IMPACT OF AI ON FUTURE WORKFORCE: A STUDY ON OIL & GAS SECTOR

by

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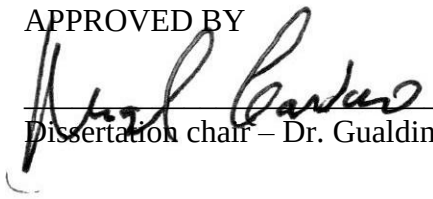

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Dedication

To the Almighty, whose divine blessings, guidance, and inspiration have been the driving force behind this doctoral journey, enabling perseverance, self-motivation, and the energy to achieve this academic milestone.

To my family, whose unwavering support and understanding have been the cornerstone of my academic journey, to my mentor who provided invaluable guidance, and to my work management, colleagues who challenged and inspired me throughout this doctoral pursuit.

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ABSTRACT

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Technological advancements in areas such as "Robotic Process Automation" (RPA), "Machine Learning" (ML), and "Artificial Intelligence" (AI) are having a profound impact on the "Oil and Gas" (O&G) industry. This research goals to understand the following questions related to specification of AI effects on O&G sector and workforce components, job position, organizational outlook, and skills disparities in the future. By examining how automation reshapes traditional tasks and creates new opportunities, the research provides insights into workforce planning for “International Oil Companies” (IOCs) and “National Oil Companies” (NOCs). The study uses surveys with structured questions and adapts a quantitative approach collecting data from 300 participants working at IOCs and NOCs across various ranks. A 5-point Likert scale means that perceptions regarding automation and opportunities in employment and reskilling are measured. Quantitative data is analyzed with statistical instruments that help identify patterns and associations about fear of automation, perceived opportunities, and effects of the education level. Research findings show that AI has both positive and negative effects on the consideration of the workforce. As automation takes over more routine and repetitive tasks, raising concerns about job losses, AI also creates new job opportunities in high-tech fields

such as data science, AI monitoring, and cybersecurity. The research also points to the fact that organizations require strategies that are robust on reskilling and general working models that will support the responsible use of AI. Therefore, the right balance needs to be made on the use of AI in O&G industry that focuses on the workforce and, at the same time, benefits from the proper advancement of technology. Focused training and education, successful organizational change and learning organization culture are among the primary strategically important factors that unlock a sustainable and efficient labor force. Based on this research, the following findings have been reached: highlighting importance of human resources and leadership to take on the dynamics and possibilities of O&G sector digitalization process.

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LIST OF ABBREVIATIONS

Abbreviations	Full Form
AI	Artificial Intelligence
RPA	Robotic Process Automation
ML	Machine Learning
IOCs	International Oil Companies
NOCs	National Oil Companies
HR	Human Resources
CPS	Cyber-Physical Systems
E&P	Exploration and Production
FMEA	Failure Mode and Effect Analysis
OD	Organization Design
SPSS	Statistical Package for The Social Sciences
DL	Deep Learning
NLP	Natural Language Processing
O&G	Oil and Gas
GHRM	Green Human Resource Management
CPD	Continuing Professional Development
DSD	Department of Skills Development
ANP	Analytic Network Process
AUVs	Autonomous Underwater Vehicles
POB	Personnel on Board
DSSs	Decision Support Systems
AIOI	Ai Occupational Influence
NCS	Norwegian Continental Shelf

NOGI	Norwegian O&G Industry
PII	Personally, Identifiable Information
OGI	Open Geometry Initiative
SVM	Support Vector Machine
SAM	Segment Anything Model
AGI	Artificial General Intelligence

CHAPTER I:

INTRODUCTION

1.1 Introduction

There were three main phases to growth of Oil and Gas (O&G) industry and implementation of associated data (Gurina, 2019). Sensor readings and data application were underutilized, even though the industry had an empirical strategy based on analogue situations (Cavalcante *et al.*, 2019). This changed with Schlumberger brothers' introduction of instruments to measure subsurface physical properties i.e., surface and wellbore electrical resistivity (Bello *et al.*, 2016) for use in decision-making. Advancements followed the combination of many data sources and the use of data to characterize and analyse fields via various modelling and simulation exercises (Klyuchnikov *et al.*, 2019). At this third stage, data from seismic, well logging, core and fluids are primarily used to design the reservoir models for simulating scenarios to develop fields effectively (Hegde and Gray, 2017).

The O&G industry is data-rich where drilling, reservoir engineering, geological modelling, plant operations and maintenance are finding applications with AI, automation and robotization that are helping industry to overcome key challenges (Rahmanifard and Plaksina, 2019). Autonomous decision making enables faster and more efficient drilling processes while smart integration of production equipment with human beings are adopting innovative operating models at the architectural level (Klyuchnikov *et al.*, 2019).

With the widespread digitalization in O&G industry, IOCs and NOCs are implementing new digital solutions so-as-to benefit across the value chain for productivity gains and cost savings (Bello *et al.*, 2015). For the deployment of various digitalization initiatives, the O&G industry would require workforce with new skill sets that can be bolstered with modern technologies. IOC/NOCs are creating employment opportunities for

data scientists, statisticians, and AI/machine learning specialists who will operate their Digital Oil Field in near future.

The study looks into how workforce of O&G industry will be transformed by application of AI and other digitalization technologies. The study also aims to assess potential organization optimization and efficiency improvement, where Human Resources (HR) professionals can echo business language to remain significant in the new industry reality.

The industry is quickly embracing AI, the most vital general-purpose technology of the present E. Brynjolfsson (2017); Cockburn, Henderson and Stern, 2018), which holds great promise for both improvement and expansion (Institute, 2018; WIPO, 2019). Already, AI has changed the laws of competition and sparked major shifts in industries such as retail, media, healthcare, transportation, and finance. Companies in various sectors are finding new ways to generate value through the use of artificial intelligence solutions, rather than depending on time-honoured, people-centric business practices (Karim R. Lakhani, 2020). The value creation process is driven by advanced algorithms that are constantly fed with fresh data and trained on big, relevant datasets; Yandex operates autonomous vehicles, Inbox Vudu organises emails by importance, and Amazon determines product prices.

However, AI is beneficial for businesses outside of tech-savvy sectors as well. Late adopters of digitalization, O&G, mining, and construction industries are increasingly reliant on AI solutions Johnson (2011); Kane *et al.* (2015), O&G companies have been actively seeking out chances to use AI for some years now, even though the field originally examined AI applications in the 1970s (Samoun *et al.*, 2019; H. Y. Hong Li, Nai Cao, He Tian *et al.,* 2021). The sector is moving towards the O&G 4.0 idea, which aims to produce

better value via the use of advanced digital technologies, and AI capabilities are growing at an exponential rate (Lu *et al.*, 2019).

The major aim of O&G corporations' AI (and other digitalization initiatives) is to increase efficiency since they're far more likely to embrace new technology than to test and alter their business models (Tekic and Koroteev, 2019; Tariq *et al.*, 2021).

Despite its complexity, O&G business provides majority of world's energy demand. Its support of the global demand for energy, power, transportation, and other key petrochemical products have contributed to the economic revolution of world (2017; Kovalchuk, 2019). Various stages of the production and distribution processes leverage cutting-edge technologies. There are three layers to this process: upstream, midstream, and downstream. Geological surveys, both onshore and offshore, and other exploration and production responsibilities are part of the upstream sector. Trading transporting refined goods, and storing natural gas and crude oil, and other related operations make up the midstream sector. Production, processing, and distribution are all part of the downstream sector.

The COVID-19 epidemic and the escalating high levels of market volatility have recently caused a slump in the O&G industry. Furthermore, fossil fuel demand and consumption are projected to drop in the long run due to the impulse for carbon taxes, and greener, cleaner energy in many nations and around the world. Therefore, to find a more efficient and cost-effective strategy to maintain the O&G business competitive, it is required to classify and identify opportunities to address the problems within the traditional modus operandi of O&G industry.

Challenges of Conventional Upstream Sector

This section explains the conservative upstream sector's problems and why the I4.0 has to be implemented.

- **Dwindling price of oil and volatility** - Investors' interest is likely to be impacted by O&G's experience with declining oil prices and excessive volatility (Tarver, 2015).
- **High cost -** The operational cost, which includes factors like the increasing expense of exploring and developing new O&G reserves, the cost of production (particularly offshore), and the cost of maintenance, remains a prominent concern (T. Andreeva, E. Zhulina, 2018).
- **High competition**- The O&G sector is now more competitive than ever before due to technological advancements that have made it possible to commercialize unconventional reserves like coalbed methane, shale gas, and oil sands and gas. Making money out of these unconventional reservoirs is a complex and expensive ordeal.
- **Environmental impact -** The production of crude oil continues to pose a significant threat to the environment. There is an increasing burden on the O&G business from the call for climate legislation and emission reduction. Furthermore, renewable energy is becoming more affordable and is seeing an increase in demand.
- **Timely decisions and forecast -** Operations are now inefficient due to a lack of "data analytics" (DA) for asset management, sophisticated monitoring, vendor and partner collaboration, and consumer-productor-partner relationships.
- **Intricacy in drilling and production process -** The drilling and production process becomes more complicated as new reserves are sought in remote and difficult-to-reach areas, posing health, safety, and environmental risks (Shukla and Karki 2016; Mojarad, Atashbari and Tantau, 2018).

The O&G industry is progressively embracing intellectualization, digitization, and automation as a means to tackle these issues. It is capitalizing on "Industry Revolution 4.0" (IR 4.0). In IR 4.0, we want to leverage new and emerging technologies to open up new ways of manufacturing, creating value, and optimizing in real-time. cyber defence, IoT, cloud storage, analytics on large datasets, augmented reality, modelling, and system integration are some of the technologies that have been highlighted as part of Industry 4.0 (I4.0) (Dalenogare *et al.*, 2018). The "Digital twins" (DT) and "cyber-physical systems" (CPS) are two examples of modern technologies made possible by the addition of several I4.0 technologies. To optimise efficiency, quality, and productivity, the physical and virtual O&G activities and cores are integrated through the fusion of I4.0 technologies. This is known as I4.0 in O&G (Elijah *et al.*, 2021).

The utilization of AI has gained significant prominence in the field of engineering, and its interpretation can be perceived through multiple lenses. Artificial intelligence, technically speaking, pertains to the volume of computer systems to imitate human intelligence utilizing algorithms and ML methodologies. AI is a rapidly evolving technology that has been applied for over 20 years in a variety of areas, such as the media, financial, retail, and medical industries. The ethos of AI is one of open sharing and publication (Bravo *et al.*, 2014).

Production control, Virtual sensing, optimization, forecasting, and simulation are just some of the many ways AI is put to use in "exploration and production" (E&P). However, AI applications have not yet become industry standards; the most prevalent AI applications in E&P industry are still limited to case studies and pilot initiatives (Bravo *et al.*, 2014). Nevertheless, AI has demonstrated significant innovation and growth potential across all disciplines, and it has become the most essential general-purpose technology

available today (Tariq *et al.*, 2021). AI solutions entail intricate algorithms that have undergone training on extensive and valuable datasets.

These datasets are consistently supplied with new data to facilitate the process of generating value Fields (Tariq *et al.*, 2021). The potential of AI-based work has been demonstrated as a promising avenue for various fields, including but not limited to optimization of development plans; detection of residual oil; better oil recovery; detection of fractures; and dynamic prediction of oilfield production (H. Y. Hong Li, Nai Cao, He Tian *et al.*, 2021). It is important to note that AI solutions are not globally available and cannot be readily procured. Rather, they necessitate customization to align with the specific business context, challenges and data of the organization (Sircar *et al.*, 2021; Tariq *et al.*, 2021). Consequently, enterprises must develop internal groups of professionals specialized in data and artificial intelligence to effectively integrate AI into their operations.

Over the upcoming decade, professionals with expertise in artificial intelligence will likely become an essential component of all innovation initiatives within O&G sector. The OGI is expected to adopt a partially data-driven approach due to this emerging trend, with the integration of AI technology across various stages of the industry (Sircar *et al.*, 2021). AI was born without any significant business influences and has been a product of academic research that has been ongoing for decades (Bravo *et al.*, 2014; Tariq *et al.*, 2021). AI is a swiftly developing field of technology with significant applications in to do with O&G business (Musa, 2023).

The OGI is renowned for its intricate and hazardous working environment, which includes hydrocarbon distribution, exploration, extraction, and refining. (Van Thuyet, Ogunlana and Dey, 2007). The sector is known for its dangerous operations, heavy machinery, and harsh working conditions, which emphasise the importance of safety and minimising risk. (Dahl and Kongsvik, 2018). Safety and risk management are of paramount

importance for O&G industry because failure of its operation can result in catastrophes, severe environmental impacts and loss of life (Dahl and Kongsvik, 2018). The industry encompasses a variety of risks involving process safety, worker safety and environmental safety, which calls for effective safety management measures (Khan, Rathnayaka and Ahmed, 2015). HRM has the major responsibility of maintaining safety in O&G industry.

According to Asad et al. (2019); Dahl & Kongsvik (2018) the duties of HRM include designing and executing safety policies, training, and safety organizational culture programs to reduce risks and create a protective working environment. HRM plays the main role in ensuring careful safety procedures and an environment that promotes safety in the business Besides. Mohamed et al. (2018) stated that HRM mainly in O&G industry works in a high-risk atmosphere which means that safety and risk control plans have to be efficient. A specific and highly significant responsibility of HRM is to strengthen safety by providing and promoting corporate safety standards and creating new ways of approach to safety management.

AI Applications in Reservoir

Reservoir Characterization and Modelling: One of the principal tasks within the framework of reservoir management is the characterization of subsurface reservoirs to forecast fluid behaviour and reservoir performance (Penna and Lupinacci, 2024). Machine learning, pattern recognition and other tools help engineers' study seismic data, well logs and reservoir simulation to build detailed reservoir models. The usage of machine learning algorithms has customarily desirable capabilities to ascertain intricate patterns in more than two-dimensional data sets and consequently can offer the engineer better ways to delineate reservoir limits, define geological characteristics, and estimate petrophysical characteristics than before. By integrating historical production data and reservoir performance metrics, machine learning models can also predict reservoir behaviour under

various operating conditions, facilitating active decision-making and risk assessment (Adewusi *et al.*, 2024). Furthermore, AI-driven reservoir characterization enables engineers to update reservoir models in real-time based on observed data, reducing uncertainty and improving the accuracy of production forecasts.

Through continuous learning and adaptation, AI algorithms enhance the reliability of reservoir models and optimize reservoir management strategies over the project lifecycle (Odili *et al.*, 2024). Production Optimization and Well Management Optimizing production rates and managing well performance are critical aspects of reservoir management, as they directly influence overall reservoir economics and asset profitability (Janatian, 2024). AI technologies offer innovative solutions for optimizing well placement, production scheduling, and reservoir drainage strategies to maximize hydrocarbon recovery while minimizing operational costs. Machine learning processes can examine production data, well logs, and surface measurements to identify production inefficiencies, detect anomalies, and optimize well performance in real time (Odonkor *et al.*, 2024).

By integrating data from sensors, downhole gauges, and production facilities, AI systems can detect changes in reservoir dynamics, identify potential equipment failures, and recommend corrective actions to mitigate production losses. Additionally, engineers may identify production trends thanks to AI-driven predictive analytics, optimize lift systems, and implement predictive maintenance strategies to progress equipment consistency and minimize downtime. By leveraging historical data and operational insights, AI algorithms empower reservoir engineers to make data-driven decisions that progress production efficacy and maximize asset value (Dahmani, 2024). Enhanced Reservoir Monitoring and Surveillance, real-time reservoir monitoring and surveillance are essential components of effective reservoir management, allowing engineers to monitor reservoir performance, detect fluid movements, and identify production anomalies

promptly. Traditional surveillance techniques, although methods like production logging and pressure transient analysis are useful for understanding reservoir behaviour, they might not be scalable or comprehensive (Ugochukwu Ikechukwu Okoli *et al.*, 2024).

AI technologies offer advanced reservoir monitoring solutions that leverage sensor networks, data fusion techniques, and ML algorithms to monitor reservoir dynamics and optimize production operations (Zainuddin *et al.*, 2024). By integrating data from surface sensors, downhole instruments, and remote monitoring systems, AI-driven surveillance platforms can detect reservoir changes, identify flow barriers, and optimize reservoir drainage strategies in real-time (Eche Samuel Okem *et al.*, 2023). Machine learning processes can examine streaming data from multiple sources, detect patterns indicative of reservoir depletion or fluid movement, and generate early warning alerts to prevent potential production disruptions (Kumar *et al.*, 2024). Furthermore, AI-based surveillance systems enable engineers to optimize well interventions, reservoir stimulation treatments, and secondary recovery operations to maximize hydrocarbon recovery while minimizing operational risks (Ugochukwu Ikechukwu Okoli *et al.*, 2024).

Challenges of AI Applications in Reservoir Management

The future of AI in reservoir management is rooted in the creation of scalable, interoperable AI platforms that enable the seamless integration of data, the deployment of models, and the provision of decision support throughout the OGI. By addressing these challenges and embracing a culture of innovation, reservoir engineers can harness the full possible of AI to optimize production, progress recovery, drive sustainable growth in O&G fields worldwide and set future directions in AI for Reservoir Management. The mixture of AI with reservoir management holds immense promise for transforming conventional practices and unlocking new frontiers in resource optimization and operational efficiency. However, the realization of this potential is contingent upon addressing several challenges

and charting a course for future development and adoption. They explore the key challenges facing AI in reservoir management and outline potential avenues for future research and innovation (Oluwatosin Reis *et al.*, 2024)

Data reliability, accuracy and easy accessibility of data presents a significant obstacle to using AI for reservoir management. Reservoir engineers rely on diverse datasets, including geological surveys, well logs, production history, and seismic data, to characterize reservoir properties and predict behaviour accurately (Ganguli, S.S., & Dimri, 2024). However, these datasets are often fragmented, heterogeneous, and subject to various sources of uncertainty and noise. Ensuring data quality and accessibility requires concerted efforts to standardize data formats, improve data integration capabilities, and implement robust data governance frameworks (Ukpoju *et al.*, 2023). Moreover, enhancing data accessibility through cloud-based platforms and data-sharing initiatives can facilitate collaboration and knowledge exchange across the industry.

Interpretability and trustworthiness of AI models are critical considerations in reservoir management, where decisions have significant financial and environmental implications. While AI algorithms demonstrate remarkable predictive capabilities, the opacity of complex models poses challenges in understanding model behavior, validating results, and incorporating domain expertise into decision-making processes (Bouazizi, S., & Ltifi, 2024). Ensuring model's interpretability and trustworthiness requires the development of explainable AI techniques that elucidate the underlying mechanisms driving model predictions. Additionally, establishing standards for model validation, uncertainty quantification, and model transparency can enhance confidence in AI-driven insights and facilitate informed decision-making by reservoir engineers. Scalability and implementation complexity for integrating AI solutions into existing reservoir management workflows poses as key challenges. Reservoir management encompasses a

diverse array of tasks, ranging from reservoir characterization and production optimization to risk assessment and decision support.

Implementing AI solutions requires overcoming technical and organizational barriers, including data integration, infrastructure compatibility, and workforce training. Moreover, scaling AI applications to accommodate large-scale reservoir systems and heterogeneous datasets necessitates robust computational infrastructure and scalable algorithms. Addressing scalability and implementation complexity requires collaborative efforts between industry stakeholders, technology providers, and research institutes to grow interoperable AI platforms, standardized protocols, and user-friendly interfaces tailored to the needs of reservoir engineers (Gloria Siwe Usiagu *et al.*, 2024).

As AI continues to evolve, several avenues for future research and innovation in reservoir management are emerging, including the development of scalable AI platforms. The future of AI in reservoir management lies in creating scalable, interoperable AI platforms that enable seamless model deployment, data integration, and decision support across the oil and gas industry (Waqar, 2024b). These platforms should leverage cloud computing, distributed computing, and advanced analytics to enable real-time data processing, predictive modelling, and optimization at scale (Gloria Siwe Usiagu *et al.*, 2024). Advancement of Explainable AI Techniques, addressing interpretability and trustworthiness of AI models requires continued research and development of explainable.

AI solutions enable reservoir engineers to understand, interpret, and generate model predictions. Reasonable AI methods, including feature importance analysis model visualization and uncertainty quantification, enhances transparency and facilitate collaboration between AI systems and human experts. Integration of multimodal data sources into reservoir management incorporates diverse data modalities, including geological, geophysical, petrophysical, and engineering data. Future research efforts

should focus on integrating multimodal data sources and leveraging advanced data fusion techniques to extract actionable insights and enhance predictive capabilities. By combining heterogeneous data streams, AI systems can provide an inclusive understanding of reservoir behaviour and optimize production strategies effectively (Sharma, R., & Gurung, 2024). Adoption of Autonomous Systems, the convergence of AI, robotics, and automation presents opportunities for the development of autonomous reservoir management systems that can adaptively monitor, analyse, and optimize reservoir operations in real-time. Autonomous systems equipped with AI-driven decision support capabilities can enhance operational efficiency, minimize human intervention, and mitigate risks associated with manual intervention (Gideon Oluseyi Daramola *et al.*, 2024; Rath *et al.*, 2024).

The Importance of Drilling In O&G Industry

Drilling is a fundamental aspect of O&G appraisal and production process. It involves the process of creating boreholes to access subsurface reservoirs containing hydrocarbons. Successful drilling operations are critical for extracting these valuable O&G resources efficiently. However, conventional drilling methods often encounter various challenges, including geological complexities, operational risks, and environmental concerns. Certainly, drilling plays a crucial role in O&G industry for numerous reasons in subsurface reservoirs accessibility as Drilling is the primary method used to access underground reservoirs where O&G deposits are located (Zainuddin *et al.*, 2024). These reservoirs can be positioned thousands of feet below the surface, and drilling provides the means to reach and extract these valuable resources.

By drilling exploratory wells, geologists and engineers can gather crucial data about subsurface geology, reservoir characteristics, and the presence of hydrocarbons. This information is vital for identifying potential O&G reserves. Resource Extraction- once a viable oil or gas reservoir is discovered, drilling is used to extract the hydrocarbons from

the reservoir (Yazdi, 2024). Production wells are drilled to establish pathways for O&G to flow to the surface, where they can be processed and transported. Well Construction, Drilling also involves the construction of wells, which serve as conduits for extracting hydrocarbons from the reservoir. Well, construction includes activities such as cementing, casing installation, and well completion, all of which are critical for ensuring the integrity and efficiency of the well.

Technological Advancements, Drilling technology has advanced significantly over the years, according to the OGI (Xia, 2024). The efficiency and efficacy of drilling operations have increased thanks to innovations including directional drilling, hydraulic fracturing (fracking), and sophisticated drilling fluids enabling access to previously inaccessible reserves and increasing production rates. Economic Impact, Drilling activities contribute significantly to the economy by creating jobs, generating revenue through O&G sales, and supporting related industries such as equipment transportation, manufacturing, and services. Energy Security, O&G remain primary sources of energy globally, and drilling plays a vital role in safeguarding a stable and reliable supply of these resources. Access to domestic O&G reserves through drilling helps reduce dependency on imports and strengthens energy security. Overall, drilling is indispensable to the OGI, serving as the cornerstone of exploration, production, and resource extraction activities (Waqar, 202a). While facing challenges such as geological complexities and environmental concerns, continued advancements in drilling technology and practices are vital for maximizing the efficacy and sustainability of O&G operations.

Traditional Drilling Methods and Challenges

Traditional drilling techniques typically rely on human expertise and manual intervention, leading to limitations in precision, productivity, and safety. Conventional methods involve the use of rotary drilling rigs, drill bits, and drilling fluids to penetrate the

earth's crust and reach target formations. Despite their widespread use, these methods face several challenges as these challenges necessitate the implementation of innovative approaches to improve drilling processes in the O&G industry. Indeed, traditional drilling methods in OGI come with their set of challenges, limited accuracy in wellbore placement, Conventional drilling methods may struggle to precisely place spud points or wellbores in desired locations within the reservoir. This can result in reduced productivity and recovery rates, as well as increased costs associated with corrective measures such as side-tracking or re-drilling.

Traditional drilling operations, often require considerable time, significant cost, and resources to complete. Delays in drilling progress can lead to cost overruns and project delays, impacting the overall profitability of O&G projects (Ukpoju *et al.*, 2023). With possibility of high-risk accidents and environmental hazards, conventional drilling activities pose inherent risks to both personnel and the environment. Accidents such as blowouts, well control issues, and equipment failures can have catastrophic consequences, including loss of life, environmental damage, and costly clean-up efforts. Inefficient utilization of resources, traditional drilling methods may not enhance the utilized of resources such as drilling fluids, casing materials, and energy. Inefficient practices can result in unnecessary waste, increased operational costs, and environmental impacts.

To address these challenges and improve drilling operations, the OGI has been increasingly turning to innovative approaches and technologies. These include Directional Drilling; by controlling the trajectory of the wellbore, directional drilling techniques enable operators to reach multiple reservoir targets from a single drilling location, maximizing resource recovery and minimizing environmental footprint. Automated Drilling Systems, Advanced automation technologies are being employed to enhance drilling precision, efficiency, and safety.

Role of Artificial Intelligence in Smart Drilling

Smart drilling technology can now attain previously unheard levels of advancement, efficiency, and safety- thanks in large part to AI. Massive volumes of data are analysed by AI systems from drilling operations, geological surveys, and equipment sensors to optimize performance and anticipate potential issues. ML algorithms enable predictive maintenance, reducing downtime and enhancing equipment reliability. Moreover, AI-powered models enhance reservoir characterization, facilitating better decision-making throughout the drilling process (Tolulope O Olorunsogo *et al.,* 2024)

Consequently, AI remains a foundation for enhancing smart drilling technologies by improving the efficiency within oil and natural gas industry, implementing safe practices, or increasing the exploitation of valuable resources. Incorporated with systems AI, piles of data garnering from the functioning drilling operations, geological investigation, and equipment sensor outputs are processed in real-time to support decisive making and enhance drilling effectiveness. The first AI function of smart drilling is that it converts the data feeds from downhole sensors, surface equipment and geophysical logs into actionable information on drilling parameters because data is collected in real-time throughout the drilling process (Ugochukwu Ikechukwu Okoli *et al.,* 2024).

ML that controls algorithms based on parameters like drilling fluid, formation, and equipment can make corresponding changes in the drilling process continually, which can maximize efficiency with minimized risk. For instance, in drilling process, it is possible to use AI to fine-tune such factors as heaviness on a bit, rotary speed, and mud flow rate to maximise the drilling performance, and at the same time shun equipment failure or need for repairs. In addition, preventive maintenance of drilling equipment is possible with the help of AI and, as a result, their durability and performance are maintained.

Nowadays, data mining tools work on equipment performance history data to build a model and subsequent predictions of future failure. In line with equipment condition and its usage, the AI-based systems for predictive maintenance enable maintenance activities to be programmed and scheduled ahead of time to ensure minimum downtime, low repair or replacement costs and maximum reliability of equipment. Furthermore, they bring light in geologically modelling the reservoirs and characterizing of the subsurface reservoir attributes (Eche Samuel Okem *et al.*, 2023). Production history, well logs, and seismic data have provided feed to devise the AI algorithms for further determination of accurate reservoir behaviour, fluid flow regime and potential drilling risks. The data also allows operators to make correct decisions on a well site location, drilling techniques, and beneficial production strategies to achieve maximum recoverable reserves and minimize hazards. On the other hand, some AI applications enhance the decision-making process at every stage of drilling gear upkeep and drive operations. Real-time data analysis and other enhanced methods of reservoir simulation allow AI algorithms to model various drilling scenarios analyse the effects of each and determine the most profitable approach to drilling.

This leads operators to be in a position to manage drilling risks and impacts, successfully reduce the influences on the environment and finally increase the number of direct returns on drill ventures. In addition, by incorporating AI, the controlled drilling systems can make decisions about the optimal performance of the drilling conditions without human interference. Machine learning algorithms combined with automation mean that autonomous drilling systems can also gain experience and learn from prior drilling episodes besides diagnosing future potential problems with well construction and enhance drilling over time. This autonomous capability decreases dependence on people's interference, increases operational safety, and improves the rate of drilling. Lastly, AI can be said to be the heart of smart drilling and plays a key role in the further growing of O&G

industry. Operators can use machine learning on parameters such as drilling process dynamics, equipment efficiency and geological conditions to create platforms that can reduce time and costs, whilst increasing reserves recovery making the production of O&G more sustainable in the long run. It is believed that as advancements in AI technology progress this aspect of smart drilling is set to transform the industry and bring out fresh opportunities for the international O&G players (Olusegun Gbenga Odunaiya *et al.*, 2024).

Digital Technologies in the O&G Sector

These days, digital technologies, among other information technology advancements, are classified as DT everywhere we look. Digitalization in O&G sector has the potential to bring about revolutionary change, but some problems must be removed before its full potential for the company and society at large can be realized (Mingaleva, Shironina and Buzmakov, 2021). The truth is that while many of the jobs and activities that are constantly being developed in organisations are digital, they are not transformative. Numerous companies in O&G industry use audio and video conferences to hold crucial meetings and exchange fresh concepts between staff and management. Making the switch from manual to electronic or digital operations in an organisation can be challenging (Gaid *et al.*, 2020).

The continuous advancement of digital technologies is important because it gives industries that use and utilise them a sustained competitive edge. To update planning and operational standards, DT gives O&G companies instruments including sensors, analytical models, and networking of numerous systems (AbuZawayda, Yusof and Aziz, 2013). By utilizing big data, they provide fresh insights into the oilfield to improve decision-making, boost output, and lower operational costs. This might be regarded as DT, which could help the company stay open during the COVID-19 epidemic. For example, during this pandemic, O&G industry has implemented modern technologies to improve operations and

drilling procedures, and it utilizes DT to speed up business procedures through digital systems.

Additionally, it has been handling and organising the data produced by the front-end processes through the use of IT applications. To streamline corporate operations and extract useful insights from the offered data pool, several top companies in O&G industry are currently deploying cutting-edge technologies. The industry understands and embraces the reality that using cutting-edge technology like IoT, AI, and big data analytics results in quicker and more precise decision-making. Using real-time historical data analysis, the O&G industries, midstream, upstream, and downstream operations will be more intricately connected, thanks to the use of sophisticated IT applications researchers. To accomplish work remotely, DT is converting manual procedures into numerical ones and developing new online domains (Bican and Brem, 2020). The COVID-19 epidemic speeded up DT in some industries, notably the O&G industry (Mukred *et al.*, 2019; Fletcher and Griffiths, 2020).

Generally, O&G industry continues to use manual processes even though it has installed numerous data systems and developed DT, which provided a valuable and invaluable answer during the COVID-19 epidemic. O&G companies understand that they need digital technology rather than physical operations to succeed despite the current market challenges. In the end, businesses that have not yet adopted digital implementation across the board cannot afford to take a cautious approach; in today's competitive market, the value that digital tools provide is essential for survival (AbuZawayda, Yusof and Aziz, 2013).

Infrastructures of The Global O&G Industry

There is a dearth of anthropological viewpoints and thorough examinations of digital infrastructures in the current social science literature on O&G development.

O&G infrastructures have been studied extensively via many theoretical perspectives, however, software's function in extractive industries' infrastructures is rarely understood. They need more ethnographic reports on the many software applications used by O&G industry around the world. It is possible to think of infrastructures as man-made networks that enable the movement of commodities, services, people, and ideas across physical space (Larkin, 2013). This study expands upon previous conceptions of O&G infrastructures and sheds light on the emergence of digital labour in this globally integrated sector by examining a fresh case study of a software company providing services to O&G companies.

Infrastructure technologies have been the focus of a plethora of recent research on O&G development, with a focus on various geographical contexts. Many studies have focused on the ins and outs of fracking technology infrastructures, but the present wave of digitisation has not been thoroughly evaluated, and researchers have not conducted many in-depth studies on its effects. Local companies and stakeholders reaped enormous benefits from the large-scale expenditures in local infrastructure that were frequently prompted by oil booms. Transportation infrastructure—including highways, pipelines, trains, and electricity lines—and residential infrastructure—including water systems, houses, and sewage lines—are all impacted socially by O&G extraction process (Haggerty *et al.*, 2018).

