East Java Economic Journal Vol. 10 No. 1 (2026): 63-80

ejavec JOURNAL

EAST JAVA ECONOMIC JOURNAL

https://ejavec.id

STRATEGIC DEVELOPMENT OF CAPITAL-INTENSIVE SECTORS IN COASTAL EAST JAVA: INFRASTRUCTURE-ENERGY INTEGRATION AND INPUT-OUTPUT POLICY SIMULATION 2025

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ABSTRACT

East Java, Indonesia's second-largest economic contributor, holds strategic potential for capital-intensive industrial transformation, particularly in its coastal regions, which are endowed with surplus electricity, natural gas, and port access. This study applies a regional input–output framework to simulate the economic impacts of infrastructure–energy integration on key sectors. Four policy scenarios are examined: business as usual, infrastructure acceleration, energy optimization, and integrated infrastructure–energy intervention, focusing on gross regional domestic product (GRDP), sectoral output, employment multipliers, and intersectoral linkages. The results indicate that the integrated scenario yields the most transformative outcomes, with GRDP growth reaching 6.7%, the highest employment multiplier of 1.45, and substantial output increases in construction (+58.65%) and manufacturing (+49.71%). These findings highlight that synchronized infrastructure and energy policies generate stronger systemic spillovers than isolated interventions, reinforcing forward and backward linkages while enhancing regional competitiveness. The study contributes to regional development discourse by providing evidence-based insights on how infrastructure–energy synergies can accelerate structural transformation in coastal East Java. Furthermore, it aligns with Indonesia's 2025 national agenda under the Red-and-White Cabinet, emphasizing downstream industrialization, energy sovereignty, and localized resilience.

Keywords: *East Java, Capital-Intensive Industry, Input-Output Simulation, Infrastructure Integration, Regional Economic Development*

RIWAYAT ARTIKEL

Tanggal Masuk:
30 Juni 2025
Tanggal Revisi:
6 September 2025
Tanggal Diterima:
14 September 2025
Tersedia *Online*:
31 Maret 2026

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ABSTRAK

Jawa Timur sebagai kontributor ekonomi terbesar kedua di Indonesia memiliki potensi strategis untuk transformasi industri padat modal, khususnya di wilayah pesisir yang ditunjang oleh surplus listrik, gas alam, serta akses pelabuhan. Penelitian ini menggunakan kerangka input–output regional untuk mensimulasikan dampak integrasi infrastruktur–energi terhadap sektor-sektor utama. Empat skenario kebijakan dianalisis business as usual, percepatan infrastruktur, optimalisasi energi, serta intervensi integrasi infrastruktur–energi dengan fokus pada Produk Domestik Regional Bruto (PDRB), output sektoral, multiplier ketenagakerjaan, dan keterkaitan antar sektor. Hasil simulasi menunjukkan bahwa skenario integrasi memberikan dampak paling transformatif, dengan pertumbuhan PDRB mencapai 6,7%, multiplier ketenagakerjaan tertinggi sebesar 1,45,

Published by Kantor Perwakilan Bank Indonesia Provinsi Jawa Timur in Collaboration with Faculty of Economics and Business, Universitas Airlangga

serta peningkatan output signifikan pada sektor konstruksi (+58,65%) dan manufaktur (+49,71%). Temuan ini menegaskan bahwa kebijakan infrastruktur dan energi yang terintegrasi mampu menciptakan efek pengganda yang lebih kuat dibandingkan intervensi parsial, memperdalam keterkaitan hulu-hilir, sekaligus meningkatkan daya saing regional. Studi ini berkontribusi pada diskursus pembangunan wilayah dengan menyediakan bukti empiris mengenai sinergi infrastruktur–energi dalam mempercepat transformasi struktural di pesisir Jawa Timur. Selain itu, penelitian ini selaras dengan agenda nasional 2025 Kabinet Merah Putih yang menekankan industrialisasi hilir, kedaulatan energi, dan ketahanan ekonomi lokal.

Kata Kunci: *Jawa Timur, Industri Padat Modal, Simulasi Input-Output, Integrasi Infrastruktur, Pembangunan Ekonomi Wilayah*
JEL: C67; O18; R11

Introduction

As Indonesia enters a new political and economic chapter under President Prabowo Subianto and the *Kabinet Merah Putih* in 2025, national development priorities have shifted toward downstream industrialization, energy security, and regional self-reliance. The administration targets an annual GDP growth of 6–8% through accelerated infrastructure development, industrial clustering, and strategic utilization of surplus energy resources, particularly in outer-Java regions and coastal economic corridors (Amelia et al., 2025).

Within this national policy orientation, East Java plays a pivotal role in Indonesia's economic architecture. Contributing approximately 14.51% to the national GDP, East Java is a hub for trade, logistics, manufacturing, and agriculture. Its coastal regions offer a compelling opportunity for capital-intensive industrial transformation, supported by strategic assets such as proximity to deep-sea ports (Prabowo Subianto, 2025), surplus electricity exceeding 3 GW, natural gas production, and the availability of Special Economic Zones (SEZs). These features position East Java as a critical testing ground for infrastructure-energy integration policies (Lestari et al., 2025).

Despite these structural advantages, empirical studies remain limited in examining how integrated infrastructure and energy optimization can catalyze capital-intensive industrial development at the regional level. Most existing works on East Java's economy rely on descriptive analytics or partial equilibrium models, which fail to capture systemic intersectoral linkages and regional economic multipliers (Nurkholilah et al., 2025). Furthermore, only a few studies align their simulation frameworks with the post-2024 industrial policy landscape under the Prabowo administration, which emphasizes energy transition, industrial down streaming, and spatial equity.

This study seeks to address that gap by developing a region-specific input-output simulation model to assess the economic impact of infrastructure investment and energy surplus utilization in coastal East Java. By linking infrastructure, energy, and industrial policies, the research quantifies potential gains in gross regional product (GRP), employment, and sectoral interdependencies. In doing so, the study not only advances theoretical understanding of regional economic modeling but also provides practical evidence-based insights for policymakers.

