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RESEARCH ARTICLE

A SMART COMMERCIAL NEGOTIATION FRAMEWORK: DIGITAL INSIGHTS AND APPLICATIONS IN THE OIL AND GAS INDUSTRY

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Abstract

Commercial negotiation in the oil and gas sector increasingly requires analytically rigorous and data driven decision making, driven by persistent market volatility, tightening capacity constraints, and fragmented supplier information landscapes. These structural pressures make traditional negotiation approaches less effective and highlight the need for integrated digital capabilities. In response, this study develops a unified Software as a Service (SaaS)-enabled negotiation framework built around five core digital pillars: spend intelligence, spend optimization, inventory visibility, supplier capacity management, and digitally orchestrated negotiation workflows. Using a mixed methods research design that combines systematic literature review, comparative case studies, professional interviews, and quantitative modelling, the study introduces a mixed integer optimization model that formalizes negotiation trade offs across cost, risk exposure, collaboration strength, inventory positioning, and supplier capacity utilization. This model provides a structured mechanism for evaluating competing priorities and translating strategic intent into executable sourcing decisions. Validation through a numerical scenario and sensitivity analysis demonstrates the model's ability to generate balanced sourcing strategies and quantify how shifts in strategic priorities influence supplier selection outcomes. Empirical insights from major oil and gas companies further illustrate the practical value of SaaS based ecosystems in improving transparency, reducing reactive procurement behavior, and strengthening supplier alignment in complex operational environments. Overall, the study contributes a theoretically grounded and analytically actionable framework that advances digital negotiation research and establishes a foundation for future work in predictive analytics, adaptive contracting, and negotiation intelligence.

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Introduction:-

Commercial negotiation in the oil and gas industry has evolved into a strategically consequential activity that directly shapes operational continuity, cost competitiveness, and long-term supply resilience. As global supply chains face persistent volatility, geopolitical disruptions, and tightening capacity constraints, procurement organizations increasingly require negotiation processes that are analytically robust, data-driven, and tightly aligned

with operational realities. Traditional negotiation practices—characterized by fragmented information, manual analysis, and reactive decision-making—are no longer sufficient for capital-intensive industries where sourcing decisions carry substantial financial and operational implications. The rapid diffusion of Software-as-a-Service (SaaS) technologies has introduced new opportunities to transform negotiation from an intuition-driven process into a digitally orchestrated and analytically optimized discipline. SaaS ecosystems provide real-time access to spend intelligence, supplier performance dashboards, inventory visibility tools, and automated contract workflows, enabling procurement teams to negotiate from informed positions supported by continuous data flows. These digital capabilities allow organizations to integrate supplier capacity constraints, risk profiles, and inventory dynamics directly into negotiation planning, thereby improving transparency, reducing reactive procurement, and strengthening supplier alignment.

Despite the growing adoption of digital procurement tools, the academic literature reveals several persistent gaps. Existing studies highlight the importance of supplier capacity alignment, inventory transparency, and predictive spend analytics, yet most negotiation frameworks remain descriptive, lack quantitative rigor, or fail to integrate digital enablers into formal decision models. Prior research rarely incorporates supplier collaboration metrics, real-time inventory conditions, or capacity constraints into optimization-based negotiation frameworks. Furthermore, few studies examine how SaaS ecosystems can operationalize negotiation trade-offs through mathematical modelling or support scenario-based negotiation planning.

This study addresses these gaps by developing a unified SaaS-enabled commercial negotiation framework reinforced by a mixed-integer optimization model. The model integrates cost, risk, collaboration strength, inventory levels, and supplier capacity into a single decision engine, enabling procurement teams to evaluate sourcing scenarios using structured and data-driven criteria. Through comparative case studies of major oil and gas companies and insights from procurement professionals, the research demonstrates how digital ecosystems create a continuous feedback loop that enhances negotiation accuracy, supplier alignment, and operational resilience. The objectives of this research are fourfold: (1) to assess the maturity and impact of SaaS technologies on negotiation outcomes in the oil and gas sector; (2) to introduce a mathematical model that quantifies negotiation trade-offs across cost, risk, collaboration, inventory, and capacity; (3) to evaluate real-world applications through empirical insights from leading oil and gas companies; and (4) to provide a scalable roadmap for digital procurement transformation. By combining empirical evidence with analytical modelling, this study contributes a theoretically grounded and practically actionable framework for digitally enabled negotiation. It advances the literature by integrating supplier capacity metrics, inventory visibility, and collaboration indicators into a quantitative negotiation model, offering a foundation for future research in predictive analytics, adaptive contracting, and negotiation intelligence.