Recent studies on the world's O&G infrastructures have also looked at offshore infrastructures, different kinds of expertise, and labour regimes (APPEL, 2012). Szolucha (2018) adds that exploration firms' large-scale energy infrastructures, constructed for shale gas extraction, have the potential to impact future political decisions. For example, studies on oil privatization in Kazakhstan and the Niger Delta have examined the intricate political infrastructures of oil production (Tantua, Devine and Maconachie, 2018). Studies of O&G

development rules at the state level also show how political institutions can be used to reduce environmental and health hazards (Fisk, Good and Nelson, 2017).

Intermediaries are vital in building energy expertise because they supply O&G industry with technologies and services on a worldwide scale (Mason, 2017). Most of the prior work highlights the strong geographic localization of O&G subsectors as well as intermediaries in spatial proximity to actual O&G deposits. For instance, Solheim & Tveterås (2017) elucidated how O&G companies receive knowledge-intensive services from intermediaries located in agglomeration economies. That is when industries are clustered in a geographic region, such firms are inclined to boost productivity and capture more of the value in O&G industry. Nevertheless, this software company ethnography is located at a different pole of the multi-scalar and multiple-material rhythmic assemblages of resource extraction, which complements and supports the corpus of research on the economic geographies of O&G development.

Enhancing Efficiency with AI in O&G Operations

AI is the latest intervention observed in the stochastic environment of O&G industry and has proven to be a nucleus of improved efficiency and disruption of conventional plans. The benefits of AI technologies have been captured in different case studies, examples as well as brainstorming which have demonstrated a clear shift to enhanced predictive maintenance, process optimization, resource utilization as well as real-time big data analysis and decision-making. Numerous industry participants have identified the cardinal technique of analytical maintenance as a definitive method of preventing potential losses due to unplanned outages and ensuring asset dependability, which is significant in oil and natural gas industry.

One example is a big oil refinery on the Gulf Coast that uses artificial intelligence to foresee when equipment may break down by looking at past data (Benedicta Ehimuan

et al., 2024). This meant that through performing routine maintenance and ensuring the identification of future maintenance requirements the refinery ensured that the facility incurred little to no amounts of downtime, thus keeping the asset as efficient as possible. Flows, the use of AI algorithms in process optimization has brought significant changes in operations throughout the O&G value chain. An offshore drilling company applied artificial intelligence to facelift its drilling routines and also diminish costs of drilling exercises. Surviving real-time data, as well as the use of ML algorithms, made it possible to increase effective drilling parameters and reduce costs. This optimization framework extended effectiveness in the form of operating efficiency and safety and environmental excellence as well.

Resource Management, through competent AI resource management techniques, the O&G firms have been in a position to maximize the use of their assets to generate the ultimate output. For instance, an O&G firm that is among the forerunners of the exploration and production methods used AI algorithms to interpret surface data and arrive at successful drilling areas. By displaying rationality in its resource distribution, and utilizing data analysis, the company acquired improved production rates and lower exploration risk rates with better operational conditions.

Dissemination and Discussion on Process Optimization, Predictive Maintenance, and Resource Allocation Predictive Maintenance is the primary method of utilizing machine algorithms to analyse equipment data to anticipate failure. Applying data analysis techniques, the AI system recognizes that equipment degradation over time and as such, can preventively arrange for maintenance to be performed rather than have the equipment break down. Operations optimization, AI algorithms also work in real-time to analyse business data and produce areas of improvement within the operations. This performance optimization is achieved through machine learning where an organization sets certain

parameters and the AI system automatically increases or decreases certain inputs to improve performance, cut out inefficiencies, and increase output.

Resource Allocation, AI resources allocation is the process of deploying resources to achieve many productivities with as little resource use as possible. Market conditions, demand estimates, and other viable limitations within production, circulation, or service delivery channels are captured and fed into the AI algorithms, which then correlate such data to arrive at the ideal allocation of resources evenly across relevant domains in a bid to improve resource utilization. Advantages of real-time data analysis and management facilitated by AI systems Enhanced Process Oversight Real-time data analysis gives O&G firms a peek into operations, which facilitates timely management action.

Real-time monitoring of KPIs by AI systems contributes to the improvement of the operational visibility of organisations and helps the stakeholders react appropriately to the rapidly changing environment and threats. More efficient decisions, AI-based analytics provides decision makers with real-time information drawn from active data feeds. Using AI tools, organizational goals are achieved by maintaining high levels of performance, accurate forecasts, performance predictions, and good scenario analysis to produce highly effective decision-making requirements that lead to effective resource management and organizational improvement. Thus, the utilization of AI technologies in functioning of O&G industry has initiated a new stage of economic performance – effectiveness, flexibility, and competitive advantage.

Future Trends and Opportunities

The disruption that has characterized O&G industry transformation is embracing AI technologies that offers a plethora of prospects. The O&G industry is increasingly embracing artificial intelligence technologies to transform its operations. Key AI technologies gaining prominence include ML, DL, and “natural language processing”

(NLP). These technologies are being applied across various segments of the O&G value chain to optimize operations, improve safety, and increase efficiency. These technologies allow organizations to glean valuable information on large amounts of data such as geological surveys, seismic imaging, and production indices for the improvement of exploration and production procedures. Edge Computing combined with IoT, collection, processing, and analysis of data are quickly transforming O&G industry. Implementing AI algorithms at the edge allows companies to enhance operational efficiency across distributed assets and make proactive decisions through predictive maintenance, real-time analytics, and anomaly detection (such corrosion ingress). Future studies should mainly concentrate on developing AI models that work better in O&G business. To legalize decision-making processes, especially in impervious models such as DL models, it is advised to use model explanation techniques (Andrianandrianina Johanesa, Equeter and Mahmoudi, 2024).

Deep learning models can be useful to collect, analyse, and predict corrosion tendencies and suggest appropriate treatments, such as inhibitors and coating systems (organic or inorganic), to limit corrosion. Consequently, the emphasis in predictive corrosion control is shifting from detecting failures in real-time to forecasting them in real-time. This entails predicting when equipment will break down by analysing past data, present environmental factors, and the current status of the equipment using methods such as "Failure Mode and Effect Analysis" (FMEA).

Considering component connections and increasing defect or service quality important ways to improve the precision of AI applications go beyond focussing on individual quality metrics when making predictions (Andrianandrianina Johanesa, Equeter and Mahmoudi, 2024). The necessity to increase safety, decrease operational costs, and maximise resource utilisation is creating a surge in the use of autonomous systems and

robotics in O&G operations. Drones, UAVs, and autonomous vehicles powered by artificial intelligence are changing the way inspection, monitoring, and maintenance services are provided by allowing businesses to reach out to inaccessible or dangerous areas with little to no human engagement. Possible Future Applications of AI in Reservoir Modelling By examining intricate geological data and production dynamics, AI technology presents possibilities for enhancing the accuracy and predictability of reservoir models. (Chuka Anthony Arinze *et al.*, 2024).

1.2 Research Problem

O&G is a giant digital industry with sophisticated technologies deployed from Oil well head to end-user enabled with cutting edge operations on unmanned Drilling, remote operations, and super computers application to process geological & seismic data. Significant efforts in capturing data and administering the learning to understand the pattern and data behaviour are essential to set up strategies to solve industrial challenges (Kaplan and Haenlein, 2020). The industry demands new skillsets in AI, statistics, big data & machine learning, where decades of yearned knowledge for decision-making are witnessing a shift to faster and better insights with Digital technologies. IOC/NOCs like Saudi Aramco, Shell, BP, and ADNOC have jump-started their AI initiatives by partnering with technology providers. Alike to other industries, O&G faces challenges with massive deployment of AI at this stage of its growth (Bello *et al.*, 2016). Previous studies have shown challenges surrounding shortage of new skill sets, systems for data management and collaborative work environments (Kelly *et al.*, 2019). While deficiency of HR in understanding the technology application in O&G and translating the business requirement to organization needs and people equation is insufficiently explored.

Driven by the fluctuating oil price since 2014, IOC/NOCs are seeking means Sharifi, Ahmadi and Ala (2021) to optimize business operations and improve productivity

while ensuring safety (Koroteev and Tekic, 2021b). Although skill shortage appears consistent with prior research, no study to date has examined how IOC/NOCs are adopting tech-based operating models, defining work management approaches and refining employment models.

1.3 Research Objective

Innovative technologies like “Robotic Process Automation” (RPA), AI, and ML are creating significant potentials across industry for innovation and growth. Advanced algorithms and data sets are gradually replacing routine, repetitive and dangerous tasks while freeing up workers for high-value-added activities. With the adoption of advanced digitalization, technology driven careers will evolve; some jobs will decline, and some will be eliminated. This study analyses how AI will change a significant part of O&G industry in coming decades impacting the organization structure, operating models (Tekic and Koroteev, 2019a), job competencies and manning. The research deep dives to investigate the impact on jobs and job families that will guide IOCs/NOCs to plan workforce of the future.

This research study primarily goals to examine and emphasise effects of AI on O&G industry's future workforce. To achieve the framed goals, this study will analyse the recent scenarios in O&G industry where AI is applied to answer following research questions: a) how future O&G workforce will be shaped in five to ten years in terms of manpower strength, b) new skill sets c) how O&G jobs will be rescoped with activities automation & elimination and potential future jobs. The literature review section will talk about the various studies and review them for the current study (Agwu *et al.*, 2018).

The literature review will discuss the latest trends and new requirements in the sector related to human capital and organization collaboration required for intensive application of AI. The research will further advance understanding of various jobs in

Upstream (Nishant, Kennedy and Corbett, 2020) that have potential for automation and defining skills & capabilities required for the future workforce, discussing the practical and theoretical consequences as well as some important limitations.

The study aims to address key tenets in assessing automation potential of O&G jobs and propose Organization Design (OD) principles for an IOC/NOC to have an agile organization structure to easily deploy AI initiatives for potential business value creation. Along with this, the study also aims for a more systematic and theoretical analysis to understand the impact on jobs and job families in O&G, which is important to plan the future workforce.

1.4 Hypotheses of the study

To assess the sensitivity of automation in O&G jobs through AI, following set of hypotheses was developed based on the literature review discussed above that showed the risk of workforce replacement with machines. Moreover, the perception of work characteristics in creating new job opportunities with digitalization.

The variables "fear of automation" and "perception of opportunities" were selected as indicators across the research and literature.

- **H1:** The more manual the tasks in O&G jobs, the higher the Fear of automation and the lower the Perceived Opportunity.
- **H2:** The higher the level of Education, the lower the Fear of automation and the higher the Perceived Opportunity.
- **H3:** There is a significant correlation between the proportion of manual tasks in a workplace and adaptability to AI.
- **H4:** There is a significant impact of fear of automation on job satisfaction with AI integration.

- **H5:** There is a significant correlation between workplace adaptability to AI and perceived opportunity.
- **H6:** There is a significant impact of job satisfaction with AI integration on the perceived opportunity.
- **H7:** There is a significant impact of workplace adaptability to AI on job satisfaction.

Since not much of research has been conducted on how fear of job loss due to increased degree of automation and perception of new opportunities due to digitalization in building up future workforce, broader ideas were utilised to test these theories. The main reason these variables were identified is because they are expected to be caused by a lack of knowledge about future trends, opportunities, risks, and challenges that digital technologies may bring.

1.5 Significance of the Study

With the widespread digitalization in O&G industry, "International Oil Companies" (IOC) and "National Oil Companies" (NOC) are implementing new digital solutions to benefit across the value chain for productivity gains and cost savings. For the deployment of various digitalization initiatives, O&G industry would require a workforce with new skill sets that can be bolstered with new technologies. IOC/NOCs are attracting employment propositions for data scientists, statisticians, and AI/machine learning specialists who will operate their Digital Oil Field in near future.

This study goals to examine how the future workforce of O&G industry will be transformed by application of AI and other digitalization technologies. The study also aims to assess potential organization optimization and efficiency improvement, where Human Resources (HR) professionals can echo business language to remain significant in the new industry reality.

Though AI's entry into the O&G industry announced the end of petroleum engineering, there is speculation about the job redundancy of petroleum engineers. Nevertheless, automation will enable engineers to better utilize the time on difficult analysis; their job requires a solid grasp of data science and the capacity to recognize and create AI-solvable tasks. Although previous studies address redefined job scope, no research has sufficiently investigated future jobs that would shape O&G industry, leveraging a deep understanding of processes aided with AI knowledge to drive business solutions.

O&G industry experienced a war for talent over the last decade and forced O&G companies to adopt various operating models. Different employment models adopted to address the skillset shortage, to an extent prompted compromise in risk and compliance which led to Texas City and Macondo incidents. A more systematic and theoretical analysis is required for cautiously addressing future jobs, organizational shift to new operating models and employment models which this study will address and this has not been extensively covered in any previous literature. This is essential for industry to not only deliver direct results but also build a meaningful workforce for next generation.

1.6 Research Purpose and Questions

Innovative technologies like RPA, AI and ML are creating significant potentials across industry for innovation and growth. Advanced algorithms and data sets are gradually replacing routine, repetitive and dangerous tasks while freeing up workers for high-value-added activities. With the adoption of advanced digitalization, technology-driven careers will evolve; some jobs will decline, and some will be eliminated. This study analyzes how AI will change a significant part of O&G industry in coming decades impacting the organization structure, operating models job competencies and manning. The research deep

dives to investigate the impact on jobs and job families that will guide IOCs/NOCs to plan workforce of the future.

The primary aim of this research study is to explore and highpoint the influence of AI on the future workforce in O&G industry. To achieve the framed goals, this study will analyze the recent scenarios in O&G industry where AI is applied to answer following research questions: a) how future O&G workforce will be shaped in five to ten years in terms of manpower strength, b) new skill sets c) how O&G jobs will be rescoped with activities automation & elimination and potential future jobs. The literature review section will talk about the various studies and review them for the current study.

The literature review will discuss the recent trends and new requirements in the sector related to human capital and organization collaboration required for intensive application of AI. The research will further advance to understand various jobs in Upstream that have potential for automation and defining skills & capabilities required for the future workforce, discussing the theoretic and practical implications as well as some important limitations.

The study aims to address key tenets in assessing automation potential of O&G jobs and propose Organization Design (OD) principles for an IOC/NOC to have an agile organization structure in-order to easily deploy AI initiatives for potential business value creation. Along with this, the study also aims for a more systematic and theoretical analysis to understand the impact on jobs and job families in O&G, which is important to plan the future workforce.

CHAPTER II:

REVIEW OF LITERATURE

2.1 Background and Context of AI in the Oil & Gas Industry

Li *et al.* (2024) advent of “Artificial General Intelligence” (AGI) is expected to bring about remarkable advancements and efficiencies in the business, which will have a significant influence on the sector. This research delves into the fundamentals of AGI and its revolutionary uses, with a specific emphasis on the upstream industry's progress made possible by LLMs and extensive computer vision systems. AI is already changing O&G industry by improving exploration and drilling methods, decreasing downtime, increasing safety, and optimizing production. Logistical procedures are made easier, maintenance expenses are reduced, repetitive jobs are automated, decision-making is improved, teamwork is fostered, and profitability is amplified through the elimination of errors and the extraction of actionable insights. Even with all these improvements, there are still certain obstacles to overcome when deploying AI technologies. For example, you need experienced experts to operate the technology, and models can only be trained on limited datasets, which limits their adaptability to new situations. New generative AI technologies, such as ChatGPT and "Segment Anything Model" (SAM), signal a period of unprecedented innovation density. These advancements show that domain-knowledge-driven AI and natural language interfaces are taking over, which bodes well for O&G sector because it will provide more accessible and individualized solutions. In this overview, they will look at the many ways AGI could revolutionize the upstream O&G business by solving intricate operational problems with human-level intellect. Along with the potential uses, they covered the challenges of deploying AGI models on a broad scale and the importance of domain-specific knowledge for getting most out of these technologies.

Waqar *et al.* (2023) observes that while building O&G infrastructure is essential for satisfying the world's demand for fossil fuels, it also comes with its fair share of hazards and obstacles, necessitating creative solutions. This study investigates applications of AI for sustainable development in O&G industry, which has recently gained attention as a possible solution to address these difficulties. In this study, they examined research tendencies from 2011–2022, using a SLR. It delves deeply into the ways AI works for O&G infrastructure building. The results show that there has been an uptick in artificial intelligence studies about O&G building projects since 2016, with a total of 115 studies examined to detect new contributions. The uniqueness of this study is in the suggestions it offers for making O&G projects more sustainable, as well as in its thorough evaluation of current research on AI applications in the industry. This study stands out because it delves into the most potential AI uses and approaches that O&G sector may take to promote long-term sustainability.

Aliyu, Mokhtar and Hussin (2022) comments that the operational life cycle of a system now incorporates a plan for integrated health management and diagnostics because of technological advancements. From what we can see, the life cycle is a useful tool for spotting irregularities, dissecting failures, and making predictions using the facts we have at hand. Data models can be built utilizing ML and statistical ideas with the use of condition data and on-site input. Connecting onboard controllers to the data-processing logic is possible after data models have been trained. This enables real-time appraisal and analysis of health. Interestingly, integration might cause O&G businesses to face a lot of problems, thus we'll have to get creative to solve this confusing dilemma. Data classification and feature extraction are two areas where ML has been the subject of intense study due to its promising future applications. It is important to study its use and practicality in pump system health management to see whether it can help make the system more resilient or if

there are any financial benefits to carrying out maintenance, repair and operations (MRO). Some potential fields of application are being considered for this dynamic field of study. The research provides an analysis of recent ML developments in AI-based system health management, with an emphasis on drive applications in the O&G industry. Different algorithms and associated theories are investigated to gain a better grasp of their limitations. The research that was looked at indicates that machine learning could be useful for predicting outcomes and identifying defects. There aren't many problems that keep people from using it, thus it's always being improved. The analysis outlined potential avenues for improvement in light of the detected shortcomings and prospects. This study delves deeper into the regularly used commercial ML technologies for drive defect prognostics and diagnostics, specifically focusing on data types utilized. Reviewing the literature reveals that NN, "Bayesian network" (BN), "support vector machine" (SVM), and hybrid models are the most commonly used algorithms in studies. The importance of picking the right training algorithms is widely acknowledged. Surprisingly, there isn't a one-size-fits-all algorithm or approach; rather, the data type and algorithm's or method's ability to fix the supplied faults determine the solution. With 46% of the total, bearing faults are the most often mentioned issue in studies of pump defect diagnosis and prognosis, with cavitation just behind at 2%. Breakage of the seal is the third most common defect, according to the research. In terms of research, leakage and obstruction are among the least investigated faults. While machine learning approaches rely on vibration and flow data to diagnose pump failures, these variables alone may not be enough to determine the state and properties of the pumps. Numerous datasets have been compiled from a variety of sources, including theoretical considerations, empirical evidence, computational models, and expert judgement. Creating experimental datasets and simulated data has always relied on field

data. Little academic focus has been placed on the data approach as compared to the algorithmic one.

Balushi and Arshad (2023) providing a thorough overview of the OGI's AI research hierarchy using bibliometric and distance-based VOS analysis. Among the many factors that have boosted global economies, the OGI stands out. The energy sector must immediately implement cutting-edge technological solutions to meet the rising need for energy while simultaneously lowering prices, enhancing efficiency, and ensuring worker safety. AI is one such technology that could completely alter OGI. Scopus, an online database, is used for the research as of April 2023. After searching using key terms, 251 papers were found that could be further analyzed with the use of VOS viewer and Herzing's Publish or Perish, which measures and analyses citations. According to the results, with 14 articles published (5.58), Among relevant journals, the one most often cited is the "Journal of Petroleum Science and Engineering" (JPS-E). When it comes to AI research in "Open Geometry Initiative" (OGI), China ranks first. OGI could be revolutionized by AI. As a result, nations that invest heavily in AI research stand to gain economically, as using AI technology can boost efficiency, cut costs, and make spaces safer. The present state of AI research in the OGI is thoroughly examined in this study, which employs bibliometric data and graphical networks.

Koroteev and Tekic (2021) examined is altering O&G business, which is a major component of the energy sector. Since the upstream sector of O&G requires the most capital and has greatest amount of uncertainty, they concentrate on it. The most current developments in AI-based tools are outlined, along with their influence on industry processes to accelerate and de-risk, based on analysis of AI application potential and examination of existing applications. Along with the function and accessibility of data in the segment, they also investigate AI methodologies and algorithms. They go on to address

the primary non-technical problems of the widespread use of AI and O&G sector, which includes issues with data, personnel, and novel forms of cooperation. Additionally, three potential future developments of artificial intelligence and how they might alter O&G sector are described (in 5, 10, and 20 years).

Li et al. (2021) AI has recently regained its position at the forefront of research across all disciplines, and the notable increase in AI-based initiatives has shown that it has the potential to be a future direction for almost every subject. An increasing number of academics are showing interest in AI technology, which is undeniably a bright future for O&G industry. To gain a better understanding of AI's role in oilfield development and its potential future trajectory in O&G industry, this study combed through the literature on various AI-based reports. Considering the findings, they have compared the pros and cons of existing AI algorithms and focused on how AI can solve important problems in oilfield development, including optimizing development plans, detecting fractures, improving oil recovery, and predicting oilfield production dynamics. The current state of AI applications in oilfield development is determined, and recommendations are offered in light of the discussion and analysis.

Since the beginning of Industry 4.0 development two years ago, O&G4.0 has also been prioritized. O&G 4.0 has the potential to revolutionize O&G industry, according to some experts and businesses, Lu et al. (2019). This might have far-reaching advantages, such as speeding up the industry's digitalization and intelligence roll outs. But O&G 4.0 has only just begun. Consequently, the idea and fundamental technologies of O&G4.0, including IoT and big data, are methodically presented in this study. Also, using examples such as intelligent oilfields, pipelines, and refineries, this study examines common midstream, upstream, and downstream application scenarios in O&G industry. A data-driven intelligence system built on highly digital infrastructure is, ultimately, what

"O&G4.0" is all about. As far as we are aware, this is the first academic study to be peer-reviewed on topic of O&G 4.0 period. The goal is to help more people working in O&G business comprehend the advantages and potential uses of this technology so that they may include it in future practical engineering projects. Also included in the study's discussion section are potential benefits and drawbacks of O&G 4.0 period. At last, they offered some pertinent policy suggestions.

Sircar et al. (2021) observes that O&G industry is dealing with some problems associated with data processing and handling. A myriad of methods and procedures resulted in the creation of massive data banks. There must be a thorough technical evaluation of this database to boost the efficiency of the gas and oil sectors. Addressing challenges faced by O&G sector, this study offers a thorough valuation of present state-of-the-art around AI and ML. It goes on to describe the numerous AI and ML approaches that can be employed to analyze and process data in various upstream O&G businesses. Results and advancements in ML and AI point to improved numerical calculation efficiency and larger data storage capacities. This report presents a synopsis of past research on benefits and drawbacks of utilizing ML and AI in upstream and downstream O&G industries. Given the presence of such an inclusive intelligent system, the maintenance cost and risk element might be completely eradicated. Developments and advancements made possible by these new technologies have grown intelligent, simplifying and streamlining the judicial process. This research is helpful for users interested in learning about the efficacy of various ML techniques for usage in O&G industry.

Ferreira, Segura and Fucs (2019) concept of AI personal assistants has gained a lot of attention in recent years. Systems like Google Assistant, Cortana from Microsoft, Siri from Apple, and Alexa from Amazon are quickly maturing into intelligent AI helpers for everyday consumers. Outside of a few accidents, such helpers have a track record of

helping people with their daily responsibilities. When it comes to industry-specific circumstances, AI assistants are still a gamble. Organizations can gain a competitive edge by integrating AI with human knowledge and experience. Companies whose strategic decisions are dependent on the actions of knowledge workers will find this to be of paramount importance. The rise of AI assistants is reshaping human-computer interaction landscape. However, how far should an AI assistant impede the work of a knowledge worker? Results from a case study using an O&G corporation and the Wizard of Oz technique are presented in this research. The results provide some insight into the question of how much interference domain-specific knowledge workers are willing to tolerate from AI assistants.

Oluseyi Daramola et al. (2024), in the research looks at how seismic imaging and data analysis tools powered by AI have come a long way, to make O&G development more efficient. They investigate some AI methods and ML models that have been used to extraordinarily accurately analyze seismic data, forecast subsurface structures, and locate possible oil sources. In addition, they go over how to handle massive amounts of seismic data utilizing HPC and big data analytics, which will allow exploration projects to make quick decisions. Drawing on real-world examples and data, they show how the O&G sector may reap the rewards and face the risks of using AI to power seismic imaging and data processing. In conclusion, this study highlights how AI technology may revolutionize exploration procedures, increasing finding of resources while decreasing operational costs and dangers. The application of AI approaches has become a game-changer in the quest to optimize O&G exploration. This study goals to improve exploration efficiency by exploring the recent state of AI seismic imaging and data analysis methods. The utilized of AI algorithms and ML models has greatly improved quality of seismic data interpretation. This has allowed for more precise identification of possible

hydrocarbon resources and the prediction of subsurface structures. In addition, exploratory decision-making is accelerated through the processing of massive seismic datasets made possible by the complementary utilized of big data analytics and high-performance computers. This study synthesizes case studies and empirical information to shed light on real pros and cons of using AI in O&G industry. AI seismic imaging and data processing have the potential to transform O&G exploration industry by reducing risks, improving workflows, and cutting operational costs. This could lead to the finding of sustainable resources in the changing energy paradigm.

Alebri (2022) study's overarching aim is to learn how workers perceive the growing interest in AI by their government and how they anticipate this trend to affect their professional futures. According to the literature, further study is needed to determine whether organizations or states are helping workers prepare for the possibility that robotic technology based on AI data analysis could render them jobless. In today's modern workplace, artificial intelligence is increasing to the top of the list of trends. While there are many positive aspects to this technology, there are also some negative aspects, such as the possibility that workers may be out of work in 10 years due to robotic automation or machines that can do the same tasks as humans with little to no human intervention. This study intended to learn how people are preparing for the future because AI-based robotic technology may threaten to devalue particular occupations. Many workers are thinking about taking classes to improve their performance on the job, according to this study's results. Furthermore, they intend to enroll in additional training programs to not only safeguard themselves against potential unemployment following the societal application of AI but also to stay abreast of the changes occurring in the world around them as they pertain to AI. There is always hope for those who desire it, even though the proportion is not very great.

Fataliyev and Mehdiyev (2020) Many cutting-edge technologies are intrinsic to Industry 4.0, including robotics, AI, IoT, cyber-physical systems, and others. These innovations allowed for realization of completely automated digital production, where intelligent algorithms managed the process in real time while maintaining constant interaction through the Internet. By digitally controlling all processes, they transformed factory's manufacturing system into an intelligent network that makes better utilized of both financial and material resources. Concurrently, data privacy concerns, especially about "personally identifiable information" (PII), have emerged as a top priority in Industry 4.0 due to the dramatic growth in data volumes. Some groups of people have made it their mission to find illegal ways to use people's personal information to get what they want. There has been a marked improvement in the security of personal data handled by video surveillance systems as video surveillance data is intrinsic to personal data. The video surveillance system consists of several components, such as cameras, analytics, data transmission lines, processing devices, and storage for personal information. In O&G industry, the suggested model is part of a larger smart video surveillance system that also includes transportation, smart field, maintenance, grid, security, etc. Tasks involving abstract ideas are examined and solutions are suggested.

According to Devold and Fjellheim (2019), several factors motivate the use of unmanned or remotely operated facilities, including inaccessible sites, potential dangers, and financial constraints. Now that we have data from remote operating facilities, they can move forward with the goal of fully autonomous plants that don't need human intervention. This study will examine the factors and technical advancements that have made this feasible economically and safely, with a focus on how AI plays a pivotal role, drawing on both external sources and client case studies. This study lays forth the groundwork for autonomous operations by outlining the essential criteria and technology required. Process

safety management is very important for businesses to make sure their operations are risk-free. Automatic controls for starting, change, and shutdown are also required so that operations can be executed even when they are not physically present. Because of the complexity and interdependence of modern processes, it is essential to conduct inspections and maintenance without human intervention and to use predictive analytics and plant-wide condition monitoring rather than relying just on tracking important equipment. When humans aren't available, like when operating pipeline scrapers, it's necessary to use robots and drones. Zero operators are very important. Factoring in the necessity to cover rest, vacation, and sick leave, as well as support activities like catering and cleaning, even just one employee translates to a total of twenty people needed to keep a site functioning all day, every day. Not only is this costly, but it also keeps a lot of people in a potentially dangerous workplace. The aforementioned is supported by technologies that enable the IoT to detect, quantify, and regulate operations; connectivity to promptly share the data; analytics to process the data, heavily utilizing AI; and suitable dashboards to deliver the data to the distant operator, subject matter expert, or vendor associate. Also covered will be the role that digital twins and digital engineering play in making these kinds of endeavors possible. Their results demonstrate the necessity for revised protocols for operations, safety, and maintenance to introduce autonomous unmanned operations. To accomplish this, we need AI that makes use of machine learning. In this article, we'll look at several real-world applications of the trend towards unmanned operations. They will showcase the cost-saving and safety-enhancing advantages of pilots and technology's broader field applications. By lowering maintenance spending, increasing availability, and doing away with operator mistakes, many of the technological and operational changes will bring about cost savings on their own.

Brekke (2020) observes that the Norwegian oil industry has undergone a revaluation because of its recent decline. A fresh wave of invention sprang from this chaos. Through semi-structured qualitative interviews, this study employs a qualitative methodology to explore innovative impacts that ML technology has had on the "Norwegian O&G industry" (NOGI). Five distinct viewpoints within the industry are the subject of these interviews. The distinct interaction between private and public players on the "Norwegian continental shelf" (NCS) is reflected in these viewpoints. The interviews include topics such as the importance of big data, application of ML to optimize abstraction procedures, and development of more environmentally friendly methods for O&G detection. The analysis's five views are presented and then parallels and divergences are examined about the part the actors—that is, the businesses—play in the NCS. Even though most businesses are creating comparable applications of machine learning, interviewees conveyed both their excitement and reluctance to embrace new technology to gain a competitive edge. Background data gathered from online searches and analyses is used throughout the research to put the interview data in context. The results show that there are ways to do what the NOGI is doing using ML that are safer, cheaper, and more sustainable. Information, sophisticated analytics, and different kinds of ML also provide up possibilities to rethink the physical location and method of doing work. The report demonstrates how ML has improved competitive advantages by bringing disruptive innovation to the NOGI.

Abdalla (2024) digitalization and automation technologies are causing a major upheaval in O&G sector. This study investigates how drilling and finishing procedures in O&G wells are affected by automation and digitization. The planning, drilling, and completion of wells have been completely transformed by the incorporation of cutting-edge technology including robotics, robot learning, and artificial intelligence. Because digitalization has made it likely to acquire, analyze, and visualize data in real-time,

operators can now make well-informed decisions and streamline the drilling and completion procedures. Automated systems, such as remotely operated machinery and robotic drilling, have improved operational effectiveness, safety, and economy. The paper talks about using digital twin models for virtual well planning and simulation, as well as smart completion technologies and autonomous drilling systems. The report also discusses the benefits and problems brought about by automation and digitization, including workforce reskilling, data security, and the necessity of industry-wide cooperation. It highlights the potential for integrating automation and digitization into O&G wells to improve reservoir management, lower environmental impact, and improve well performance.

Alotaibi, Hajri and Rashidi (2023) To optimize IT infrastructure dependability through secure and safe support of operations and maintenance to maximize resources, intelligent information technology infrastructure is seen as an enabler to improve digital transformation in O&G sectors. O&G firms can improve their performance and profitability by assuring business continuity with communication rooms, smart IT buildings, and shelters that use intelligent technologies. By demonstrating the beneficial effects on development elements like maintenance, operations, security, safety, and resource optimization, this study explains the benefits of using intelligent IT infrastructure in O&G business. On top of that, it gives solutions to the problems that arise when offering smart IT services to a remote area.