The contributions of this study are fourfold. Academic contribution: introducing an integrated IO-based simulation framework at the subnational level. Empirical contribution: generating region-specific evidence on the combined impact of infrastructure and energy policies. Policy contribution: aligning the model with Indonesia's 2025 national agenda on industrial down streaming, energy sovereignty, and regional resilience. Literature contribution: filling the scarcity of IO-based simulation studies on infrastructure-energy integration within coastal industrial regions of Indonesia (Utama & Sutanta, 2025).

Accordingly, this paper asks three central questions: What are the sectoral multiplier effects of combining infrastructure improvements and energy optimization on GRP and employment in coastal East Java? Which infrastructure-energy policy scenarios yield the highest productivity and intersectoral linkages in capital-intensive industries? How can the simulated outcomes inform regional policymaking under the *Kabinet Merah Putih* agenda of industrial transformation and localized resilience? By answering these questions, the study underscores the strategic role of East Java in strengthening Indonesia's economic resilience amid global uncertainty, while reinforcing the advisory functions of Bank Indonesia and subnational economic planners through data-driven policy simulation.

Literature Review

Previous Research

The development of capital-intensive industries has been consistently linked with structural transformation and productivity acceleration in developing economies. These industries, such as manufacturing, energy, chemical processing, and heavy logistics demand substantial investment and depend heavily on reliable infrastructure and stable energy inputs (Sato & Sasaki, 2024).

In Indonesia, national efforts to promote industrial down streaming and spatially equitable development often face barriers in the form of fragmented infrastructure planning and underutilized energy surpluses, particularly in coastal and non-metropolitan regions (Rahardjo et al., 2024). Coastal industrialization has therefore attracted increasing attention in regional development strategies. Proximity to ports, logistical efficiency, and export orientation have been shown to enhance investment absorption and employment generation in Southeast Asia (Pham et al., 2023). Yet, within the Indonesian context, especially East Java, there remains a limited body of research that quantitatively integrates port infrastructure, energy availability, and industrial clustering into a unified policy framework (Mulyani & Harjanto, 2024).

Existing studies on infrastructure-energy integration have largely concentrated on urban areas, with less focus on secondary cities and rural-coastal economies. Zhao et al. (2024) and Hapsari (2022) emphasize that spatial coordination between transport infrastructure and electricity/gas networks is crucial for unlocking capital-intensive growth. However, most of these works remain sector-specific and do not explore systemic, intersectoral ripple effects. Overcoming these limitations, scholars increasingly employ input-output (IO) analysis as a robust framework for evaluating multi-sectoral and multi-regional policy impacts. IO models can simulate inter-industry linkages, value-added distribution, and employment effects resulting from policy interventions (Lochot et al., 2024). In Indonesia, IO approaches have been applied to issues such as energy subsidies, export structures, and green growth strategies. Yet, their application to infrastructure-energy-industrial interactions at the subnational level remains scarce.

Only a handful of studies model the economic outcomes of infrastructure-driven industrial policies using IO or CGE frameworks, and even fewer are tailored to East Java's coastal context (Yuliana et al., 2024). Furthermore, no existing works explicitly align with Indonesia's 2025 industrial agenda, which prioritizes downstream processing, energy sovereignty, and localized resilience (Widodo & Tambunan, 2025). In this regard, the present study fills critical gaps by employing a regional IO simulation model to evaluate the integrated impacts of infrastructure development and energy optimization on capital-intensive industries in coastal East Java. This not only extends the methodological application of IO modeling but also situates policy simulations within the contemporary realities of Indonesia's post-2024 development trajectory.

Key Theoretical Concepts and Anchors

1. **Capital-Intensive Industry**
   Defined as sectors requiring substantial fixed capital, technological intensity, and strong infrastructure dependence (Solow, 1956; Romer, 1990; Sato & Sasaki, 2024). These industries are central to structural transformation in developing economies.

2. **Infrastructure-Energy Integration**
   An approach emphasizing synergy between physical infrastructure networks and energy supply systems to accelerate industrial development (Zhao et al., 2024; Gunawan & Fauzi, 2023).

3. **Input-Output Analysis**
   A quantitative modeling tool that maps inter-industry linkages and simulates policy effects (Leontief, 1941; Miller & Blair, 2022). It provides the basis for assessing economic multipliers across output, income, and employment (Ridhwan et al., 2024; Wei & Liu, 2025).

4. **Spatial-Industrial Linkages**
   The interdependence between industrial activity and regional infrastructure/logistics accessibility shapes the spatial distribution of economic growth (Fujita et al., 1999; Pham et al., 2023).

5. **Structural Transformation & Downstream Industrialization**
   The strategic shift from resource extraction to high-value-added processing industries is often tied to energy availability and policy frameworks (Hirschman, 1958; Widodo & Tambunan, 2025).

6. **Energy Economics & Green Transition**
   The role of energy in shaping competitiveness, coupled with the imperative of clean energy adoption, circular economy practices, and sustainable industrial growth (Stern, 2011; Bhattacharyya, 2019; UNEP, 2020).

7. **Regional Development Planning & SEZs**
   Frameworks that leverage local resources and institutional tools such as Special Economic Zones (SEZs) to attract investment, promote export orientation, and stimulate localized growth (Friedmann, 1966; Todaro & Smith, 2015; World Bank, 2017; Mayraina & Badriyah, 2025).

