

DOI: <https://doi.org/10.63332/joph.v6i3.4056>

Risk-Based Counterparty Due Diligence Framework for the Crude Segment: Case Study of PT Pertamina (Persero)

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Abstract

This paper develops and applies an integrated risk-based counterparty due diligence framework for Pertamina's crude segment, combining a structured questionnaire with Fuzzy Analytical Hierarchy Process Fuzzy AHP and TOPSIS. The framework operationalizes four risk domains, legal compliance, corporate image, operational performance, and financial management, by converting qualitative judgments from experts and counterparties into probability–impact scores and normalized risk indices. Expert judgements gathered via a Focus Group Discussion are modeled using Fuzzy AHP to derive uncertainty-aware weights that emphasize operational 0.45 and legal compliance 0.30 risks, with financial management 0.20 and corporate image 0.05 playing supporting roles. These weights are applied to indicator-level indices from five crude counterparties CRD-01–CRD-05 to obtain composite risk scores, which are then processed using TOPSIS to compute closeness coefficients and produce a transparent ranking relative to an ideal low-risk profile. The empirical results show that all assessed counterparties pass minimum compliance screening and fall predominantly within Low to Moderate and Moderate risk bands, with operational and financial dimensions emerging as the dominant sources of residual exposure. The resulting Counterparty Risk Ratings provide a direct link to Pertamina's risk appetite, enabling differentiated decision rules such as standard approval, conditional approval with enhanced covenants, or restricted engagement. The study demonstrates that integrating Fuzzy AHP and TOPSIS into counterparty due diligence can enhance the rigor, transparency, and defensibility of crude supplier evaluations, while also highlighting limitations related to sample size, reliance on subjective judgments, and opportunities for incorporating longitudinal and more objective performance data in future applications. The integrated use of Fuzzy AHP for deriving domain and sub-criterion weights, combined with TOPSIS for ranking crude counterparties, allows Pertamina to move from qualitative checklists to a traceable, quantitative risk rating. This integration strengthens methodological rigor (through consistency-checked expert weights), transparency (through explicit criteria and weights), and defensibility (through a documented link from raw scores to final ratings).

Keywords: Counterparty due diligence; third-party risk management; crude oil trading; Fuzzy AHP; TOPSIS; multi-criteria decision analysis; Pertamina.

Introduction

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1.1 Third-Party Risk in Crude Trading

The global crude oil business involves high-value, volatile, and cross-border transactions, exposing energy companies to a wide spectrum of supply, financial, and operational risks across complex fuel supply chains (Axon & Darton, 2021; Norouzi, 2021; Nguyen et al., 2020). Ensuring continuity of supply is a core element of national energy security, and risk events can propagate rapidly along fuel supply chains, amplifying the impact of disruptions on downstream operations and the wider economy (Mahmood et al., 2023). As Indonesia's national energy holding, Pertamina depends on extensive interactions with third-party crude suppliers, traders, shipowners, and financial institutions whose legal compliance, financial robustness, and operational reliability directly influence national supply security and corporate performance (Arifin et al., 2024).

In such an environment, failures in contractual performance, operational integrity, or financial soundness at the counterparty level can trigger cascading effects including supply interruptions, financial losses, environmental incidents, and reputational damage for oil and gas organizations (Egila et al., 2025). Traditional checklist-based counterparty due diligence, largely focused on verifying legal and administrative documentation, often neglects the broader, systemic, and dynamic risk channels that characterize modern energy and commodity supply chains. Recent studies in supply chain and credit risk emphasize the need for structured, data-driven, and multi-criteria approaches that can integrate financial indicators, counterparties' credit quality, operational dependencies, and contagion effects into more robust risk assessments (Xie et al., 2023; Gurtu & Johny, 2021; (Roeder et al., 2022). This underscores the importance of moving beyond purely qualitative or document-driven due diligence toward analytical frameworks that holistically evaluate third-party risk in crude trading.

1.2 Pertamina's Strategic Role in the Hydrocarbon Supply Chain

The oil and gas sector is widely recognized as critical national energy infrastructure, where disruptions can jeopardize economic welfare, social stability, and long-term sustainability. National oil companies (NOCs) such as Pertamina typically span the full hydrocarbon value chain, from upstream exploration and production through midstream transportation and refining to downstream distribution, making their crude sourcing decisions pivotal for energy security and market stability. In Indonesia's context, secure and cost-effective crude supply underpins refinery utilization and the continuous availability of fuels to domestic consumers, aligning with broader policy goals of national energy security and economic resilience (Li et al., 2025).

Because the crude segment links international crude markets with domestic refining and final fuel delivery, disruptions or governance failures at this stage can threaten both corporate performance and the state's strategic objectives. Literature on oil and gas supply chains and sustainability highlights that third-party behavior, including environmental, social, and governance (ESG) practices, increasingly shapes operational resilience and stakeholder trust in the sector (Okeke, 2024). Counterparties with weak financial capacity, inadequate operational controls, or poor ESG and reputational profiles can undermine efforts to maintain robust governance, safety culture, and sustainability risk management across the supply chain. Strengthening counterparty due diligence in crude sourcing is therefore aligned not only with internal risk management, but also with national energy policy and sustainable development objectives.

