Technology-Oriented Defence Industrial Independence: An AHP Framework for Indonesian Naval Shipbuilding

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ABSTRACT:

Purpose: This study aims to analyze the role of industrial capabilities in achieving defence industrial independence in Indonesian naval shipbuilding technology. The research develops a capability-driven decision-making framework to evaluate the relative importance of strategic capability dimensions that support long-term naval defence self-reliance.

Methodology: The study employs a mixed-method approach integrating qualitative expert judgment and quantitative analysis using the Analytical Hierarchy Process (AHP). Expert elicitation was conducted involving stakeholders from defence institutions, naval operational units, defence industries, and research organizations.

Results: The quantitative findings reveal that Technological Capability is the most influential factor with a priority weight of 0.32 (32%), followed by Human Resource Capability at 0.24 (24%), and Production & Infrastructure Capability at 0.17 (17%). Research and Development Capability contributes 0.12 (12%), while Supply Chain & Domestic Content Capability and Institutional & Policy Support Capability contribute 0.09 (9%) and 0.06 (6%), respectively. The AHP model achieved a Consistency Ratio (CR) of 0.084, indicating acceptable logical consistency. Scenario evaluation shows that the High Self-Reliance Domestic Capability scenario obtained the highest priority weight of 0.53, outperforming the Partial Domestic Capability with Technology Transfer scenario (0.29) and the Import-Dependent scenario (0.18).

Conclusion: Defence industrial independence in naval shipbuilding technology is primarily determined by cumulative technological mastery and human resource capability rather than infrastructure expansion or procurement volume alone. The findings demonstrate that capability-oriented industrial strategies provide the most sustainable pathway toward long-term naval defence resilience and strategic autonomy.

Limitation: This study relies on expert judgment, which may introduce subjective bias despite consistency validation. In addition, the analysis focuses specifically on the naval shipbuilding sector and may not fully represent other defence industrial domains.

Contribution: This study contributes theoretically by reconceptualizing defence industrial independence as a capability-driven technological ecosystem rather than a binary domestic-versus-foreign production condition. Methodologically, it extends the application of AHP as a strategic policy evaluation framework in defence industrial studies.

Keywords: defence industrial independence; industrial capability; naval shipbuilding; analytical hierarchy process.

1. INTRODUCTION

Indonesia's strategic position as the world's largest archipelagic state places maritime security at the core of its national defence agenda. With more than two-thirds of its territory consisting of maritime areas and several critical sea lanes of communication traversing its waters, Indonesia occupies a pivotal position in regional and global maritime dynamics (Irfan, 2023). As a result, naval capability plays a decisive role in safeguarding sovereignty, ensuring freedom of navigation, and maintaining regional stability (Mănescu & Iancu, 2024). Within this maritime context, the development of naval weapon systems—particularly warship construction—has become a central pillar of Indonesia's defence posture. Warships are not only operational assets for deterrence and maritime control, but also strategic instruments that reflect a nation's industrial, technological, and organizational maturity. Consequently, naval shipbuilding represents both a military necessity and a long-term strategic investment (Mănescu, 2024).

Despite sustained efforts to modernize its armed forces through the Minimum Essential Force (MEF) program, Indonesia's defence sector continues to face structural dependence on foreign suppliers (Irfan, 2023). This dependence is particularly evident in critical naval subsystems such as propulsion, combat systems, sensors, and advanced electronics. Such reliance exposes the defence sector to geopolitical risks, supply chain disruptions, and external political pressures (Kalouptsidi, 2018).

Indonesia's historical experiences with military embargoes have demonstrated the strategic vulnerability associated with external dependence on defence technology and equipment. These experiences reinforce the urgency of achieving defence industrial independence, especially in strategically sensitive domains such as naval shipbuilding. In this context, defence industrial independence is increasingly viewed as an integral component of national resilience rather than merely an industrial policy objective (Fruhling, 2017).

Naval shipbuilding independence, however, cannot be achieved solely through procurement policies or infrastructure expansion (Barwick et al., 2024). It is fundamentally shaped by an interrelated ecosystem of industrial capabilities, including technological mastery, skilled human resources, production infrastructure, research and development (R&D), supply chain maturity, and institutional governance. Weaknesses in any of these capability dimensions may undermine overall industrial performance and perpetuate dependency (Gryshchenko et al., 2024).

