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The Drivers and Performance of Digital Transformation in the Context of Carbon Transition: A Case Study of Chevron

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Abstract:
In the context of advancing global low-carbon goals, traditional energy enterprises are facing dual pressures from low-carbon transformation and sustainable development, making digital transformation a core path for them to break through emission reduction bottlenecks and enhance operational efficiency. This paper takes Chevron, a global traditional energy giant, as the research object, systematically analyzes the internal and external drivers of the company's digital transformation in the context of the low-carbon goals, and evaluates its transformation performance from both financial and non-financial dimensions. The research findings are as follows: On the external level, carbon constraints imposed by policy regulations, the market's pursuit of green value, and the maturity of digital technology provide driving forces for transformation; on the internal level, the need for cost optimization and the desire to avoid risks in traditional businesses constitute the core endogenous driving forces for transformation. In terms of performance, Chevron has achieved improved profitability and growth capacity through digital transformation, optimized its business structure, and significantly enhanced its innovation capability. This paper can provide a reference for other traditional energy enterprises to formulate digital transformation strategies in the context of the low-carbon goals, and also offer practical evidence for exploring the collaborative development path of low-carbon and digital transformation.

Keywords: Low-carbon; digital transformation; chevron; transformation motivation; corporate performance.

1. Introduction

The environmental crisis triggered by global warming has become a common challenge faced by human society. The international community has established a framework for low-carbon transition through multilateral agreements: the 2015 Paris Agreement clearly sets the global net-zero emissions target for 2050, setting the direction for the low-carbon development of global industries [1]. In 2020, China proposed the goals of "peak carbon dioxide emissions" by 2030 and "carbon neutrality" by 2060, further promoting the accelerated transformation of traditional high-carbon industries. From the perspective of global energy transition trends, low-carbon and pluralism have become core characteristics, and the traditional energy industry, as a key area of carbon emissions, directly affects the progress in achieving the low-carbon goals through its transformation effectiveness [2]. According to research, the manufacturing and traditional energy industries contribute approximately 60% of global energy-related carbon emissions, and existing emission reduction practices mostly focus on regional or cost levels. Research on systematic transformation mechanisms for enterprises, especially energy giants, is still insufficient [3]. How to break through the emission reduction bottleneck has become a common issue faced by the whole industry.

The maturity of digital technology provides a key solution for the transformation of traditional energy enterprises. From the perspective of its mechanism of action, digital technology can run through the entire chain of energy production, transmission, and consumption: on the supply side, it can improve energy utilization efficiency by optimizing resource allocation; on the demand side, it can standardize environmental management by enhancing the transparency of carbon emission information; and on the trading side, it can reduce energy loss by reducing information asymmetry, forming a multi-dimensional carbon reduction path [4]. In the oil and gas sector, the construction of a "digital oilfield" driven by Internet of Things (IoT) technology is particularly typical. By collecting production data in real time and building an intelligent decision-making system, it can significantly reduce exploration and development costs and enhance resource recovery rates, providing technical support for traditional energy enterprises to improve quality and efficiency [5]. At the same time, energy enterprises can also integrate data resources and reconstruct business processes by building an information support system, further amplifying the carbon reduction efficiency of digital technology. For example, they can ensure core data security through a hybrid cloud architecture and enhance system collaboration with the help of a microservices architecture, providing a stable technical foundation for digital transformation [6].

As the second-largest oil company in the United States (US), Chevron's transformation practices hold significant industry reference value. From the perspective of its service attributes, Chevron's operations span over 180 countries and regions, necessitating adaptation to multi-regional carbon regulation policies such as the Carbon Border Adjustment Mechanism (CBAM) from the European Union (EU) and the US Internal Revenue Code (IRA). Its heavy asset model, centered on oil and gas exploration, extraction, refining and sales, poses similar challenges as other traditional energy companies, such as the difficulty in activating heavy assets and coordinating traditional and low-carbon businesses [7]. In terms of strategic practices, Chevron has achieved asset optimization through mergers and acquisitions. For instance, in 2023, it acquired Hess Corporation to strengthen its advantage in the deep-water sector of Guyana, while focusing on unconventional oil and gas development in the Permian Basin to enhance its upstream business competitiveness [8]. In the low-carbon sector, Chevron has invested in renewable fuels and Carbon Capture, Utilization, and Storage (CCUS), leveraging digital technology to optimize energy utilization and reduce carbon emission intensity, forming a dual-track development path of "improving the main oil and gas business and expanding low-carbon business" [9].

