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BIBLIOMETRIC ANALYSIS OF DIGITAL TRANSFORMATION IN THE OIL AND GAS INDUSTRY: A COMPARATIVE STUDY OF MALAYSIA, NORWAY, AND THE UNITED KINGDOM USING LENS.ORG AND VOSVIEWER

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Abstract:

This study addresses the uneven adoption of digital transformation in the oil and gas industry by benchmarking Malaysia against advanced economies such as Norway and the United Kingdom (UK). Specifically, this research aims to identify key trends, influential sources, and thematic differences in digital transformation research across these three countries. Using a bibliometric methodology, 258 publications from 2010 to 2024 were retrieved from Lens.org and analysed with VOSviewer software. The main analyses included co-occurrence analysis, examination of publication trends, and citation mapping. Results revealed distinct national priorities: Malaysia focuses on workforce readiness and infrastructure development, Norway emphasizes sustainability and renewable energy integration, and the UK leads in innovation and process optimization. The co-occurrence analysis further delineated thematic clusters such as engineering practices, digital technology adoption, and sustainability policies, each shaped by the specific regulatory, industrial, and technological contexts of the nations studied. These findings provide valuable insights for policymakers and industry stakeholders aiming to enhance innovation, sustainability, and competitiveness. Future research should investigate practical strategies for cross-border collaboration and implementing best practices in digital transformation to accelerate sustainable development in the oil and gas industry.

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Keywords:

Bibliometric Analysis, Digital Transformation, Lens.Org, VOSviewer.

Introduction

As the global energy transition accelerates, the oil and gas sector remain critical to energy security, necessitating innovation, competitiveness, and sustainability in an evolving landscape. Digital transformation has emerged as a strategic enabler, enhancing efficiency, reliability, and resilience to address the industry's growing complexity and global challenges (Haouel & Nemeslaki, 2024). Advanced technologies play a pivotal role in optimizing operations and mitigating market volatility, positioning digitalization as an essential component of the sector's long-term viability.

Malaysia's National OGSE Industry Blueprint (2021–2030) recognizes the need for industry-wide transformation to advance the country's oil and gas sector along the value chain, moving beyond low technological sophistication and fragmented industry structures (Malaysia Petroleum Resources Corporation, 2021). However, Malaysia behind global leaders such as Norway and the United Kingdom in fully capitalizing on digital transformation. Norway, through its state energy company Equinor, has pioneered data-driven optimization strategies, while the UK leverages its robust research and development ecosystem to drive innovation in oil and gas (Haouel & Nemeslaki, 2024). These cases exemplify how digital transformation enhances competitiveness and fosters technological advancements.

Despite the growing body of research on digital transformation in oil and gas, significant gaps remain. While studies have explored digitalization in leading economies such as Norway and the UK, there is limited comparative analysis that benchmarks Malaysia's digital transformation progress against these advanced economies. Malaysia's oil and gas sector, a key contributor to the national economy, faces challenges in adopting digital technologies due to infrastructure limitations, skills gaps, and fragmented industry structures (Malaysia Petroleum Resources Corporation, 2021). Additionally, the effectiveness of digital adoption in supporting sustainability goals and regulatory compliance in Malaysia remains underexplored. The COVID-19 pandemic accelerated the adoption of digital solutions in the oil and gas industry, demonstrating the necessity of resilient and flexible digital infrastructures (Hawash et al., 2020). However, research assessing how different regions adapted to this shift remains scarce.

This study aims to benchmark Malaysia's progress against advanced economies, identifying key gaps and opportunities for regional adaptation. The analysis reveals disparities in digital adoption across Malaysia, Norway, and the UK, reflecting variations in technological integration and industry readiness. This study aims to bridge these research gaps by conducting a bibliometric analysis of digital transformation in the oil and gas industry, with a specific focus on Malaysia, the UK, and Norway. The objective of this study is to analyse research trends in digital transformation within the oil and gas industry, identifying key themes, leading authors, and influential publications. A comprehensive analysis of digital transformation trends in Malaysia, the UK, and Norway will provide valuable insights into best practices, implementation barriers, and future opportunities for Malaysia's oil and gas industry. The findings are aimed to provide valuable insights for policymakers and industry stakeholders to

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align Malaysia's oil and gas sector with international standards and accelerate its transition toward sustainable development.

Literature Review

Digital transformation is the incorporation of digital technologies to redesign business processes, operate cost-effectively, and gain a competitive edge. As a strategic imperative for tackling issues such as unstable markets, inefficient operations, and expanding environmental regulations among others, digital transformation has become a priority across the oil and gas industry (Haouel & Nemeslaki, 2024; Prestidge, 2021).

