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Original Article

Enhancing Upstream Productivity in the Natural Gas Supply Chain: A Resource-based View and Transaction Cost Economics Perspective on Performance-based contracting at an Indonesian Private Oil and Gas Company

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Abstract: *The Indonesian upstream oil and gas sector faces significant productivity challenges stemming from market volatility, complex logistics, and heavy regulatory oversight. This study investigates strategies for enhancing supply chain productivity at PT XYZ Energi, a large private Indonesian oil and gas company, by applying the theoretical lenses of the Resource-Based View (RBV) and Transaction Cost Economics (TCE) to evaluate the effectiveness of the company's current transactional contracting model. A qualitative, descriptive case study design was conducted in two primary phases: first, content analysis of secondary corporate data and a semi-structured interview with a key internal expert to identify structural supply chain bottlenecks; and second, the Analytic Hierarchy Process (AHP) and Game Theory to formalize the expert's qualitative judgments mathematically and objectively evaluate the strategic utility payoffs of alternative contracting models. The analysis reveals that the current transactional approach traps the company in a sub-optimal Nash Equilibrium, capping total expected utility at 0.775, with high monitoring administrative costs and severe vulnerability to vendor moral hazard; a global sensitivity analysis further exposes a structural break-even point at a 35.20% cost-weight threshold beyond which the system collapses into a low-oversight state. To resolve this strategic deadlock, the study proposes adapting Performance-Based Contracting (PBC), which demonstrates a mathematically dominant strategic payoff of 0.994 a 28.2% optimization leap by shifting operational risk to the vendor, thereby reducing transaction costs while building sustainable, long-term competitive advantage and national vendor capacity.*

Keywords: *Analytic Hierarchy Process, Game Theory, Performance-Based Contracting, Procurement, Resource-Based View, Supply Chain Management, Transaction Cost Economics, Upstream Oil and Gas.*

I. INTRODUCTION

The global oil and gas industry contributed nearly 31% of global energy consumption in 2022 (IEA, 2023), yet extreme price volatility, geopolitical risk, demand shocks, and energy transition pressures increasingly challenge its stability. Brent crude prices swung from USD 115/barrel in 2014 to USD 26/barrel in 2016 before surging above USD 100/barrel in 2022, while the COVID-19 pandemic briefly drove West Texas Intermediate futures into negative territory. This persistent volatility makes the long-term capital planning that upstream projects require exceptionally difficult. Indonesia remains highly dependent on fossil fuelscoal (37%), oil (31%), and natural gas (19%) dominated the 2022 primary energy mix (MEMR, 2023)and the government targets 1 million barrels of oil per day and 12 billion standard cubic feet of gas per day by 2030 (SKK Migas, 2023), demands that cannot be met without efficient procurement systems and stronger private sector participation.

Within this context, PT XYZ Energi (hereinafter XYZ), one of Indonesia's largest private oil and gas companies, faces four interlocking supply chain challenges: dependency on a limited pool of globally qualified suppliers for critical services; high logistics complexity across remote offshore and onshore assets; a heavy regulatory burden, as procurement under the Production Sharing Contract (PSC) regime is governed by SKK Migas approval cycles and PTK-007 guidelines; and severe input price volatility of up to 30% annually for drilling equipment and services. Compared with global majors that have moved toward performance-based, risk-sharing contract models, XYZ still relies heavily on transactional, lowest-price contracting, which fosters adversarial supplier relationships, discourages innovation, and concentrates delay and cost-overrun risk on the buyer. Industry benchmarks indicate that the average project cycle time from discovery to onstream is roughly seven years against a streamlined best practice of under five, a gap of more than two years that represents a substantial transaction cost attributable to regulatory and contracting friction (SKK Migas, 2021).

This study addresses three research questions: (1) What are the key supply chain challenges in XYZ's upstream operations? (2) How effective are XYZ's current procurement and contracting strategies? (3) How can best-practice contracting strategies, such as Performance-Based Contracting (PBC), be adapted to improve the productivity and resilience of XYZ's upstream supply chain? While prior reports highlight that Indonesian procurement is heavily shaped by local content (TKDN) compliance and supplier risks (Hadju et al., 2023; SKK Migas, 2022), there is a distinct lack of academic research examining how Indonesian private (non-state-owned) oil and gas companies navigate these constraints, and little work that quantitatively formalizes such institutional friction into a strategic contracting decision model. This paper contributes by integrating TCE, RBV, and Principal-Agent Theory with an AHP-driven Game Theory payoff model, providing a traceable bridge from qualitative expert judgment to a formal quantitative evaluation of contracting strategy.

