School of social sciences

Supply chain management

Postgraduate Dissertation

Supply chain management issues in the oil and gas industry

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Patras, Greece, July 2024

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I extend my deepest gratitude to my parents, whose unwavering support and encouragement have been the foundation of my academic journey. Their sacrifices, belief in my abilities, and constant encouragement have been the driving force behind the completion of this thesis. Their resilience and commitment to my education have been a constant source of inspiration.

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Acknowledgments

Abstract

The objective of this study is to assess the significance of supply chain management in the oil and gas sector by examining secondary sources of literature. The study delved into the special attributes of the industry, the significance of supply chain management, the obstacles associated with supply chain management, and the potential prospects and effective strategies that may be adopted. The study utilized a methodology of literature review. The sources were approached in a critical manner and data were extracted which led to the formulation of a SWOT analysis, that highlighted the opportunities and significant problems in the sector. The findings indicate that the supply chain is crucial in the oil and gas industry, and any disruptions in this interconnected system can have substantial and far-reaching consequences. To enhance the robustness of the supply chain, it is imperative for the sector to take proactive measures in anticipating potential challenges by fully understanding the ramifications of geopolitical tensions, natural disasters, and limitations in infrastructure. To guarantee the long-term stability and effectiveness of the supply chain, it will be imperative to embrace sustainable methodologies, leverage digital technology, and foster collaboration. Companies need to place particular emphasis on effective communication throughout their supply chain and align their strategic objectives across the organisation, rather than depending on irregular and isolated efforts.

Keywords

Supply chain management, oil, gas, energy, environmental sustainability

Θέματα της διοίκησης εφοδιαστικής αλυσίδας στις βιομηχανίες του πετρελαίου και του φυσικού αερίου

Γεώργιος Παυλίδης

Περίληψη

Στόχος της παρούσας μελέτης είναι να αξιολογήσει τη σημασία της διαχείρισης της εφοδιαστικής αλυσίδας στον τομέα του πετρελαίου και του φυσικού αερίου εξετάζοντας δευτερογενείς βιβλιογραφικές πηγές. Η μελέτη εμβάθυνε στα ιδιαίτερα χαρακτηριστικά του κλάδου, στη σημασία της διαχείρισης της εφοδιαστικής αλυσίδας, στα εμπόδια που συνδέονται με τη διαχείριση της εφοδιαστικής αλυσίδας, καθώς και στις πιθανές μελλοντικές προοπτικές και τις αποτελεσματικές στρατηγικές που μπορούν να υιοθετηθούν. Η μελέτη χρησιμοποίησε τη μεθοδολογία της βιβλιογραφικής ανασκόπησης. Τα ευρήματα δείχνουν ότι η αλυσίδα εφοδιασμού είναι ζωτικής σημασίας στον κλάδο του πετρελαίου και του φυσικού αερίου και ότι τυχόν διαταραχές σε αυτό το διασυνδεδεμένο σύστημα μπορεί να έχουν σημαντικές και εκτεταμένες συνέπειες. Προκειμένου να ενισχυθεί η ευρωστία της αλυσίδας εφοδιασμού, είναι επιτακτική ανάγκη ο τομέας να λάβει προληπτικά μέτρα για την πρόβλεψη πιθανών προκλήσεων, κατανοώντας πλήρως τις επιπτώσεις των γεωπολιτικών εντάσεων, των φυσικών καταστροφών και των περιορισμών στις υποδομές. Προκειμένου να εξασφαλιστεί η μακροπρόθεσμη σταθερότητα και αποτελεσματικότητα της αλυσίδας εφοδιασμού, θα είναι επιτακτική ανάγκη να υιοθετηθούν βιώσιμες μεθοδολογίες, να αξιοποιηθεί η ψηφιακή τεχνολογία και να προωθηθεί η συνεργασία.

Λέξεις – Κλειδιά

Διοίκηση εφοδιαστικής αλυσίδας, πετρέλαιο, φυσικό αέριο, ενέργεια, περιβαλλοντική βιωσιμότητα

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1.Introduction

1.1. Background

The oil and gas industry possesses an extensive and intricate supply chain. The various actions involved in the extraction, production, distribution, handling, manufacture, storage, transportation, and utilization of oil and natural gas are conducted within an extensive network of participants (Yusuf et al., 2014). Every phase in the oil and gas supply chain is interconnected with the subsequent one. Consequently, it is imperative to thoroughly examine and comprehend multiple interconnected relationships. These processes may encompass transportation, sales, material management, technology, refining, and various other activities. Furthermore, there are also utilized supply chain management systems and technologies. Efficient management of the supply chain is crucial in the oil and gas business to optimize resource use. This aids in reducing the operational expenses and the profitability of the oil and gas industry. Strict adherence to supply chain management is crucial in the oil and gas sector, including all stages from planning to execution. An efficient supply chain is essential in the oil and gas sector for optimal operational performance, financial prudence, and overall adaptability (B.O., 2023). The significance of proficient supply chain management becomes increasingly apparent due to several challenges, including geopolitical considerations and the escalating demand for more environmentally friendly energy alternatives. The oil and gas industry utilizes offshore drilling rigs to extract vital resources from deep inside the earth, which are crucial for our industrialized civilization. The process begins with a comprehensive examination, explores the core aspects of reservoirs, and concludes with the extraction of crude oil, which is the essential substance of the industry. Following that, a compelling sequence of purifying processes transforms unprocessed ingredients into a range of products, each serving a vital purpose in our daily lives. The intricate procedure, involving both exploration and dissemination, depends on the seamless collaboration of various elements.

The Oil and Gas supply chain and procurement are vital components that facilitate the efficient functioning of the energy industry. This intricate system manages the procurement, transportation, and distribution of oil and gas resources, overseeing several stages including

exploration, extraction, refining, and distribution. The efficacy of the sector relies significantly on the execution of robust procurement strategies, ensuring the acquisition of essential equipment, materials, and services required for activities like as exploration, extraction, and hydrocarbon processing. An efficiently synchronized supply chain is essential for the timely delivery of resources, minimizing operational disruptions, and optimizing costs (Qode, 2023).

1.2. Aim & Objectives

The aim of this study is to analyse the importance of supply chain management in the oil and gas industry through the analysis of secondary, literature sources. More specifically, the characteristics of the industry, the importance of supply chain management, the challenges in relation to supply chain management, as well as future opportunities and good practices that can be implemented were explored. In this research, a literature review will be conducted from a critical perspective, which will lead to the formulation of an extensive SWOT analysis. In this way, it will be possible to formulate clear recommendations to solve a very important issue, supply chain management in the oil and gas industry

1.3. Structure

The paper is structured in five chapters. Chapter one is the introduction to the research, chapter two presents the theoretical framework in relation to the concept of supply chain management, chapter three focuses on the oil and gas sector and the importance of supply chain management in this sector, chapter four presents-opportunities and problems related to supply chain management in the industry and finally chapter five presents the conclusions of the research.

2. Supply Chain Management

2.1. Definition and characteristics

Supply chain management (SCM) refers to the systematic administration of the movement of goods and services to and from a firm. It encompasses all the stages involved in transforming raw materials and components into finished products and delivering them to the end customer. An efficient supply chain management (SCM) system helps optimize a company's operations by eliminating inefficiencies, maximizing customer satisfaction, and gaining a competitive edge in the market (Fernando, 2023).

SCM refers to the comprehensive management of the complete production process of a product or service, beginning from the initial raw materials to the ultimate delivery of the finished product to the end consumer. A corporation establishes a network of suppliers, referred to as "links" in the chain, to facilitate the movement of the product from raw material suppliers to organizations that directly serve users (IBM, 2023).

SCM is crucial since it enables the attainment of several corporate objectives. Controlling production procedures can enhance product quality, thereby mitigating the likelihood of recalls and lawsuits, and contributing to the establishment of a robust consumer brand. Simultaneously, exercising authority over shipping protocols can enhance customer service by preventing expensive shortages or instances of excessive inventory. In general, supply chain management offers many prospects for organizations to enhance their profit margins and is particularly crucial for businesses with extensive and global operations (Zhang & Zu, 2013).

SCM is a continuous endeavour undertaken by firms to optimize the efficiency and cost-effectiveness of their supply chains. SCM aims to centrally manage or connect the production, transportation, and distribution of a product. Through effective supply chain management, organizations can reduce superfluous expenses and eliminate unnecessary processes, resulting in expedited product delivery to the consumer. This is achieved through implementing stricter oversight over internal inventories, internal production processes, distribution channels, sales activities, and the inventories of firm vendors.

SCM operates on the premise that the production and distribution of almost every product involves the collaboration of several entities within a supply chain. While supply chains have been in existence for a long time, it is only in recent years that firms have started recognizing their significance as an added value to their operations.

The role of a SCM encompasses more than just conventional logistics and procurement. It involves identifying strategies to enhance productivity, minimize expenses, mitigate supply shortages, and proactively plan for unforeseen circumstances. The SCM process typically has five distinct phases.

To get optimal outcomes from SCM, the initial step typically involves strategic planning to align the supply with customer requirements and production demands. Companies should endeavour to anticipate their future requirements and respond accordingly. This analysis will consider the requisite raw materials or components at each stage of the manufacturing process, as well as the capacity and constraints of the equipment, and the manpower requirements. Major corporations frequently depend on enterprise resource planning (ERP) software to facilitate the coordination of their operations.

The SCM procedure culminates in helping for product and customer returns. It is unfortunate when a consumer must return a product, but it is even more problematic if the reason for the return is a mistake made by the company. The process of returning things, also known as reverse logistics, requires the company to have the necessary skills to accept the returned items and accurately provide refunds for them. Regardless of whether a corporation is initiating a product recall, or a customer is expressing dissatisfaction with the product, it is imperative to address and resolve the issue in the customer transaction (Zhang & Zu, 2013).

Returns can serve as a vital source of feedback, aiding the company in identifying faulty or inadequately constructed products and implementing any required modifications. However, if the root reason of a customer return is not addressed, the process will be considered unsuccessful, and there is a high probability that future returns will continue to occur (Zhang & Zu, 2013).

The supply chain serves as the most prominent representation of the firm for customers and consumers. A company's corporate reputation and long-term viability are safeguarded to a greater extent when its SCM is superior and more efficient (IBM, 2023).

SCM varies among firms. Every corporation possesses unique objectives, limitations, and advantages that will influence its SCM procedure. There are several models that a corporation might employ to direct its SCM endeavours (Fernando, 2023). The continuous flow model, commonly used in established industries, is one of the most conventional approaches to supply chain management. The continuous flow model is based on the assumption that a company consistently produces the same product, anticipating small fluctuations in consumer demand, and thus offers secure results, although it can be inefficient in cases of significant fluctuations. On the other hand, a more flexible model is more suitable for organisations that face fluctuations in demand or produce products on demand. This approach emphasises adaptability, as a company may face a particular demand at any time and must be prepared to adapt accordingly.

Similarly, a speed-based model gives priority to rapid turnover of a product that has a short shelf life. By using an efficient supply chain model, a company aims to exploit a prevailing pattern, manufacture items rapidly and ensure full sale of the product before the trend is completed. The agile model is best suited for organizations affected by seasonal fluctuations. Some companies may experience significantly increased demand during peak periods and reduced volume requirements during other periods. An adaptable SCM model allows for efficient scaling of capacity and easily adapts to uncertain industry conditions.

In industries characterized by tight margins, organizations may seek to gain advantage by optimizing the SCM process. This involves optimizing the use of equipment and machinery, as well as effectively overseeing inventory management and order processing. If, of course, any of the aforementioned models is not individually suitable for a company's requirements, it can opt for a customized model. This is particularly the case in sectors that are highly specialised and have demanding technical criteria, such as a car manufacturer.

Efficient SCM operations are highly dependent on robust supplier relationships. Sourcing involves collaborating with vendors to procure the necessary materials for the entire production process. Various industries will possess distinct sourcing prerequisites. However, in essence, SCM sourcing entails guaranteeing that (Fernando, 2023):

• The raw materials or components adhere to the manufacturing specifications necessary for the production of goods.

• The prices paid to the vendor align with market anticipations.

• The vendor possesses the capability to provide emergency materials in response to unforeseen circumstances.

• The vendor has a demonstrated history of delivering goods punctually and of commendable quality.

Effective SCM is particularly crucial in situations when manufacturers are dealing with perishable items. When procuring items, organizations should consider the lead times and the supplier's capacity to meet their requirements.

At the core of the SCM process lies the utilization of machinery and manpower by the company to convert the raw materials or components received from suppliers into a novel product or entity. The ultimate objective of the manufacturing process is to produce this final product, although it does not represent the concluding phase of SCM (Power, 2005).

The manufacturing process can be further subdivided into sub-tasks, including assembly, testing, inspection, and packing. Throughout the manufacturing process, organizations must remain vigilant of waste or other variables that may lead to variations from their initial intentions. For instance, if a company is using a greater quantity of raw materials than first

intended and acquired as a result of insufficient staff training, it must address the problem or reevaluate the previous phases in SCM (Fernando, 2023).

