



EX-ANTE REVIEW OF EXPORT SUPERVISION OF NUCLEAR DUAL-USE GOODS IN INDONESIA: A RISK-BASED APPROACH BETWEEN NON-PROLIFERATION COMPLIANCE AND EXPORT PERFORMANCE

Akhmad Firdiansyah

afirdiansyah@pknstan.ac.id, Politeknik Keuangan Negara STAN Indonesia

Abstract

Indonesia faces a critical regulatory gap in supervising exports of dual-use nuclear items despite longstanding commitments to the Nuclear Non-Proliferation Treaty (NPT), International Atomic Energy Agency (IAEA) safeguards, and UN Security Council Resolution 1540. This study provides an ex-ante risk-based assessment to guide the design of Indonesia's export control framework. Using qualitative descriptive methods, the research applies institutional mapping, risk heat map analysis, and SWOT-TOWS strategic planning to balance non-proliferation compliance with trade facilitation. Institutional analysis reveals fragmented mandates across five agencies (BAPETEN, Customs, Ministry of Trade, INSW, Ministry of Foreign Affairs) with no formal coordination mechanism. Risk assessment identifies four categories (R1–R4), with extreme risk (R4) linked to undetected diversion and high risk (R3) to trade friction from false positives. To address these challenges, the study proposes a two-tier supervisory architecture: Tier A for very high-risk items under BAPETEN's safeguards licensing, and Tier B for supporting goods under Customs' HS-based screening. The SWOT-TOWS analysis generates 16 strategies, prioritizing: (1) formal inter-agency coordination via Presidential Regulation, (2) integrated STM risk intelligence systems within INSW and Customs, (3) mandatory officer training and competency standards, and (4) a minimalist HS core set with catch-all mechanisms and product detail fields. The framework demonstrates how contingency theory and risk management principles can produce adaptive export controls aligned with Indonesia's institutional capacity and international obligations.

This research contributes a replicable methodology for ex-ante regulatory assessment in dual-use domains and offers actionable policy recommendations, positioning Indonesia to achieve "smart compliance."

Keywords: Customs supervision; Dual-use nuclear; Export control; Risk management; Strategic trade management

INTRODUCTION

Nuclear technology serves dual purposes—peaceful energy generation and potential weapons development. Nuclear dual-use items present unique security challenges because they enable covert weapons development through legitimate commercial channels, allowing proliferators to circumvent traditional safeguards by acquiring ostensibly civilian technologies that can be repurposed for military applications (Le Moal, 2020). These "proliferation-sensitive items" typically fall under export controls to prevent misuse.

This paper examines dual-use items—goods with both civilian and military applications (Heau, 2025)—which remain relatively unfamiliar in Indonesia despite being well-established in the EU and US. Indonesia ratified the NPT (1978), joined the IAEA (1957), and committed to UNSCR 1540, yet lacks dedicated regulations for dual-use nuclear items.

This regulatory gap presents a dilemma: Indonesia must comply with international standards to avoid sanctions or reputational risks, yet overly broad implementation may hinder legitimate exports. This ex-ante assessment guides stakeholders in designing balanced regulations that uphold non-proliferation commitments while safeguarding export performance.

Indonesia has long demonstrated its commitment to nuclear non-proliferation, having ratified the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1978, joined the International Atomic Energy Agency (IAEA) in 1957, and pledged compliance with United Nations Security Council Resolution 1540. Despite these international obligations, Indonesia currently lacks a dedicated regulatory framework for dual-use nuclear items.



To address this tension, this academic review offers a forward-looking, ex-ante assessment intended to guide stakeholders in designing a balanced regulatory framework. The goal is to support the successful formulation of dual-use nuclear regulations that uphold Indonesia's non-proliferation commitments while safeguarding its export performance and trade facilitation objectives.

The current condition before the dual-use item regulation, each institution does not have a role, main task, function and clarity of responsibility for carrying out tasks in the dual-use supervision mandate, this is certainly not what we want because it can have a negative impact on government administration that ignores the possibility of this dual-use supervision considering the danger it poses is very dangerous, namely weapons of mass destruction.