II. LITERATURE REVIEW

A) Supply Chain Management in Oil and Gas

A supply chain is a network of organizations that create and deliver a product from upstream suppliers to downstream customers, and its management involves the integrated coordination of product, information, and financial flows (Pujawan & Mahendrawathi, 2017). In the capital-intensive oil and gas sector, effective SCM is a primary driver of operational efficiency, cost control, and competitive advantage (Marti & Sebrang, 2021). No single SCM paradigm suffices in this environment: Lean SCM maximizes value by eliminating waste but is vulnerable to the high uncertainty of upstream projects (Womack & Jones, 1996; Afolayan & Ogedengbe, 2015); Agile SCM provides responsiveness to unpredictable market and regulatory change (Christopher, 2016; Purwanto & Nurdin, 2020); and Supply Chain Resilience focuses on the capacity to manage risk, absorb disruption, and recoveran emphasis that intensified in Indonesia after the COVID-19 pandemic and can itself become a source of competitive advantage (Sutjipto et al., 2025; Rini, 2021).

B) Procurement and Contracting Theories

Three complementary theories frame procurement as a strategic governance decision. Transaction Cost Economics (TCE) holds that the optimal procurement strategy minimizes the total costs of searching, negotiating, monitoring, and enforcing contracts (Williamson, 1985; Ketokivi & Mahoney, 2020). Upstream projects are characterized by high uncertainty and high asset specificity, creating supplier opportunism risk that simple transactional contracts cannot govern efficiently. The Resource-Based View (RBV) argues that sustained competitive advantage derives from resources that are Valuable, Rare, Inimitable, and Non-substitutable (VRIN) (Barney, 1991; Salmi et al., 2024); collaborative, long-term supplier relationships that secure access to unique capabilities constitute such resources. Principal-Agent Theory (PAT) explains the post-award management problem: information asymmetry and divergent interests between the principal (the operator) and the agent (the contractor) generate moral hazard and heavy monitoring costs under cost-based contracts (Jensen & Meckling, 1976; Eisenhardt, 1989). Performance-Based Contracting (PBC) is PAT's prescriptive solution, aligning incentives by paying for verifiable outcomes such as equipment uptime rather than inputs (Wuyts & Verhoef, 2016). Risk-management best practice in the sector similarly recommends moving from risk-shifting toward strategic risk-sharing executed through long-term, performance-based alliances (Afolayan & Ogedengbe, 2015; ISO 31000, 2018; Tarantola et al., 2021), while sustainability pressures stakeholder accountability, the Triple Bottom Line, and Indonesia's TKDN local content policy extend procurement objectives beyond cost (Freeman, 1984; Elkington, 1997; Febrianti, 2024).