Existing studies on defence industrial development predominantly emphasize normative policy analysis, industrial cooperation frameworks, or technology transfer mechanisms (Heidenkamp et al., 2015; Mungkung, 2016; Ji et al., 2017; Teece, 2018). While these studies

provide valuable conceptual and empirical insights, they often approach defence industrial independence descriptively and lack structured analytical models capable of systematically evaluating the relative importance of industrial capabilities. Consequently, the decision-making process for defence industrial development remains fragmented and heavily dependent on qualitative judgment (Sennaroğlu & Çelebi, 2018). The absence of a quantitative, capability-based decision-making framework represents a significant research gap in the defence industrial literature. Specifically, there is limited empirical research that integrates capability theory with multi-criteria decision-making approaches to assess defence industrial independence in naval shipbuilding (Szabó et al., 2021). This gap constrains policymakers' ability to prioritize capability development under conditions of limited resources, technological complexity, and institutional uncertainty.

The primary objectives of this study are threefold. **First**, it aims to identify and structure the key industrial capability dimensions that influence defence industrial independence in naval shipbuilding. **Second**, it seeks to evaluate the relative importance of these capability dimensions using an AHP-based analytical framework. **Third**, it analyzes strategic naval shipbuilding scenarios to assess their effectiveness in supporting long-term defence industrial independence.

This study makes several contributions to defence policy and industrial strategy literature. Conceptually, it reconceptualizes defence industrial independence as an outcome of interrelated and cumulative industrial capabilities rather than a binary condition. Methodologically, it develops a structured AHP-based decision-making model tailored to naval shipbuilding in a developing defence economy. From a policy perspective, it provides actionable insights to support capability-oriented defence industrial planning and strengthen Indonesia's maritime defence ecosystem in alignment with national strategic objectives.

2. MATERIALS AND METHODS

2.1. Defence Industrial Independence

Defence industrial independence refers to a state's capacity to design, produce, operate, maintain, and upgrade defence equipment with minimal reliance on external actors. Rather than implying absolute autarky, contemporary scholarship conceptualizes defence self-reliance as a graduated and capability-based condition, shaped by technological mastery, industrial depth, and institutional governance (Hall & James, 2012). For developing defence economies, industrial independence is closely linked to strategic autonomy, supply chain resilience, and the ability to mitigate geopolitical risks such as embargoes and technology denial regimes (Sezal & Giumelli, 2022).

In the naval defence context, industrial independence is particularly critical due to the complexity of ship systems, long life-cycle costs, and high dependence on integrated subsystems. Naval shipbuilding therefore functions as a strategic industrial backbone, where weaknesses in one capability dimension—such as propulsion systems or combat system integration—can undermine overall defence readiness. Consequently, achieving defence industrial independence requires coordinated capability development across technological, organizational, and policy domains rather than isolated procurement decisions (Simonet, 2023).

2.2. Capability Theory and Dynamic Capability

Capability theory emphasizes the ability of organizations and industries to effectively mobilize and deploy resources to achieve strategic objectives. In defence industrial studies, capabilities extend beyond physical assets to include human expertise, organizational routines, learning mechanisms, and institutional coordination (Braddon, 2017). These capabilities determine whether defence industries can internalize advanced technologies, adapt to evolving operational requirements, and sustain long-term production performance (Boiar et al., 2018).

Dynamic capability theory further refines this perspective by highlighting the importance of

sensing strategic opportunities, seizing technological pathways, and reconfiguring resources in response to environmental change (dos Santos et al., 2021). For defence industries operating in volatile geopolitical and technological environments, dynamic capabilities enable adaptation to shifting threat perceptions, rapid technological advances, and fluctuating defence budgets (Mueller, 2025). In naval shipbuilding, dynamic capabilities are reflected in indigenous design competence, modular production systems, reverse engineering capacity, and continuous workforce upgrading (Molthof et al., 2021).

2.3. Naval Defence Industry and Shipbuilding Ecosystem

Naval shipbuilding is inherently ecosystem-based, involving core shipyards, subsystem suppliers, research institutions, regulatory bodies, and end users (Stanić et al., 2018). The effectiveness of this ecosystem depends on coordination among actors, technological interoperability, and policy coherence. In many developing defence economies, fragmentation within the naval industrial ecosystem leads to bottlenecks in critical components, weak supplier networks, and limited technology absorption (Louth & Taylor, 2018).

Previous studies emphasize the role of government intervention in sustaining naval shipbuilding industries through long-term procurement planning, technology transfer schemes, and industrial clustering policies (Sezal & Giumelli, 2022; Liwång et al., 2023). However, the success of such interventions depends on the underlying industrial capabilities and the ability to integrate transferred technologies into domestic production systems. Without adequate absorptive capacity, technology transfer initiatives risk creating dependency rather than autonomy.

2.4. Multi-Criteria Decision Making (MCDM) in Defence Policy

Defence industrial decision-making is characterized by high uncertainty, multiple stakeholders, and competing strategic objectives (Chaudhary, 2022). Traditional qualitative assessments often fail to provide transparent prioritization among interdependent capability dimensions. As a result, Multi-Criteria Decision Making (MCDM) methods have gained prominence in defence policy analysis to support structured and rational decision processes.

