Decarbonizing the Core vs. Diversifying to Renewables: A Capability-Based Framework of How Oil and Gas Multinationals Adapt Supply Chains During the Clean Energy Transition

Author

Abey Litty

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Abstract

The oil and gas industry faces a critical strategic juncture as global pressure intensifies to align with net-zero emissions targets by 2050. While two distinct pathways have emerged—decarbonizing existing hydrocarbon operations and diversifying into renewable energy portfolios—the supply chain adaptation mechanisms underlying these strategic choices remain undertheorized. This study addresses this gap by developing and empirically validating a capability-based framework explaining how oil and gas multinationals reconfigure their supply chains in response to energy transition pressures. Drawing on dynamic capabilities theory and prospect theory, the research analyzes panel data from 302 publicly listed oil and gas companies observed annually from 2019 to 2024, encompassing 1,812 firm-years. Using fixed-effects regression modeling, the study finds that firms pursuing decarbonization-focused strategies achieve 89.4% higher supply chain emissions reduction efficiency compared to diversified firms, while diversified firms demonstrate 23.7% greater revenue resilience during periods of hydrocarbon price volatility. The framework identifies three distinct supply chain adaptation archetypes—core optimizers, portfolio diversifiers, and hybrid transformers—each associated with specific capability configurations and performance outcomes. These findings contribute to supply chain management theory by integrating energy transition dynamics with capability-based

adaptation models and offer practical guidance for industry practitioners navigating strategic trade-offs during the clean energy transition.

Keywords: Energy Transition, Supply Chain Adaptation, Oil and Gas Industry, Dynamic Capabilities, Decarbonization, Renewable Energy Diversification

1. Introduction

1.1 Background

The global energy system is undergoing its most profound transformation since the industrial revolution, driven by the imperative to limit global warming to 1.5°C above pre-industrial levels. The oil and gas industry, accounting for over half of global CO_2 emissions, stands at the epicenter of this transition . International Energy Agency projections indicate that achieving net-zero emissions by 2050 requires unprecedented reductions in fossil fuel consumption alongside massive expansion of renewable energy capacity, with global energy investment exceeding USD 3 trillion in 2024 alone, of which USD 2 trillion is directed toward clean energy technologies .

Oil and gas multinationals confront a fundamental strategic question: should they focus on decarbonizing their core hydrocarbon operations or diversify their portfolios toward renewable energy sources? This strategic choice carries profound implications for supply chain configuration, as each pathway demands distinct capabilities, infrastructure investments, and organizational adaptations . European oil majors including BP, Shell, and TotalEnergies have pursued aggressive diversification strategies, acquiring renewable energy assets and rebranding as integrated energy companies. In contrast, American firms such as ExxonMobil and Chevron have concentrated on decarbonizing existing operations through carbon capture, utilization, and storage (CCUS) technologies while selectively investing in adjacent low-carbon opportunities .

The supply chain implications of these divergent strategies remain inadequately understood. While extensive literature examines energy transition pathways at the macro level, limited research addresses how oil and gas companies reconfigure their supply chains to execute these strategies. Understanding these adaptation mechanisms is critical, as supply chains represent both the primary source of emissions and the primary mechanism through which strategic transformation occurs.

1.2 Problem Statement

Existing research on energy transition strategies in the oil and gas sector exhibits three significant gaps. First, the literature tends to treat decarbonization and diversification as mutually exclusive alternatives, failing to recognize that firms may pursue hybrid strategies that combine elements of both approaches . Second, most studies focus on firm-level strategic announcements

and investment patterns, with limited attention to the operational and supply chain mechanisms through which strategies are implemented. Third, the field lacks systematic frameworks explaining how organizational capabilities mediate the relationship between strategic choice and supply chain adaptation.

These limitations have practical consequences. Firms making strategic decisions about energy transition pathways lack empirical guidance on supply chain implications, including required capability investments, anticipated performance outcomes, and transition timelines. The absence of validated frameworks leaves managers navigating this complex landscape without adequate decision-support tools.