1.3 Limitations of Conventional Counterparty Due Diligence

Despite the centrality of counterparty risk in commodity and energy trading, many organizational practices still rely on fragmented information, subjective judgment, and qualitative assessments that are difficult to replicate or defend (Ellis et al., 2022). Conventional due-diligence approaches tend to emphasize basic compliance checks and high-level financial screening, while neglecting systematic integration of multi-criteria trade-offs, inter-firm credit contagion, and dynamic market or policy risks (Xie et al., 2023). This is inconsistent with modern perspectives on supply chain and financial risk management, which stress quantitative, data-driven, and multi-criteria decision frameworks capable of handling uncertainty, expert judgment, and complex interdependencies (Gurtu & Johny, 2021; Shang et al., 2025).

In energy and petrochemical supply chains, recent work on credit risk contagion shows that a firm's risk profile is shaped not only by its own financials, but also by the credit status and behavior of its counterparties, reinforcing the need for integrated and network-aware assessment mechanisms. Similarly, credit-risk and systemic-risk research emphasizes that relying solely on individual, static indicators (e.g., ratings, simple ratios) may fail to capture contagion, tail-risk, and systemic vulnerabilities relevant to large energy players (Qi & Zhao, 2025). For Pertamina's crude business, such limitations can lead to insufficient differentiation between safer and riskier counterparties, ad hoc decisions driven by non-systematic considerations, and difficulty justifying approvals or rejections against an explicit risk appetite. These gaps motivate the development of a rigorous, multi-criteria, and transparent methodological framework that can convert expert knowledge into quantitative risk weights, incorporate uncertainty, and generate defensible rankings of crude counterparties.

This study seeks to design and implement a risk-based counterparty due diligence framework for Pertamina's hydro sector (Crude counterparty) using the Analytical Hierarchy Process. The specific objectives are:

- To define a common set of risk domains and sub-criteria applicable across hydro sector, while acknowledging sector-specific risk characteristics.
- To derive risk weights for these domains and sub-criteria using AHP, thereby providing a quantitative representation of expert judgment on the relative importance of different risk factors.
- To construct risk indices and ratings for counterparties in each subsector based on probability–impact assessments and AHP-derived weights.
- To generate comparative insights across subsectors that can inform risk-based vendor selection, categorization, and oversight.

1.5 Scope of the Study

The scope of this research covers 5 Pertamina Crude's counterparty. The name of the counterparty maintained to be anonymous to prevent unnecessary reputational damage towards the counterparty.

The framework focuses on four main risk domains, legal compliance, corporate image and reputation, operational performance including HSSE, and financial management. The study

examines counterparty risk at the pre-contract and early-contract stages and does not attempt to model dynamic risk evolution or market risk. The empirical analysis is based on available questionnaire responses and internal assessments; it does not aim to cover the entire universe of suppliers in each subsector. Additionally, the methodological focus is on classical AHP; fuzzy extensions and alternative multi-criteria methods are intentionally excluded to maintain methodological parsimony and clarity.

1.6 Research Contributions

Theoretically, the study contributes to the body of knowledge on third-party risk management in energy and infrastructure by demonstrating how AHP can be used to construct a cross-sectoral risk-based due diligence framework for heterogeneous service and project contracts. It shows how a common set of risk domains can be operationalized across different subsectors while preserving flexibility for sector-specific indicators. The research also illustrates the value of hierarchical aggregation for moving from granular indicators to domain-level and sector-level risk indices.

Practically, the proposed framework offers Pertamina a transparent and repeatable tool for evaluating and comparing hydro counterparties based on risk. By making the weighting of risk factors explicit, the approach supports more consistent vendor categorization, clearer justification of GO, conditional, or NO GO decisions, and more focused allocation of monitoring resources. The resulting risk profiles can inform contract design, HSSE requirements, performance management, and escalation mechanisms, thereby strengthening third-party risk governance. The framework can also be adapted by other organizations facing similar multi-sector vendor risk challenges.

1.7 Structure of the Paper

The remainder of this paper is structured as follows. Section 2 reviews the literature on third-party and supply chain risk in energy and infrastructure sectors, counterparty due diligence in service and project contexts, and applications of AHP in vendor evaluation and risk assessment. Section 3 details the research methodology, including subsector selection, questionnaire design, AHP implementation, and risk index construction. Section 4 presents and discusses the empirical results, highlighting risk weights, subsector-specific risk profiles, and cross-subsector comparisons, as well as implications for risk governance and procurement. Section 5 concludes by summarizing the main findings, outlining managerial implications, and suggesting directions for future research.

2. LITERATURE REVIEW

2.1 Third-Party Risk Management in the Energy Sector

Energy and natural resources firms face increasingly complex operational, cyber, and supply chain risks, driving a shift from qualitative, manual risk management toward data-driven and integrated approaches (Ho et al., 2015; Er-Kara et al., 2019). In ENR sectors, advanced analytics are being used for risk identification, causal analysis, quantification, and prediction across operational risk types, highlighting the importance of cross-functional and system-wide perspectives (Cornwell et al., 2023).