Deif and Vivek (2022) The project's research group is putting its hopes on the ups and downs of AI applications in the mining and petroleum industries. Examining the supply chain for O&G from upstream to downstream, this study uses a location-based approach to examine the pros and cons of various AI systems. To summarize the findings in these areas, a literature review method is used. A descriptive and comparative analysis of the

evaluated literature followed. Analyses performed provided useful information regarding the dynamics of AI deployment in O&G sector. Additionally, to guarantee effective deployment of AI, some suggestions were detailed for O&G business executives, practitioners, legislators, and IT managers.

2.2 AI and Digital Transformation in Oil & Gas Sector

Padmanabhan, Jayasangar and Gamage (2023) A mountain of data has been amassed by O&G sector over many years. The industry's continued viability depends on the efficient management of this massive amount of data, which is now referred to as big data. Improving connectivity and optimizing system procedures are only two of the numerous advantages that digital transformation offers. Right now, O&G business may benefit from digitization since it would speed up the process of finding answers and give value to all parties involved. Some obstacles have been recognized, such as the potential for digitalization's advantages to go unnoticed by individuals who truly require them and the growing danger of data breaches. The business world and the public can both profit from the suggestions that have been made. A solid partnership between O&G business, technology solution provider and decision-makers are necessary for the successful deployment of digital transformation.

Brock and von Wangenheim (2019) AI has recently seen a renaissance in the eyes of both academics and business leaders. Some see AI, propelled by public interest and technical developments, as a revolutionary technology with the ability to change humanity. However, there is still a lack of concrete guidance for managers on how to implement AI into their company's operations. Case studies and two worldwide polls of senior managers from various industries provide the data for this study, which demonstrates how digital transformation programs at most companies incorporate AI and other advanced digital technology. Demystifying some of the revolutionary claims made about AI, the digital

transformation projects that utilize AI mostly serve to assist organizations' existing businesses. Next, the research lays out a plan for digital transformation AI implementation, with details on how to handle data, intelligence, grounding, integration, teamwork, agility, and leadership.

Feroz, Zo and Chiravuri (2021) Advances in digital technologies like AI, CC, big data analytics, and IoT have sparked enormous changes in industry, society, and organizations. This phenomenon is known as digital transformation. Research mapping digital transition in the field of environmental sustainability is currently lacking. Utilizing by showing a thorough literature analysis, the effects of digital transformation on the environmental sustainability area are highlighted in this research. Pollution management, sustainable production, sustainable cities, and waste control are the four main areas that will undergo alterations according to findings. Each important area's transformations are further subdivided. Regarding organizational capacities, performance, and digital transformation strategy as they pertain to environmental sustainability, this study suggests a course of future research.

Llopis-Albert, Rubio and Valero (2021) introduction of cutting-edge digital technology has disrupted the automotive sector and its long-standing business practices. New opportunities in Industry 4.0 are popping up, therefore companies need to adapt. To predict how digital transformation will affect company performance models and the happiness of various stakeholders, this research used "fuzzy-set qualitative comparative analysis" (FSQCA). There are a lot of people and things that have come up because of the automotive sector going digital. The research touches on several topics, such as linked and autonomous vehicles, mobility as a service, big data, digital resources for purchasing automobiles, etc. More stringent environmental laws addressing environment change and requiring the exploration of renewable energy sources to power electric vehicles which in

turn increases the disruptive effect of the slow but steady market introduction of electric automobiles. However, the research looks at how digital transformation has affected the car sector from several angles, including those of governments, consumers, service providers, public transportation providers, and producers of automobiles and related products. An empirical analysis based on a complex case study has been effectively conducted using the methodology. In it, we see a fresh take on digital transformation in Spain's car sector using fsQCA. Manufacturers will ultimately benefit from increased profitability, productivity, and competitiveness as a result of investing in sufficient measures for addition to digital transformation, as shown in the results. More and better services will be available to consumers, and they will be more satisfied with the services they get.

Haouel and Nemeslaki (2023) O&G industry can gain from digital technology in three ways: more hydrocarbon recovery, safer ecosystems, and more reliable operations. This research looks at the digital transformation trends in O&G supply chain and the projects undertaken by Equinor, a petroleum refining corporation based in Norway. Finding out where O&G industry stands in terms of digital strategy and what possibilities there are for digitalization is the primary goal. According to the results, the biggest companies in the sector should keep investing into their collaborative ecosystem, which consists of partnerships with suppliers and startups and a shared platform for easy data sharing that can boost their economic standing. A digital strategy roadmap, similar to that of Equinor, should be developed by them without delay. Equally crucial is the maintenance of R&D investments and the recruitment of competent specialists to encourage technological advancement and widespread use. To be able to safeguard the organization from future cyberattacks or other hazards, it is crucial to enhance employees' digital abilities and cultivate a digital culture company-wide. Market dynamics (including supply,

demand, and investment) and the management of energy networks will undergo worldwide transformations with the effective deployment of a digital solution.

D’Almeida et al. (2022) Some companies have found new ways to generate value through the utilization of digital and AI technology, which has led to the emergence of new business models and prospects, collectively referred to as Industry 4.0. Following in footsteps of other industries, the oil business has begun to use digitization to address a variety of issues. This study demonstrates practical uses of digital transformation to address issues in oil well drilling and production operations, backed by substantial research in the specialized literature. Hydrate formation and clogged pipes were the primary topics of the research. The results prove that data generated by control systems and the many sensors employed in drilling and oil well lifecycle operations can be leveraged to provide chances for computational and AI approaches. Smart equipment, real-time monitoring, and smart surveillance systems are all part of the new technology that comes with digital transformation. To prevent or lessen issues or accidents that can cause expenses or, in the worst-case scenario, the well's loss, these innovations are linked to fault detection and prediction systems in a good oil setting. Additionally, the study highlights the growing collaboration between universities, research centers, and the oil industry to comprehend and conquer the obstacles linked to the introduction and expanded utilization of digital transformation technologies.

Su, Yao and Liu (2022) Enterprises' strategic resources are increasingly preoccupied with data. Through the use of IoT devices, backed by Blockchain technology—which possesses qualities of immutability and trustworthiness in distributed storage—O&G businesses can access vast quantities of diverse data. Therefore, intelligent applications of Big Data and AI will make prudent use of trustworthy data. Through its worldwide mutual trust protocol, Blockchain technology connects IoT, big data analysis,

and AI implementation; it facilitates the efficient coordination of many parties' activities and, in the end, breaks down information islands. Sharing data cannot occur without first establishing data governance. Data Sharing is an essential project that improves data governance skills in digital transformation and encourages top-notch growth in O&G sector. It breaks down data islands and business barriers. Examining the Data Governance capacities of O&G companies, this study examines the present state and issues of Data Governance through the lens of digital transformation. In addition, as a whole, the Data Governance system in O&G sector is going to be enhanced by implementing a plan to use Blockchain technology.

Ghosh, Zailani and Sum (2023) Several fields have found effective solutions to their challenges by utilizing ML, a form of AI. There is a lot of room for growing and investment in the energy, O&G industries. First, operating costs are reduced. Second, efficiency is improved. Third, cycle period is reduced. Fourth, the knowledge and expertise of experienced people are replaced. Fifth, the information gap in the organization is filled. The use of AI can greatly simplify some upstream and downstream operations in O&G industry. Streamlining and improving scheduling, upkeep, and product delivery would be the main advantages. The use of AI to identify and prevent corrosion in refinery operations is also gaining traction.

Dazok Donald Jambol et al. (2024) Managing equipment maintenance is a major challenge for O&G sector because their assets are complicated and vital. Inefficient and reactive traditional maintenance methods cause expensive downtime and security hazards. The advent of AI and predictive maintenance technology, however, provides a game-changing answer to these problems. The potential of AI to revolutionize O&G equipment management is investigated in this study. By analyzing equipment data and applying ML algorithms, AI-driven predictive maintenance may anticipate when a repair is needed,

preventing breakdowns. The use of AI in real-time equipment monitoring allows operators to proactively address possible faults by spotting them early. Overall equipment reliability and safety are enhanced, maintenance costs are reduced, and downtime is minimized using this strategy. Data collecting, analysis, and integration with current maintenance processes are all essential components of an all-encompassing plan for implementing AI-driven predictive maintenance. Increased equipment uptime, greater operational efficiency, and extended asset lifespan are just a few of the many benefits that O&G firms may reap from successfully implementing AI-driven predictive maintenance. This study examines the present state of O&G equipment management, drawing attention to the shortcomings of reactive maintenance methods and the necessity of proactive strategies. The article continues by outlining the concepts and advantages of AI-driven predictive maintenance and providing case studies of its effective application. The report concludes with suggestions for O&G firms wishing to revamp their equipment management procedures and a discussion of the factors to think about when deploying AI-driven predictive maintenance.

Ritter (2019) An examination of the process by which a small Norwegian company supplying digital services to the international O&G sector shaped its competence is presented in this article. After the oil price collapse in 2014, the focus switched to building business intelligence tools for O&G companies rather than consulting reports regarding the dependability of resource extraction operations. Their goal is to use information gathered from ethnographic fieldwork to determine how knowledge practices change within the intermediary. According to the study, the firm's salespeople and consultants were tasked with developing innovative methods of mediating interactions between staff and clients through interfaces. According to their claims, the studied company was able to make the

shift to software development because its internal expert groups were able to effectively share information about the product.

Trevathan, Rhodes and Rubin (2020) Opportunities for organizations to revamp their business capacities in preparation for future sustainability arise as a result of major digital advances. Adopting new platforms offered by disruptive technologies requires organizations to build an agile business culture, create and develop new competencies, and adapt or retire existing business models. For businesses, losing touch with changing digital initiatives is the surest path to falling behind the competition or perhaps becoming obsolete. Implementing and overseeing game-changing digital solutions might appear daunting, but the alternative is even more perilous. In an industry where change is notoriously tough, O&G companies, potential benefits of incorporating digital technology. The success of digital projects that have been implemented depends on investing in the correct technologies that match the organization's size, core skills, and culture. This study presents case studies that examine digital investment portfolios in O&G industry. The purpose of these evaluations is to assess the magnitude of the investments, the capabilities of the portfolios, and something of value that has come out of the incorporation of digital processes into both design and operations. Using a systems perspective, the study examined the pros and cons of digital integration in three areas, with a special emphasis on O&G drilling and completion operations: data value chains and workflows; data architecture standardization; and complete lifecycle integration. For a digital investment portfolio to thrive in this dynamic industry, a business strategy roadmap was also developed to provide chances for realization of value.

Hanga and Kovalchuk (2019) There have always been difficulties and obstacles in O&G industry. Countless procedures and parties are involved, and they all produce massive amounts of data. The decentralized and worldwide structure of the company makes

handling and analyzing this data a monumental undertaking. There are a lot of things that need to be taken care of, including coordinating various data sources, owners, and formats; making sure that data streams are validated, encrypted, and monitored as they travel through the intricate business process pipeline; and using data to gain insights that can improve company efficiency, plan maintenance, and avoid fraud and theft. Many fields, including the OGI, have recently come to embrace AI and ML as viable alternatives to human workers for more complicated jobs. Also, distributed systems are met by "multi-agent systems" (MAS), a branch of spread AI, and MAS has found successful applications in many different arenas. Numerous studies have examined how OGI may reap the benefits of ML and MAS in areas such as SCM, operational efficiency, and handling of production and maintenance tasks. Although MAS has performed well in simulated settings, they have not yet achieved the anticipated level of adoption among O&G firms. This is because ML has only been implemented for one-off assignments. Unlocking the full potential of ML and MAS and promoting their wider adoption in OGI requires additional study in the respective domains. Notably, there are numerous advantages to the industry's future growth that can be achieved by integrating ML into MAS. To help make ML and MAS more widely used in OGI, this study will compile all the work done so far on these topics, figure out why they haven't been adopted yet, and offer solutions.

Choubey and Karmakar (2021) produced by the O&G industry's many operational procedures. The O&G industry is now very concerned about the recording and appropriate use of this data. Quick and accurate judgements can be made with the use of predictive and inferential data analytics. The O&G business is increasingly relying on data analytics for decision-making, despite numerous obstacles. The aforementioned field of study has accomplished a considerable degree of progress. Thanks to advancements in AI and ML, once intractable issues may now have simple solutions. Data collected from gas and oil

wells can be combined with historical data to increase production. To make data-driven decisions, O&G industry is increasingly utilizing a variety of analytical modelling approaches. From the early stages of crude oil exploration to the final delivery of its products, this study covers the latest advancements in efficiently utilizing the data gathered through the applications of AI and ML approaches. Additionally, they touch on O&G industry's plans and the extent to which these practices have been adopted. The current study has the potential to lay out a technical framework for selecting appropriate technologies that can efficiently extract useful information from the vast amounts of data produced by O&G sector.

Zeynalli, Butdayev and Salmanov (2019) An organization's whole suite of operations, from process automation to execution and control, are impacted by digital transformation, which is a massive business change. That has an immediate influence on the enterprise's infrastructure as well as the operational model reform. This study research into the latest digital transformation trends in the business and examines the actions of SOCAR AQS in this region. The impetus behind digital transformation in O&G industry has been building in recent years. Leaders in O&G sector have been using digital innovations and advancements since the 1980s. Several ways of thinking about digital transformation are considered in the research. The end product of an effective digital transformation is not a brand-new company, but rather a reorganization of the current valued assets. Digital transformation encompasses both technical advancements and shifts in the responsibilities of upper-level management. Offering practical examples and insights into the digital transformation journey. The report delves into various case studies to gain insight into how top firms are embracing digital transformation to improve their operations and attain better productivity, efficiency, and cost optimization. Businesses in O&G industry are now able to make money through digital transformation, cutting costs even

further. In contrast to consumer markets where companies like Uber and Airbnb have achieved phenomenal success without owning any assets and have instead built an ecosystem to help consumers discover what they need, the industry as a whole has yet to settle on a single, definitive model or strategy. Because of the intense rivalry between companies in O&G industry and others, this is a delicate subject in the industrial sector in general. But the industry will be reshaped for the next generation by whichever industrial enterprises succeed in combining AI, big data, and cloud computing to their advantage.

Samylovskaya et al. (2022) examine the present and future of digital technology adoption in the Russian Arctic O&G mining sector. Using a worldwide perspective, the study's authors examined how the O&G mining industry is embracing digital technologies. Additionally, they looked at the track records of Russian enterprises in this field. In the realm of digitization, the most important tendencies and potential future developments in extraction of O&G resources in the Russian Arctic were recognized. Along with this, the researchers watched O&G industry's competition with RES and thought about the possibilities of digital technology entering the business. Consequently, the writers have reached the following verdicts: (1) The use of digital tools in Russian enterprises is expanding into more and more areas of enterprise administration. Educating the effectiveness of business process management is the primary goal of digitalization in Russia's O&G sector. However, digitalization is hindered by a shortage of trained workers, an inadequate material and technical base, and a worsening of cyber-security risks. (3) The introduction of additional sanctions has the potential to spur significant enhancements in Russian software development and execution, but it also has the potential to increase the cost of Arctic projects, making them unfeasible to develop. (4) The COVID-19 epidemic has prompted digital communications advancements and the extensive automation of O&G industry business processes and output. Fifthly, among Russian O&G firms, "Gazprom

Neft" PJSC and "NK Rosneft" PJSC are at top of the digital technology development industry. (6) When it comes to digitalization, "Gazprom" PJSC is still behind the curve, but in 2022, they should see some significant improvements. (7) Factors affecting the digitalization of the Arctic region's industries include the region's heavy reliance on foreign software and technological solutions, the nature of Russia's O&G sector as a whole, the challenge of ensuring cybersecurity in Arctic O&G projects, and the frequency and severity of power outages. Although hydrocarbon energy will continue to rule the market for the time being, (8) using RES as the primary source of power in Arctic regions is the best and most promising option.

Dudnik et al. (2021) evidence of the merits of "open innovation" (OI) as a strategy for preparing the energy sector to adopt AI technologies. The purpose of this empirical study was to associate energy businesses in Russia and France to ascertain OI's degree of preparedness for the deployment of AI technology. Organizational AI readiness indicators were empirically derived using Student's t-test, the fuzzy sets method, and the Fibonacci sequence. Employing fuzzy sets and variance expression, these important parameters were factored into the integrated readiness indicator for enterprises to use AI. As compared to businesses in developed markets, where the cost of AI technology is a deciding factor, Russian companies are not yet ready to deploy AI. Utilizing OI and introducing AI technologies have complementary impacts, as demonstrated by the groundbreaking "Energy-as-a-Service" business model. The uniqueness of this study lies in its intention to add to the ongoing discussion in the literature by providing evidence that energy businesses that have previously advocated for open innovation in their operations are better equipped to incorporate AI into their operations.

Wanasinghe et al. (2021) include potential health and safety hazards, to working at an O&G plant. This includes facilities for production, processing, storage, and drilling rigs.

The utilization of cutting-edge digital technology, such as wearable or mobile devices, robotic drones, extended reality technologies, smart sensors, cloud computing, and big data analytics, may help O&G professionals overcome some of their obstacles. The O&G sector is not unfamiliar with these technologies, but the majority of its current digital transformation projects are process- or business-centric. In these types of initiatives, increasing revenue, efficiency, and production is the primary goal of implementing new technologies. That means they might ignore the problems that employees are experiencing. Addressing the issues faced by O&G workers is critical, as they are among the industry's essential assets. To help O&G sector use current digital technology to improve working conditions, health, and safety of their employees, this study suggests a human-centric digital transformational framework. The study presents an overview of the critical difficulties encountered by oilfield workers, a system architecture for implementing a digital transformation focused on people, the opportunities presented by this architecture, and a summary of the main obstacles to this framework.

Hajizadeh, (2019) The O&G industry has recently adopted digitalization of workflows as a means to increase corporate value through the application of advanced analytics and ML. Businesses are eager to adopt these new technologies but often run into problems when trying to implement their models, provide customers with real outcomes, and earn a good return on investment. This research provides a SWOT analysis for technology enablement and strategic management in addition to reviewing some of the latest trends and advances in the field. The O&G industry needs to take advantage of new technologies, maintain a steady focus on strategy, and put together teams of data scientists and domain experts who are both nimble and collaborative if they want to use ML to its full potential in mission-critical jobs.

2.3 Impact of AI on Workforce Structure

Johnson et al. (2021) used bibliometric analysis on data collected from job advertisements to discover "Big Data and Artificial intelligence" (BD&AI) gaps, workforce trends, and opportunities. To conduct bibliometric research and create word cooccurrence diagrams, the study team first used BD&AI-related articles that were published in high-influence journals. This allowed them to identify fields of industry that are being affected by technological advances. After compiling data from job ads, the team outlined the necessary skill sets for success in BD&AI-driven businesses. To close the knowledge gap between businesses and schools, the research team assessed the BD&AI programs offered by different schools and performed a SWOT analysis. For enterprises to obtain a competitive edge through the application of BD&AI, this multi-step study approach predicts upcoming technology changes in different industry clusters, and skills that are now needed by workers, and offers suggestions for a roadmap for workforce development.

Theben *et al.* (2023) Already, the widespread adoption of AI is reshaping traditional job roles. The potential for greater output, streamlined operations, and a competitive edge are the primary drivers of artificial intelligence adoption. A source of long-term competitive advantage and a major factor in driving performance is employee engagement. Few studies have studied the connection between AI adoption and employee engagement, and what little research there is suggests a possible inverse association. This study examines how the three facets of employee engagement—commitment, vigor, and absorption—relate to the adoption of AI and the influence of work complexity. It also looks at how training provision mediates this relationship. They evaluated their hypothesis using structural equation modelling on 211 employees who thought AI was strategically significant for their companies. Consistent with earlier findings, this study confirms that implementing AI reduces employee engagement.

Gabriel et al. (2022) Several AI-based solutions hold enormous promise for corporations in terms of revenue growth. For the design, though, the technical system alone is insufficient. In its place, the socio-technical system approach must be considered throughout the whole design process of the workflow system. A synergy between human and AI capabilities is thus made possible. The researcher of this work offers a method that modifies the HTO analysis to elicit sociotechnical requirements during the design phase of AI-based systems. The development of a mission statement is the initial step. Data and systems that are already in place are documented using a thorough process model. Surveys and interviews ensure that all pertinent stakeholder groups are considered. A whole set of requirements can be derived using the approach. An illustration from the realm of industry is development of an intelligent workforce planning system is used to illustrate implementation of the technique.

Kansu (2019) Researchers have been convinced that automated technologies that do not require human interaction could revolutionize several jobs in the economy due to recent advancements in ML. Finding out where and how ML will impact the workforce is the primary aim of this research. Expanding on their summary figures, this article delves more into the areas of the economy that are anticipated to be most affected by ML. To better manage labor mobility and allocation of human resources in light of forthcoming technology changes, this article proposes a policy model that combines data on technical appropriateness with labor market statistics.

Edward Felten, Manav Raj (2019) Despite AI's potential to boost the economy, many are worried it could eventually supplant human workers. They developed a novel metric they named the “AI Occupational Influence” (AIOI) to study the connection between AI and workforce. Improvements in particular AI applications, such as picture identification, translation, or strategic game playing, are connected to skills and jobs

through the AIOI metric. Researchers examine the correlation between AI and salary, employment, and polarization in the labor market using this metric. They prove that generally speaking, jobs affected by AI see a little but beneficial shift in earnings while seeing no shift in employment. There is a substantial positive link between higher-income occupations and our measure of AI effect, as well as employment and salaries. This suggests that occupations with higher software skill needs are the primary drivers of the positive correlation with wages. The results indicate that the availability of supplementary knowledge and tools could be crucial in predicting AI's effect and that the technology could worsen existing divisions in the labor market.

Pereira et al. (2023) When it comes to HRM, AI has the potential to deliver both benefits and drawbacks. Academics have been looking at how AI affects workplace outcomes more closely for the last 20 years, but there hasn't been an inclusive literature assessment of all this research. This literature analysis is necessary for two reasons: (a) to direct future studies on AI's influence in the workplace, and (b) to assist managers in making effective use of AI to boost productivity and efficiency in the workplace and overall business results. To our knowledge, this is the first comprehensive study to investigate how AI affects productivity on the job. They look at 60 studies published in 30 top international journals (AJG 3 and 4) spanning 25 years (1995-2020) and draw connections between them through a thorough systematic examination and analysis of previous research. Using the 'antecedents, phenomenon, outcomes process paradigm and the key functions of human resource management, they examine studies that explore the AI-workplace outcomes nexus at various levels of study. Using the 'antecedents, phenomena, results' paradigm, they analyze the selected publications according to publication year, theory, methodology, and important themes.

Howard (2019) Numerous disciplines and fields have contributed to the development of AI, including decision theory, computer science, statistics, cognitive psychology, neurology, language, cybernetics, and logic. AI as we know it today was born in 1956 as a little summer session at Dartmouth College. Since then, ML has enabled a variety of AI applications, including searches on Internet, e-commerce websites, speech and image recognition, cognitive robotic devices, sensor technologies, "decision support systems" (DSSs), and ML. AI is expected to mimic the influence of past general-purpose technologies such as electronics, steam engines, electricity, railroads, and Internet in terms of its potential to drastically alter economic and social institutions as its use becomes more pervasive in everyday life. Concerns about future workplace safety and health are heightened by the introduction of innovative AI applications. This study will examine the history of AI, current state of ML techniques, and emerging AI applications being created for use in robotics, sensor technologies, and smart DSSs. They also examine some of the possible implications of AI on nature of work in the future, including how human-machine interactions will be handled and loss of jobs as a result of automation. A proactive rather than reactive strategy will be used by occupational research and practice when strategic foresight regarding AI applications in the workplace is exercised. To lessen the influence of AI on the health, safety, and well-being of workers, it is essential to understand the possibilities and threats that AI poses to the industry's future.

Du (2024) Examining the effects of AI and automation on job market, this study provides a thorough overview of the literature. Some are worried that widespread use of AI and automation may lead to job losses and wage inequalities as these technologies develop and become more integrated into different industries. An evaluation of relevant literature is conducted in the study, which delves into topics such as job substitution and changes in company structure. Also discussed are the effects on employment prospects of

skill-biased technological development. The assessment stresses the importance of preventative actions in the face of automation's threats, such as funding K-12 and higher education, encouraging new forms of innovation and employment, and exploring options like a universal basic income.

García de Soto et al. (2022) The building industry's answer to Industry 4.0 is called Construction 4.0. It boils down to the AEC/FM sector going digital and automating everything. There will be more anxiety about the future of work and salaries as technology like robots becomes integrated into various parts of the construction process. Robots may increase efficiency and safety on the job site, but they shouldn't eliminate the need for human workers in the building industry. There will likely be a demand for people with digital talents in addition to designers, for example, and current positions will likely change over time. All of the functions were tested during the building stage of a concrete wall that was constructed utilizing robotics. This study's findings suggest that robots and traditional construction methods will coexist in the future, creating new positions at the managerial and operations/execution levels as well as increasing employment unpredictability. While this study does not aim to provide a precise picture of the AEC/FM roles' future evolution due to Construction 4.0, it does spark discussion and research in the field.

2.4 AI and Job Automation in the Oil & Gas Industry

Tariq et al. (2021) provided an inclusive overview of the roles played by data scientists and ML in various areas of petroleum engineering and geosciences, including unconventional reservoirs, oil well stimulation, production, drilling, and reservoir characterization. It also highlighted the recently developed field of unconventional reservoirs. They also talk about O&G industry's plans for data science and ML in future, focusing on the things ML needs to do to improve prediction. Additionally, this research compares and contrasts several ML methods employed by O&G sector. They

anticipate a promising future in solving O&G industry's complex problems that have so far eluded analytical solutions and numerical simulation, advanced ML algorithms, thanks to the advent of powerful computers, and extensive data generation from various industry tools. Considering log data and additional information about the goal data, ML tools may incorporate every detail. Their shortcomings notwithstanding, they are unrestricted by the data and/or processing resource needs of numerical simulants or the limiting assumptions of analytical solutions. An all-inclusive reference for ML submissions in the industry, this report is thorough. The research concluded that ML methods have enormous promise for addressing prediction, classification, and clustering issues across the board in O&G sector. An increasingly efficient O&G sector is necessitating the use of ML and big data handling techniques due to the massive amounts of data generated by routine industry operations.

Musa (2023) To maintain a competitive edge, lessen their influence on the environment, and advance sustainability, O&G industries must update and modify their procedures. This entails spending money on automation, data analytics, and AI to simplify processes, increase productivity, and decrease expenses. This research focuses on how O&G sectors have been transformed by AI technology. Nonetheless, AI has completely transformed the O&G sectors by mechanizing operations such as drilling and production, enhancing the safety and dependability of equipment, and offering invaluable insights into the management of reservoirs and supply chains. Not to mention the hazards and limitations, such as the fact that fresh resources are required to train datasets with limited generalizability. Thus, AI in engineering has the potential to save costs and boost quality, but there are ethical concerns that must be considered, such as the potential loss of jobs and need to confirm that AI judgements are in line with society's ideals. Both the technological and ethical aspects of AI integration must be thoroughly investigated. This study confirms previous findings that AI has tremendous promise for O&G sector, but it also stresses the

importance of giving the technology due diligence before putting it into practice. They can simplify operations in this crucial sector and open doors to discoveries by harnessing the potential of AI.

Chuka Anthony Arinze *et al.* (2024) In this research, they explore the relevance, difficulties, and possibilities of AI in O&G industry. Constant change characterizes O&G industry, making safety and efficiency top priorities. The ever-changing complexity of the sector makes it difficult for traditional engineering procedures, despite their robustness, to keep up. However, a paradigm shift is on the horizon with the arrival of AI technology, opening up possibilities for optimization and risk mitigation that have never been seen before. This study delves into the many ways AI can improve engineering operations all along the gas and oil value chain. The study delves at how AI—which includes ML, DL, and predictive analytics—may optimize exploration, production, transportation, and refining by providing decision-makers with real-time insights. Predictive maintenance solutions allow proactive asset management and minimize downtime, leading to efficiency improvements. Improvements in resource allocation, operational streamlining, output maximization, and cost reduction are all outcomes of process optimization methods driven by AI. Better risk assessment and hazard identification are two further benefits of incorporating AI, which contribute to a safer work environment. To prevent accidents and intervene proactively, AI systems sift through massive databases in search of irregularities and possible dangers using complex algorithms. The path towards AI integration, however, is not devoid of obstacles. Cybersecurity issues, legal frameworks, and technical intricacies all present formidable obstacles that must be carefully navigated. Furthermore, strong governance structures are required to guarantee the ethical deployment of AI due to concerns about algorithmic bias and data privacy. The study ends by describing prospective advancements and patterns in O&G sector's employment of AI in the years to come. It

highlights the possibility of constant innovation and disruption, which could alter the workforce's composition and the demand for specific skills. The industry is propelled towards a more sustainable and resilient future when it embraces AI, which fosters operational excellence.

Wanasinghe et al. (2024) Amid Industry 4.0, this study offers a new method for determining the reskilling needs, job merging paths, and an approximate timescale for changing offshore O&G drilling jobs. Potential employment merging as a result of technology adoption is the main emphasis of the suggested algorithm. To take into account modulation factors (such as the cost of developing and economic benefits, regulatory readiness, labor market dynamics, implementing new technologies, and social acceptance) that either facilitate or impede the adoption of technology, it adds a scaling factor called digital readiness level. To forecast automation trends for each profession being studied, a mathematical model is developed. and a feature-based method is created to evaluate the commonalities between jobs. These make it easier to think about possible job merger scenarios and the related timeline. The suggested algorithm is offered as a case study on Canadian offshore O&G drilling vocations since technology adoption is contingent on the sector, location, employment, and stakeholder's capacity to handle the change. Nonetheless, different businesses or occupational structures can benefit from the use of this technique and methodology. An average offshore drilling platform will have six "personnel on board" (POB) by 2058, according to the suggested algorithm. To test how well the suggested method handles different feature values and weighting variables, a sensitivity analysis was carried out. Only one job out of three maintains its status quo after 2058, and that's after accounting for changes to feature values and weighting variables of up to 20% of their original values. In contrast to the similar work in the baseline results, the task that went through all three pathways still used the same source jobs.

Bangera and Bhat (2023) Producing and transporting O&G requires complex systems and modern technology, which can be rather costly. These businesses are among the first to investigate the potential of AI. Industry leaders are pouring resources into data technologies and artificial intelligence to stay ahead of the curve while world around them undergoes a fast transformation. Using AI to its full potential solves the big problems plaguing the oilfield right now. AI has the potential to revolutionize every sector of the value chain, and O&G industry is increasingly aware of this. The promise of AI meets the primary challenges faced by oilfield today. In this analysis, they looked at O&G industry as a whole, at the problems it faces, and at how it has come to rely on AI to make a dent in those problems. The O&G industry may now utilize AI to assess potential reserves, tailor drilling and completion strategies to local geology, and determine the dangers associated with individual wells. The research summarizes the utilized of AI in O&G industry's sustainability efforts. An analysis of one example that demonstrates how AI has impacted the growth of the gas and oil professions.

Adamu et al. (2024) Recent innovations in ICT, along with advances in robotics and AI, have further revolutionized the way essential human industries, such as O&G industry, function. In Nigeria, technical advancements have mostly come from the O&G industry, which supports the country's economy. However, automating machines and processes is just the beginning of what automation entails. Consequently, how digitalization has altered job satisfaction and distribution of skills in Nigeria's O&G sector. Statistical analysis was the tool of choice for this investigation. Researchers surveyed 10,671 people working in the sector. By applying the Yamane Taro technique, they were able to choose a sample size of 385 subjects. As a means of gathering information, a questionnaire was distributed. A mean score of 3.75 out of 5.00 shows that the industry's adoption of automation is moderate, according to the data. While this does point to a

substantial deployment, it does not mean it is widespread across the sector. It was also determined that automation, on average, boosts job satisfaction (mean score: 3.80). On the other hand, workers were worried about losing their jobs due to automation, therefore it's clear that we need mixed methods. Finally, the research shows that automation has had a big and complicated effect on O&G sector in Nigeria. There has to be a significant investment in automation and personnel training for the Nigerian O&G industry.