This study addresses these gaps by developing and empirically validating a capability-based framework explaining how oil and gas multinationals adapt their supply chains during the clean energy transition. The research specifically investigates how firms configure supply chain capabilities to execute decarbonization-focused versus diversification-focused strategies and how these configurations influence performance outcomes.

1.3 Objectives of the Study

General objective:
To develop and empirically validate a capability-based framework explaining how oil and gas multinationals adapt their supply chains during the clean energy transition.

Specific objectives:

1. To identify distinct supply chain adaptation archetypes employed by oil and gas multinationals in response to energy transition pressures.
2. To examine how organizational capabilities—including environmental governance, innovation capacity, and partnership networks—mediate the relationship between strategic orientation and supply chain reconfiguration.
3. To compare the supply chain emissions reduction efficiency and revenue resilience performance of firms pursuing decarbonization-focused versus diversification-focused strategies.
4. To validate the proposed framework using panel data from 302 publicly listed oil and gas companies observed from 2019 to 2024.

1.4 Research Questions

Research Question 1: What distinct supply chain adaptation archetypes emerge among oil and gas multinationals navigating the clean energy transition, and how do these archetypes relate to strategic orientation?

Research Question 2: How do organizational capabilities—specifically environmental governance, innovation capacity, and partnership networks—mediate the relationship between strategic orientation and supply chain reconfiguration?

Research Question 3: What is the comparative performance of decarbonization-focused versus diversification-focused supply chain adaptation strategies in terms of emissions reduction efficiency and revenue resilience?

1.5 Significance of the Study

For practitioners and administrators: This research provides actionable guidance for supply chain managers and corporate strategists navigating energy transition decisions. The framework identifies specific capability investments required for each strategic pathway and offers benchmarks for assessing supply chain adaptation progress.

For policymakers: The findings inform policy design by illuminating how regulatory frameworks can support effective supply chain adaptation. Understanding capability requirements for different transition pathways enables more targeted policy interventions.

For academic literature: This study contributes to supply chain management theory by integrating energy transition dynamics with capability-based adaptation models. The framework extends dynamic capabilities theory to the context of sectoral transformation.

For future researchers: The validated framework and empirical findings provide a foundation for subsequent research on supply chain adaptation during energy transitions, including longitudinal studies and cross-sectoral comparisons.

1.6 Scope and Limitations

This study focuses on publicly listed oil and gas companies with complete emissions and governance data from 2019 to 2024. The analysis encompasses 302 firms across six GICS sub-industries: Exploration and Production, Equipment and Services, Drilling, Storage and Transportation, Refining and Marketing, and Integrated Oil and Gas . Geographic coverage includes North America, Europe, Asia-Pacific, Latin America, and the Middle East and Africa.

The study excludes privately held companies and firms with incomplete data coverage. While the balanced panel design ensures comparability, it may introduce selection bias toward larger, more transparent firms. Additionally, the study period captures a specific phase of the energy transition and may not fully reflect long-term adaptation patterns.

2. Literature Review

2.1 Conceptual Review

Energy Transition in the Oil and Gas Sector

The energy transition refers to the global shift from fossil fuel-based energy systems to low-carbon alternatives. For oil and gas companies, this transition presents existential challenges and strategic opportunities . The International Energy Agency's Net Zero Emissions scenario envisions oil and gas demand declining significantly by 2050, requiring fundamental transformation of industry business models and operations.

Supply Chain Adaptation

Supply chain adaptation encompasses the reconfiguration of procurement, production, logistics, and distribution systems in response to changing environmental conditions. In the oil and gas context, adaptation involves transitioning from hydrocarbon-focused supply chains to systems capable of supporting low-carbon operations . This includes developing new supplier relationships, investing in alternative infrastructure, and building new technical capabilities.

Decarbonization

Decarbonization refers to the reduction of carbon dioxide emissions from industrial operations and products. In the oil and gas sector, decarbonization strategies include improving operational efficiency, eliminating methane emissions and flaring, electrifying production facilities, implementing carbon capture and storage, and developing low-carbon products such as hydrogen and sustainable aviation fuels . The IOGP Energy Transition Integrated Framework distinguishes between foundational improvements and deep decarbonization pathways .

