

Artificial Intelligence, Institutional Governance, and Green Industrial Transformation: A Comparative Analysis of Indonesia's Digital Manufacturing Transition and Malaysia's Smart Industrial Ecosystem

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Abstract (English)

This article examines the relationship between institutional governance, artificial intelligence (AI)-driven industrial transformation, and sustainable economic development through a comparative analysis of Indonesia's digital manufacturing transition and Malaysia's smart industrial ecosystem. The study argues that the economic consequences of AI adoption in emerging economies are shaped not merely by technological capability, but by institutional coordination, industrial governance, regulatory coherence, financial systems, and sustainability-oriented policy frameworks. Drawing upon institutional economics, comparative business systems theory, and innovation governance literature, the article investigates how state capacity, industrial policy coordination, digital infrastructure, and corporate adaptation influence industrial competitiveness and socio-economic resilience.

Using comparative institutional-economic analysis supported by data from BPS Statistics Indonesia, Bank Indonesia, OECD, IMF, World Bank, ASEAN industrial datasets, ESG governance reports, and productivity indicators, the findings reveal substantial divergence between Indonesia and Malaysia in industrial digitalization pathways. Indonesia demonstrates strong digital-market expansion and manufacturing digitization potential, particularly in labor-intensive sectors and MSME-linked production chains, yet continues to face institutional fragmentation, technological capability disparities, and uneven regional industrial readiness. Malaysia exhibits stronger technological governance integration, industrial automation

capability, and sustainability-oriented industrial coordination, although industrial concentration and external technological dependence remain structural vulnerabilities.

This article contributes to the literature by integrating AI governance, industrial transformation, and comparative business systems analysis within the Southeast Asian context. It proposes a conceptual model linking institutional capacity, AI-enabled innovation coordination, industrial adaptability, and sustainable economic resilience. The study further demonstrates that inclusive and sustainable AI-driven industrial transformation requires governance systems capable of balancing technological upgrading, labor adaptation, environmental sustainability, and long-term socio-economic competitiveness.

Keywords: *artificial intelligence; industrial transformation; digital economy; institutional governance; sustainability; manufacturing; comparative business systems; Indonesia; Malaysia; innovation policy*

Abstrak (Indonesia)

Artikel ini mengkaji hubungan antara tata kelola kelembagaan, transformasi industri berbasis kecerdasan buatan (AI), dan pembangunan ekonomi berkelanjutan melalui analisis komparatif transisi manufaktur digital Indonesia dan ekosistem industri cerdas Malaysia. Studi ini berpendapat bahwa konsekuensi ekonomi dari adopsi AI di negara berkembang dibentuk bukan hanya oleh kemampuan teknologi, tetapi juga oleh koordinasi kelembagaan, tata kelola industri, koherensi regulasi, sistem keuangan, dan kerangka kebijakan yang berorientasi pada keberlanjutan. Dengan mengacu pada ekonomi kelembagaan, teori sistem bisnis komparatif, dan literatur tata kelola inovasi, artikel ini menyelidiki bagaimana kapasitas negara, koordinasi kebijakan industri, infrastruktur digital, dan adaptasi perusahaan memengaruhi daya saing industri dan ketahanan sosial-ekonomi.

Menggunakan analisis ekonomi-kelembagaan komparatif yang didukung oleh data dari Badan Statistik Indonesia (BPS), Bank Indonesia, OECD, IMF, Bank Dunia, kumpulan data industri ASEAN, laporan tata kelola ESG, dan indikator produktivitas, temuan menunjukkan perbedaan substansial antara Indonesia dan Malaysia dalam jalur digitalisasi industri. Indonesia menunjukkan potensi ekspansi pasar digital dan

digitalisasi manufaktur yang kuat, khususnya di sektor padat karya dan rantai produksi yang terkait dengan UMKM, namun terus menghadapi fragmentasi kelembagaan, kesenjangan kemampuan teknologi, dan kesiapan industri regional yang tidak merata. Malaysia menunjukkan integrasi tata kelola teknologi yang lebih kuat, kemampuan otomatisasi industri, dan koordinasi industri yang berorientasi pada keberlanjutan, meskipun konsentrasi industri dan ketergantungan teknologi eksternal tetap menjadi kerentanan struktural.