Nwankwo, Bagam and Usoaku (2024) analyze how the rise of automation has affected human capital development in Nigeria's O&G sector. In particular, it looked at how the workforce may adjust to changes brought about by automation and the possibilities for reskilling and upskilling. Using a questionnaire, 385 individuals were chosen at random from a pool of 10,671 employees at three large Nigerian O&G businesses for this descriptive survey research study. They used a multi-stage sampling strategy to target industry experts, using the Yamane Taro method to determine the sample. The results show that people are generally optimistic about prospects for reskilling and upskilling; the industry is making an effort to train its employees to deal with automation since the total mean score is 4.02. Nevertheless, the fact that there is a range of answers shows that these programs could use some work in terms of accessibility and organization. The research shows that there are issues with training efficacy, managerial assistance, and the pace of technology improvements, but generally, the workforce demonstrates a great capacity to adapt with an overall mean score of 4.14 regarding automation-driven changes. Researchers in Nigeria found that although O&G sector is taking steps to combat automation by training employees to reskill and upskill, they could do more to help their employees and make sure that everyone has a fair chance to participate in these programs. Maintaining industry growth and making sure workers can reap automation's benefits both depend on these initiatives.

Olajiga1 et al. (2024) Researched in this study are uses, advantages, disadvantages, and potential future developments of AI in smart drilling technology. Smart drilling solutions use AI to maximize efficiency, automate routine tasks, and make proactive decisions at every stage of the drilling process. From initial planning design to continuous monitoring and control, systems powered by AI enhance operational performance, lessen hazards, and maximize resource recovery. Potentially considerable benefits may be reaped from smart drilling technologies, despite obstacles including data integration, technological uptake, and regulatory compliance. These technologies offer some advantages, the most important of which are higher efficiency, safety, precision, and sustainability. In the future, there will be many chances to innovate and progress, such as creating more sophisticated AI algorithms, incorporating IoT and big data analytics, and prioritizing environmental sustainability. To adapt to the changing O&G well-building scenario, the industry may seize new growth prospects by embracing innovation, collaborating, and committing to sustainability. The potential for smart drilling technology to revolutionize well building is immense, opening the door to safer, more efficient, and environmentally friendly drilling practices in the O&G sector. By providing previously unseen degrees of accuracy and security in well development, smart drilling technology is causing a paradigm shift in O&G sector. Improved drilling parameters, less risk, and more resource recovery are all outcomes of these technologies' incorporation of AI into the drilling process. These technologies offer some advantages, the most important of which are higher efficiency, safety, precision, and sustainability. In the future, there will be many chances to innovate and progress, such as creating more sophisticated AI algorithms, incorporating IoT and big data analytics, and prioritizing environmental sustainability.

Nguyen, Gosine and Warrian (2020) The digitization of the O&G business relies on BD analytics, among other things. Improving decision-making, operational efficiency,

and risk mitigation in the workplace are the primary goals of its data management and processing capabilities. As seismic data is processed more efficiently, the industry gains a greater grasp of BD applications. The sector is still cautious when it comes to implementing new technologies, though. Factors such as cybersecurity measures taken to protect BD system from hackers and integration challenges with current systems contribute to the sluggish rate of technology implementation. Workplace privacy concerns are heightened by potential use of physiological and location-tracking data in certain wearable device apps. The effectiveness and practical benefits of applying BD to O&G activities are questionable due to these constraints. This study's overarching goal is to conduct an O&G industry-specific systematic review of BD analytics. The purpose of this study is to assess influence of both technical and non-technical elements on the uptake of BD technology. Prospects and threats associated with BD technology adoption in O&G sector, as well as data privacy consequences, network design, BD development platforms, and cybersecurity, are all included in the research.

Shukla and Karki (2016) The growing number of people living in cities and factories is driving up the demand for natural O&G. The global production of giant oil sources is decreasing, which is prompting the quest for new fossil reserves, both conventional and non-conventional. As extensive onshore and shallow-water offshore oil deposits continue to be depleted, the search for fossil fuels has moved to offshore fields with deep-water and ultra-deep-water. As expected, new reserves are situated in inhospitable, secluded, and dangerous areas. To meet the increasing need for energy, major technological improvements are required because the extraction of oil from offshore areas poses serious dangers to "health, safety, and environment" (HSE). The devastating "Deepwater Horizon offshore oil platform" explosion the largest oil spill accident in history, is a prime illustration of the kind of catastrophe that human civilization just cannot

afford to repeat. So, for a safer future, we need to build a system that can drill more efficiently, inspect more accurately and intelligently, respond faster to bad incidents, and control damage more effectively. The successful integration of robots in the manufacturing and space industries shows that robotic automation and assistance are the only ways to produce oil safely and economically shortly. These days, robotic technologies such as "autonomous underwater vehicles" (AUVs), underwater welding, teleoperation of unmanned drilling and production platforms, and underwater manipulators enable offshore rigs to transition between shallow and ultra-deep waters with ease. The bulk of these technologies are considered semi-autonomous because of the products' fragility and the environmental issues they face. This indicates that although a human operator is still present, their role is limited to supplying cognitive support to guarantee the operation is carried out safely. In this research, we compiled a list of the most important robotic systems that offshore O&G installations utilize today.

Elijah et al. (2021) The oil demand is decreasing as a result of COVID-19, market instability in O&G sector, and push for cleaner energy alternatives are all factors prompting the industry to innovate and digitize. Because of this, academics and businesses alike are showing an interest in studying how O&G industry might benefit from Industry 4.0 standards. While studies have shown how some of these I4.0 technologies have been put to use, this field has yet to see a thorough examination of how O&G upstream companies have been using them. Research in this area focuses on the most recent initiatives in O&G upstream industry that have been organized around Industry 4.0 technology. The first step in this direction is a discussion of the I4.0 framework, and the second is a 223-document systematic literature evaluation that takes an integrated stance and covers the years 2012–2021. There are advantages and disadvantages to implementing I4.0 that have been detected. Beyond that, the paper's contribution is a structure it offers for the O&G upstream

sector to adopt I4.0. At last, we offer some potential avenues for further study and development in areas like frameworks, standardization, communication technologies, quantum computing, edge computing, and innovative upstream sectors that could benefit from implementing I4.0. This evaluation's outcomes reveal that the upstream sector is actively investigating and implementing I4.0 technology. I4.0 technologies such as VR and additive manufacturing, on the other hand, have seen very little use.

Patrick Oputa Odili et al. (2024) analysis of how AI has changed the way O&G companies find and hire new employees. Finding out how AI is changing the face of recruitment and what that means for businesses and jobseekers is the main goal. To find out what opportunities and threats are linked to using AI in hiring processes, the technique systematically evaluates relevant literature, case studies, and industry reports. By automating mundane operations, boosting applicant targeting, and enabling data-driven decision-making, AI greatly improves the efficacy and efficiency of O&G recruitment, according to the results. More and more, businesses are turning to AI-powered technologies like virtual assistants, predictive analytics, and algorithms that analyze resumes to make better hiring decisions faster and with less bias. On the other hand, the study highlights some possible obstacles, such as ethical considerations, the necessity of AI algorithm transparency, and the danger of becoming too dependent on technology. According to the research, O&G firms must proceed with caution when implementing AI, even though at it offers significant advantages in streamlining the selection and recruitment processes. To keep up with the ever-changing nature of the labor market, it is necessary to update AI systems frequently and strike a balance between technological progress and human judgment. According to the research, a combination of AI and human knowledge will most likely govern the future of recruitment in this sector.

2.5 New Skill Sets and Competencies for the Future Workforce

Ada, Ilic and Sagnak (2021) Businesses are facing new work demands as a result of the radical changes and advances brought about by Industry 4.0, which include increased global connectivity, automation, and technology innovations. As a result of this mandate, HR professionals will need to reevaluate how they learn and use information about recruiting and other HR duties that are vital in the modern workplace. Human resource managers can use this study's analysis of the relative relevance of various skill sets to develop a strategy for staff selection in the age of Industry 4.0. The weights of the factors were computed using Fuzzy "Analytic Network Process" (ANP). The most essential component was a person's ability to manage projects effectively. Financial management, literacy, digital literacy, technology-based skills, innovation, and creativity were additional important aspects. The findings are discussed, and their consequences are highlighted.

Li (2022) Industry 4.0, the fourth industrial revolution, is changing the workforce and increasing access to new skills and information, which both impact globalization significantly. Fifty-nine percent of workers will need to acquire new skills by the year 2025 due to introduction of new technology. according to WEF two-thirds of the competencies now valued in job postings will be obsolete in the next five years. In 2025, a third of the necessary abilities will be technological competencies that aren't considered critical for jobs just yet. They center their discussion in this study on how to reskill and upskill workers, so they are prepared for the future, specifically in the age of Industry 4.0 and beyond. They have laid out the most important talent sets needed by businesses to implement Industry 4.0 and provided a road map for how people might improve their own skill sets. Organizations should include lifelong learning in their strategic objectives, according to the study's conclusions. The future workforce will need a commitment to reskilling and upskilling on the part of both individuals and businesses, with career development playing a crucial role. It is crucial to ensure that reskilling and upskilling

opportunities are easily accessible, available, and cheap for workers. An innovative viewpoint on a learning society prepared for the future as a key constituent of the industry 4.0 vision is presented in this study.

Saari et al. (2021) A new era has begun, according to Klaus Schwab, executive chairman and founder of the WEF. This new era is called the 4IR, and it will be driven by three megatrends: physical systems, digital, and biological. The future of employment and people's daily lives will be changed by these trends. Before 4IR arrives, more work needs to be done to determine what industries are trending, what jobs are in demand, and what opportunities may emerge at the same time, with a focus on enhancing the possibility of skill development by 4IR. Both current and future jobs will necessitate different skill sets, which will modify people's work habits. Understanding individual concerns about work, skills, and education, as well as the differences between developed and emerging economies, is the goal of the essay. This study employed a focus group and a qualitative research approach to gather data. Participants in the focus group discussions will include academics from various TVET institutions, members of the industry lead bodies appointed by "Department of Skills Development" (DSD) of different industries, and stakeholders from the competence body, which is Malaysia's DSD. The goal of the discussions is to enhance human potential for skills development by the 4IR. The research revealed four key areas that can serve as a framework for 4IR skill development: enabling digital skills, proficiency with high-impact technologies, an entrepreneurial mentality, and, finally, talented individuals with a mix of technical and soft skills.

Cummins et al. (2019) The demand for a deeper comprehension of the competencies essential to maintain a workforce competitive on a global scale has grown in response to the rise of automation and other modern technologies. Utilizing information from “Program for International Assessment of Adult Competencies”, this study examined

adults' problem-solving skills in technologically advanced settings across South Korea, Singapore, Germany, Estonia, Japan, Canada, UK, USA, and Australia. Scores fell with age in every country except the United States, which had the lowest average. The percentage of survey takers ranked lowest in terms of skill and highest in terms of top-level expertise was lower in the US. This study's findings raise questions about the efficacy of current policies and programs aimed at adult education in the United States and raise the possibility that reforms are required to equip all citizens with marketable skills.

Vista (2020) As a result of systemic changes, the nature of labor may change as the world changes at a rapid pace. Building the workforce's capacity to adapt to an uncertain future requires a focus on future-proofing their skill sets. A method of identifying and quantifying these abilities is necessary before they can be further developed. An empirically justified approach to skill valuation is crucial. An approach to skill valuation is proposed in this study that centers on the degree to which a skill allows for occupational transitions as its metric of value. A graph-theoretic approach is subsequently used to generate this valuation metric. In line with previous skill valuations in the literature, results demonstrate that this assessment represents the importance of skills. There is a discussion of the possible extensions and limitations of this approach.

Leitao et al. (2020) recognized as 4.0 industrial revolution, are pushing for the digitalization of the manufacturing sector to create smarter and more efficient factories. The digital maturity level of industrial sector organizations can be improved with the help of current and future personnel who possess the skills necessary to fully embrace this multidisciplinary vision. Furthermore, in response to these novel techniques, new types of jobs are appearing, necessitating the re-education and re-skilling of the current workforce, with an emphasis on digital literacy. In this light, this paper examines the impact and knowledge gap in six manufacturing domains—collaborative robotics (cobots), data

analytics, cybersecurity, machine automation, mechatronics additive manufacturing, and human-machine interface—about the successful adoption of digitization.

Karacay (2018) The capacity to adapt to changing business requirements is crucial to a company's sustainability and competitive advantage in today's global economy. As a result of developments in new digital technologies, commonly referred to as Industry 4.0, dynamics of most industries have been undergoing a significant shift, ushering in the 4IR. Workers will need to acquire new digital skills as a result of process automation and rise of innovative business models. To build a workforce fit for the future, it will be necessary to do more than just find and cultivate fresh talent; existing employees will also need to undergo re-skilling training and have their work procedures re-designed to close the gap in skills between employers and workers. The influence of Industry 4.0 on talent development is the subject of this research.

Assunção and Goulart (2016) The labor market has changed significantly since middle of the twentieth century, necessitating new approaches to employee development and selection on the part of managers. Within this framework, they were able to have fruitful conversations about identifying competencies and occupational training. Academic conceptual knowledge of professional qualification and competence is advanced by this study's theoretical analysis, which also encourages discussion and investigation into the future relevance of various competencies to businesses. A better understanding of the differences between the French and American views on these topics emerges by looking at their development through time. The current context is explored while focusing on the American model of competence, which is the most popular in Brazil, and its interfaces. The text's goal is to find competencies that deal with the modern workplace and, taking into account the traits of the companies of the future that have been discussed in the

literature, thoughts on how individual competencies (knowledge, skills, and attitudes) will converge to meet the demands of the labor market of the future.

Saatci and Ovaci, (2020) Emerging nations can achieve economic growth through innovation. If they want to harness innovation's potential, emerging economies need knowledgeable workers. That is, in this new industrial revolution, employers are looking for workers who can think critically and solve problems. Consequently, one of the skill sets needed to achieve the objective of sustainable growth through innovation is the innovation competency of particular persons. Studying how different personality qualities affect people's innovative competencies is main goal of this research. The innovation competency model was tested using a hierarchical regression analysis to see how it related to the big five personality qualities. This model was created as a component of the "Framework for Innovation Competencies Development and Assessment" (FINCODA) project, which was an EU initiative. A person's innovative competencies are related to their openness, conscientiousness, extraversion, and neuroticism, according to the results.

Brun and Urazaliyeva (2019) Labor force development in developed industrial economies has traditionally followed the "triple-helix" model, which involves public and private sectors working together to make sure human capital investments are worthwhile. However, there are large chasms between educational outputs and business needs because model has been less widely used in post-Soviet states. Researchers in Kazakhstan looked into what made its O&G sector more competitive, and their findings are detailed in this study. The study specifically provides a relative case study of successful workforce development strategies in sector and details the outcomes of roundtable discussions and stakeholder interviews conducted for the sector in Kazakhstan. The discussions focused on the character and difficulties of workforce development in the country. The competitiveness of the country's O&G industry is hindered by a lack of correlation between

industry demands and the technical training provided by domestic educational institutions. The study's authors conclude that public and state managers should play a pivotal role in reshaping country's educational training standards by mediating between businesses and schools to address education's failure to meet employers' demands.

Fadare, Akintunde Adetoye a and Omiko (2024) Employees can hone their skills and advance in their careers through CPD, or continuous professional development. Particularly in a dangerous field like the O&G business, experts need to maintain proficiency and improve their abilities. Continuous and continuous learning and adaptability are essential in this industry due to the high-risk nature of the work, the strictness of regulations, quick pace of technical change, and the unpredictability of market conditions. If the sector wants to keep up with the times and operate cutting-edge technology, it must invest in its human resources. This article delves into importance of "continuing professional development" (CPD) for O&G workers, outlining the many ways in which CPD helps both individuals and businesses. In it, the steps of CPD are laid out, beginning with recognition and planning and ending with application. The essay delves into practical answers to common problems and discusses successful ways of adopting CPD. Successful CPD initiatives have a significant impact on safety, efficiency, and regulatory compliance, as shown by real-world case studies from industry leaders like Shell and BP. The results show that both professional development and company output are greatly improved by a well-organized CPD program. Data for this study came from a mix of qualitative and quantitative sources, including surveys and questionnaires filled out by people working in O&G sector, as well as training materials, business surveys, and studies.

2.6 Future of Workforce Planning in Oil & Gas

Penesis et al. (2017) Increasing the number of highly skilled engineers and related professionals in Australia over the next three to five years will be crucial in meeting the

demands of country's advanced manufacturing and maritime sectors. Problems in finding enough competent workers have arisen as a result of Australia's relatively low graduation rates in STEM subjects compared to other developed nations. In this study, they examine Tasmania as a case study to show how a literature analysis revealed a skills gap and how semi-structured interviews with businesses in relevant industries yielded qualitative data on the talents of the future. Adaptability in course offerings, collaboration with industry to guarantee reliable and high-quality learning outcomes, and a culture of open dialogue and teamwork based on shared knowledge of the opportunities and challenges facing the education and training sector are all things that the results make abundantly clear.

Adedoyin Tolulope Oyewole et al. (2024) Due to the complex safety difficulties and inherent operational risks in the O&G industry, strong HRM policies are required to provide effective safety measures and minimize risk. Improved workplace safety and reduced operational risks are the primary goals of HRM methods in O&G industry, which are the subject of this in-depth analysis. In this analysis, we look at the ever-changing O&G sector, which employs people from all over the world and is defined by complex technological processes, dangerous working conditions, and constant change. The study critically examines current literature and case studies to highlight the crucial requirement of human resource management techniques that training employees, emphasize safety culture, and proactive risk management. Critical components include creating a safety-centric company culture, conducting thorough hiring processes to find people with a strong safety mentality, and providing continuous training to raise awareness and competency levels. In addition, this research delves into how the O&G industry is utilizing data analytics and technology to inform HRM practices. Potential safety concerns can be identified and addressed proactively through the application of contemporary technology for predictive analytics, real-time monitoring, and employee training. The study goes on to

say that HRM plays a key part in creating an environment where employees feel comfortable being open and honest when reporting issues and that encouraging communication and collaboration among workers is crucial. Findings from this review add to our knowledge of HRM's complex function in the O&G sector about safety promotion and risk mitigation. As the sector undergoes continuous change, organizations must prioritize the implementation of new HRM practices to ensure a secure and robust operational environment while protecting their workers.

Kumar, Salman and Sahu (2024) Examine the development, state, and possible directions of human resource management in Indian oil corporations. The purpose of this study is to offer a thorough analysis of evolution of human resources practices, the challenges that HR departments encounter in the present day, and the essential strategic orientations for developing and adapting in the future. The study combined quantitative and qualitative data using a mixed-methods methodology. Major Indian oil firms' HR departments and staff were surveyed and interviewed to obtain primary data. Sources for the secondary data included reports from the industry, scholarly articles, and corporate records. To find important trends and problems, the study uses theme analysis; to quantify the influence of different factors on HR practices, it uses statistical analysis. Researchers in India discovered that oil companies' HR departments are now more than just administrators; they're actively involved in driving company growth. Managing a varied and developing workforce, keeping up with the ever-changing global economy, and fixing problems with regulatory compliance are all pressing difficulties today. It appears that digital transformation, inclusion and diversity, and strategic workforce planning will be given more attention in the future. Indian oil corporations' HR practitioners and legislators can benefit greatly from the findings. These new issues call attention to the necessity for creative HR tactics to deal with them, such as encouraging diversity and inclusion in the

workplace and incorporating cutting-edge technology. The report also suggests enhancing HR methods to increase organizational success and employee happiness.

AL-Qadhi and Abdullah (2021) This research aimed to determine the competency model's core competency level. 350 technical staff members from the operation, maintenance, and safety division, together with experts and O&G staff, were included in the purposive sample. Statistical techniques (SPSS and SEM) were used to evaluate and interpret the data. The competency model is critical for the safety of employees in the petroleum industry throughout commissioning, shutdown, troubleshooting, operations, and maintenance. The results of the data interpretation show that the rigorous training had a positive effect on employees' core competency, with few particular deficiencies in safety and troubleshooting. The plan to address these gaps is recommended. Sixty per cent of the company’s core competencies were successful because of this characteristic.

Pegram, Falcone and Kolios (2018) Countries with natural resource stocks often employ job role localization as a local content strategy to get the most out of their investments in these resources over the long run. This study seeks to collect, organize, and analyze pertinent literature to discover best practices for future application of local content and job role localization strategies. Currently, there is a wide range of approaches taken by different nations and groups when formulating and implementing such programs. Following a comprehensive definitional analysis of topical words, this section delves into the theoretical foundations and driving forces behind local content. It then moves on to evaluate the existing literature on job role localization, specifically looking at the qualifiers for localization and the obstacles to it. Concluding this critical study is a critical discussion of methods for assessing local content policies.

Petrenko, Denisov and Metsik (2022) The prosperity of nations that rely on oil exports is in jeopardy as an outcome of technological advancements that have diminished

the importance of oil. The growth of Kazakhstan's O&G industry is crucial to the country's economic future. The study's overarching goal is to foretell O&G industry's trajectory into the future and provide policymakers and businesses across sectors with a road map for responding to the growing uncertainties they face. The writers offered methodological support and practical involvement in a foresight session, and the article contains the materials of a Delphi poll with 211 industry experts and a group discussion with 75 participants. An increase in environmental criteria (85%) and the expansion of autonomous production based on digital management (about 90%) are the top two predicted trends in the industry's future development, out of nine overall. Methodologically, the author takes a practical approach to medium-term technology foresight in the sector. Assumptions about future technology developments form the bedrock of O&G industry's ideal future. The "Most Advanced, Yet Acceptable" guiding principle was used to shape the improved image in reaction to environmental concerns. The future of Kazakhstan's business will be characterized by a fully automated and robotic production process that is abandoned. Plans based on industry foresight estimates to mitigate risks related to sector development are a national priority for Kazakhstan, as they have a major influence on the overall economy.

Yuan Li and He (2021) The economic situation in our nation has been steadily improving as a result of the ongoing commitment to reform and opening up. The fields of science and technology, in particular, have been blossoming with new developments and innovations since the turn of the century. Technology and science have been merged in several sectors and fields. There has been a shift away from using antiquated practices that cannot keep up with modern innovation. Talents from all walks of life are desperately needed in this environment to ensure the industry's growth is more streamlined and expert. Using data from the literature, this article first examines the present state of human resources, then summarizes the key issues plaguing the talent market at the moment and

finally proposes numerous critical functions of talent planning. To lay the groundwork for future talent market predictions and opportunities, the primary goal is to analyze and classify the distribution of technical personnel and the overall cultural level of human resources. There is evidence that only 17% of the population has a bachelor's degree or higher. As a result, it's clear that city's human resources have a poor level of education and, generally speaking, aren't good enough to satisfy the demands of economic development; they're also keen to get better.

Balycheva and Dybdahl (2022) Operational safety is of the utmost importance in O&G industry, particularly in light of the recent surge in the discovery of hydrocarbon reserves in unconventional, remote, and Arctic regions. Integral to the design of any sophisticated information technology system for process control are safety systems. These systems are typically designed as part of a larger technical effort. To make well-informed suggestions for the safety systems' needs definition, this study provides a decision-making framework. By bringing together maintenance planning, challenges of safety system design, and personnel scheduling, this study adds to the body of knowledge in field of strategic planning for IT solutions in hazardous industrial sites. Throughout a solution's lifetime, this collaborative decision-making makes it feasible to investigate potential costs and benefits of investing in the systems' complexity vs spending money on the personnel. They use Markov analysis to carry out the dependability modelling. Use the multi-objective decision-making framework to figure out what the design of the safety system, the strategy for maintenance, and the organization of the workforce need. Engineering project management in the petroleum industry, particularly as it relates to development of technological solutions, can benefit from this study.

Vochin et al. (2023) An Austrian O&G company's human resources managers and professionals' level of awareness regarding "Green Human Resource

Management" (GHRM) is presented in this article. This strategy is centered on incorporating eco-friendly practices into different HR roles in a company. It also acknowledges that HR is an integral part of sustainability efforts by coordinating associated policies and practices in areas like as training, organizational effectiveness, diversity, equity, and nondiscrimination. A qualitative research methodology was employed to get the data. They set out to investigate in detail how the HR department incorporates the principles of social, environmental, and economic sustainability into the organization's policies, procedures, and plans. Therefore, HR choices and actions in this area can have far-reaching effects on society, environment, and welfare of stakeholders and employees in the long run. How corporate sustainability is incorporated into the broader company and HR strategy forms the theoretical basis of the study. To examine the connections between HR strategy and sustainability in greater detail, they conducted interviews in the following areas: Training and Organizational Effectiveness; Diversity, equity, and non-discrimination; and Talent recruitment and retention (Recruitment). Results from the study corroborate the hypothesis that GHRM contributes to the long-term viability of Austrian O&G corporation that participated in the interviews. Human resource managers and experts are familiar with Green HRM, but they might do more to help their companies develop the skills necessary to create a sustainable future. With this in mind, businesses should priorities hiring environmentally conscious workers and craft HR practices around the Green HRM idea. Organizations may help create a better, more responsible future by incorporating sustainability ideas into HR practices. This will also help create a great work environment that recruits, develops, and keeps the best employees.

Essa Yousuf Majid Al Suwaidi and Akmal (2022) Development and training aimed at lowering the turnover rate at the UAE-based O&G company. A high incidence of employee turnover has been plaguing O&G industry, which is crucial to the economy of

UAE. The purpose of this investigate is to explore the connection between O&G company employee turnover and training and development programs in the UAE. A theoretical stance was taken in conducting the investigation. By establishing a connection between T&D and employee turnover, the study comprehensively evaluates and analyses the literature. With the use of keywords such as Training and development, job satisfaction, retention, intrinsic motivation, and happiness, researchers scoured databases like Google Scholar, Emerald, and Science Direct for studies that examined the effects of various theories on lowering employee turnover rates at O&G companies in the UAE. The evidence indicates that association between training and development and job retention will be mediated by job satisfaction which informed the development of a framework for employee retention through development and training. Staff retention in UAE O&G sector can benefit from the suggested structure. Beyond that, it has other potential applications in different types of organizations. Value added and product quality were both increased in settings where employees were taught to manage multiple production lines simultaneously, according to the majority of the literature. Employee performance will be greatly enhanced by this. This study's policy implications include the expectation that its implementation will lead to a growth in job satisfaction, the retention of associated staff, and development of new research avenues.

CHAPTER III:
METHODOLOGY

3.1 Overview of the Research Problem

O&G industry is a giant digital industry with sophistical technologies deployed from Oil well head to end-user enabled with cutting-edge operations on unmanned Drilling,

remote operations, and supercomputer applications to process geological & seismic data. Significant efforts in capturing data and administering the learning to understand the pattern and data behavior are essential to set up strategies to solve industrial challenges (Haenlein, Huang and Kaplan, 2022). The industry demands new skillsets on AI, statistics, big data & machine learning, where decades of yearned knowledge for decision-making is witnessing a shift to faster and better insights with Digital technologies.

IOC/NOCs like BP, Saudi Aramco, Shell, and ADNOC have jump-started their AI creativities by investing violently in startups and R&D. Alike to other industries, O&G faces challenges with massive deployment of AI at this stage of its development (Bello *et al.*, 2015). Previous studies have shown challenges surrounding shortage of new skill sets, systems for data management and collaborative work environments (Kelly *et al.*, 2019). While is a deficiency of HR in understanding the technology application in O&G and translating the business requirement to organization needs and people equation is insufficiently explored.

Driven by the fluctuating oil price since 2014, IOC/NOCs are seeking means Sharifi, Ahmadi and Ala (2021) to optimize business operations, improve productivity while ensuring safety (Koroteev and Tekic, 2021b). Although skill shortage appears consistent with prior research, no study to date has examined how IOC/NOCs are adopting tech-based operating models, defining work management approach and refining employment models.

3.2 Operationalization of Theoretical Constructs

The operationalization of theoretical constructs in this study ensures the alignment between abstract concepts and measurable variables. “AI adoption” is examined by assessing the extent of automation, AI tools, and digital technologies integrated into participants' workflows. The construct of “workforce dynamics” is operationalized through

variables such as changes in job roles, task automation, and employment models within the sector. “Job security and fear of automation” are measured using participants’ perceptions regarding the potential displacement of their roles by AI technologies. ‘New skill requirements’ are as defined where participants believe what additional skills and technical knowledge is required to be able to manage change resulting from AI such as ML, data analytics and digital literacy.

Moreover, “perceived organizational readiness for AI” is assessed by asking participants about access to training and development opportunities and other programs that are relevant to technological change. On the construct “Job satisfaction with AI integration”, the respondents are asked if they think that AI helps decrease the repetitive work done by them, improves efficiency at work, and helps them in having a positive work experience. ‘‘Perceived opportunities created by AI’’ are measured using variables showing perceived opportunities for career progress, more challenging jobs, and new positions. By defining these constructs in a way that enables their measurement with Likert scale items (including Strongly Disagree = 1 and Strongly Agree = 5 which often used for structured questionnaire), the proposed examination allows for qualitative disclosure and viable quantitative examination in illustrating the ways O&G workforce is evolving with the aid of artificial intelligence.

3.3 Research Design

Analyzing the experience of the case study-based qualitative research work to understand the topic ‘from within’ surveying managers, expert professionals and professionals engaged in the field. Primary data was collected through a survey involving of participants’ perceptions of AI’s impact on job positions, the skills required, and

workforce characteristics. To make sense of the data collected and identify patterns of initial unnerving experiences within the quantitative data, statistical analysis was utilized as the approach (Braun and Clarke, 2006; von Grafenstein, 2018). This approach provided significant insights into workforce transformation driven by AI, offering a deeper understanding of the challenges and opportunities faced by O&G sector.

3.4 Research Purpose and Questions

Modern technology such as "Robotic Process Automation" (RPA), ML, and AI are creating significant potential across the industry for innovation and growth. Advanced algorithms and data sets are gradually replacing routine, repetitive and dangerous tasks while freeing up workers for high-value-added activities. With the adoption of advanced digitalization, technology-driven careers will evolve; some jobs will decline, and some will be eliminated. This study analyzes how AI will change a significant part of O&G industry in coming decades impacting the organization structure, operating models (Koroteev and Tekic, 2021b), job competencies and manning. The research deep dives to investigate the impact on jobs and job families that will guide IOCs/NOCs to plan workforce of the future.

This study's overarching aim is to investigate and shed light on how AI will affect the O&G industry's future workforce. To accomplish the stated objectives, this study will use artificial intelligence (AI) to examine current situations in O&G business and provide answers to the following questions: a) how future O&G workforce will be shaped in five to ten years in terms of manpower strength, b) new skill sets c) how O&G jobs will be rescoped with activities automation-elimination and potential future jobs.

3.5 Population and Sampling

The population for the study consisted of at least “N = 300” participants, including industry professionals, managers, engineers, and AI experts with experience or exposure to AI technologies within the sector. Specifically, convenience sampling method was used,

allowing for easy access to the participants and their availability; however, participants were identified based on position or job role to the study context. This was suitable in the study as it is among non-probability sampling techniques because of the likeliness in selecting target population of this unique workforce (Etikan, 2016). The selected participants offered information on how AI influences job profiles, skill expectations, and workers' shift patterns. Convenience sampling was chosen in this research to help the research get a diverse yet a manageable sample size that was of importance in the collection of qualitative data. Voltaire compliance and data confidentiality form part of research ethics that were observed when conducting the research (Flint *et al.*, 2012).