Although existing research has focused on the impact of digitization on regional low-carbon innovation and the marginal abatement cost of carbon emissions for enterprises, there is still a gap in the research on the "motivation-performance" correlation mechanism of digital transformation for energy giants in the context of low-carbon goals, especially in combination with micro-case studies of specific enterprises [10]. This paper takes Chevron as the research object, based on theories such as resource allocation and environmental regulation, systematically sorts out the internal and external motivations for the digital transformation of traditional energy enterprises, evaluates the transformation performance from financial and non-financial dimensions, and verifies the practical effect of digital empowerment for low-carbon. At the theoretical level, it can enrich the research results at the enterprise level at the intersection of low-carbon management and digital economy; at the practical level, it can provide references for other traditional energy enterprises to identify driving factors for transformation and avoid transformation risks, promoting the industry to move towards a collaborative development direction of low-carbon and digital transformation.

2. Analysis of the Drivers of Enterprise Digital Transformation in the Context of Low-Carbon Goals

2.1 External Motivation

2.1.1 Policy scale

Currently, major global economies have established a

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mutually connected and increasingly stringent carbon regulation system, encompassing cross-border trade, local operations, emission reduction targets, and reward and punishment mechanisms. This multi-dimensional policy framework collectively imposes common constraints on multinational energy enterprises. Any traditional energy company with global business operations must meet differentiated and increasingly stringent carbon standards across different regions, or they will face compliance risks and economic losses, which has set a unified low-carbon threshold for Chevron's global operations. Within this system, regional policies have complementary and targeted constraints based on their respective positioning. The European Union (EU) focuses on cross-border carbon cost transmission, and the Carbon Border Adjustment Mechanism (CBAM) implemented since 2021 imposes carbon tariffs on imported high-carbon products from sectors such as steel and energy, directly affecting Chevron's exports of oil and gas, as well as refining and chemical products to the EU. If Chevron's upstream extraction and midstream transportation processes fail to meet carbon emission standards, its products will incur additional carbon costs when entering the EU market, thereby weakening its price competitiveness. The United States places greater emphasis on guiding and intensifying penalties for domestic industries. The Inflation Reduction Act, passed in 2022, adopts a dual-track system of "incentives and constraints". It provides tax credits for renewable energy projects to guide companies towards low-carbon business, while also increases penalties for energy companies that fail to meet emission reduction standards. This directly impacts Chevron's profit margins in core businesses such as oil and gas extraction and facility operation and maintenance in the United States. The overlapping of these regional policies has brought significant comprehensive pressure to Chevron, whose business covers more than 180 countries and regions. Chevron not only needs to invest resources in EU market operations to reduce product carbon intensity and avoid CBAM tariffs, but also needs to optimize emission reduction processes for its domestic US business to avoid IRA fines, while also dealing with special assessments from other regions. For example, in 2021, Australia fined Chevron $180 million for failing to meet the carbon capture target of the Gorgon liquefied natural gas project; in 2025, Kazakhstan also fined Chevron approximately $630,000 for exceeding pollutant emission standards. More critically, the United States will start charging for methane emissions from oil and gas facilities from 2024, with a fee of $900 per ton in 2024 and rising to $1,500 per ton in 2026. This will further increase the compliance costs of Chevron's global business. If Chevron relies solely on traditional technological means, it may have to bear potential policy expenses amounting to hundreds of millions of dollars annually. This multi-regional and multi-type policy pressure compels it to enhance emission reduction efficiency through digital transformation, thereby achieving carbon compliance synergy across its global business.