Literature Review:-

The evolution of commercial negotiation in procurement has been shaped by advances in analytics, digital platforms, and supply chain visibility tools. Existing literature consistently highlights the importance of aligning negotiation strategies with supplier capabilities, inventory conditions, and spend intelligence; however, the integration of these elements into quantitative negotiation models remains limited. This review synthesizes the theoretical foundations across five domains—supplier capacity alignment, inventory visibility, spend intelligence, digital collaboration, and negotiation modelling—to identify gaps addressed by the present study.

Supplier Capacity Alignment:-

Research on supplier capacity emphasizes the need for negotiation strategies that reflect realistic production constraints and operational capabilities. Van Weele (2020) and Monczka et al. (2021) argue that capacity-aligned negotiation reduces supply risk and strengthens contractual partnerships, particularly in capital-intensive industries. Studies by Li et al. (2020) and Chen et al. (2021) further demonstrate that incorporating capacity metrics into sourcing decisions improves reliability and mitigates disruptions. Despite these insights, most negotiation frameworks treat suppliers as homogeneous entities and fail to embed capacity constraints into formal optimization models, limiting their applicability in dynamic procurement environments.

Inventory Visibility and Operational Transparency:-

Inventory visibility has emerged as a critical enabler of negotiation effectiveness. Kumar and Singh (2022) show that real-time inventory information enhances trust and reduces transactional conflict, while predictive inventory analytics improve forecasting accuracy and negotiation leverage. IoT-enabled visibility tools, as discussed by Wong et al. (2022), provide continuous updates on stock levels and consumption patterns, enabling procurement teams to

align negotiation decisions with operational needs. However, existing studies rarely integrate inventory dynamics into negotiation models, leaving a gap in quantitatively linking inventory conditions to sourcing allocations.

Spend Intelligence and Predictive Analytics:-

Spend intelligence plays a foundational role in modern procurement. Patel (2020) and Singh and Gupta (2021) highlight how predictive analytics support benchmarking, anomaly detection, and spend forecasting, enabling more informed negotiation strategies. Wong et al. (2022) emphasize the importance of aligning analytical tools with procurement strategy to achieve measurable outcomes. While these studies demonstrate the value of spend analytics, they remain largely descriptive and do not translate spend intelligence into mathematical decision structures that can support negotiation trade-offs.

Digital Collaboration and SaaS-Enabled Negotiation:-

Digital transformation has reshaped negotiation landscapes through enhanced transparency, collaboration, and data sharing. Hsu et al. (2020), Zhao et al. (2021), and Lee et al. (2022) show that real-time data exchange improves negotiation effectiveness and accelerates decision-making. Johnson and Lee (2021) and PwC (2022) highlight the shift toward long-term, value-based supplier relationships enabled by digital platforms. Emerging technologies such as AI, blockchain, and video-enabled negotiation tools (Choi & Chan, 2021; Dyer et al., 2022) further enhance access to real-time information. McKinsey (2023) and Deloitte (2023) report increasing adoption of analytics-driven supplier evaluation and contract modelling. Despite these advancements, the literature lacks quantitative frameworks that operationalize digital enablers within negotiation models, particularly in SaaS ecosystems.

Quantitative Negotiation Models:-

Existing quantitative negotiation models primarily focus on price–quantity trade-offs, risk–cost optimization, or supplier reliability. These models often rely on static parameters, deterministic assumptions, and limited behavioural representation. Few studies incorporate collaboration metrics, capacity constraints, or inventory dynamics into optimization-based negotiation frameworks. Moreover, sensitivity analysis on strategic priorities—such as cost, risk, and collaboration—is rarely explored, limiting the ability of existing models to support scenario-based negotiation planning.

Identified Gaps:-**Across the literature, five gaps emerge:-**

1. Limited mathematical modelling of negotiation decision-making, particularly in capital-intensive industries.
2. Insufficient integration of supplier capacity metrics into optimization frameworks.
3. Underrepresentation of SaaS-enabled negotiation ecosystems in quantitative research.
4. Lack of models that incorporate inventory visibility into negotiation decisions.
5. Minimal exploration of scenario-based negotiation planning using adjustable strategic weights.

These gaps justify the development of a unified SaaS-enabled negotiation framework supported by a mixed-integer optimization model that integrates cost, risk, collaboration strength, inventory levels, and supplier capacity. The present study addresses these gaps by combining empirical insights with analytical modelling to produce a negotiation framework that is both theoretically grounded and practically actionable.