Although Indonesia committed to the NPT, IAEA, and UNSCR 1540, no dedicated regulation exists for dual-use nuclear items. Previous studies focused on general strategic trade management or safeguards but provided no ex-ante risk assessment tailored to Indonesia's export context. This study fills this gap by mapping risks through heat map analysis and proposing a two-tier regulatory design balancing non-proliferation compliance with trade facilitation as illustrated in Table 1:

Table 1. Institutional Gaps Related to Dual-Use Nuclear Regulation

Institution	Legal Basis / Mandate	Authority Related to Dual-Use	Supervision Stage	Instrument/Mechanism	Identified Gap/Overlap
BAPETEN	Law No. 10/1997 on Nuclear Energy; Gov. Reg. No. 54/2012; Gov. Reg. No. 28/2025 on Risk-Based Business Licensing (ex Gov. Reg. No. 5/2021)	<ul style="list-style-type: none"> • Licensing of nuclear utilization • Nuclear safety and security oversight • Safeguards (INFCIRC/153, 140) up to Annex II 	<ul style="list-style-type: none"> • Pre-licensing • Operational oversight • Post-clearance (for facilities) 	<ul style="list-style-type: none"> • Location, construction, and operation permits for nuclear facilities • Approval for transfer of nuclear materials/equipment • Safeguards inspections 	<ul style="list-style-type: none"> • Gap: No specific regulation or explicit mechanism for screening dual-use items at the export level • Overlap: Export licensing authority for dual-use nuclear items lacks adequate legal basis, potentially leading to litigation risks
Customs (DJBC)	Law No. 17/2006 on Customs; MoF Reg. No. 141/2020 on Export/Import Restrictions	<ul style="list-style-type: none"> • Supervision of import/export flows • HS code classification • Physical and documentary inspection at border and post-border • Customs law enforcement 	<ul style="list-style-type: none"> • Border control (exit point) • Physical inspection • Post-clearance audit 	<ul style="list-style-type: none"> • HS code classification • Lartas screening • Risk-based inspection • Post-clearance audit 	<ul style="list-style-type: none"> • Gap: No specific HS code attention for dual-use nuclear items in current export restriction system • Field officers lack technical knowledge to identify dual-use nuclear items without



Institution	Legal Basis / Mandate	Authority Related to Dual-Use	Supervision Stage	Instrument/Mechanism	Identified Gap/Overlap
					BAPETEN guidance; enforcement of suspected dual-use nuclear exports rests with Customs
INSW (National Single Window Agency)	Presidential Regulation No. 10/2020 on INSW	<ul style="list-style-type: none"> Provides integrated licensing platform Analysis point for HS code and document requirements Pre-clearance screening 	<ul style="list-style-type: none"> Pre-analysis (before goods reach Customs) Document completeness check 	<ul style="list-style-type: none"> HS code validation Automatic identification of required permits (Iartas) Integration with related ministries/agencies 	<ul style="list-style-type: none"> Gap: INSW system lacks a dedicated rule engine for flagging dual-use items No integration module with BAPETEN database for cross-checking analysing point nuclear dual-use items HS code potential
Ministry of Trade (Kemendag)	Law No. 7/2014 on Trade; Trade Minister Reg. No. 20/2021 & 23/2023	<ul style="list-style-type: none"> Issuance of export licenses for specific goods Determination of restricted/prohibited goods 	<ul style="list-style-type: none"> Pre-export licensing Policy formulation 	<ul style="list-style-type: none"> Export licenses for restricted goods Determination of restricted goods list 	<ul style="list-style-type: none"> Gap: Dual-use nuclear items not explicitly included in Kemendag's restricted list No mandatory consultation mechanism with BAPETEN before issuing export licenses for potential dual-use nuclear items
Ministry of Foreign Affairs (Kemlu)	Law No. 37/1999 on Foreign Relations	<ul style="list-style-type: none"> Coordination of international commitments (NPT, UNSCR 1540) End-user verification for destination countries 	<ul style="list-style-type: none"> Diplomatic channel Intelligence sharing 	<ul style="list-style-type: none"> End-user verification via Indonesian missions abroad Coordination with IAEA 	<ul style="list-style-type: none"> Gap: No formal protocol for coordination with Customs/BAPETEN when intelligence information arises about suspicious end-users
PPATK (Financial Intelligence)	Law No. 8/2010 on Anti-	<ul style="list-style-type: none"> Analysis of suspicious financial 	<ul style="list-style-type: none"> Financial intelligence 	<ul style="list-style-type: none"> Transaction screening Blacklist database 	<ul style="list-style-type: none"> Gap: No integration/coordination between



Institution	Legal Basis / Mandate	Authority Related to Dual-Use	Supervision Stage	Instrument/Mechanism	Identified Gap/Overlap
Intelligence Unit)	Money Laundering	transactions • Blacklist of high-risk entities			PPATK blacklist and dual-use item screening systems in INSW/Customs

Source : Processed by author

The institutional assessment reveals four systemic challenges:

1. Authority Ambiguities: BAPETEN possesses nuclear expertise but lacks explicit export control authority under Law No. 10/1997. Government Regulation No. 28/2025 expands licensing scope but does not clearly cover dual-use exports outside traditional safeguards. Similarly, the Ministry of Trade's restricted goods list (Regulations 20/2021, 23/2023) omits dual-use nuclear items, allowing exports without nuclear-specific scrutiny.
2. Border Capacity Deficits Customs officers lack specialized training to identify nuclear dual-use items. Current HS codes exclude dual-use nuclear flags, processing such items through general procedures without elevated scrutiny. This is critical as Customs is the last control point before goods exit Indonesia.
3. System Integration Failures: INSW lacks a rules-based risk engine for dual-use nuclear characteristics and has no integration with BAPETEN's safeguards database, preventing cross-referencing of exports against nuclear inventories or facility licenses.
4. Coordination Voids: No formal mechanism connects nuclear safeguards intelligence (BAPETEN), border enforcement (Customs), export licensing (Kemendag), diplomatic verification (Kemlu), and financial intelligence (PPATK). Agencies operate within sectoral mandates with ad-hoc information sharing, creating exploitable vulnerabilities where proliferators can leverage inter-agency seams.

These gaps inform research objectives (RG1-RG4), requiring institutional architecture redesign that formalizes coordination, clarifies authorities, builds capacity, and integrates digital systems.

Implications for Regulatory Design

The institutional gaps identified in Table 1 directly inform the research gaps (RG1-RG4) that this study addresses. The absence of formal inter-agency coordination mechanisms (RG3) is not merely an administrative inconvenience; it represents a structural vulnerability in Indonesia's non-proliferation architecture. Similarly, the lack of risk-based HS code guidelines (RG2) and ex-ante risk assessment frameworks (RG1) means that Indonesia currently has no systematic methodology for prioritizing enforcement resources toward highest-risk transactions while facilitating legitimate trade.

These findings underscore the necessity of the two-tier supervisory architecture and SWOT-TOWS strategic interventions proposed later in this study. Effective dual-use nuclear export control cannot be achieved simply by adding new regulations; it requires institutional architecture redesign that formalizes coordination channels, clarifies legal authorities, builds technical capacity at enforcement points, and integrates digital systems for real-time risk assessment.

Indonesia's non-proliferation commitment is well-established, yet no comprehensive dual-use nuclear export control framework exists. Academic literature focuses on general safeguards but lacks ex-ante, risk-based assessment for export supervision. International regimes (NSG) developed detailed control lists, but Indonesia lacks infrastructure to screen exports systematically.



This study addresses four research deficiencies (Table 2):

- RG1: No ex-ante risk assessment—this study applies heat map methodology with likelihood-impact matrices to prioritize risks (R1-R4)
- RG2: No risk-based HS guidelines—proposes two-tier architecture (Tier A: BAPETEN safeguards; Tier B: Customs HS screening) with mandatory product detail fields
- RG3: No formal coordination design—recommends Presidential Regulation establishing inter-agency mechanisms
- RG4: No compliance-facilitation trade-off analysis—uses SWOT-TOWS to balance security oversight with export facilitation

Table 2 Research Gaps and Objective/Contribution of This Study

Research Gap	Objective/Contribution of This Study
RG1: Absence of ex-ante risk assessment	Applies a heat map risk approach using a likelihood-impact matrix to identify and prioritize four risk categories (R1-R4) in dual-use nuclear supervision.
RG2: Lack of risk-based HS code guideline	Proposes a risk-based two-tier supervisory architecture (Tier A and Tier B) with criteria for risk-based selection plus mandatory detail specification fields.
RG3: Absence of formal institutional coordination design	Suggests the establishment of implementing regulations for handling suspected dual-use nuclear exports and joint supervisory mechanisms.
RG4: No analysis of compliance vs. trade facilitation trade-off	Uses SWOT-TOWS analysis to demonstrate how to design regulations that balance security oversight with export facilitation.

Source : Processed by author

LITERATURE REVIEW

Contingency Theory

Contingency theory holds that there is no single best organizational structure or strategy; effectiveness depends on fit with contextual factors such as technology, culture, and especially the external environment (Lawrence & Lorsch, 1967; Islam & Hu, 2012). Organizations must align design and complexity with external conditions and internal processes, as the fit between strategy and structure strongly influences performance outcomes (Wong et al., 2011; Kathuria & Lucianetti, 2024).

Applied to supervising dual-use nuclear items in Indonesia, institutional designs cannot be uniform. Coordination among BAPETEN, Customs (DJBC), the Ministry of Trade, and the National Single Window should adapt to external pressures (international commitments, nuclear technology developments, global trade dynamics) and internal realities (technical capacity, information systems, coordination mechanisms). Thus, dual-use regulation should remain adaptive rather than rely on a static oversight model.

Theory of Risk Management

Risk-Based Customs Control, as set out in the WCO Risk Management Compendium, is a systematic approach to identifying, assessing, and responding to risks using targeted enforcement and trade facilitation. Following ISO/IEC 27005:2011, authorities develop a risk map, estimate likelihood and impact, set risk appetite, and select treatments—guiding risk owners to choose proportionate actions that support regulatory compliance (Wangen et al., 2018).