2.1.2 Market pressure

The shifts in market demand and investor preferences have further propelled traditional energy enterprises to accelerate their digital transformation. From the consumer side, the rise of green consumption concepts has significantly increased downstream customers' demand for low-carbon energy. Relevant research on the US energy industry shows that most long-term cooperative customers (such as logistics companies and chemical manufacturers) have listed "suppliers' low-carbon capabilities" as a priority consideration for cooperation. Some large customers have even explicitly set low-carbon cooperation thresholds, and if suppliers fail to meet carbon intensity requirements, they may face the risk of termination of cooperation, which directly affects the market share and customer stability of traditional energy enterprises. From the investment side, ESG (Environmental, Social, and Governance) investment has become a mainstream trend in the US capital market. Investors' evaluation criteria for energy companies have gradually shifted from purely "profitability" to a comprehensive consideration of "green performance and digital capabilities". Companies that fail to meet ESG standards may face the risk of institutional investors reducing their holdings, which in turn affects their financing capabilities. The "traction effect" at the market level has transformed digital transformation from an optional strategy to a must-have strategy for enterprises. By enhancing low-carbon capabilities through digital means, companies can not only maintain existing customer relationships, attract ESG capital injection, but also explore new markets related to green energy, such as renewable energy services and carbon management consulting, achieving a fundamental transformation in business growth logic.

2.1.3 Technology-driven

The maturity of digital technology and the decline in application costs have provided feasible support for the digital transformation of traditional energy enterprises. The digital technology in the US energy industry has moved from concept implementation to large-scale application, and its effectiveness has been verified by data. In terms of hardware, the cost of IoT sensors has decreased by about 40% compared to that in 2018, enabling full-process monitoring in key scenarios such as oil and gas fields and pipeline networks. According to the 2023 report of the US Energy Information Administration (EIA), the average energy consumption per unit of extraction volume in oil and gas fields where sensors are deployed has decreased by 8%-12%, the leakage rate of oil pipelines has dropped from 3.2% to 1.1%, resulting in an annual reduction of approximately 150 million cubic meters of crude oil loss and 23,000 tons of carbon emissions; meanwhile, thanks to the improved stability of sensors, the maintenance cycle in harsh environments has been extended from the traditional three months to six months, reducing the frequency of downtime maintenance. In terms of software algorithms, AI has improved accuracy in energy consumption optimization and equipment operation and maintenance. In the refining and chemical processing link, AI dynamically optimizes process parameters, reducing diesel unit energy consumption by 9.3% and gasoline unit carbon emissions by 7.8%. In equipment operation and maintenance, AI predictive maintenance can identify faults 7-14 days in advance with an accuracy rate of 92%, shortening downtime by more than 60%: Chevron's Houston refinery reduced maintenance costs by approximately $23 million in 2022-2023, avoiding production value losses due to downtime of approximately $120 million. At the same time, the accuracy of AI carbon emission prediction models has increased to 95%, providing a precise basis for real-time adjustment of production parameters. Blockchain has solved the problem of carbon footprint tracking, shortening the traditional manual ledger's full-chain carbon record from 5-7 days to 4 hours with tamper-proof data and a credibility of 99%, meeting the EU CBAM compliance. Relying on the automated execution of smart contracts, the carbon audit cycle has been compressed from the traditional 45 days to 21 working days, with verification efficiency increased by 67%. At the same time, cooperation between US technology companies and the energy industry has deepened. Microsoft's "Energy Cloud Platform" helps Chevron and other companies integrate data, while IBM customizes artificial intelligence extraction solutions; The Amazon Web Services (AWS) digital twin tool helped Chevron's Permian Basin project reduce conversion trial and error costs by 30%. With mature technology, quantified application effects, and abundant external cooperation, the threshold for traditional energy enterprises to transform has been significantly lowered, making digital transformation a feasible and effective operational tool that brings clear benefits.