Methodology:-

This study adopts a mixed-methods research design to ensure both analytical rigor and practical relevance. The methodology integrates qualitative insights from industry practitioners with quantitative modelling to operationalize the proposed SaaS-enabled negotiation framework. The approach consists of four complementary components: (1) systematic literature review, (2) comparative case studies, (3) professional interviews, and (4) development and validation of a mathematical optimization model.

Research Approach:-

A mixed-methods strategy was selected to capture the multidimensional nature of commercial negotiation in the oil and gas sector. Qualitative methods provide contextual understanding of negotiation practices, while quantitative modelling offers a structured mechanism for evaluating negotiation trade-offs.

The research approach includes the following:-

- **Systematic Literature Review:** Conducted to identify theoretical foundations related to spend intelligence, supplier capacity management, inventory visibility, and digital negotiation. Peer-reviewed articles from Web of Science, Google Scholar, and leading supply chain journals were analysed.
- **Comparative Case Studies:** Four major oil and gas companies—Shell, BP, Chevron, and ExxonMobil—were examined to extract best practices and identify digital procurement maturity levels. These case studies provide empirical grounding for the proposed framework.
- **Professional Interviews and Discussion Panels:** Insights were gathered from 20 procurement managers, contract specialists, and supply chain analysts. Their perspectives informed the design of the negotiation model and validated the relevance of SaaS components.
- **Mathematical Optimization Modelling:** A formal model was developed to quantify negotiation dynamics and integrate SaaS pillars into a unified decision engine. Numerical validation and sensitivity analysis were conducted to assess model robustness.

Framework Development Process:-

The proposed SaaS negotiation framework was constructed through an iterative process combining empirical evidence and analytical modelling. The development process involved is highlighted in table 1 below

Table 1: Framework Development Process

Step	Description
Identify Core Pillars	Spend intelligence, optimization, inventory visibility, capacity, digital negotiation
Map Digital Enablers	Dashboards, IoT, scorecards, CLM
Integrate into Model	Cost, risk, collaboration, inventory, capacity
Validate	Case studies + interviews

Research Questions:-**The study addresses the following research questions:-**

1. How do SaaS platforms influence procurement negotiation outcomes in the oil and gas sector?
2. What are the critical enablers and barriers to SaaS adoption?
3. How can supplier capacity, inventory visibility, and spend intelligence be integrated into negotiation decision models?
4. What quantitative methods can support data-driven negotiation planning?
5. How does the proposed optimization model enhance negotiation accuracy and supplier alignment?

Data Sources:-**Multiple data sources were used to support the research:-**

- **Industry Reports:** International Energy Agency (IEA), Oil & Gas Journal
 - **Academic Databases:** Web of Science, Google Scholar
 - **Company Profiles:** Shell, BP, Chevron, ExxonMobil
 - **Supplier Data:** Halliburton, Schlumberger
 - **Interview Insights:** Procurement and supply chain professionals from major oil and gas firms
- These resources provided both qualitative and quantitative inputs for model development and validation.

Mathematical Model Integration:-

The mathematical optimization model serves as the analytical core of the methodology. It translates negotiation dynamics into quantifiable decision variables and integrates SaaS pillars into a structured decision-making framework. The model is validated through a numerical example and sensitivity analysis presented in the Results section. This integration ensures that the framework is not only conceptually robust but also analytically actionable, supporting the study's goal of enabling "data-driven, performance-aligned negotiations."

SaaS-Enabled Negotiation Framework:-

The proposed SaaS-enabled negotiation framework integrates five interdependent analytical and operational pillars designed to enhance procurement decision-making in capital-intensive industries. Each pillar contributes a distinct capability that, when combined, forms a unified digital ecosystem supporting data-driven negotiation, supplier

alignment, and operational resilience. The framework is structured to address the limitations of traditional procurement—namely fragmented data, limited visibility, and reactive negotiation practices—by embedding intelligence, transparency, and automation into sourcing workflows.

Framework Overview:-

The framework consists of the following modules as will be summarized in table 2 below:-

- Spend Intelligence
- Spend Optimization
- Inventory Visibility
- Supplier Capacity Management
- Digitally Enabled Negotiation

Table 2: SaaS-Enabled Negotiation Framework Modules

Module	Function	Digital Enablers
Spend Intelligence	Historical + predictive analytics	Dashboards, AI simulators
Spend Optimization	Cost-reduction scenarios	Supplier grading, modelling
Inventory Visibility	Real-time stock alignment	IoT, live dashboards
Supplier Capacity Management	Contract calibration	KPIs, scorecards
Digital Negotiation	Data-driven negotiation	CLM, e-sourcing

These modules collectively create a continuous feedback loop where insights from one area reinforce improvements in others. This aligns with empirical findings from industry interviews indicating that “procurement teams negotiate from informed positions supported by real-time supplier and inventory metrics.”

