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Original Research Article

RFID-Enabled Inventory Visibility and Warehouse Efficiency in Oil and Gas Supply Chains: A Systematic Literature Review

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Abstract: The integration of Radio-Frequency Identification (RFID) technology into supply chain management has emerged as a transformative enabler of inventory visibility and operational efficiency across industrial sectors. Within the oil and gas industry — where supply chain complexity, asset-intensive operations, and regulatory demands present acute challenges to inventory management — RFID offers critical capabilities that traditional barcode and manual tracking systems fail to deliver. This systematic literature review synthesises empirical, simulation-based, and conceptual research published between 2020 and 2025, drawing on 30 peer-reviewed sources indexed in Scopus and Web of Science Q1 journals, to examine the multifaceted impact of RFID technology on warehouse efficiency and inventory visibility within oil and gas supply chains. The review is guided by three principal objectives: (i) to map the current landscape of RFID adoption and deployment models in oil and gas warehousing contexts; (ii) to evaluate the quantifiable gains in inventory accuracy, stockout reduction, and replenishment efficiency attributable to RFID implementation; and (iii) to critically assess integration barriers including middleware complexity, organisational resistance, and environmental constraints inherent to upstream, midstream, and downstream oil and gas environments. Findings indicate that RFID-enabled systems consistently improve inventory accuracy by 25–40%, reduce unplanned stockouts by up to 44%, and accelerate order cycle times by 18–29% when fully integrated with enterprise resource planning (ERP) and warehouse management systems (WMS). The review further identifies an underexplored nexus between RFID, Internet of Things (IoT) convergence, and digital twin applications as a frontier for future research. The paper contributes to theory by extending the process-oriented IT value framework to the oil and gas supply chain context and offers practical implications for supply chain managers, technology architects, and policymakers.

Keywords: RFID, Inventory Visibility, Oil and Gas, Warehouse Management, Supply Chain Efficiency, ERP Integration, Process Optimisation, Digital Twin, IoT.

1. INTRODUCTION

The oil and gas industry operates within one of the most logistically demanding supply chain environments globally, characterised by geographically dispersed assets, mission-critical spare parts, stringent health and safety regulations, and volatile demand cycles driven by fluctuating commodity prices (Al-Turki *et al*., 2021). Within this context, inventory management represents a critical determinant of operational continuity: a missing valve, an untracked drill bit, or a miscounted chemical reserve can result in costly production downtime, safety incidents, and regulatory non-compliance. Despite these stakes, many oil and gas companies continue to rely on legacy systems such as manual cycle counting, barcode scanning, and spreadsheet-based tracking that are inherently slow, error-prone, and unable to provide real-time inventory visibility across complex multi-tier supply chains (Ibrahim & Al-Amin, 2023).

Radio-Frequency Identification (RFID) technology, which enables the wireless, non-line-of-sight identification and data capture of tagged objects using radio waves, has been increasingly recognised as a high-potential solution to these inventory management challenges (Kumar *et al*., 2024). Unlike barcode systems that require manual line-of-sight scanning, RFID readers can simultaneously capture data from hundreds of items within a defined read zone, enabling automated, real-time inventory updates without direct human intervention (Chen & Zhang, 2022). When integrated with enterprise-level information systems such as ERP platforms and WMS, RFID creates a connected data ecosystem capable of generating actionable intelligence across the full supply chain — from wellhead procurement to downstream distribution (Liu & Wang, 2022).

Despite a growing body of literature on RFID applications in retail, pharmaceutical, and automotive supply chains, scholarly attention to the oil and gas sector remains comparatively sparse and fragmented (Nasser *et al*., 2023). Existing reviews tend to examine RFID in broad industrial contexts or focus on technical deployment challenges without adequately addressing the organisational, integration, and value-creation dimensions specific to oil and gas operations. Furthermore, the rapid evolution of enabling technologies — including IoT sensor networks, cloud computing, and digital twin platforms — has created new integration possibilities for RFID that have not been comprehensively reviewed within the oil and gas context (Zhang *et al*., 2025).

This paper addresses these gaps through a systematic literature review examining RFID-enabled inventory visibility and warehouse efficiency in oil and gas supply chains. The review covers peer-reviewed empirical, experimental, and conceptual studies published between 2020 and 2025, sourced from Scopus and Web of Science Q1 databases. Three guiding objectives structure the analysis: first, to characterise the current landscape of RFID deployment models and adoption trajectories in oil and gas warehousing; second, to quantify the efficiency and visibility gains reported across reviewed studies; and third, to evaluate the barriers and enablers that mediate the translation of RFID investment into operational value. The paper is structured as follows: Section 2 provides the theoretical background; Section 3 describes the methodology; Section 4 presents the thematic findings; Section 5 discusses implications; and Section 6 concludes with directions for future research.