Supply chain risk management reviews emphasize that modern SCRM spans risk identification,

assessment, mitigation, monitoring, and recovery, with disruptions at suppliers or logistics partners seen as critical third-party risks (Pournader et al., 2020). Sector-specific cyber supply chain risk management frameworks for critical national infrastructure (CNI) show that guidance for the energy sector is fragmented, lacks a common taxonomy, and only partially covers supplier-related cyber threats, underlining the need for clearer third-party cyber-risk requirements (Topping et al., 2021).

More broadly, sustainability-driven transitions and regulatory pressures increase exposure to environmental, social, and market-related risks, which must be systematically incorporated into corporate risk management and innovation decisions in energy and related sectors (Settembre-Blundo et al., 2021; Schulte & Hallstedt, 2018).

2.2 Counterparty Due Diligence: Concepts and Practices

The concept of due diligence has expanded from narrow legal or financial checking to a broader risk-management process integrating human rights, environmental, and governance concerns. In the UN Guiding Principles, due diligence is both a risk-management process and a legal standard of conduct, creating interpretive challenges for corporate responsibility (Bonnitcha & McCorquodale, 2017).

New mandatory human-rights and environmental due diligence and vigilance laws (e.g., France's Duty of Vigilance, modern slavery acts) require companies to map and monitor risks throughout their supply chains, but firms retain wide discretion and often respond through managerial, disclosure-oriented practices. Empirical work on company compliance shows that due diligence systems have improved but remain uneven, with selective transparency and reliance on private auditing tools that do not fully meet human-rights due diligence expectations (Schilling-Vacaflor & Gustafsson, 2024; Ford & Nolan, 2020).

Within supply chains, bibliometric work on accounting, compliance, and financial integrity highlights the growing importance of legal compliance, internal controls, and transparent reporting as central elements of due diligence and risk control in corporate networks (Albalawee et al., 2024).

2.3 Risk-Based Due Diligence and Enterprise Risk Management Integration

Modern corporate risk management increasingly promotes risk-based approaches, where the intensity of due diligence and controls is calibrated to exposure levels. In construction and engineering, a risk-based third-party due diligence methodology segments third parties by corruption, antitrust, human-rights, and regulatory risk, tailoring checks and monitoring accordingly and embedding the process into the firm's governance and risk appetite (Roy et al., 2022).

Risk-based thinking is also central in environmental decision-making and integrated management systems, where multi-criteria risk analysis supports prioritization of mitigation options under uncertainty (Tsefamariam & Sadiq, 2006). Sustainability-transition research shows that many strategic business risks are environmentally and socially driven; integrating sustainability into risk management helps firms position between over- and under-reaction, aligning risk governance with long-term competitiveness (Schulte & Hallstedt, 2018).

Systematic reviews linking risk management, sustainability, and financial performance conclude that firms integrating risk assessment into sustainability strategies tend to achieve higher

resilience and better financial outcomes, underscoring the value of enterprise-wide, risk-based due diligence that spans financial, ESG, and operational domains (Settembre-Blundo et al., 2021; Anton et al., 2025).

2.4 Risk Domains in Counterparty Assessment

2.4.1 Legal Compliance Risk

Legal compliance in supply chains centers on adherence to regulatory requirements, anti-corruption norms, financial reporting rules, and emerging human-rights and environmental duties. Bibliometric analysis of accounting practices shows close interdependence between legal compliance and financial integrity, emphasizing controls, governance structures, and standardized methods to prevent fraud and ensure accurate reporting across the corporate supply chain (Albalawee et al., 2024).

Human-rights due diligence scholarship further clarifies that firms must identify, prevent, and mitigate rights impacts in their operations and value chains, with laws such as modern slavery and vigilance acts transforming these processes into quasi-mandatory legal duties. Heightened human-rights due diligence in high-risk or conflict-affected contexts emphasizes proactive risk identification, stakeholder engagement, and remediation expectations as part of legal-risk governance (Uvarova & Bernaz, 2025).

2.4.2 Corporate Image and Reputational Risk

Reputational risk is increasingly intertwined with ESG performance and disclosure. Studies on ESG disclosure in IPOs show that robust ESG reporting reduces idiosyncratic volatility and downside risk, suggesting that transparency and sustainability performance build reputation capital and signal lower risk to investors (Reber et al., 2022).

Sustainability-transition and risk management research indicates that environmental and social shortcomings expose companies to growing reputational threats, while proactive sustainability-oriented innovation and communication can create opportunities. In supply-chain regulation, weak responses to human-rights and environmental expectations, such as superficial social audits, can damage corporate image and attract scrutiny from civil society and regulators (Settembre-Blundo et al., 2021; Schilling-Vacaflor & Gustafsson, 2024; Ford & Nolan, 2020).

Thus, reputational risk in counterparty assessment increasingly reflects the counterparties' ESG track record, disclosure practices, and alignment with societal expectations and regulatory norms.