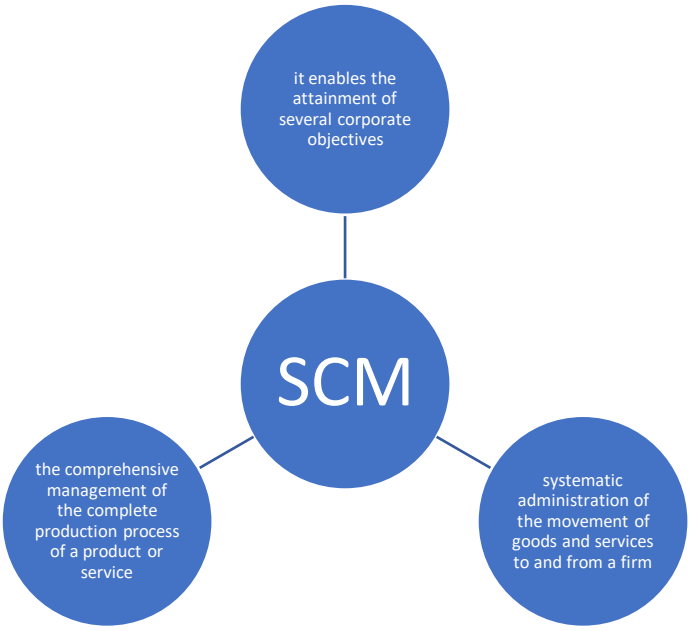

Figure 1: SCM Definitions

After the completion of product manufacturing and the conclusion of sales transactions, a corporation must ensure the delivery of such products to its clients. An organization that possesses efficient SCM would own strong logistical capabilities and delivery routes to guarantee prompt, secure, and cost-effective delivery of its merchandise (Agus, 2013).

An efficient SCM system reduces expenses, inefficiencies, and lead time in the production process. The prevailing norm in the sector is a just-in-time supply chain, wherein retail purchases trigger automatic replenishment orders to manufacturers. Retail shelves can be replenished promptly once products are sold. An effective approach to enhance this process is to scrutinize the data obtained from supply chain collaborators in order to identify areas for additional enhancements (IBM, 2023).

For example, if a consumer places an order for a quantity of product that exceeds the manufacturer's capacity to supply, the buyer has the right to express dissatisfaction with the quality of service. By conducting data analysis, firms might potentially predict a shortage in advance, thereby preventing buyer dissatisfaction.

2.2. Modern trends in supply chain management

Traditional supply networks primarily emphasized the availability, transportation, and cost of physical assets. In contrast, today's supply chains revolve around the management of data, services, and goods that are combined into comprehensive solutions. Contemporary SCM systems encompass a broader scope beyond mere considerations of location and timing. SCM has a direct impact on the quality of products and services, the timeliness of delivery, the expenses incurred, the satisfaction of customers, and ultimately, the overall profitability of a business (IBM, 2023).

A typical supply chain has access to 50 times more data compared to a period of just five years prior. However, only a fraction amounting to less than 25% of this data is being subjected to analysis. Consequently, the loss of crucial, time-sensitive data, including meteorological data, unexpected labour shortages, political instability, and rapid increases in demand, might occur. Contemporary supply chains utilize vast quantities of data produced during the chain process and are managed by analytical professionals and data scientists. Future leaders in SCM and their management of Enterprise Resource Planning (ERP) systems will likely prioritize the optimization of data utilization. This involves assessing the data in real-time with minimal delay (IBM, 2023).

2.2.1. Reversed Supply Chain

Occasionally, firms are compelled to establish reverse supply chains due to environmental rules or customer concerns. Starting in 2003, European Union regulations mandated that tire manufacturers in Europe must ensure the recycling of one used tire for every new tire they sell. Alternatively, some organizations were proactively seizing opportunities to save their operational expenses by repurposing items or components. Some corporations are now incorporating reverse supply chains as essential components of their new business models. For example, Bosch has established a prosperous enterprise by selling reconditioned power hand tools (Guide & Wassenhove, 2002).

Regardless of whether a corporation is voluntarily or involuntarily building a reverse supply chain, it will encounter numerous obstacles. The company must educate its clients and build new channels of communication with them. It needs to determine which activities to

outsource and which to handle internally, while also finding ways to minimize costs and explore novel approaches to generate value. Additionally, it may be required to adhere to rigorous environmental regulations. (Guide & Wassenhove, 2002)

In order to make logical judgments on the configuration of a reverse supply chain, it is advisable to partition the chain into its five fundamental constituents and evaluate the various alternatives, expenses, and advantages associated with each component (Prahinski et al., 2006)

The act of collecting the previously used product is crucial for establishing a profitable chain. It is crucial to meticulously oversee the calibre, volume, and timeliness of product returns. Otherwise, enterprises may face a situation where they receive a large number of returned products that vary in quality to such an extent that it becomes hard to efficiently remanufacture them. Companies frequently require tight collaboration with retailers and other distributors to effectively manage collection efforts.

Reverse logistics refers to the process of managing the flow of products or materials from their final destination back to their point of origin for the purpose of recapturing value or proper disposal. After being gathered, products must be delivered to facilities for the purpose of examination, categorization, and final determination of their fate. There is no universally optimal architecture for a reverse logistics network; each design must be customized based on the specific products and the economic considerations of their reuse. Large and heavy items such as tires necessitate distinct handling methods compared to small and delicate items like cameras. Companies should take into account not only the expenses associated with transportation and storage, but also the rate at which the value of returned products will diminish and the necessity for product control. Outsourcing the logistics to a specialist is often a sensible decision in many instances (Guide & Wassenhove, 2002).

The process of evaluating, sorting, and rating returned products requires a significant amount of manual effort and consumes a considerable amount of time. However, the efficiency of the process can be enhanced if a corporation implements quality criteria for returns and utilizes sensors, bar codes, and other advanced technology to automate the tracking and testing procedures. Typically, a corporation should aim to make judgments about how to handle returns—taking into account factors like quality, product configuration, or other variables—as early as possible in the returns process. This can significantly reduce

logistics expenses and expedite the introduction of remanufactured products to the market (Gobbi, 2011).

Companies can derive value from returned products by extracting and refurbishing components for reuse or by fully remanufacturing the products for resale. The reconditioning and remanufacturing processes are often characterized by a higher level of unpredictability compared to traditional manufacturing. This is mostly due to the significant uncertainty around the timing and quality of returned products. Once again, by making intelligent choices at the beginning of the process, namely when accepting and categorizing returns, it is possible to minimize production inconsistencies and, consequently, save expenses (Prahinski et al., 2006).

Prior to selling a recycled product, a corporation must ascertain the existence of demand or the necessity to establish a new market. If it is the second option, the corporation should anticipate significant expenditures in customer education and additional marketing endeavours. The target audience for remanufactured items or components encompasses both the initial buyers and potential new customers in diverse areas. The corporation may, for instance, aim to attract clients who are unable to afford the new products but would eagerly seize the opportunity to purchase pre-owned versions at reduced costs (Guide & Wassenhove, 2002).

Typically, the organizations that achieve the highest level of success in managing their reverse supply chains are the ones that tightly integrate them with their forward supply chains, resulting in a closed-loop system. For instance, they strategically consider recycling and reconditioning within the process of making product design and production decisions. Bosch serves as a commendable illustration. The company integrates sensors into the motors of its power tools to determine the viability of motor reconditioning. The method significantly decreases the expenses associated with inspection and disposition, allowing the company to generate profits from the remanufactured instruments. Implementing reverse supply chains can yield significant benefits when approached with a proactive mindset (Guide & Wassenhove, 2002).

2.2.2. Closed Loop Supply Chain

Supply chains are becoming more intricate as organizations aim to enhance efficiency and sustainability. A closed loop supply chain refers to a system in which products are recycled or reused after they have reached the end of their useful life. This approach can benefit an organization by reducing waste, minimizing environmental impact, and even generating cost savings (Radiant, 2022).

A closed loop supply chain refers to a system where products or materials are recycled or reused inside the same supply chain, rather than being disposed of or sent to a landfill. A closed loop supply chain (CLSC) is a supply chain that aims to reintegrate materials and resources into the production process through reuse or recycling, rather than disposing of them. The objective of a closed loop supply chain is to establish a sustainable system wherein waste is minimized or completely eradicated. This form of SCM is sometimes juxtaposed with the conventional linear model of a supply chain, wherein resources are taken, utilized for product creation, and subsequently sold to consumers, who ultimately discard them (Ramezani et al., 2014).

In a closed loop supply chain, a portion of the waste generated during the production process is reclaimed and repurposed to produce new products, rather than being disposed of. This contributes to mitigating the environmental impact of the production process and can also result in cost reductions. A closed loop supply chain is a system that involves the reuse or recycling of resources and products rather than their disposal as waste. This can yield numerous advantages for both enterprises and the ecosystem. Utilizing recycled materials diminishes the necessity of extracting fresh primary materials from the Earth, so preserving energy and conserving resources. Additionally, it has the capacity to diminish pollutants and curb greenhouse gas emissions stemming from manufacturing procedures. Closed loop supply chains can also yield cost savings for enterprises by mitigating the ongoing requirement for new material procurement. Furthermore, closed loop supply chains frequently generate employment prospects in recycling and reuse sectors (Radiant, 2022).

Through the implementation of closed-loop supply chains, businesses can contribute to the establishment of a circular economy that yields advantages for both individuals and the environment. There are a number of industries that are particularly well-suited to closed loop supply chains over traditional supply chains. Enterprises that extensively utilize raw

materials or generate substantial waste are ideal candidates for closed loop supply chains. As an illustration, the food and beverage sector frequently produce a substantial quantity of food waste, which can be repurposed or recycled in alternative goods. Similarly, the textile sector consumes substantial amounts of water and energy during its production process. Implementing closed loop supply chains can effectively mitigate its environmental footprint (Shekarian, 2020).

Implementing a closed loop supply chain can be advantageous for any industry seeking to minimize its environmental impact. In a closed loop system, materials are continuously recycled, enabling enterprises to operate in a more sustainable manner and minimizing their environmental footprint. Initially, it necessitates that businesses gather and monitor data regarding the specific materials they utilize. This enables them to discern which materials are suitable for reuse and which require replacement. Furthermore, it is imperative for businesses to cultivate alliances with suppliers capable of furnishing recycled resources. Lastly, it is imperative for enterprises to provide the necessary infrastructure to efficiently handle and recycle commodities by means of reverse logistics, reintegrating them into the production process (Radiant, 2022).

Although closed loop supply chains are more intricate and necessitate greater coordination compared to standard linear supply chains, they have several benefits. Businesses can decrease their need on new materials, resulting in financial savings and diminished environmental effects. Moreover, closed loop supply chains have the potential to provide additional sources of income through the selling of recycled materials. Ultimately, closed loop supply chains offer a more sustainable method of doing business that can benefit both the environment and the bottom line. The role of asset management in a closed loop supply chain is to effectively manage and control the assets involved in the supply chain process. This includes tracking, monitoring, and optimizing the utilization of resources such as equipment, vehicles, and inventory. Asset management ensures that these assets are efficiently utilized, maintained, and returned to the supply chain loop, contributing to the overall effectiveness and sustainability of the closed loop supply chain. Asset management is crucial in a closed loop supply chain to ensure accurate tracking and accountability of materials and goods. Through effective asset management across the supply chain, firms may reduce waste and maximize resource use. Furthermore, asset management can

facilitate the identification of prospects for reutilization and recycling, hence advancing closed loop aims. Effective asset management begins with precise inventory control. Businesses must possess precise knowledge of their current inventory to prevent overproduction and needless waste. Moreover, it is essential to have the capability to monitor the precise whereabouts of these commodities across the whole supply chain. Having this degree of visibility is crucial for closed loop activities. Asset management includes not only inventory control but also the monitoring of product lifecycles. Having knowledge on the anticipated lifespan of items allows firms to strategically prepare for maintenance, restoration, or substitution. This information is essential for the effective disposal or recycling process. Through effective asset management over the entire life cycle, firms may guarantee efficient utilization of materials and the achievement of closed loop objectives (Bottani et al., 2015).

Numerous enterprises are keen in transitioning to a closed loop supply chain, although they may lack clarity on the initial steps to take. One method to initiate the transition is by incorporating an asset management solution. Implementing this technology enables firms to efficiently monitor and control their assets, resulting in an optimized and environmentally friendly supply chain (Radiant, 2022).

A closed loop supply chain is a system that ensures the recycling of all waste and byproducts, reintegrating them into the production process to establish a sustainable and ecologically sound cycle. The advantages of adopting a closed loop supply chain are extensive, rendering it an appealing choice for firms seeking to diminish their ecological footprint while simultaneously enhancing efficacy and cutting expenses (Shekarian, 2020).

2.2.3. Emerging technologies in supply chain

SCM plays a crucial role in meeting the needs of organizations in many industries. It involves the coordination and optimization of procedures, resources, and record flows to enable the smooth movement of products and services from suppliers to customers. In the rapidly changing business landscape, where effectiveness and environmental friendliness are crucial, utilizing cutting-edge technology has become necessary (Unlu, 2023).

The Internet of Things (IoT) has revolutionized supply chain management. IoT, short for Internet of Things, is a network of networked devices equipped with sensors and software

that enable them to collect and manipulate data. The Internet of Things (IoT) allows for the immediate monitoring and tracking of products, as well as the control of stock, the ability to foresee and prevent issues, and increased visibility throughout the delivery chain in the context of supply chain management. Through leveraging the potential of IoT, enterprises may streamline their supply chain operations, minimize inefficiencies, and save costs (Ben Daya et al., 2019).