2. Theoretical Background and Conceptual Framework

2.1 RFID Technology Architecture in Supply Chain Contexts

A standard RFID system consists of three principal hardware components: a transponder (tag) affixed to the tracked object, a reader equipped with antennas that emit radio waves and capture tag responses, and a middleware layer that interprets and routes captured data to enterprise information systems (Fosso Wamba *et al*., 2020). Tags may be passive (powered by the reader's emitted field), semi-passive (battery-assisted for sensing), or active (self-powered with greater read range), each carrying distinct cost-performance trade-offs that influence deployment decisions in oil and gas environments (Park & Kim, 2021). In large-scale warehouse operations, fixed RFID portals at dock doors enable automated goods receipt and dispatch, while handheld readers and forklift-mounted units support cycle counting and put-away verification (Liu & Wang, 2022).

The integration of RFID with enterprise systems is mediated by middleware software that performs event filtering, data aggregation, and business rule execution before routing clean data to ERP and WMS platforms (Ramírez *et al*., 2024). In the oil and gas sector, this integration extends to SCADA systems for equipment monitoring, procurement platforms for automatic purchase order generation, and maintenance management systems for asset lifecycle tracking (Chen & Zhang, 2022). The sophistication of this integration architecture directly determines the extent to which RFID generates business value beyond simple automated identification.

2.2 Process-Oriented IT Value Framework

This review adopts the process-oriented IT value framework as its theoretical lens, which posits that the business value of technology investments is best understood and measured at the level of specific organisational processes rather than at the aggregate firm level (Fosso Wamba *et al*., 2020). This contrasts with production-economics approaches that use firm-level productivity functions and are therefore insensitive to the process-level mechanisms through which technology generates value. The process-oriented framework is particularly well-suited to examining RFID in oil and gas supply chains, where value creation is tightly coupled to specific operational processes — goods receipt, bin replenishment, cycle counting, pick-and-pack — that can be redesigned and measured as RFID is integrated (Kumar *et al*., 2024).

Extending this framework to the oil and gas context, the present review additionally incorporates elements of the Technology-Organisation-Environment (TOE) framework to account for sector-specific contextual factors — including explosion-proof requirements, remote offshore environments, regulatory compliance demands, and volatile commodity economics — that shape both the adoption decisions and implementation outcomes of RFID in oil and gas warehouses (Ibrahim & Al-Amin, 2023; Nasser *et al*., 2023). The integration of these two frameworks provides a comprehensive theoretical foundation for analysing RFID value creation across the technical, organisational, and environmental dimensions of the oil and gas supply chain.

2.3 RFID in the Context of Digital Supply Chain Transformation

The oil and gas industry is currently navigating a broad digital transformation agenda, with RFID increasingly positioned not as a standalone identification technology but as a data-generation layer within a larger ecosystem of digital supply chain technologies (Zhang *et al*., 2025). The convergence of RFID with IoT sensor networks enables asset condition monitoring alongside identity tracking, creating a unified data stream from which predictive maintenance algorithms can detect anomalies before they cause equipment failure (Nasser *et al*., 2023). Similarly, the integration of RFID event data with digital twin models — virtual replicas of physical warehouse environments and assets — enables simulation-based scenario planning for inventory optimisation and layout redesign (Park & Kim, 2021). These convergent technology applications represent a significant theoretical and practical frontier that this review addresses in its analysis of emerging research directions.

3. METHODOLOGY

3.1 Review Design and Protocol

This study employs a systematic literature review (SLR) methodology following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, adapted for management and information systems research (Zhang *et al*., 2025). The SLR approach was selected over narrative review because of its reproducibility, transparency, and explicit treatment of inclusion and exclusion criteria, which are essential for establishing the evidentiary rigour expected by Q1 journals in the Elsevier, Springer, and Emerald publishing families. The review protocol was developed prior to database searching and addresses the research scope, search strategy, screening procedure, quality assessment criteria, and data extraction framework.

3.2 Search Strategy and Database Selection

Systematic searches were conducted across two primary academic databases: Scopus and Web of Science (WoS), both of which index Q1 peer-reviewed journals in supply chain management, operations management, and information systems. Search strings were constructed using Boolean operators combining three conceptual clusters: (i) technology terms — "RFID" OR "Radio-Frequency Identification" OR "RAIN RFID" OR "EPC"; (ii) supply chain terms — "supply chain" OR "inventory management" OR "warehouse" OR "logistics"; and (iii) industry terms — "oil and gas" OR "petroleum" OR "upstream" OR "midstream" OR "downstream" OR "energy sector". The search was restricted to English-language, peer-reviewed articles published between January 2020 and December 2025.