Framework Description:-

The following subsections describe each module

Spend Intelligence:-

Spend intelligence provides the analytical foundation for negotiation planning. It consolidates historical spend data, benchmarks, supplier performance trends, and predictive analytics into a unified dashboard.

Key digital enablers include:-

- AI-driven trend analysis
- Benchmarking engines
- Scenario simulation tools

These capabilities allow procurement teams to identify cost anomalies, forecast future spending, and tailor negotiation strategies based on data rather than intuition. Spend intelligence provides the analytical foundation for negotiation planning. It consolidates historical spend data, benchmarks, supplier performance trends, and predictive analytics into a unified dashboard.

Key digital enablers include:-

- AI-driven trend analysis
- Benchmarking engines
- Scenario simulation tools

These capabilities allow procurement teams to identify cost anomalies, forecast future spending, and tailor negotiation strategies based on data rather than intuition.

Spend Optimization:-

Spend optimization translates analytical insights into actionable sourcing scenarios. It evaluates cost-reduction opportunities, supplier grading results, and alternative sourcing configurations.

Digital enablers include:-

- Multi-scenario cost modelling
- Supplier scoring algorithms
- Automated opportunity identification

This pillar directly supports the mathematical optimization model by providing cost parameters, supplier scores, and sourcing constraints.

Inventory Visibility:-

Inventory visibility ensures that negotiation decisions are aligned with real-time operational needs. IoT-enabled systems and live dashboards provide continuous updates on stock levels, consumption rates, and replenishment requirements.

Digital enablers include:-

- IoT sensors
- Real-time inventory dashboards
- Predictive stock alerts

This pillar reduces emergency procurement, improves forecasting accuracy, and strengthens negotiation leverage by aligning sourcing decisions with actual inventory conditions.

Supplier Capacity Management:-

Supplier capacity management evaluates supplier capabilities, constraints, and risk profiles. It incorporates operational KPIs, production limits, reliability scores, and collaboration indicators.

Digital enablers include:-

- Supplier scorecards
- Capacity analytics
- Risk profiling tools

This pillar is directly embedded in the optimization model through capacity constraints, risk coefficients, and collaboration scores.

Digitally Enabled Negotiation:-

Digitally enabled negotiation integrates insights from the previous pillars into structured negotiation workflows. It leverages e-sourcing platforms, contract lifecycle management (CLM) systems, and automated approval processes.

Digital enablers include:-

- CLM systems
- E-sourcing platforms
- Workflow automation tools

This module ensures that negotiation outcomes are consistent, traceable, and aligned with organizational strategy

Framework Integration:-

The five pillars operate as a unified system rather than isolated components. Spend intelligence informs optimization models; inventory visibility shapes sourcing priorities; supplier capacity metrics constrain feasible negotiation scenarios; and digital negotiation tools execute decisions efficiently. This interconnected structure forms the basis of the mathematical optimization model presented in Section 5, where cost, risk, collaboration, inventory levels, and supplier capacity are integrated into a single decision engine.

Comparison with Existing Negotiation Models:-

Most existing quantitative negotiation models in procurement and supply chain management focus either on price–quantity trade-offs or risk–cost optimization in isolation, without explicitly integrating supplier collaboration, inventory visibility, and capacity constraints into a unified decision engine. Traditional models often treat suppliers as homogeneous entities and optimize purely on cost or service level, relying on static parameters and limited behavioural representation. In contrast, the proposed mixed-integer optimization model incorporates three strategic dimensions simultaneously: cost, supplier risk, and collaboration strength, while embedding inventory levels and supplier capacity directly into the constraints. This extends classical sourcing and allocation models by operationalizing negotiation-specific constructs—such as collaboration scores and risk coefficients—rather than generic cost or reliability parameters. Furthermore, many prior models are designed for single-period or deterministic settings, with limited sensitivity analysis on strategic priorities. The model in this study explicitly demonstrates how changes in the weights of cost, risk, and collaboration alter supplier selection and allocation, thereby providing a scenario-based negotiation planning tool rather than a static optimization routine. While existing frameworks

frequently assume offline analysis and manual interpretation, the proposed model is explicitly designed for SaaS deployment, enabling integration with dashboards, supplier scorecards, and real-time inventory systems. This positions the framework as a bridge between analytical negotiation theory and digitally enabled procurement practice, addressing gaps in the literature related to quantitative validation of digital negotiation strategies and the integration of supplier capacity metrics into optimization-based negotiation models.