Artificial Intelligence (AI) and Machine Learning (ML) technologies are revolutionizing SCM by automating decision-making processes and enabling predictive analytics. Artificial intelligence (AI) and machine learning (ML) algorithms have the capability to analyse vast quantities of data, detect patterns, and generate accurate predictions. Within the realm of supply chain management, this technology has the capability to enhance the efficiency of forecasting, inventory control, route optimization, and risk assessment. Through the utilization of artificial intelligence (AI) and machine learning (ML), agencies have the ability to optimize the performance of their distribution chain, minimize errors, and improve customer satisfaction (Unlu, 2023).

Blockchain technology, renowned for its decentralized and unchangeable characteristics, provides exceptional transparency, security, and traceability in supply chain activities. Blockchain enables the creation of a transparent and immutable digital record, which provides continuous and comprehensive visibility into the supply chain, effectively preventing fraud, counterfeiting, and illegal alterations. Furthermore, blockchain has the capability to optimize processes like as contract management, invoicing, and supplier authentication. Integrating blockchain technology into the control of delivery chains improves the use of robotics and automation in managing supply chains (Chang & Chen, 2020).

The incorporation of robots and automation technology into SCM offers a multitude of benefits. Robots have the ability to carry out repetitive operations with accuracy, swiftness, and effectiveness, hence reducing human errors and increasing productivity. Automated systems, conveyor belts, and sorting machines facilitate efficient operations and enable the optimal movement of materials. Robotics and automation are crucial in warehouse management, inventory management, and order fulfilment. Through the utilization of these

technologies, firms can attain expedited order processing, save labour expenses, and improve overall supply chain efficiency (Unlu, 2023).

Predictive analytics leverages historical and real-time data to provide accurate predictions and educated decisions. Predictive analytics in SCM can enhance demand forecasting, inventory control, and supply chain risk evaluation. Through the identification of demand trends, organizations can prevent both stockouts and overstocking, resulting in cost savings and enhanced customer satisfaction. Predictive analytics enables the implementation of preventative maintenance strategies for equipment and devices, resulting in reduced downtime and enhanced operational performance (Lima-Junior et al., 2019).

Cloud computing provides a scalable and cost-effective option for supply chain management. Through the utilization of cloud-based platforms, organizations may consolidate data, engage with relevant parties, and obtain real-time insights across the entire supply chain. Cloud-based payment chain management systems give access to crucial information from any location, enabling prompt decision-making and smooth collaboration. Moreover, cloud computing facilitates the integration of nascent technologies like as IoT, AI, and blockchain, thereby unleashing their complete capabilities (Cao et al., 2017).

3D printing, also known as additive production, transforms delivery chain operations by allowing manufacturing and customisation to be done as needed. Through the utilization of 3D printing, companies can reduce lead times, save transportation expenses, and enhance stock management. By producing goods in proximity to the point of consumption, carbon emissions associated with transportation can be significantly reduced. Furthermore, 3D printing provides a viable and environmentally conscious approach to minimizing textile waste and advocating for the use of sustainable materials (Unlu, 2023).

Drones are integral components of the supply system, specifically for last-mile shipping. Drones have the capability to perform inventory monitoring, conduct aerial surveillance of warehouses, and deliver applications to remote or inaccessible regions. Through the utilization of drones, enterprises can achieve expedited and cost-efficient delivery, reduce traffic congestion, and minimize their environmental impact. Nevertheless, the widespread implementation of drone technology in delivery chain management necessitates the resolution of legislative and operational obstacles (Rejeb et al., 2023).

Augmented Reality (AR) and Virtual Reality (VR) technologies provide immersive and interactive experiences that improve the efficiency of delivery chains and training programs. Augmented reality (AR) can deliver real-time data and instructions to employees, enhancing picking accuracy and reducing errors. Virtual reality (VR) can be employed for the purpose of creating digital simulations and educational courses, allowing employees to practice intricate tasks within a secure and regulated setting. By incorporating Augmented Reality (AR) and Virtual Reality (VR) into the operations of the delivery chain, organizations can enhance efficiency, reduce training costs, and enhance worker safety (Rejeb et al., 2020).

Sustainability has emerged as a crucial imperative for companies globally, and SCM plays a pivotal role in attaining environmental objectives. Organizations are implementing sustainable measures such as reducing carbon emissions, managing waste effectively, procuring ethically, and adopting renewable energy sources. Integrating emerging technologies such as IoT, AI, blockchain, and 3-D printing can significantly enhance sustainability initiatives. Through the optimization of supply chain methodologies, waste reduction, and the implementation of ethical standards, organizations can establish a more environmentally friendly and more sustainable supply chain (Unlu, 2023).

Although evolving technologies in SCM offer significant advantages, there are also obstacles that need to be addressed. Organizations must address information privacy, security, and compatibility issues when using technologies such as IoT, blockchain, and cloud computing. Incorporating novel technologies into existing systems and procedures necessitates careful strategizing and effective administration. Assessing the cost-benefit analysis, guaranteeing scalability, and instructing colleagues Case studies are essential as they provide real-world examples of successful implementations on a global scale (Unlu, 2023).

Many organisations have successfully implemented emerging technologies in their supply chain management, resulting in significant improvements in efficiency and environmental friendliness. This shows that also in the area studied in this research, many improvements can be made regarding supply chain management and the problems and disruptions associated with it.

For example, one extremely important company with a wide reach, Walmart used blockchain technology to enhance the traceability of food products, thus improving food

safety and reducing the time required for recalls. In the sector considered in this research, the use of similar technology could lead to dramatic results, and of course reduce costs and environmental risk. Similarly, Amazon makes extensive use of artificial intelligence and robotics in its fulfilment centres, which facilitates rapid processing and delivery of orders, while Zipline uses unmanned aerial vehicles (drones) to transport medical supplies to remote areas, thus improving access to healthcare services (Chang & Chen, 2020). Through the application of similar technologies in the field of supply chain management in the oil sector, controls could be made easier and the communication between different parts of supply chain is going to be easier.

Developments in emerging technologies will continue to occur in the area of SCM. The frequent integration of technologies such as artificial intelligence, IoT, blockchain, and robotics allows for seamless visibility, automation, and optimization. Moreover, the advent of 5G networks will enhance connectivity and enable real-time data exchange across the entire delivery chain. Advanced analytics and AI-based decision making will be enhanced, allowing organisations to rely on predictions, reduce disruptions and achieve sustainable supply chains.

The application of emerging technologies has the potential to completely transform the management of delivery chains, resulting in improved efficiency and a greater focus on sustainability. The integration of IoT, AI, blockchain, robots, predictive analytics, cloud computing, 3D printing, drones, AR and VR is revolutionising various elements of delivery, from logistics to inventory management. By using these technologies, groups can achieve cost savings, improve customer happiness, reduce environmental impact and gain competitive advantage. However, meticulous strategizing, addressing barriers and considering viable initiatives are important for successful implementation. The future of supply chain management depends on the adoption and utilization of these developing technologies to the maximum extent possible (Unlu, 2023).

3. Oil and Gas Industry Overview

3.1. Global and regional market trends

The oil and gas industry is a major global sector in terms of monetary value, with an approximate global revenue of $5 trillion as of 2022. Oil has a vital role in the worldwide economic system, affecting several sectors such as transportation, heating, energy, industrial output, and manufacturing. The oil and gas sector is categorized into three distinct segments: upstream, midstream, and downstream. Upstream companies, often known as exploration and production (E&P) companies, locate reserves and drill wells for extracting oil and gas. Midstream firms are tasked with the transportation of resources from the wells to refineries. Downstream companies have the responsibility of refining and selling the final products. Drilling businesses engage in contractual agreements with exploration and production (E&P) companies to extract oil and gas. Well-servicing firms engage in associated construction and maintenance operations at well sites (McClay, 2022).

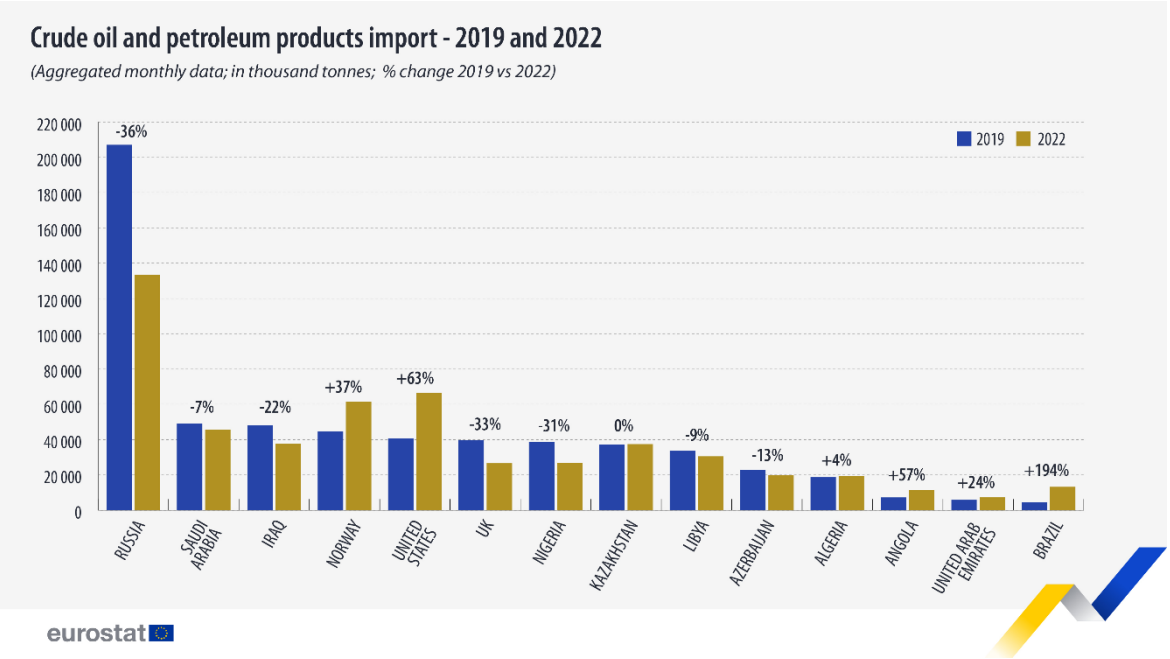

Figure 2 Crude oil and petroleum 2019-2022 (Image source: https://ec.europa.eu/eurostat/web/products-eurostat-news/w/DDN-20230504-1)

The oil and gas production process involves multiple stages, including resource discovery, transportation to a refinery, and transformation into a marketable finished product.

Alternatively, referred to as the upstream, midstream, and downstream sectors of the industry. Crude oil and natural gas are composed of hydrocarbons, which are naturally existing substances located in rock formations within the Earth's crust. These organic raw materials are formed through the compaction of plant and animal remnants in sedimentary rocks like sandstone, limestone, and shale. The sedimentary rock is formed from the accumulation of materials in prehistoric oceans and other aqueous environments. As sedimentary layers accumulated on the ocean floor, the decomposing organic matter of plants and animals became incorporated into the developing rock. Under specific temperatures and pressure ranges deep within the earth's crust, the organic material undergoes a transformation into oil and gas. Due to their lower density compared to water, oil and gas move through permeable sedimentary rock towards the surface of the Earth. An oil and gas reservoir is created when hydrocarbons become trapped behind cap rock that is less permeable. These oil and gas reservoirs serve as our primary sources of crude oil and natural gas (Li et al., 2017).

Hydrocarbons are extracted from the underground reservoir by drilling through the impermeable cap rock. Upon reaching the reservoir, the drill bit can be used to construct a profitable oil or gas well, allowing for the extraction of hydrocarbons by pumping them to the surface. If the drilling activity fails to discover economically feasible amounts of hydrocarbons, the well is categorized as a dry hole and usually sealed and abandoned (Schwab et al, 2019).

The method of extracting hydrocarbons from rock formations, such as oil shale, involves pumping a high-pressure fluid into the ground to fracture the rock. This technique is commonly referred to as "fracking" (McClay, 2022).

Upstream businesses encompass enterprises engaged in the exploration and extraction of oil and gas. These firms engage in global exploration to locate reservoirs of raw materials and subsequently conduct drilling operations to obtain those materials. These companies are commonly referred to as "E&P" which stands for "exploration and production" (Haider, 2020)

The upstream segment is distinguished by its elevated risks, substantial investment capital requirements, prolonged duration due to the time-consuming process of locating and drilling, as well as its reliance on advanced technology. Practically every source of money

coming in and every item listed in the financial statements of exploration and production (E&P) companies are directly connected to the extraction and production of oil and gas (Haider, 2020).

Typically, exploration and production (E&P) businesses do not possess their own drilling equipment or hire a dedicated drilling rig team. Alternatively, they use contract drilling firms to carry out well drilling on their behalf, with the firms typically invoicing the E&P business based on the duration of their services. Drillers do not produce revenue directly linked to oil and gas production, unlike E&P businesses. After the drilling of a well, a range of actions are undertaken to generate and sustain its production in the long term. These activities are referred to as well servicing and encompass logging, cementing, casing, perforating, fracturing, and maintenance. Oil drilling and oil maintenance are distinct business activities in the oil and gas industry (Haider, 2020).

Exploration and production (E&P) businesses are frequently assessed based on the valuation of their oil and gas reserves. These unexploited resources are crucial for determining their prospective profits (McClay, 2022).

