataset ASEAN, laporan Bank Dunia, indikator tata kelola ESG, dan statistik daya saing industri, temuan

menunjukkan divergensi kelembagaan yang signifikan antara Indonesia dan Thailand. Indonesia menunjukkan ekspansi industri yang kuat melalui hilirisasi mineral, restrukturisasi ekspor, dan arus masuk investasi yang terkait dengan ekosistem kendaraan listrik berbasis nikel, namun menghadapi fragmentasi tata kelola, tekanan lingkungan, dan pembangunan regional yang tidak merata. Thailand menunjukkan tata kelola berorientasi keberlanjutan yang lebih terintegrasi melalui kerangka kerja BCG, yang memungkinkan koordinasi industri hijau dan penyelarasan inovasi yang lebih kuat, meskipun ketergantungan industri pada permintaan eksternal dan konsentrasi teknologi tetap menjadi kerentanan struktural.

Artikel ini berkontribusi pada literatur dengan mengintegrasikan hilirisasi industri, tata kelola ESG, dan analisis sistem bisnis komparatif dalam konteks Asia Tenggara. Studi ini mengusulkan model konseptual yang menghubungkan koherensi kelembagaan, tata kelola keberlanjutan, adaptabilitas industri, dan ketahanan ekonomi. Temuan menunjukkan bahwa transformasi industri berkelanjutan membutuhkan sistem tata kelola terkoordinasi yang mampu mengintegrasikan peningkatan industri, keberlanjutan lingkungan, inklusi sosial, dan daya saing berbasis inovasi dalam ekonomi pasar berkembang.

Kata Kunci : hilirisasi industri; tata kelola ESG; ekonomi hijau; industrialisasi nikel; keberlanjutan; sistem bisnis komparatif; ketahanan ekonomi; Indonesia; Thailand; kebijakan industri

Introduction

The global economy is undergoing a profound structural transition shaped by climate-related industrial restructuring, green technological innovation, ESG-oriented investment governance, and strategic competition over critical mineral supply chains. Across emerging economies, industrial policy increasingly intersects with sustainability governance, energy transition agendas, and technological modernization. The rapid expansion of electric vehicle (EV) industries, renewable-energy systems, and green-manufacturing ecosystems has intensified global demand for critical minerals such as

nickel, lithium, cobalt, and copper, thereby repositioning resource-rich economies within new geopolitical and industrial-development frameworks.

Simultaneously, sustainability-oriented economic governance has become central to investment legitimacy and industrial competitiveness. ESG standards, carbon-transition mechanisms, and sustainable-finance systems increasingly influence industrial investment allocation, global trade access, and long-term developmental capacity. According to the OECD (2024), emerging economies face mounting pressure to align industrial transformation strategies with environmental sustainability, technological upgrading, and socio-economic inclusion. Consequently, industrial modernization can no longer be understood solely through traditional growth indicators; instead, it must be analyzed through the interaction between institutional governance, sustainability coordination, innovation systems, and regional resilience.

Within Southeast Asia, Indonesia and Thailand represent two significant yet institutionally divergent models of sustainable industrial transformation. Indonesia has pursued aggressive mineral downstreaming policies centered on nickel industrialization and EV battery ecosystems, while Thailand has adopted a broader sustainability-oriented industrial framework through its Bio-Circular-Green (BCG) economic model. Both strategies seek to enhance competitiveness, attract investment, and strengthen long-term economic resilience, yet they differ substantially in governance architecture, policy orientation, sustainability integration, and business-system coordination.

Indonesia's nickel downstreaming strategy emerged as a central pillar of industrial transformation following export restrictions on raw mineral commodities and the expansion of domestic processing industries. The government's downstreaming agenda aims to increase value-added industrial production, reduce dependency on raw commodity exports, and position Indonesia as a strategic global hub within EV battery supply chains. According to BPS Statistics Indonesia (2024), exports of processed nickel products increased significantly between 2020 and 2024, while foreign direct investment inflows into smelter development and EV-related industries accelerated substantially. The World Bank (2024) similarly notes that Indonesia has become one of the world's most strategically significant nickel-processing economies.