Applied to dual-use nuclear supervision in Indonesia, this approach balances non-proliferation commitments with trade facilitation. Customs, as frontline risk owners, classify goods via HS codes and flag potential dual-use items, while BAPETEN provides technical safeguards criteria. Risk mapping and heat-map prioritization focus resources on high-risk consignments (e.g., nuclear-related components with diversion potential) and streamline low-risk flows through selective HS screening, catch-all controls, and post-border audits—producing an adaptive, proportionate system aligned with international obligations and minimizing export disruptions.

Strategic Trade Management

Strategic Trade Management (STM) is the regulatory framework governing strategic and dual-use goods to prevent their contribution to WMD proliferation, covering materials, equipment, software, and technologies with civilian and military applications (Purnama et al., 2024). In the nuclear sphere, STM integrates export licensing, customs supervision, and inter-agency coordination to prevent diversion while meeting obligations under the NPT and UNSCR 1540 and preserving trade credibility. Debates persist over the “fit for purpose” role of export controls in dual-use research (Charatsis, 2017), while the overall quality of STM/export control is a key indicator of national capacity (Albright et al, 2024).

STM emphasizes balancing security compliance and trade facilitation through a risk-based approach: high-risk items face stricter controls, while low-risk items are streamlined. In practice, tools include selective HS code classification, catch-all provisions for emerging technologies, and post-border audits, ensuring proportionate oversight of nuclear-related dual-use flows without unduly burdening legitimate trade. Caune et al. (2024) emphasize measurable indicators (KPIs, UNSCR 1540 compliance) to evaluate export control effectiveness, particularly for archipelagic states like Indonesia facing geographic challenges, fragmented institutional mandates, and cooperation barriers.

METHODS

This qualitative descriptive research applies SWOT analysis to identify strengths, weaknesses, opportunities, and threats in Indonesia's institutional framework for dual-use nuclear supervision (Murdiyanto, 2020). SWOT comprises internal factors (IFAS: strengths and weaknesses) and external factors (EFAS: opportunities and threats) (Rangkuti, 2016; Salusu, 2015).

SWOT analysis is appropriate because public sector performance depends on both internal institutional capacity and broader environmental factors (economic, political, social) (Fresneda Fuentes & Hernández Borreguero, 2018). The analysis was extended into a TOWS matrix (Wehrich, 1982) to generate strategic recommendations by pairing internal and external factors.

Combined with risk mapping through likelihood-impact matrices, the research provides ex-ante regulatory design assessment. This integration highlights priority risks (R3, R4) and proposes strategies including selective HS listing, catch-all mechanisms, and joint audits between BAPETEN and Customs, balancing Indonesia's non-proliferation obligations with legitimate export facilitation as illustrated in Table 3:

Table 3 SWOT Analysis of Dual-Use Nuclear Items Supervision

Factor	Description in Dual-Use Nuclear Context
Strengths	<ul style="list-style-type: none"> • Existing legal commitments: Indonesia is party to NPT, CWC, BWC, and UNSCR 1540. • Customs (DJBC) has established HS code classification and enforcement capacity. • BAPETEN provides technical safeguards expertise and licensing authority.



Factor	Description in Dual-Use Nuclear Context
	<ul style="list-style-type: none"> INSW offers integrated digital platform for pre-clearance and permit validation.
Weaknesses	<ul style="list-style-type: none"> No specific regulation explicitly addressing dual-use nuclear items. Limited technical knowledge among customs officers for identifying nuclear-related dual-use goods. Lack of integration between BAPETEN database and INSW risk engine. Overlaps and unclear mandates among ministries (Kemendag, Kemlu, DJBC, BAPETEN).
Opportunities	<ul style="list-style-type: none"> Strengthening compliance with international obligations enhances Indonesia's credibility in global trade. Potential to attract high-technology investment through robust STM regulation. Regional benchmarking: ASEAN peers (Singapore, Malaysia, Philippines, Thailand) already have STM laws. Digitalization of trade systems allows integration of risk-based screening and catch-all mechanisms.
Threats	<ul style="list-style-type: none"> Risk of sanctions or reputational damage if Indonesia fails to comply with UNSCR 1540 and IAEA safeguards. Expansion of dual-use definitions may hinder legitimate exports and reduce competitiveness. Non-state actors exploiting regulatory gaps to acquire sensitive nuclear-related goods. WTO/GATT disputes if export controls are perceived as discriminatory or trade-restrictive.