Midstream firms mostly specialize in the transportation of goods or resources. They are responsible for transporting the harvested raw materials to refineries for oil and gas processing. Midstream companies are distinguished by their activities of transporting, hauling, utilizing pipelines, and storing unprocessed goods. The midstream sector is characterized by stringent regulation, especially regarding pipeline transmission, and minimal capital risk. The category is inherently reliant on the success of upstream enterprises (Colson, 1999).

The downstream sector comprises of refineries and gas stations. Refineries are the entities accountable for eliminating contaminants and transforming crude oil and natural gas into consumer products, including gasoline, aviation fuel, heating oil, and asphalt. Gas stations serve as locations where people refuel their vehicles at the pump. Oil production in barrels is quantified by exploration and production (E&P) companies. A barrel, commonly denoted as bbl, is equivalent to 42 U.S. gallons. Production is commonly quantified by companies using the units of barrels per day or barrels per quarter (McClay, 2022).

In the oil industry, it is customary to use the prefix "M" to represent 1,000 and the prefix "MM" to represent 1 million. Hence, the abbreviation "Mbbl" is usually used to represent 1,000 barrels, whereas "MMbbl" is used to represent 1 million barrels. For instance, when an exploration and production (E&P) business discloses a production figure of seven thousand barrels (Mbbl) per day, it signifies a daily output of 7,000 barrels of oil (McClay, 2022).

Similar to drilling, numerous public firms engage in well service operations. The revenue of service firms is directly correlated with the degree of activity in the oil and gas industry. Rig count and usage rates serve as metrics for quantifying the level of activity taking place in the United States at any given moment (Colson, 1999).

Exploration and production (E&P) businesses disclose their oil and natural gas reserves, which represent the amount of oil and gas they possess that remains untapped underground, using the standard units of barrels (bbl) and thousand cubic feet (mcf). Reserves are frequently employed to assess the worth of exploration and production (E&P) firms and to forecast their revenue and earnings. Public oil and gas firms are obligated to provide information about confirmed quantities of oil and gas reserves as additional data, although this is not included in their financial statements (Weijermars, 2009).

Undoubtedly, fresh reserves serve as a crucial means of generating future income, prompting E&P businesses to invest significant time and resources in the exploration of undiscovered reservoirs. Should an exploration and production (E&P) business cease its exploration activities, it will be left with a limited quantity of reserves and a diminishing supply of oil and gas. Revenue is bound to decrease gradually. Essentially, exploration and production (E&P) corporations can only sustain or increase their revenue by procuring or discovering fresh reserves (McClay, 2022).

An integrated oil company is a type of corporation that is involved in all aspects of the oil and gas industry, including exploration, production, refining, and distribution. An integrated oil business engages in many phases of oil production, encompassing both upstream and downstream activities. Presently, numerous prominent oil businesses worldwide are classified as integrated oil and gas corporations, meaning they have distinct divisions dedicated to each stage of the oil and gas production process. Being an integrated firm enables comprehensive oversight and enhanced operational effectiveness. Additionally, it

allows for multiple sources of income and the act of spreading out investments. Nevertheless, the substantial capital expenses associated with oil exploration and refining provide significant obstacles for potential new entrants (Weijermars, 2009).

As of 2022, the United States has the position of being the foremost global producer of crude oil, with Saudi Arabia, Russia, Canada, and China following suit. The leading countries in natural gas production are Russia, the United States, the European Union, Canada, and Iran.

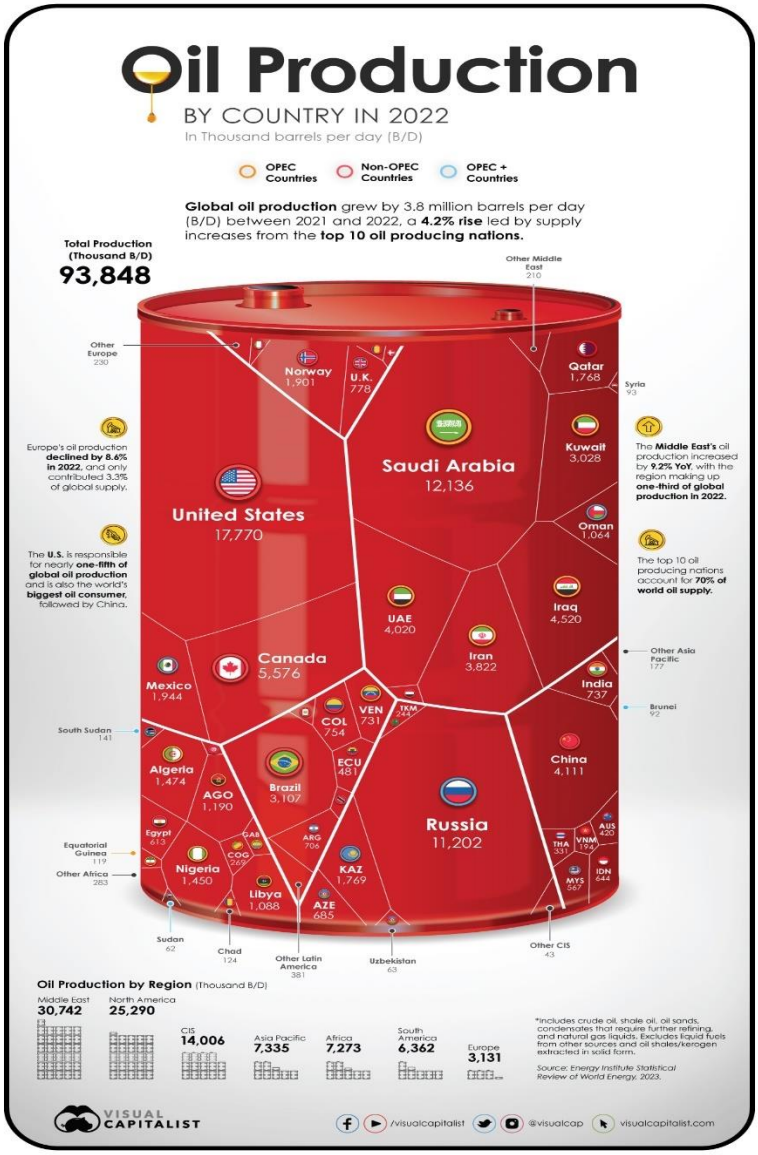

Figure 3: Oil production per country (Image source: https://www.visualcapitalist.com/charted-worlds-biggest-oil-producers-in-2022/#google_vignette)

Reserves are unextracted deposits of crude oil or natural gas that are still located underground. The three categories of reserves are classified as "proven," "probable," and

"possible." These factors are indicative of the probability of achieving effective drilling in certain deposits. The oil and gas business assigns a 90% level of confidence to proven reserves, commonly referred to as P90, indicating a high likelihood of production. In the industry, probable reserves are assigned a 50% probability (P50) of being produced, whereas prospective reserves are assigned a 10% probability (P10) of being produced (McClay, 2022).

The observable trends in the oil and gas industry in 2023 indicate a highly unstable business undergoing significant global transformation, driven by increasing pressure on governments globally to transition to renewable energy sources. Artificial intelligence (AI) gained significant traction in the oil and gas industry in 2023, as it offers the ability to rapidly and effectively evaluate data, hence facilitating informed decision-making. Artificial intelligence has the capability to automate physical labour, hence enhancing safety on construction sites and providing a distinct edge for high-risk offshore projects (Thomas, 2023).

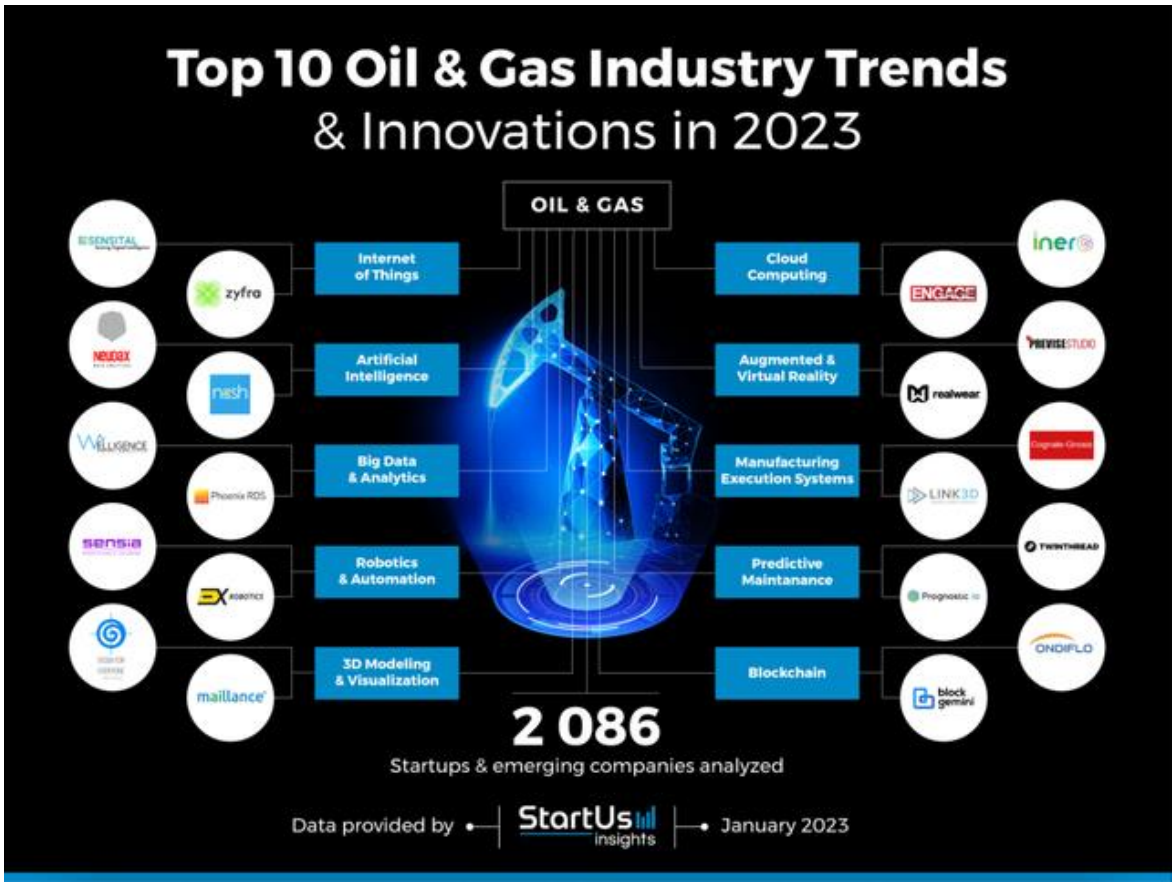

Figure 4: Top ten trends in the sector of oil & Gas 2023 (Source: https://www.iadd-intl.org/discover-top-10-oil-gas-industry-trends-innovations-in-2023)

According to a recent analysis by GlobalData, a company affiliated with Offshore Technology, artificial intelligence (AI) has become a very promising technology for digitizing the oil and gas industry. Similar to the power industry, AI enables the implementation of predictive maintenance models and operational optimization. Additionally, it possesses distinct uses in the exploration, administration, and commercialization of novel hydrocarbons. By introducing stability into the inherently dynamic market, it is possible to enhance decision-making, decrease costs, and improve efficiency.

The aforementioned research highlights Chevron, Ecopetrol, Petrobras, Reliance Industries, Repsol, Rosneft, Saudi Aramco, Shell, and BP as prominent firms that are at the forefront of utilizing artificial intelligence in the integrated oil and gas sector (Bagheri et al., 2023).

Specifically, BP has a track record of making investments in artificial intelligence. In 2017, the company formed a partnership with Microsoft Azure, leveraging Machine Learning (ML) technology to optimize drilling operations. In 2020, it formed a collaboration with Bluware to employ deep learning techniques in the analysis of subsurface data. In May 2023, Poweverse, an energy technology business founded by Lightsource BP, introduced its home energy management platform for residential customers, which utilizes artificial intelligence.

GlobalData also identifies some underperforming entities that are failing to fully realize the potential of artificial intelligence. The companies mentioned include CNPC, MOL, ONGC, PKN Orlen, and QatarEnergy (Thomas, 2023).

GlobalData's analysis reveals that the oil and gas business witnessed a total of 1,571 mergers and acquisitions (M&A) transactions in 2023. In October, ExxonMobil made a financially significant announcement by agreeing to buy a complete ownership of Pioneer Natural Resources. Expected to be concluded in June 2024, the acquisition has an equity value of $59.6bn and an enterprise value $64.5bn.

Equally noteworthy was Chevron's acquisition of a complete ownership interest in Hess, a company actively involved in the exploration and extraction of crude oil and natural gas in offshore Guyana. The agreement, which was reached in October, has a value of $60 billion and is scheduled to be finalized by June 2024.

An examination of employment patterns in the offshore oil and gas industry indicated that the environment was a prominent and progressively significant factor influencing job opportunities. In January 2023, there were 1,811 available positions, which rose to 2,203 in November, reaching a peak of 2,891 in June. Among the several occupations pertaining to the environment, chemical engineers and electrical and electronic engineers stood out as constantly popular (Thomas, 2023).

Nevertheless, employment rates experienced a decline throughout the entire industry. In Q3 2023, the oil and gas business accounted for 6.5% of all jobs in all sectors, a decrease from 10.1% in Q3 2022. Simultaneously, there was a notable surge in employment opportunities within the electricity industry, with job postings in this area rising from 0.4% in Q3 2022 to 3.0% in Q3 2023. Saudi Kayan Petrochemical and John Wood Group were among the leading oil and gas recruiters in the first quarter of 2023. In the second quarter, John Wood

Group, Halliburton, and Valvoline maintained their leading positions. In the third quarter, Marathon Petroleum, Baker Hughes, and NOV emerged as the top employers (Marcel et al., 2023).