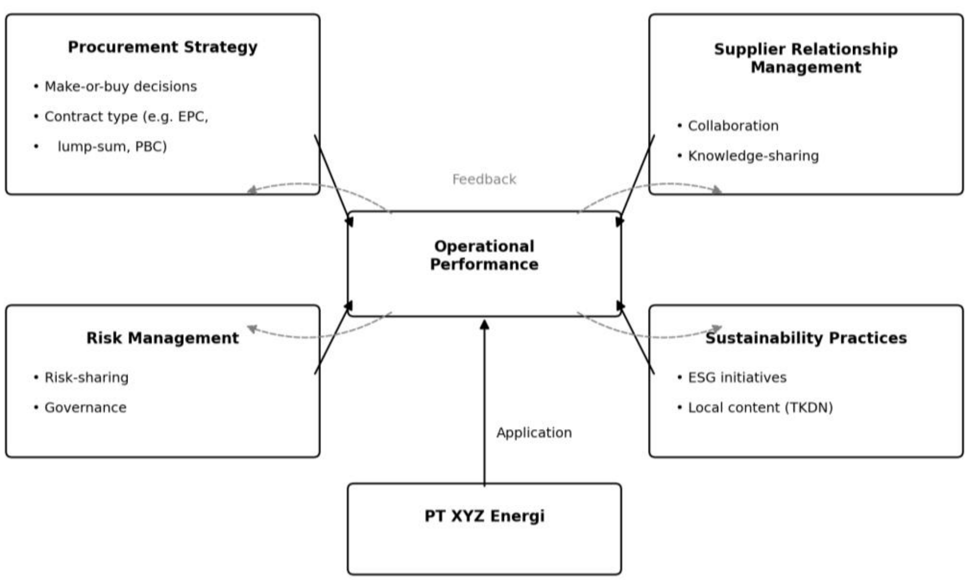

Figure 1. Conceptual framework

C) Analytical Framework

The study's conceptual framework (Figure 1) links four constructs procurement strategy (TCE), supplier relationship management (RBV), risk management, and sustainability practices (Stakeholder Theory/TBL) to operational performance as the dependent variable. To operationalize the framework, these constructs are translated into four decision criteria used in the AHP model: Operational Reliability, Regulatory Compliance, Cost Efficiency, and Vendor Sustainability. Operational performance is then measured as the total expected utility of each contracting strategy in a game-theoretic payoff model, ensuring that the quantitative analysis directly operationalizes the framework. The Analytic Hierarchy Process (Saaty, 1980) provides the structured mechanism for converting expert pairwise judgments into priority weights, and non-cooperative game theory (Nash, 1951) provides the equilibrium logic for evaluating strategic interaction between the operator and its vendors.

III. RESEARCH METHODOLOGY

This study employs a qualitative, descriptive-evaluative case study design (Yin, 2018; Creswell, 2014) focused on a single entity, executed in two primary phases. Phase 1 is diagnostic: primary data from a semi-structured, in-depth interview with a key internal expert a Manager of Category Management with more than 16 years of industry experience and nine years at XYZ is triangulated with secondary data from the company's 2022–2024 Annual and Sustainability Reports and SKK Migas regulatory documents (PTK-007) (Patton, 2015; Sekaran & Bougie, 2016). Qualitative content analysis with deductive theoretical coding (Hsieh & Shannon, 2005; Miles, Huberman, & Saldaña, 2014) maps interview excerpts onto TCE, RBV, and PAT constructs to identify structural bottlenecks (RQ1).

Phase 2 formalizes the expert's judgments quantitatively. First, the AHP (Saaty, 1980) converts pairwise comparisons of the four decision criteria elicited on Saaty's 1–9 scale into priority weights through matrix normalization and row averaging, with judgment consistency verified via the Consistency Index $CI = (\lambda max - n)/(n - 1)$ and Consistency Ratio $CR = CI/RI$ ($RI = 0.90$ for $n = 4$). Second, the AHP weights parameterize a non-cooperative strategic game between XYZ (Principal) and its vendor (Agent) under information asymmetry (Nash, 1951). The utility of each contracting strategy is computed with a weighted utility scoring model, $U = \Sigma\, w_i \cdot P_i$, in which performance scores are not assigned arbitrarily but derived from a Unified Priority Coverage Model: P_i(High Monitoring) = $w_i/wmax$ and P_i(Low Monitoring) = $1 - w_i/wmax$, where wmax is the maximum criterion weight, with cost efficiency scored 0 under High Monitoring (budget exhaustion) and 1 under Low Monitoring (full administrative savings). A global sensitivity analysis then stress-tests each strategy: the weight of each criterion is shifted from 0% to 100% with the remaining weights rescaled proportionally, and the performance scores re-derived at every simulation point from the shifted weight vector, so that both the weights and the performance structure respond dynamically to each scenario (RQ2–RQ3).

IV. RESULTS AND DISCUSSION

A) Baseline Performance and Qualitative Findings

Secondary data confirm that XYZ sustains competitive regional cost leadership unit production cost moved from 6.9/boe (2022) to 8.2/boe (2024) on production of 152–163 moped and repeatedly received SKK Migas Supply Chain Management KPI awards and top TKDN realization recognition. From the RBV perspective, thematic coding identifies two internal capabilities driving productivity: a cohesive, agile SCM team culture and a mature paperless digital repository that functions as a VRIN resource accelerating data retrieval and decision-making. From the TCE perspective, however, productivity is hampered by external process friction: extreme asset specificity (specialized valve components with fabrication lead times of up to six months) and bureaucratic bottlenecks in TKDN verification and PTK-007 approval cycles, which are most acute in EPC projects. From the PAT perspective, the most critical impediment is information asymmetry: local vendors, insulated by protective local content regulation, exhibit moral hazard latent quality failures such as forging defects are often discovered four to five months into a contract, generating costly Non-Productive Time (NPT). These findings answer RQ1: the binding constraints on upstream productivity are institutional and contractual rather than internal-capability deficits.