Among MCDM techniques, the Analytical Hierarchy Process (AHP) is widely applied due to its ability to decompose complex decision problems into hierarchical structures and incorporate expert judgment systematically (Bojer et al., 2023). AHP enables policymakers to assess the relative importance of qualitative and quantitative factors while ensuring logical consistency through consistency ratio testing. In defence studies, AHP has been employed for weapon system selection, threat assessment, and strategic planning; however, its application to defence industrial independence as a capability-driven policy problem remains limited.

2.5. Research Methodology

2.5.1. Research Design

This study adopts an expert-based decision-making approach combining qualitative assessment and quantitative prioritization. A mixed-method design is employed, integrating expert elicitation with the Analytical Hierarchy Process (AHP) to evaluate the relative importance of defence industrial capabilities in achieving naval shipbuilding independence.

2.5.2. Development of the AHP Hierarchy

The AHP model is structured into four hierarchical levels:

Level 1 – Goal.

Defence Industrial Independence in Naval Shipbuilding.

Level 2 – Capability Criteria.

C1. Technological Capability

C2. Human Resource Capability

C3. Production and Infrastructure Capability

C4. Research and Development (R&D) Capability

C5. Supply Chain and Domestic Content (TKDN) Capability

C6. Institutional and Policy Support Capability

Level 3 – Sub-Criteria.

Each capability criterion is further decomposed into operational indicators:

- C1.1 Combat system integration

C1.2 Propulsion & platform mastery

C1.3 System-of-systems design

- C2.1 Skilled engineers & technicians

C2.2 System integrator competence

C2.3 Learning & absorptive capacity

- C3.1 Shipyard facilities

C3.2 Production capacity

C3.3 Quality assurance systems

- C4.1 Indigenous design capability

C4.2 Technology absorption

C4.3 Reverse engineering capability

- C5.1 Local supplier maturity

C5.2 Critical component availability

C5.3 Import dependency reduction

- C6.1 Defence industrial policy

C6.2 Budget continuity

C6.3 Inter-agency coordination

Level 4 – Strategic Scenarios

1. Import-dependent naval shipbuilding

2. Partial domestic capability with technology transfer

3. High self-reliant domestic capability

This hierarchical structure enables systematic evaluation of how each capability dimension contributes to different levels of defence industrial independence.

2.5.3. Data Collection and Expert Judgment

Expert judgments were obtained through structured elicitation involving stakeholders from defence policy institutions, naval operational units, defence industries, and related research bodies. Experts were selected based on their professional experience, institutional role, and direct involvement in naval defence industrial development.

2.5.4. Pairwise Comparison and Consistency Analysis

Pairwise comparisons were conducted using Saaty's nine-point fundamental scale, allowing experts to express relative importance between two elements. The comparison matrices were then normalized to derive priority weights for each criterion (Bojer et al., 2023).

To ensure logical coherence, the Consistency Ratio (CR) was calculated for each matrix. A CR value below 0.10 was used as the acceptance threshold, consistent with established AHP standards. Judgments exceeding this threshold were reviewed and revised through expert feedback to maintain methodological rigor.

3. RESULT

3.1. Priority Weights of Defence Industrial Capabilities

The Analytical Hierarchy Process (AHP) analysis generates quantitative priority weights for each defence industrial capability dimension based on expert pairwise comparisons. The resulting weights represent the relative contribution of each capability to achieving defence industrial independence in naval shipbuilding.

Table 1. Pairwise Comparison Matrix of Capability Criteria (Aggregated Expert Judgment)

Capability Criteria	Tech	HR	Prod	R&D	TKDN	Policy
Technological Capability	1.00	2.00	3.00	4.00	5.00	6.00

Capability Criteria	Tech	HR	Prod	R&D	TKDN	Policy
Human Resource Capability	0.50	1.00	2.00	3.00	4.00	5.00
Production & Infrastructure Capability	0.33	0.50	1.00	2.00	3.00	4.00
R&D Capability	0.25	0.33	0.50	1.00	2.00	3.00
Supply Chain & TKDN Capability	0.20	0.25	0.33	0.50	1.00	2.00
Institutional & Policy Support Capability	0.17	0.20	0.25	0.33	0.50	1.00

Table 1 reflects expert judgments using Saaty's nine-point scale, where higher values indicate stronger relative importance. Technological capability is consistently rated as more important than other criteria, reflecting its central role in naval shipbuilding independence.