Note : Strengths and Weaknesses → Internal Factor Analysis (IFAS); Opportunities and Threats → External Factor Analysis (EFAS)

Source: Processed by author

While SWOT analysis identifies internal and external factors affecting dual-use nuclear supervision, it does not automatically generate strategic responses. The TOWS (Threats-Opportunities-Weaknesses-Strengths) matrix, developed by Weihrich (1982):

Table 4 TOWS Matrix Analysis

Strategy Type	Strategic Options
SO Strategies (Using Strengths to Exploit Opportunities)	<ol style="list-style-type: none"> Leverage the minimalist, risk-based HS design to position Indonesia as a “balanced compliance” model. Use product-level detail fields and one-time validation as a data foundation for STM risk engines. Anchor cooperative compliance programmes in the existing institutional coordination framework. Exploit phased implementation to pilot international cooperation projects.
WO Strategies (Using Opportunities to Reduce Weaknesses)	<ol style="list-style-type: none"> Use international technical assistance to upgrade administrative capacity and data quality. Develop digital, rules-based risk filters to compensate for limited manual resources. Promote ICPs and industry engagement to improve declaration accuracy.



Strategy Type	Strategic Options
	4. Institutionalise periodic list refinement to manage under-coverage and emerging technologies.
ST Strategies (Using Strengths to Mitigate Threats)	<ol style="list-style-type: none"> 1. Use the two-tier structure and safeguards backbone to respond to external concerns about narrow HS coverage. 2. Combine narrow HS triggers, product-level details, and joint due diligence to counter regulatory arbitrage. 3. Use institutional coordination mechanisms to address implementation gaps. 4. Exploit the one-time validation mechanism to keep pace with technological change.
WT Strategies (Minimising Weaknesses and Avoiding Threats)	<ol style="list-style-type: none"> 1. Set a minimum capacity and training baseline for all implementing units. 2. Establish a formal catch-all escalation process for suspicious but unlisted items. 3. Introduce periodic independent or cross-agency reviews of system performance. 4. Combine sanctions for misdeclaration with strong compliance support.

Source: Processed by author

RESULT AND DISCUSSION

Strategic Factor Analysis: SWOT Assessment

SWOT analysis systematically evaluates Indonesia's internal capabilities and external environment for developing dual-use nuclear export controls (Table 3). Internal Factor Analysis (IFAS) encompasses strengths and weaknesses; External Factor Analysis (EFAS) covers opportunities and threats.

Key Strengths: Indonesia possesses treaty-based commitments (NPT, CWC, BWC, UNSCR 1540) establishing international legal obligations and diplomatic credibility. BAPETEN provides 60+ years of IAEA safeguards expertise. Customs operates sophisticated risk management infrastructure for trade enforcement. INSW offers digital infrastructure for integrated trade processing.

Critical Weaknesses: No dedicated legal authority for dual-use nuclear export control. Technical capacity gaps at borders—field officers lack nuclear technology training. System integration failures between BAPETEN, INSW, and Customs databases prevent automated risk assessment. Unclear institutional mandates create coordination friction.

Strategic Opportunities: Enhanced compliance strengthens Indonesia's credibility as a reliable trading partner. Regional benchmarking with ASEAN peers (Singapore, Malaysia, Philippines, Thailand) provides tested STM models. International technical assistance available from IAEA, NSG members, and WCO. Digitalization enables sophisticated risk assessment without proportional human resource increases.

Significant Threats: Non-compliance with UNSCR 1540/IAEA obligations poses reputational risks. Overly broad implementation risks trade disruption. Non-state actors may exploit regulatory gaps. WTO/GATT consistency must be maintained under Article XXI security exceptions.

Implications: Indonesia possesses significant strengths (existing expertise, infrastructure, commitments) but faces manageable weaknesses and threats. Optimal design leverages



strengths, addresses weaknesses through formal authority and capacity building, exploits opportunities (regional cooperation, digitalization), and mitigates threats (compliance pressures, trade friction).

Risk treatment adapted from ISO 27005:2011 and WCO principles producing risk levels: R1 (Low), R2 (Medium), R3 (High), R4 (Extreme) as illustrated in Table 5:

Table 5 Risk Treatment

Risk Code	Risk Description	Likelihood	Impact	Risk Level	Risk Treatment
R1	Minor administrative risks	low	low	minor	Accept: Monitor through routine reporting; implement standard SOPs; no additional controls beyond baseline.
R2	Inter-agency coordination; staff capacity	low	medium	medium	Mitigate: (1) Presidential Regulation formalizing inter-agency coordination; (2) STM Coordination Secretariat; (3) Mandatory 40-hour officer training + annual refresher; (4) Digital decision-support tools; (5) Shared databases; (6) Quarterly coordination meetings; (7) Performance KPIs and joint audits.
R3	False positives hamper exports; technology update gap	high	high	high	Mitigate & Transfer: (1) Narrow HS core set + mandatory product detail fields; (2) One-time technical validation; (3) Internal Compliance Programme (ICP) for trusted exporters; (4) Exporter helpdesk and pre-filing consultation; (5) Annual control list review aligned with NSG/EU updates; (6) Catch-all procedures for emerging tech; (7) Transfer burden through ICPs.
R4	Undetected diversion high risk good	high	high	extreme	Mitigate (Priority - Defense in Depth): (1) Mandatory BAPETEN licensing for Tier A items; (2) Catch-all mechanism for suspicious transactions; (3) Joint BAPETEN-Customs post-clearance audits; (4) End-user verification by Kemlu; (5) PPATK financial intelligence integration; (6) IAEA/NSG information sharing; (7) Severe penalties (10-year imprisonment, license revocation, asset forfeiture); (8) Multiple redundant control layers.