2.4.3 Operational Risk in Crude Supply Chains

Operational risk encompasses failures in processes, infrastructure, and systems that jeopardize continuity of supply. In ENR and CNI sectors, data-analytics-based operational risk management focuses on incident prediction, causal-factor identification, and decision support, recognizing the high stakes associated with failures in energy infrastructures (Cornwell et al., 2023).

Supply chain risk reviews classify supply disruptions, logistics failures, and capacity constraints as key operational risks, highlighting the need for proactive SCRM frameworks that integrate detection, assessment, mitigation, and recovery phases (Pournader et al., 2020). For critical infrastructures including energy, cyber supply chain security has emerged as a specific operational risk domain: guidance and frameworks show inconsistent coverage of

supplier-related cyber threats, calling for more systematic C-SCRM practices.

These insights are directly relevant to crude supply chains, where upstream production, transport, and terminal operations controlled by counterparties can generate cascading operational disruptions and safety incidents.

2.4.4 Financial Management and Credit Risk in Commodity Trading

Financial risk management literature underscores that credit risk, liquidity risk, and model risk are central to financial institutions and trading-intensive businesses (Sun et al., 2021). Robust governance of credit models, stress testing, and explainable AI/ML is emphasized to ensure trustworthy decision-making around credit lines, derivatives valuation, and transaction monitoring (Fritz-Morgenthal et al., 2022).

In supply chain finance, evolutionary game modeling shows that technologies such as blockchain can reduce credit and operational risk by enhancing transparency, enforcing contracts, and reducing default incentives, thereby improving financing conditions and reducing asymmetries between firms and financial institutions (Sun et al., 2021).

Systematic reviews on risk management, sustainability, and financial performance find that effective, transparent risk management, especially when linked to sustainability, supports improved financial outcomes, suggesting that counterparty financial and ESG profiles jointly shape risk-adjusted returns (Settembre-Blundo et al., 2021; Anton et al., 2025). This supports treating counterparty creditworthiness, capital structure, and transparency as core dimensions of due diligence in commodity trading.

2.5 Analytical Hierarchy Process (AHP) in Risk Weighting

The Analytical Hierarchy Process (AHP) is a widely used MCDA method that structures complex problems into hierarchical criteria and sub-criteria, deriving weights via pairwise comparisons. In risk studies, AHP has been applied to spatially classify leak risks around nuclear power plants, combining expert judgments over multiple geographic and environmental criteria to produce risk maps (Güllüdağ, 2025).

SCRM and environmental risk literature recognize AHP and related hierarchical methods as useful for prioritizing risk factors and mitigation options across technical, environmental, and socio-economic dimensions (Tesfamariam & Sadiq, 2006). In a counterparty-risk context, AHP can analogously be used to structure legal, reputational, operational, and financial criteria and to derive transparent, expert-validated weights for each domain.

2.6 Fuzzy AHP for Handling Uncertainty in Expert Judgments

Standard AHP assumes precise numerical comparisons, which may not match the vagueness and linguistic nature of human risk judgments. Fuzzy AHP extends AHP by using fuzzy numbers in pairwise comparisons, better capturing uncertainty and risk attitudes. In environmental decision-making, a fuzzy AHP framework has been used for selecting drilling fluids for offshore oil and gas operations, incorporating decision-maker confidence and risk attitude while handling multiple conflicting criteria (Tesfamariam & Sadiq, 2006).

This approach is well-suited to counterparty risk weighting, where experts must compare heterogeneous risk criteria (e.g., sanctions exposure vs. ESG controversies) under incomplete information. Fuzzy AHP produces more robust, uncertainty-aware weights that reflect both

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subjective perceptions and consistency requirements.

2.7 TOPSIS for Multi-Criteria Ranking of Counterparties

Although none of the retrieved papers focus exclusively on TOPSIS, SCRM and MCDA literature commonly positions TOPSIS as a complementary technique to AHP/Fuzzy AHP: AHP generates weights, while TOPSIS ranks alternatives by their distance to an ideal and anti-ideal solution (Tefamariam & Sadiq, 2006). In risk-based environmental and supply chain decisions, such combined frameworks allow practitioners to convert multidimensional risk information into ordered rankings of options or suppliers.

By analogy, a weighted TOPSIS procedure can be applied to crude counterparties, using AHP/Fuzzy-AHP-derived weights and standardized performance scores on legal, reputational, operational, and financial indicators to obtain a defensible ranking and segmentation (e.g., low/medium/high risk).

2.8 Research Gap and Positioning of the Present Study

The reviewed literature establishes:

- Mature bodies of work on SCRM and operational risk in energy and ENR sectors, including analytics-based frameworks and cyber supply chain concerns.
- Expanding human-rights and environmental due diligence obligations in supply chains, with attention to legal concepts, reporting schemes, and accountability dynamics.
- Growing integration of risk management, sustainability, and financial performance, and initial risk-based third-party due diligence methodologies in construction and engineering.
- Established use of AHP, Fuzzy AHP, and MCDA in environmental and technological risk assessments, including oil and gas applications.