B) AHP Priority Structure

The expert's pairwise comparison matrix and the derived priority weights are presented in Tables 1 and 2. Vendor Sustainability emerges as the dominant strategic priority (48.0%), followed by Operational Reliability (36.3%), Regulatory Compliance (9.9%), and Cost Efficiency (5.8%)a structure that reflects the national capacity-building mandate embedded in Indonesian upstream governance.

Table 1: Raw Pairwise Comparison Matrix (A)

Criteria	Rel (C1)	Comp (C2)	Cost (C3)	Sust (C4)
Reliability (C1)	1.000	9.000	7.000	0.333
Compliance (C2)	0.111	1.000	3.000	0.200
Cost (C3)	0.143	0.333	1.000	0.200
Sustainability (C4)	3.000	5.000	5.000	1.000
Column Sum	4.254	15.333	16.000	1.733

Table 2: Priority Weights and Consistency Check

Criterion	Priority Weight (w)	Aw	Consistency Value
Operational Reliability	0.363 (36.3%)	1.818	5.008
Regulatory Compliance	0.099 (9.9%)	0.409	4.131
Cost Efficiency	0.058 (5.8%)	0.237	4.086
Vendor Sustainability	0.480 (48.0%)	2.354	4.904

The consistency check yields λ max = 4.532, CI = 0.177, and CR = 0.196. This exceeds Saaty's (1980) conventional 0.10 threshold, indicating moderate inconsistency in the expert's manual judgments a common occurrence when a single practitioner compares intangible strategic criteria. Rather than mechanically revising the informant's authentic judgments, the study retains the original matrix for transparency, treats the weights as indicative priorities rather than precise cardinal measures, and verifies through global sensitivity analysis (Section 4.4) that the strategic conclusions do not depend on the exact weight values.

C) Game-Theoretic Payoff Structure

Applying the Unified Priority Coverage Model to the baseline weights yields the performance scores and expected utilities in Table 3. Under the traditional contracting regime, both players are locked in an inefficient Nash Equilibrium: because XYZ cannot verify every operational action in real time, the vendor's rational strategy is low effort, and to counter this moral hazard XYZ is forced into High Monitoring securing reliability and compliance but acting as a transaction cost tax that annihilates cost efficiency and caps total expected utility at 0.775. The alternative, Low Monitoring, yields only 0.225 as reliability and sustainability collapse.

Table 3: Strategic Payoff Matrix (Expected Utility Outcomes)

Strategic Scenario	P Rel (w = 36.3%)	P Comp (w = 9.9%)	P Cost (w = 5.8%)	P Sust (w = 48.0%)	Total Expected Utility (U)
Low Monitoring	0.244	0.794	1.000	0.000	0.225
High Monitoring	0.756	0.206	0.000	1.000	0.775
Proposed PBC	1.000	1.000	0.900	1.000	0.994

D) Global Sensitivity Analysis: The Strategic Deadlock

Figure 2 plots the sensitivity of both traditional strategies to the Vendor Sustainability weight. High monitoring dominates across the entire spectrum: it holds a utility of 0.750 at 0% weight, dips moderately to 0.672 at 20% as oversight coverage redistributes, recovers through the 0.775 baseline at 48%, and climbs to 1.000 at 100%, where Low Monitoring collapses to zero. The curves never intersect, proving that under traditional contracting XYZ cannot reduce oversight without destroying sustainability value.