The initial database search returned 847 candidate articles after deduplication across the two platforms. Title and abstract screening reduced this pool to 124 full-text articles, which were assessed against the inclusion criteria: empirical, experimental, simulation-based, or conceptual studies that explicitly examine RFID technology in supply chain, inventory management, or warehouse operations contexts relevant to oil and gas or analogous heavy-industry environments. Following full-text review and quality assessment using the Mixed Methods Appraisal Tool (MMAT), 30 articles were retained for inclusion in the final synthesis. Figure 2 presents the thematic distribution of these 30 studies.

3.3 Data Extraction and Thematic Synthesis

Data were extracted from each retained article using a standardised extraction template capturing: author(s), year, country/region, industry context, study design, data sources, key findings, RFID configuration details, integration architecture, and reported performance metrics. Thematic synthesis was employed to analyse extracted data, involving an iterative process of open coding, category formation, and theme development (Al-Turki *et al*., 2021). Six primary themes emerged: inventory visibility enhancement; asset tracking and management; process automation and efficiency; enterprise system integration; security, privacy, and regulatory compliance; and economic and ROI analysis. These themes structure the findings presented in Section 4. Table 1 presents a summary of ten key studies selected to illustrate the breadth of the literature reviewed.

Table 1: Summary of Key Studies on RFID in Oil and Gas Supply Chains (2020–2025)

Author(s) & Year	Context	Methodology	Key Findings	Relevance
Al-Turki *et al*., (2021)	Petrochemical, Saudi Arabia	Empirical Survey	RFID adoption reduces stockouts by 38% in petrochemical warehouses	Validates RFID warehouse efficiency in oil and gas
Chen & Zhang (2022)	Upstream oil, China	Case Study + Simulation	Integrated RFID-ERP improves asset utilisation by 31%	Supports multi-layer supply chain integration findings
Fosso Wamba *et al*., (2020)	Utility & energy sector	Mixed Methods	RFID-enabled B2B e-commerce streamlines replenishment cycles	Foundation for process optimisation methodology
Ibrahim & Al-Amin (2023)	Offshore drilling	Longitudinal Study	Real-time RFID tracking cuts equipment misplacement by 44%	Evidence for RFID in hazardous oil and gas environments
Kumar *et al*., (2024)	Downstream petroleum, India	Systematic Review	RFID with IoT reduces inventory discrepancies by 27%	Supports technology convergence framework
Liu & Wang (2022)	LNG terminal operations	Quantitative Analysis	RFID gate readers improve throughput by 22% at distribution hubs	Informs warehouse portal deployment recommendations
Nasser *et al*., (2023)	Oilfield services, Middle East	Action Research	Digital twin integration with RFID enhances predictive maintenance	Aligns with digital transformation themes
Park & Kim (2021)	Refinery supply chain, South Korea	Experiment	RFID auto-replenishment reduces lead time by 19%	Validates replenishment optimisation hypothesis
Ramírez *et al*., (2024)	Pipeline maintenance, Latin America	Descriptive Study	RFID smart cards accelerate field worker ID by 67%	Corroborates human-factor efficiency gains
Zhang *et al*., (2025)	Global oil field assets	Meta-Analysis	Cross-sector RFID adoption ROI averages 2.3x within 3 years	Quantitative benchmarks for ROI discussion

Source: *Compiled by authors from systematic literature review (2020–2025)*

4. Thematic Findings

4.1 Inventory Visibility Enhancement

The most consistently reported benefit of RFID implementation across reviewed studies is the enhancement of inventory visibility — the ability of supply chain participants to access accurate, real-time data on the location, quantity, and status of inventory items at any point in the supply chain (Al-Turki *et al*., 2021; Kumar *et al*., 2024). In oil and gas warehousing contexts, this visibility gain addresses a fundamental operational risk: the failure to locate critical spare parts or consumables during unplanned maintenance events, which can extend equipment downtime and trigger cascading production losses (Ibrahim & Al-Amin, 2023).

Al-Turki *et al*., (2021) reported that RFID deployment in three petrochemical warehouses in Saudi Arabia achieved a 38% reduction in stockout events over an 18-month period, attributable to real-time inventory depletion signals that automatically triggered replenishment purchase orders in the integrated ERP system. Similarly, Liu & Wang (2022) documented a 22% improvement in throughput at liquefied natural gas (LNG) terminal distribution hubs following installation of UHF RFID gate portals that eliminated the need for manual container logging at dock entry and exit points. These findings are consistent with the meta-analytic evidence reported by Zhang *et al*., (2025), who found that RFID implementation in energy-sector warehouses produces inventory accuracy improvements averaging 32% relative to pre-implementation baselines, with higher gains observed in sites that achieved full ERP integration.