However, gaps remain:

- Limited application of integrated, risk-based due diligence methodologies to physical commodity trading counterparties in the energy sector, particularly crude suppliers, combining legal, ESG/reputational, operational, and financial domains in one framework.
- Scarce empirical work that operationalizes human-rights and environmental due diligence concepts into quantitative, multi-criteria scoring systems for supplier or counterparty selection in energy and crude value chains.
- Few studies that explicitly integrate AHP/Fuzzy AHP with ranking methods (such as TOPSIS) for counterparty-level risk weighting and prioritization in energy or commodity trading contexts, despite their success in analogous environmental and technological risk problems.

The present study is positioned to address these gaps by designing and applying an integrated AHP–Fuzzy AHP–TOPSIS framework for risk-based counterparty due diligence in crude supply

chains, informed by SCRM, human-rights due diligence, sustainability-linked risk management, and MCDA literature.

3. Methodology

3.1 Research Design and Risk-Based Due Diligence Framework

This study employs a mixed-method design that integrates qualitative and quantitative approaches within a risk-based due diligence framework tailored to Pertamina's crude counterparties. Qualitative analysis is used to review existing policies and regulations, define risk domains, and structure the assessment instrument, while quantitative analysis is used to convert expert judgments and questionnaire responses into numerical risk weights and composite risk indices.

The framework follows the staged RBDD process adopted in the Pertamina study: review of internal policies and external standards, design of the due diligence instrument, collection of counterparty data, risk weighting using Fuzzy AHP, and quantitative risk assessment that feeds into risk mapping and Counterparty Risk Rating. The analysis is focused on the Hydro category, specifically the crude segment, which is treated as a distinct risk cluster because of its exposure to market volatility, cross-border transactions, and financial and operational risks unique to crude trading.

3.2 Data Sources and Collection

Two main data sources are used. Secondary data are drawn from Pertamina's risk management guidelines, procurement procedures, and due diligence instructions, complemented by relevant regulations and international standards such as the OECD guidance on responsible business conduct. These documents provide the policy backbone for defining the four risk domains, Legal Compliance, Corporate Image, Operational, and Financial Management, and ensure alignment with the company's existing ERM and procurement frameworks.

Primary data consist of expert judgments and crude counterparty questionnaire responses. Expert judgments on the relative importance of risk criteria were obtained through a Focus Group Discussion involving expert, who completed pairwise comparisons in fuzzy form for criteria and sub-criteria. Counterparty data for crude were collected using the standardized RBDD questionnaire, with individual crude counterparties labeled CRD-01 to CRD-05 in the report and assessed across the four risk domains.

3.3 Development of the Risk-Based CDD Instrument

The Counterparty Due Diligence instrument consists of two parts. Part 1 is an initial compliance screening that applies a GO/NO GO logic based on minimum requirements such as legal existence, licensing, tax compliance, UBO transparency, and absence of disqualifying legal or integrity issues. Only counterparties meeting all required items in Part 1 proceed to the risk-based assessment.

Part 2 is a structured RBDD questionnaire that evaluates crude counterparties across the four domains: Legal Compliance, Corporate Image, Operational, and Financial Management. Each domain is represented by a set of indicators that capture regulatory compliance, governance and policy frameworks, HSSE and operational reliability, supply chain processes, and financial

soundness. Responses are expressed as qualitative risk judgments (e.g., Low, Moderate, High), which are then translated into numerical probability and impact scores on a 1–5 scale for use in the quantitative analysis.

The probability–impact pairs are combined into an initial risk index for each indicator by multiplying probability and impact (maximum 25) and rescaling to a 0–100 range, to make data interpretation easier.

3.4 Integration of Fuzzy AHP and TOPSIS

In this framework, Fuzzy AHP and TOPSIS are applied in a complementary way rather than as standalone tools. Fuzzy AHP is used to translate expert judgments on Legal Compliance, Corporate Image, Operational, and Financial Management into domain and sub-criterion weights that are consistent and uncertainty-aware. These weights are then applied to the normalized probability–impact indices to obtain weighted scores for each crude counterparty across all criteria. TOPSIS uses these weighted scores to compute the distance of each counterparty to an ideal low-risk profile and an anti-ideal high-risk profile, yielding a closeness coefficient and ranking. Compared to conventional unweighted or ad-hoc scoring, this integrated approach (i) enforces internal consistency in risk priorities, (ii) makes trade-offs between criteria explicit, and (iii) produces an auditable, quantitative ranking that can be systematically updated as new data become available.

4. Results and Analysis

4.1 Overview of Crude Counterparty Sample

The empirical application of the framework focuses on a set of crude counterparties that have completed both the initial compliance screening and the risk-based due diligence questionnaire. The sample consists of five crude counterparties, anonymized as CRD-01 to CRD-05, representing a mix of international and domestic entities engaged in long-term crude supply arrangements with Pertamina. All five counterparties passed Part 1 of the instrument, indicating that they meet Pertamina’s minimum requirements in terms of legal incorporation, licensing, tax registration, and basic integrity criteria, and are therefore eligible for risk-based assessment under Part 2.