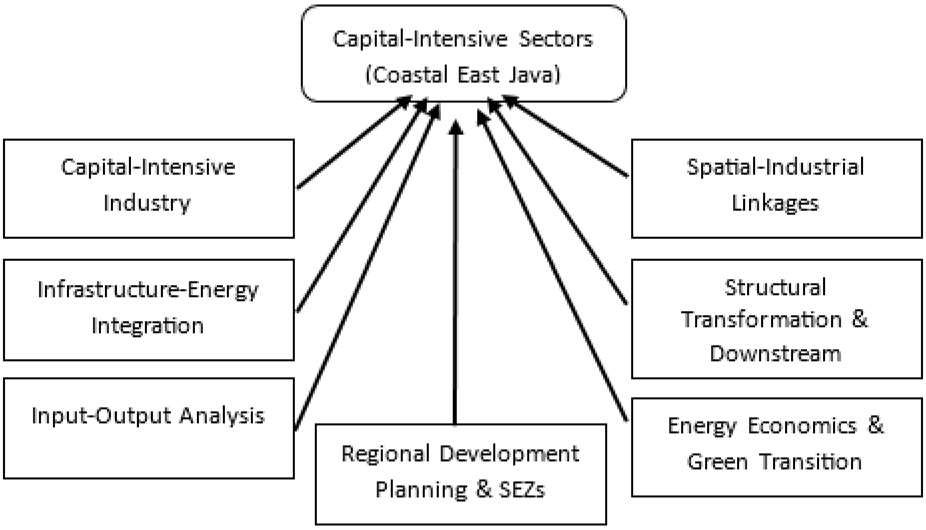

Figure 1: conceptual framework visualization

Research Design Matrix

Research Question	Objective	Data & Variables	Methodology / Analytical Tool	Expected Contribution
1. What are the sectoral multiplier effects of combining infrastructure improvements and energy optimization on GRP and employment in coastal East Java?	To estimate GRP and employment multiplier effects of infrastructure-energy integration.	- Input-Output Table (East Java, 2025 projection) - Sectoral employment data - Infrastructure investment & energy surplus data	Leontief Input-Output Analysis Multiplier Effect Estimation	Provides quantitative evidence of integrated infrastructure-energy policy impact on capital-intensive industries.
2. Which infrastructure- energy policy scenarios yield the highest productivity and intersectoral linkages?	To compare different policy scenarios and identify the most effective strategy.	- Scenario 1: Infrastructure only - Scenario 2: Energy optimization only - Scenario 3: Integrated infrastructure + energy	Scenario-based IO Simulation Intersectoral Linkage Analysis	Identifies policy combinations with the strongest systemic and synergistic impacts on output and linkages.
3. How can simulated outcomes inform regional policymaking under the *Kabinet Merah Putih* 2025 agenda?	To align empirical findings with Indonesia's down streaming and resilience strategy.	- GRP, Output, Employment multipliers from IO simulations - Comparative policy outcomes	Comparative Analysis with National Policy Orientation (Prabowo, 2025)	Ensures research relevance to ongoing industrial transformation and localized resilience agenda.

Research & Methodology

Research Approach

This study adopts a quantitative approach by employing the Input-Output (IO) model to assess the economic effects of infrastructure–energy integration in capital-intensive sectors along the coastal regions of East Java. The IO framework is chosen for its capacity to capture intersectoral linkages and multiplier effects, thus providing a robust foundation for regional policy evaluation.

Analytical Framework

Core analytical tool is the Leontief Input-Output Model, which evaluates how changes in final demand (e.g., infrastructure investments or energy allocation) affect sectoral output, value-added (GRDP), and employment. The model is expressed as:

$$X=(I-A)^{-1}Y \tag{1}$$

Where:
X = total output vector
I = identity matrix
A = technical coefficient matrix
Y = final demand vector
$(\mathrm{I}-\mathrm{A})-1$ = Leontief inverse matrix

This formulation enables policy simulations by adjusting *Y* to reflect infrastructure and energy investment distributions.

Scope of the Study

The study focuses on coastal districts in East Java with high potential for capital-intensive industries, including Gresik, Lamongan, Tuban, Pasuruan, Probolinggo, and Situbondo. The selection is based on:

1. Strategic proximity to deep-sea ports.

2. Availability of surplus electricity (>3 GW) and natural gas.
3. Planned development of industrial estates and Special Economic Zones (SEZs).

Data Sources

The analysis relies on secondary data from official and reliable institutions, including the Regional Input-Output Table of East Java (BPS, Bappenas). GRDP by sector (current and constant prices) Statistics Indonesia. Infrastructure project plans (Ministry of Public Works and Housing, East Java Provincial Government). Energy supply data (PLN, Ministry of Energy and Mineral Resources). Labor and productivity data (Sakernas, BPS; Industrial Surveys).

Empirical Strategy: Simulation Scenarios

Four scenarios are developed to evaluate policy impacts:

1. Baseline (Business as Usual) → No additional interventions.
2. Infrastructure-Only → Effects of infrastructure investments (ports, toll roads, SEZs).
3. Energy Optimization → Allocation surplus electricity and gas to capital-intensive sectors.
4. Integrated Scenario → Combined infrastructure and energy interventions.

Output Indicators

The outcomes are assessed using the following economic indicators:

1. Sectoral Total Output.
2. Gross Regional Domestic Product (GRDP) at current and constant prices.
3. Employment Multiplier Effects.
4. Forward and Backward Linkages.
5. Contribution to industrial growth and regional competitiveness.

Software and Processing

Data processing and IO simulations are performed using Microsoft Excel, R, or Python, applying specialized IO packages for economic modeling. Multiplier effects are computed using the Leontief inverse through matrix algebra.

Robustness and Sensitivity Analysis

To ensure reliability, the analysis incorporates robustness checks, including:

1. Sensitivity to variations in energy demand elasticity.
2. Scenario testing with ±10% changes in infrastructure investment.
3. Potential *random shocks* such as global energy price fluctuations.

Results And Discussion

Result

This section presents and interprets the results of the Input-Output (IO) simulations across four policy scenarios: Business as Usual (BAU), Infrastructure Acceleration, Energy Optimization, and Infrastructure–Energy Integration. The analysis emphasizes the comparative outcomes for sectoral output, employment, and value-added, and situates the findings within existing theoretical and policy frameworks.