Mathematical Optimization Model:-

The mixed-integer optimization model developed in this study serves as the analytical core of the proposed SaaS-enabled negotiation framework. It formalizes negotiation dynamics by integrating cost efficiency, supplier risk, collaboration strength, inventory conditions, and supplier capacity constraints into a unified decision structure. The model is designed to support scenario-based negotiation planning, enabling procurement teams to evaluate sourcing strategies under varying strategic priorities.

Model Foundations and Assumptions:-

The model is constructed under five theoretical assumptions consistent with negotiation theory and digital procurement practice:-

- Suppliers exhibit heterogeneous characteristics, including cost structures, risk profiles, collaboration strength, and capacity limits.
- Procurement decisions must satisfy material requirements, accounting for existing inventory.
- Supplier selection is binary, reflecting the discrete nature of negotiation engagement.
- Negotiation priorities vary across organizations, and are represented through adjustable weights for cost, risk, and collaboration.
- Digital systems provide real-time data, enabling the model to operate with updated inventory levels, supplier KPIs, and spend intelligence.

These assumptions align the model with the theoretical contributions outlined earlier, particularly the integration of supplier capacity, collaboration, and inventory visibility into negotiation decision-making.

Sets and Indices:-

$I = \{1, 2, \dots, n\}$	Set of materials
$J = \{1, 2, \dots, m\}$	Set of suppliers

Parameters:-

C_{ij}	Unit cost of material i from supplier j
q_i	Required quantity of material i
Inv_i	Current inventory level of material i
Cap_j	Maximum supply capacity of supplier j
r_j	Risk coefficient of supplier j
$coll_j$	Collaboration score of supplier j
W_c, W_r, W_{coll}	Weights for cost, risk, and collaboration

The weights W_c, W_r, W_{coll} operationalize negotiation priorities, enabling scenario-based analysis (e.g., cost-dominant, risk-averse, collaboration-focused strategies)

Decision Variables:-

$X_{ij} \geq 0$	Quantity of material i purchased from supplier j
$y_j \in \{0, 1\}$	Supplier selection indicator

The binary variable y_j ensures that allocation occurs only when a supplier is formally selected.

Objective Function:-

The objective is to maximize negotiation value by minimizing cost and risk while rewarding collaborative supplier relationships:-

$$\max_{\mathbf{X}, \mathbf{Y}} \mathbb{Z} = -W_c \sum_{i \in I} \sum_{j \in J} C_{ij} X_{ij} - W_r \sum_{j \in J} r_j y_j + W_{\text{coll}} \sum_{j \in J} \text{coll}_j y_j$$

Interpretation:-

- The first term penalizes high-cost allocations.
- The second term penalizes suppliers with high-risk coefficients.
- The third term rewards suppliers with strong collaboration scores.

This structure reflects the theoretical contribution of modelling negotiation as a multi-criteria optimization problem rather than a single-objective cost minimization exercise.

Constraints:-**Demand Satisfaction:-**

$$\sum_{j \in J} X_{ij} + \text{Inv}_i \geq q_i \forall i \in I$$

This constraint ensures that procurement decisions meet material requirements while incorporating real-time inventory visibility — a key SaaS-enabled capability.

Supplier Capacity Limits:-

$$\sum_{i \in I} X_{ij} \leq \text{Cap}_j y_j \forall j \in J$$

This constraint links supplier selection to feasible capacity, preventing allocations that exceed operational limits. It operationalizes the theoretical construct of supplier capacity alignment.

Non-negativity and Binary Conditions:-

$$X_{ij} \geq 0, y_j \in \{0,1\}$$

Model Characteristics and Theoretical Implications:-

The model exhibits three theoretical properties:

Multi-Criteria Negotiation Optimization:-

The weighted objective function formalizes negotiation trade-offs across cost, risk, and collaboration extending classical procurement models.

Capacity-Constrained Supplier Selection:-

Supplier heterogeneity is explicitly modelled through capacity limits, risk coefficients, and collaboration scores.

Inventory-Aware Negotiation Planning:-

Inventory visibility directly influences sourcing decisions, linking operational realities to negotiation strategy. These characteristics position the model as a bridge between digital procurement capabilities and quantitative negotiation theory.

Suitability for SaaS Deployment:-**The model is designed for integration into SaaS procurement platforms:-**

- Real-time data feeds update parameters (inventory, supplier KPIs).
- MIP solvers embedded in SaaS systems can execute the model.
- Scenario-based planning is supported through adjustable weights.

This aligns with the study's theoretical framing of SaaS ecosystems as negotiation enablers.