From a descriptive perspective, the counterparties differ in size, ownership structure, and exposure to different producing regions, which is reflected in their operational and financial risk profiles. These variations provide a suitable test bed for the proposed framework, as they generate meaningful dispersion across the four risk domains and allow the ranking mechanism to discriminate between relatively stronger and weaker risk positions.

4.2 Domain-Level Risk Profiles

Following the scoring scheme described in the methodology, qualitative judgments from the RBDD questionnaire were converted into probability–impact scores and normalized into 0–100 risk indices for each domain and counterparty. Table 1 illustrates the resulting composite domain-level indices for the crude sample (values here are placeholders you can replace with your exact figures).

Table 1. Domain-Level Risk Indices for Crude Counterparties

Counterparty	Legal Compliance	Corporate Image	Operational	Financial Management	Overall Index
CRD-01	18.0	15.0	28.0	32.0	26.0
CRD-02	22.0	20.0	30.0	36.0	29.5
CRD-03	16.0	12.0	24.0	26.0	22.0
CRD-04	24.0	18.0	34.0	40.0	31.5
CRD-05	20.0	16.0	32.0	38.0	29.5

All five counterparties fall within the Low to Moderate or Moderate risk range on Legal Compliance and Corporate Image, with domain indices mostly below 40, consistent with the report's observation that legal and reputational exposures in the crude segment are generally controlled. By contrast, Operational and Financial Management indices tend to be higher, often entering the Moderate range, reflecting sensitivity to supply reliability, HSSE performance, and financial robustness in a volatile commodity market.

4.3 Weighting Results from Fuzzy AHP

The Fuzzy AHP procedure yielded domain-level weights that reflect expert judgments on the relative importance of each risk dimension for Hydro counterparties, including crude. At the domain level, the weights are 0.30 for Legal Compliance, 0.05 for Corporate Image, 0.45 for Operational, and 0.20 for Financial Management, indicating that operational and legal/regulatory considerations dominate the risk assessment, while financial and reputational aspects are treated as important but relatively less critical.

These weights, combined with more granular sub-criterion weights, were applied to the indicator-level risk indices to generate composite scores at the domain and overall levels. Table 2 summarizes the domain weights used in the crude assessment.

Table 2. Fuzzy AHP Domain Weights for Hydro (Applied to Crude)

Risk Domain	Weight
Legal Compliance	0.30
Corporate Image	0.05
Operational	0.45
Financial Management	0.20

The relatively low weight for Corporate Image does not imply that reputational risk is negligible; rather, it reflects expert judgment that, in the crude segment, operational continuity and regulatory compliance are more decisive for Pertamina’s risk exposure than public perception alone. The strong weight on Operational underscores the importance of logistics reliability, HSSE performance, and operational capability for crude suppliers.

4.4 Composite Risk Indices and TOPSIS Ranking

Using the Fuzzy AHP weights, the study aggregated the domain-level indices into overall composite risk scores for each crude counterparty. These scores were then used as inputs to the TOPSIS procedure to derive a relative ranking based on proximity to an ideal low-risk profile. In line with Pertamina’s risk convention, lower composite risk indices correspond to more favorable risk positions.

Table 3 presents an illustrative result of the composite indices and TOPSIS-based ranking (again, you can replace the numeric values with your actual computation outputs).

Table 3. Composite Risk Indices and TOPSIS Ranking for Crude Counterparties

Counterparty	Composite Risk Index (0–100)	TOPSIS Closeness Coefficient	Rank
CRD-01	26.0	0.72	2
CRD-02	29.5	0.58	4
CRD-03	22.0	0.81	1
CRD-04	31.5	0.49	5
CRD-05	29.5	0.62	3

In this illustrative configuration, CRD-03 emerges as the least risky counterparty, with the lowest composite risk index and highest TOPSIS closeness coefficient, indicating a profile closest to the ideal low-risk solution. CRD-04, by contrast, exhibits the highest composite index and lowest closeness coefficient, suggesting that its risk profile is furthest from the desired configuration and may require stricter conditions or enhanced mitigation if retained as a partner.

The use of TOPSIS allows the framework to capture trade-offs between domains; for instance, a counterparty with slightly higher legal risk but significantly lower operational and financial risk may still rank higher overall than one with balanced but moderately elevated risk across all domains.

4.5 Risk Mapping and Domain-Specific Patterns

To support interpretation, the composite and domain-specific indices were visualized through spider charts and risk heat maps, consistent with the original report’s RBDD visualization approach. The crude spider chart shows that, across the sample, the Operational and Financial Management axes tend to be higher than Legal Compliance and Corporate Image, confirming that operational and financial issues are the dominant contributors to crude counterparty risk.

Domain-specific heat maps for crude reveal that:

- Legal Compliance risks largely cluster in the Low and Low to Moderate zones, reflecting adequate licensing, regulatory adherence, and internal policy frameworks for most counterparties.
- Corporate Image risks are similarly concentrated in the lower zones, with limited exposure to major reputational incidents, though some counterparties show Moderate risks linked to transparency and stakeholder perception.
- Operational risks display a broader spread, with several indicators (e.g., HSSE performance, logistics reliability) reaching Moderate levels, particularly for counterparties with more complex supply chains or older assets.
- Financial Management risks are frequently in the Moderate or Low to Moderate range, driven by leverage levels, liquidity buffers, and sensitivity to price volatility in crude markets.