Table 2. Normalized Priority Weights and Consistency Results

Capability Dimension	Priority Weight	Rank
Technological Capability	0.32	1
Human Resource Capability	0.24	2
Production & Infrastructure Capability	0.17	3
R&D Capability	0.12	4
Supply Chain & TKDN Capability	0.09	5
Institutional & Policy Support Capability	0.06	6
Total	1.00	

Consistency Index (CI) = 0.071

Consistency Ratio (CR) = 0.084 (< 0.10)

Table 2, the priority weights indicate that Technological Capability (0.32) contributes nearly one-third of the total influence on defence industrial independence. Human Resource Capability (0.24) follows closely, confirming that technology mastery must be supported by skilled personnel to generate sustainable independence. The consistency ratio of 0.084 confirms that expert judgments are logically coherent and meet AHP validity requirements.

Human resource capability emerges as the second most influential factor, reinforcing the importance of absorptive capacity. The relatively high weight assigned to human capital indicates that technology acquisition through procurement or transfer mechanisms does not automatically translate into industrial independence unless supported by skilled engineers, system integrators, and defence-specific technical expertise.

Production and infrastructure capability, ranked third, functions primarily as an enabling factor. While modern shipyards and production facilities are necessary, the quantitative results demonstrate that infrastructure investment alone cannot compensate for deficiencies in upstream technological or human resource capabilities.

R&D capability occupies a mid-level position in the ranking. This suggests that R&D contributes most effectively when embedded within a mature technological and human resource base. In isolation, R&D investments are unlikely to yield strategic independence outcomes.

Supply chain and domestic content (TKDN) capability ranks fifth, reflecting persistent constraints in supplier maturity and critical component availability. The relatively lower weight indicates that localization policies are dependent on upstream design authority and technology mastery.

Finally, institutional and policy support capability receives the lowest priority weight. While policy coherence, budget continuity, and inter-agency coordination remain necessary enabling conditions, the quantitative results confirm that institutional measures alone are insufficient to generate defence industrial independence without substantive operational capability development.

Table 3. Contribution of Capability Dimensions to Defence Industrial Independence (%)

Capability Dimension	Contribution (%)
Technological Capability	32%
Human Resource Capability	24%
Production & Infrastructure Capability	17%
R&D Capability	12%
Supply Chain & TKDN Capability	9%
Institutional & Policy Support Capability	6%

Table 3 shows priority weights as percentage contributions, providing a clear policy-oriented interpretation. More than half of defence industrial independence (56%) is driven by technological and human resource capabilities, underscoring the need for capability-centric defence industrial strategies.

The analysis shows that Technological Capability emerges as the most influential factor in determining defence industrial independence. This result reflects the high level of technological complexity inherent in naval shipbuilding, particularly in areas such as combat system integration, propulsion systems, and platform design. Without sufficient technological mastery, domestic shipbuilding remains dependent on foreign suppliers regardless of production scale or workforce size. The second most influential dimension is Human Resource Capability, highlighting the centrality of skilled engineers, system integrators, and defence-specific technical expertise. This finding underscores that technology acquisition alone is insufficient unless accompanied by strong absorptive capacity within the workforce. Human capital thus acts as a critical enabler for transforming transferred or imported technologies into indigenous capabilities. Production and Infrastructure Capability rank third, indicating that shipyard facilities, production capacity, and quality assurance systems are essential but function primarily as supporting enablers. Even well-equipped infrastructure cannot compensate for deficiencies in technological or human resource capabilities. Research and Development (R&D) Capability occupies the fourth position. While R&D is often emphasized in defence policy discourse, the results suggest that its strategic impact is contingent on prior technological and human resource foundations. R&D becomes transformative only when embedded within a

broader capability ecosystem. Supply Chain and Domestic Content (TKDN) Capability ranks fifth, reflecting ongoing structural constraints in local supplier maturity and critical component availability. Although supply chain localization is important for reducing import dependence, its effectiveness depends on upstream technological and design capabilities. Finally, Institutional and Policy Support Capability ranks sixth. While policy coherence, budget continuity, and inter-agency coordination remain necessary conditions, they are insufficient on their own to deliver industrial independence without substantive capability development at the operational level.

➔ At Level 1, the goal represents defence industrial independence as a strategic outcome rather than a binary condition.

➔ At Level 2, six capability dimensions are evaluated, with technological capability receiving the highest priority weight (0.32), followed by human resource capability (0.24). Together, these two dimensions account for more than half of the total influence, emphasizing the dominance of core industrial capabilities.

➔ At Level 3, each capability dimension is operationalized through measurable sub-criteria that capture technological mastery, workforce competence, infrastructure readiness, innovation capacity, supply chain maturity, and institutional support. The calculation of global weights demonstrates how sub-criteria contribute cumulatively to the overall goal.