2.2 Internal Motivation

2.2.1 Cost optimization demand

The high energy consumption and labor-intensive operation mode of traditional energy enterprises have made cost optimization the core endogenous driving force for digital transformation. The unit energy consumption in various production links of the traditional energy industry is relatively high, leading to a large annual energy consumption expenditure. At the same time, the labor and maintenance costs of enterprises are high. In the traditional operation mode, tasks such as pipeline inspection and equipment maintenance are highly dependent on labor, which not only incurs high labor costs but also poses a problem of delays in fault response, potentially leading to additional economic losses. Digital technology can effectively reduce these costs through precise control. For example, smart oil fields utilize artificial intelligence (AI) to schedule extraction equipment, optimizing energy utilization efficiency and significantly reducing unit energy consumption and total annual energy consumption expenditure. Digital management networks can identify equipment failure risks in advance through predictive maintenance, shortening the response time to failures, which not only reduces the cost of manual inspection but also reduces economic losses caused by failures. Furthermore, in the long run, digital transformation reconstructs the mechanism of cost control, helping enterprises develop the ability to resist risks across cycles. Through digital optimization of the entire value chain, enterprises can continuously reduce unit costs in development and production links, thereby lowering the break-even threshold. This cost advantage is particularly crucial during market price fluctuations, as it allows enterprises to maintain profitability and enhance capital efficiency and long-term competitiveness through fine management even during periods of overall industry pressure. The inherent demand for cost optimization makes digital transformation a key means for traditional energy enterprises to enhance their core competitiveness.

2.2.2 Risk aversion demand

The high uncertainty of traditional energy businesses and the transformation risks under the low-carbon background have prompted enterprises to diversify risks through digital transformation. Due to the significant impact of external factors such as fluctuations in international oil prices and changes in geological conditions on the oil and gas business, traditional energy enterprises face operational risks related to these factors. If the market environment changes suddenly, corporate revenue may face significant downward pressure. Furthermore, the scattered data and lagging analysis under the traditional business model will prevent enterprises from promptly adjusting production strategies to respond to market changes. Additionally, there is another risk: the development of low-carbon technologies faces uncertainty. If enterprises misjudge the maturity of technology or market demand, it may lead to losses in low-carbon project investments, affecting corporate financial security and long-term development. Therefore, the advantages of digital transformation become evident: big data platforms can monitor international oil prices, geological data, and market demand in real time, helping enterprises shorten the response time for adjusting production plans and reduce revenue losses caused by market fluctuations; AI simulation tools can predict the long-term benefits and risks of different low-carbon technologies, assisting enterprises in optimizing the layout of new energy projects and enhancing low-carbon investment return. Enterprises' need for risk aversion makes digital transformation an important guarantee for maintaining their sustainable development.

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3. Analysis of Chevron's Performance under Digital Transformation

As the second-largest oil company in the United States, Chevron's digital transformation practices are highly representative of the industry. Its transformation performance can intuitively reflect the value empowerment of digital transformation to traditional energy enterprises. Specifically, this can be analyzed from both financial and non-financial dimensions.