Artikel ini berkontribusi pada literatur dengan mengintegrasikan tata kelola AI, transformasi industri, dan analisis sistem bisnis komparatif dalam konteks Asia Tenggara. Artikel ini mengusulkan model konseptual yang menghubungkan kapasitas kelembagaan, koordinasi inovasi yang didukung AI, adaptabilitas industri, dan ketahanan ekonomi berkelanjutan. Studi ini lebih lanjut menunjukkan bahwa transformasi industri yang inklusif dan berkelanjutan yang didorong oleh AI membutuhkan sistem tata kelola yang mampu menyeimbangkan peningkatan teknologi, adaptasi tenaga kerja, keberlanjutan lingkungan, dan daya saing sosial-ekonomi jangka panjang.

Kata kunci: kecerdasan buatan; transformasi industri; ekonomi digital; tata kelola kelembagaan; keberlanjutan; manufaktur; sistem bisnis komparatif; Indonesia; Malaysia; kebijakan inovasi

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Introduction

The global economy is experiencing a structural transformation driven by artificial intelligence (AI), digital industrialization, platform-based production systems, and sustainability-oriented economic governance. Across both advanced and emerging economies, AI increasingly influences manufacturing systems, labor productivity, financial coordination, supply-chain management, and industrial competitiveness. According to the OECD (2024), AI adoption has become a central determinant of long-term productivity growth, technological competitiveness, and industrial resilience. Simultaneously, the transition toward green industrial development and ESG-oriented

governance frameworks has intensified the importance of sustainable technological modernization within emerging economies.

These developments are particularly significant in Southeast Asia, where industrial transformation intersects with digital-economic expansion, demographic transition, and regional competitiveness pressures. Indonesia and Malaysia represent two strategically important comparative cases within ASEAN because both economies are pursuing AI-driven industrial modernization while operating under different institutional governance systems, industrial structures, and technological capabilities.

Indonesia has emerged as one of Southeast Asia's fastest-growing digital economies, supported by rapid platform expansion, digital-financial integration, and manufacturing modernization initiatives such as Making Indonesia 4.0. The Indonesian government has prioritized AI adoption in manufacturing, logistics, agriculture, healthcare, and smart-city development as part of broader industrial-upgrading strategies (Ministry of Industry Indonesia, 2023). Manufacturing contributes approximately 18–19 percent of Indonesia's GDP and remains a major source of employment and export revenue (BPS, 2024). Furthermore, the expansion of AI-supported automation, cloud computing, predictive analytics, and digital supply-chain systems increasingly influences productivity structures within industrial clusters located in Java, Batam, and several emerging industrial regions.

However, Indonesia's industrial digitalization remains institutionally uneven. Significant disparities persist between advanced industrial corridors and peripheral regions regarding technological infrastructure, workforce capability, innovation ecosystems, and industrial readiness. The World Bank (2024) indicates that Indonesia continues to face structural constraints in research commercialization, advanced digital-skills formation, and institutional interoperability between industrial policy agencies, regional governments, universities, and private-sector actors. While AI adoption has accelerated among large firms and digitally integrated enterprises, many MSMEs and labor-intensive sectors remain technologically vulnerable.

Malaysia presents a contrasting institutional and industrial configuration. The country has pursued a more coordinated smart-industry strategy through Industry4WRD, National Fourth Industrial Revolution Policy, and sustainability-

oriented manufacturing governance frameworks. Malaysia's industrial structure is more technologically integrated than Indonesia's, particularly within electronics manufacturing, semiconductor production, and export-oriented industrial clusters. According to the IMF (2024), Malaysia demonstrates stronger industrial automation rates and higher advanced-manufacturing integration relative to most ASEAN economies.

Nevertheless, Malaysia also faces important structural challenges. The country's technological ecosystem remains highly dependent on multinational corporations and foreign technological infrastructures. Furthermore, industrial concentration in high-tech export sectors creates vulnerability to external demand shocks and global supply-chain disruptions. Labor-market polarization and automation-related employment risks also generate socio-economic concerns.