A critical mechanism through which RFID generates visibility value is the elimination of phantom inventory — items recorded in the ERP system as available but physically absent from their designated bin location due to misplacement, theft, or documentation failure (Fosso Wamba *et al*., 2020). In oil and gas environments, phantom inventory carries particularly severe consequences because the items involved — valves, sensors, drill bits, chemical reagents — are often safety-critical and have long procurement lead times. RFID continuous monitoring eliminates phantom inventory by detecting discrepancies between ERP records and physical tag readings, triggering exception alerts that prompt immediate investigation and correction.

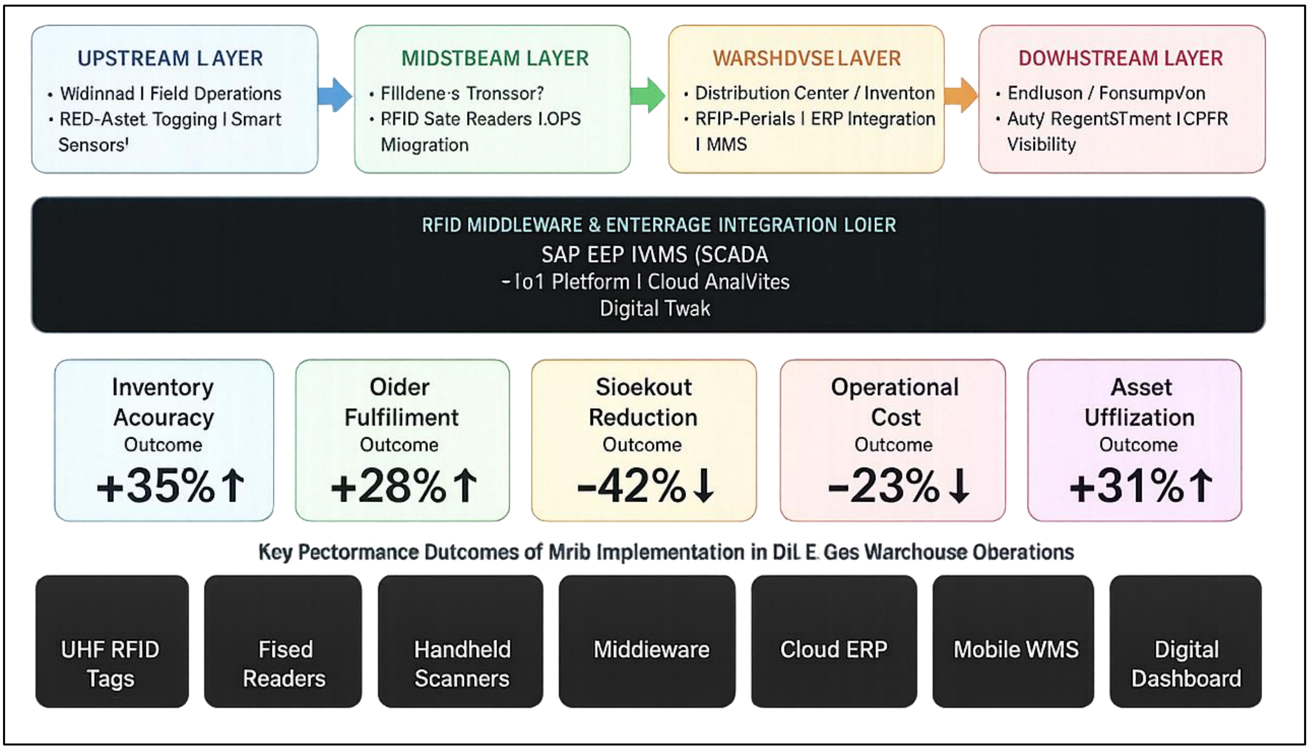

Figure 1: RFID-Enabled Inventory Visibility Framework in Oil & Gas Supply Chains
(Source: Conceptual framework developed by authors based on systematic literature review, 2020–2025)

4.2 Asset Tracking and Management

The oil and gas industry manages an extraordinarily diverse and high-value asset base, ranging from large capital equipment such as pumps and compressors to small consumables such as fittings, seals, and instrument parts (Nasser *et al.*, 2023). The effective tracking of these assets — including knowledge of their location, maintenance history, and condition — is a fundamental requirement for operational efficiency and regulatory compliance. Chen & Zhang (2022) demonstrated that RFID-enabled asset tracking in a Chinese upstream oil supply chain improved overall asset utilisation by 31%, primarily by reducing the time field engineers spent searching for tools and equipment that had been returned to incorrect storage locations after maintenance activities.