The latest oil market report from the International Energy Agency (IEA) highlights a notable decline in market sentiment during November and December. This decline occurred as robust oil supply from non-OPEC+ nations combined with a slowdown in global oil demand growth. By December, oil prices had plummeted almost $25 per barrel from September, reaching their lowest point in half a year. As of the current moment, the price of Brent Crude was at $80.21 per barrel, while WTI Crude Oil was priced at $75.00.

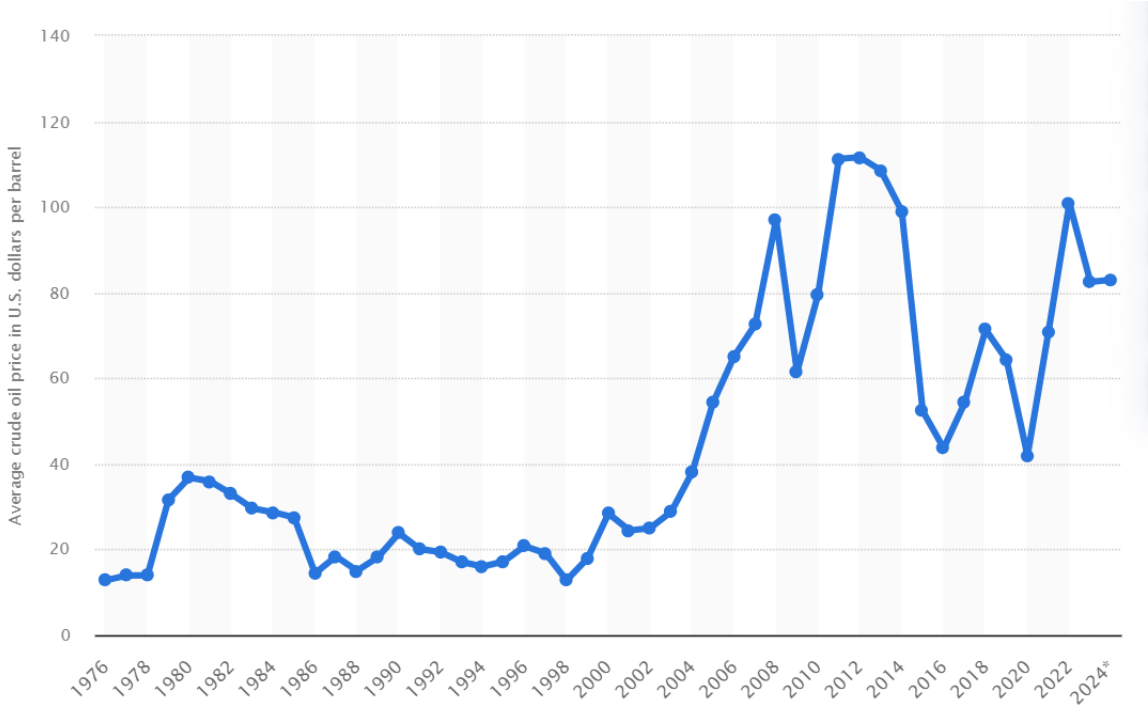

Figure 5: Crude oil price 1976-2024 (Image source: https://www.statista.com/statistics/262860/uk-brent-crude-oil-price-changes-since-1976/)

Before this decline, the industry had elevated prices, driven by the August decrease to a 13-month low in oil stockpiles. The International Energy Agency (IEA) stated that non-OECD oil stockpiles decreased by 20.8 million barrels (mb), with the most significant decline observed in China. Additionally, OECD inventories decreased by 3.2 mb. In July, the stocks of the OECD industry increased by 26.7 million barrels to reach 2,814 million barrels, which is 102.6 million barrels lower than the average of the past five years (Thomas, 2023).

Concurrently, in the gas industry, prices have consistently fluctuated. This can be attributed to Russia's invasion of Ukraine in February 2022, which has caused challenges in the market. Despite the presence of large storage capacity in Europe, the situation remains unstable.

According to the IEA, the supply of gas was limited during the first three quarters of 2023. Despite an increase in liquefied natural gas (LNG) supply by 11 billion cubic meters, it was not enough to compensate for the significant decrease in Russian piped gas supplies to the European Union, which declined by 38 billion cubic meters. In August 2023, there was a significant increase in volatility, as indicated by the European benchmark. This was mostly due to the threats of strikes in Australia and unforeseen outages in Norway, which resulted in a pessimistic prognosis for gas supply in the near future (Ateed, 2024).

The consumption of gas is expected to reach a plateau as European, US, and Asia-Pacific economies progressively shift towards renewable energy sources. According to the IEA, Eurasia's demand is projected to increase by only 2% compared to its 2021 level by 2026. In the future, market prices will be determined by the increase in demand in Asian markets (namely China), Africa, and the Middle East. These regions are expected to witness the expansion of gas-intensive sectors, particularly in Iran, Israel, and Saudi Arabia (Thomas, 2023).

3.2. Key players and stakeholders in the industry

The oil and gas industry has seen substantial changes in its approach to stakeholder management. Until recently, the primary emphasis was exclusively on financial gain and manufacturing. This has been altered by heightened consciousness of environmental concerns, intensified public examination, and more stringent laws. There is currently a transition occurring towards the adoption of more environmentally friendly methods (Lieutenant, 2023).

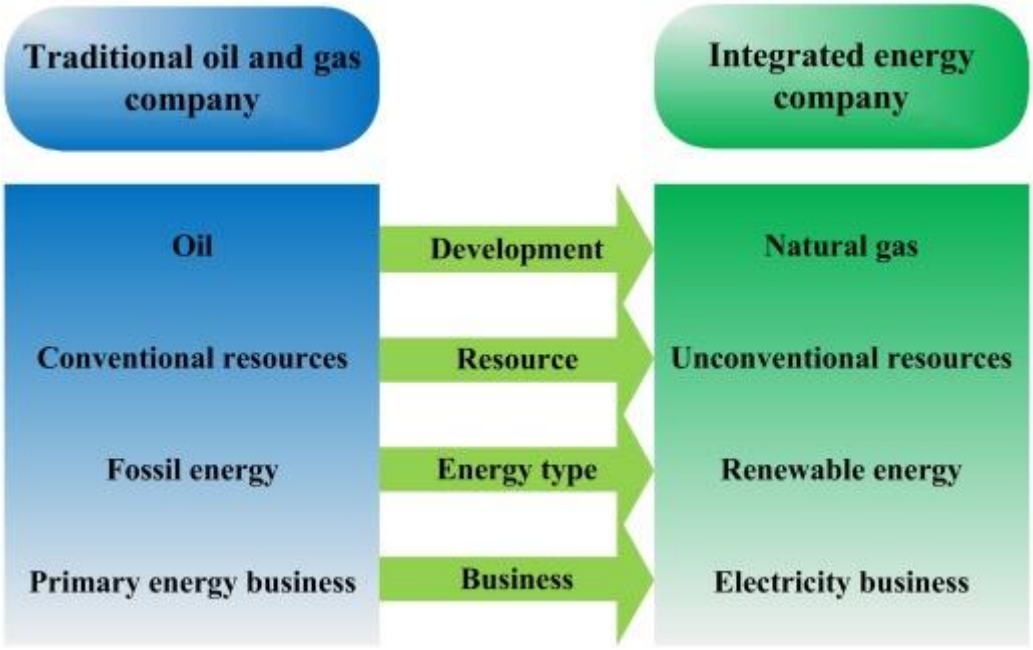

Figure 6: Environmental transition (Lu et al., 2019)

The industry is allocating resources towards the adoption of more environmentally friendly technology, promoting the growth and well-being of local communities, and enhancing the level of openness and accountability. Presently, companies give greater importance to engaging stakeholders in a proactive manner, with a specific focus on establishing trust and addressing problems related to the environment, society, and governance (ESG) (Lieutenant, 2023).

These endeavours are promoting the development of more favourable partnerships and facilitating the path to sustained profitability in light of evolving stakeholder expectations. A stakeholder is an individual or group that has a vested interest or concern in a certain project, organization, or system. A stakeholder refers to any individual, group, or organization that possesses an interest in, is impacted by, or possesses the ability to exert influence over the activities and choices of a firm or industry. Stakeholders encompass both internal entities, like as employees and shareholders, as well as external entities, including local communities, regulators, and environmental groups. Their concerns and interests encompass a wide range of factors, including financial gains, environmental preservation, job prospects, adherence to regulations, and fostering communal growth. Businesses and industries must acknowledge and respond to the demands of stakeholders and actively

include them in order to function efficiently and preserve their social legitimacy (Doni et al., 2022).

The oil and gas business holds immense global importance for several stakeholders. For more than a century, the oil and gas industry has been a fundamental pillar of the global economy. The energy sources it generates propel industrial activities, propel vehicles, and provide heat to households. The by-products of this substance are utilized in a myriad of items, ranging from plastics to medications. Consequently, the sector exerts influence over geopolitics, trade dynamics, and the economic stability of states. The sector relies heavily on public affairs and government relations (Nicoletti & You, 2020).

Although crucial for contemporary society, the oil and gas industry is currently facing attention due to its environmental repercussions. This has stimulated a movement towards implementing sustainable practices and adopting alternate energy sources. Simultaneously, stakeholders persist in relying on the industry to drive economic advancement and ensure energy stability. The stakeholders in the oil and gas business are individuals, organizations, and entities that have a vested interest in the activities and outcomes of this industry. The oil and gas business is responsible for handling a diverse range of stakeholders, each possessing distinct interests, concerns, and influences, which occasionally clash directly (Lieutenant, 2023).

Oil and gas stakeholders can be classified into several primary categories (companies, citizens, environmental organisations, personnel, engineers). It is essential for the industry's long-term viability and public perception to acknowledge and proactively handle connections with these stakeholders. Employees and workers refer to individuals who are directly employed by the companies, encompassing field labourers, engineers, administrative personnel, and executives. Investors and shareholders refer to individuals or entities who allocate funds to oil and gas enterprises with the anticipation of receiving a financial gain in return (Chinweze et al., 2015).

Government and regulators are responsible for supervising business, granting permits, imposing taxes, and implementing rules to ensure compliance with environmental and safety standards. Local communities refer to the individuals residing in close proximity to extraction or processing sites, who experience direct impacts from these operations. Suppliers and contractors refer to businesses that offer equipment, services, or consultancy

specifically to oil and gas firms. Environmental and social non-governmental organizations (NGOs) are entities that promote the preservation of the environment, safeguard human rights, and advocate for sustainable practices. Customers encompass a wide spectrum, including both individual consumers and huge industrial enterprises, who depend on oil and gas products for energy and production purposes. Rivals are other corporations in the oil and gas industry, as well as a growing number of enterprises in the renewable energy sector. Also, media have the ability to influence public opinion and can bring attention to both favourable and unfavourable actions inside industries (Doni et al., 2022).

Environmental and social non-governmental organizations (NGOs) play a crucial role in shaping public opinion and driving the implementation of more stringent legislation. Therefore, it is imperative to address the issues raised by these NGOs. They promote and support initiatives aimed at preserving the environment, upholding human rights, and implementing sustainable operational methods (Chinweze et al., 2015).

Indigenous Peoples refer to the native communities that could potentially be affected by exploration and extraction operations conducted on or near their ancestral territories. Trade unions are advocating for the rights and interests of the labour force. Academia and researchers engage in the study of several industries, providing valuable insights and even pioneering novel technology or approaches. The general public impressions have also a significant impact on policy decisions, brand reputation, and consumer choices. Although all stakeholders in the oil and gas industry have a part to play, certain individuals or groups possess a notably substantial influence on the day-to-day functioning, strategic choices, and overall sustainability of organizations. Effective engagement with key stakeholders is essential for companies to successfully navigate problems and maximize opportunities (Lieutenant, 2023).

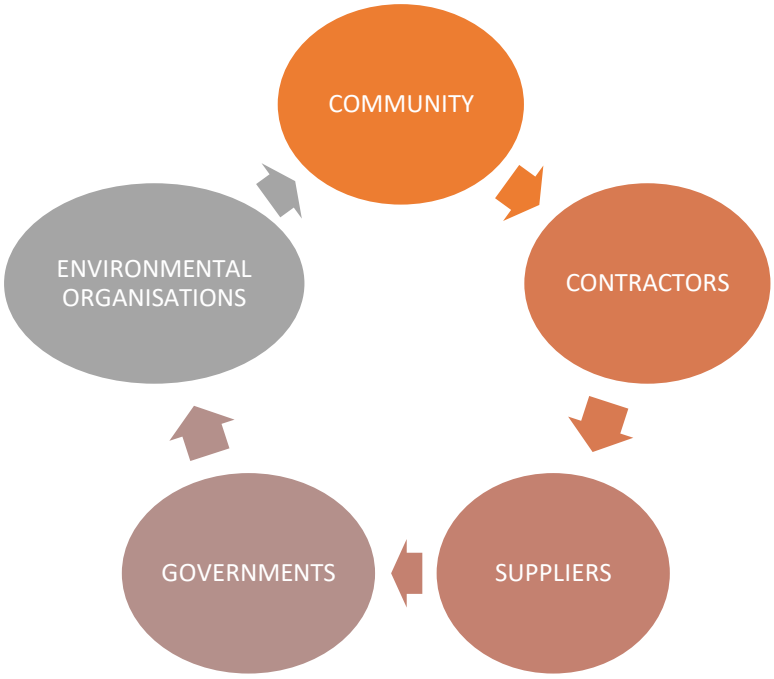

Figure 7: Major stakeholders

Oil serves as a predominant global energy source, with oil firms supplying billions of barrels of petroleum products on a daily basis to fuel transportation and industries. The industry has not yet been fully affected by the increasing public concern on climate change and efforts to decrease the usage of carbon-based fuels. Exxon and Shell, two prominent players in the oil and gas industry, are also among the most lucrative corporations globally.