These developments raise important theoretical and policy questions concerning the relationship between institutional governance, AI adoption, industrial competitiveness, and sustainable development in emerging economies. Existing scholarship has extensively explored digital transformation, Industry 4.0, and innovation systems; however, substantial analytical fragmentation persists regarding the interaction between institutional coordination, AI governance, business systems, and socio-economic sustainability.

While previous studies emphasize the productivity-enhancing potential of AI and automation (Brynjolfsson & McAfee, 2014; Acemoglu & Restrepo, 2019), other scholars argue that technological upgrading produces uneven developmental outcomes depending on institutional structures and labor-market governance (Rodrik, 2021; Mazzucato, 2021). Hall and Soskice (2001) further demonstrate that business systems and institutional complementarities shape national innovation capacities differently across capitalist systems. Yet Southeast Asian industrial transformation research frequently prioritizes technological indicators without adequately integrating institutional governance and comparative business systems analysis.

Several studies on Indonesia emphasize digital transformation and industrial modernization. Hill and Narjoko (2020) argue that Indonesia's manufacturing competitiveness increasingly depends on digital integration and productivity upgrading. Tambunan (2022) highlights the importance of MSME technological inclusion for

inclusive industrial transformation. Other scholars emphasize the role of fintech ecosystems and digital entrepreneurship in supporting economic resilience (Zhang & Chen, 2021). However, current scholarship often remains fragmented across separate discussions of MSMEs, manufacturing, AI, fintech, or industrial policy.

Research on Malaysia similarly emphasizes technological competitiveness and industrial upgrading. Rasiah (2022) argues that Malaysia's smart-manufacturing transition has strengthened export competitiveness and technological capability formation. Other studies highlight the country's relatively advanced institutional coordination within electronics manufacturing and industrial automation sectors (UNIDO, 2023). However, existing literature remains limited in examining the sustainability implications of AI adoption, labor transformation, and institutional dependency.

Current scholarship therefore reveals at least six major gaps. First, there is a theoretical gap concerning the integration of institutional economics, AI governance, and comparative business systems analysis within emerging economies. Second, empirical studies often neglect cross-country institutional comparison despite substantial variation in Southeast Asian industrial governance systems. Third, research on AI transformation frequently prioritizes technological capability while underestimating governance coordination and institutional adaptation. Fourth, the relationship between industrial AI adoption and sustainability-oriented development remains insufficiently theorized. Fifth, existing literature inadequately explains how institutional structures mediate labor adaptation and socio-economic resilience during technological transition. Sixth, policy-oriented studies frequently emphasize industrial modernization without adequately examining governance fragmentation and implementation asymmetry.

This article addresses these gaps through a comparative analysis of Indonesia's digital manufacturing transition and Malaysia's smart industrial ecosystem. The study argues that AI-driven industrial transformation is institutionally embedded and that sustainable industrial competitiveness depends on governance systems capable of coordinating technological innovation, labor adaptation, environmental sustainability, and industrial resilience.

The novelty of this article lies in three principal contributions. First, it integrates institutional economics, AI governance, and comparative business systems analysis into a unified framework explaining industrial transformation in emerging economies. Second, it advances comparative Southeast Asian evidence regarding how institutional divergence shapes AI-driven industrial outcomes. Third, it develops a sustainability-oriented analytical model linking institutional capacity, AI-enabled innovation coordination, industrial adaptability, and socio-economic resilience.

The analytical framework conceptualizes institutional capacity as the foundational mechanism shaping AI governance effectiveness. Institutional coherence influences innovation coordination; innovation coordination shapes industrial adaptability and productivity upgrading; industrial adaptability determines economic resilience and sustainable development outcomes. Within this framework, AI functions not merely as a technological tool but as an institutional-economic process embedded within governance systems, labor structures, industrial policy architectures, and sustainability frameworks.

Accordingly, this article seeks to analyze how institutional governance structures shape AI-driven industrial transformation, business competitiveness, and sustainable socio-economic development through a comparative examination of Indonesia and Malaysia.