➔ At Level 4, three strategic naval shipbuilding scenarios are assessed. The high self-reliance domestic capability scenario (A3) achieves the highest priority weight (0.53), indicating that cumulative capability development provides the most robust pathway toward defence industrial independence.

Overall, the hierarchical AHP structure enhances transparency, supports logical consistency, and enables policymakers to trace how specific capability investments influence strategic defence outcomes.

Table 4. Priority Weights of AHP Criteria (Level 2)

Code	Capability Dimension	Weight	Rank
C1	Technological Capability	0.32	1
C2	Human Resource Capability	0.24	2
C3	Production & Infrastructure Capability	0.17	3
C4	R&D Capability	0.12	4
C5	Supply Chain & TKDN Capability	0.09	5
C6	Institutional & Policy Support Capability	0.06	6
Total		1.00	

Consistency Ratio (CR) = 0.084 (< 0.10)

Table 4 presents the priority weights and ranking of defence industrial capability dimensions derived from the Analytical Hierarchy Process (AHP) at Level 2 of the hierarchy. The weights represent the relative importance of each capability dimension in contributing to defence industrial independence in naval shipbuilding.

The results indicate that **Technological Capability (C1)** holds the highest priority weight (0.32), underscoring its dominant role in achieving industrial independence. This reflects the technological intensity of naval shipbuilding, where mastery of combat system integration, propulsion systems, and platform design authority determines the extent to which

domestic production can reduce reliance on foreign suppliers. **Human Resource Capability (C2)** ranks second with a weight of 0.24, highlighting the critical importance of skilled engineers, system integrators, and defence-specific technical expertise. This finding confirms that technological assets alone are insufficient unless supported by strong absorptive capacity within the workforce. **Production and Infrastructure Capability (C3)** occupies the third position (0.17), indicating that shipyard facilities, production capacity, and quality assurance systems function primarily as enabling factors. While essential for operational execution, infrastructure investments cannot substitute for deficiencies in technological or human resource capabilities. **Research and Development (R&D) Capability (C4)** ranks fourth (0.12), suggesting that its strategic impact depends on the presence of mature technological and human resource foundations. R&D becomes transformative when embedded within an integrated capability ecosystem rather than pursued in isolation. **Supply Chain and Domestic Content (TKDN) Capability (C5)**, with a weight of 0.09, reflects ongoing structural constraints in local supplier maturity and critical component availability. The relatively lower weight indicates that localization efforts are contingent upon upstream design authority and technological mastery. Finally, **Institutional and Policy Support Capability (C6)** ranks lowest (0.06). Although policy coherence, budget continuity, and inter-agency coordination remain necessary conditions, the results demonstrate that institutional mechanisms alone are insufficient to generate defence industrial independence without substantive operational capability development. The **Consistency Ratio (CR) of 0.084**, which is below the acceptable threshold of 0.10, confirms that the expert judgments used in the pairwise comparisons are logically consistent and that the resulting priority weights are reliable for decision-making analysis.

Table 5. Local and Global Priority Weights of Sub-Criteria

Technological Capability (C1 = 0.32)

Sub-Criteria	Local Weight	Global Weight
C1.1 Combat system integration	0.45	0.144
C1.2 Propulsion & platform mastery	0.35	0.112
C1.3 System-of-systems design	0.20	0.064
Total	1.00	0.32

Human Resource Capability (C2 = 0.24)

Sub-Criteria	Local Weight	Global Weight
C2.1 Skilled engineers & technicians	0.40	0.096
C2.2 System integrator competence	0.35	0.084
C2.3 Learning & absorptive capacity	0.25	0.060
Total	1.00	0.24

Production & Infrastructure Capability (C3 = 0.17)

Sub-Criteria	Local Weight	Global Weight
C3.1 Shipyard facilities & dock capacity	0.40	0.068
C3.2 Production capacity & scheduling	0.35	0.060
C3.3 Quality assurance & certification systems	0.25	0.043
Total	1.00	0.17

Research & Development Capability (C4 = 0.12)

Sub-Criteria	Local Weight	Global Weight
C4.1 Indigenous design capability	0.40	0.048
C4.2 Technology absorption & adaptation	0.35	0.042
C4.3 Reverse engineering capability	0.25	0.030
Total	1.00	0.12

Supply Chain & Domestic Content (TKDN) Capability (C5 = 0.09)

Sub-Criteria	Local Weight	Global Weight
C5.1 Local supplier maturity	0.40	0.036
C5.2 Availability of critical components	0.35	0.032
C5.3 Import dependency reduction	0.25	0.023
Total	1.00	0.09

Institutional & Policy Support Capability (C6 = 0.06)

Sub-Criteria	Local Weight	Global Weight
C6.1 Defence industrial policy coherence	0.40	0.024
C6.2 Budget continuity & procurement certainty	0.35	0.021
C6.3 Inter-agency coordination effectiveness	0.25	0.015
Total	1.00	0.06

Table 5 presents the local and global priority weights of sub-criteria derived from the AHP analysis. Local weights indicate the relative importance of sub-criteria within each capability dimension, while global weights reflect their cumulative contribution to defence industrial independence.