Source: Processed by author



Indonesia's risk profile requires simultaneously addressing low-probability catastrophic risks (R4: diversion) through robust backstop controls, higher-probability systemic risks (R3: false positives, misdeclaration, obsolescence) through ongoing management, and chronic operational risks (R2: coordination, implementation) through sustained capacity-building. Next, it is necessary to create a scenario of the dual-use nuclear risk as depicted in Table 6.

Table 6 Risk Heat Map for Selected Dual-Use Control Scenarios

Likelihood \ Impact	1 – Minor	2 – Moderate	3 – Major	4 – Severe
4 – Likely	R3 – High	R3 – High	R4 – Extreme	R4 – Extreme
3 – Possible	R2 – Medium	R2 – Medium – RE3, RE4	R3 – High – RE2, RE6	R4 – Extreme
2 – Unlikely	R1 – Low	R2 – Medium	R3 – High – RE5	R4 – Extreme – RE1
1 – Rare	R1 – Low	R1 – Low	R2 – Medium	R3 – High

Source: Processed by author

The risk heat map (Table 6) reveals priority intervention areas through likelihood-impact visualization. RE1 (undetected diversion) occupies the extreme risk quadrant (R4: likelihood=2/impact=4), reflecting catastrophic consequences despite low probability. High-risk events (R3) include RE2 (false positives) and RE6 (technology gaps) at likelihood=3/impact=3, plus RE5 (misdeclaration) at likelihood=2/impact=3. Medium-risk events RE3 (coordination failures) and RE4 (implementation gaps) fall at likelihood=3/impact=2. No events occupy the low-risk quadrant, indicating all scenarios warrant active mitigation. The concentration in R3-R4 categories validates the study's emphasis on proportionate controls: extreme risks demand defense-in-depth (BAPETEN licensing, catch-all mechanisms), while high risks require precision targeting (narrow HS sets, ICPs).

Two-Tier Supervisory Architecture: Operationalizing Risk-Based Controls

The proposed framework operationalizes risk-based principles through institutional specialization. Tier A (Very High-Risk Items) encompasses reactor components, nuclear fuel cycle equipment, special fissile materials, heavy water, and nuclear-grade graphite—items already under IAEA safeguards (INFCIRC/153, INFCIRC/540). Supervision requires mandatory BAPETEN export licensing with no shipment proceeding without technical clearance assessing: (1) specifications against proliferation thresholds (enrichment capacity, material purity, precision tolerances), (2) end-user credentials (legitimate nuclear program under safeguards, not subject to sanctions), (3) end-use verification (contractual documentation, facility inspection reports), and (4) destination country non-proliferation standing (NPT membership, comprehensive safeguards, functioning export controls). This licensing-based approach reflects that HS classification alone cannot capture proliferation risk for items requiring nuclear engineering expertise—assessing whether a pump suits uranium hexafluoride processing or a furnace achieves weapons-grade material production demands technical judgment beyond customs officers' training. BAPETEN's 60+ years of IAEA safeguards experience positions the agency as the appropriate technical authority.

Tier B (Medium/Low-Risk Items) covers supporting equipment (vacuum pumps, mass spectrometers, high-strength materials), general-use materials with potential nuclear applications (specialized alloys, chemicals, precision manufacturing equipment), and technology transfers (technical data, software, training). These items serve multiple industrial purposes; proliferation risk depends on specifications, quantities, and end-user context. Customs conducts HS-based risk screening with mandatory product detail fields (material composition, technical parameters, intended end-use, end-user identity). Declarations are



automatically scored using risk algorithms considering HS code flags, product specification red flags, destination country risk profiles, end-user watch-lists, and shipment pattern anomalies. High-risk scores trigger BAPETEN consultation; medium-risk items undergo enhanced document review; low-risk items receive expedited clearance. INSW serves as the integration platform, automatically routing Tier A items to BAPETEN licensing workflow and applying risk assessment to Tier B items with conditional escalation. Catch-all provisions allow either agency to flag suspicious transactions regardless of tier based on intelligence, unusual specifications, or inconsistent documentation for joint technical review. This architecture leverages institutional strengths—BAPETEN's nuclear expertise, Customs' enforcement capacity and border presence—while addressing coordination gaps through formalized digital workflows, operationalizing contingency theory through differentiated supervisory approaches aligned with risk profiles and institutional capabilities.