However, Indonesia's downstreaming model also generates substantial institutional and sustainability challenges. Environmental governance remains uneven across mining and processing regions, particularly concerning deforestation, carbon-intensive energy use, and ecological degradation associated with smelter expansion. Regional inequality persists between resource-producing areas and industrial-processing centers, while governance fragmentation across ministries, local governments, and industrial regulators complicates policy coordination. Furthermore, concerns regarding labor standards, ESG compliance, and long-term technological upgrading increasingly shape international perceptions of Indonesia's industrial sustainability trajectory.

Thailand presents a contrasting model emphasizing integrated sustainability governance and innovation-driven industrial adaptation. The Thai government's BCG framework seeks to align industrial competitiveness with circular economy principles, bio-economy innovation, and green-growth strategies. According to the IMF (2024), Thailand demonstrates stronger institutional integration between industrial policy, environmental governance, and sustainability-oriented innovation systems relative to several ASEAN economies. The BCG model prioritizes renewable energy, sustainable agriculture, circular production systems, and green industrial innovation as mechanisms for long-term competitiveness.

Nevertheless, Thailand also faces structural vulnerabilities. Export dependency, aging demographics, technological concentration in selected industrial sectors, and exposure to global market volatility remain significant economic constraints. Additionally, the transition toward sustainability-oriented industries requires substantial investment in technological capability development and workforce adaptation.

These developments raise important theoretical and policy questions regarding how institutional governance structures shape sustainable industrial transformation in emerging economies. Existing scholarship has extensively explored industrial policy, resource governance, ESG systems, and green economic transition independently, yet substantial analytical fragmentation remains concerning the interaction between institutional coordination, industrial transformation, sustainability governance, and socio-economic resilience.

While previous studies emphasize the developmental role of industrial policy and state coordination (Rodrik, 2021; Wade, 2018), other scholars argue that sustainability transitions require integrated governance systems capable of aligning environmental regulation, technological innovation, and industrial competitiveness (Mazzucato, 2021; Geels, 2020). Institutional economists similarly argue that economic performance depends fundamentally on governance quality, regulatory coherence, and institutional adaptability (North, 1990).

Within the Indonesian context, studies by Hill and Narjoko (2020) and Tambunan (2022) emphasize the importance of industrial upgrading and resource-based transformation. Other scholars argue that Indonesia's downstreaming strategy strengthens export diversification and strategic industrial positioning (Warburton, 2023). However, existing literature frequently prioritizes export growth and investment expansion without adequately examining sustainability governance, regional inequality, and ESG-related institutional coordination.

Research on Thailand similarly emphasizes sustainability-oriented industrial governance and green innovation systems. OECD (2023) reports that Thailand's BCG strategy represents one of Southeast Asia's most integrated sustainability-transition frameworks. Nevertheless, existing scholarship often underestimates structural vulnerabilities associated with technological dependency, export concentration, and uneven industrial capability distribution.

Current scholarship therefore reveals several important gaps. First, there remains a theoretical gap concerning the integration of institutional economics, ESG governance, and comparative business systems analysis within emerging-market industrial transformation. Second, empirical studies often neglect comparative institutional analysis despite substantial variation across Southeast Asian industrial governance systems. Third, existing research inadequately explains how sustainability governance shapes industrial competitiveness and resilience outcomes. Fourth, limited attention has been devoted to the relationship between industrial downstreaming, regional inequality, and long-term socio-economic sustainability. Fifth, policy-oriented studies frequently prioritize growth acceleration without sufficiently addressing institutional fragmentation and environmental governance asymmetry.

This article addresses these gaps through a comparative analysis of Indonesia's nickel downstreaming strategy and Thailand's BCG economic model. The study argues that sustainable industrial transformation depends not merely on industrial expansion or resource advantage but on governance systems capable of coordinating technological upgrading, sustainability integration, ESG compliance, regional inclusivity, and innovation-driven development.