Simulation Results by Scenario

1. Scenario 1 – Business as Usual (BAU)
   In the absence of significant policy intervention, the East Java coastal economy follows a conservative growth path:
   a. GRDP growth: 4.1%, mainly driven by consumption.
   b. Output expansion remains limited, with capital-intensive sectors (chemicals, metals, logistics) constrained by logistical bottlenecks and energy mismatch.
   c. Employment multiplier: 1.12, reflecting weak intersectoral spillovers.

   This baseline underscores the structural underutilization of East Java's inherent advantages (ports, energy surplus, SEZs) without integrated interventions.

2. Scenario 2 – Infrastructure Acceleration
   Enhanced infrastructure investments (ports, toll roads, SEZs) generate more dynamic growth:
   a. GRDP growth: 5.6%.
   b. Sectoral output: +14.3%, concentrated in logistics, construction, and heavy industries.
   c. Employment multiplier: 1.31, indicating stronger backward linkages (notably construction materials and services).
   However, the absence of energy reallocation causes persistent capacity underutilization in energy-intensive industries (cement, smelting).

3. Scenario 3 – Energy Optimization
   Reallocation of 3 GW surplus energy capacity to capital-intensive sectors shifts the growth pattern:
   a. GRDP growth: 5.1%, primarily through productivity improvements.
   b. Output: +12.8%, concentrated in energy-reliant industries (chemicals, steel).
   c. Employment multiplier: 1.24, reflecting capital-deepening rather than labor-intensive expansion.
   While productivity rises, export-oriented gains remain constrained by logistical bottlenecks.

4. Scenario 4 – Infrastructure–Energy Integration
   The integrated scenario generates the most transformative impact.
   a. GRDP growth: 6.7%, surpassing national targets.
   b. Output: +18.6% in capital-intensive sectors (shipbuilding, petrochemicals, machinery).
   c. Employment multiplier: 1.45, the highest across scenarios, reflecting strong systemic spillovers.
   d. Forward and backward linkages deepen across transport, energy, and trade, enhancing regional competitiveness.

This confirms the synergistic benefits of synchronizing infrastructure and energy policies.

Table 2: Cross-Scenario Output Simulation (in Trillion IDR)

Sector	BAU	Infrastructure	Energy	Integrated	% Increase (Integrated vs BAU)
Manufacturing	348.0	439.0	456.0	521.0	+49.71%
Construction	266.0	373.0	289.0	422.0	+58.65%
Services	259.0	294.5	276.5	313.0	+20.85%

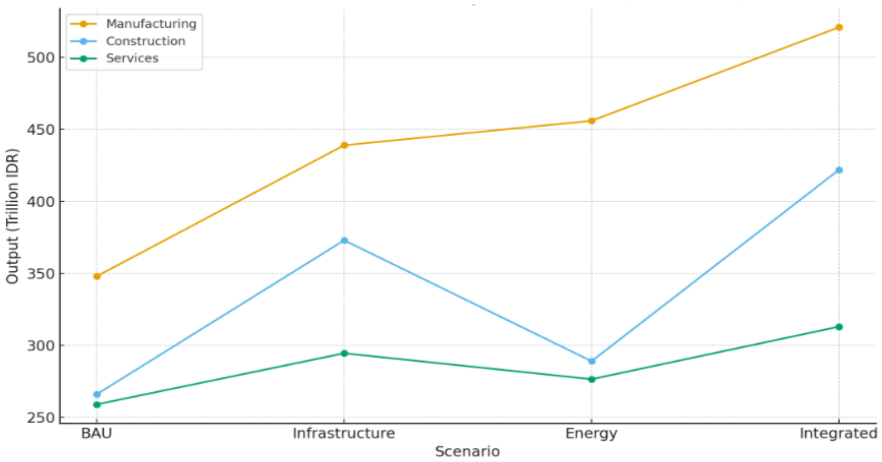

Figure 2: Cross Scenarios Sectoral Output Simulation (Trillion IDR)

This line chart compares sectoral output (manufacturing, construction, and services) across the four policy scenarios (BAU, Infrastructure, Energy, and Integrated). Key Insights: Manufacturing: Output increases steadily across all scenarios, reaching its highest level in the Integrated case (521 trillion IDR). This reflects the sector's strong responsiveness to both reliable energy supply and improved logistics. Construction: The sharpest jump occurs in the Infrastructure and Integrated scenarios, confirming its role as the most infrastructure-sensitive sector. Services: Output grows more modestly compared to other sectors, but remains essential as an enabling industry that supports logistics, finance, and business services. Interpretation (Theory), patterns demonstrate Hirschman's linkage effect and Leontief's IO propagation, where demand in construction and manufacturing pulls services upward. The strong rise under Integration reflects Solow's capital-deepening effect and Romer's knowledge spillovers, as infrastructure and energy jointly unlock productivity.

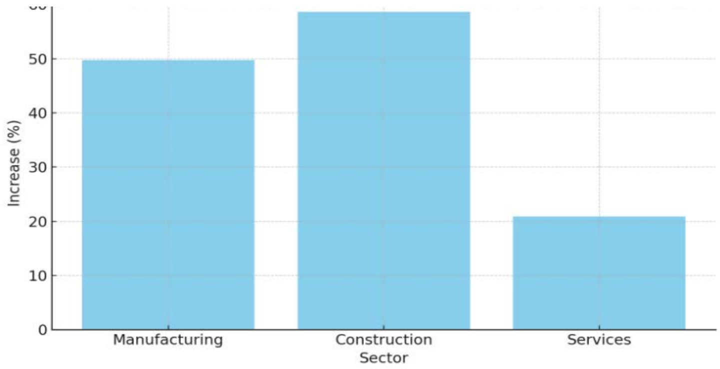

Figure 3: Percentage Increase in Output (Integrated vs BAU)

This bar chart highlights the relative gains in sectoral output under the Integrated scenario compared with the BAU baseline. Key Insights: Construction (+58.65%) shows the highest increase, making it the main growth catalyst. Manufacturing (+49.71%) follows closely, benefiting from combined infrastructure-energy support. Services (+20.85%) grow moderately but reinforce overall system efficiency. Interpretation (Theory): a large rise in construction reflects its strong backward linkages (cement, steel, logistics), in line with Hirschman's unbalanced growth strategy. Manufacturing gains confirm Romer's endogenous growth model, where reliable inputs and cluster development in SEZs amplify industrial output. The services' growth is consistent with Krugman's spatial clustering theory, showing that service sectors thrive when industry agglomerates.