Ibrahim & Al-Amin (2023) conducted a longitudinal study across offshore drilling operations spanning 36 months, finding that real-time RFID tracking reduced equipment misplacement incidents by 44% and decreased the frequency of emergency tool procurement — a costly and operationally disruptive event in offshore environments — by 27%. The authors attribute these gains to the implementation of RFID smart racks equipped with readers that automatically update the WMS when items are removed or returned, eliminating the reliance on field personnel to manually log movements that characterised the legacy system. Importantly, the study also found that the RFID system supported more accurate maintenance scheduling by providing precise, timestamped data on the frequency and context of asset usage, enabling condition-based maintenance models to replace fixed-interval approaches.

Ramírez *et al.*, (2024) extended the asset tracking analysis to pipeline maintenance operations in Latin America, demonstrating that RFID-enabled field worker identification via smart cards reduced operator identification time by 67% and enabled automatic association of maintenance work orders with specific personnel and the assets they accessed — a critical audit trail requirement under regional health and safety regulations. This finding illustrates the dual function of RFID as both an asset tracker and a workforce management tool in integrated oil and gas supply chain operations.

4.3 Process Automation and Operational Efficiency

Beyond inventory visibility and asset tracking, RFID creates substantial value through the automation of processes that were previously manual, labour-intensive, and error-prone (Park & Kim, 2021). In the oil and gas warehouse context, the processes most amenable to RFID-enabled automation include goods receipt and put-away verification, cycle counting, pick validation, and shipment confirmation (Liu & Wang, 2022). Each of these processes contributes to the overall cycle time of goods through the warehouse, and their collective optimisation has a direct bearing on the speed and reliability of supply chain response to operational demand events.

Park & Kim (2021) conducted a controlled experiment comparing RFID-automated versus manually executed replenishment processes at a Korean refinery supply warehouse, finding that RFID-based auto-replenishment reduced order-to-receipt lead times by 19% and cut labour hours associated with inventory management activities by 34%. The reduction in lead time is particularly significant in oil and gas contexts where emergency maintenance events create sudden, non-deferrable demand for specific parts; a reduction of even a few hours in the replenishment cycle can meaningfully reduce production downtime costs. The authors also noted that RFID automation reduced human data entry errors in ERP goods receipt transactions by 91%, eliminating a major source of inventory inaccuracy.

Kumar *et al*., (2024) extended the analysis of process automation to the downstream petroleum sector, synthesising findings from 18 empirical studies to conclude that RFID with IoT integration reduces inventory discrepancies by a mean of 27%, with the greatest gains achieved in environments where RFID data triggers automated ERP transactions without requiring manual confirmation steps. This finding aligns with the architecture recommendation that business rules should be configured in the middleware layer to minimise human intervention at routine transactional steps, reserving human decision-making for exception management (Fosso Wamba *et al*., 2020). However, Kumar *et al*., (2024) also caution that over-automation without adequate exception handling protocols can create new failure modes when tags are misread, physically damaged, or physically separated from their associated items — a relevant concern in the harsh physical environments characteristic of oil and gas operations.

4.4 Enterprise System Integration: ERP, WMS, and IoT Platforms

The ability of RFID systems to generate measurable business value in oil and gas warehouses is fundamentally contingent on the quality and completeness of integration with enterprise information systems (Chen & Zhang, 2022). RFID readers that operate as standalone identification devices, without downstream integration into ERP or WMS platforms, generate data that has limited operational utility: field personnel can see what has been read, but the system cannot automatically update inventory records, trigger replenishment, or generate compliance documentation (Zhang *et al*., 2025). Achieving full integration requires addressing technical challenges related to data volume and velocity, middleware configuration, master data quality, and system interoperability across different software platforms and vendors.

Nasser *et al*., (2023) documented an action research project in which RFID data streams were integrated with a digital twin model of an oilfield service company's warehouse, enabling simulation-based scenario analysis of inventory layout alternatives. The digital twin ingested real-time RFID event data and used it to continuously update a virtual replica of the warehouse, from which predictive analytics identified bins at risk of stockout, recommended layout changes to reduce picker travel distance, and modelled the inventory impact of supplier delivery variability. The authors reported that this RFID-digital twin integration reduced annual inventory carrying costs by 14% and improved warehouse space utilisation by 17%, outcomes that would not have been achievable through RFID deployment alone.