The novelty of this article lies in three principal contributions. First, it integrates sustainability governance, industrial downstreaming, and comparative business systems analysis into a unified framework explaining green industrial transformation in Southeast Asia. Second, it advances comparative evidence demonstrating how institutional divergence shapes industrial sustainability trajectories. Third, it develops a conceptual model linking institutional coherence, ESG governance, industrial adaptability, and economic resilience.

The analytical framework conceptualizes institutional capacity as the mediating variable connecting industrial transformation with sustainable development outcomes. Institutional coherence influences sustainability governance; sustainability governance shapes industrial adaptability and investment legitimacy; industrial adaptability determines economic resilience and long-term socio-economic sustainability. In this framework, industrial transformation is understood as an institutional-economic process embedded within governance architectures, environmental regulation systems, technological ecosystems, and regional development structures.

Accordingly, this article seeks to analyze how institutional governance structures shape sustainable industrial transformation, economic competitiveness, and socio-economic resilience through a comparative examination of Indonesia's nickel downstreaming strategy and Thailand's BCG economic model.

Method

Bagian ini

This study employs a comparative institutional-economic research design integrating comparative business systems analysis, sustainability-transition frameworks, and political economy approaches to examine how institutional structures shape sustainable industrial

transformation in Southeast Asia. Indonesia and Thailand were selected because both economies pursue strategic industrial transformation under distinct governance architectures while confronting shared pressures associated with green transition, global competitiveness, ESG-oriented investment, and regional economic restructuring. Indonesia represents a resource-based downstreaming economy emphasizing mineral industrialization, export restructuring, and EV supply-chain integration, whereas Thailand represents a sustainability-oriented industrial system centered on circular economy principles, green innovation governance, and coordinated sustainability policy frameworks. The analytical framework synthesizes institutional economics derived from North (1990), comparative business systems perspectives from Hall and Soskice (2001), and sustainability-transition theory advanced by Geels (2020) and Mazzucato (2021). Institutional variables examined include governance coherence, ESG regulatory integration, industrial-policy coordination, regional development capacity, sustainability governance, innovation-system integration, and investment coordination. Economic variables include industrial productivity, export diversification, green investment flows, manufacturing competitiveness, labor adaptation indicators, regional inequality, and environmental governance performance.

The empirical analysis utilizes comparative secondary data derived from BPS Statistics Indonesia, Bank Indonesia, OECD sustainability reports, IMF regional economic datasets, ASEAN industrial statistics, World Bank governance indicators, ESG performance assessments, UNCTAD investment reports, and peer-reviewed academic literature published between 2020 and 2026. Comparative interpretation was conducted through institutional process analysis, industrial-policy comparison, sustainability-governance mapping, and cross-case economic evaluation to identify causal mechanisms linking institutional capacity with industrial resilience and sustainable development outcomes. Analytical validity was strengthened through triangulation between macroeconomic indicators, environmental-governance reports, industrial competitiveness datasets, and sustainability assessments. Ethical considerations were addressed through exclusive reliance on publicly verifiable institutional and statistical evidence, thereby avoiding fabricated interviews or unverifiable claims. The principal limitation concerns evolving sustainability metrics and industrial-transition dynamics across emerging economies; however, analytical consistency was maintained through standardized institutional interpretation and comparative variable alignment.

Findings and Discussion

1. Institutional Governance and Divergent Green Industrial Transformation Models

The comparative analysis reveals significant institutional divergence between Indonesia's downstreaming strategy and Thailand's sustainability-oriented BCG framework. Indonesia's industrial transformation model is centered on resource-based industrial expansion through state-supported mineral processing and EV-related industrial integration. Thailand, by contrast, emphasizes coordinated sustainability governance linking industrial competitiveness with green innovation and circular-economy development.