The largest oil corporations are headquartered in the United States, Saudi Arabia, China, the United Kingdom, and France. An oil firm has the capacity to manufacture and distribute a diverse range of petrochemical and petroleum products, including gasoline, diesel, kerosene, synthetic rubbers, and jet fuel (Reiff, 2023).

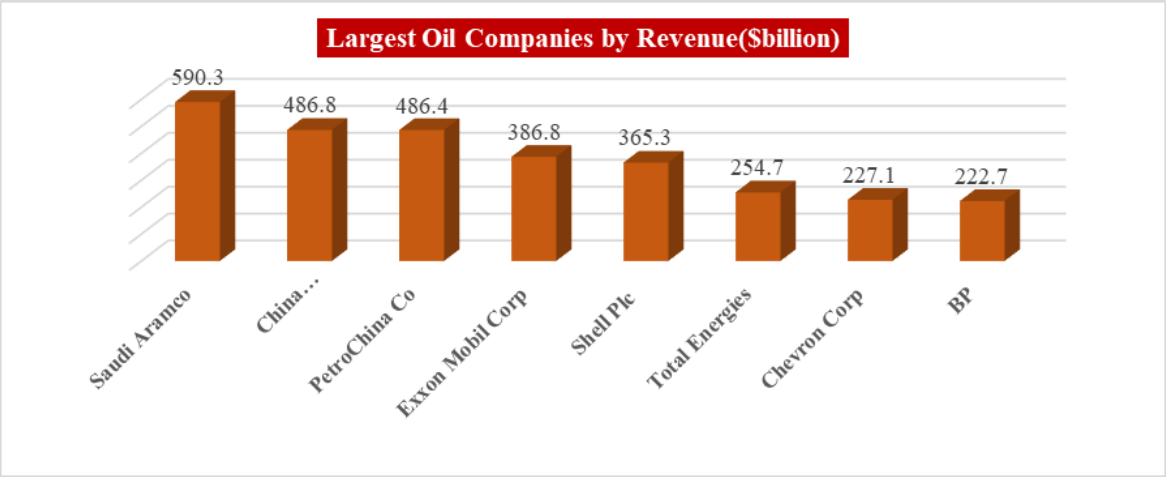

Figure 8: Largest companies by revenue

1. Saudi Arabian Oil Co. (Saudi Aramco)

Saudi Aramco, the largest integrated oil and gas firm globally, does not have its stock traded in the United States.

- Total revenue over the past twelve months is $590.3 billion.
- The trailing twelve-month net income is $156.5 billion.
- The market capitalization is $1.8 trillion.
- 1-Year Trailing Total Return: -3.7%
- Stock Exchange: Saudi Arabian Stock Exchange

Saudi Aramco is a global oil-producing corporation that holds the title of being the greatest in terms of revenue, making it one of the largest firms in the world across all industries. This corporation is the sole entity on this list that is not publicly traded in the United States. Saudi Aramco, the largest integrated oil and gas business globally, operates operations in strategic innovation centres across the United States, Europe, and Asia (Reiff, 2023).

2. China Petroleum & Chemical Corp. (SNPMF)

- China Petroleum & Chemical Corp. (SNPMF) has generated a total revenue of $486.8 billion over the past twelve months.
- The trailing twelve-month net income is $10.5 billion.
- The market capitalization is now valued at $55.7 billion.
- 1-Year Trailing Total Return: 18.6% OTC Markets

China Petroleum & Chemical is engaged in the production and distribution of several petrochemical and petroleum commodities. The company offers a range of products such as gasoline, diesel, kerosene, synthetic rubbers and resins, jet fuel, and chemical fertilizers, among other related items. China Petroleum & Chemical, commonly referred to as Sinopec, is one of the leading global enterprises in the oil refining, gas, and petrochemical industries (Reiff, 2023).

3.PetroChina Co. Ltd. (PCCYF)

- Total revenue during the past twelve months: $486.4 billion
- The trailing twelve-month net income is $20.9 billion.
- The market capitalization is $78.7 billion.
- 1-Year Trailing Total Return: 12.5%

PetroChina is the publicly traded subsidiary of the state-owned China National Petroleum Corporation. PetroChina is the foremost producer and distributor of oil and gas in China, accounting for around 50% and 60% of China's respective domestic oil and gas production (Reiff, 2023).

4. Exxon Mobil Corp. (XOM)

- Exxon Mobil Corp. (XOM) has generated a total revenue of $386.8 billion during the past twelve months.
- The trailing twelve-month net income is $51.9 billion.
- The market capitalization is now valued at $445 billion.
- 1-Year Trailing Overall gain: 85.6%
- Stock Exchange: New York Stock Exchange

Exxon Mobil engages in the exploration, production, trading, transportation, and sale of oil and natural gas. This company is a dominant force in the energy and chemical manufacturing industry, known for its high profitability. It has operations and markets its products worldwide, and also conducts oil and natural gas exploration on all six continents. ExxonMobil sells fuels, lubricants, and chemicals through four distinct brands: Esso, Exxon, Mobil, and ExxonMobil (Li et al., 2022).

5.Shell PLC

- SHELL has generated a total revenue of $365.3 billion over the past twelve months.
- The trailing twelve-month net income is $43.4 billion.
- The market capitalization is now valued at $201.8 billion.
- 1-Year Trailing Total Return: 37.47%
- Stock Exchange: New York Stock Exchange

Shell is a global energy corporation operating in 70 countries, engaged in the exploration, extraction, refining, and distribution of oil and natural gas, as well as the production and selling of chemicals (Li et al., 2022).

6. TotalEnergies SE (TTE)

- TotalEnergies SE (TTE) has generated a total revenue of $254.7 billion over the past twelve months.
- The trailing twelve-month net income is $23.1 billion.
- The market capitalization is now valued at $157.1 billion.
- 1-Year Trailing The overall return is 34.3%.
- Stock Exchange: New York Stock Exchange

TotalEnergies, with its main office located in France, engages in the exploration and extraction of crude oil, natural gas, and low-carbon electricity generation. Total engages in the refining and manufacturing of petrochemical goods. The corporation possesses and manages gas stations across Europe, the United States, and Africa.

7. Chevron Corp. (CVX)

- Chevron Corp. (CVX) has generated a total revenue of $227.1 billion for the trailing twelve months (TTM).
- The trailing twelve-month net income is $34.2 billion.
- The market capitalization is now valued at $337.8 billion.
- 1-Year Trailing Total Return: 56.8%
- Stock exchange: New York Stock Exchange

Chevron is a vertically integrated oil firm that engages in both upstream and downstream operations. The upstream sector is responsible for the exploration and extraction of oil and natural gas, whereas downstream activities encompass refining, transportation, and

marketing. Chevron is engaged in chemical and mining operations, in addition to non-energy industries such as technological development (Li et al., 2022).

8. BP PLC (BP)

- BP PLC (BP) has generated a total revenue of $222.7 billion during the past twelve months.
- The trailing twelve-month net income is a negative $11 billion.
- The market capitalization is now valued at $105.3 billion.
- One-year trailing overall return is 38.4%.
- Stock Exchange: New York Stock Exchange

BP, a British oil business, engages in the exploration, production, and supply of oil and petrochemicals. The corporation engages in the process of purifying and marketing petroleum derivatives, which encompass various chemical compounds such as acetic acid, ethylene, polyethylene, and terephthalic acid. The business's strategic direction will shift from being primarily an international oil company with a focus on resource production to becoming an integrated energy corporation with a primary focus on providing solutions for customers and investors. BP's portfolio encompasses renowned brands like as Castrol, Aral, and Amoco (Li et al., 2022).

9.Marathon Petroleum Corp. (MPC)

- Marathon Petroleum Corp. (MPC) has generated a total revenue of $173 billion over the trailing twelve months (TTM).
- TTM Net Income: $12 billion
- The market capitalization is $57.1 billion.
- 1-Year Trailing Total Return: 85.3%
- Stock Exchange: New York Stock Exchange

Marathon operates nationwide, refining and transporting petroleum products. Marathon is the proprietor of an extensive network of petroleum pipelines spanning hundreds of km.

10.Valero Energy Corp. (VLO)

- Valero Energy Corp. (VLO) has generated a total revenue of $170.5 billion during the past twelve months.
- The trailing twelve-month net income is $9.4 billion.
- The market capitalization is now valued at $47.3 billion.
- 1-Year Trailing Total Return: 78.3%
- Stock Exchange: New York Stock Exchange

Valero is the foremost autonomous petroleum refiner globally and the second-largest producer of renewable fuels worldwide. Valero operates a total of 15 refineries located in the United States, Canada, and the United Kingdom. Additionally, they have 33 wind turbines situated in the United States.

(Reiff, 2023)

Saudi Aramco	➢ Total revenue over the past twelve months is $590.3 billion. ➢ The trailing twelve-month net income is $156.5 billion. ➢ The market capitalization is $1.8 trillion. ➢ 1-Year Trailing Total Return: -3.7% ➢ Stock Exchange: Saudi Arabian Stock Exchange
China Petroleum & Chemical Corp. (SNPMF)	➢ China Petroleum & Chemical Corp. (SNPMF) has generated a total revenue of $486.8 billion over the past twelve months. ➢ The trailing twelve-month net income is $10.5 billion. ➢ The market capitalization is now valued at $55.7 billion.

	➢ 1-Year Trailing Total Return: 18.6% OTC Markets
Petro China Co. Ltd. (PCCYF)	➢ Total revenue during the past twelve months: $486.4 billion ➢ The trailing twelve-month net income is $20.9 billion. ➢ The market capitalization is $78.7 billion. ➢ 1-Year Trailing Total Return: 12.5%
Exxon Mobil Corp. (XOM)	➢ Exxon Mobil Corp. (XOM) has generated a total revenue of $386.8 billion during the past twelve months. ➢ The trailing twelve-month net income is $51.9 billion. ➢ The market capitalization is now valued at $445 billion. ➢ 1-Year Trailing Overall gain: 85.6% ➢ Stock Exchange: New York Stock Exchange
Shell PLC	➢ SHELL has generated a total revenue of $365.3 billion over the past twelve months. ➢ The trailing twelve-month net income is $43.4 billion. ➢ The market capitalization is now valued at $201.8 billion.

	➢ 1-Year Trailing Total Return: 37.47% ➢ Stock Exchange: New York Stock Exchange
TotalEnergies SE (TTE)	➢ TotalEnergies SE (TTE) has generated a total revenue of $254.7 billion over the past twelve months. ➢ The trailing twelve-month net income is $23.1 billion. ➢ The market capitalization is now valued at $157.1 billion. ➢ 1-Year Trailing The overall return is 34.3%. ➢ Stock Exchange: New York Stock Exchange
Marathon Petroleum Corp. (MPC)	➢ Marathon Petroleum Corp. (MPC) has generated a total revenue of $173 billion over the trailing twelve months (TTM). ➢ TTM Net Income: $12 billion ➢ The market capitalization is $57.1 billion. ➢ 1-Year Trailing Total Return: 85.3% ➢ Stock Exchange: New York Stock Exchange
Valero Energy Corp. (VLO)	➢ Valero Energy Corp. (VLO) has generated a total revenue of $170.5 billion during the past twelve months.

	➢ The trailing twelve-month net income is $9.4 billion. ➢ The market capitalization is now valued at $47.3 billion. ➢ 1-Year Trailing Total Return: 78.3% ➢ Stock Exchange: New York Stock Exchange

3.3 Importance of Efficient Supply Chain in Oil and Gas

It is currently an opportune moment for oil and gas firms to achieve operational success by optimizing their supply networks. Following a year of unprecedented earnings, the sector is allocating funds towards the development of innovative processes and technology. Concurrently, it is undergoing transformation to align with the requirements of regulators and stakeholders, while also making preparations for economic instability arising from sustained inflation and the condition of global financial markets. Despite the impact of COVID-19 and current international tax and trade policies, the importance of SCM as a key factor for firms' success has been recognized. However, many organizations still face difficulties in obtaining the necessary visibility to make prompt and efficient decisions. Oil and gas firms should evaluate their supply chain operating model and its alignment with their overall objectives and goals inside the organization. Additionally, they should establish a revised understanding of return on investment (Thompson & Armstrong, 2013).

In the oil and gas industry, having an effective supply chain is crucial for operational performance, financial prudence, and overall adaptability. In light of several obstacles such as geopolitical concerns and the growing need for cleaner energy options, the importance of skilled SCM becomes more evident. The oil and gas business operates through extensive offshore drilling rigs that harvest the essential resources for our industrialized society from deep inside the earth. The process commences with thorough investigation, delves into the core of reservoirs, and culminates in the extraction of crude oil, the vital essence of the

industry. Subsequently, a captivating series of purification procedures converts raw materials into a variety of goods, each fulfilling an essential function in our everyday existence (Qode, 2023).