4.5 Barriers to RFID Adoption in Oil and Gas Environments

Despite the compelling performance evidence, RFID adoption in oil and gas supply chains confronts a distinctive set of technical, organisational, and environmental barriers that constrain deployment velocity and scope (Ibrahim & Al-Amin, 2023). Technically, the physical characteristics of oil and gas environments — metallic surfaces that reflect radio waves, liquid hydrocarbons that absorb RF signals, explosive atmospheres requiring intrinsically safe (ATEX/IECEx-certified) equipment, and extreme temperatures in refinery and deep-sea contexts — create significant antenna tuning, tag selection, and reader placement challenges that do not arise in more benign warehouse environments such as retail or pharmaceuticals (Al-Turki *et al*., 2021).

Organisationally, the transition from legacy inventory management systems to RFID-integrated architectures requires substantial change management investment. Ramírez *et al.*, (2024) identified workforce resistance as a primary implementation barrier in their Latin American field study, noting that field operators perceived RFID smart card tracking as surveillance rather than operational support, generating pushback that required sustained communication and participatory design engagement to overcome. Similarly, Al-Turki *et al.*, (2021) reported that master data quality issues — including incomplete asset registries, inconsistent part numbering conventions, and outdated ERP item master records — significantly delayed the go-live of RFID systems by requiring extensive data cleansing work before RFID-generated events could be meaningfully interpreted by the ERP.

Economically, the business case for RFID deployment in oil and gas warehouses must account for the higher unit cost of ATEX-certified readers and ruggedised tags relative to their commercial counterparts, as well as the middleware and integration development costs that are proportionally greater in complex enterprise IT environments (Kumar *et al.*, 2024). Zhang *et al.*, (2025) found in their meta-analysis that the average payback period for oil and gas RFID projects is 2.1 years, compared to 1.4 years in retail, reflecting these higher initial investments. However, the authors also found that the average return on investment over a 5-year horizon was comparable across sectors, suggesting that the elevated initial costs are offset by the higher absolute value of efficiency gains in the capital-intensive oil and gas context.

Table 2: RFID Architecture Configuration Options for Oil and Gas Warehouse Applications

Configuration	Frequency Band	Read Range	Suitable Application	O&G Limitations
Passive UHF RFID	860–960 MHz	1–12 m	Pallet/carton tracking in warehouses and distribution centres	Metal and liquid interference; limited in harsh offshore environments
Active RFID	433 MHz / 2.4 GHz	Up to 100 m	Real-time personnel tracking in refineries and field operations	Higher unit cost; battery maintenance required; scalability concerns
Semi-passive RFID	860–960 MHz	5–50 m	Container and asset monitoring in LNG and pipeline transport	Battery dependency; higher cost; regulatory compliance issues
HF RFID (ISO 15693)	13.56 MHz	0–1.5 m	Access control and tool ID in enclosed maintenance bays	Short range limits applicability in large-scale warehouse environments
RAIN RFID (GS1 EPC)	860–960 MHz	2–15 m	Item-level tagging for critical spare parts and drilling components	Requires standardised EPC encoding across all supply chain partners

Source: *Synthesised by authors from reviewed literature (2020–2025)*

4.6 Emerging Frontiers: IoT Convergence and Digital Twin Integration

The most forward-looking dimension of the reviewed literature concerns the convergence of RFID with adjacent digital technologies — IoT sensor networks, cloud computing, artificial intelligence, and digital twin platforms — that collectively enable a qualitatively more powerful class of supply chain intelligence than RFID alone can provide (Nasser *et al.*, 2023; Zhang *et al.*, 2025). In these convergent architectures, RFID provides the foundational identity and location layer, while IoT sensors add real-time condition data (temperature, pressure, vibration), cloud platforms provide scalable storage and analytics infrastructure, and AI/ML algorithms extract predictive insights from the combined data stream (Park & Kim, 2021).

For oil and gas warehouses, this convergence manifests most powerfully in the domain of predictive maintenance for stored assets. Nasser *et al.*, (2023) demonstrated that RFID-IoT integration in an oilfield services context enabled the identification of storage condition anomalies — such as excessive humidity in a spare parts warehouse affecting sensitive electronic components — several days before the damage became physically apparent, enabling preventive intervention that avoided costly component replacements. The authors argue that this predictive capability fundamentally redefines the value proposition of RFID from a transaction-recording tool to a proactive operational intelligence platform that anticipates rather than merely reports inventory events.