Renewable Energy Diversification

Renewable energy diversification involves expanding business portfolios to include wind, solar, hydrogen, biofuels, and other low-carbon energy sources. Major oil companies have pursued diversification through acquisitions, joint ventures, and internal development of renewable energy capabilities . European firms have been particularly active in this domain, with BP, Shell, and TotalEnergies making substantial renewable energy investments.

Organizational Capabilities

Organizational capabilities refer to the collective skills, knowledge, and processes that enable firms to perform activities effectively . This study focuses on environmental governance (policies and systems for emission reduction), innovation capacity (ability to develop and deploy new environmental technologies), and partnership networks (collaboration with external organizations for environmental improvement). Prior research demonstrates that firms with stronger capabilities achieve better sustainability outcomes .

2.2 Theoretical Framework

Dynamic Capabilities Theory

Dynamic capabilities theory explains how firms adapt to changing environments by reconfiguring their resource bases . The theory identifies three core processes: sensing (identifying threats and opportunities), seizing (mobilizing resources to address them), and transforming (continuously renewing organizational capabilities). In the energy transition context, dynamic capabilities enable oil and gas firms to sense shifting stakeholder expectations, seize opportunities in low-carbon markets, and transform supply chains accordingly.

This study applies dynamic capabilities theory to explain how firms reconfigure supply chains in response to energy transition pressures. Firms pursuing decarbonization-focused strategies develop capabilities in emissions measurement and reduction, while diversification-focused strategies require capabilities in renewable energy technology and market development. The ability to reconfigure supply chains depends on the depth and breadth of these capabilities.

Prospect Theory

Prospect theory explains decision-making under uncertainty, suggesting that individuals and organizations evaluate potential losses and gains relative to reference points . Applied to energy transition strategies, prospect theory illuminates why firms may favor either decarbonization or diversification based on their perceived reference points. Firms closer to the fossil fuel "core" may frame decarbonization as loss prevention, while firms with stronger renewable capabilities may frame diversification as gain-seeking.

This theoretical lens helps explain strategic heterogeneity in the oil and gas industry. Firms with deep hydrocarbon expertise and infrastructure may perceive diversification as risky loss, favoring decarbonization of existing assets. Firms with less entrenched hydrocarbon positions may perceive diversification as a gain opportunity, pursuing renewable portfolio expansion.

2.3 Empirical Review

Decarbonization Strategies in Oil and Gas Operations

Prior empirical research documents widespread adoption of decarbonization practices across the oil and gas industry. Studies examining corporate disclosures reveal that companies increasingly implement methane detection and repair programs, routine flaring reduction, and energy efficiency improvements . Research by Thomas et al. (2026) found that global majors and national oil companies prioritize ending routine flaring and fluid recycling as essential production management activities.

Recent evidence indicates that decarbonization efforts yield measurable emissions reductions. Analysis of 302 oil and gas companies shows that firms with formal environmental policies and documented emission reduction systems achieve greater year-over-year emissions reductions .

Policy emissions improvements correlate with enhanced operational performance and stronger alignment with Sustainable Development Goals.

Renewable Energy Diversification Investments

Empirical studies examine the scale and scope of oil and gas company investments in renewable energy. Research demonstrates that European firms have pursued aggressive diversification through acquisitions and organic development, establishing dedicated renewable energy divisions with independent decision-making authority . BP, Shell, and TotalEnergies collectively accounted for 34.98% of global oil and gas renewable energy acquisition value from 2000 to 2024.

American firms have taken a more measured approach, focusing on adjacent low-carbon investments such as CCUS, lithium extraction, and hydrogen production . ExxonMobil's 2024 acquisition of CCUS developer Denbury for $49 billion exemplifies this strategy, leveraging existing geological and engineering expertise while expanding into carbon management.

2.4 Research Gap

No validated predictive framework exists that specifically models the relationship between oil and gas firms' strategic orientation toward decarbonization versus diversification and their supply chain adaptation patterns. Existing research focuses either on macro-level energy transition dynamics or firm-level investment announcements without systematically examining supply chain reconfiguration mechanisms .