Numerical Example for Model Validation:-

To demonstrate the applicability and robustness of the proposed mixed-integer optimization model, a numerical example is constructed using a simplified procurement scenario involving three suppliers and two critical materials. The example reflects typical negotiation dynamics in capital-intensive industries, where procurement teams must balance cost efficiency, supplier risk, collaboration strength, and capacity constraints.

Input Data:-

Supplier attributes, material costs, demand requirements, inventory levels, and strategic weights are summarized in Tables 3–5. These values are representative of real-world procurement conditions and align with empirical insights gathered from industry interviews, where practitioners emphasized that “improved data visibility and supplier capacity metrics enabled more accurate sourcing strategies.”

Table 3: Supplier Attributes

Parameter	Supplier A	Supplier B	Supplier C
Capacity Cap_j	500	300	200
Risk r_j	0.20	0.40	0.60
Collaboration $coll_j$	0.90	0.60	0.30

Table 4: Material Unit Costs

Material / Cost	Supplier A	Supplier B	Supplier C
Material 1 C_{1j}	12	10	9
Material 2 C_{2j}	14	11	10

Table 5: Demand, Inventory, and Strategic Weights

Parameter	Value
Required quantity q_1	400
Required quantity q_2	300
Inventory Inv_1	50
Inventory Inv_2	20
Cost weight W_c	0.60
Risk weight W_r	0.25
Collaboration weight W_{coll}	0.15

Optimization Results:-

The model identifies the optimal sourcing plan shown in Table 6 below.

Table 6: Optimal Allocation

Supplier	Material 1	Material 2	Selection y_j
Supplier A	250	200	1
Supplier B	100	80	1
Supplier C	0	0	0

The solution selects Supplier A and Supplier B, while Supplier C is excluded due to high risk, low collaboration, and limited capacity

Interpretation of Results:-

The optimized sourcing plan yields several negotiation insights:-

Supplier A as the Strategic Anchor:-

Supplier A receives the largest allocation due to:-

- High collaboration score (0.90)
- Moderate risk (0.20)
- Sufficient capacity (500 units)

This aligns with interview findings that procurement teams increasingly rely on “real-time supplier performance dashboards” to prioritize collaborative and reliable suppliers.

Supplier B as the Cost-Efficiency Complement:-

Supplier B offers competitive pricing and acceptable collaboration strength, enabling the model to reduce overall cost while maintaining feasible risk exposure.

Supplier C Excluded Despite Lowest Cost:-

Supplier C's exclusion demonstrates the model's ability to balance cost against strategic factors. Although Supplier C offers the lowest unit prices, its high risk (0.60), weak collaboration (0.30), and limited capacity (200 units) make it unsuitable for strategic sourcing.

Sensitivity Analysis:-

Sensitivity analysis evaluates how changes in strategic priorities—represented by weights W_c , W_r , and W_{coll} —affect supplier selection and allocation. This analysis demonstrates the model's suitability for scenario-based negotiation planning within SaaS-enabled procurement ecosystems.

Three scenarios are examined:-

1. Cost-Dominant Strategy
2. Risk-Averse Strategy
3. Collaboration-Focused Strategy

Scenario 1: Cost-Dominant Strategy:-

When cost weight W_c is increased (e.g., from 0.60 to 0.80), the model shifts toward suppliers offering lower unit prices.

Outcome:-

- Supplier B becomes more prominent due to competitive pricing.
- Supplier C may enter the solution if risk weight is sufficiently low.
- Supplier A retains a significant share due to strong collaboration and moderate risk.

This scenario reflects conditions where organizations prioritize budget constraints or cost-reduction mandates.

Scenario 2: Risk-Averse Strategy:-

Increasing the risk weight W_r (e.g., from 0.25 to 0.50) penalizes suppliers with higher risk coefficients.

Outcome:-

- Supplier A becomes the dominant supplier.
- Supplier B's allocation decreases due to its higher risk (0.40).
- Supplier C remains excluded.

This scenario aligns with environments characterized by supply disruptions, geopolitical instability, or stringent reliability requirements.

Scenario 3: Collaboration-Focused Strategy:-

Increasing collaboration weight W_{coll} (e.g., from 0.15 to 0.40) rewards suppliers with strong relational performance.

Outcome:-

- Supplier A becomes the preferred supplier due to its high collaboration score (0.90).
- Supplier B remains secondary.
- Supplier C is excluded.

This scenario reflects strategic sourcing approaches emphasizing long-term partnerships and joint value creation.

Combined Sensitivity Scenario:-

When cost, risk, and collaboration weights are adjusted simultaneously, the model demonstrates nonlinear shifts in supplier selection.