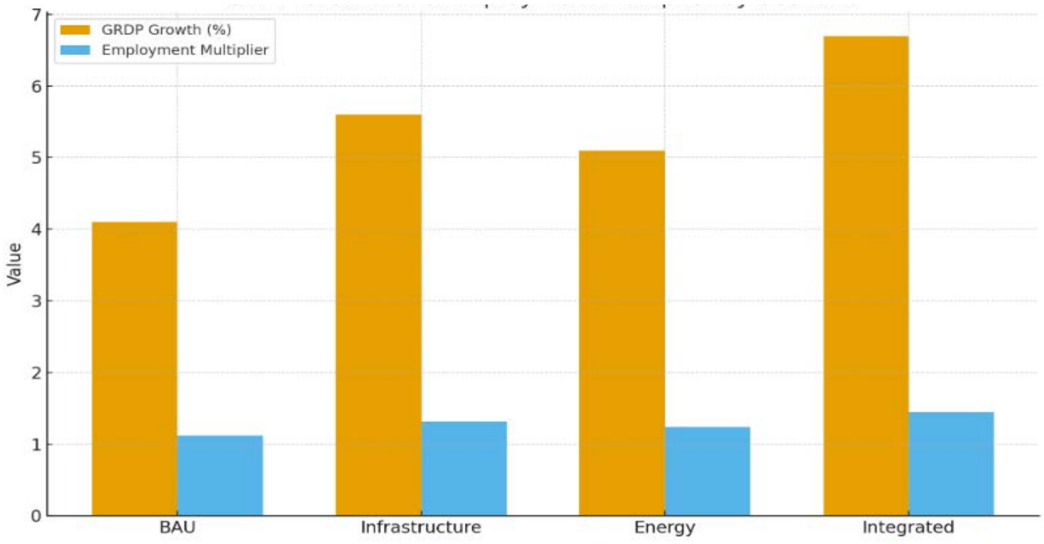

Figure 4: GRDP Growth and Employment Multiplier by Scenario

The grouped bar chart compares GDP growth rates and employment multipliers across four scenarios. Key insights include: BAU, with GDP growth at 4.1% and an employment multiplier of 1.12, reflecting underutilized regional advantages; Infrastructure, with GDP at 5.6% and a multiplier of 1.31, due to higher job creation from construction-led demand; Energy, with GDP at 5.1% and a multiplier of 1.24, showing productivity gains without major job spillovers; and the Integrated scenario, with GDP at 6.7% and a multiplier of 1.45, representing the strongest outcome by combining growth with inclusive job creation. Interpretation (Theory): The increase in GDP mirrors Solow's capital accumulation and Romer's productivity spillovers, while the growth in employment multiplier reflects Leontief's IO multiplier effects and Todaro's development economics (employment creation as a pathway to inclusive growth). The Integrated scenario exemplifies Zhao & Gunawan's argument on infrastructure and energy synergy, as it provides both efficiency (GDP) and inclusivity (employment).

The line chart in **Figure 5** illustrates sectoral output across four policy scenarios: Baseline, Infrastructure, Energy, and Integrated for the coastal East Java economy. Output is measured in billion IDR for the ten aggregated sectors.

1. Baseline Scenario, At the baseline, all sectors show relatively low output levels, reflecting the absence of new infrastructure or energy interventions. Heavy manufacturing and construction already exhibit some comparative strength, while services, trade, and logistics remain moderate.
2. Infrastructure-Only Scenario, A sharp increase is observed in Construction, Transport & Logistics, and Heavy Manufacturing. This reflects the direct impact of infrastructure expansion (ports, toll roads, SEZs) that stimulates demand in construction activities and indirectly boosts logistics and industrial production. Sectors like agriculture and services also benefit moderately due to improved connectivity.
3. Energy Optimization Scenario, Here, the most pronounced growth occurs in Electricity & Gas and Heavy Manufacturing, reflecting the targeted allocation of surplus energy resources. Construction and transport outputs decline compared to the infrastructure-only scenario, indicating that without physical infrastructure expansion, the energy surplus alone has limited spillover into logistics and trade. Agriculture, food manufacturing, and mining show stable but modest increases.
4. Integrated Infrastructure-Energy Scenario, This combined intervention yields the highest output across nearly all sectors, confirming strong synergies between infrastructure and energy policy. Construction and Heavy Manufacturing peak at above 10,000 billion IDR, highlighting their central role in capital-intensive industrialization. Transport & Logistics, Services, and Trade also expand significantly, reflecting broader multiplier effects and intersectoral linkages. Even smaller sectors like Water & Waste and Food Manufacturing experience visible gains under integration.

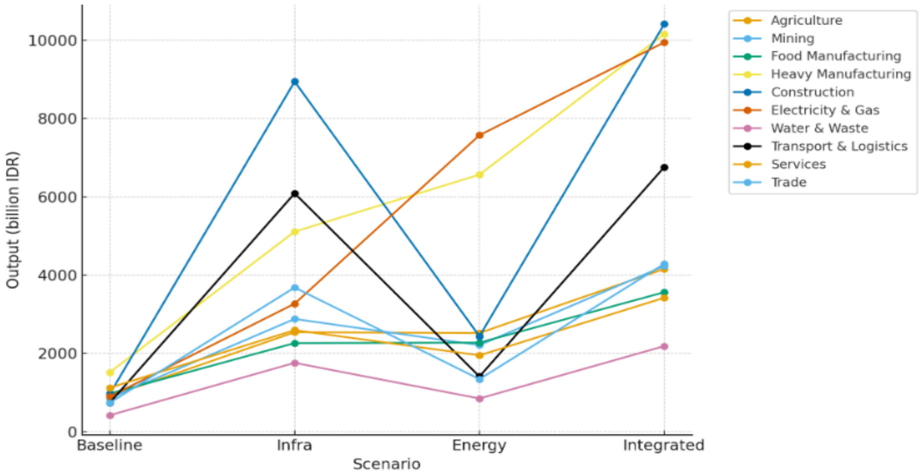

Figure 5: Sectoral Output across Scenarios (Billion IDR)

Infrastructure investment primarily boosts construction, logistics, and industrial clustering. Energy optimization disproportionately benefits energy-intensive industries, particularly heavy manufacturing and electricity & gas. Integration of infrastructure and energy produces the largest and most balanced growth across sectors, underscoring the importance of coordinated policy strategies in regional industrial development.