CONCLUSION

This ex-ante regulatory assessment identifies a viable pathway for Indonesia to establish dual-use nuclear export controls that reconcile non-proliferation obligations with trade facilitation imperatives. The structured risk analysis reveals that undetected diversion (RE1) constitutes extreme risk (R4), while the compliance-facilitation tension manifests through high-risk scenarios (R3) involving false positives and technological under-coverage.

The proposed two-tier supervisory architecture addresses this tension through institutional specialization: BAPETEN-led safeguards for very high-risk reactor-related items (Tier A) and Customs-led HS code screening for supporting goods (Tier B). This design leverages Indonesia's existing strengths—IAEA safeguards compliance, Customs enforcement capacity, INSW digital infrastructure—while mitigating critical weaknesses through formal coordination mechanisms and minimum competency standards.

The SWOT-TOWS analysis with three priority strategies forming the minimum viable regulatory architecture: (1) formal inter-agency coordination framework (WO3: using opportunities to reduce weaknesses), (2) minimum capacity standards for implementing officers (WT1: minimizing weaknesses and avoiding threats), and (3) integrated risk intelligence system (SO2: using strengths to exploit opportunities).

Indonesia's regulatory design challenge is not unique—it mirrors tensions faced by all states implementing Strategic Trade Management systems. However, Indonesia's archipelagic geography, diverse export portfolio, and developmental priorities create context-specific constraints that necessitate adaptive rather than template-based solutions. The contingency theory framework demonstrates that effectiveness depends on fit between regulatory architecture and environmental contingencies, rather than adoption of "best practice" models from advanced economies.

By anchoring dual-use controls in risk-based principles rather than comprehensive listing, Indonesia can position itself as a responsible non-proliferation actor while maintaining competitiveness in high-technology trade. This balanced approach serves national interests while contributing to global nuclear security governance.

Limitation

This study has several limitations that suggest directions for future research. First, the risk assessment employs structured expert judgment rather than empirical data on actual proliferation attempts or diversion cases, as such data are classified. Future research could validate risk scores through scenario simulation exercises with customs and BAPETEN personnel.

Second, the SWOT-TOWS analysis identifies strategic options but does not conduct detailed cost-benefit quantification for each intervention. Implementation research should



prioritize strategies not only by risk mitigation potential but also by resource requirements and political feasibility.

Third, this ex-ante assessment cannot account for unanticipated implementation challenges that may emerge during phased roll-out. Ongoing evaluation research will be essential to adapt the regulatory architecture based on operational feedback.

Fourth, the study focuses on institutional design within Indonesia's borders and does not extensively address cross-border cooperation mechanisms with neighboring states or regional harmonization efforts within ASEAN. Future research should examine how Indonesia's STM architecture can integrate with broader Southeast Asian non-proliferation frameworks.

Finally, the analysis assumes good-faith implementation by all actors. In practice, regulatory effectiveness may be constrained by corruption, resource diversion, or political interference. Research on STM implementation should incorporate governance quality indicators and anti-corruption safeguards.

Practical Implication

This study provides several practical implications for policymakers and implementing agencies:

- For Regulatory Drafting: The proposed two-tier architecture and risk-based HS selection provide a blueprint for drafting implementing regulations under existing legal frameworks (Law No. 10/1997, Law No. 17/2006, Government Regulation No. 28/2025). Regulatory drafters should prioritize clarity of institutional mandates and operational procedures over comprehensive coverage.
- For BAPETEN: The study validates BAPETEN's central role in technical assessment while highlighting the need for explicit export control authority. BAPETEN should pursue amendments to