3.6 Participant Selection

Table 3.1: Inclusion and Exclusion Criteria

Criteria	**Inclusion**	**Exclusion**
Industry	Professionals working in the oil and gas sector.	Individuals not associated with the oil and gas sector.
Role/Experience	Managers, engineers, technicians, AI specialists, or employees exposed to AI technologies.	Administrative staff or those with no exposure to AI-related tools or processes.
Work Experience	Participants with a minimum of 1 year of experience in the industry.	Individuals with less than 1 year of work experience.
Geographic Scope	Employees from any oil and gas company, regardless of location.	Participants from industries outside the oil and gas sector.
Language	Participants fluent in English (or with translation support).	Non-English speakers without translation support.
Consent	Individuals who provide informed consent.	Participants who decline to give informed consent.

3.7 Instrumentation:

Fear of Automation:

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am worried that my job might be replaced by automation or AI in the near future.					
Automation technologies threaten my job security in the O&G industry.					
I feel anxious about the role of AI in reshaping my current job responsibilities.					
My job involves tasks that are highly vulnerable to being automated.					
I believe that AI will eventually reduce the demand for my current job role.					

Manual Tasks:

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A significant part of my job involves routine or repetitive tasks.					
Physical/manual tasks are a major part of my job responsibilities.					
I believe my job role is primarily task-driven and could be automated easily.					
My job doesn't require much critical thinking or creative problem-solving.					

Most of the work I do could be efficiently handled by machines or AI technologies.					

Workplace Adaptability to AI:

Statement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
My organization is preparing employees well for the upcoming changes due to AI.					
I have access to training or resources to improve my understanding of AI technologies.					
I am confident in my ability to adapt to new technologies introduced by AI.					
My organization encourages employees to learn about digitalization and AI.					
I believe AI will positively transform the workplace culture in the O&G sector.					

Perceived Opportunity:

Statement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I see AI and automation as an opportunity to enhance my career in the O&G industry.					
AI technologies will create new job opportunities in my organization.					
Learning about AI and digital technologies will help me progress in my career.					

Automation allows employees to focus on more complex and value-added tasks.					
I am optimistic about the impact of digitalization on the future of work in the O&G industry.					

Job Satisfaction with AI Integration:

Statement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
The introduction of AI will increase my job satisfaction by reducing monotonous tasks.					
I believe AI will enhance my ability to perform my job effectively.					
I expect that AI will allow me to work on more meaningful and impactful projects.					
AI-driven automation will give me more time to focus on personal development and learning.					
The integration of AI in my workplace has made my job more dynamic and engaging.					

3.8 Data collection procedures:

In the study, the primary data was gathered by conducting a structured questionnaire survey. These methods enabled detailed investigation of the participants' experiences, views and insights on the implementation of AI technologies at the workplace. Probing questions were posed to get an enhanced understanding (Kallio *et al.*, 2016). Employing the convenience sampling technique, participants were surveyed through a

questionnaire form. For data credibility, member checking was used where participants were given a chance to review on preliminary analysis of findings (Birt *et al.*, 2016). At every stage of data collection, this study adhered to all applicable ethical standards, including those about informed consent and confidentiality.

3.9 Data Analysis

In data analysis for the study, there was the use of which is an abbreviation for "Statistical Package for the Social Sciences" (SPSS). Such raw data is to be subjected to the methods of quantitative methodology belonging to the field of sciences for purposes of analysis and interpretation. In analyzing collected data from the participants, descriptive analyses tools such as means and frequencies were employed to show participants' characteristics and their responses respectively while standard deviation was used to determine variability of data collected. Further, plausible hypothesis testing like 'Spearman's rank correlation' was also utilized to establish relations between variables – level of AI exposure and perceptions of changed workforce (United States) – (Hauke and Kossowski, 2011). To determine the relationship that varies on changes in roles of workforce, skills demand and job satisfaction on adoption of AI into the sector, "ordinal regression analysis" was used.

Data were tested for normality using skewness and kurtosis to confirm the assumptions for statistical analysis were met. Using SPSS proved easier in handling data to give outputs on trends in a workforce to understand changes resulting from AI. In its interpretation, all statistical findings were expressed in terms of significance levels (p-values), as is recommended in most quantitative research studies.

3.10 Research design limitations:

1. **Convenience Sampling Bias**

- The convenience sampling approach may have skewed the sample towards particular viewpoints because participants were chosen based on availability rather than by random selection, which restricts the findings' ability to be applied broadly.

2. **Restricted Access to Key Informants**
    - Due to the specialized nature of the workforce, accessing senior executives or individuals with deep AI expertise across all operational levels was challenging, which may restrict the depth of insights.
3. **Sample Size Constraints**
    - Although 300 participants provide valuable quantitative data, the relatively small sample size for a large and diverse industry like O&G limits broader applicability, particularly in different geographical regions or organizational contexts.
4. **Dynamic Nature of AI Developments**
    - Given the rapid evolution of AI technologies, some insights gathered during the study might become outdated quickly, limiting the long-term relevance of findings for workforce planning.
5. **Sector-Specific Focus**
    - Focusing exclusively on O&G industry means the findings may not fully apply to other sectors with differing adoption rates, challenges, or workforce dynamics related to AI.
6. **Dependence on Self-Reported Data**
    - Since many insights are based on participants' experience and their perception of an event, they are likely to recall wrong or exaggerate or under- state their findings.

3.11 Conclusion

Finally, the present study aims to call on academicians and O&G industry decision-makers' attention to the importance of both opportunities and risks that the AI revolution creates for the future labor market in the industry. It is provoking changes in work roles and automating tasks, and opening new job opportunities for accessing, analyzing, learning from, and working with data and technology. On the one hand, automation presents new opportunities for adding value through various tasks that employees can perform, on the other hand, its implementation raises important considerations about personnel replacement and ability to change.

In the light of the findings of this work highlights the imperative of placing an increased emphasis as to the necessity for organizations to foster reskilling strategies and establish an organizational culture that promotes technology adoption. In addition, more attention will be given to SWP, corresponding to new developments in the application of AI technologies, which will become important for optimizing organizational performance, maintaining high employee satisfaction, and long-term company development in O&G industry. But issues like, small number of participants, the qualitative analysis of data collected and the constantly evolving field of AI, the findings of the present study need to be updated from time to time.

CHAPTER IV:

RESULTS

4.1 Reliability Analysis

Table 4.1: Reliability Statistics

Cronbach's Alpha	N of Items
.749	25

Table 4.1 shows that the 25 items' Cronbach's Alpha of 0.749 suggests adequate internal consistency, suggesting they are moderately linked and assess a common concept, although there is potential for improvement.

4.2 Frequency Analysis

Demographic Details of Respondents

Table 4.2: Demographic Details

		Frequency	Percent
Age Group	18–24 Years	34	11.3
	25–34 Years	112	37.3
	35–44 Years	93	31
	45–54 Years	44	14.7
	55 Years and above	17	5.7
Gender	Male	126	42
	Female	150	50
	Prefer not to say	24	8
Educational Qualification	High School Diploma or Equivalent	12	4
	Associate degree	49	16.3
	Bachelor's Degree	86	28.7
	Master's Degree	116	38.7
	Doctorate (PhD)	37	12.3
Current Job Role/Title	Engineer/Technical Specialist	15	5
	Data Scientist/Analyst	44	14.7

	Manager/Supervisor	85	28.3
	Executive/Director	86	28.7
	Human Resources	37	12.3
	IT/Technology Specialist	25	8.3
	Other	8	2.7
Years of Experience in the O&G Industry	Less than 5 years	29	9.7
	5-10 years	100	33.3
	11-15 years	97	32.3
	16-20 years	47	15.7
	More than 20 years	27	9
Company Type	International Oil Company (IOC)	35	11.7
	National Oil Company (NOC)	155	51.7
	Oilfield Services Company	89	29.7
	Other	21	7
Level of Familiarity with AI and Digital Technologies	Not Familiar	8	2.7
	Basic Understanding	33	11
	Intermediate Knowledge	152	50.7
	Advanced Knowledge	85	28.3

	Expert/Hands-on Experience	22	7.3
Country/Region of Employment	North America	10	3.3
	South America	26	8.7
	Europe	68	22.7
	Middle East	119	39.7
	Africa	34	11.3
	Asia-Pacific	38	12.7
	Other	5	1.7

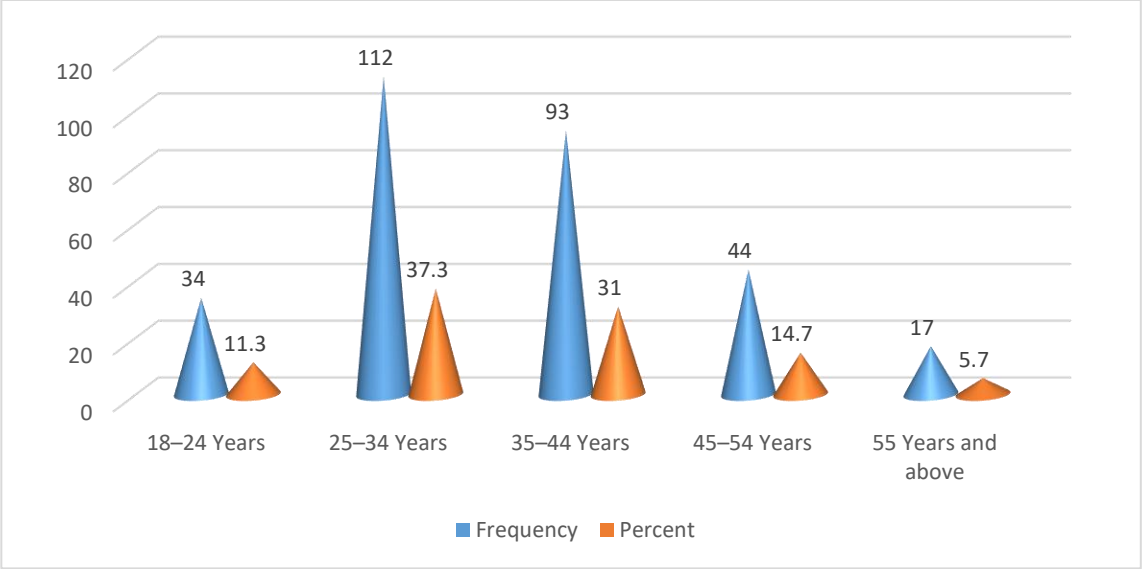

Figure 4.1: Age

As seen in Figure 4.1, 37.3% of participants are 25–34 years old, followed by 31.0% who are 35–44. Participants aged 18–24 make up 11.3%, while 45–54 make up 14.7%. Seniors (5.7%) make up the smallest percentage. The participants are likely youthful to middle-aged.

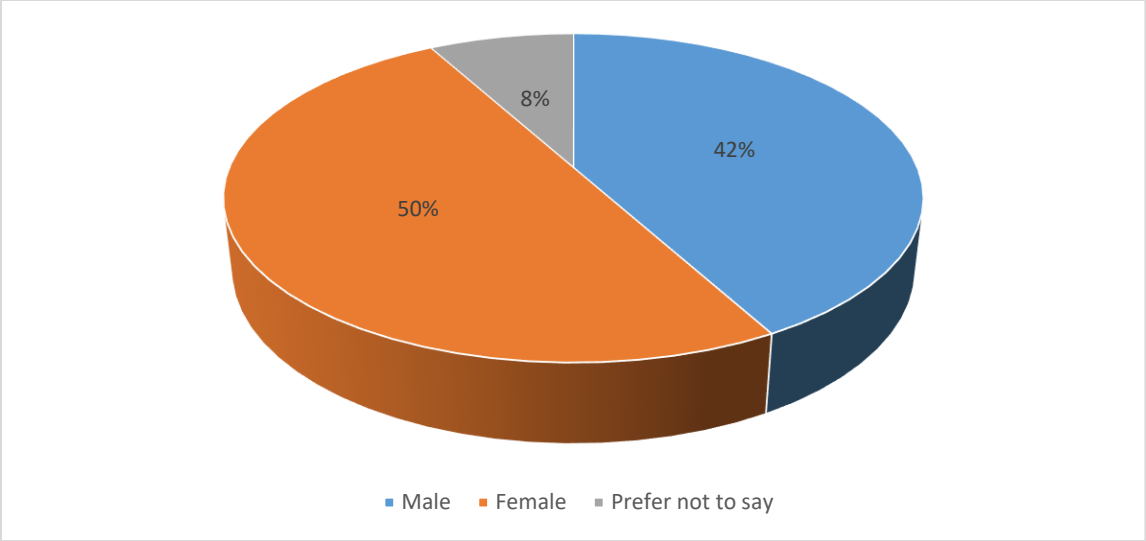

Figure 4.2: Gender

According to Figure 4.2, 50.0% of participants are female, and 42.0% are male. A large percentage of respondents, 8.0%, elected not to declare their gender.

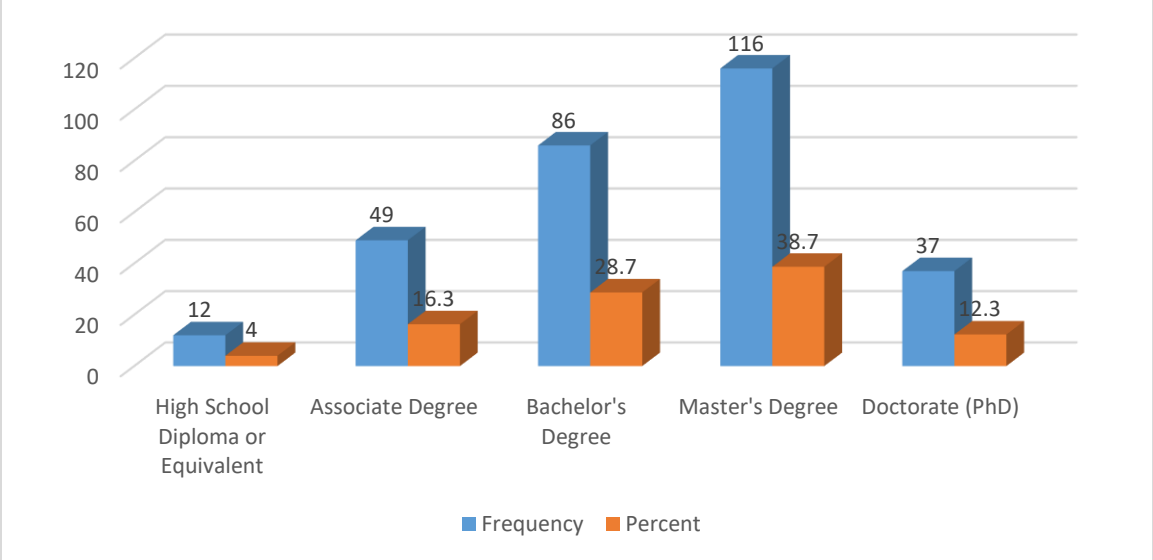

Figure 4.3: Educational Qualification

In figure 4.3, 38.7% of participants have a Master's degree, followed by 28.7% with a Bachelor's. Doctorates account for 12.3% and associate degrees for 16.3%. Four per cent

had a high school diploma or equivalent, suggesting a highly educated participation population.

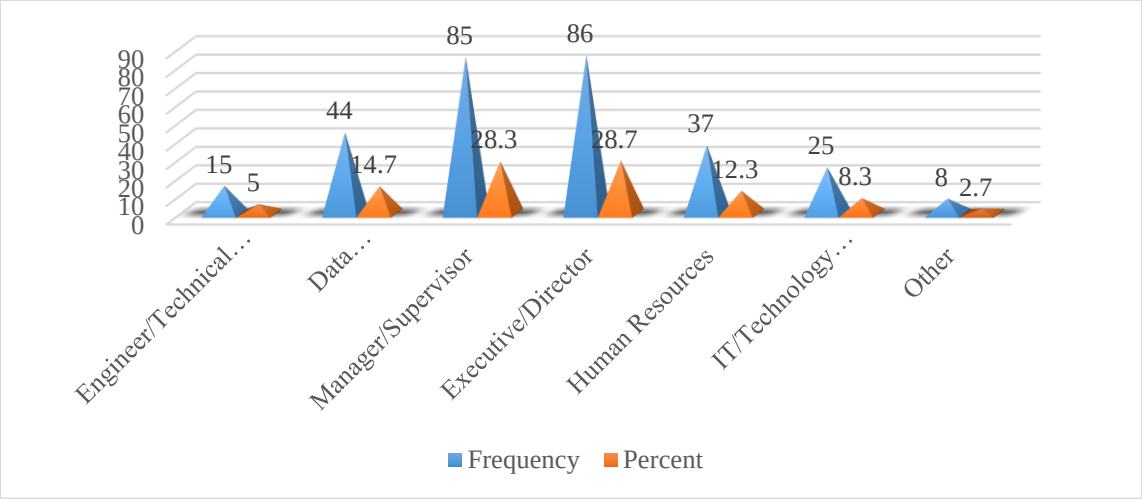

Figure 4.4: Current Job Role/Title

According to Figure 4.4, Executives/Directors (28.7%) and Managers/Supervisors (28.3%) make up more than half of the sample. HR professionals make up 12.3%, IT/Technology Specialists 8.3%, and Data Scientists/Analysts 14.7%. 2.7% are "Other" and 5% are engineers/technical specialists, reflecting a diversified professional background.

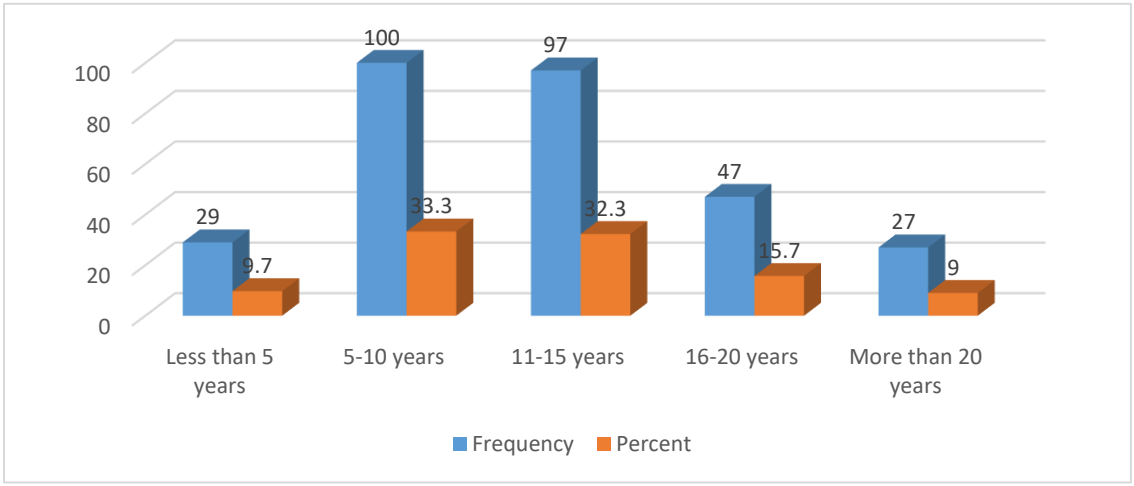

Figure 4.5: Years of Experience in the O&G Industry

As shown in Figure 4.5, the data on years of experience in the Oil & Gas (O&G) industry, most participants have 5–10 years (33.3%) or 11–15 years (32.3%) of experience, making up the majority of the sample. Those with 16–20 years account for 15.7%, while participants with less than 5 years and more than 20 years represent smaller proportions at 9.7% and 9%, respectively. This indicates a workforce with predominantly mid-level experience in the industry.

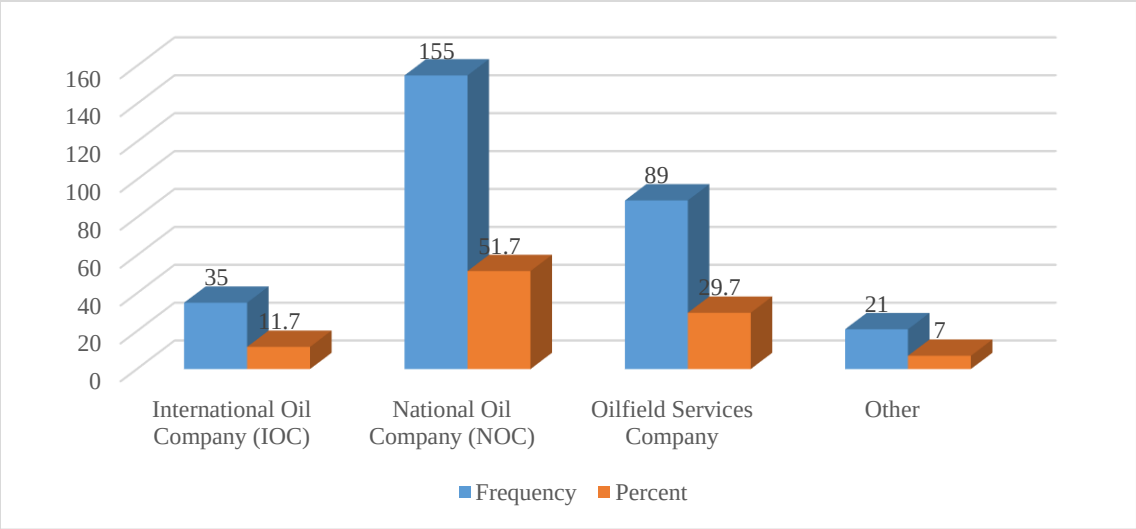

Figure 4.6: Company Type

Figure 4.6, data on respondent's experience indicates that National Oil Companies (NOC) dominate with 155 participants representing 51.7% of the total, followed by Oilfield Services Companies with 89 participants (29.7%). International Oil Companies (IOC) account for 35 participants (11.7%), while the remaining 21 participants (7%) fall under the other category.

Fear of Automation

Table 4.3: Fear of Automation

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	Frequency	44	189	31	30	6

I am worried that my job might be replaced by automation or AI in the near future.	Percent	14.7	63	10.3	10	2
Automation technologies threaten my job security in the O&G industry.	Frequency	25	59	84	129	3
	Percent	8.3	19.7	28	43	1
I feel anxious about the role of AI in reshaping my current job responsibilities.	Frequency	20	115	112	40	13
	Percent	6.7	38.3	37.3	13.3	4.3
My job involves tasks that are highly vulnerable to being automated.	Frequency	20	89	110	75	6
	Percent	6.7	29.7	36.7	25	2
I believe that AI will eventually reduce the demand for my current job role.	Frequency	20	79	94	78	29
	Percent	6.7	26.3	31.3	26	9.7

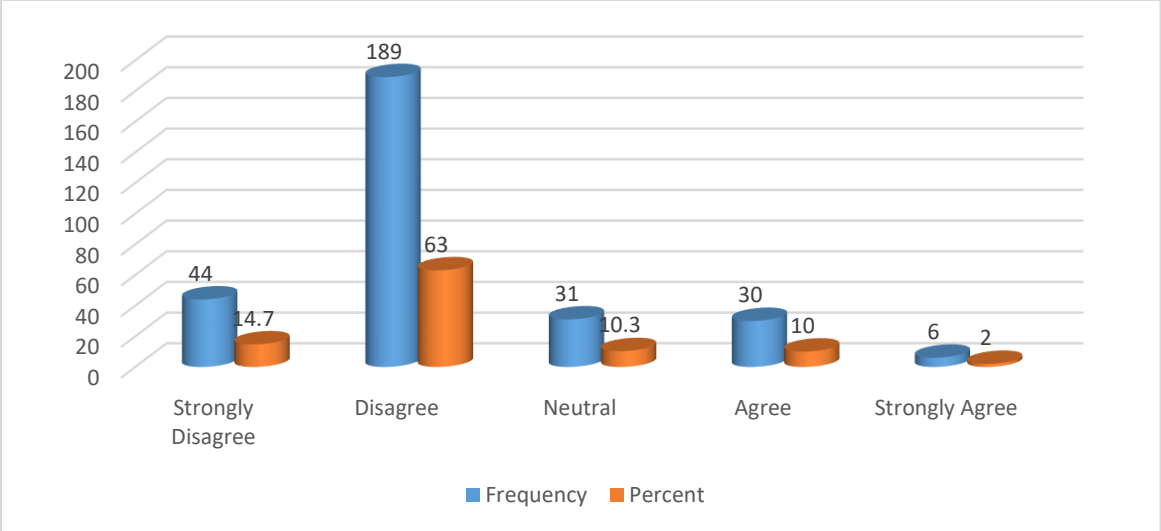

Figure 4.7: I am worried that my job might be replaced by automation or AI in the near future.

In Figure 4.7, 63.0% of participants doubt that automation or AI will soon replace their occupations, while 14.7% strongly disagree. Only 12.0% agree (10.0%) or strongly

agree (2.0%), while 10.3% are indifferent. Most participants appear confident in their jobs regarding automation or AI-driven job displacement.

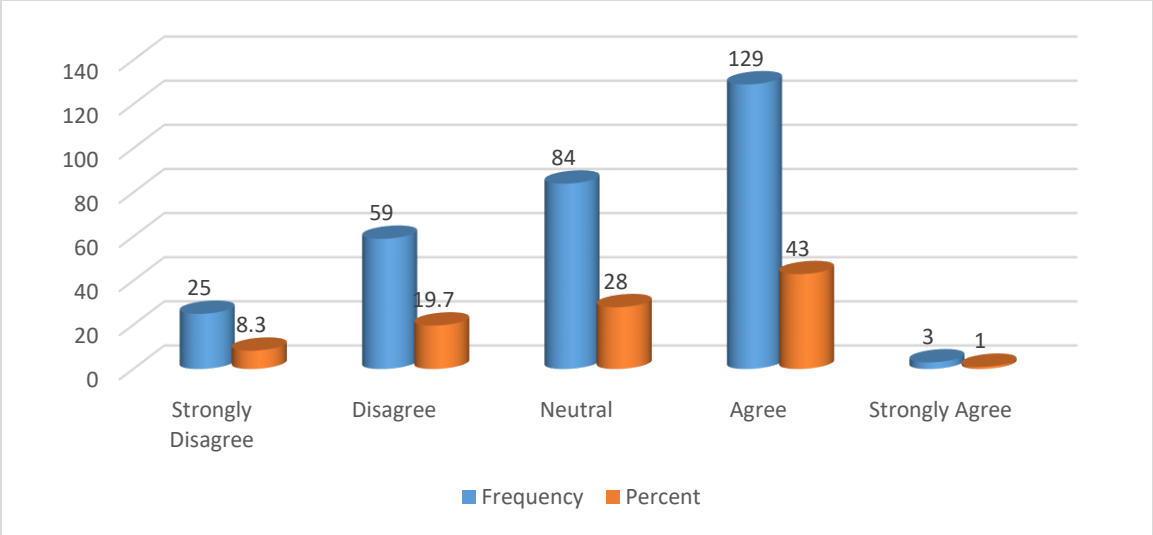

Figure 4.8: Automation technologies threaten my job security in the O&G industry.

As shown in Figure 4.8, 43.0% of participants believe automation technologies endanger their O&G job security, with 1.0% strongly agreeing. Conversely, 28.0% are neutral, suggesting indecision. Overall, 28.0% disagree or strongly disagree (19.7% and 8.3%), indicating that a majority of respondents consider automation as an employment threat.

The key insight here is that there's significant concern about automation in the O&G workforce, with nearly half (43%) feeling their jobs could be at risk. However, there's also considerable uncertainty (28% neutral) and a notable portion (28%) who feel secure despite automation advances. This split suggests there may be varying levels of exposure to automation across different roles or departments within the O&G industry, or different levels of confidence in employees' ability to adapt to technological changes.

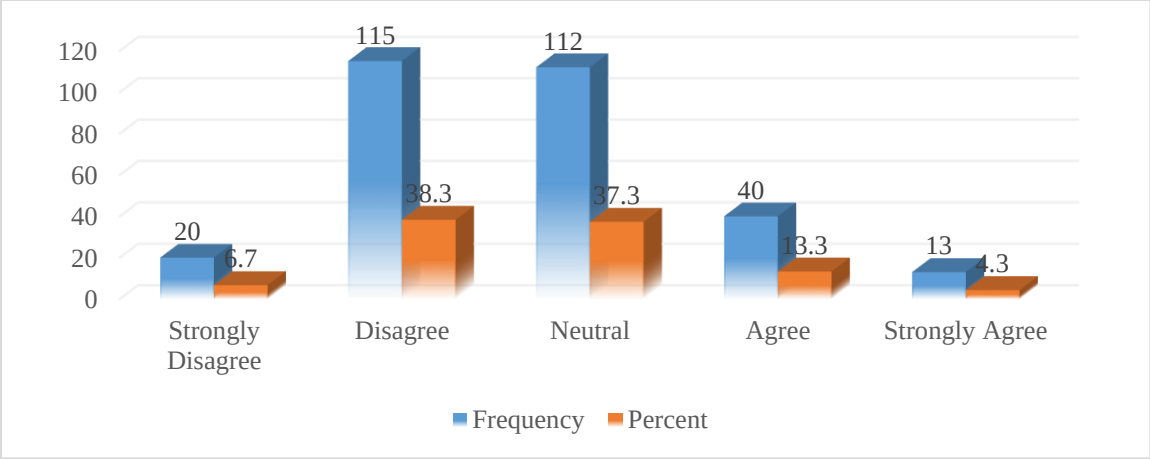

Figure 4.9: I feel anxious about the role of AI in reshaping my current job responsibilities.

Based on the survey data shown in the Figure 4.9, the majority of respondent's express concern or uncertainty about AI's impact on their job responsibilities. Specifically, 42% of respondents (115 + 20 = 135 people) disagree or strongly disagree with feeling anxious about AI reshaping their jobs, while 16.6% (53 people) agree or strongly agree with feeling anxious. A notable portion - 35.3% (112 people) - remain neutral on the matter. This suggests that while there's a larger proportion of employees who aren't anxious about AI's impact on their work, there's still significant uncertainty among workers about how AI will affect their job responsibilities.

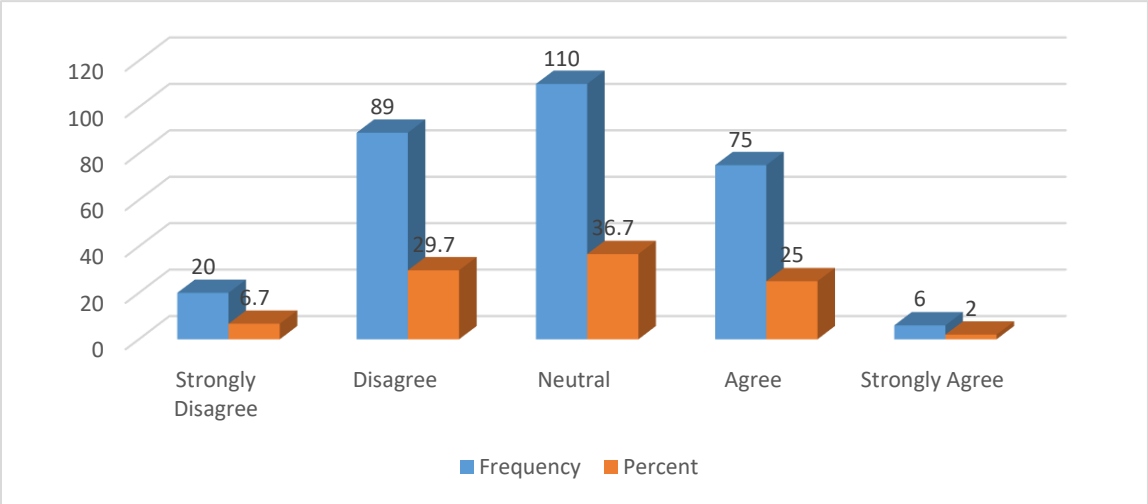

Figure 4.10: My job involves tasks that are highly vulnerable to being automated.