Method

This study employs a comparative institutional-economic research design integrating comparative business systems analysis, political economy approaches, and innovation-governance frameworks to examine how institutional structures shape AI-driven industrial transformation in emerging Southeast Asian economies. Indonesia and Malaysia were selected as comparative cases because both countries are pursuing industrial modernization and AI integration within ASEAN while demonstrating substantial variation in governance coordination, industrial capability, digital infrastructure, and sustainability-oriented policy frameworks. Indonesia represents a large decentralized emerging economy characterized by extensive manufacturing potential, expanding digital-market ecosystems, and uneven technological integration across regions and industries. Malaysia represents a more centralized and technologically

integrated industrial economy with stronger advanced-manufacturing capacity and export-oriented smart-industry governance. The analytical framework synthesizes institutional economics derived from North (1990), comparative business systems theory from Hall and Soskice (2001), and mission-oriented innovation governance perspectives advanced by Mazzucato (2021). Institutional variables examined include regulatory coherence, industrial-policy coordination, AI governance capacity, innovation-system integration, sustainability governance, labor-market adaptation, and financial-industrial interoperability. Economic variables include manufacturing productivity, export competitiveness, technological readiness, ESG integration, labor transformation indicators, industrial investment trends, and regional development disparities.

The empirical analysis relies on comparative secondary datasets derived from BPS Statistics Indonesia, Bank Indonesia, Malaysia Digital Economy Corporation reports, IMF industrial indicators, OECD digital-economy datasets, ASEAN industrial statistics, World Bank development indicators, ESG governance reports, UNIDO industrial competitiveness assessments, and peer-reviewed academic literature published between 2020 and 2026. Comparative interpretation was conducted through institutional process analysis, industrial-policy comparison, productivity assessment, and governance-structure mapping to identify causal mechanisms linking institutional capacity with AI-enabled industrial transformation outcomes. Analytical validity was strengthened through triangulation between macroeconomic indicators, industrial competitiveness reports, sustainability assessments, and innovation-governance datasets. Ethical considerations were addressed through the exclusive use of publicly verifiable institutional and statistical sources, thereby avoiding fabricated interviews or unverifiable qualitative claims. The principal limitation concerns the rapidly evolving nature of AI technologies and industrial policy environments, which may produce temporal inconsistencies across datasets; however, comparative analytical consistency was maintained through standardized variable interpretation and institutional-context alignment.

Findings and Discussion

1. Institutional Governance and Divergent AI Industrial Transformation Pathways

The comparison between Indonesia and Malaysia reveals substantial institutional divergence in AI-driven industrial transformation strategies. Indonesia's industrial digitalization trajectory is characterized by decentralized governance coordination involving multiple ministries, regional governments, industrial agencies, and private-sector actors. Malaysia demonstrates a more centralized and technologically integrated governance model emphasizing industrial automation, smart manufacturing, and export-oriented technological upgrading.

Indonesia's industrial policy framework, particularly Making Indonesia 4.0, seeks to integrate AI technologies into manufacturing, logistics, food processing, automotive production, and textile industries. According to the Ministry of Industry Indonesia (2023), industrial automation investment increased significantly between 2021 and 2024, particularly among medium-to-large manufacturing enterprises. Bank Indonesia (2024) similarly reports increasing digital integration within industrial supply-chain financing and logistics management systems.

However, the findings indicate that Indonesia's governance fragmentation constrains industrial interoperability and innovation coordination. Regional industrial ecosystems demonstrate uneven readiness regarding technological infrastructure, digital-skills capacity, and industrial upgrading capability. Provinces such as West Java and Banten possess substantially stronger industrial AI readiness than eastern Indonesian regions. This reflects structural asymmetry within Indonesia's decentralized governance architecture.

Malaysia exhibits stronger institutional coherence regarding industrial AI governance. Government-led coordination through Industry4WRD and national AI frameworks has enabled more integrated industrial modernization, particularly within electronics manufacturing and smart-production systems. OECD (2024) data indicate that Malaysia demonstrates higher industrial robotics adoption rates and stronger advanced-manufacturing integration compared with Indonesia.

Nevertheless, Malaysia's industrial ecosystem also reveals structural dependency risks. Technological capability remains concentrated within multinational production networks, limiting domestic technological sovereignty. Consequently, while Malaysia

demonstrates stronger industrial coordination, Indonesia exhibits greater domestic-market diversification and entrepreneurial industrial potential.