Indonesia's downstreaming agenda has generated substantial industrial expansion. According to BPS (2024), exports of processed nickel products increased dramatically following restrictions on raw nickel exports. Foreign investment inflows into nickel smelters and EV battery ecosystems also expanded significantly between 2020 and 2024. This transformation strengthened Indonesia's strategic position within global EV supply chains.

However, the findings indicate that Indonesia's governance architecture remains fragmented. Institutional coordination between environmental regulators, mining authorities, industrial ministries, regional governments, and ESG-monitoring systems remains uneven. This fragmentation produces inconsistent sustainability enforcement and regional governance asymmetry. Several industrial regions continue to experience environmental degradation, carbon-intensive energy dependency, and infrastructure-related social tensions.

Thailand demonstrates a more integrated governance structure through the BCG framework. Sustainability governance is institutionally embedded within industrial planning, investment coordination, and technological innovation systems. OECD (2023) reports that Thailand exhibits stronger alignment between environmental governance and industrial modernization compared with many regional economies.

Nevertheless, Thailand's governance system also reveals structural limitations. Sustainability-oriented industrial transformation remains concentrated within selected sectors and urban-industrial corridors. Smaller enterprises and peripheral regions often experience limited integration into advanced sustainability ecosystems.

The comparison suggests that institutional coherence influences not only industrial competitiveness but also the sustainability legitimacy of industrial transformation. Indonesia's model accelerates industrial expansion but weakens governance consistency, whereas Thailand's integrated framework strengthens sustainability coordination while limiting large-scale industrial acceleration.

2. ESG Governance, Investment Coordination, and Industrial Competitiveness

ESG governance increasingly shapes industrial legitimacy, foreign investment attraction, and long-term competitiveness within global markets. Indonesia's downstreaming strategy has

attracted substantial investment from China, South Korea, and other international actors seeking access to critical mineral supply chains. Bank Indonesia (2024) reports that investment inflows into EV-related industries contributed significantly to industrial growth and export diversification.

However, ESG-related concerns increasingly affect Indonesia's industrial reputation. International sustainability assessments continue to highlight environmental risks associated with mining expansion, coal-based energy use in smelter operations, and uneven labor-governance standards. These issues create potential constraints regarding future access to sustainability-sensitive export markets and green-financing systems.

Thailand demonstrates stronger ESG integration within industrial governance frameworks. Green-finance coordination, circular production systems, and sustainability certification mechanisms are more institutionally embedded. This strengthens investment credibility and export legitimacy within environmentally regulated markets.

However, Thailand's sustainability governance also involves higher compliance costs and slower industrial expansion in certain sectors. Consequently, the comparison reveals an important trade-off between rapid industrial acceleration and sustainability-oriented governance integration.

These findings support Geels' (2020) argument that sustainability transitions depend on coordinated socio-technical governance systems rather than isolated technological adaptation. Industrial competitiveness increasingly depends on ESG legitimacy, environmental governance quality, and sustainability-oriented institutional coordination.

Table 1. Analytical Matrix of Comparative Indonesian Economic and Business Development

Variable	Case 1: Indonesia Nickel Downstreaming	Case 2: Thailand BCG Economic Model	Empiri cal Evidence	Analyti cal Interpretation
Governan ce Structure	Resource- based industrial coordination	Sustainabi lity-oriented integrated governance	Indone sian downstreamin g policy versus Thailand's BCG framework	Instituti onal architecture shapes sustainability outcomes

Industrial Orientation	EV battery and mineral processing expansion	Circular economy and green innovation	Rapid Indonesian smelter investment versus Thai sustainability integration	Different industrial pathways influence competitiveness
ESG Governance	Fragmented environmental coordination	Stronger sustainability alignment	ESG concerns in Indonesian mining versus Thai green-certification systems	Governance legitimacy affects global investment perception
Regional Development	Uneven industrial concentration	Cluster-based sustainability integration	Industrial disparity across Indonesian regions	Institutional coordination influences regional inclusivity
Innovation Ecosystem	Processing-oriented technological upgrading	Green innovation and sustainability systems	Indonesian industrial expansion versus Thai circular innovation ecosystems	Innovation structures shape long-term resilience
Economic Resilience	Commodity-linked industrial growth	Diversified sustainability-oriented competitiveness	Strong Indonesian export growth versus broader Thai	Resilient pathways differ institutionally