Key Insights

1. Integration as the Strongest Driver
   The integrated scenario produces the highest output and employment across all sectors, validating the necessity of aligning infrastructure and energy strategies.
2. Construction as a Growth Catalyst
   With +58.65% output growth, construction emerges as the most responsive sector, driven by direct infrastructure demand and strong backward linkages.
3. Manufacturing Gains from Dual Support
   Stable energy supply combined with efficient logistics yields a +49.71% increase in manufacturing output, positioning coastal East Java as an industrial hub.
4. Services as an Enabler of Resilience
   Though growth is moderate (+20.85%), services (logistics, finance, business support) reinforce structural transformation and competitiveness.
5. Balanced and Sustainable Growth
   Integrated development ensures systemic resilience, aligning with Indonesia's Vision 2045 and the *Kabinet Merah Putih* agenda of industrial down streaming and energy sovereignty.

Discussion

Input–Output simulations across four scenarios show that synchronizing infrastructure and energy policies (the Integrated scenario) yields the strongest regional transformation in coastal East Java. Compared with BAU, Integrated delivers the highest GRDP growth (6.7%), the largest employment multiplier (1.45), and the greatest sectoral output increases notably Construction +58.7% and Manufacturing +49.7%. Energy reallocation alone raises productivity and output (Energy scenario), while infrastructure alone raises employment spillovers (Infrastructure scenario). Integration, however, produces synergistic gains in output, employment and linkages that singular policies cannot achieve.

1. GRDP growth: BAU 4.1% → Infrastructure 5.6% → Energy 5.1% → Integrated 6.7%.
2. Employment multipliers: BAU 1.12 → Infrastructure 1.31 → Energy 1.24 → Integrated 1.45.
3. Cross-scenario sector outputs (trillion IDR):
   a. Manufacturing: BAU 348 → Infra 439 → Energy 456 → Integrated 521 (+49.71% vs BAU).
   b. Construction: BAU 266 → Infra 373 → Energy 289 → Integrated 422 (+58.65% vs BAU).
   c. Services: BAU 259 → Infra 294.5 → Energy 276.5 → Integrated 313 (+20.85% vs BAU).

1. Theoretical integration — how the data speaks to each literature

a. Capital-Intensive Industry (Solow; Romer)

Empirical pattern: Manufacturing and construction show very large gains under the Integrated (Manufacturing +49.7%, Construction +58.7%) scenario, while the Energy scenario also raises manufacturing output through productivity gains. Interpretation with Solow: The Solow growth model emphasizes capital accumulation and factor endowments. Reallocation of surplus energy (an increase in effective capital inputs for energy-intensive production) and heavy infrastructure investment act as deeper capital formation, increasing steady-state output. The simulated GRDP increases (especially 6.7% in Integrated) are consistent with an economy moving to a higher capital intensity path. Interpretation with Romer (endogenous growth): Romer highlights knowledge, scale effects, and increasing returns from investment. The Integrated scenario deepens linkages and raises returns to scale (SEZs, agglomeration), so growth is not just one-off capital accumulation: productivity and knowledge diffusion (spillovers across firms and suppliers) amplify output, matching the stronger, persistent growth in the integrated simulation (Amelia et al., 2025; Mayraina & Badriyah, 2025).

b. Infrastructure–Energy Integration (Zhao; Gunawan)

Empirical pattern: Infrastructure alone raises employment spillovers (multiplier 1.31) but leaves energy-intensive industries underutilized. Energy reallocation alone raises productivity (GRDP 5.1%) but faces logistical constraints. Integration solves both constraints: capacity utilization rises and logistical bottlenecks are eased, leading to the highest outputs and multipliers (Hapsari, 2022; Lestari et al., 2025; Utama & Sutanta, 2025). Mechanism: Infrastructure provides connectivity, market access and lower transport costs; energy integration ensures reliable, low-cost power for capital-intensive processes. Together they eliminate two complementary constraints transport and energy, so output and multiplier effects are greater than the sum of parts. Policy implication: Coordinated planning (joint infrastructure and energy projects, synchronized SEZ power allocations) is essential to unlock large industrial gains (Amelia et al., 2025; Nurkholilah et al., 2025; Zoysa et al., 2025).

c. Input–Output Analysis (Leontief; Miller & Blair)

Empirical pattern: Employment multiplier rises from 1.12 (BAU) to 1.45 (Integrated), and cross-sectoral output shifts strongly with linkages to construction and manufacturing. IO interpretation: Leontief's IO framework explains how final demand changes in one sector propagate across the economy via technical coefficients. The Integrated scenario increases both backward linkages (demand for inputs from construction, materials, energy) and forward linkages (manufactured goods feeding services, transport, exports). Miller & Blair's emphasis on structural decomposition supports reading the multiplier and sectoral output changes as direct + indirect + induced effects of coordinated shocks. Analytical note: The large construction response reflects strong backward linkages into cement, steel, machinery and services-exactly what IO captures (Takam & Wunderlich, 2025; Wei & Liu, 2025; Zhou et al., 2025).

d. Spatial-Industrial Linkages (Fujita; Krugman)