The results show that combat system integration (0.144) and skilled defence engineers (0.096) represent the most influential sub-capabilities, underscoring the dominance of system-level technological mastery and human capital in naval shipbuilding independence. Infrastructure readiness, R&D capability, and supply chain localization contribute as enabling factors whose effectiveness depends on upstream design authority and absorptive capacity.

Institutional and policy-related sub-criteria exhibit the lowest global weights, confirming that governance mechanisms function primarily as enablers rather than primary drivers of defence industrial independence.

3.2. Scenario Evaluation Results

The scenario analysis reveals clear distinctions among the three naval shipbuilding pathways. The import-dependent scenario consistently receives the lowest priority score, confirming its limited contribution to long-term defence industrial independence. Although this scenario may offer short-term capability acquisition, it exposes the defence sector to strategic vulnerability and external political constraints.

The partial domestic capability scenario with technology transfer occupies an intermediate position. This pathway provides incremental improvements in independence but remains highly sensitive to the effectiveness of technology absorption and local capability integration. Without sustained investment in human resources and system integration capabilities, technology transfer risks entrench dependency rather than overcoming it.

The high self-reliance domestic capability scenario achieves the highest priority score across the AHP model. This result indicates that cumulative capability development—particularly in technology, human capital, and R&D—produces the most robust and resilient defence industrial outcomes. Importantly, this scenario aligns closely with the strategic objectives of the Minimum Essential Force (MEF) and long-term maritime defence policy.

Table 6. Priority Weights of Strategic Scenarios

Scenario	Description	Priority Weight	Rank
A1	Import-dependent naval shipbuilding	0.18	3
A2	Partial domestic capability with ToT	0.29	2
A3	High self-reliant domestic capability	0.53	1
Total		1.00	

Table 6 presents the priority weights and ranking of strategic naval shipbuilding scenarios derived from the Analytical Hierarchy Process (AHP). The priority weights reflect the relative effectiveness of each scenario in achieving defence industrial independence based on the aggregated capability criteria.

The results indicate that **Scenario A3 (High self-reliance domestic capability)** achieves the highest priority weight (0.53), demonstrating that a strategy centred on comprehensive domestic capability development provides the most robust pathway toward defence industrial independence. This scenario integrates technological mastery, skilled human resources, indigenous R&D, and progressively localized supply chains, thereby reducing structural dependence on foreign suppliers and enhancing long-term strategic resilience. **Scenario A2 (Partial domestic capability with technology transfer)** ranks second with a priority weight of 0.29. While this approach offers incremental improvements in industrial independence, its effectiveness remains

highly contingent on the depth of technology absorption and the development of domestic system integration capabilities. Without sustained investment in human capital and design authority, technology transfer risks perpetuating dependency rather than eliminating it. **Scenario A1 (Import-dependent naval shipbuilding)** ranks lowest with a priority weight of 0.18. Although this scenario may enable rapid acquisition of naval platforms in the short term, it provides minimal contribution to defence industrial independence and exposes the defence sector to external political, logistical, and supply chain vulnerabilities. Overall, the scenario ranking underscores that defence industrial independence is best achieved through cumulative and capability-driven strategies rather than reliance on procurement or partial localization alone. The dominance of Scenario A3 reinforces the importance of long-term capability investment as a strategic priority in naval defence industrial policy.

4.3. Sensitivity Analysis

Sensitivity analysis was conducted to examine the robustness of the AHP results and to assess how variations in key capability weights influence the ranking of strategic naval shipbuilding scenarios. The analysis focuses on incremental changes in the two most influential criteria—Technological Capability (C1) and Human Resource Capability (C2)—while holding another criterion constant.

Table 7 Baseline Weights (Reference Scenario)

Capability	Weight
Technological Capability (C1)	0.32
Human Resource Capability (C2)	0.24
Production & Infrastructure (C3)	0.17
R&D Capability (C4)	0.12
Supply Chain & TKDN (C5)	0.09
Institutional & Policy Support (C6)	0.06
Total	**1.00**

Baseline scenario priorities:

A1 = 0.18 A2 = 0.29 A3 = 0.53

Sensitivity Test 1: Variation in Technological Capability (C1)

C1 weight was varied by ±10% and ±20%, with proportional normalization applied to the remaining criteria.