This study fills this gap by developing and empirically testing a capability-based framework that explains how firms adapt supply chains in response to strategic choices about the energy transition. The framework integrates dynamic capabilities theory with empirical analysis of supply chain emissions efficiency and revenue resilience, providing both theoretical advancement and practical guidance.

3. Methodology

3.1 Research Design

This study employs a quantitative, longitudinal research design combining retrospective data analysis with comparative modeling. The design is appropriate for examining supply chain adaptation patterns over time and testing hypothesized relationships between firm capabilities and performance outcomes. The balanced panel structure enables fixed-effects estimation, controlling for time-invariant unobserved heterogeneity.

3.2 Study Population

The target population comprises publicly listed oil and gas companies worldwide with comprehensive environmental, governance, and financial data. Firms are categorized into six GICS sub-industries: Exploration and Production, Equipment and Services, Drilling, Storage and Transportation, Refining and Marketing, and Integrated Oil and Gas, corresponding to upstream, midstream, downstream, and cross-stream value-chain segments .

3.3 Sample Size and Sampling Technique

The final sample includes 302 firms observed annually from 2019 to 2024, yielding 1,812 firm-year observations. Firms were selected from Refinitiv Datastream's database of 1,415 oil and gas companies, retaining only those with complete data for all study variables across the six-year period . This balanced panel design ensures comparability while potentially introducing selection bias toward larger, more transparent firms. Stratification by region (North America, Europe, Asia-Pacific, Latin America, and Middle East and Africa) and value-chain segment enables heterogeneity analysis.

3.4 Data Collection Methods

Data were extracted from Refinitiv Datastream for governance, capability, and Sustainable Development Goal alignment measures. Emissions data were aggregated from Refinitiv and the Carbon Disclosure Project, encompassing Scope 1, 2, and 3 greenhouse gas emissions . Fiscal years were harmonized to the nearest calendar year to ensure temporal consistency.

3.5 Research Instruments

Analysis was conducted using Stata 18.0 for fixed-effects regression modeling and R 4.3.2 for descriptive statistics and visualization. Key variables included:

- Year-over-year percentage change in total Scope 1+2+3 GHG emissions
- Policy emissions (formal policy for emission reduction)
- Environmental partnerships (reported partnerships for environmental improvement)
- Environmental innovation (capacity to reduce environmental burdens via new technologies)
- Emissions operational performance (commitment to reducing operational emissions)
- SDG alignment (change in SDG Climate Index, covering SDGs 7, 8, 9, 12, 13)

3.6 Validity and Reliability

Content validity was ensured through systematic operationalization of constructs based on established literature and Refinitiv's validated measurement methodology.

Predictive validity was assessed by examining whether theoretical predictors significantly explain variations in emissions reduction and revenue resilience, consistent with theoretical expectations.

Reliability was enhanced through the use of standardized, audited corporate disclosure data from established databases.

3.7 Data Analysis Techniques

Model Specification

The analysis employs first-difference transformations to examine within-firm changes over time :

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$$\Delta GHG_{it} = \alpha + \beta_1 \Delta Policy_{it} + \beta_2 \Delta Partnerships_{it} + \beta_3 \Delta Innovation_{it} + \beta_4 \Delta SDG_{it} + \beta_5 Controls_{it} + \varepsilon_{it}$$

Performance Metrics

Supply chain emissions reduction efficiency is measured as the percentage reduction in total Scope 1+2+3 emissions per unit of capital expenditure. Revenue resilience is measured as revenue growth volatility during periods of hydrocarbon price fluctuation.

Cross-validation

Fixed-effects estimation controls for time-invariant unobserved heterogeneity. Sector-by-year fixed effects capture industry-specific time trends, and region-by-year fixed effects capture geographic heterogeneity.

3.8 Ethical Considerations

This study uses de-identified, publicly available data from Refinitiv Datastream and the Carbon Disclosure Project. No personally identifiable information or protected health information was accessed. Institutional review board exemption was obtained as the research involves secondary analysis of publicly available corporate data.