The complex process, encompassing discovery and distribution, relies on the harmonious interaction of multiple components. Here, the focus is on the behind-the-scenes protagonist - the oil and gas supply chain. The lack of an effective supply network would cause this immense industry to fail (Qode, 2023).

SCM plays a crucial role in the oil and gas industry, ensuring smooth and efficient operations. The orchestration entails the smooth and coordinated transportation of unprocessed materials, parts, and processed goods over a worldwide platform. The significance of SCM in the oil and gas industry is particularly evident in this context. Envision a realm where every musical note in this symphony is impeccably synchronized, where any delays are minimized, and resources are utilized to their fullest potential. This utopia is the outcome of efficient SCM in the oil and gas sector, where every component of the chain works together to provide a seamless and dependable delivery of energy resources (Yusuf et al., 2014).

The oil and gas supply chain encounters complex obstacles across several stages, including exploration, production, transportation, and distribution. In the upstream sector, the process of finding and exploiting new reserves is becoming more intricate, sometimes taking place in remote or difficult environments. The midstream sector faces challenges in efficiently moving crude oil and natural gas over long distances, necessitating strong infrastructure. Refining and processing activities in the downstream sector need to adjust to shifting market demands, strict environmental restrictions, and the changing landscape of renewable energy sources. The primary difficulty lies in ensuring a robust and adaptable supply chain in the face of geopolitical uncertainties, fluctuating prices, and the need to embrace sustainable practices. The oil and gas supply chain faces the difficulty of effectively navigating intricate obstacles by requiring innovation, technical breakthroughs, and strategic planning (Ebrahimi et al., 2022).

The Oil and Gas supply chain and procurement are essential elements that support the smooth operation of the energy industry. This complex system oversees the acquisition, conveyance, and dissemination of oil and gas resources, overseeing many phases such as

exploration, extraction, refining, and distribution. The sector's effectiveness is heavily dependent on the implementation of strong procurement strategies, which guarantee the acquisition of vital equipment, materials, and services necessary for activities like exploration, extraction, and hydrocarbon processing. An effectively coordinated supply chain is crucial for the prompt delivery of resources, reducing operating interruptions, and optimizing expenses. The Oil and Gas industry requires a unified strategy for managing supply chain and procurement, which includes strategic planning, reducing risks, and working closely with suppliers and stakeholders to improve overall operational resilience. The efficient integration of these processes not only enhances cost-efficiency but also significantly contributes to the industry's ability to survive and adapt to changing market conditions. The Oil and Gas supply chain and procurement are crucial components that significantly influence the achievement, durability, and adaptability of the energy sector (Qode, 2023).

3.4. Impact of Supply Chain disruptions on operations, costs, and profitability

The energy sector is susceptible to several risks within its supply chain networks, such as severe weather events, cyber assaults, trade conflicts, labour unrest, and fluctuations in supply and demand. The proliferation of COVID-19 caused a cessation in the manufacturing of various industrial commodities, including steel and sand. Furthermore, the industry has been grappling with inflationary pressures and the geopolitical and economic concerns arising from Russia's incursion into Ukraine. Unforeseen interruptions can greatly affect energy supply chain networks, leading to reduced profitability and predictability of energy projects. This is because the allocation of resources towards supply chain networks constitutes a substantial proportion of both capital expenditures (CAPEX) and operating expenditures (OPEX) for energy companies. Indeed, our research has revealed that the procurement of products and services can make up nearly 80% of capital expenditure (CAPEX) for upstream enterprises, especially for resource-intensive drilling and completions operations (Sehgal, 2022).

Furthermore, it is worth noting that any delays in the supply chain of the oil and gas industry may jeopardize over 20% of the industry's planned capital expenditure growth for the year.

Exploration and production (E&P) businesses determine their risk calculation by considering various criteria, one of which is the projected retirement rate for jack-ups and floaters. Enhancing supply chain resilience helps mitigate risks by optimizing the efficiency of capital investments and accelerating the commencement of profitable capital projects. In addition, resilience would facilitate the ability of oil and gas businesses to efficiently meet the rising energy demand in the short and medium term, while also ensuring the provision of required energy supplies during the energy transition. Regarding this matter, implementing current modifications will result in long-term advantages (Sehgal, 2022).

The energy industry's supply chain networks difficulty cannot be solely attributed to the pandemic, inflationary pressures, and the war in Ukraine, despite their significant impact. They have only exposed and intensified weaknesses that have been developing for years. These factors consist of the absence of digital operational platforms that align materials and work crews, the widespread use of spot purchase or single-source supplier contracts, and a general lack of investment in enhancing the resilience of the building supply chain (Valle 2023).

Based on Accenture's analysis of investor presentations and recent conversations with major oil and gas businesses, it appears that the primary obstacles in supply chain networks can be classified into four distinct categories (Accenture, 2023):

- Providers
- Logistics
- Activities or tasks
- SCM and transportation of goods to customers

Collectively, these disruptions in supply chain networks are having a substantial impact. According to Accenture's analyses, they have the capability to increase the breakeven cost of a new well by $10 to $15 or even more per barrel. Given the current state of commodity prices, it is highly probable that oil and gas businesses will be able to easily bear these expenses. However, exceptionally high prices are not permanent. Each period of economic expansion is inevitably succeeded by a period of economic contraction. If prices experience a significant decline, the addition of $10 or $15 to the cost of each barrel of oil will become unviable (Sehgal, 2022).

In the future, there are several important subjects that are anticipated to influence the operational aspects of the oil and gas industry's supply chain in the coming three years. These projections consider geopolitical and financial events, along with rising trends:

The oil and gas industry is expected to see increasing pressure to decrease its carbon emissions, leading to a transition towards more environmentally friendly energy sources. The change will require modifications in the supply chain, such as incorporating renewable energy infrastructure and advancing carbon capture and storage technology. The oil and gas supply chain may be affected by ongoing geopolitical conflicts, trade disputes, and shifts in global leadership. The sector will need to adjust and maintain the robustness of its supply chain in response to developments in the Middle East, Eastern Europe, and Asia, as well as its partnerships with important consumers (Kendel Taylor, 2011).

The oil and gas supply chain will experience greater automation and efficiency due to the progress made in digital technologies, including artificial intelligence, robotics, and blockchain. These advancements will optimize the management of inventories, improve the ability to foresee maintenance needs, and simplify the process of coordinating logistics. As a result, operational resilience and cost-effectiveness will be enhanced (Valle 2023).

4. Challenges & Opportunities

The worldwide oil and gas sector is significantly dependent on an intricate and interlinked supply chain to guarantee the seamless movement of resources, equipment, and services. The stability and effectiveness of this supply chain are crucial for the industry's overall operations, impacting output levels, pricing dynamics, and geo-political ties. The oil and gas industry has suffered significant negative impacts due to disruptions in the supply chain, resulting in wide-ranging ramifications for production and market dynamics. These interruptions can arise from a multitude of sources, such as geopolitical conflicts, natural disasters, infrastructure limitations, and global financial occurrences (Valle, 2023).

The presence of political instability and conflicts in regions abundant in oil has always presented considerable obstacles to the supply chain. For example, the geopolitical tensions in the Middle East, including the current hostilities in Syria and Yemen, have caused disruptions in oil transportation routes and had an impact on the supply of oil. Geopolitical

tensions in significant oil-producing areas frequently cause disruptions in the supply chain, resulting in price fluctuations and uncertainties in the worldwide market (Kendel Taylor, 2011).

Catastrophic events, such as hurricanes and earthquakes, can have a profound effect on the oil and gas supply chain. Natural calamities underscore the susceptibility of the oil and gas supply chain, revealing the industry to abrupt interruptions and consequent economic consequences. Insufficient infrastructure, encompassing pipelines, ports, and storage facilities, might impede the seamless operation of the supply chain. Instances of congestion in the pipeline network that links oil-producing areas to refineries and export terminals have regularly hindered production and caused difficulties in managing operations. Infrastructure development investment is essential for the oil and gas industry to address supply chain limitations and guarantee consistent operations (Ramsay, 2011).

The supply chain is essential to the functioning of the oil and gas sector, since it allows for the efficient movement of resources and ensures seamless operations. Interferences to this intricate network can have significant consequences for production levels, pricing dynamics, and global market stability. By recognizing the influence of geopolitical and financial occurrences and adopting developing patterns, the sector can ready itself for possible interruptions and difficulties in the supply chain over the next three years (Valle, 2023).

In order to lessen the impact of geopolitical concerns and decrease reliance on particular locations, the industry is expected to expand its sources of supply. These actions may entail the exploration of untapped oil and gas deposits, the formation of advantageous alliances with up-and-coming producers, and the allocation of resources towards alternate transportation channels, such as pipelines and LNG facilities. Infrastructure investments are essential for enhancing the efficiency and dependability of the supply chain. This includes the process of improving current pipelines, increasing storage capabilities, and optimizing port infrastructure. By strengthening infrastructure, the sector can reduce congestion and maximize the efficient flow of resources throughout the supply chain (Moon et al., 2008).

Effective resolution of supply chain disruptions necessitates collaboration among industry players, encompassing producers, suppliers, and logistics providers. Implementing resilient risk management measures, such as contingency plans, supply chain transparency, and real-

time data analytics, can facilitate prompt reactions to unforeseen circumstances and mitigate their effects on business operations (Valle, 2023).

The oil and gas supply chain will undergo a significant transformation through the utilization of digitalization and emerging technologies. The utilization of automation, data analytics, and the Internet of Things (IoT) will facilitate the continuous monitoring of assets, the ability to foresee maintenance needs, and the improvement of decision-making processes. The utilization of blockchain technology has the potential to enhance transparency and effectiveness in supply chain transactions, hence diminishing fraudulent activities and enhancing the ability to track and trace products (Aryal et al., 2020).

With the infiltration of technology into many aspects of our lives, the oil and gas business is adopting the digital revolution. Specialized software designed specifically for the oil and gas supply chain has emerged as a significant contributor, introducing innovative solutions. The implementation of real-time inventory tracking, accurate demand forecasting, and effective communication throughout the supply chain has become essential (Qode, 2023).

The implementation of digital supply chain in the oil and gas industry is becoming increasingly prominent, utilizing advanced technology such as IoT sensors, artificial intelligence, and blockchain. The integration of these components beyond the capabilities of traditional SCM (Qode, 2023).

Oil and gas firms presently have the opportunity to address persistent difficulties and develop a more robust stance against forthcoming dangers. Given the current high levels of commodity prices, it is possible to create supply chain strategies that would facilitate the continued transition to renewable energy, while ensuring the security and dependability of the energy system. Companies can enhance their risk management capabilities by conducting stress tests to assess the resilience of their supply chain networks and contingency plans under different disruption situations. By generating digital replicas of complete supply chain networks, encompassing suppliers, business divisions, products, and other elements, firms can simulate and evaluate potential disruptions in a wide range of materials or services. It is advisable for organizations to conduct annual stress tests on their supply chain networks. The implementation of stress testing enabled the lubricants division of an energy corporation to gain insight into the risks associated with its supply chain, as well as the potential consequences (Sehgal, 2022).

Implementing supply chain control towers or incident command centres can effectively mitigate these issues. A prominent American exploration and production business discovered this when it implemented an upstream supply chain control tower, which oversees numerous production platforms, drilling rigs, data systems, and air/shipping fleets. As a component of a broader overhaul of its supply chain operations, the control tower significantly contributed to the company's 20% reduction in operating expenses, as well as a 2% to 5% increase in asset uptime and production (Sehgal, 2022).

Traditionally, oil and gas supply chain executives have been primarily driven by the desire to achieve cost savings. Today, the focus has shifted from just saving money to considering the entire value chain and the overall impact of the supply chain function on driving growth and enhancing operational value. Given the increasing inflation costs, decarbonization efforts, and operational demands, it is crucial to reframe existing models and obtain support from top-level management to establish an inclusive and empowering environment for driving change. Oil and gas firms that achieve internal alignment and effectively communicate throughout the supply chain will have a favourable influence on discovering innovative methods to enhance value (Thompson & Armstrong, 2023).

In order to achieve success, it is imperative for oil and gas companies to engage in efficient collaboration throughout their supply chain and ensure that their strategic objectives are harmonized across the entire organization, rather than relying on sporadic and isolated efforts. In the oil and gas business, SCM is often regarded as an administrative function that lacks investment and resources to bring about significant changes, rather than being recognized as a source of competitive advantage. Presently, firms are facing difficulties in achieving desired outcomes due to their complex reporting structure, significant lack of alignment, and inadequate supply chain controls (Thompson & Armstrong, 2023).

An effective supply chain capacity should have comprehensive visibility throughout the entire process, achieved through simulation and risk monitoring. It should also involve continuous identification of backup supply sources, a robust operating model that can withstand disruptions, and skilled personnel to support its operations. More advanced companies in this process can promptly address evolving requirements, such as ensuring a steady supply, and effectively handle disruptive factors by gaining a more comprehensive understanding of their supply chain network. By disrupting conventional techniques, the

function will not only enhance its resilience, but also gain a more comprehensive understanding of supply chain risk and identify opportunities that foster innovation and create sustainable growth in the long run (Valle, 2023).