The comparison suggests that institutional governance influences not only the pace but also the direction and sustainability of AI-driven industrial transformation. Indonesia's decentralized ecosystem supports broader industrial participation yet weakens policy coherence, whereas Malaysia's centralized governance strengthens technological integration but may constrain adaptive diversification.

2. AI Adoption, Manufacturing Productivity, and Business Competitiveness

AI adoption increasingly functions as a determinant of manufacturing productivity and industrial competitiveness across both comparative cases. Indonesia has experienced rising adoption of predictive analytics, automated logistics systems, AI-supported inventory management, and machine-learning applications within industrial sectors. Manufacturing firms integrated into export-oriented supply chains demonstrate particularly strong technological adaptation.

However, productivity gains remain unevenly distributed. Large enterprises possess significantly greater technological capability, financing access, and digital infrastructure than MSMEs and labor-intensive firms. BPS (2024) indicates that manufacturing productivity growth remains concentrated within technologically integrated industrial clusters, while smaller enterprises continue to face capability constraints.

This reflects a broader institutional challenge involving technological diffusion. Indonesia's innovation ecosystem remains fragmented between universities, industrial agencies, and private-sector actors. Research commercialization rates remain relatively low compared with technologically advanced ASEAN economies. Consequently, AI adoption frequently occurs through imported technologies rather than domestically generated innovation systems.

Malaysia demonstrates stronger productivity integration within advanced manufacturing sectors. Semiconductor production, electronics assembly, and smart-factory systems increasingly utilize AI-supported industrial automation. IMF (2024) reports higher manufacturing value-added productivity in Malaysia relative to Indonesia, particularly within technology-intensive sectors.

Nevertheless, Malaysia's productivity gains also reveal structural concentration. Technological integration remains heavily dependent on multinational corporations and export-oriented industrial clusters. Domestic SMEs often experience limited participation in advanced technological ecosystems.

These findings support Rodrik's (2021) argument that productive transformation depends on institutional coordination rather than technological adoption alone. AI technologies generate sustainable competitiveness only when embedded within coherent innovation systems, industrial financing mechanisms, workforce-development structures, and governance frameworks.

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

Variable	Case 1: Indonesia Digital Manufacturing Transition	Case 2: Malaysia Smart Industrial Ecosystem	Empiri cal Evidence	Analytic al Interpretation
Governance Structure	Decentralized multi-level industrial governance	Centralized smart-industry coordination	Multiple industrial agencies in Indonesia versus integrated Industry4WRD framework	Institutional coherence shapes technological interoperability
AI Industrial Orientation	Broad manufacturing modernization	High-tech export-oriented automation	Indonesian labor-intensive industrial expansion versus Malaysian	Industrial structures determine AI adoption trajectories

				electronics concentration	
Innovati on Ecosystem	ted innovation coordination	Fragmen ted technological governance	Integra ted technological governance	Lower Indonesian R&D commercializ ation versus stronger Malaysian industrial linkage	Innovati on systems influence productivity transformation
Labor Adaptation	Uneven digital-skills readiness	er technical workforce integration	Strong technical workforce integration	Region al Indonesian skills disparities versus concentrated Malaysian technical training	Human capital mediates industrial resilience
Sustaina bility Governance	Emergin g ESG integration	er industrial coordination	Strong green- industrial coordination	ESG adoption expansion in both economies	Sustaina bility increasingly shapes industrial legitimacy
Financial and Industrial Integration	Expandi ng fintech- industrial linkage	finance coordination	Export- finance coordination	Indone sian industrial fintech growth versus	Financial governance affects

			Malaysian industrial financing systems	technological scaling
Economic Resilience	Strong domestic-market adaptability	Strong export competitiveness	Indonesian internal demand resilience versus Malaysian export dependency	Resilience models differ institutionally

The comparative matrix demonstrates that AI-driven industrial transformation is deeply conditioned by institutional governance systems. Indonesia's industrial ecosystem emphasizes broad-based industrial modernization and market expansion, whereas Malaysia prioritizes advanced-manufacturing integration and technological specialization. Both systems generate distinctive strengths and vulnerabilities.