Above Figure 4.10, regarding job automation vulnerability, the largest group - 110 respondents (36.7%) - maintains a neutral stance about whether their jobs are vulnerable to automation. However, a significant portion of respondents - 109 people (36.4%, combining "Strongly Disagree" and "Disagree") - don't believe their jobs are highly vulnerable to automation. On the other hand, 81 respondents (27.2%, combining "Agree" and "Strongly Agree") feel their jobs are susceptible to automation.

This suggests that while there's a fair even split in perceptions, slightly more employees feel confident that their jobs are resistant to automation, though a substantial portion remain uncertain. The relatively high number of neutral responses might indicate that many workers are still unsure about which aspects of their jobs could potentially be automated in the future.

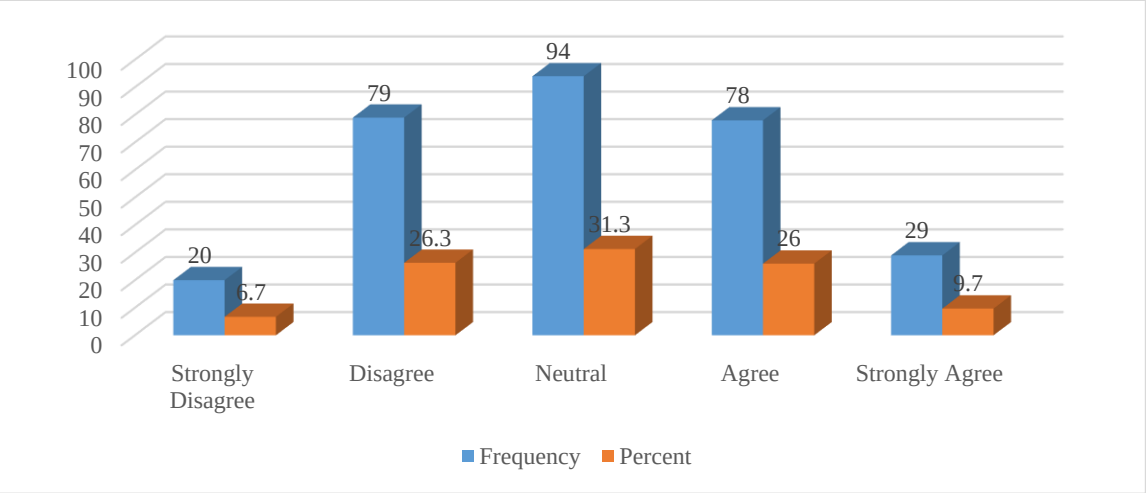

Figure 4.11: I believe that AI will eventually reduce the demand for my current job role.

The survey results regarding AI-related employment demand- Figure 4.11 demonstrates that there's a fairly balanced distribution with a slight lean towards disagreement. Out of all respondents, 33% (99 people combining "Strongly Disagree" and "Disagree") don't believe AI will reduce demand for their current role. On the other hand, 35.7% (107 people combining "Agree" and "Strongly Agree") believe AI will eventually

decrease demand for their position. The remaining 31.3% (94 people) maintain a neutral stance.

This relatively even split suggests there's no clear consensus among workers about AI's future impact on job demand. What's particularly interesting is that despite earlier data showing less anxiety about AI's impact on job responsibilities, there's more concern about AI's potential to reduce overall job demand in their field. This might indicate that while workers feel confident about adapting to AI in their current roles, they have more uncertainty about long-term job market effects.

Manual Tasks

Table 4.4: Manual Tasks

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A significant part of my job involves routine or repetitive tasks.	Frequency	37	182	32	25	24
	Percent	12.3	60.7	10.7	8.3	8
Physical/manual tasks are a major part of my job responsibilities.	Frequency	20	48	90	135	7
	Percent	6.7	16	30	45	2.3
I believe my job role is primarily task-driven and could be automated easily.	Frequency	15	104	125	44	12
	Percent	5	34.7	41.7	14.7	4
My job doesn’t require much critical thinking or creative problem-solving.	Frequency	29	103	104	56	8
	Percent	9.7	34.3	34.7	18.7	2.7
	Frequency	23	67	108	75	27

Most of the work I do could be efficiently handled by machines or AI technologies.	Percent	7.7	22.3	36	25	9

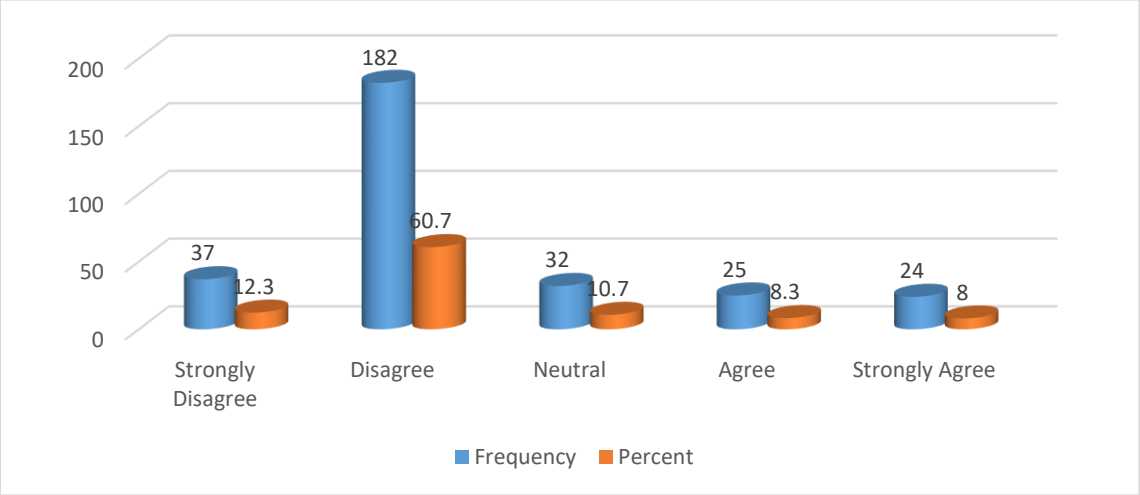

Figure 4.12: A significant part of my job involves routine or repetitive tasks.

Figure 4.12 shows that 60.7% of participants reject and 12.3% completely oppose the idea that a large part of their profession includes routine or repetitive duties, showing that most find their work less monotonous. 10.7% are impartial, 8.3% agree, and 8.0% entirely concur, suggesting most employees engage in varied, dynamic work rather than standardized processes.

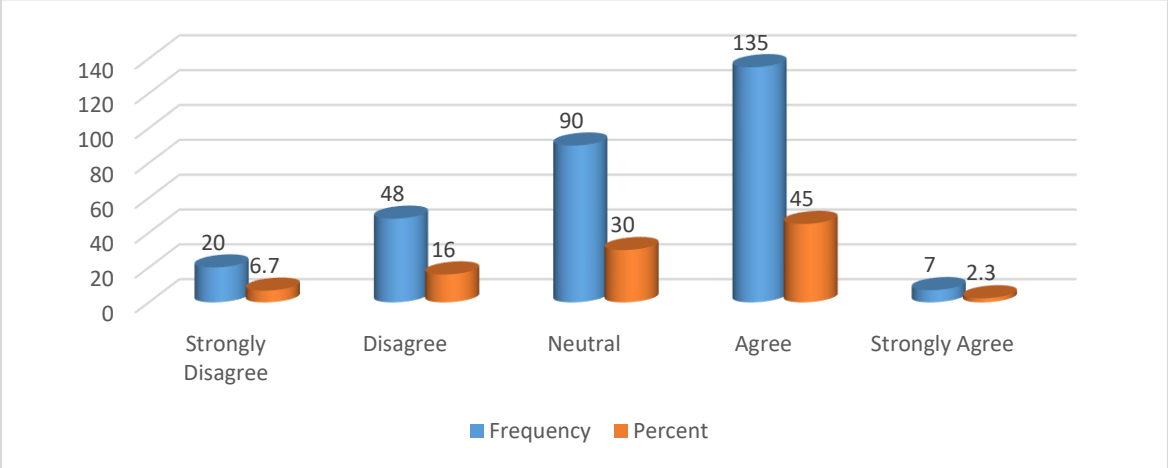

Figure 4.13: Physical/manual tasks are a major part of my job responsibilities.

As shown in Figure 4.13, a significant majority of employees (47.3%) agree or strongly agree that physical/manual tasks are a major part of their job responsibilities, while 22.7% disagree or strongly disagree, and a substantial portion (30%) remain neutral. This indicates that manual work is a predominant aspect of the workforce's daily activities.

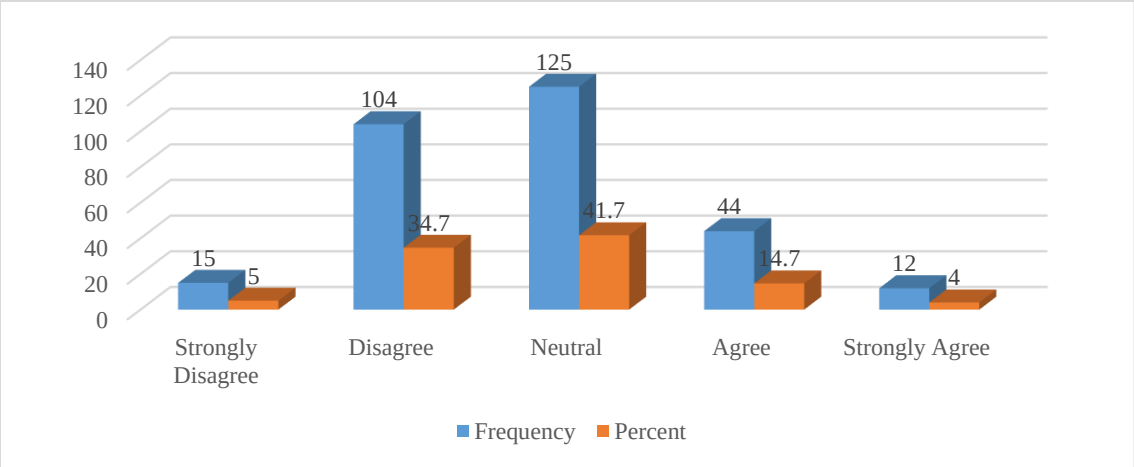

Figure 4.14: I believe my job role is primarily task-driven and could be automated easily.

The data in Figure 4.14 strongly indicates that most employees (39.7%) disagree or strongly disagree that their jobs could be easily automated, while only 18.7% agree or strongly agree with this assessment, and a notable 41.7% remain neutral. This demonstrates that respondents generally perceive their roles as requiring human judgment and skills that would be difficult to automate.

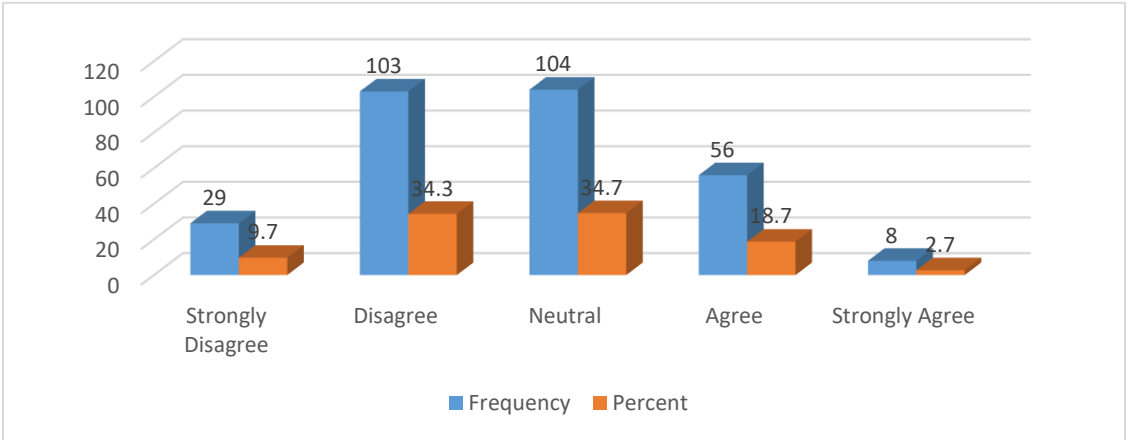

Figure 4.15: My job doesn't require much critical thinking or creative problem-solving.

The data in Figure 4.15 reveals that most employees (44% combining those who strongly disagree and disagree) reject the notion that their jobs lack critical thinking or creative problem-solving requirements, while only 21.4% agree or strongly agree with this statement, and 34.7% remain neutral, suggesting that the participants' generally views their roles as requiring significant cognitive engagement and creative solutions or fewer people feels their occupations lack critical thinking or innovation.

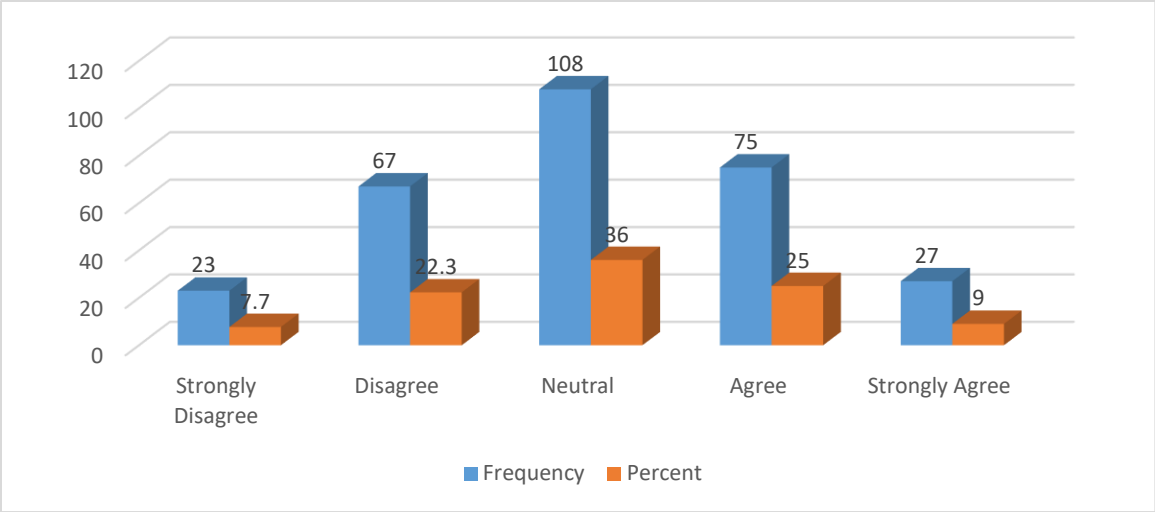

Figure 4.16: Most of the work I do could be efficiently handled by machines or AI technologies.

The survey in Figure 4.16 shows a mixed perspective, with 34% of respondents agreeing or strongly agreeing that their work could be handled by machines or AI, while 30% disagree or strongly disagree, and the largest group (36%) remains neutral, suggesting considerable uncertainty about the potential for AI and automation to replace their job functions.

Workplace Adaptability to AI

Table 4.5: Workplace Adaptability to AI

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

My organization is preparing employees well for the upcoming changes due to AI.	Frequency	27	181	21	48	23
	Percent	9	60.3	7	16	7.7
I have access to training or resources to improve my understanding of AI technologies.	Frequency	15	32	86	141	26
	Percent	5	10.7	28.7	47	8.7
I am confident in my ability to adapt to new technologies introduced by AI.	Frequency	8	67	123	77	25
	Percent	2.7	22.3	41	25.7	8.3
My organization encourages employees to learn about digitalization and AI.	Frequency	6	103	93	68	30
	Percent	2	34.3	31	22.7	10
I believe AI will positively transform the workplace culture in the O&G sector.	Frequency	12	52	106	94	36
	Percent	4	17.3	35.3	31.3	12

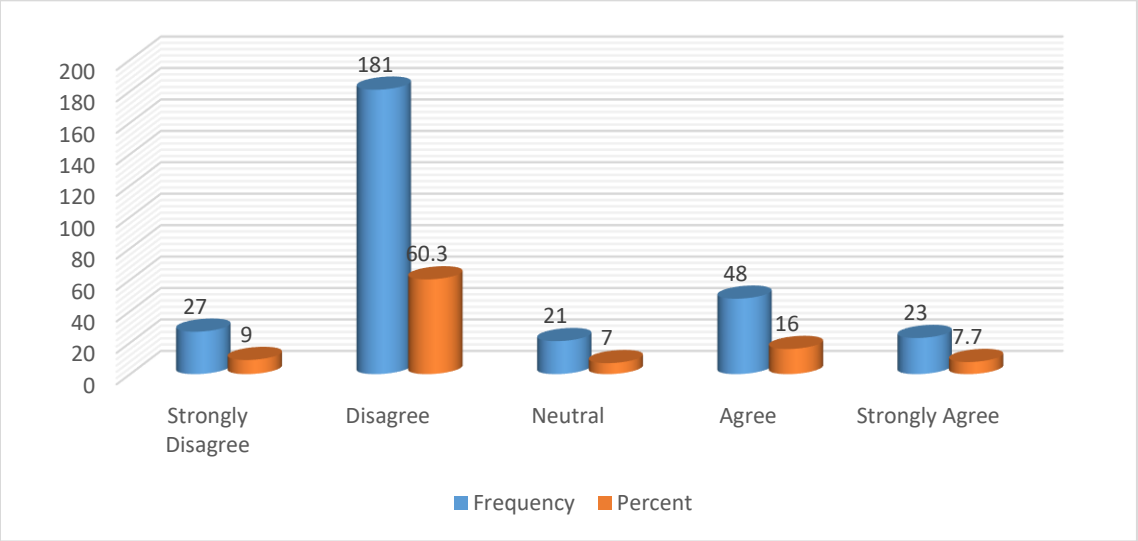

Figure 4.17: My organization is preparing employees well for the upcoming changes due to AI.

The survey data in Figure 4.17 reveals a concerning trend: over 60% of employees disagree that they're being adequately prepared for AI-related changes, with only 23.7% feeling positively about the preparation efforts. The strong negative sentiment (181 disagreeing and 27 strongly disagreeing) suggests an urgent need for the organization to enhance its AI readiness initiatives through better training, clearer communication, and more robust support systems for employees.

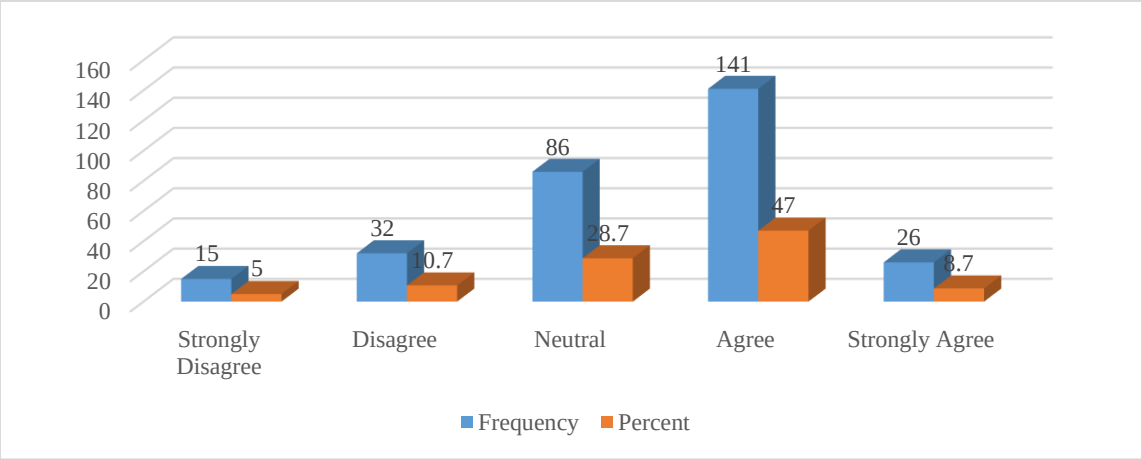

Figure 4.18: I have access to training or resources to improve my understanding of AI technologies.

The data in Figure 4.18 shows a notably positive response regarding access to AI training and resources, with approximately 56% of respondents (141 agree and 26 strongly agree) indicating they have access to these resources. Only about 15.7% disagree (32 disagree and 15 strongly disagree), while a considerable portion (86 respondents or 28.7%) remain neutral. This suggests that while the organization has made AI learning resources available to employees, there might still be room to increase awareness or improve the accessibility of these resources, particularly for those who are neutral or uncertain about their access.

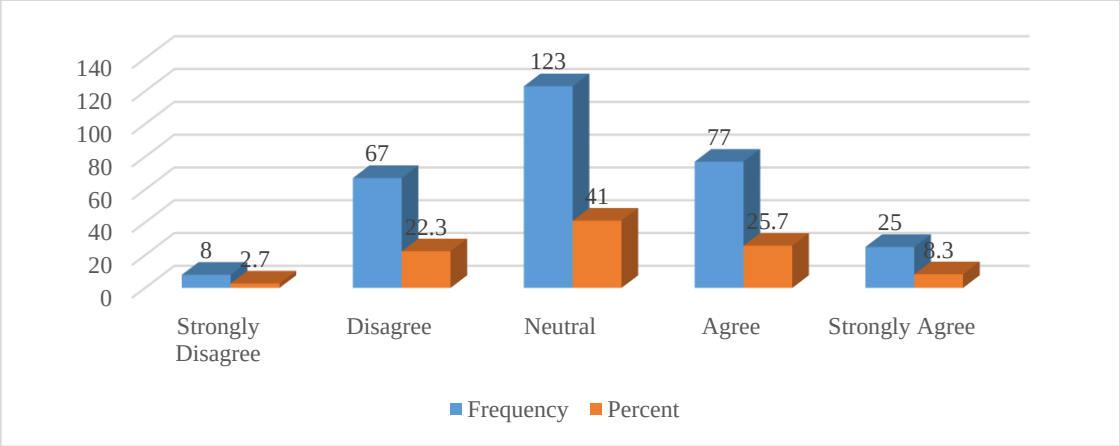

Figure 4.19: I am confident in my ability to adapt to new technologies introduced by AI.

The above figure 4.19 depicts respondent's varying confidence in adopting emerging AI technology. 25% doubt their abilities (22.3% reject and 2.7% highly reject), whereas 34% are confident. Notably, 41% are unfavorable showing adaptation doubt. This implies that while some employees feel prepared, many are doubtful or lack confidence, emphasizing the need for stronger support systems and training to improve AI-driven change adaptation.

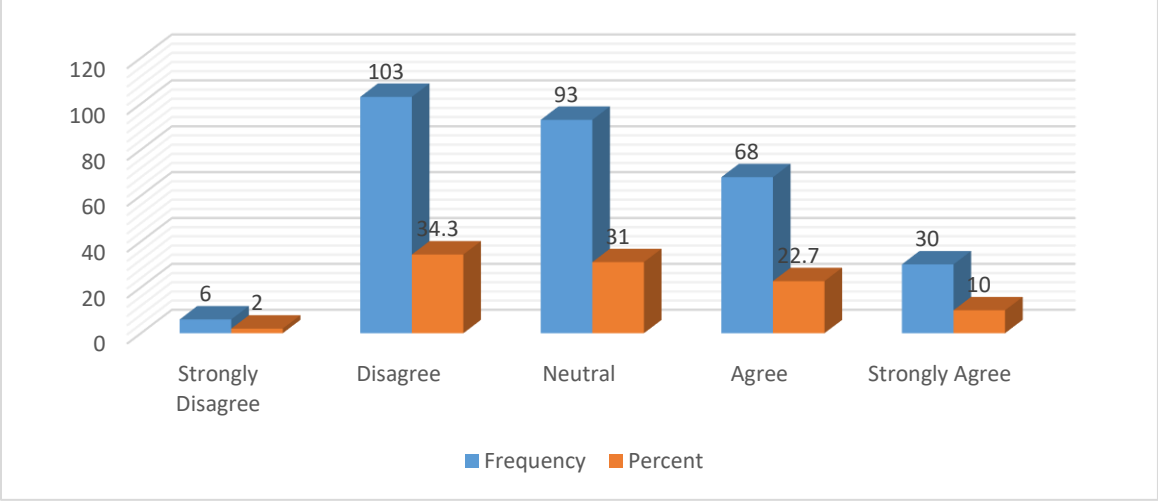

Figure 4.20: My organization encourages employees to learn about digitalization and AI.

Figure 4.20 shows a mixed view of the company's digitalization and AI education support. However, 34.3% disagree, and 2% strongly disagree that such an incentive is

offered, demonstrating a significant support gap. In addition, 31% are neutral, indicating confusion or strong opinions. This relatively even distribution across negative, neutral, and positive responses, with a slight lean toward disagreement, indicates that many organizations may need to strengthen their initiatives to encourage employee learning in digital technologies and AI.

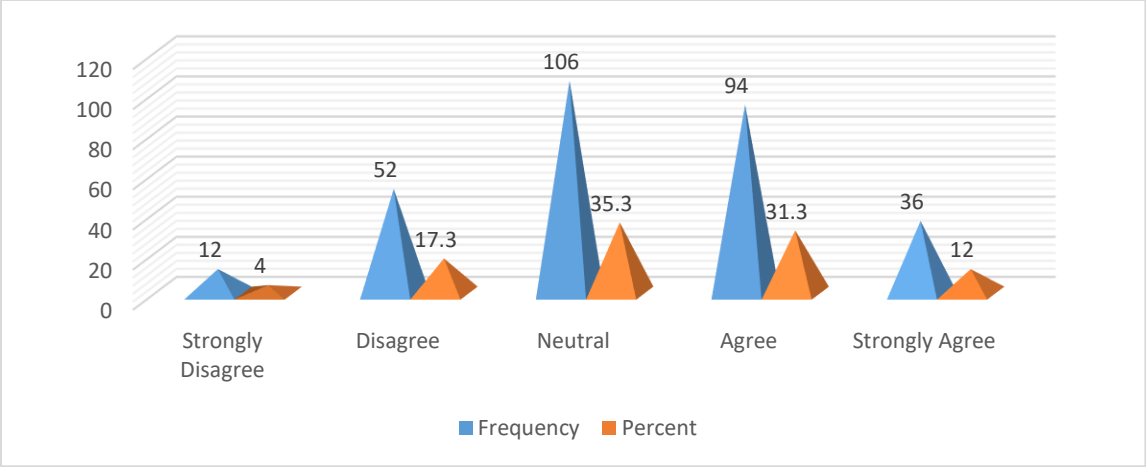

Figure 4.21: I believe AI will positively transform the workplace culture in the O&G sector.

Above Figure 4.21 displays optimistic expectations and uncertainty about AI's impact on oil and gas workplace culture. 43.3% of respondents (31.3% agree and 12% strongly agree) believe AI will benefit them. 21.3% (17.3% disagree and 4% strongly disagree) are doubtful, and 35.3% shows neutral response, showing substantial ambiguity. These numbers suggest that while there's generally more optimism than pessimism about AI's impact on O&G workplace culture, there's still significant uncertainty as reflected in the high number of neutral responses. To boost employee trust in AI's cultural influence, the organizations should better convey its benefits while addressing employee concerns.

Perceived Opportunity

Table 4.6 Perceived Opportunity

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

I see AI and automation as an opportunity to enhance my career in the O&G industry.	Frequency	28	168	25	39	40
	Percent	9.3	56	8.3	13	13.3
AI technologies will create new job opportunities in my organization.	Frequency	8	34	84	138	36
	Percent	2.7	11.3	28	46	12
Learning about AI and digital technologies will help me progress in my career.	Frequency	10	57	122	74	37
	Percent	3.3	19	40.7	24.7	12.3
Automation allows employees to focus on more complex and value-added tasks.	Frequency	7	105	82	66	40
	Percent	2.3	35	27.3	22	13.3
I am optimistic about the impact of digitalization on the future of work in the O&G industry.	Frequency	11	55	111	72	51
	Percent	3.7	18.3	37	24	17

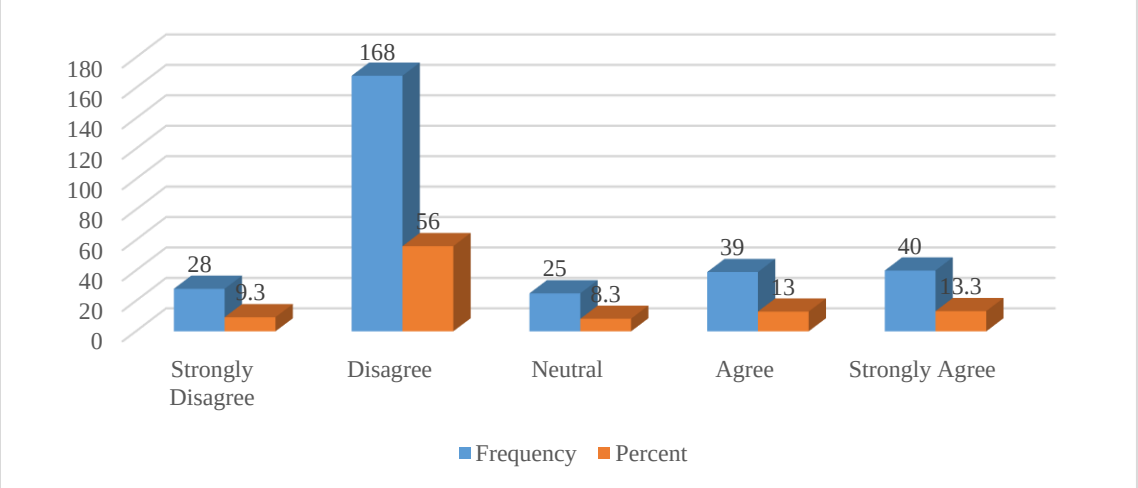

Figure 4.22: I see AI and automation as an opportunity to enhance my career in the O&G industry.

This graph, Figure 4.22 shows employee's attitudes toward AI and automation as a career enhancement opportunity in the Oil & Gas industry. Notably, there's a strong

negative sentiment, with 65.3% of respondents expressing disagreement (56% disagree and 9.3% strongly disagree, representing 168 and 28 respondents respectively). Only 26.6% see AI as a career opportunity, with 13% agreeing and 13.3% strongly agreeing (39 and 40 respondents respectively). A small portion, 8.3% (25 respondents), remain neutral. These findings suggest a significant concern or skepticism among O&G workers about how AI and automation might impact their career prospects, with most viewing it as a potential threat rather than an opportunity for career enhancement; hence the organizations must effectively promote the employment prospects that these technologies will provide.

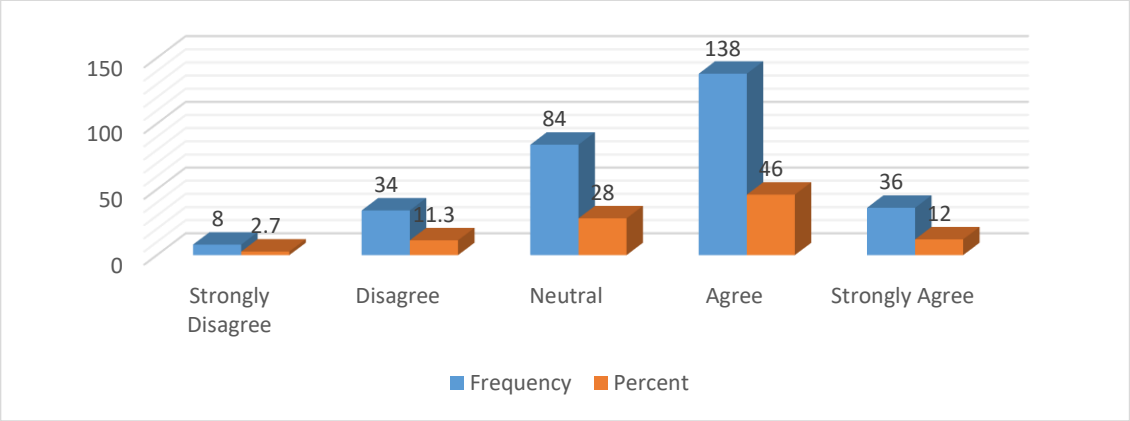

Figure 4.23: AI technologies will create new job opportunities in my organization.