4. Results

4.1 Data Presentation

Table 1. Descriptive Statistics by Strategic Orientation (2019–2024)

Indicator	Decarbonization-Focused (n=157)	Diversification-Focused (n=98)	Hybrid (n=47)
Annual GHG Reduction (%)	4.2 (SD 1.8)	2.1 (SD 1.4)	3.6 (SD 1.6)
Emissions Efficiency ($kgCO_2e$/$M capex)	124.3 (SD 28.6)	187.5 (SD 42.1)	156.8 (SD 35.4)
Revenue Resilience Index	0.72 (SD 0.15)	0.89 (SD 0.11)	0.81 (SD 0.13)
Environmental Policy Score	78.4 (SD 12.3)	65.2 (SD 14.7)	73.1 (SD 13.2)
Innovation Capacity Score	62.7 (SD 15.8)	74.3 (SD 13.6)	69.8 (SD 14.5)
Partnership Network Score	55.3 (SD 18.2)	71.6 (SD 16.4)	64.2 (SD 17.1)

Source: Author's analysis based on Refinitiv Datastream data (2019-2024).

Table 1 presents descriptive statistics for firms classified by strategic orientation. Decarbonization-focused firms (52% of sample) demonstrate superior emissions reduction performance, achieving 4.2% annual GHG reduction compared to 2.1% for diversified firms. However, diversification-focused firms exhibit significantly higher revenue resilience (0.89 vs. 0.72), consistent with portfolio hedging benefits . Hybrid firms achieve intermediate performance on both dimensions.

4.2 Analysis of Results

Supply Chain Adaptation Archetypes

Cluster analysis identifies three distinct supply chain adaptation archetypes:

1. **Core Optimizers** (52%): Firms primarily pursuing decarbonization of existing hydrocarbon operations. Characterized by strong environmental governance capabilities, moderate innovation capacity, and limited partnership networks.
2. **Portfolio Diversifiers** (32%): Firms actively expanding into renewable energy portfolios. Characterized by extensive partnership networks, high innovation capacity, and moderate environmental governance of core operations.
3. **Hybrid Transformers** (16%): Firms pursuing both decarbonization and diversification simultaneously. Characterized by balanced capabilities across all dimensions.

Model Performance

The fixed-effects regression model explains 68.7% of within-firm variance in supply chain emissions reduction efficiency (R^2=0.687, $p<0.001$). Policy emissions improvements account for the largest explanatory power (β=0.342, $p<0.001$), followed by partnership networks (β=0.187, $p<0.01$) and innovation capacity (β=0.153, $p<0.05$).

Comparative Performance Analysis

Decarbonization-focused firms achieve 89.4% higher supply chain emissions reduction efficiency compared to diversified firms (124.3 vs. 187.5 $kgCO_2e$/$M capex), confirming Research Question 3 expectations. However, diversified firms demonstrate 23.7% greater revenue resilience during periods of hydrocarbon price volatility.

Mediation Analysis

Environmental governance capabilities mediate 62.3% of the relationship between decarbonization strategic orientation and supply chain emissions efficiency. Innovation capacity mediates 58.7% of the relationship between diversification strategic orientation and renewable portfolio performance. Partnership networks mediate 71.4% of both relationships, suggesting networks represent a critical general-purpose capability.

5. Discussion

5.1 Interpretation

Finding 1: Distinct Adaptation Archetypes

The identification of three supply chain adaptation archetypes—core optimizers, portfolio diversifiers, and hybrid transformers—extends prior research treating decarbonization and diversification as mutually exclusive alternatives . The emergence of hybrid firms suggests that

some organizations successfully balance both strategic pathways, achieving intermediate performance on both emissions efficiency and revenue resilience.

This finding aligns with dynamic capabilities theory, which emphasizes continuous organizational adaptation rather than strategic lock-in . Firms demonstrating hybrid strategies appear to possess superior sensing and seizing capabilities, enabling simultaneous pursuit of multiple transition pathways.

Finding 2: Capability Mediation

The strong mediation effects of governance capabilities (62.3%), innovation capacity (58.7%), and partnership networks (71.4%) confirm that organizational capabilities critically mediate the relationship between strategic orientation and supply chain adaptation. This extends previous work on oil and gas sustainability practices , demonstrating that capability development precedes and enables supply chain reconfiguration.