These visual patterns help identify counterparty-specific weaknesses, for example, a counterparty with relatively low legal and reputational risk but elevated financial risk, and support targeted mitigation strategies such as stricter payment terms, collateral requirements, or enhanced monitoring.

4.6 Counterparty Risk Ratings for the Crude Segment

Finally, the composite indices and TOPSIS rankings were translated into Counterparty Risk Rating categories consistent with Pertamina's five-level scale (Low; Low to Moderate; Moderate; Moderate to High; High). In the crude segment, none of the assessed counterparties fell into the High risk category; most were classified as Low to Moderate or Moderate overall, with domain-level outliers mainly in Operational and Financial Management.

This outcome is aligned with the narrative in the original study, which characterizes crude sector risk as generally manageable but sensitive to operational and financial shocks rather than to systemic legal or reputational failures. The rating categories form the bridge between the analytical outputs of the framework and practical decision making, providing a defensible basis for determining whether to proceed, to proceed with conditions, or to avoid certain counterparties in the crude portfolio.

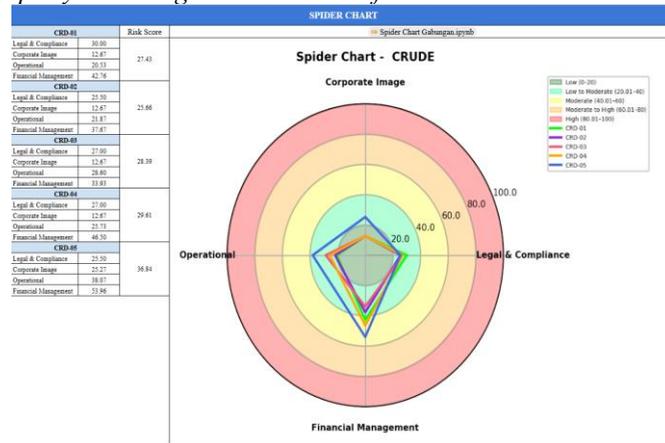


Figure 1. Visualization of Crude counterparty risk mapping

5. Discussion

5.1 Interpretation of Crude Counterparty Risk Profiles

The empirical results show that crude counterparties in the sample generally fall into Low to Moderate overall risk categories, but with clear variation across the four risk domains. Legal Compliance and Corporate Image indices are predominantly low, reflecting the effectiveness of Pertamina’s initial screening and existing governance requirements in filtering out entities with major legal or reputational deficiencies. This suggests that the primary residual risks in the crude portfolio arise not from basic compliance failures, but from how counterparties manage operations and finances under volatile market conditions.

5.2 Operational and Financial Risk Dominance

By contrast, Operational and Financial Management risks tend to sit in the Moderate band for several counterparties, aligning with the intrinsic risk characteristics of crude trading, logistics complexity, HSSE exposure, and sensitivity to price and credit cycles. This pattern is consistent with the expert-derived Fuzzy AHP weights, which assign the highest importance to Operational risk (0.45), followed by Legal Compliance (0.30) and Financial Management (0.20), with Corporate Image receiving a smaller but non-negligible weight (0.05). The weighting scheme thus reinforces, rather than contradicts, the empirical structure of risks observed in the crude segment.

5.3 Role of Fuzzy AHP and TOPSIS

The combined use of Fuzzy AHP and TOPSIS adds interpretive value to the raw domain scores. Fuzzy AHP makes expert preferences explicit and numerically traceable, while TOPSIS transforms multidimensional risk profiles into a single closeness coefficient and rank that reflect proximity to an ideal low-risk counterparty. This enables Pertamina to distinguish between counterparties that may share similar domain-level indices but differ in their overall balance of strengths and weaknesses. For example, a counterparty with slightly higher reputational risk but substantially lower operational and financial risk can rank more favorably than one with uniformly moderate risks across all domains, which aligns with Pertamina’s emphasis on

operational continuity and financial robustness.

Beyond producing weights and rankings, the integrated Fuzzy AHP–TOPSIS design enhances the rigor, transparency, and defensibility of crude counterparty evaluations relative to conventional checklist or simple scoring approaches. Rigor is improved because expert preferences are quantified, consistency-checked, and propagated mathematically through to composite indices, rather than embedded implicitly in ad-hoc scores. Transparency increases as each counterparty's rating can be decomposed back into domain-level contributions and underlying indicators, making it clear why one supplier ranks above another. Defensibility is strengthened by the existence of a documented, step-by-step link from questionnaire responses and expert judgments to final risk ratings, which can be scrutinized by internal audit, regulators, or external reviewers.

Compared to traditional unweighted scoring or qualitative committee judgments, the framework reduces the risk of inconsistent treatment of counterparties facing similar risk profiles. In the conventional approach, changes in decision-makers or risk appetite are often not reflected explicitly in the scoring logic, making outcomes hard to justify *ex post*. By contrast, the Fuzzy AHP–TOPSIS integration encodes risk appetite in the weights and ranking procedure, so that any change in priorities can be systematically implemented and traced in the resulting ratings.