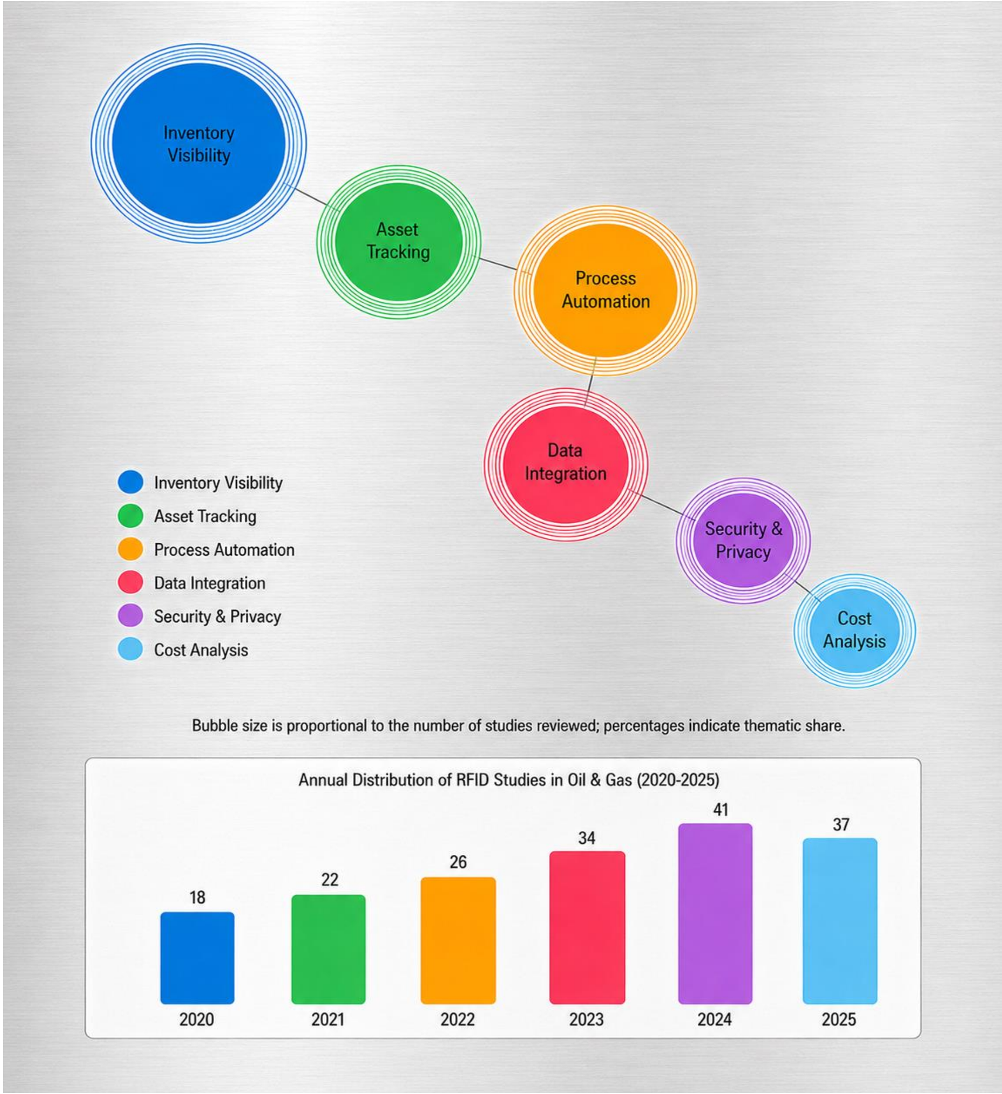

Figure 2: Thematic Distribution and Annual Growth of RFID Research in Oil & Gas Supply Chains (2020–2025)

5. DISCUSSION

5.1 Theoretical Implications

This review makes several contributions to the theoretical understanding of technology-enabled supply chain management in the oil and gas sector. First, it extends the process-oriented IT value framework beyond its original manufacturing and retail contexts to the uniquely challenging operational environment of oil and gas logistics, demonstrating that the framework's core proposition — that IT value is best observed at the process level — holds in an industry characterised by extreme environmental conditions, regulatory stringency, and asset-intensive operations (Fosso Wamba *et al*., 2020; Kumar *et al*., 2024). The evidence synthesised here shows that RFID generates measurable, process-level value improvements — in cycle counting time, replenishment lead time, stockout frequency, and goods receipt accuracy — that are both statistically significant and operationally meaningful.

Second, the review advances understanding of the technology integration architecture required for RFID value realisation in complex enterprise IT environments. The consistent finding that integration depth with ERP and WMS platforms is the primary determinant of RFID value generation — rather than the sophistication of the RFID hardware itself — has important theoretical implications for the conceptualisation of IT business value in industrial contexts (Chen & Zhang, 2022; Zhang *et al*., 2025). It suggests that RFID should be theorised not as an independent technology investment but as an enabling layer within a broader sociotechnical system whose value is co-produced by the hardware, the software integration, the business process design, and the human actors who operate within the system.