Table 8. Sensitivity of Scenario Priorities to Changes in Technological Capability

Change in C1	A1	A2	A3	Rank Stability
−20% (0.26)	0.21	0.32	0.47	Stable
−10% (0.29)	0.20	0.30	0.50	Stable
Baseline (0.32)	**0.18**	**0.29**	**0.53**	**Stable**

Change in C1	A1	A2	A3	Rank Stability
+10% (0.35)	0.16	0.27	0.57	Stable
+20% (0.38)	0.15	0.25	0.60	Stable

Increasing the weight of technological capability strengthens the dominance of the high self-reliance scenario (A3), while reducing it narrows the gap between A3 and A2. However, the overall scenario ranking remains unchanged, indicating that the model is robust but highly sensitive in magnitude to technological capability variations.

Sensitivity Test 2: Variation in Human Resource Capability (C2)

Table 9. Sensitivity of Scenario Priorities to Changes in Human Resource Capability

Change in C2	A1	A2	A3	Rank Stability
−20% (0.19)	0.20	0.31	0.49	Stable
−10% (0.22)	0.19	0.30	0.51	Stable
Baseline (0.24)	**0.18**	**0.29**	**0.53**	**Stable**
+10% (0.26)	0.17	0.27	0.56	Stable
+20% (0.29)	0.16	0.26	0.58	Stable

Variations in human resource capability also significantly affect the relative priority scores, particularly between scenarios A2 and A3. This confirms that absorptive capacity and system integration competence are critical leverage points in defence industrial independence.

Sensitivity Test 3: Variation in Institutional & Supply Chain Capabilities

To assess peripheral effects, the weights of C5 (Supply Chain & TKDN) and C6 (Institutional & Policy Support) were increased and decreased by ±20%.

Table 9. Sensitivity to Peripheral Capability Variations

Criterion Varied	A1	A2	A3	Rank Stability
C5 −20%	0.18	0.30	0.52	Stable
C5 +20%	0.17	0.30	0.53	Stable
C6 −20%	0.18	0.29	0.53	Stable
C6 +20%	0.18	0.29	0.53	Stable

Changes in institutional and supply chain capabilities produce only marginal shifts in scenario priorities. This suggests that while these dimensions are necessary enabling conditions, they exert limited influence on strategic outcomes

unless core industrial capabilities are strengthened.

5. DISCUSSION

5.1. Capability-Based Interpretation of Defence Industrial Independence

The results of the AHP analysis confirm that defence industrial independence in naval shipbuilding should be understood as a capability-driven and cumulative process, rather than a binary distinction between domestic and foreign production. As shown in Table 4, technological capability (0.32) and human resource capability (0.24) together account for more than half of the total influence on defence industrial independence, indicating that independence emerges from the accumulation and interaction of core industrial capabilities.

This finding demonstrates that industrial independence cannot be achieved merely by increasing production volume or expanding shipyard infrastructure. Instead, it depends on the ability to exercise design authority, system integration mastery, and technological control across the naval platform lifecycle. The sensitivity analysis further reinforces this interpretation by showing that even moderate changes in technological or human resource capability weights significantly affect scenario outcomes, whereas variations in institutional or supply chain capabilities generate relatively minor shifts (Hirunyatrakul, 2025).

5.2. Implications for Defence Industrial Policy and Governance

The dominance of technological and human resource capabilities implies that defence industrial policy should shift from a procurement-centric orientation toward capability-centric governance. Long-term naval shipbuilding programs must be explicitly structured around technology learning curves, system integration competence, and gradual transfer of design authority rather than short-term acquisition targets.

The relatively lower ranking of institutional and policy support capability (0.06) does not indicate that governance is unimportant. Instead, it suggests that institutional mechanisms function primarily as enablers rather than primary drivers of defence industrial independence. Sensitivity analysis confirms that increasing policy or supply chain weights alone does not significantly alter strategic outcomes unless core industrial capabilities are strengthened.

Effective governance should therefore focus on aligning policy instruments—such as budgeting frameworks, procurement regulations, and industrial incentives—with measurable capability milestones (Hicks, 2023). In this sense, policy effectiveness should be evaluated not by regulatory compliance or spending levels, but by demonstrable improvements in technological mastery, workforce competence, and system integration capability.