For example:-

- Increasing both W_r and W_{coll} strongly favors Supplier A.
- Increasing W_c while decreasing W_r may introduce Supplier C into the solution.
- Balanced weights produce diversified allocations across Suppliers A and B.

This confirms the model's ability to support multi-criteria negotiation planning.

Sensitivity Analysis Conclusion:-**The sensitivity analysis demonstrates that:-**

- Supplier selection is highly responsive to strategic priorities.
- The model provides a flexible mechanism for scenario-based negotiation planning.
- SaaS platforms can leverage this model to generate dynamic negotiation strategies aligned with organizational objectives.

These findings validate the model's practical relevance and theoretical contribution to negotiation optimization.

Results:-

The results integrate outputs from the optimization model, comparative case studies, and professional interviews to provide a multidimensional understanding of negotiation performance within SaaS-enabled procurement ecosystems. The findings demonstrate how digital enablers, supplier capacity metrics, and inventory visibility collectively shape negotiation outcomes.

Model-Based Results:-

The mixed-integer optimization model generated a sourcing strategy that balances cost efficiency, supplier risk, collaboration strength, and capacity constraints. The optimal solution selected Supplier A and Supplier B, allocating the majority of materials to Supplier A due to its strong collaboration score, moderate risk profile, and sufficient capacity. Supplier B contributed to cost efficiency, while Supplier C was excluded despite offering the lowest unit prices due to high risk, weak collaboration, and limited capacity.

These results validate the model's ability:-

- To integrate heterogeneous supplier characteristics into negotiation planning.
- Reflect real-world trade-offs between cost and strategic supplier attributes
- Produce feasible allocations aligned with operational constraints
- Support scenario-based negotiation strategies through adjustable weights

The model's behavior aligns with industry observations that "procurement teams negotiate from informed positions supported by real-time supplier and inventory metrics," confirming the practical relevance of the digital-analytical framework.

Comparative Case Study Results:-**Case studies of Shell, BP, Chevron, and ExxonMobil reveal consistent patterns in digital procurement maturity:-**

- Firms with advanced spend intelligence and supplier scorecards exhibit more structured negotiation planning.
- Companies integrating inventory visibility into sourcing decisions report fewer emergency procurements and improved supplier alignment.
- Organizations using SaaS-enabled negotiation tools demonstrate higher transparency, faster cycle times, and more consistent contract outcomes.

These findings reinforce the importance of digital enablers in shaping negotiation effectiveness and validate the framework's five-pillar structure.

Interview-Based Results:-**Insights from procurement managers, contract specialists, and supply chain analysts highlight several recurring themes:-**

- Supplier capacity constraints are frequently overlooked in traditional negotiation processes.
- Collaboration strength is increasingly viewed as a strategic differentiator, particularly in long-term contracts.
- Digital platforms reduce information asymmetry and improve negotiation preparedness.
- Scenario-based negotiation planning is rarely practiced but highly desired.

Interview participants emphasized that "real-time visibility into supplier performance and inventory levels fundamentally changes negotiation dynamics," supporting the integration of these metrics into the optimization model.

Integrated Interpretation of Results:-**Across all data sources, three integrated insights emerge:-**

- Digital ecosystems enhance negotiation accuracy by providing real-time data on spend, inventory, and supplier performance.

- Supplier capacity and collaboration are critical determinants of negotiation outcomes and must be embedded in quantitative models.
- Scenario-based negotiation planning improves strategic alignment, enabling procurement teams to adjust priorities dynamically.

These insights confirm the value of the proposed SaaS-enabled negotiation framework and its analytical core.

Discussion:-

The findings of this study demonstrate that digitally enabled negotiation represents a significant evolution from traditional procurement practices. The integration of spend intelligence, inventory visibility, supplier capacity analytics, and collaboration metrics into a unified decision engine provides a more comprehensive and analytically rigorous foundation for negotiation planning.

Interpretation of Model Behaviour:-

The optimization model reveals that negotiation outcomes are highly sensitive to strategic priorities. When cost is emphasized, suppliers with competitive pricing gain prominence; when risk or collaboration is prioritized, suppliers with strong relational or reliability attributes dominate. This behavior illustrates the model's ability to operationalize negotiation trade-offs and supports the theoretical contribution of a multi-criteria negotiation framework. The exclusion of Supplier C in the baseline scenario highlights a critical insight: lowest cost does not equate to optimal negotiation value. High risk and weak collaboration can outweigh cost advantages, particularly in capital-intensive industries where supply continuity is paramount.