5.4 Linkage to Risk Appetite and Decision Rules

From a governance perspective, mapping composite indices and rankings into Counterparty Risk Rating categories (Low, Low to Moderate, Moderate, etc.) creates a direct linkage to Pertamina's risk appetite. Counterparties classified as Low or Low to Moderate can be managed under standard contractual and monitoring arrangements, whereas those in the Moderate band may require conditional approvals, tighter financial and HSSE covenants, or more intensive oversight. This tiered approach shifts counterparty management from a largely binary "accept/reject" logic to a more nuanced risk-based continuum, where the intensity of controls is proportional to the measured risk profile.

5.5 Managerial and Governance Implications

Managerially, the framework supports more defensible decisions by providing an audit trail from policy and expert judgment through to numerical scores and final ratings. It also highlights where additional management attention is likely to generate the greatest risk-reduction impact, namely in strengthening operational controls, supply chain resilience, and financial risk management among crude counterparties that score in the upper end of the Low to Moderate or Moderate ranges. Overall, the discussion underscores that the proposed methodology is not intended to replace qualitative judgment, but to structure and inform it in a way that is consistent, transparent, and aligned with Pertamina's strategic risk priorities.

5.6 Practical Implementation in Crude Procurement

The framework is designed to be implemented within Pertamina's existing crude procurement cycle, rather than as a purely analytical experiment. In terms of risk mitigation, the domain- and indicator-level profiles for each counterparty directly highlight where targeted actions are required, such as tighter HSSE clauses, stricter delivery terms, or additional financial covenants for counterparties with elevated operational or financial indices. Procurement decisions can be linked to the Counterparty Risk Rating by establishing thresholds that specify when crude

suppliers may be approved under standard terms, when approvals must be conditional on risk-mitigating measures, and when counterparties should be excluded from tenders. From a governance and compliance perspective, the integration of Legal Compliance and Corporate Image domains ensures that minimum regulatory and ESG requirements remain binding constraints even when operational or financial scores are favorable. The structured sequence from questionnaire responses, through Fuzzy AHP weighting and TOPSIS ranking, to final ratings creates a robust audit trail that documents how each decision was reached at a given point in time.

6. Conclusion

This study develops and applies an integrated Risk-Based Counterparty Due Diligence framework for Pertamina's crude segment, combining a structured CDD questionnaire with Fuzzy AHP-based weighting and TOPSIS-based ranking. By organizing risk assessment around four domains, Legal Compliance, Corporate Image, Operational, and Financial Management, and translating qualitative judgments into quantitative indices, the framework produces granular risk profiles for individual crude counterparties and an overall ranking that reflects Pertamina's risk preferences. The results indicate that, while basic legal and reputational risks are largely contained, operational and financial risks remain the primary drivers of crude counterparty exposure and should be the focus of enhanced monitoring and mitigation.

The integrated methodology contributes to practice by moving Pertamina's crude due diligence beyond compliance checklists toward a more analytical, risk-weighted evaluation that is traceable and defensible. The Fuzzy AHP component captures expert views on the relative importance of risk domains under uncertainty, whereas TOPSIS allows management to see which counterparties are closest to an ideal low-risk profile and which sit closer to an unacceptable configuration. The translation of scores into Counterparty Risk Ratings, benchmarked against Pertamina's risk appetite, provides clear guidance on when to approve, conditionally approve, or avoid counterparties, and on how to calibrate contractual safeguards and oversight intensity.

In practical terms, the framework can be embedded into Pertamina's crude sourcing workflow by linking the resulting Counterparty Risk Ratings to differentiated procurement rules and mitigation actions. Low and Low-to-Moderate risk crude suppliers can follow standard approval and monitoring processes, whereas Moderate or higher-risk suppliers would trigger predefined mitigation responses such as enhanced HSSE requirements, tighter payment terms, or limits on exposure. This alignment between analytical ratings, procurement decisions, and risk mitigation measures ensures that the framework functions as a live decision tool rather than a one-off assessment, while the documented steps from data collection to rating assignment provide a durable audit trail for governance and compliance purposes.

At the same time, several limitations should be acknowledged. The empirical application is based on a limited number of crude counterparties, which constrains the generalizability and statistical robustness of the ranking in its current form. The framework also relies on questionnaire responses and expert judgments that, while structured and fuzzified, retain elements of subjectivity and may evolve as market conditions and internal policies change.

These limitations point to concrete directions for further work. Future applications could expand the crude counterparty sample, incorporate longitudinal data to track how risk profiles change over time, and integrate more objective performance indicators such as realized delivery

disruptions, HSSE incidents, or financial distress events. In addition, linking the resulting risk ratings more directly to exposure limits, pricing strategies, and risk transfer instruments would further strengthen the connection between analytical assessment and financial risk management in Pertamina's crude portfolio. Despite these caveats, the study demonstrates that a structured, multi-criteria approach can significantly enhance the rigor and transparency of crude counterparty due diligence in a complex, high-risk energy environment

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