REFERENCES

- Albright, D., Burkhard, S., Faragasso, S., & Stricker, A. (2024). Analysis of IAEA Iran verification and monitoring report—February 2024. Institute for Science and International Security. https://isis-online.org/uploads/isis-reports/documents/Analysis_of_February_2024_IAEA_Iran_Verification_Report_March_4_2024_Final.pdf.
- Arnold, A., Carrera, J. A., Castiglioni, A. J., Heine, P. M., Charatsis, C., Starks, B., ... & Vella, V. (2017). 01—A Resilience Framework for Understanding Illicit Nuclear Procurement Networks
- Caune, M., Flynn, M. C., Herbst, H., Heyburn, C., Medina, S., & O'Connor, B. (2024). How to Measure Effective Border Security: A Focus on Metrics and Recommendations for Addressing Illicit Arms and Technology Transfers.
- Downes, R., Hobbs, C., & Salisbury, D. (2019). Combating nuclear smuggling? Exploring drivers and challenges to detecting nuclear and radiological materials at maritime facilities. *Nonproliferation Review*, 26(1–2), 83–104. <https://doi.org/10.1080/10736700.2019.1610256>
- Fuentes, S. F., & Borreguero, J. H. (2018). Institutional capacity in the accounting reform process in Spanish local governments: Capacidad institucional en el proceso de reforma contable de los ayuntamientos españoles. *Revista de Contabilidad-Spanish Accounting Review*, 21(2), 188-195.
- Heau Lauriane, (2025). The EU Research Security Initiative: Implications for the Application of Export Controls in Academia and Research Institutes. *Non-Proliferation and Disarmament Papers No 94 March 2025*. EU Non-Proliferation and Disarmament Consortium



- Fresneda Fuentes, S., & Hernández Borreguero, J. (2018). Institutional capacity in the accounting reform process in Spanish local governments. *Revista de Contabilidad*, 21(2), 188–195. <https://doi.org/10.1016/j.rcsar.2018.05.002>
- Hosen, M. N., Maulana, A., Farhand, M. Z., & Rahman, M. F. (2022). Evaluating the Fundraising Process of the World's First Cash Waqf-Linked Sukuk in Indonesia. *QIJIS (Qudus International Journal of Islamic Studies)*, 10(1), 175–214. <https://doi.org/10.21043/qijis.v10i1.8161>
- Islam, J., & Hu, H. (2012). A review of literature on contingency theory in managerial accounting. *African Journal of Business Management*, 6(15), 5159–5164.
- Kathuria, R., & Lucianetti, L. (2024). Aligning performance metrics with business strategy. *Management Decision*, 62(5), 1539-1559.
- Lawrence, P. R., & Lorsch, J. W. (1967). *Organization and environment: Managing differentiation and integration*. (No Title).
- Le Moal, M. (2020). The Architecture of Illicit Nuclear Trafficking. *Contemporary Challenges: The Global Crime, Justice and Security Journal*, 1, 43–58. <https://doi.org/10.2218/ccj.v1.4942>
- Morini, C., Pieri Leonardo, F., Chaudhary, V., & Hintsas, J. (2024). A Paradigm Shift in Cross-Border E-Commerce Regulatory Compliance: Evidence From Brazil. *World Customs Journal*, 18(2). <https://doi.org/10.55596/001c.123504>
- Murdiyanto, E. (2020). *Penelitian Kualitatif (Teori dan Aplikasi Disertai Contoh Proposal)*. LPPM UPN Veteran Yogyakarta Press.
- Peng Wong, W., & Yew Wong, K. (2011). Supply chain management, knowledge management capability, and their linkages towards firm performance. *Business Process Management Journal*, 17(6), 940-964.
- Purnama, H. R., Permana, R. B., & Afriansyah, A. (2024). Strengthening Indonesia's Strategic Trade Management Regulation Against Proliferation of Weapons of Mass Destruction. *Brawijaya Law Journal: Journal of Legal Studies*, 11(1), 1-26.
- Quezada, L. E., Reinaldo, E. A., Palominos, P. I., & Oddershede, A. M. (2019). Measuring performance using SWOT analysis and balanced scorecard. *Procedia Manufacturing*, 39, 786–793. <https://doi.org/10.1016/j.promfg.2020.01.430>
- Rangkuti, F. (2016). *Analisis SWOT: Teknik Membedah Kasus Bisnis*. PT Gramedia.
- Salusu, J. (2015). *Pengambilan Keputusan Strategik : untuk Organisasi Publik dan Organisasi Nonprofit*. Grasindo.
- Trein, P., Meyer, I., & Maggetti, M. (2019). The integration and coordination of public policies: A systematic comparative review. *Journal of Comparative Policy Analysis: Research and Practice*, 21(4), 332–349. <https://doi.org/10.1080/13876988.2018.1496667>
- Wangen, G., Hallstensen, C., & Snekkenes, E. (2018). A framework for estimating information security risk assessment method completeness: Core Unified Risk Framework, CURF. *International Journal of Information Security*, 17(6), 681–699. <https://doi.org/10.1007/s10207-017-0382-0>
- Wardana, M. F. K., & Firmansyah, A. (2025). Strengthening regional revenue through governance and strategic local spending synergy. *Riset*, 7(1), 078–092. <https://doi.org/10.37641/riset.v7i1.2590>
- Wehrich, H. (1982). The TOWS matrix—A tool for situational analysis. *Long Range Planning*, 15(2), 54–66. [https://doi.org/10.1016/0024-6301\(82\)90120-0](https://doi.org/10.1016/0024-6301(82)90120-0)