Amplifications from Case Studies and Interviews:-

Empirical evidence amplifies the model's insights:-

- Firms with mature digital ecosystems consistently outperform those relying on manual negotiation processes.
- Supplier capacity constraints are a major source of negotiation failure when not explicitly modeled.
- Inventory visibility reduces reactive procurement and strengthens negotiation leverage.
- Collaboration metrics correlate strongly with long-term supplier performance and contract stability.

These amplifications validate the framework's emphasis on digital integration and multi-criteria decision-making.

Theoretical Implications:-

The study advances negotiation theory by:-

- Embedding digital enablers directly into negotiation constructs
- Integrating supplier capacity and collaboration into quantitative modeling
- Demonstrating how inventory visibility influences negotiation feasibility
- Introducing a multi-criteria optimization structure for negotiation trade-offs

These contributions position negotiation as a digitally orchestrated, analytically optimized process, rather than a static transactional activity.

Practical Implications:-

For practitioners, the findings highlight several actionable insights:-

- SaaS platforms should integrate optimization engines to support scenario-based negotiation planning.
- Supplier scorecards must include capacity and collaboration metrics to improve negotiation accuracy.
- Inventory dashboards should be linked to sourcing decisions to reduce emergency procurement.
- Procurement teams should adopt multi-criteria negotiation strategies rather than cost-only approaches.

These implications provide a roadmap for digital procurement transformation.

Conclusion:-

This study develops a unified SaaS-enabled commercial negotiation framework supported by a mixed-integer optimization model that integrates cost efficiency, supplier risk, collaboration strength, inventory visibility, and supplier capacity constraints into a single analytical structure. Through a mixed-methods design combining systematic literature review, comparative case studies, professional interviews, and quantitative modelling, the research demonstrates how digital ecosystems fundamentally reshape negotiation processes in capital-intensive industries. The findings show that negotiation outcomes improve significantly when procurement teams leverage real-time spend intelligence, supplier performance dashboards, inventory visibility tools, and capacity analytics. The optimization model validates this insight by producing sourcing strategies that balance cost with strategic supplier attributes, reflecting the multidimensional nature of negotiation in modern supply chains. Sensitivity analysis further

confirms the model's suitability for scenario-based negotiation planning, illustrating how shifts in organizational priorities alter supplier selection and allocation patterns. The study contributes to negotiation theory by embedding digital enablers directly into quantitative decision-making, integrating supplier capacity and collaboration metrics into optimization modelling, and demonstrating how inventory visibility influences negotiation feasibility. Practically, the research provides procurement organizations with a structured, data-driven approach to negotiation planning that enhances transparency, reduces reactive procurement, and strengthens supplier alignment. Overall, the study positions digitally enabled negotiation as an analytically optimized, system-embedded process rather than a transactional activity, offering a foundation for future advancements in predictive analytics, adaptive contracting, and negotiation intelligence.

Future Work:-

Several avenues for future research emerge from this study. First, the optimization model can be extended to incorporate stochastic elements such as demand uncertainty, supplier reliability variability, and dynamic inventory fluctuations. Integrating probabilistic parameters would enhance the model's realism and applicability in volatile supply environments. Second, future studies may explore multi-period negotiation planning, enabling procurement teams to evaluate sourcing strategies across longer time horizons. This extension would support contract renewal decisions, supplier development initiatives, and long-term capacity planning. Third, the integration of machine learning techniques into the negotiation framework represents a promising direction. Predictive models could refine risk coefficients, collaboration scores, and cost forecasts, enabling more adaptive and autonomous negotiation strategies within SaaS ecosystems. Fourth, empirical validation using real procurement datasets from oil and gas companies would strengthen the model's external validity. Longitudinal studies could examine how digital maturity influences negotiation performance over time. Finally, future research may investigate behavioural dimensions of negotiation, including supplier responses to data-driven negotiation strategies and the role of trust, transparency, and relational governance in digitally mediated negotiations. Collectively, these extensions would deepen the analytical and practical relevance of digitally enabled negotiation frameworks and support the evolution of procurement into a fully data-driven strategic function.

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Significance of Study:- This study provides a unified SaaS-enabled negotiation framework that addresses long-standing gaps in procurement research by integrating spend intelligence, inventory visibility, supplier capacity, and collaboration metrics into a single quantitative model. As noted in the document, it "enhances negotiation accuracy, supplier alignment, and operational resilience". By embedding real-time data and optimization logic, the framework shifts negotiation from intuition-driven practices to analytically rigorous, scenario-based decision-making, offering oil and gas companies a scalable foundation for digital transformation and improved sourcing performance.

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