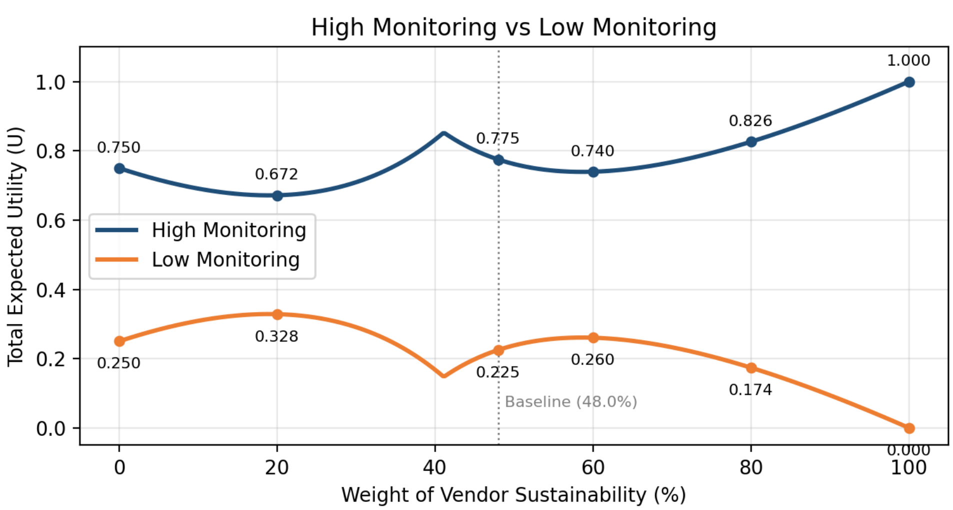

Figure 2. Sensitivity Analysis of Vendor Sustainability

The cost efficiency simulation in Figure 3, by contrast, exposes a structural vulnerability. Because Low Monitoring achieves an isolated cost performance of 1.000 against High Monitoring's 0.000, the utility curves form a dynamic cross-interaction: High Monitoring deteriorates from 0.775 at the 5.8% baseline to 0.658 at 20%, 0.377 at 40%, and 0.112 at 60%, while Low Monitoring rises symmetrically. A precise break-even point occurs at 35.20% of cost weight, where both strategies yield an identical utility of 0.500 (linear interpolation between the 20% and 40% simulation points approximates this crossing at

31.26%). Should macroeconomic shocks force management to prioritize cost containment beyond this threshold, the model mandates a switch to Low Monitoringaccepting catastrophic reliability and sustainability risk. This is the strategic deadlock of transactional contracting: financial efficiency can only be purchased with operational safety (RQ2).

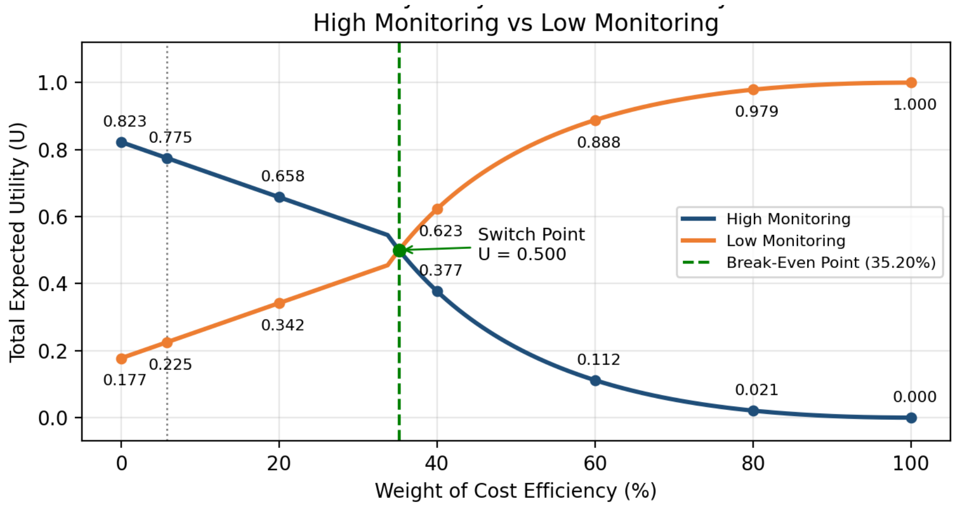

Figure 3. Sensitivity Analysis of Cost Efficiency with Break-Even Threshold

E) Breaking the Deadlock: Performance-Based Contracting

PBC is introduced as a third strategy that rewrites the vendor's payoff function through formalized risk-reward sharing anchored in PAT. Tying vendor profit margins to quantifiable outcomes equipment uptime, zero-defect delivery, TKDN milestones makes low effort self-penalizing, shifting the vendor's rational strategy to high effort and allowing XYZ to dismantle expensive manual inspection. The PBC performance scores are anchored in institutional economics: reliability and compliance reach 1.000 through incentive alignment and gatekeeper penalty clauses; sustainability reaches 1.000 as long-term performance targets compel vendors to invest in their own capabilities (RBV); and cost efficiency reaches 0.900, the residual 10% representing the ex-ante transaction costs of contract design, KPI legal alignment, and automated governance (TCE). As Table 3 and Figure 4 show, PBC achieves a total expected utility of 0.994 a 28.2% optimization leap over the High Monitoring status quo and, because it's cost baseline starts at 0.900, its utility curve remains dominant across the entire sensitivity spectrum, eliminating the cost-safety trade-off (RQ3). The equilibrium shift can be interpreted through Ketokivi and Mahoney's (2020) synthesis: PBC simultaneously economizes on transaction costs and converts the supplier relationship itself into a VRIN resource, aligning the TCE and RBV logics rather than trading them off.