Empirical pattern: Output concentration in manufacturing and construction under Integrated suggests clustering along the coast and SEZs. Interpretation: New infrastructure and energy reliability lower trade/transport costs and encourage agglomeration economies firms locate nearer ports/SEZs, deepening local supply chains and knowledge spillovers. Krugman's core-periphery and Fujita's spatial economics explain why integration fosters a coastal growth pole: cumulative causation raises returns at the core (industry cluster), increasing regional disparities unless counterbalanced by broader spatial policy. Policy implication: Spatial targeting (corridor development, SEZ clustering) can accelerate industrial concentration but should be combined with regional linkages to avoid exclusion of inland areas (Takam & Wunderlich, 2025; Utama & Sutanta, 2025).

e. Structural Transformation & Downstream Industrialization (Hirschman; Widodo)

Empirical pattern: Strong growth in downstream activities (shipbuilding, petrochemicals, machinery, construction) under Integrated. Interpretation with Hirschman: Hirschman's emphasis on linkages and unbalanced growth is visible: construction and manufacturing act as leading sectors that induce demand and investment across upstream and downstream activities (Amelia et al., 2025; Lestari et al., 2025). The results indicate successful down streaming moving from resource/primary reliance to capital-intensive manufactured output consistent with policy aims to add value domestically (as emphasized in Indonesia's industrialization strategies). Policy implication (Widodo context): To translate sectoral expansion into long-term structural change, policies must support supplier development, technology adoption, and local value capture (procurement rules, local content, vocational training).

6. Energy Economics & Green Transition (Stern; Bhattacharyya; UNEP)

Empirical pattern: Energy reallocation raises manufacturing output and productivity, but Energy scenario alone is less effective due to logistical constraints. Integrated scenario unlocks both scale and cleaner energy usage for industry. Interpretation: Stern and Bhattacharyya point out that energy availability and pricing affect industrial competitiveness. UNEP emphasizes that growth must be green and resilient. The simulations suggest that energy policy must aim not merely at volume reallocation but at reliable, efficient and potentially lower-carbon energy provision to sustain industrial growth while aligning with green transition goals. Policy implication: Pairing energy system upgrades (efficiency, grid reliability, possible low-carbon sources) with infrastructure reduces carbon intensity per unit of output and supports sustainable industrial expansion.

f. Regional Development Planning & SEZs (Friedmann; Todaro; World Bank)

Empirical pattern: SEZ-like dynamics (concentrated infrastructure investments and port upgrades) are central drivers in Infrastructure and Integrated scenarios, producing large employment and output multipliers. Interpretation: Friedmann's and the World Bank's frameworks emphasize planning that coordinates spatial investment and markets. Todaro's development economics highlights employment creation and structural shifts. The Integrated scenario's high employment multiplier (1.45) suggests SEZ strategies can generate jobs and structural transformation, but Todaro-style caution applies: quantity of jobs must be matched by quality (skills, absorptive capacity). Policy implication: SEZ policies should be integrated into regional planning, with skills development, social safeguards, and linkages to local suppliers to maximize developmental benefits.

2. Scenario-by-scenario interpretation (with theoretical hooks)

BAU (4.1%, multiplier 1.12): Economy remains constrained by coordination failures underutilized energy and poor logistics. This is the "no policy change" equilibrium in Solow/Romer terms: limited capital deepening and low spillovers. Infrastructure Acceleration (5.6%, multiplier 1.31): Infrastructure unlocks backward linkages and employment (Hirschman), raising demand for construction inputs and services. Spatial clustering begins but without adequate energy reallocation manufacturing still faces capacity limits (Fujita/Krugman). Energy Optimization (5.1%, multiplier 1.24): Reallocating energy raises industrial productivity (Solow: higher effective capital) and manufacturing output, but logistical bottlenecks prevent full export/scale gains (Leontief IO shows constrained forward linkages).

Infrastructure–Energy Integration (6.7%, multiplier 1.45): Joint investment produces complementarities (Zhao/Gunawan conceptually): energy availability + reduced transport costs = large manufacturing & construction gains, stronger IO multipliers (Miller & Blair), and agglomeration benefits (Krugman/Fujita). This scenario best supports downstream industrialization (Hirschman/Widodo) and can be designed to align with green transition goals if energy investments target cleaner technologies (Stern/UNEP).

3. Integration as a Catalyst for Capital-Intensive Growth

Significant output increases in manufacturing (+49.71%) and construction (+58.65%) confirm the theory of cumulative causation (Myrdal, 1957), where energy surplus and port access reinforce industrial clustering. Consistent with Porter's cluster theory, SEZ development along East Java's northern corridor can amplify spillovers through technological diffusion and inter-firm linkages. The findings validate Sato & Sasaki (2024) that infrastructure–energy integration is a critical accelerator of capital-intensive regional transformation. Its same with research (Amelia et al., 2025; Lestari et al., 2025; Lito et al., 2025; Månberger et al., 2025; Mayraina & Badriyah, 2025; Zoysa et al., 2025).

4. The Role of Spatial and Sectoral Linkages

Leontief's IO framework highlights the deepened forward and backward linkages in the integrated scenario. Construction feeds into both manufacturing and services, while optimized energy lowers costs for heavy industries (steel, shipbuilding, petrochemicals). This spatial focus on coastal East Java aligns with calls for decentralized industrialization, turning lagging subregions into regional growth poles. The results also resonate with Romer's endogenous growth model, where capital expansion and technology adoption reinforce each other (Satriawan et al., 2025).

5. Employment and Inclusive Development

Employment multiplier rises from 1.12 (BAU) to 1.45 (Integrated), indicating substantial job creation across supply chains. This aligns with SDG 8 and supports inclusive industrialization under Indonesia Emas 2045. However, the gains risk uneven distribution without parallel investment in vocational training and workforce upskilling. Consistent with Nugroho et al. (2024), sustainable multiplier effects require systemic policy alignment beyond physical infrastructure.