Integrated supply chain solutions are essential for ensuring transparency throughout the processes of planning, procurement, materials management, manufacturing, and logistics. Oil and gas firms may enhance the safety, production capacity, and dependability of their assets while reducing costs by utilizing data and digital technologies in their supply chain management. Integrating data across different processes and maintenance systems allows for automation and improved visibility of inventories. It also streamlines tools for field staff and provides easy access to important monitoring, maintenance, and reliability applications, along with relevant data and key performance indicators (KPIs). Mobile digital workflows provide prompt and efficient execution in real-time while digital twins, augmented reality, and virtual reality tools enhance safety, expedite troubleshooting, and reduce downtime (Thompson & Armstrong, 2023).

To summarize, the supply chain plays a vital role in the oil and gas sector, and any interruptions in this interconnected system can have significant and wide-ranging impacts. To strengthen supply chain resilience, the industry should proactively anticipate future issues by comprehending the consequences of geopolitical tensions, natural disasters, and infrastructure limits. To ensure the stability and efficiency of the supply chain in the future, it will be crucial to adopt sustainable practices, utilize digital technology, and promote collaboration (Valle, 2023).

Following, a SWOT analysis of the sector will be presented, according to the literature review. It shows the strengths, opportunities, weaknesses and threats:

Strengths	**Opportunities**
High profits Flexibility International reach Strong market position	Emerging Technologies The oil and gas supply chain will undergo significant transformation through the use of digitalisation and emerging technologies.

	Oil and gas companies today have the opportunity to address persistent challenges and develop a more robust posture in the face of upcoming risks. Cooperation
Weaknesses Catastrophic events, such as hurricanes and earthquakes, can have a profound effect on the oil and gas supply chain. Environmental impact Inadequate infrastructure, including pipelines, ports and storage facilities	**Threats** Geopolitical tensions Economic fluctuations Strict regulations

Conclusion

An efficient supply chain is essential in the oil and gas sector to ensure optimal operational performance, financial efficiency, and overall flexibility. The significance of proficient SCM becomes increasingly apparent due to several challenges, including geopolitical considerations and the escalating demand for more environmentally friendly energy alternatives. The oil and gas industry utilizes offshore drilling rigs to extract vital resources from deep inside the earth, which are crucial for our industrialized civilization. The process begins with a comprehensive examination, explores the core aspects of reservoirs, and concludes with the extraction of crude oil, which is the essential substance of the industry. Following that, a compelling sequence of purification processes transforms basic substances into a range of products, each serving a crucial purpose in our daily lives.

The intricate procedure, involving the exploration and dissemination, depends on the seamless interaction of several elements. Here, the main emphasis is placed on the behind-the-scenes central character - the oil and gas supply chain. The absence of a proficient distribution network would result in the failure of this substantial industry.

SCM is essential in the oil and gas business to ensure seamless and effective operations. The orchestration involves the efficient and synchronized movement of raw materials, components, and finished products throughout a global network.

The global oil and gas industry heavily relies on a complex and interconnected supply chain to ensure the smooth flow of resources, equipment, and services. The stability and effectiveness of this supply chain are vital for the industry's overall operations, influencing output levels, pricing dynamics, and geopolitical relationships. The oil and gas industry has experienced substantial adverse effects as a result of disruptions in the supply chain, leading to far-reaching consequences for production and market dynamics. These interruptions might originate from various sources, including geopolitical wars, natural disasters, infrastructure constraints, and global financial events.

The existence of political instability and conflicts in oil-rich countries has consistently posed significant challenges to the supply chain. For instance, the geopolitical tensions in the Middle East, such as the ongoing conflicts in Syria and Yemen, have resulted in disruptions

to oil shipping routes and have affected the oil supply. Geopolitical conflicts in major oil-producing regions sometimes lead to disruptions in the supply chain, causing price volatility and creating uncertainties in the global market.

Devastating occurrences, such as hurricanes and earthquakes, can exert a significant impact on the oil and gas supply chain. Natural disasters highlight the vulnerability of the oil and gas supply chain, exposing the business to sudden disruptions and subsequent economic repercussions. Inadequate infrastructure, including pipelines, ports, and storage facilities, could hinder the smooth functioning of the supply chain. Recurring instances of congestion in the pipeline network connecting oil-producing regions to refineries and export terminals have consistently impeded production and posed challenges in operational management. Investing in infrastructure development is crucial for the oil and gas industry to overcome supply chain constraints and ensure uninterrupted operations. To mitigate geopolitical risks and reduce dependence on certain regions, the industry is projected to diversify its sources of supply. These efforts may involve investigating undiscovered oil and gas reserves, establishing beneficial partnerships with emerging producers, and investing resources in alternative transportation methods like pipelines and LNG facilities.

Historically, oil and gas supply chain executives have been predominantly motivated by the goal of attaining cost reductions. Today, there is a shift in focus from solely saving money to taking into account the full value chain and the total influence of the supply chain function on generating growth and improving operational value. In light of the rising inflation expenses, decarbonization initiatives, and operational requirements, it is imperative to redefine current models and secure endorsement from senior management in order to develop an all-encompassing and empowering atmosphere for facilitating transformation. Oil and gas companies that establish internal alignment and effectively communicate across the supply chain will positively impact the discovery of novel approaches to generate value.

To attain success, oil and gas companies must prioritize effective communication across their supply chain and align their strategic objectives throughout the organization, rather than depending on irregular and isolated efforts. SCM in the oil and gas industry is commonly seen as an administrative task that is not given enough attention and resources to make substantial improvements. It is not acknowledged as a potential source of competitive advantage. Currently, companies are encountering challenges in attaining intended results

as a result of their intricate reporting hierarchy, substantial lack of coordination, and insufficient supply chain oversight.

References

Accenture (2022), Supply Chain Oil & Gas Industry. Retrieved from: https://www.accenture.com/za-en

Agus, A. (2013). The Importance of Supply Chain Management on Financial Optimization. *Jurnal Teknik Industri*, *15*(2), 77-84.

Aryal, A., Liao, Y., Nattuthurai, P., & Li, B. (2020). The emerging big data analytics and IoT in supply chain management: a systematic review. *Supply Chain Management: An International Journal*, *25*(2), 141-156.

Ateed, E. H. (2024). The Impact of Russia-Ukraine War on the Global Energy Crisis. In *Analyzing Energy Crises and the Impact of Country Policies on the World* (pp. 119-138). IGI Global.

Bagheri, B. (2023). *Corporate Social Responsibility Reporting and Performance: Will the Oil and Gas Sector Join the Energy Transition?* (Doctoral dissertation, The University of Texas at San Antonio).

Ben-Daya, M., Hassini, E., & Bahroun, Z. (2019). Internet of things and supply chain management: a literature review. *International journal of production research*, *57*(15-16), 4719-4742.

B.O. (2023). Supply Chain Management in Oil & Gas industry. Blue Ocean Corporation.

Bottani, E., Montanari, R., Rinaldi, M., & Vignali, G. (2015). Modeling and multi-objective optimization of closed loop supply chains: A case study. *Computers & Industrial Engineering*, *87*, 328-342.

Cao, Q., Schniederjans, D. G., & Schniederjans, M. (2017). Establishing the use of cloud computing in supply chain management. *Operations Management Research*, *10*, 47-63.

Chang, S. E., & Chen, Y. (2020). When blockchain meets supply chain: A systematic literature review on current development and potential applications. *Ieee Access*, *8*, 62478-62494.

Chinweze, C., Echetebu, C., & Onyeri, I. (2015). Stakeholders engagement in the Oil and Gas Industry in Nigeria. In *AIA 15 Conference*.

Colson, J. (1999). Upstream, midstream, downstream-the valuation of royalties on federal oil and gas leases. *U. Colo. L. Rev.*, *70*, 563.

Doni, F., Corvino, A., & Bianchi Martini, S. (2022). Corporate governance model, stakeholder engagement and social issues evidence from European oil and gas industry. *Social Responsibility Journal*, *18*(3), 636-662.

Ebrahimi, S. B., & Bagheri, E. (2022). Optimizing profit and reliability using a bi-objective mathematical model for oil and gas supply chain under disruption risks. *Computers & Industrial Engineering*, *163*, 107849.

Fernando, J. (2023). Supply Chain Management (SCM): How It Works & Why It's Important. Investopedia.

Haider, W. H. (2020, January). Estimates of total oil & gas reserves in the world, future of oil and gas companies and smart investments by E & P companies in renewable energy sources for future energy needs. In *International petroleum technology conference* (p. D011S009R002). IPTC.

Kendall-Taylor, A. (2011). Instability and oil: How political time horizons affect oil revenue management. *Studies in Comparative International Development*, *46*, 321-348.

Li, M., Trencher, G., & Asuka, J. (2022). The clean energy claims of BP, Chevron, ExxonMobil and Shell: A mismatch between discourse, actions and investments. *PloS one*, *17*(2), e0263596.

McClay, R. (2022). How the Oil and Gas Industry Works. Investopedia.

Marcel, V., Gordon, D., Ogeer, N., & Omonbude, E. (2023). Left behind: emerging oil and gas producers in a warming world. *Climate Policy*, *23*(9), 1151-1166.

Moon, G., & Leblanc, L. A. (2008). The risk adjustment of required rate of return for supply chain infrastructure investments. *Transportation Journal*, *47*(1), 5-16.

Nicoletti, J., & You, F. (2020). Multiobjective economic and environmental optimization of global crude oil purchase and sale planning with noncooperative stakeholders. *Applied Energy*, *259*, 114222.

Prahinski, C., & Kocabasoglu, C. (2006). Empirical research opportunities in reverse supply chains. *Omega*, *34*(6), 519-532.

Radiant (2022). What Is A Closed Loop Supply Chain? Retrieved from: radiantrfid.com

Ramezani, M., Kimiagari, A. M., & Karimi, B. (2014). Closed-loop supply chain network design: A financial approach. *Applied Mathematical Modelling*, *38*(15-16), 4099-4119.

Ramsay, K. W. (2011). Revisiting the resource curse: natural disasters, the price of oil, and democracy. *International Organization*, *65*(3), 507-529.

Reiff, N. (2023). 10 Biggest Oil Companies. Investopedia.

Rejeb, A., Keogh, J. G., Wamba, S. F., & Treiblmaier, H. (2020). The potentials of augmented reality in supply chain management: A state-of-the-art review. *Management review quarterly*, 1-38.

Rejeb, A., Rejeb, K., Simske, S. J., & Treiblmaier, H. (2023). Drones for supply chain management and logistics: a review and research agenda. *International Journal of Logistics Research and Applications*, *26*(6), 708-731.

Schwab, A. P., Su, J., Wetzel, S., Pekarek, S., & Banks, M. K. (1999). Extraction of petroleum hydrocarbons from soil by mechanical shaking. *Environmental science & technology*, *33*(11), 1940-1945.

Shekarian, E. (2020). A review of factors affecting closed-loop supply chain models. *Journal of Cleaner Production*, *253*, 119823.

Thomas, E. (2023). 2023 in data: the trends that shaped the oil and gas sector. Retrieved from: www.offshore-technology.com

Thomson, R. & Armstrong, J. (2023). Why oil and gas companies should optimize their supply chain function. EY.

Guide, D. & Wassenhove, L. (2002). The Reverse Supply Chain. Harvard Business Review.

IBM (2023). What is supply chain management? Retrieved from: https://www.ibm.com/topics/supply-chain-management

Lieutenant, L. (2023). Key Stakeholders in the Oil and Gas Industry. Borealis.

Lima-Junior, F. R., & Carpinetti, L. C. R. (2019). Predicting supply chain performance based on SCOR® metrics and multilayer perceptron neural networks. *International Journal of Production Economics*, *212*, 19-38.

Li, J., Tang, M., Ye, Z., Chen, L., & Zhou, Y. (2017). Scale formation and control in oil and gas fields: A review. *Journal of Dispersion Science and Technology*, *38*(5), 661-670.

Lu, H., Guo, L., & Zhang, Y. (2019). Oil and gas companies' low-carbon emission transition to integrated energy companies. *Science of the total environment*, *686*, 1202-1209.

Sehgal, P. (2022). Reliable energy requires resilient supply chains. Accenture.

Power, D. (2005). Supply chain management integration and implementation: a literature review. *Supply chain management: an International journal*, *10*(4), 252-263.

Prahinski, C., & Kocabasoglu, C. (2006). Empirical research opportunities in reverse supply chains. *Omega*, *34*(6), 519-532.

Qode (2023). The 5 Key Importance of Supply Chain Management in Oil & Gas Industry. Retrieved from: https://www.qodenext.com/blog/importance-of-supply-chain-management-in-oil-and-gas-industry/

Unlu, Z. (2023). Emerging Technologies in Supply Chain Management: Enhancing Efficiency and Sustainability. LinkedIn.

Valle, E. (2023). The Crucial Impact of Supply Chain on the Oil and Gas Industry: Insights and Projections. LinkedIn.

Weijermars, R. (2009). Accelerating the three dimensions of E&P clockspeed–a novel strategy for optimizing utility in the oil & gas industry. *Applied Energy*, *86*(10), 2222-2243.

Yusuf, Y. Y., Gunasekaran, A., Musa, A., Dauda, M., El-Berishy, N. M., & Cang, S. (2014). A relational study of supply chain agility, competitiveness and business performance in the oil and gas industry. *International Journal of Production Economics*, *147*, 531-543.

Zhang, W., & Wu, X. (2013). The importance of supply chain management. *International Journal of Business and Social Science*, *4*(16).

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