Indonesia's broader domestic market and entrepreneurial industrial diversity provide stronger internal resilience during external economic volatility. However, fragmented governance weakens systemic industrial upgrading. Malaysia's integrated industrial coordination enhances productivity and export competitiveness but creates vulnerability to external technological dependency and global market fluctuations.

The evidence therefore indicates that sustainable industrial competitiveness depends not only on AI adoption rates but also on governance coordination, innovation-system integration, workforce adaptation, and sustainability-oriented institutional frameworks.

3. Labor Transformation, Human Capital, and Institutional Adaptability

AI-driven industrial transformation significantly influences labor structures, workforce capability requirements, and socio-economic adaptation processes. Indonesia's manufacturing sector remains highly labor-intensive, particularly within

textiles, food processing, footwear, and basic assembly industries. Consequently, AI adoption generates both productivity opportunities and employment-transition risks.

The findings indicate that Indonesia faces substantial workforce adaptation challenges. Digital-skills formation remains uneven across regions and industrial sectors. While large urban industrial corridors increasingly integrate AI-supported production systems, many workers in peripheral manufacturing ecosystems lack access to advanced technical training and digital capability development.

This reflects broader institutional limitations within vocational education coordination, industrial training systems, and workforce-transition governance. The World Bank (2024) identifies persistent mismatches between industrial technological requirements and labor-market capability structures in Indonesia. Consequently, AI adoption risks reinforcing regional inequality and labor-market segmentation unless accompanied by coordinated human-capital policies.

Malaysia demonstrates relatively stronger technical workforce integration through industry-linked vocational training and advanced manufacturing education systems. Industrial automation has been more effectively integrated into workforce-development strategies, particularly within electronics manufacturing clusters.

However, automation-related labor polarization also remains evident in Malaysia. High-skilled technical workers experience rising demand, whereas low-skilled industrial labor faces increasing displacement risks. This suggests that technological upgrading alone does not guarantee inclusive development outcomes.

The comparison reveals that institutional adaptability is central to sustainable labor transformation. Emerging economies must coordinate AI adoption with education reform, vocational training, labor-market protection, and social policy adaptation. Failure to align industrial modernization with human-capital governance may generate productivity growth alongside rising socio-economic inequality.

4. Sustainability, ESG Governance, and Economic Resilience

The evidence indicates that sustainability governance increasingly shapes industrial legitimacy, investment flows, and long-term economic competitiveness in both Indonesia and Malaysia. Global investors and multinational production networks

increasingly prioritize ESG compliance, low-carbon industrial practices, and sustainable supply-chain governance.

Indonesia has expanded ESG-oriented industrial governance, particularly within mining downstreaming, renewable energy investment, and green-manufacturing initiatives. Nevertheless, sustainability governance remains uneven across industrial sectors and regional administrations. Environmental monitoring systems, green-financing coordination, and industrial-carbon governance continue to face institutional fragmentation.

Malaysia demonstrates stronger sustainability integration within export-oriented manufacturing systems. Green-manufacturing standards, energy-efficiency policies, and industrial sustainability certifications are more institutionally embedded, particularly within electronics and technology-intensive sectors.

However, both countries remain vulnerable to global sustainability pressures and technological transition risks. AI-driven industrial systems increase energy consumption and infrastructure dependency, creating additional environmental governance challenges.

The comparison further demonstrates that economic resilience is institutionally mediated. Indonesia's diversified domestic economy provides stronger demand-side resilience, whereas Malaysia's advanced-manufacturing ecosystem provides productivity advantages but greater export dependency. Sustainable resilience therefore depends on governance systems capable of integrating technological innovation, environmental sustainability, labor adaptation, and industrial diversification.

These findings contribute to sustainability-transition literature by demonstrating that AI-driven industrial transformation in emerging economies involves complex institutional trade-offs between productivity growth, labor inclusion, environmental governance, and technological competitiveness. Effective governance requires integrated coordination across industrial policy, education systems, sustainability frameworks, financial governance, and innovation ecosystems.