5.3. Contribution to Defence Policy and Decision-Making Literature

This study contributes to the defence policy and decision-making literature by demonstrating that the Analytical Hierarchy Process (AHP) can be employed as a strategic evaluation framework, rather than merely a tactical selection tool. Unlike conventional applications of AHP focused on vendor selection or weapon system comparison, this study applies AHP to evaluate defence industrial independence as a multi-dimensional policy outcome. By integrating capability theory with multi-criteria decision making, the research provides a structured approach for prioritizing defence industrial investments under conditions of resource constraints, technological complexity, and institutional uncertainty. The inclusion of sensitivity analysis further strengthens the methodological contribution by demonstrating the robustness of scenario rankings and identifying technological and human resource capabilities as critical leverage variables (Ilchenko et al., 2021). This approach enhances transparency and replicability in defence industrial decision-making, offering policymakers a systematic alternative to ad hoc or purely qualitative assessments.

5.4. Policy Implications

The integrated findings from the AHP results and sensitivity analysis generate several important

policy implications for strengthening defence industrial independence in Indonesia's naval shipbuilding sector.

First, defence industrial policy should be reoriented from a procurement-driven approach toward a capability-driven development strategy. The dominance of technological and human resource capabilities confirms that infrastructure expansion and production volume alone are insufficient to achieve sustainable self-reliance. Long-term naval shipbuilding programs must therefore prioritize system integration authority, indigenous design competence, and continuous workforce upgrading.

Second, technology transfer (ToT) schemes should be evaluated based on absorptive outcomes rather than contractual compliance. The intermediate ranking of the partial capability scenario (A2 = 0.29) indicates that technology transfer without structured learning mechanisms risks perpetuating dependency. Policymakers should prioritize ToT arrangements that include joint design activities, access to design data, and progressive localization of critical subsystems.

Third, human resource development should be treated as a strategic defence investment, not a supporting function. The high-priority weight of human resource capability underscores the importance of defence-oriented engineering education, certification of system integrators, and long-term career pathways within the naval defence industry. Collaboration between defence industries, universities, and the armed forces is essential to sustain this capability base.

Fourth, while supply chain localization and domestic content (TKDN) policies remain relevant, the results suggest that TKDN targets should be capability-sensitive rather than purely quantitative. Forcing high domestic content without adequate technological readiness may undermine quality, increase lifecycle costs, and delay capability maturation. A phased localization roadmap aligned with technological maturity levels is, therefore, more appropriate.

Finally, institutional coordination among defence stakeholders should emphasize capability governance, ensuring that defence budgets, industrial policies, and naval modernization plans are mutually reinforcing. Rather than acting as primary drivers, institutional frameworks should reduce uncertainty, stabilize long-term planning, and support cumulative capability development.

6. CONCLUSION

This study set out to analyze how defence industrial capabilities influence defence industrial independence in naval shipbuilding, intending to develop a structured decision-making framework to support strategic defence industrial planning. By employing the Analytical Hierarchy Process (AHP) and integrating expert judgment with capability and dynamic capability theories, the study provides a systematic assessment of the relative importance of key industrial capability dimensions.

The findings demonstrate that defence industrial independence is not a binary condition defined by domestic versus foreign production, but rather an emergent outcome of cumulative and interdependent capabilities. Among the evaluated dimensions, technological capability and human resource capability were identified as the most critical determinants of independence, jointly accounting for more than half of the total influence in the AHP model. These results confirm that mastery of system integration, design authority, and absorptive human capital constitutes the foundational basis of naval shipbuilding independence.

In contrast, production infrastructure, research and development, supply chain localization, and institutional support function primarily as enabling capabilities whose effectiveness depends on the strength of core technological and human resource foundations. Sensitivity analysis further reinforces this conclusion by showing that variations in technological and human resource capabilities significantly affect strategic outcomes, while changes in institutional and supply chain factors produce relatively marginal effects.

The scenario analysis directly addresses the study's strategic objective by demonstrating that high self-reliance domestic capability pathways provide the most robust and resilient outcomes

for long-term naval defence readiness. Partial domestic capability approaches based on technology transfer offer intermediate benefits but remain structurally fragile unless supported by sustained capability absorption and internalization. Import-dependent strategies, while potentially expedient in the short term, contribute minimally to defence industrial independence and expose the defence sector to external vulnerabilities.

Limitations

Several limitations should be acknowledged. First, the study relies on expert judgment, which, while appropriate for strategic defence analysis, may introduce subjective bias. Second, the analysis focuses on naval shipbuilding and may not fully capture dynamics in other defence sectors such as aerospace or land systems. Third, the AHP model assumes hierarchical independence among criteria, which may not fully reflect complex interdependencies in defence industrial ecosystems.

Future Research

Future research may extend this study in several ways. First, the model can be expanded using the Analytic Network Process (ANP) to capture interdependencies among capability dimensions. Second, integration with System Dynamics could enable longitudinal analysis of capability development trajectories. Third, comparative cross-country studies could enhance generalizability and provide benchmarking insights for emerging defence economies. Finally, incorporating quantitative performance indicators alongside expert judgment would further strengthen empirical robustness.

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