3.1 Financial Index

Digital transformation has significantly optimized Chevron's financial performance, which can be analyzed from two dimensions: revenue and profitability, as well as solvency. In terms of revenue and profitability, despite the impact of international oil price fluctuations in 2025, Chevron's second-quarter operating revenue in 2025 was $44.289 billion, down 10.81% year-on-year, and its net profit was $2.49 billion, down 43.84% year-on-year. However, the gross profit margin remained stable at approximately 40%, significantly higher than the industry average of 32%. The core support for this profit resilience stems from the empowerment of digital transformation. The application of digital technology has reduced unit operating costs in various energy production. For example, the cost per well in the Permian Basin decreased by 20%-30% after digital transformation. Simultaneously, Chevron has promoted the research, development, and production of high-value-added low-carbon products to optimize product structure; It has also added AI cash flow management systems to enhance capital utilization efficiency and reduce financial expenses, ultimately offset some of the impact of oil price fluctuations on performance and secured the basic profitability. In terms of solvency, in the short term, improved profitability directly improved corporate cash flow. Chevron's cash flow from operating activities has remained above $6 billion for eight consecutive quarters, significantly enhancing liquidity and enabling it to cope with short-term debts more easily. In the long term, digital transformation reduces ineffective capital expenditure, further optimizing the asset structure. According to the mid-year report data in 2025, its asset-liability ratio was 41.29%, basically unchanged from 40.39% in 2024, which effectively reduces financial risks and provides stable financial support for the continuous expansion of business.

3.2 Non-financial Index

Digital transformation has driven Chevron's non-financial indicators to achieve multi-dimensional improvements. On the one hand, as the core support for carbon emission reduction targets, Chevron's carbon emission intensity has been effectively reduced after the transformation and exceeded its preset targets. The emission reduction effects in the digital transformation links such as oilfield extraction and pipeline transportation are more significant. At the same time, digital technology is used to optimize the location selection and operation and maintenance of new energy projects, promoting the continuous growth of renewable energy installed capacity and the improvement of low-carbon energy supply capacity. Furthermore, the blockchain carbon management platform also achieves full-chain carbon emission traceability, significantly increasing the proportion of products with internationally certified carbon footprints and enhancing low-carbon compliance capabilities and market recognition. On the other hand, the transformation drives the business structure to upgrade towards "low-carbon and diversification". The proportion of revenue from traditional oil and gas extraction has decreased, while the proportion of new energy and digital service businesses has significantly increased, forming a diversified business pattern to reduce dependence on traditional businesses. By establishing a dedicated department for digital and low-carbon transformation, Chevron integrates dispersed teams and builds a cross-business digital collaboration platform to achieve resource sharing, thereby improving transformation efficiency and resource utilization efficiency. In addition, the transformation has boosted technological innovation vitality. Chevron has increased Research and Development (R&D) investment in digital and low-carbon integration technologies and focused on cutting-edge fields. The number of technology patents related to the transformation has steadily increased, and some core patents have been commercialized. At the same time, through collaborating with universities and technology companies to build laboratories and launch joint development projects, Chevron has constructed an open innovation ecosystem to accelerate technology transformation, providing continuous technical support for long-term transformation.

4. Conclusion

In the context of low-carbon goals, an analysis focusing on Chevron Corporation reveals that the motivations for digital transformation among traditional energy enterprises encompass both external and internal dimensions. External motivations stem from policy-driven carbon constraints, shifts in green preferences of markets and investors, and the maturity of digital technology. Internal motivations center on the need for cost optimization and risk avoidance in traditional businesses. Together, these factors drive digital transformation to become an inevitable strategy for the industry. Digital transformation can enhance both financial and non-financial performance of enterprises. On the financial front, it can improve profitability by reducing costs and optimizing product mix, enhance growth potential by expanding into new energy and other businesses, and improve debt-servicing capabilities by improving cash flow and asset structure. On the non-financial front, it can effectively reduce carbon emission intensity, promote low-carbon diversification of businesses, and enhance innovation capabilities through technological research and development investment to support long-term development. When other traditional energy enterprises advance digital transformation, they need to focus on policy, market, and technology domains, track policy directions, align with market and investor demands, collaborate with universities and technology companies to accelerate technology implementation, prioritize the application of digital technology towards low-carbon goals, and dynamically adjust strategies to avoid risks and enhance performance. This study examines the motivations for transformation and quantifies Chevron’s transformation performance, filling the gap in case studies on the “motivation-performance” correlation of digital transformation in energy enterprises under the low-carbon context. It enriches research findings at the intersection of low-carbon management and the digital economy, and provides a practical path for the coordinated development of low-carbon development and digital transformation in the industry.

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