Sustainability Implications	Sustainability adaptation			
	Environmental and social governance pressures	Green-industrial legitimacy	Carbon-intensive processing versus sustainability integration	Sustainable competitiveness depends on governance balance

The comparative matrix demonstrates that sustainable industrial transformation is institutionally embedded. Indonesia's downstreaming model prioritizes strategic industrial acceleration and export restructuring, whereas Thailand emphasizes integrated sustainability governance and green industrial legitimacy.

Indonesia's model provides stronger short-term industrial expansion and strategic positioning within EV supply chains. However, fragmented ESG governance may weaken long-term sustainability legitimacy. Thailand's integrated framework strengthens sustainability-oriented competitiveness but may reduce rapid industrial acceleration capacity.

The evidence therefore suggests that sustainable competitiveness depends on balancing industrial expansion with governance legitimacy, environmental sustainability, and regional inclusivity.

3. Regional Inequality, Labor Transformation, and Socio-Economic Adaptation

Industrial transformation generates uneven regional and labor-market consequences across both comparative cases. Indonesia's downstreaming strategy has concentrated investment and industrial expansion within resource-producing regions such as Sulawesi and Maluku. While industrial activity increased local infrastructure investment and employment opportunities, regional inequality remains significant.

The findings indicate that industrial-processing zones often generate enclave-style economic growth disconnected from broader regional capability development. Local MSMEs frequently experience limited integration into advanced industrial supply chains. Furthermore, labor-market adaptation remains uneven because technological upgrading increasingly favors technically skilled workers.

This reflects broader institutional limitations regarding vocational training systems, local industrial capability formation, and inclusive regional development coordination. The evidence suggests that industrial transformation without institutional inclusivity may reinforce socio-economic asymmetry.

Thailand's BCG model demonstrates stronger integration between sustainability policy and community-based economic systems, particularly within bio-economy sectors and green-tourism ecosystems. However, industrial concentration in advanced urban corridors remains evident.

The comparison indicates that socio-economic resilience depends not solely on industrial growth but on institutional mechanisms capable of integrating local communities, workforce adaptation, MSME participation, and sustainability-oriented development.

4. Innovation Governance and Long-Term Economic Resilience

Innovation governance constitutes a central determinant of long-term industrial resilience in both comparative cases. Indonesia's industrial innovation ecosystem remains heavily oriented toward processing expansion and infrastructure acceleration. Research commercialization, advanced technological capability formation, and domestic innovation-system integration remain relatively limited.

This creates structural dependency on external technologies, foreign capital, and imported industrial expertise. Consequently, Indonesia risks becoming a processing-centered industrial economy without achieving higher-value technological sovereignty.

Thailand demonstrates stronger integration between universities, industrial innovation systems, and sustainability-oriented technological governance. Green innovation, renewable-energy systems, and circular-economy technologies receive stronger institutional support.

However, Thailand also faces dependency risks associated with export-oriented industrial specialization and technological concentration. Long-term resilience therefore depends on continuous innovation adaptation and institutional flexibility.

The comparison reveals that sustainable industrial transformation requires governance systems capable of integrating innovation coordination, ESG governance, regional inclusivity, and industrial diversification. Economic resilience is therefore institutionally mediated rather than solely determined by industrial output expansion.

Conceptual Model

Institutional Coherence → ESG Governance Integration → Industrial Adaptability → Economic Resilience → Sustainable Development

This article proposes a conceptual model explaining how institutional structures shape sustainable industrial transformation outcomes in emerging economies. Institutional coherence functions as the foundational mechanism influencing ESG governance effectiveness, industrial-policy coordination, environmental regulation, and innovation-system integration.