Figure 4.23 shows that most employees expect AI technology to create new jobs. Most, 58% (46% agreement and 12% highly accept), anticipate AI to create new jobs. However, 14% (11.3% reject and 2.7% firmly oppose) are skeptical and 28% have neutral stance, indicating ambiguity. This distribution suggests that despite concerns about AI's impact on existing jobs, most employees believe AI will generate new employment opportunities within their organizations, indicating a generally optimistic view of AI's role in future job creation. However, organizations will have to address skeptical concerns of employees and provide more facts to reassure them.

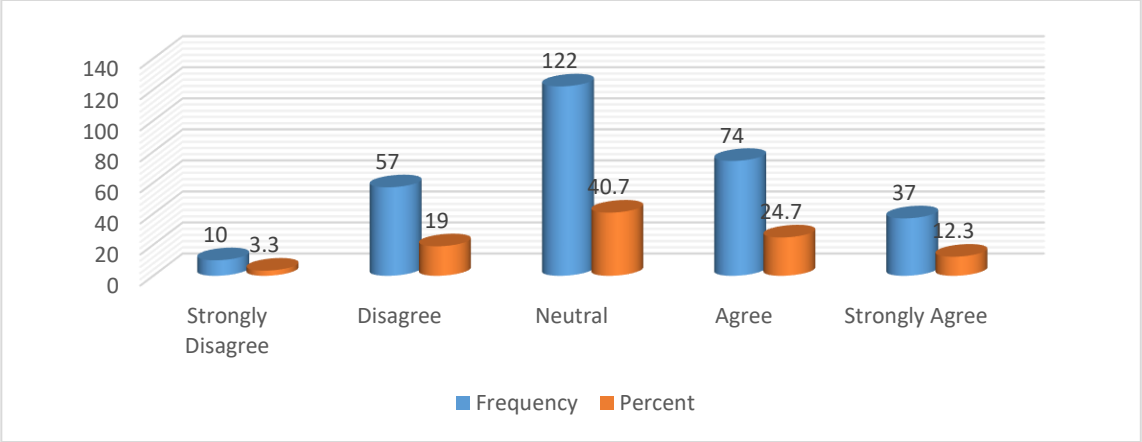

Figure 4.24: Learning about AI and digital technologies will help me progress in my career.

Figure 4.24 indicates a mixed view on AI and digital technology education for professional advancement. 37% (24.7% approve and 12.3% fully concur) think it will help them improve, whereas 22.3% (19% dislike and 3.3% greatly disagree) don't. Additionally, 40.7% are indifferent, indicating career growth uncertainty. The high number of neutral responses suggests uncertainty about how AI and digital skills will impact career progression, though there is a slight lean toward positive perceptions over negative ones. This implies that although some employees comprehend the potential benefits, others need more information and help to address their worries and fears.

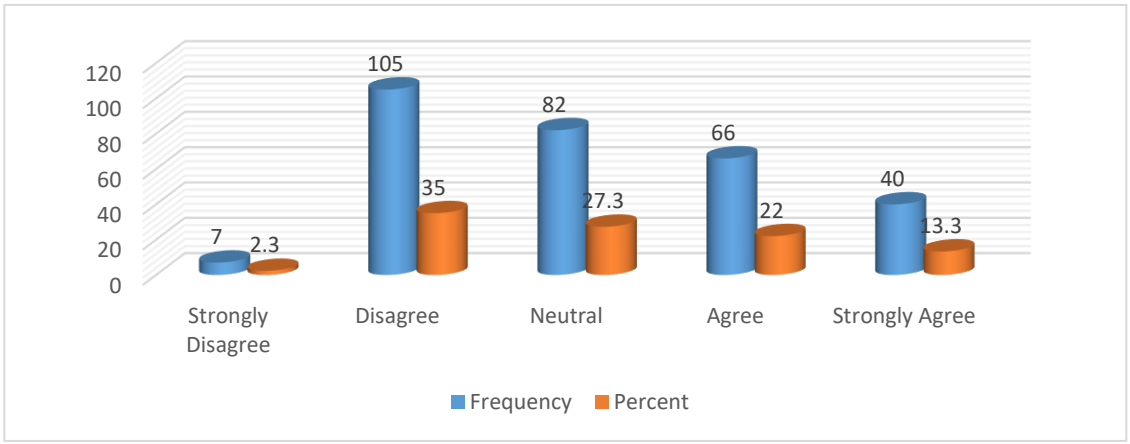

Figure 4.25: Automation allows employees to focus on more complex and value-added tasks.

Figure 4.25 shows varied opinions on whether automation lets workers focus on more sophisticated and valuable activities. 35.3% (22% agree and 13.3% strongly agree) think automation supports this change. However, 37.3% (35% disagree and 2.3% strongly disagree) disagree. Neutral 27.3% are uncertain or ambivalent. These numbers suggest that while some employees see automation as a way to elevate their work to more complex tasks, there's significant skepticism about this claim, with the largest group disagreeing that automation leads to more value-added work opportunities.

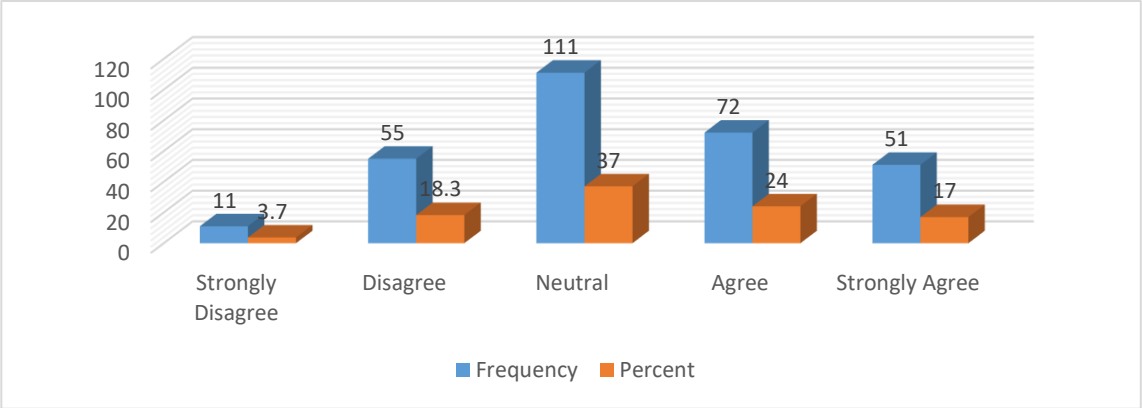

Figure 4.26: I am optimistic about the impact of digitalization on the future of work in the O&G industry.

Figure 4.26 displays varying views on employee optimism about digitalization's impact on the Oil & Gas industry's future of work. While 41% (24% approve and 17% firmly agree) are enthusiastic about its possibilities, 22% (18.3% disagree and 3.7% completely reject) are not, whereas 37% maintains a neutral stance. This suggests a cautiously positive outlook toward digitalization in the O&G industry, with twice as many employees feeling optimistic compared to those feeling pessimistic, though the large neutral group indicates significant uncertainty about the future impact. To address those population with skepticism and ambiguity, the organization need to have additional communication and reassurance communications highlighting digitalization’s long-term benefits.

Job Satisfaction with AI Integration

Table 4.7: Job Satisfaction with AI Integration:

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The introduction of AI will increase my job satisfaction by reducing monotonous tasks.	Frequency	27	171	14	43	45
	Percent	9	57	4.7	14.3	15
I believe AI will enhance my ability to perform my job effectively.	Frequency	7	28	82	141	42
	Percent	2.3	9.3	27.3	47	14
I expect that AI will allow me to work on more meaningful and impactful projects.	Frequency	8	60	126	70	36
	Percent	2.7	20	42	23.3	12
AI-driven automation will give me more time to focus on personal development and learning.	Frequency	7	113	89	57	34
	Percent	2.3	37.7	29.7	19	11.3
The integration of AI in my workplace has made my job more dynamic and engaging.	Frequency	15	51	106	88	40
	Percent	5	17	35.3	29.3	13.3

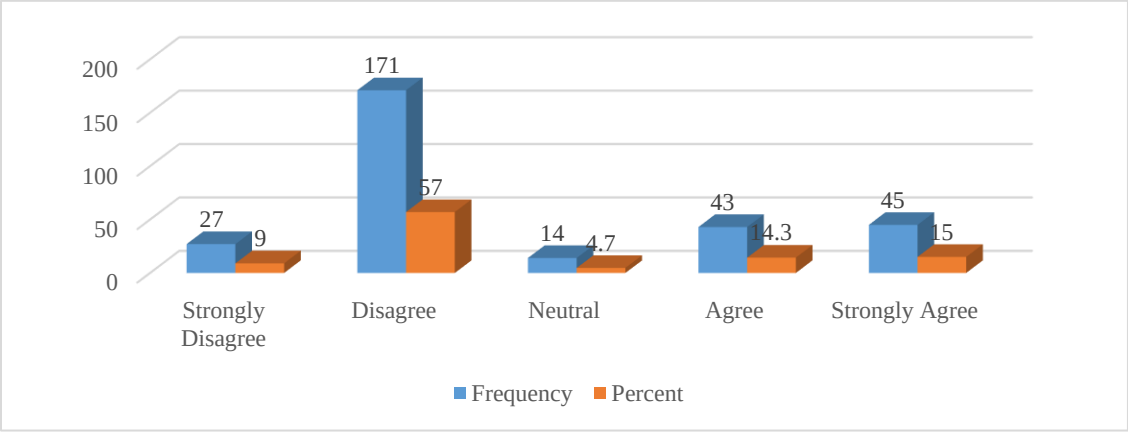

Figure 4.27: The introduction of AI will increase my job satisfaction by reducing monotonous tasks.

Based on the graph in Figure 4.27, there appears to be significant skepticism about AI's potential to increase job satisfaction through reducing monotonous tasks. Majority of respondents (171 people or 57%) disagree with this statement, while an additional 27 people (9%) strongly disagree. Only 88 people (approximately 29.3% combined) express agreement or strong agreement with the notion that AI will improve their job satisfaction. A small portion (14 people or 4.7%) remain neutral on the matter. This suggests that despite the widespread discussion of AI's potential to automate routine tasks, many workers are not convinced this will lead to greater job satisfaction.

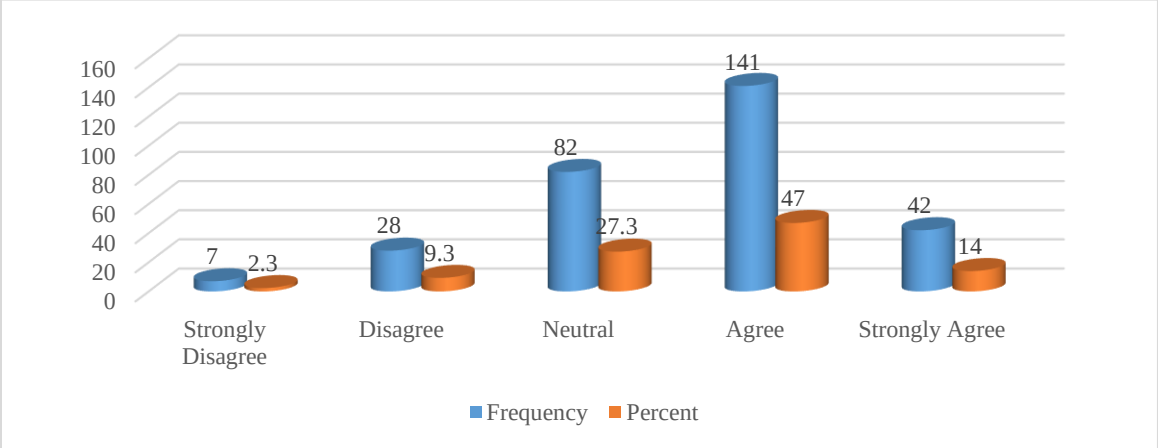

Figure 4.28: I believe AI will enhance my ability to perform my job effectively.

Figure 4.28 shows a notably more positive outlook regarding AI's impact on job performance compared to job satisfaction. A clear majority of respondents believe AI will enhance their ability to work effectively, with 141 people (47%) agreeing and 42 people (14%) strongly agreeing, totaling 61% of positive responses. Only a small portion expresses disagreement, with 28 people (9.3%) disagreeing and 7 people (2.3%) strongly disagreeing. A substantial neutral group of 82 people (27.3%) neither agrees nor disagrees. This suggests that while people may have concerns about job satisfaction, they generally recognize AI's potential to improve their work performance and effectiveness.

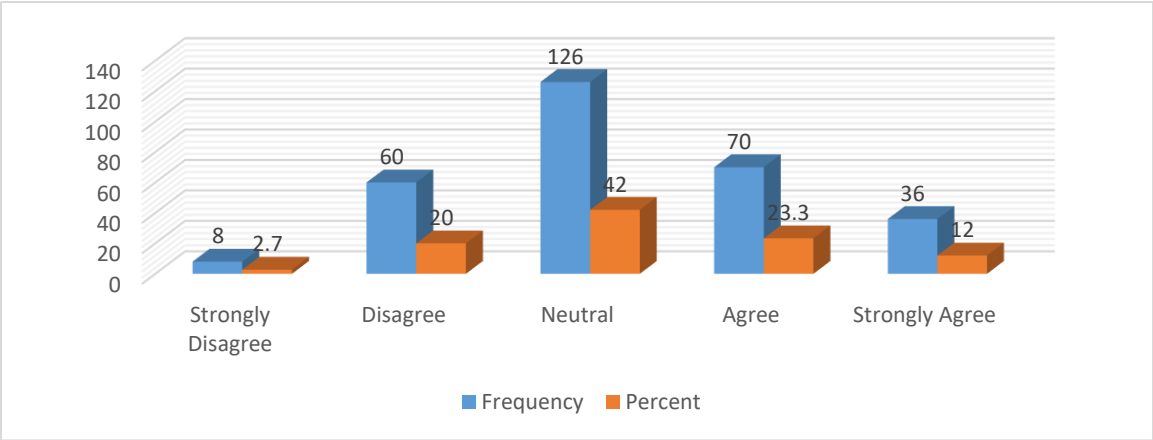

Figure 4.29: I expect that AI will allow me to work on more meaningful and impactful projects.

Figure 4.29 shows a mixed but somewhat positive outlook regarding AI's potential to enable more meaningful work. The largest group consists of neutral respondents, with 126 people (42%) neither agreeing nor disagreeing. Among those who took a position, there's a slight lean toward optimism, with 106 people (35.3% combined) either agreeing or strongly agreeing that AI will lead to more meaningful and impactful projects. On the contrary, 68 people (22.7% combined) disagree or strongly disagree with this sentiment. This distribution suggests that while there's some optimism about AI's potential to elevate work quality, there's still significant uncertainty about AI's capacity to create more meaningful job possibilities.

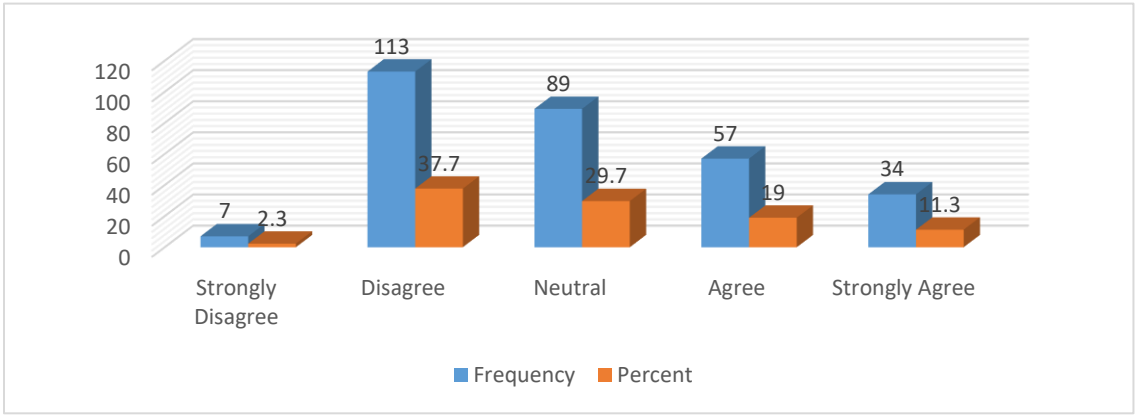

Figure 4.30: AI-driven automation will give me more time to focus on personal development and learning.

Figure 4.30 reveals a somewhat pessimistic view regarding AI's potential to free up time for personal development and learning. A significant portion of respondents (113 people or 37.7%) disagree with this statement, and an additional 7 people (2.3%) strongly disagree, totaling 40% negative responses. While 91 people (30.3% combined) either agree or strongly agree that AI will provide more time for personal growth, a substantial group of 89 people (29.7%) remains neutral.

When viewed alongside the previous graphs, an interesting pattern emerges, while people believe AI will help them work more effectively, they're less convinced it will translate into practical benefits like increased job satisfaction, meaningful work, or additional time for personal development. This might suggest concerns that efficiency gains from AI could be absorbed by other work demands rather than being reinvested in employee development.

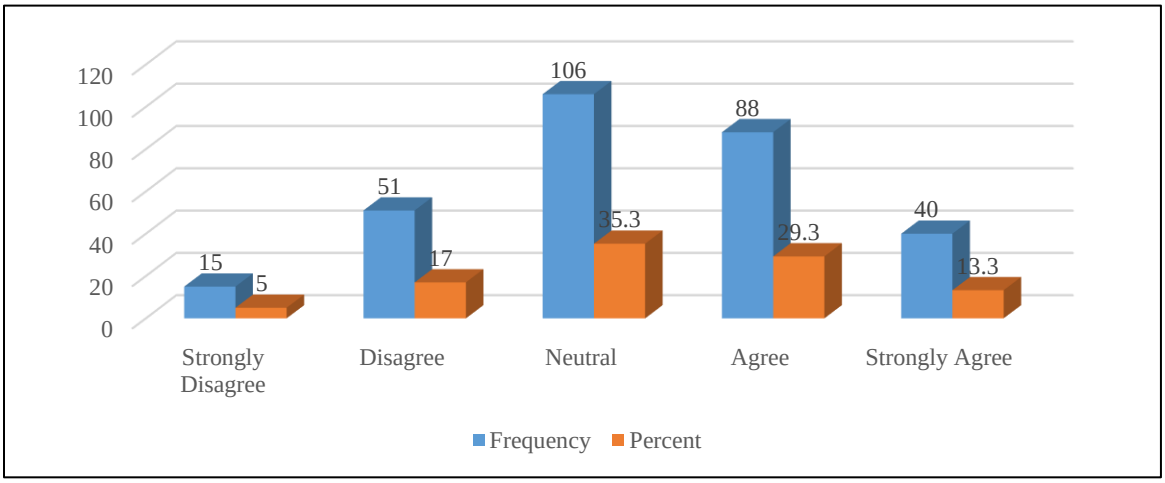

Figure 4.31: The integration of AI in my workplace has made my job more dynamic and engaging.

Figure 4.31 shows a relatively positive perception of AI's influence on job engagement and dynamism. The largest portion of respondents (128 people or 42.6% combined) either agree or strongly agree that AI has made their jobs more dynamic and engaging. However, there's also significant neutrality, with 106 people (35.3%) neither

agreeing nor disagreeing. A smaller group of 66 people (22% combined) disagree or strongly disagree with this statement.

Comparing this to the previous graphs, we see an interesting contrast: while people were skeptical about AI increasing job satisfaction through reducing monotonous tasks, they seem more positive about its role in making work more dynamic and engaging. This suggests that AI's influence on work quality might be more nuanced than simply automating routine tasks - it may be creating new and interesting ways of working that employees find engaging, even if they don't necessarily associate this with overall job satisfaction.

4.3 Descriptive

Table 4.8: Descriptive Statistics

Descriptive Statistics				
	N	Mean		Std. Deviation
	Statistic	Statistic	Std. Error	Statistic
Age Group	300	2.66	.060	1.043
Gender	300	1.66	.036	.621
Educational Qualification	300	3.39	.059	1.027
Current Job Role/Title	300	3.64	.079	1.377
Years of Experience in the O&G Industry	300	2.81	.063	1.098
Company Type	300	2.32	.044	.770
Level of Familiarity with AI and Digital Technologies	300	3.27	.049	.851
Country/Region of Employment	300	3.92	.074	1.281

Fear of Automation	300	3.0167	.03321	.57517
Manual Tasks	300	3.0800	.03503	.60676
Workplace Adaptability to AI	300	3.3233	.03682	.63782
Perceived Opportunity	300	3.3800	.04232	.73307
Job Satisfaction with AI Integration	300	3.4100	.04386	.75971
Valid N (listwise)	300			

Table 4.8 describes AI integration and employment satisfaction. In the 300-person sample, the mean age group score is 2.66 (Std. Deviation = 1.043), demonstrating a balanced age distribution. Mean gender score is 1.66 (SD = 0.621), indicating moderate gender representation. A diverse educational background is shown by the mean score of 3.39 (Std. Deviation = 1.027). The sample's mean current employment role/title score is 3.64 (Std. Deviation = 1.377), reflecting varied job roles. Moderately experienced O&G personnel average 2.81 years (SD = 1.098). Company type has a balanced distribution with a mean of 2.32 (SD = 0.770). AI and digital technology expertise averages 3.27 (SD = 0.851), showing high AI familiarity. Country/region employment mean score is 3.92 (Std. Deviation = 1.281), showing regional diversity. Fear of automation is 3.02 (Std. Deviation = 0.575), whereas manual activities average 3.08 (0.607), showing moderate job displacement fears. AI workplace adaptability averages 3.32 (Std. Deviation = 0.638), demonstrating positive perceptions about workplace AI adoption. A perceived opportunity score of 3.38 (Std. Deviation = 0.733) indicates confidence in AI's potential advantages. AI integration job satisfaction is 3.41 (Std. Deviation = 0.760), indicating overall positive sentiment.

4.4 Hypothesis Testing

Hypothesis 1

H1: The more manual the tasks in O&G jobs, the higher the Fear of automation and the lower the Perceived Opportunity.

Hypothesis 1a:

- **H01a:** There is no significant impact of manual tasks in O&G jobs in increasing the fear of automation.
- **H1a:** There is a significant impact of manual tasks in O&G jobs in increasing the fear of automation.

Table 4.9: Correlation

			Fear of Automation	Manual Tasks
Spearman's rho	Fear of Automation	Correlation Coefficient	1.000	.426**
		Sig. (2-tailed)	.	.000
		N	300	300
	Manual Tasks	Correlation Coefficient	.426**	1.000
		Sig. (2-tailed)	.000	.
		N	300	300

Table 4.9 shows a statistically significant positive correlation between manual tasks and fear of automation in O&G jobs with a Spearman's rho's correlation coefficient of 0.426. This shows that automation anxiety grows with manual jobs. The association is confirmed to be statistically significant with a p-value of 0.000, which is lower than the recommended threshold of 0.01. Based on the p-value of 0.000, we may reject the null

hypothesis and accept the alternative one. This leads us to the conclusion that the fear of automation is significantly correlated with manual jobs.

Hypothesis 1b:

- **H01b:** There is no significant impact of manual tasks in O&G jobs in lowering the Perceived Opportunity.
- **H1b:** There is a significant impact of manual tasks in O&G jobs in lowering the Perceived Opportunity.

Table 4.10: Correlation

			Manual Tasks	Perceived Opportunity
Spearman's rho	Manual Tasks	Correlation Coefficient	1.000	-.067
		Sig. (2-tailed)	.	.245
		N	300	300
	Perceived Opportunity	Correlation Coefficient	-.067	1.000
		Sig. (2-tailed)	.245	.
		N	300	300

Table 4.10 shows correlation between manual tasks and perceived opportunity in O&G jobs. The Spearman's rho correlation coefficient is -0.067, indicating a very weak negative correlation between manual tasks and perceived opportunity. This suggests that as the number of manual tasks increases, the perceived opportunity slightly decreases, but the relationship is very weak.

The significance level (p-value) is 0.245, which is greater than 0.01. This means we fail to reject the null hypothesis. Therefore, we conclude that there is no significant impact of manual tasks in O&G jobs on lowering the perceived opportunity.

Hypothesis 2

H2: The higher the level of Education, the lower the Fear of automation and the higher the Perceived Opportunity.

Hypothesis 2a:

- **H02a:** There is no significant impact of education level in lowering the fear of automation.
- **H2a:** There is a significant impact of education level in lowering the fear of automation.

*Table 4.11: Educational Qualification * Fear of Automation Crosstabulation*

Count							
		Fear of Automation					Total
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
Educational Qualification	High School Diploma or Equivalent	0	0	10	2	0	12
	Associate degree	0	2	38	9	0	49
	Bachelor's Degree	0	9	64	12	1	86
	Master's Degree	3	10	93	9	1	116

	Doctorate (PhD)	4	2	26	4	1	37
Total		7	23	231	36	3	300

In Table 4.11, educational qualifications and fear of automation are compared to show how people differ in their views. Most high school graduates (10 out of 12) are ambivalent about automation. Many associate degree holders (38 out of 49) are indifferent, whereas fewer disagree (2) or agree (9). Bachelor's degree holders are significantly more neutral (64 out of 86), yet 9 disagree and 12 agree. Most Master's degree holders (93 out of 116) are indifferent, with a few objecting (10) or agreeing (9). The same tendency is seen among PhD holders, with 26 indifferent, 4 agreeing, 2 disagreeing, and 4 strongly disagreeing.

Table 4.12: Correlation

			Educational Qualification	Fear of Automation
Spearman's rho	Educational Qualification	Correlation Coefficient	1.000	-.133*
		Sig. (2-tailed)	.	.021
		N	300	300
	Fear of Automation	Correlation Coefficient	-.133*	1.000
		Sig. (2-tailed)	.021	.
		N	300	300

In Table 4.12, the data shows a significant negative correlation between educational qualification and fear of automation, with a Spearman's rho correlation coefficient of -0.133. This shows that as the level of education increases, the fear of automation slightly

decreases. The significance level (p-value) is 0.021, which is less than 0.05, confirming that the correlation is statistically significant.

Given the p-value is 0.021, we reject the null hypothesis (H02a) and accept the alternative hypothesis (H2a), concluding that there is a significant impact of education level in lowering the fear of automation i.e., education level reduces automation anxiety.

Hypothesis 2b:

- **H02b:** There is no significant impact of education level in increasing the Perceived Opportunity.
- **H2b:** There is a significant impact of education level in increasing the Perceived Opportunity.

*Table 4.13: Educational Qualification * Perceived Opportunity Crosstabulation*

Count							
		Perceived Opportunity					Total
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
Educational Qualification	High School Diploma or Equivalent	0	0	9	2	1	12
	Associate degree	0	4	39	5	1	49
	Bachelor's Degree	0	1	55	15	15	86
	Master's Degree	1	1	83	16	15	116
	Doctorate (PhD)	0	0	21	12	4	37
Total		1	6	207	50	36	300

Table 4.13 shows how people with different educational backgrounds view automation prospects. Most High School Diploma or Equivalent holders (9/12) are indifferent to perceived opportunity, with a small portion agreeing (2) or strongly agreeing (1). Most responders with an Associate Degree are neutral (39 out of 49), with some disagreement (4) and agreement (5). Bachelor's degree holders agree more (15 out of 86), while 55 are neutral and 1 disagrees. Master's degree holders are mostly indifferent (83 out of 116); however, a significant fraction agree (16) or strongly agree (15) that AI provides an opportunity. Finally, PhDs mostly view the opportunity as neutral (21 out of 37), but some agree (12) or strongly agree (4).

Table 4.14: Correlation

			Educational Qualification	Perceived Opportunity
Spearman's rho	Educational Qualification	Correlation Coefficient	1.000	.130*
		Sig. (2-tailed)	.	.024
		N	300	300
	Perceived Opportunity	Correlation Coefficient	.130*	1.000
		Sig. (2-tailed)	.024	.
		N	300	300

The data in Table 4.14 shows a significant positive correlation between educational qualification and perceived opportunity, with a correlation coefficient of 0.130. This shows that as the level of education increases, the perceived opportunity also increases, although the relationship is relatively weak. The significance level (p-value) is 0.024, which is less than 0.05, confirming that the correlation is statistically significant.

Given the p-value is 0.024, we reject the null hypothesis (H02b) and accept the alternative hypothesis (H2b), concluding that there is a significant impact of education level in increasing the perceived opportunity. Although the association is modest, higher-educated people are more likely to see AI as offering more prospects.

Hypothesis 3

- **H03:** There is no significant correlation between the proportion of manual tasks in a workplace and adaptability to AI.
- **H3:** There is a significant correlation between the proportion of manual tasks in a workplace and adaptability to AI.

Table 4.15: Correlation

			Manual Tasks	Workplace Adaptability to AI
Spearman's rho	Manual Tasks	Correlation Coefficient	1.000	-.046
		Sig. (2-tailed)	.	.426
		N	300	300
	Workplace Adaptability to AI	Correlation Coefficient	-.046	1.000
		Sig. (2-tailed)	.426	.
		N	300	300

Table 4.15 demonstrates no significant association between workplace adaptation to AI and manual task percentage, with a Spearman's rho correlation coefficient of -0.046 and a p-value of 0.426, which is larger than 0.05. This advises that workplace AI adaptability is unrelated to manual task percentage. These results fail to reject the null hypothesis (H03) that manual activities do not affect AI adaptability. The alternative

hypothesis (H3) of a substantial association fails. The evidence demonstrates that the number of manual tasks in a workplace does not have a meaningful relationship with how well that workplace can adapt to AI implementation.

Hypothesis 4

- **H04:** There is no significant impact of fear of automation on job satisfaction with AI integration.
- **H4:** There is a significant impact of fear of automation on job satisfaction with AI integration.

Table 4.16: Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	145.897			
Final	140.142	5.755	1	.016

The model fitting data in Table 4.16 shows a statistically significant improvement with predictors. The -2 Log Likelihood score dropped from 145.897 (Intercept Only) to 140.142 (Final Model), indicating a better model fit. The Chi-Square value of 5.755 with 1 df has a p-value of 0.016, which is below the 0.05 threshold, showing that predictors significantly increase the model's ability to explain the result. The Logit link function enhances this logistic regression model's suitability for analysis.

Table 4.17 Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	166.740	15	.000
Deviance	107.958	15	.000

Table 4.17 goodness-of-fit statistics show the model does not fit the data. The Pearson Chi-Square (166.740) and Deviance (107.958) values have 0.000 p-values, which

are statistically significant. This shows that model may be unable to explain data fluctuation due to a large difference between observed and anticipated values. The findings show that while the predictors may help the model, they may need refining or more predictors to suit better.

Table 4.18: Pseudo R-Square

Cox and Snell	.019
Nagelkerke	.023
McFadden	.010

Table 4.18 pseudo R-square values show the model's explanatory capability. Cox, Snell, Nagelkerke, and McFadden values are 0.019, 0.023, and 0.010. These values show that the model's predictors explain little outcome variable variance. The rescaled Nagelkerke R-square says 2.3% of the variation is accounted for, but the McFadden R-square of 0.010 indicates a very low model fit.

Table 4.19: Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[JS_AI = 1.00]	-7.409	1.195	38.457	1	.000	-9.750	-5.067
	[JS_AI = 2.00]	-5.441	.767	50.293	1	.000	-6.945	-3.938
	[JS_AI = 3.00]	-.827	.637	1.684	1	.194	-2.076	.422

	[JS_AI = 4.00]	.197	.638	.095	1	.758	-1.054	1.448
Location	FA	-.557	.212	6.945	1	.008	-.972	-.143
Link function: Logit.								

Figure 4.19 reveals that fear of automation (FA) negatively impacts job satisfaction with AI integration (JS_AI) by -0.557 ($p = 0.008$). Fear is linked to decreased satisfaction. The confidence interval (-0.972 to -0.143) confirms this finding's reliability. Significant thresholds for JS_AI categories 1.00 and 2.00 indicate stronger effects with lesser satisfaction. Therefore, the null hypothesis (H04) is rejected, and the alternative hypothesis (H4) is validated, showing that AI integration can boost work satisfaction by lowering automation anxiety.