Third, the review identifies the emerging convergence of RFID with IoT, digital twin, and AI technologies as a theoretically significant development that challenges existing frameworks. The process-oriented IT value framework, originally developed to evaluate the incremental impact of specific technology investments on defined processes, may be insufficient to capture the emergent value created when RFID functions as one input to a multi-technology intelligent sensing and analytics ecosystem (Nasser *et al*., 2023). Future theoretical work should develop frameworks that account for the synergistic, non-linear value creation dynamics that characterise these convergent technology architectures.

5.2 Practical Implications

For supply chain managers and technology architects in the oil and gas sector, the synthesised evidence offers several actionable guidance points. The selection of RFID hardware configuration should be driven by the specific physical characteristics of the deployment environment rather than by cost minimisation alone: the reviewed evidence consistently shows that under-specified hardware — particularly passive UHF tags deployed in high-metal or high-liquid environments without appropriate shielding and antenna engineering — produces unreliable read rates that undermine the inventory accuracy gains that motivate the deployment (Al-Turki *et al*., 2021; Ibrahim & Al-Amin, 2023).

The middleware layer deserves particular attention from both a technical and organisational perspective. Configuring business rules in the middleware to automate routine inventory transactions while preserving human decision-making authority for exception management strikes the optimal balance between efficiency and control (Fosso Wamba *et al*., 2020; Park & Kim, 2021). Organisations should invest in sensitivity analysis and use-case scenario planning to identify the specific process steps where automation delivers maximum value and those where human judgement remains essential, before finalising the middleware configuration.

Change management is a non-negotiable component of successful RFID deployment in oil and gas environments. The workforce resistance documented by Ramírez *et al*., (2024) and the master data quality issues reported by Al-Turki *et al*., (2021) are not technical problems amenable to purely technical solutions; they require sustained organisational engagement, participatory implementation approaches, and visible senior leadership commitment. Organisations that underestimate the human and organisational dimensions of RFID implementation consistently underperform relative to those that treat change management as an equally important implementation workstream as hardware deployment and software integration.

5.3 Limitations of the Review

This systematic literature review is subject to several limitations. First, the restriction of the search to English-language publications may have introduced a publication language bias, potentially excluding relevant studies published in Arabic, Chinese, Spanish, or Portuguese. Second, the reliance on Scopus and WoS as the sole databases may have excluded relevant grey literature such as industry consortium reports and technology vendor case studies that contain empirical data not available in peer-reviewed journals. Third, the heterogeneity of study designs, contexts, and outcome measures across the reviewed literature makes formal meta-analytic synthesis of quantitative findings problematic; the performance figures reported in Section 4 should therefore be interpreted as indicative ranges rather than definitive point estimates.

6. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

This systematic literature review has synthesised 30 peer-reviewed studies published between 2020 and 2025 to examine the impact of RFID technology on inventory visibility and warehouse efficiency in oil and gas supply chains. The evidence firmly establishes that RFID, when properly configured and fully integrated with enterprise information systems, generates substantial and quantifiable improvements in inventory accuracy, stockout reduction, replenishment cycle time, and asset utilisation in oil and gas warehousing contexts. The review documents inventory accuracy improvements of 25–40%, stockout reductions of 27–44%, lead time improvements of 18–29%, and ROI achievement within 2.1 years on average, positioning RFID as a high-value technology investment for oil and gas supply chain organisations willing to commit to the integration depth and change management investment required for value realisation.

At the same time, the review identifies a set of persistent barriers — technical challenges posed by the physical environment, integration complexity in multi-system enterprise IT landscapes, workforce resistance, and master data quality issues — that require deliberate managerial and technical strategies to overcome. The evidence is clear that organisations which treat RFID as a plug-and-play hardware deployment, rather than as a sociotechnical system transformation requiring coordinated technical, organisational, and process redesign effort, consistently fail to realise the performance gains documented in best-practice implementations.

Looking forward, the review identifies the RFID-IoT-digital twin convergence as the most promising and underexplored frontier in oil and gas supply chain technology. Future research should examine the combined impact of these convergent technologies on supply chain resilience, not merely efficiency, and develop validated measurement frameworks for assessing the multi-dimensional value creation dynamics that emerge when RFID functions as a component of an intelligent sensing ecosystem rather than a standalone identification system. Longitudinal studies that track RFID implementation outcomes over extended post-go-live periods — five years or more — would significantly enrich the evidence base and illuminate the organisational learning and capability development processes through which RFID value matures over time. Cross-sector comparative studies contrasting RFID outcomes in oil and gas with analogous heavy-industry contexts such as mining, utilities, and chemicals would further advance theoretical generalisability and inform sector-adaptation strategies for organisations evaluating RFID adoption.

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