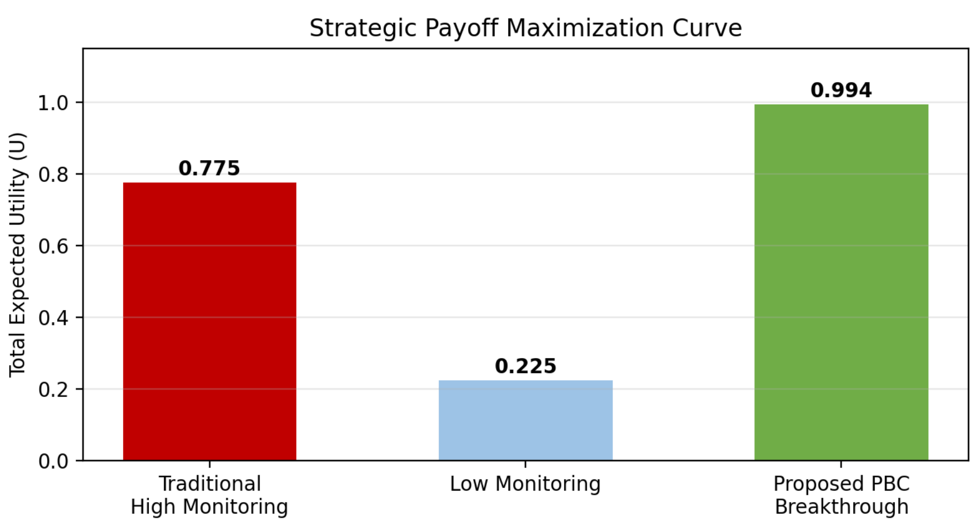

Figure 4. Strategic Payoff Comparison of the Three Contracting Strategies

F) Generalizability: Positioning the Findings in the Indonesian Industry Context

Because this is a single-case study, a natural question is whether the diagnosed deadlock and the proposed remedy travel beyond XYZ. The institutional mechanisms at the core of the diagnosis high asset specificity, multi-stage PTK-007 approval cycles, and a TKDN-protected, financially thin local vendor pool that breeds moral hazard are properties of the Indonesian Production Sharing Contract regime rather than of XYZ specifically: every operator that procures under SKK Migas governance is exposed to them. For state-owned Pertamina and its upstream subsidiaries, which operate under the same procurement framework, the deadlock is plausibly at least as binding: layered internal procurement governance, public-accountability pressures, and national-assignment objectives tend to reinforce input-based, monitoring-heavy contracting, and an SOE's priority structure would likely weight national capacity-building objectives the criterion that already dominates XYZ's AHP hierarchy at 48% even more heavily.

International operators active in Indonesia illustrate the opposite pole. Global majors such as ExxonMobil and BP arrive with globally standardized performance- and alliance-based contracting templates and long-standing strategic vendor relationships, and their large Indonesian developments are frequently cited within the industry as execution benchmarks despite facing the same PTK-007 and TKDN environment. This contrast is consistent with the central claim of this study: observed productivity differences trace primarily to contract governance rather than to ownership, nationality, or technology. Two caveats apply, The comparison is indicative, drawn from publicly documented institutional characteristics rather than from primary data collected at these firms; and the transferability of the specific AHP weights is bounded, since each operator's priority structure reflects its own strategic posture. Formal multi-case validation across an SOE, a private national operator, and an international major is therefore identified as a priority for future research in Section 5.