Conceptual Model

Institutional Capacity → AI Governance Coordination → Industrial Adaptability → Economic Resilience → Sustainable Development

This article proposes a conceptual model explaining how institutional structures shape AI-driven industrial transformation outcomes in emerging economies. Institutional capacity functions as the foundational mechanism determining the effectiveness of AI governance, industrial-policy coordination, technological regulation, workforce adaptation, and sustainability integration.

Strong institutional capacity strengthens AI governance coordination by enabling interoperability between industrial ministries, innovation agencies, universities, financial institutions, and private-sector actors. Effective governance coordination subsequently enhances industrial adaptability through technological upgrading, productivity transformation, supply-chain modernization, and workforce capability development.

Industrial adaptability strengthens economic resilience by improving firms' capacity to respond to technological disruption, external market volatility, automation pressures, and sustainability-oriented global market standards. Finally, economic resilience contributes to sustainable development through inclusive industrial growth, labor-market adaptation, environmental governance integration, and long-term socio-economic competitiveness.

The comparative evidence from Indonesia and Malaysia indicates that institutional fragmentation weakens the transition from technological adoption toward sustainable industrial competitiveness, whereas coherent governance systems strengthen adaptive resilience and long-term developmental capacity.

Conclusion

This study examined how institutional governance structures shape AI-driven industrial transformation, business competitiveness, and sustainable socio-economic development through a comparative analysis of Indonesia's digital manufacturing transition and Malaysia's smart industrial ecosystem. The findings demonstrate that the developmental consequences of artificial intelligence adoption are institutionally mediated rather than technologically deterministic.

Indonesia demonstrates substantial advantages in domestic-market scale, entrepreneurial industrial diversification, and manufacturing expansion potential. The country's digital-industrial transition has accelerated through fintech integration, manufacturing modernization, and AI-supported operational systems. However, institutional fragmentation, uneven regional capability formation, limited innovation-system integration, and workforce adaptation disparities constrain the transition toward sustainable industrial competitiveness.

Malaysia exhibits stronger institutional coordination, advanced-manufacturing integration, and sustainability-oriented industrial governance. Centralized smart-industry frameworks have strengthened technological productivity and export competitiveness. Nevertheless, Malaysia's industrial ecosystem remains vulnerable to external technological dependency, export concentration, and labor polarization associated with automation.

Theoretically, this article contributes to comparative institutional economics and business systems scholarship by integrating AI governance, industrial transformation, and sustainability-oriented development into a unified analytical framework. The study advances the argument that AI-driven industrial modernization depends fundamentally on governance coordination involving innovation systems, workforce institutions, sustainability frameworks, and industrial-policy integration.

Empirically, the article contributes comparative Southeast Asian evidence explaining how institutional divergence produces different industrial transformation trajectories despite similar regional digitalization pressures. The findings further demonstrate that AI adoption does not automatically generate inclusive development unless accompanied by coordinated governance mechanisms supporting labor adaptation, technological capability formation, sustainability integration, and industrial interoperability.

From a policy perspective, Indonesia requires stronger coordination between industrial ministries, regional governments, universities, vocational institutions, and private-sector innovation ecosystems. AI governance should therefore prioritize not only industrial automation but also workforce transformation, sustainability-oriented

industrial standards, domestic technological capability formation, and regional industrial equalization.

The sustainability implications are equally significant. Emerging economies must ensure that AI-driven industrial transformation contributes to inclusive productivity growth, environmental responsibility, and socio-economic resilience rather than reinforcing technological inequality and institutional fragmentation. Long-term industrial competitiveness increasingly depends on governance systems capable of integrating technological innovation with sustainability-oriented institutional adaptation.

Several limitations remain within this study. The analysis relies primarily on macro-institutional comparative evidence and secondary datasets rather than firm-level behavioral analysis. Future research should therefore examine sector-specific AI governance dynamics, labor-market adaptation at the microeconomic level, ESG-industrial integration, and comparative AI policy evolution across additional ASEAN economies.

Ultimately, this article argues that sustainable industrial transformation in emerging economies depends not merely on technological acceleration but on institutional capacity to coordinate innovation, labor adaptation, sustainability governance, and long-term developmental resilience within an increasingly AI-driven global 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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