Hypothesis 5

- **H05:** There is no significant correlation between workplace adaptability to AI and the perceived opportunity.
- **H5:** There is a significant correlation between workplace adaptability to AI and perceived opportunity.

Table 4.20: Correlations

			Workplace Adaptability to AI	Perceived Opportunity
Spearman's rho	Workplace Adaptability to AI	Correlation Coefficient	1.000	.635**
		Sig. (2-tailed)	.	.000
		N	300	300

	Perceived Opportunity	Correlation Coefficient	.635**	1.000
		Sig. (2-tailed)	.000	.
		N	300	300

Table 4.20 shows the correlation analysis that reveals a strong, positive, and statistically significant correlation between workplace adaptability to AI and perceived opportunity ($r_s = 0.635$, $p < 0.001$). Since $p < 0.01$, the null hypothesis (H05) is rejected. This indicates that workplaces with higher adaptability to AI are strongly associated with higher levels of perceived opportunities. The correlation coefficient of 0.635 suggests a substantial relationship, meaning that as workplace adaptability to AI increases, employees tend to perceive significantly more opportunities or prospective benefits related to AI integration.

Hypothesis 6

- **H06:** There is no significant impact of job satisfaction with AI integration on the perceived opportunity.
- **H6:** There is a significant impact of job satisfaction with AI integration on the perceived opportunity.

Table 4.21: Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	252.180			
Final	69.030	183.150	1	.000

Table 4.21 reveals that predictors significantly enhance model fit. From 252.180 (Intercept Only) to 69.030 (Final Model), the model's unexplained variation decreases significantly. The final model explains the result better than the intercept-only model,

according to the Chi-Square value of 183.150 with 1 df and a p-value of 0.000. The Logit link function validates this logistic regression analysis.

Table 4.22: Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	901.073	15	.000
Deviance	41.510	15	.000

Table 4.22 shows poor model fit, with Pearson Chi-Square (901.073, p = 0.000) and Deviance (41.510, p = 0.000) values revealing considerable disparities between observed and predicted values. This shows that the model does not suit the data well and needs modifications or predictions. The Logit link is suitable for logistic regression analysis.

Table 4.23: Pseudo R-Square

Cox and Snell	.457
Nagelkerke	.546
McFadden	.337

Table 4.23 pseudo R-square values suggest a modest model fit. Cox and Snell (0.457) and Nagelkerke (0.546) estimate the model explains 45.7% to 54.6% of the variance, whereas McFadden (0.337) estimates 33.7%. A decent but improve able model fit is shown by these numbers.

Table 4.24: Parameter Estimates

	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound

Threshold	[PO = 1.00]	1.994	1.166	2.925	1	.087	-.291	4.280
	[PO = 2.00]	4.316	.755	32.691	1	.000	2.836	5.795
	[PO = 3.00]	10.188	.834	149.312	1	.000	8.554	11.822
	[PO = 4.00]	12.511	1.015	151.863	1	.000	10.521	14.500
Location	JS_AI	2.660	.230	133.901	1	.000	2.210	3.111
Link function: Logit.								

Table 4.24 parameter estimates reveal that job satisfaction with AI integration (JS_AI) significantly improves perceived opportunity. PO = 2.00, PO = 3.00, and PO = 4.00 are significant (p = 0.000), while PO = 1.00 is not (p = 0.087). The JS_AI location parameter is very significant (estimate = 2.660, p = 0.000), showing that AI work satisfaction increases perceived opportunity. This validates the alternative hypothesis (H6) and rejects the null hypothesis (H06), proving work happiness affects perceived opportunity.

Hypothesis 7

- **H07:** There is no significant impact of workplace adaptability to AI on job satisfaction.
- **H7:** There is a significant impact of workplace adaptability to AI on job satisfaction.

Table 4.25: Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.

Intercept Only	217.747			
Final	68.439	149.308	1	.000

The model fitting data in Table 4.25 demonstrates a considerable improvement after integrating predictors. The intercept-only model has 217.747 -2 Log Likelihood, whereas the final model has 68.439, reducing unexplained variance. The resulting model fits better than the intercept-only model and has a Chi-Square value of 149.308 with 1 df and a p-value of 0.000. The Logit link function suits logistic regression analysis.

Table 4.26: Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	299.824	15	.000
Deviance	40.260	15	.000

Table 4.26 shows that the model does not fit the data well, with Pearson Chi-Square (299.824, p = 0.000) and Deviance (40.260, p = 0.000) showing significant findings. The model is statistically significant; however, it may need tweaks to suit better. The logistic regression analysis uses Logit link function properly.

Table 4.27: Pseudo R-Square

Cox and Snell	.392
Nagelkerke	.464
McFadden	.268

Table 4.27 pseudo-R-square values indicate a modest model fit. Cox and Snell (0.392) and Nagelkerke (0.464) estimate that the model explains 39.2% to 46.4% of the variation. The lower McFadden value (0.268) suggests 26.8% explanatory power. These findings show a good match but suggest model enhancements. Logit link is suitable for logistic regression.

Table 4.28: Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[JS_AI = 1.00]	2.205	1.191	3.428	1	.064	-.129	4.540
	[JS_AI = 2.00]	4.585	.821	31.183	1	.000	2.976	6.194
	[JS_AI = 3.00]	10.004	.880	129.249	1	.000	8.279	11.728
	[JS_AI = 4.00]	11.772	.981	143.897	1	.000	9.848	13.695
Location	WA_AI	2.709	.254	114.086	1	.000	2.212	3.206
Link function: Logit.								

Table 4.28 parameter estimations demonstrate that workplace adaptation to AI (WA_AI) strongly affects job satisfaction with AI integration. JS_AI = 2.00, JS_AI = 3.00, and JS_AI = 4.00 are significant (p = 0.000), while JS_AI = 1.00 is not (p = 0.064). The WA_AI parameter estimate (2.709, p = 0.000) demonstrates that workplace flexibility increases job satisfaction. These findings suggest that AI adaptability is associated with job satisfaction, supporting the alternative hypothesis (H7) and rejecting the null hypothesis (H07).

4.5 Summary of Findings

This investigation provided a comprehensive insight into the integration of AI in the O&G sector, examining multiple factors, including manual task frequency, educational attainment, automation risk perception, and job satisfaction. The findings reveal several significant correlations that merit attention from industry stakeholders.

A direct relationship exists between manual job roles and automation anxiety, with employees in manual positions expressing heightened concerns about AI-driven job displacement. The level of manual work performed by employees does not impact their perceptions regarding workplace opportunities and AI adaptability even though other factors might affect these perceptions. Education level shows a direct connection to the perception of automation threats where higher educated professionals have lower job loss concerns alongside increased expectations of new career opportunities through AI systems in the workplace.

The study demonstrates that workplace adaptation performance toward AI automation exists without dependence on the nature of work tasks which suggests employees adapt better based on their organizational support levels and general work experience than on their job functions. All indicators show that job satisfied employees feel less contentment after their organization implements AI system technology. Organizations which effectively embrace change recognition tend to detect multiple AI-related possibilities because cultural aspects within the organization directly influence AI acceptance rates. Employee awareness of work-related changes introduced by AI creates organizations that tend to identify potential benefits from technological alterations.

The study reveals direct relationships between worker perception of artificial intelligence opportunities and the positive experience they receive from working with AI technologies. Adaptability at work directly leads to better job satisfaction rates since organizations need to support their staff during technical transition phases. The researched data presents crucial information for the O&G industry because modern technology now connects with established operational systems.

Organizations in the O&G industry must create strategic plans to handle employee worries while launching specific training programs and building complete workplace

assistance frameworks. Organizations require capabilities to understand and address employee concerns regarding AI deployment in order to achieve success while developing conditions that support technological growth.

4.6 Conclusion

The research gives crucial information about automation and AI adoption in O&G industry by studying the connections between job types and employee education levels and their concern about technology displacement and work environment adjustments. All test data demonstrated a positive correlation linking manual jobs with elevated perceptions of threats from automation in the workforce. Data reveals that manual tasks do not necessarily affect workers' perceptions of career opportunities even when these tasks are associated with perceived threats. The divided responses from employees reveal the multifaceted nature of workforce automation which shows that work-related fears about displacement do not diminish their ability to detect opportunities in their profession. Results show that workers have multi-faceted reactions to automation through distinct psychological processes combining awareness of threats and identification of possibilities because these factors do not exist as opposite entities

A positive association exists between educational achievement and automation acceptance because educated people display better understanding of AI and automation technologies. The length of educational experience shows a direct link with reduced threats about automation combined with increased recognition of its prospects. Higher education seems to provide students with skills which help them embrace both technological modifications and innovation. Research findings show that appropriate educational programs have potential to reduce anxieties from automation which could positively transform public attitudes about AI implementation. Training and education serve two

essential purposes to educate workers about technological developments as well as to ease workforce automation concerns.

Research findings establish that employee fear of automation negatively impacts their satisfaction with accepting AI technology thus requiring organizations to prioritize employee concern management when introducing new technology. People who believed that AI presented more opportunities during adaptability assessments reported greater job satisfaction. The findings show why organizations must prepare themselves in the O&G sector before implementing AI systems. Organizations must develop education programs and training sessions to manage employee fear of automation and showcase professional advancements that come with AI implementation. Taking this proactive stance allows organizations to simultaneously limit job loss risks and make staff aware of new career options that appear due to automation across the changing industry. Workforce development presents itself as a significant organizational approach during the O&G sector's technological evolution.

CHAPTER V:

DISCUSSION

5.1 Discussion of Results

The survey evaluates employee recognition in O&G sector about automation and AI combined with their adoption disposition and industry-wide integration implications. The first round of surveys reveals different perceptions about job automation risks, but the second group identifies opportunities for improved career contentment. Respondents' worries over automation are well articulated along with the employment insecurity, kind of reps, and exposure of the reps' positions to AI-based technologies.

A major consideration evidenced in the results is the fear of job loss through outsourcing by advanced technologies such as AI and automation. The study conducted by Erebak and Turgut (2021) shown that workers' worries about the rate of technological advancement impact their view of job security as a result of automation, and that workers' perceptions of job security as it relates to their employment influence the degree of automation they prefer with technology. Such apprehensions are not unfounded anxieties

about the future of work due to digital Disruption (Frey and Osborne, 2017). Oil and gas industry workers, like most workers from other industries, feel vulnerable because their functions may be automated. This anxiety is further fueled by the knowledge that many of the jobs within the sector are repetitive in nature and, therefore, prone to being more automated than their counterparts in other sectors.

Nevertheless, there is a more complicated reaction that employees give when asked about the possibility and prospects of AI and automation. On the one hand, many employees perceive automation as a threat, while on the other hand, there are many seeing it as a potential to grow professionally (Bhargava *et al.*, 2021). This ambivalence is not exceptional when new technologies are discussed, workers may see particular technologies as threats to their employment, yet they also see those same technologies as opportunities that can work to their advantage. The belief that deep learning could create new career paths in the organization, which will improve employability, is an optimistic view of how AI will impact work. Lots of respondents mention that awareness of AI and digital technologies is necessary for career growth and understanding that increased knowledge of novel technologies may lead to new opportunities in organization and industry (Ziyadin *et al.*, 2020).

The study also helped to answer the question of how many organizations are ready to support their workers through this change. There is a significant dearth of matching about requirements for training and support and the resources available. On the one hand, some of the respondents shared that they had some kind of training or resources on AI, while the rest largely believed their institutions were not ready to prepare them for the new shifts. This testifies that a more focused effort may be needed for companies to prepare and train their employees for the new technologies that shape the industry. Certain opportunities have been identified as potentially important in explaining perceived

worker's anxiety about AI and addressing the need for widespread workforce development, including paid training and development related to AI and digital technologies (George, 2024).

With regards to job satisfaction, workers seem to be a bit optimistic about how AI could further improve their employment experience. As it can be seen, most of the respondents have echoed their logic that the use of AI means that many facile and repetitive works would, in turn, free them and allow for better and more productive or meaningful work. This perception is crucial because it indicates that the employees do not primarily consider AI as an automation tool for firing workers but can also consider it as an optimization tool for their work lives. Downsizing routine tasks may result in decreased routine tasks, leading to more creative and problem-solving positions that may cause more satisfaction in the workplace. In addition, proponents of AI also envision this as a way for employees in organizations to be able to follow self-development, hence enhancing the working environment and organizational culture (Zirar, Ali and Islam, 2023).

The results also raise awareness of the importance of employers' and employees' further discussions about the use of AI systems at work. With more and more workforces being affected by automation and AI, it becomes important for organizations to engage their employees in a dialogue about the changing nature of work. Disclosing how AI technology will impact the work processes and job roles, will aid in gaining organizational trust. Furthermore, engaging employees in the conversation to introduce artificial intelligence can be a way of making people feel empowered and responsible for decision-making, which can lead to better acceptance (Bhargava *et al.*, 2021).

Overall, the employees of O&G sector are highly concerned about job displacement by automation and AI, while at the same time quite optimistic about the role that AI can play in improving careers, job satisfaction and work characteristics. On this basis, the study

stresses the need for organizations to be well-equipped to address the needs of their workforce during this change process, especially regarding digital competencies and training requirements. In this manner, organizations can at least create a narrative or more constructive perception of what AI is and how it can be beneficial, thus mitigating many of the negative attitudes toward the technology and the changes it brings (Bankins *et al.*, 2024).

The findings from this study offer theoretical and practical implications for diverse correlations between manual activities in the O&G profession, threat perception of automation, perceived benefits, experience, AI acceptability, and job satisfaction with AI integration. The findings have shown a positive and significant association between manual tasks and the perception of automation, which suggests that as manual tasks go up, so does the perception of automation. Similarly, no directed relationship was found for manual work and perceived opportunity indicating that work and manual tasks do not affect how employees perceive opportunities in the sector. A lower fear of automation was observed with a higher number of years in education; this analysis supports the idea that education helps workers feel less threatened by automation. Also, the perception of opportunity was higher among educated workers, in line with this notion of education making workers more productive and having a better vision of workplace opportunities, especially in embracing new technologies like AI.

Notably, there was no direct relationship between the degree of manual tasks and the extent to which employees accept AI, which means that performing manual tasks does not particularly reveal much about an employee's acceptance of AI. This could mean that other factors, including an organization's internal environment, the nature of work and certain traits of users, have a greater influence on AI usage adaptability. Negative associations with aspects of automation were found to have a similar effect on satisfaction

with AI in the work context, which implies that employees who feel threatened by automation routines demonstrated low satisfaction with the AI implementation in their workplace. In addition, the acceptance of AI in the workplace positively correlates with the perception of opportunities. This means that employees who embrace AI-driven changes are more likely to perceive these changes as beneficial and opportunity-rich

Moreover, the study found that job satisfaction with proactively implemented AI solutions positively influences perceived opportunities. When employees are satisfied with AI technologies, they perceive new opportunities that can be embraced. Finally, the correlation between workplace adaptability to AI and job satisfaction also works in the same direction, proving thereby that if employees embrace changes such as AI in the workplace, they are likely to be more satisfied with their jobs. These findings build on other works in the literature, which show that education, flexibility, and a favorable attitude towards technological advancement as a way of fighting negative sentiments about automation and perceiving more opportunities in the workplace. Further, it was also observed that in some areas, there were few important variables or key factors for not yielding satisfactory correlations which may be industry factors, organizational culture, leadership, etc.

5.2 Discussion of Research Question One

The evolving landscape of O&G industry is set to undergo substantial workforce transformations driven by rapid technological advancements in automation and artificial intelligence. Research indicates that skill-biased technological change will precipitate a significant shift in workforce dynamics, with a growing emphasis on high-skilled roles centered on AI operations, complex data analysis, and system optimization (Arntz, Gregory, Zierahn, 2016). As technological integration accelerates, incumbent employees will be compelled to retool their skill sets, pursuing advanced qualifications that align with

emerging digital and technical proficiencies. The O&G field will lose specific traditional career paths while creating new positions oriented toward essential domains such as artificial intelligence supervision and cybersecurity and advanced data analytics according to (Frey and Osborne, 2017). Professional development and adaptable education strategies must be implemented proactively because an emerging workforce requires these features for operating within a technologically advanced industrial environment.

The workforce of O&G workers' demands advanced educational programs and specialized training to adapt to the upcoming technology-based industry. The industry transformation requires complete skill development strategies which combine technical expertise training with technological adaptation techniques. The coming decade will result in fundamental changes to the workforce structure because it will lose employees but simultaneously need many skilled staff who understand modern technological systems and advanced digital capabilities. Educational institutions and corporate training programs must collaborate to create adaptive learning frameworks that rapidly equip professionals with emerging skills in AI integration, data analytics, cybersecurity, and automated technologies specific to the O&G sector. This strategic approach to workforce development will be essential in ensuring the industry's continued efficiency, competitiveness, and technological resilience.

5.3 Discussion of Research Question Two

Future human capital in O&G industry is likely to knowledge significant changes in the next five to ten years as automation and AI continue to dominate the industry. With more and more traditional work processes being offloaded to AI, there will be less demand for labor in the future but more demand for a skilled technical and digitally knowledgeable workforce. Some new skills will appear – especially the importance of which will grow significantly: AI, big data, and automation technologies (Frey and Osborne, 2017). It will

compel current employees to follow the changing trend by getting educational institutes to for upskilling on robotics, machine learning, and even cybersecurity, among others, to be employment-ready in the market (Arntz, Gregory, Zierahn, 2016). There can be a reduction in certain jobs. However, new positions concerning overseeing the functioning of automated systems, especially in regard to data analysis of various AI applications, will most probably be created (West, 2018).

The capacity to manage the relationship between human labor and AI-centered tools while applying expertise and judgment to advanced technology responses will be a valuable factor for future employees. Thus, organizations will have to invest on retraining and skill enhancement schemes so that employees can meet the bar set by technologies in a highly digitalized world (Davenport *et al.*, 2020). In summary, the future may show that the manpower will be less, yet the future workforce will be more specific and suited to work in tandem with AI devices in specific tasks.

5.4 Discussion of Research Question Three

The O&G industry has lately been experiencing significant change, especially considering automation and AI applications which is redesigning job roles. Such technologies as robotic process automation, AI-driven prediction and maintenance, and auto-drilling technologies threaten to replace boring and dangerous tasks in near future, with the result that the future workforce may require different sets of skills. It considers routine, repetitive physical tasks including surveillance of equipment or performing inspection, will no longer require human input since the AI system will do them. On the other hand, the need for human inputs who can control and correctly implement these automated structures will be realized. Some of these are titled; AI system managers, automation engineers or data analysts with abilities to understand the outcome of the AI in charge and improve the efficacy of the system (Koroteev and Tekic, 2021b).

This automation of routine tasks will also bring about new occupations where people bring technical skills together with sectorial knowledge. These roles will include activities that involve decision-making and strategic content, criteria that still call for human input. For example, such positions as energy managers, resource and process managers, and production efficiency specialists will need to understand the basics of artificial intelligence along with those aspects of the job that are specific to the field in question (Susskind and Susskind, 2015). There will be a demand for flexibility at the workforce level, and a clear awareness of AI systems and how they complement and interface with conventional O&G businesses. In the climate of dramatic transformations in the world of work, reskilling strategies and educational models would also be critical for upskilling today's workforce to fulfill these new responsibilities (Sabat, Shortt and Robson, 2020).

Furthermore, it will be necessary to address AI-driven cyber-attacks with a multi-pronged strategy that includes strong threat intelligence, adaptive defensive systems, and ethical concerns. Cybersecurity defenses that use AI show potential in areas such as detection, response automation, and analyst augmentation (Babajide Tolulope Familoni, 2024). In this respect, O&G companies will have necessarily to embrace automation while having to cope with and control such new risks, thus generating jobs that are not only about the widespread digitization process but also about the dire need to ensure its integrity.

In the O&G sector, future work environments will demand increasingly specialized and technologically sophisticated roles. As traditional positions become obsolete, emerging jobs will center on critical technological interfaces, including AI interaction, human oversight, and cybersecurity management. These transformative workforce dynamics will fundamentally reshape the industry's employment landscape, emphasizing technical proficiency, adaptive skills, and advanced digital competencies (Arntz, Gregory,

Zierahn, 2016). Technology-driven transformation will shape the professional industry to select individuals who demonstrate mastery in operating advanced technological networks while keeping an eye on AI-based operations as well as ensuring the O&G sector maintains extremely stable digital foundations.

CHAPTER VI:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

This research work examines O&G industry employee thoughts about automation and artificial intelligence technologies which demonstrate diverse results of technological advancement. The workforce accepts AI's dual ability to endanger existing positions and create freshly available employment opportunities because it both eliminates monotonous work and improves general job contentment. A major conclusion shows major organizational deficiencies since training methods and human resource strategies fail to equip staff members for environments combining human workers with artificial intelligence systems. The research demonstrates an immediate necessity for extensive training initiatives which let workers adjust to technology so they can move through modern technological changes. Strategic proactive measures need to be applied to exploit AI transformation in O&G because they create ready and resilient workforce structures.

The analysis provides deep findings regarding O&G employees' view on automation and Artificial Intelligence by showing their strong relationship with employees' educational qualifications and technological adoption abilities. People with advanced educational backgrounds fear technological hazards less and welcome AI innovation better because they grasp complex technological developments in detail. AI serves as both a

threat of professional replacement and an advancement opportunity in employees' eyes particularly among chlorinated industry staff members.

The upcoming O&G sector human capital environment will consist of a strategic direction with fewer positions requiring basic skills. The future O&G sector will need experts with complex technical abilities to fill jobs including AI managers and automation engineers as well as cybersecurity professionals. The implementation of automation will automatically phase out monotonous operations to generate positions that need expert abilities and crucial thought processes and complete management duties.

Workforce development requires essential transformation because modern technology demands employees to maintain continuous learning as well as develop adaptability and master technical skills. Organizations should develop proactive training initiatives which train workers with essential competencies to handle the advanced professional environment built by AI and automation to build organizational resonance against technological evolution's fast pace.

The evolving technology within the O&G sector demands purposeful transformation of its workforce to tackle cybersecurity risks and integrate ethical systems while developing thorough approaches for employee adjustment. Inside organizations they should create advanced programs for staff development which use positive communication about AI adoption coupled with supported training programs and AI awareness activities that boost employee acceptance of technological evolution. The growing automation revolution will demand that workers learn how to use advanced AI tools to achieve higher organizational performance levels through creative employment solutions.

Complex difficulties within labor force technology advancement require developing employees who possess digital skills for managing upcoming industrial demands. Organizations need to develop a complete strategy that bridges technology

development with employee skill building so workers transform from receiving technical changes into leading the business transformation as AI Champions.

The O&G sector can find enduring success in industrial innovation through active workforce support and broad technological education development making its workforce ready for modern AI and automated professional environments.

6.2 Implications

The obtained research findings carry substantial importance for scientific theory analysis and for both practitioners working in O&G production and for policy-making authorities along with human capital development specialists.

- **For Organizations:**

The O&G industry needs to understand automation and AI technologies for its employees as both threats and opportunities. Managers and organizations must commit a significant amount to investing in competencies upgrading programs or reskilling initiatives, to provide their workforce with appropriate technical and digital skills. Training programs related to introduction of AI technologies, analysis of data, and cybersecurity are necessary to increase the preparedness of employees, at the same time, such initiatives will improve the attitude towards these technologies. Furthermore, to minimize employee resistance to change brought by AI applications throughout the various work processes, the employees shall be encouraged to participate in discussions concerning the application of AI in workplaces.

- **For Workforce Development:**

This study appreciates the need for education and skills development training in managing concerns stemming from job losses attributed to automation. Experience and training in AI show that the higher level of education is, the greater willingness to accept

technological innovation. These programs should be aimed at filling the skill gap and focus on making adequate, or specified, professional training for those fields more available through workforce development. Employee flexibility enhancement can be achieved by implementing structured paid training and specific career development about new assignments.

- **For Industry Practices:**

The O&G sector prepares to welcome a future change driven by AI together with automation which requires basic reorganization of workforce structures and business approaches. The technology revolution needs professional positions in AI engineering and energy management while it predicts decreased demand for robotic and repetitive work.

Businesses should handle artificial intelligence deployment through strategic planning and resource investment to achieve the best possible technological outcomes. Companies need to combine technology capabilities with operation frameworks so they can eliminate computational integration issues while creating a whole-digital transformation solution.

Successful stakeholder management represents the most essential factor for companies to handle technological changes effectively. The use of AI permits O&G companies to enhance operational efficiency and decrease work hours as well as generate new employment positions that match forthcoming technological trends through prompt workforce adjustment initiatives together with specialized training programs and advanced technological solutions. Organizations must disrupt their conventional AI perception to understand it as an enabler for evolutionary change and business superiority in digital industrial environments. These implications can be managed through appropriate responses

from the stakeholders in O&G industry to achieve benefits of AI importance, reduction of working hours, and job creation when the technology is well deployed.

6.3 Recommendations for Future Research

Accordingly, future studies should look at the following critical areas to enhance a proper understanding of effects of AI and automation on O&G workforce and its ramifications as follows.

First, scholars must study the potential post-implementation psychological and social consequences of AI use on employees and prospective workers for the new economy that AI is creating, such as anxiety level, job satisfaction, and occupational objectives. Knowledge of how workers manage change, labor anxiety and automation, and variations in working environments is crucial for developing interventions.

Second, qualitative and quantitative studies and surveys should explore case-specific practices of reskilling and upskilling initiatives across O&G firms, analyzing their effectiveness in enhancing employees' behavioral flexibility as well as job security, and organizational output. There is a need to establish which type of training (for instance, computer skills, robotics/ AI) and nature of training (experience, exposure, mentorship) are most suitable, especially in the instance of re-deployment. Also, shedding light on the involvement initiatives and their relation to organization culture, managers and employee's communication can offer other ways to reduce resistance to technological alterations.

Future research could explore developing indexes to evaluate AI's impact on workforce diversity and inclusion. Researchers would investigate whether automation potentially disrupts organizational equity by analyzing workforce displacement patterns across demographics. A critical focus would be identifying potential segregation mechanisms in technological workforce transformations. The study would aim to develop methodological approaches for understanding and mitigating workforce disruption risks.

Specific attention would be given to analyzing reintegration or relocation strategies for employees displaced by automation, with consideration of variations by age, sex, and racial categories.

The current study could also be further developed in terms of the ethical, legal, and regulation considerations regarding AI integration, where data protection, IT security, and who is responsible for AI decision-making should be the issues of interest in the forthcoming research.

Future studies across two or multiple industries or various geographical locations may be informative to understand the variation in AI adoption and consequent impacts on workers. Finally, future research incorporating AI technology with human resource management, organizational behavior and industrial engineering would help provide a comprehensive outlook on how AI is transforming work systems and enhancing workforce productivity.

6.4 Conclusion

Conclusively, the deployment of Artificial Intelligence and automation within O&G industry is twofold; on the positive side, it is the efficiency improvement, and on the negative side; workforce reduction. As much as employees hold fears of the possibility of losing their jobs through automation, they also have faith and trust in AI to bring in increased job satisfaction, career advancement and a better work environment. This uncertainty underlines the importance of organizations having clear communication procedures and processes for handling employee concerns, efficient change management reflecting the organizational culture, and efficient training/re-skilling programs to upskill the workforce. These will be important as far as dispelling negative attitudes towards AI technologies as well as assuring the workers can manage the current technological landscape.

Also, the future of the O&G workforce will be much more specialized as more and higher levels of technical skills will be required in areas such as AI monitoring, data analytics and cybersecurity among others. Essential activities that employees now carry out will be replaced with temporal, routine and predictable job tasks, thus freeing up the workers to perform less routine, more valuable, strategic jobs that require analytical thinking, judgment, discretion, and decision-making. In anticipation of this shift, organizations need to embark on up-skilling their employees to bolster their competitiveness as the level of automation rises. This investment provides job safety benefits and brings enhanced flexibility together with performance improvements to all personnel.

The O&G sector's work environment will be defined by how well businesses control the deployment of automation technology and human-employee interaction. Organizations must effectively support their workforce when implementing AI systems because technology capabilities alone will not determine the success of AI implementation. AI can also fuel growth and ready the O&G workforce of the future by fostering the environment to promote lifelong learning, adaptability and groundbreaking ideas in the O&G industry. A strategic process centered on worker well-being when adopting AI will enable organizations to achieve maximum automation results while preserving employee care during their transition to a sustainable O&G industry future.

Organizations within the O&G industry must establish methods to manage the technology-human interaction because automation shows signs of becoming widespread in future operational frameworks. AI application requires human support while all AI-induced changes rest upon the effectiveness of workforce preparation strategies organizations implement. The implementation of strategic machine learning technologies produces major benefits for oil and gas companies through increased organizational

flexibility innovative capabilities and new approach development. Organizations need to integrate AI through methods which support their current employees' effectiveness. The optimal implementation of AI technology in O&G will showcase how organizations advocate both technological progress and workforce sustainability.

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APPENDIX A:

DATASET

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	Age (	Gend	Educa	Curre	Years	Comp	Level	Coun	I am w	Auton	I feel a	My job	I belie	A sign	Physic	I belie	My job	Most (	My or	I have	I am c	My or	I belie	I see A	AI tec	Learn
2	3	1	4	3	3	2	3	4	1	1	4	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4
3	2	2	3	2	2	2	2	4	2	2	2	2	2	2	2	2	2	2	4	4	4	4	3	4	4	4
4	2	1	4	7	1	4	2	4	2	2	1	2	2	2	1	2	2	2	2	2	4	2	4	4	4	4
5	4	1	4	2	5	2	2	4	2	2	2	4	4	4	3	4	3	3	2	2	2	2	4	4	4	4
6	3	2	4	7	1	4	3	6	3	3	3	3	3	3	3	1	1	1	3	3	5	5	5	5	5	5
7	4	1	3	5	3	2	2	4	3	2	2	4	2	3	1	2	1	2	4	4	5	5	5	5	5	5
8	5	1	1	1	3	2	3	4	3	3	2	2	2	4	4	4	2	4	5	5	4	5	4	4	4	4
9	5	1	1	1	3	2	3	4	2	3	3	3	4	4	4	4	4	3	4	4	4	4	3	4	2	3
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28	4	2	5	4	5	4	4	6	1	1	1	1	1	1	1	1	1	1	3	4	4	4	5	5	5	5
29	3	2	3	3	4	2	3	4	1	1	2	4	3	3	4	2	1	2	5	3	4	4	4	4	4	4
30	4	2	4	4	2	2	4	7	1	1	1	3	2	2	2	2	4	2	1	1	1	1	1	1	1	1
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32	4	1	4	2	4	3	4	4	2	2	2	2	2	1	2	2	2	2	5	4	4	4	4	5	5	5
33	3	1	5	4	5	2	3	4	1	1	1	1	1	2	1	1	1	1	4	4	3	3	3	4	4	4
34	4	2	5	4	5	2	3	3	2	2	1	1	1	1	1	1	1	1	5	5	5	5	5	5	5	5
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36	3	2	4	1	3	1	3	3	3	2	2	3	3	3	4	3	4	4	4	4	4	4	4	4	4	3
37	2	1	3	6	3	2	3	6	2	3	3	3	3	2	2	2	2	2	4	4	4	4	4	4	5	5
38	2	2	4	1	2	2	3	6	2	2	2	3	3	3	3	3	3	3	4	4	4	4	4	5	5	4
39	2	1	3	2	2	2	3	6	2	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5
40	2	2	3	2	2	2	3	4	2	3	2	2	2	4	4	3	3	3	4	4	4	4	4	5	4	4
41	3	2	3	6	2	1	3	6	2	3	3	3	3	2	3	3	3	3	4	4	4	4	4	4	3	3
42	3	2	3	5	3	2	3	3	2	2	2	1	1	3	3	4	2	2	4	4	4	4	4	5	5	5
43	3	2	3	2	3	2	3	3	2	2	2	2	2	4	4	4	4	4	4	3	4	4	4	5	5	5
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