Strong institutional coherence enhances ESG governance integration by enabling interoperability between industrial ministries, environmental agencies, financial regulators, local governments, and private-sector actors. Effective ESG integration subsequently strengthens industrial adaptability through sustainability-oriented investment attraction, technological upgrading, and green innovation coordination.

Industrial adaptability improves economic resilience by increasing firms' capacity to respond to market volatility, sustainability pressures, technological transition, and environmental governance requirements. Economic resilience ultimately contributes to sustainable development through inclusive industrial growth, environmental sustainability, regional capability development, and long-term socio-economic competitiveness.

The comparative evidence from Indonesia and Thailand indicates that fragmented governance weakens the transition from industrial expansion toward sustainable competitiveness, whereas integrated governance systems strengthen long-term resilience and sustainability legitimacy.

Conclusion

This study examined how institutional governance structures shape sustainable industrial transformation, economic competitiveness, and socio-economic resilience through a comparative analysis of Indonesia's nickel downstreaming strategy and Thailand's BCG economic model. The findings demonstrate that sustainable industrial transformation depends fundamentally on governance coordination rather than solely on industrial expansion or resource endowment.

Indonesia demonstrates substantial advantages in resource-based industrial acceleration, export restructuring, and strategic positioning within global EV supply chains. The downstreaming agenda strengthened industrial investment and manufacturing expansion while enhancing Indonesia's geopolitical-economic significance. However, institutional fragmentation, uneven ESG governance, regional inequality, and environmental pressures constrain long-term sustainability legitimacy and inclusive development outcomes.

Thailand exhibits stronger sustainability-oriented governance integration, green industrial coordination, and ESG legitimacy through the BCG framework. Institutional alignment between environmental governance, industrial innovation, and sustainability

policy strengthened long-term competitiveness and investment credibility. Nevertheless, structural dependency on export-oriented sectors and technological concentration remains a significant vulnerability.

Theoretically, this article contributes to comparative institutional economics and sustainability-transition scholarship by integrating industrial downstreaming, ESG governance, and comparative business systems analysis within a unified framework explaining green industrial transformation in emerging economies. The study advances the argument that industrial competitiveness increasingly depends on institutional capacity to coordinate sustainability governance, technological upgrading, innovation systems, and socio-economic inclusivity.

Empirically, the article contributes comparative Southeast Asian evidence demonstrating how institutional divergence shapes industrial resilience, sustainability legitimacy, and long-term competitiveness. The findings further reveal that industrial transformation without governance integration risks generating environmental pressure, regional inequality, and technological dependency despite short-term growth acceleration.

From a policy perspective, Indonesia requires stronger ESG governance coordination, regional industrial inclusivity mechanisms, renewable-energy integration, and innovation-system development. Sustainable downstreaming should therefore prioritize environmental accountability, local capability formation, labor adaptation, and technological upgrading rather than relying exclusively on processing expansion and foreign investment inflows.

The sustainability implications are equally significant. Emerging economies must ensure that industrial modernization contributes to environmental resilience, inclusive development, and long-term innovation capacity rather than reinforcing ecological vulnerability and institutional fragmentation. Sustainable competitiveness increasingly depends on governance systems capable of balancing industrial growth, ESG legitimacy, technological adaptation, and socio-economic equity.

Several limitations remain within this study. The analysis primarily relies on macro-institutional comparative evidence and secondary datasets rather than micro-level industrial behavioral analysis. Future research should therefore examine firm-level ESG

adaptation, green-finance dynamics, local community resilience, and comparative industrial-transition pathways across additional ASEAN economies.

Ultimately, this article argues that sustainable industrial transformation in emerging economies depends not merely on industrial acceleration but on institutional capacity to integrate sustainability governance, innovation coordination, regional inclusivity, and long-term developmental resilience within the evolving global green economy.

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Finally, all interpretations, conclusions, and any remaining limitations contained in this article are entirely the responsibility of the authors.

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