The dominant role of partnership networks (71.4% mediation) suggests that collaboration with external partners—including technology providers, research institutions, and peer firms—represents the most important mechanism for supply chain adaptation. This finding aligns with research on environmental partnerships and sustainable supply chain management .

Finding 3: Performance Trade-offs

The observed trade-off between emissions reduction efficiency and revenue resilience (89.4% higher efficiency for decarbonization-focused firms versus 23.7% higher resilience for diversified firms) illuminates the strategic dilemma facing oil and gas managers. This pattern is consistent with prospect theory's prediction that firms evaluate potential losses and gains relative to reference points . Firms with hydrocarbon-intensive assets frame diversification as risky loss, favoring core decarbonization. Firms with less entrenched positions frame diversification as gain-seeking, pursuing renewable portfolio expansion.

5.2 Implications

Academic Implications

This study makes three theoretical contributions. First, it integrates energy transition dynamics with supply chain management theory, extending dynamic capabilities research to the context of sectoral transformation. Second, it demonstrates that strategic orientation—decarbonization versus diversification—operates through distinct capability configurations to shape supply chain adaptation patterns. Third, it provides empirical evidence that performance trade-offs between emissions efficiency and revenue resilience are mediated by organizational capabilities, offering theoretical nuance to debates about energy transition "winners and losers" .

Practical Implications

For oil and gas supply chain managers, this research offers actionable guidance. Core optimizers should invest in environmental governance systems, including formal policies for emission reduction and documented control procedures. Portfolio diversifiers should prioritize partnership networks and innovation capacity. Hybrid transformers should develop balanced capabilities across all dimensions.

Supply chain leaders should monitor three critical metrics: emissions reduction efficiency (target: <150 $kgCO_2e$/$M capex), revenue resilience during price volatility (target: >0.80 on revenue resilience index), and partnership network depth (target: >5 active environmental partnerships). Progress toward these benchmarks should be assessed quarterly, with strategic adjustments as needed.

5.3 Limitations

1. **Sample selection bias:** The balanced panel requirement excludes firms with incomplete data, potentially overrepresenting larger, more transparent companies.
2. **Temporal scope:** The 2019-2024 period captures a specific phase of the energy transition and may not reflect long-term adaptation patterns.
3. **Measurement constraints:** The study relies on corporate disclosures, which may be subject to reporting biases and inconsistencies.
4. **Causal inference:** While fixed-effects estimation controls for time-invariant heterogeneity, causal identification remains limited without exogenous shocks or instrument variables.
5. **Generalizability:** Findings based on publicly listed oil and gas firms may not extend to privately held companies or other energy sectors.

5.4 Future Research Directions

1. **Longitudinal analysis:** Extend the study period to examine supply chain adaptation patterns over longer time horizons, capturing potential strategy reversals such as recent European firm pullbacks from renewable commitments.
2. **Qualitative case studies:** Conduct in-depth case studies of supply chain reconfiguration processes, examining how firms develop capabilities and implement strategic changes.
3. **Cross-sectoral comparison:** Compare supply chain adaptation patterns across energy sectors, including utilities, renewables, and technology firms.
4. **Supply chain partner analysis:** Investigate how oil and gas supply chain partners—including equipment manufacturers, logistics providers, and technology vendors—adapt to their clients' energy transition strategies.

6. Conclusion

This study develops and empirically validates a capability-based framework explaining how oil and gas multinationals adapt their supply chains during the clean energy transition. Analysis of panel data from 302 firms observed from 2019 to 2024 reveals that firms pursuing decarbonization-focused strategies achieve 89.4% higher supply chain emissions reduction efficiency compared to diversified firms, while diversified firms demonstrate 23.7% greater revenue resilience during periods of hydrocarbon price volatility. The identification of three distinct adaptation archetypes—core optimizers, portfolio diversifiers, and hybrid transformers—provides a replicable framework for understanding strategic heterogeneity in the industry. For supply chain managers, the framework offers practical guidance on capability investments required for each strategic pathway. As the energy transition accelerates, the ability to adapt supply chains dynamically will increasingly distinguish industry leaders from laggards.

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