G) Managerial Implications and Implementation Risks

Three implementation recommendations follow. First, targeted PBC deployment: the transition should begin with high-risk, high-asset-specificity categoriescomplex EPC projects and specialized drilling services replacing cost-reimbursable wrappers with compensation gated behind guaranteed uptime, zero-defect milestones, and preventive maintenance schedules. Second, cultivation of strategic supplier alliances: local vendors should be reframed from regulatory obligations into extensions of operational capacity, with extended contract horizons providing the revenue predictability vendors need to secure independent financing in exchange for continuous technological upgrading, evolving domestic supplier capabilities into VRIN resources. Third, digital contract governance: because PBC exchanges ex-post monitoring costs for ex-ante design and measurement costs, XYZ should leverage its mature paperless repository to deploy dashboards that automatically verify TKDN certificates, track uptime via sensor data, and trigger automated penalty or bonus execution, sustaining the 0.900 cost utility baseline. A phased roadmap is proposed: legal design and SKK Migas/PTK-007 alignment (months 1–6); a pilot on a medium-risk offshore fabrication project with risk-capacity-based vendor pre-qualification (months 7–12); and validation against the 0.994 utility baseline followed by scaling to all Tier-1 suppliers alongside a national capacity-building program (years 1–3).

The transition also carries field-level risks that the roadmap must manage explicitly rather than assume away. The first is vendor readiness: many TKDN-protected local vendors lack the balance-sheet strength to absorb transferred operational risk, so an abrupt shift to penalty-backed outcome contracts could bankrupt partners or shrink the qualified pool further. Mitigation lies in risk-capacity pre-qualification, graduated risk transfer that begins with bonus-only incentives before introducing penalty exposure, performance bonding and insurance instruments, and the capacity-building program that expands vendors' ability to carry risk over time. The second is regulatory friction: PTK-007's cost-recovery logic remains input-oriented, so outcome-based payments can create disputes over whether performance bonuses and at-risk fees are recoverable costs. This is precisely why the roadmap's first phase is regulatory co-design with SKK Migas hybrid contract wrappers that retain a cost-recoverable base and layer performance incentives on top offer a compliant transition path while pilot documentation builds regulatory precedent. The third is KPI measurability: outcome-based compensation invites dispute wherever measurement is subjective, and a contested KPI regime can reproduce the very transaction costs PBC is meant to eliminate. Mitigation requires jointly agreed measurement protocols fixed at contract signature, sensor-based and automatically logged performance data, independent verification for contested readings, and the digital governance dashboards described above. Acknowledging these risks does not weaken the recommendation; it defines the conditions under which the modeled 0.994 utility is actually attainable, and it explains why the roadmap is gated so that each phase must demonstrate risk containment before the next is funded.

V. CONCLUSION

This study diagnosed the productivity constraints of an Indonesian private upstream operator and quantitatively evaluated its contracting strategy by formalizing expert judgment through AHP and Game Theory. Three conclusions emerge. First, upstream productivity is constrained less by internal capability than by institutional friction: asset specificity, logistical complexity, rigid PTK-007 approval cycles, and TKDN-driven dependency on a limited vendor pool that breeds information asymmetry and moral hazard. Second, the current transactional model traps the company in a sub-optimal Nash EquilibriumHigh

Monitoring secures reliability at a utility ceiling of 0.775 while exhausting cost efficiency, and a break-even threshold at a 35.20% cost weight exposes the system to a forced collapse into low oversight under macroeconomic stress. Third, Performance-Based Contracting is the mathematically dominant resolution, achieving 0.994 expected utility by shifting operational risk to the vendor, aligning incentives, and converting supplier relationships into strategic resources.

The study's limitations qualify these findings. The results are contextualized to a single private Production Sharing Contractor; the industry comparison in Section 4.6 suggests the mechanisms extend to other operators under the same regime, but that comparison is indicative rather than empirical. The PBC utility score is a theoretical ex-ante optimization rather than post-implementation evidence; its attainability is conditional on managing the vendor-readiness, regulatory, and measurement risks identified in Section 4.7; and the AHP consistency ratio (CR = 0.196) derived from a single expert exceeds the conventional 0.10 threshold, although the sensitivity analysis demonstrates that the strategic conclusions are robust to substantial weight variation. Future research should validate PBC empirically through longitudinal audits of pilot projects, conduct formal multi-case comparisons across state-owned, private national, and international operators in Indonesia, aggregate judgments from multiple experts (e.g., via geometric means) to improve AHP consistency, and explore blockchain-enabled smart contracts and artificial intelligence to minimize information asymmetry further and automate incentive execution across the national supply chain network.

Interest Conflicts

The authors declare that there is no conflict of interest concerning the publishing of this paper.

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