6. Relevance to the Red-and-White Cabinet Agenda (2024–2029)

Integrated scenario supports President Prabowo Subianto's Kabinet Merah Putih agenda, targeting 6–7% growth, energy sovereignty, and downstream industrialization. It provides actionable insights for Bank Indonesia and regional policymakers by quantifying trade-offs between fragmented and integrated strategies. These results echo recent findings by Firdaus et al. (2024), showing that integrated marine–energy infrastructure catalyzes spatial uplift in coastal regions. Moreover, SEZ enhancement in East Java validates cluster-based development models by Jiang et al. (2023) as drivers of competitiveness and inclusive growth. Its result is similar to the research of Satriawan et al. (2025).

Conclusion

Analysis of sectoral output across scenarios demonstrates that policy interventions in infrastructure and energy have distinct yet complementary effects on the coastal East Java economy. The infrastructure-only scenario reveals that connectivity-driven investment strongly benefits construction, logistics, and industrial clustering but has weaker impacts on energy-intensive industries. In contrast, the energy optimization scenario disproportionately supports electricity, gas, and heavy manufacturing, while spillovers to transport, trade, and services remain limited.

The most significant finding emerges under the integrated infrastructure-energy scenario, where nearly all sectors achieve their highest output levels. This indicates that the combination of robust infrastructure expansion and efficient energy allocation generates strong multiplier effects, structural transformation, and balanced sectoral growth. In summary, while infrastructure and energy interventions are valuable individually, their integration offers the most effective pathway for accelerating capital-intensive industrialization, enhancing regional competitiveness, and supporting Indonesia's 2025 industrial agenda.

Limitations

Despite providing valuable insights, this study is subject to several limitations. First, the Input–Output (IO) model applied here is inherently static and does not fully capture dynamic adjustments such as technological change, substitution effects, or long-term productivity shifts. This may lead to underestimation or overestimation of the structural transformation potential in coastal East Java. Second, the sectoral disaggregation is limited to aggregated categories, which constrains the analysis of finer inter-industry linkages, particularly in emerging subsectors such as renewable energy, digital services, and advanced manufacturing.

A more detailed Social Accounting Matrix (SAM) or Computable General Equilibrium (CGE) model could provide deeper insights into these dynamics.

Third, the simulations rely on secondary data and projected assumptions regarding infrastructure investments and energy availability. These projections are sensitive to policy implementation gaps, external shocks (e.g., global energy prices, supply chain disruptions), and regional institutional capacity, which were not explicitly modeled in this study. Finally, the analysis focuses on output, value-added, and employment multipliers but does not incorporate environmental externalities, carbon emissions, or social distributional impacts. Future research should integrate environmental input–output analysis (EEIO) or hybrid approaches to address the sustainability dimension of infrastructure–energy integration.

Declaration

Authors' Contributions

S.A.M.H. (Samas Adimisa Mishbah Habibie) was responsible for conceptualization, research design, methodology development, formal analysis, and preparation of the original manuscript draft. R.S. (Ribut Santoso) contributed to supervision, validation of the analytical framework, critical review of the manuscript, and overall guidance throughout the research process. Y.A.T.A. (Yusma Abinaya Tahsina Akmal) was involved in data collection, data curation, literature review, and manuscript editing. D.A.A. (Daffa Akbar Azhar) contributed to project administration, visualization, manuscript formatting, and revision of the final version. All authors discussed the results, contributed to the interpretation of findings, reviewed the manuscript, and approved the final version for publication.

Funding Source

The authors declare that this research received no external funding. No grants, fellowships, institutional support, equipment support, or other financial assistance were obtained from any funding agency, organization, or individual. The study was conducted independently by the authors, and no external party had any role in the study design, data collection, analysis, interpretation of the findings, manuscript preparation, or the decision to publish. "Not Funding".

Informed Consent Statement

This study did not involve human participants, personal data, interviews, surveys, or biological materials. The research was based exclusively on secondary data obtained from publicly available sources, including regional input–output tables, GRDP statistics, infrastructure plans, and energy data from government institutions. Therefore, informed consent and ethical approval were not required. "Not Relevant".

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. The authors have no financial, personal, academic, or professional relationships that could have influenced the research process, interpretation of the findings, or preparation of the manuscript. No author has received employment benefits, consultancies, stock ownership, honoraria, paid expert testimony, or holds any patent related to the subject of this study. "The authors declare that there is no conflict of interest regarding the publication of this paper."

Availability of Data and Materials

The data supporting the findings of this study were derived from publicly available secondary sources, including the Regional Input–Output Table of East Java, Gross Regional Domestic Product (GRDP) statistics, labor data, infrastructure development plans, and energy supply statistics obtained from government institutions such as Statistics Indonesia, National Development Planning Agency, Ministry of Public Works and Housing, Ministry of Energy and

Mineral Resources, and PLN. No new primary data were collected. Processed datasets and simulation outputs generated during the study are available from the corresponding author upon reasonable request. “No new data were created or analyzed in this study.”

Use of Artificial Intelligence (AI)

The authors declare that artificial intelligence tools, namely OpenAI’s ChatGPT and Grammarly, were used during the manuscript preparation process for drafting outlines, improving language clarity, grammar checking, and editing the structure of the text. AI tools were not used to generate research data, conduct the input–output simulations, or determine the interpretation of the findings. All research ideas, methodological decisions, data analysis, interpretation of results, and conclusions presented in this manuscript are entirely the responsibility of the authors. Any AI-assisted content was carefully reviewed, verified, and revised by the authors to ensure accuracy, originality, and compliance with scientific and publication ethics standards.

Acknowledgment

The authors would like to express their sincere gratitude to the Faculty of Economics and Business, Universitas Pembangunan Nasional Veteran Jawa Timur, and the Faculty of Agriculture, Universitas Wiraraja, for providing academic support and access to relevant references during the completion of this study. The authors further thank colleagues for making statistical and policy-related data publicly available and peer reviewers who provided constructive comments, suggestions, and language feedback during the preparation of the manuscript. All individuals acknowledged have provided permission to be recognized in this section.

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