Digital transformation in the oil and gas industry is driven by emerging technologies such as the Internet of Things (IoT), big data, and cloud computing, which collectively enhance operational efficiency through real-time monitoring, predictive maintenance, and automated reliability updates, ultimately leading to significant cost optimization (Hawash et al., 2020; Wei et al., 2024). AI, Internet of Things (IoT), blockchain, and digital twins are among technologies increasingly utilized to optimize operations and decision-making processes (Koroteev & Tekic, 2021; Masoud et al., 2023). Digital solutions streamline operations, reducing restoration time and increasing resource efficiency, thereby lowering overall costs (Majocco et al., 2024). Additionally, sustainability targets play a critical role in accelerating digital adoption, as these technologies facilitate the integration of renewable energy sources and contribute to reducing greenhouse gas emissions, aligning with global regulatory requirements (Chen & Kim, 2023; Khan et al., 2024). Furthermore, advancements in remote monitoring and hazard identification systems enhance worker safety and minimize risks in hazardous environments (Masoud et al., 2023).

Digital transformation initiatives vary across regions. In Malaysia, efforts under the National Digital Economy Blueprint have fostered digital adoption in the oil and gas sector, while Norway and the United Kingdom leverage advanced technology ecosystems to integrate IT solutions with traditional business practices, supporting the transition towards renewable energy (Alkubaisi, 2022; Hawash et al., 2020).

Several key technologies underpin digital transformation in the oil and gas industry. IoT enables real-time data collection and remote site monitoring, enhancing operational visibility (Elijah et al., 2021). Artificial Intelligence (AI) and Machine Learning (ML) facilitate predictive analytics and automate complex decision-making processes (Koroteev & Tekic, 2021). Blockchain technology strengthens transaction security and enhances supply chain transparency (Masoud et al., 2023), while digital twin technology creates virtual models of physical assets for predictive maintenance and scenario analysis (Zakaria et al., 2024). Additionally, scalable data storage and processing capabilities support knowledge extraction from vast datasets generated by digital systems (Hawash et al., 2020).

The pace and strategies of digital transformation differ by region. In Malaysia, digitalization efforts primarily focus on enhancing operational efficiency through infrastructure development and workforce upskilling (Alkubaisi, 2022). Norway, recognized for its advanced environmental policies, integrates digital solutions into its sustainable energy framework (Haouel & Nemeslaki, 2024). Meanwhile, the United Kingdom prioritizes innovation-driven policies to enhance competitiveness in both upstream and downstream operations (Prestidge,

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2021). These regional variations provide valuable insights for comparative analysis, highlighting both shared themes and distinct strategic approaches.

Despite its advantages, digital transformation in the oil and gas industry presents several challenges. High initial implementation costs remain a significant barrier to widespread adoption (Majocco et al., 2024). Additionally, the development of a digitally skilled workforce necessitates targeted training programs (Prestidge, 2021; Tijan et al., 2021). Managing and securing the vast amounts of data generated by digital technologies poses another challenge, alongside organizational resistance to change, which can hinder the adoption of digital initiatives (Masoud et al., 2023). Moreover, increasing reliance on digital systems heightens cybersecurity risks, requiring robust security measures (Zakaria et al., 2024).

Looking ahead, digital transformation will continue to present opportunities for the oil and gas sector, particularly in advancing sustainability efforts. Digital tools will play a crucial role in integrating renewable energy sources and achieving decarbonization targets (Hawash et al., 2020). Enhanced transparency through digital technologies may facilitate global collaborations, such as those between Malaysia, Norway, and the United Kingdom, accelerating innovation and digital adoption (Wei et al., 2024). AI-driven insights will remain instrumental in decision-making, while blockchain and digital twin technologies will further support sustainable environmental practices and operational efficiencies (Koroteev & Tekic, 2021; Zakaria et al., 2024).

Method

This study adopts bibliometric analysis using tools like Lens.org and VOSviewer as show as Figure 1 to provide valuable insights into regional and thematic variations in digital transformation research. Bibliometric analysis has become an effective tool for analyzing research trends, mapping innovation trajectories, and exploring collaboration patterns in the field of digital transformation. This methodology has been successfully used to investigate sustainable oil and gas production to yield practical and usable insight into changing industry practices (Tamala et al., 2022). Utilizing tools like Lens.org and VOSviewer, explores digital transformation in the oil and gas industries of Malaysia, Norway, and the United Kingdom.

A total of 213 research titles related to the digital transformation of the oil and gas industry were extracted on the 24th of December 2024 through comprehensive research. Specific search strings were constructed to identify relevant publications for each country:

Malaysia: ("Digital Transformation" OR "Digitalization" OR "Digital Innovation")
AND ("Oil and Gas" OR "Petroleum Industry" OR "Energy Sector" OR "Hydrocarbon Industry")
AND ("Technology Adoption" OR "Industry 4.0" OR "Digital Technologies" OR "Smart Technologies" OR "IoT" OR "AI" OR "Big Data" OR "Cloud Computing").
Filters: Institution Country/Region = (Malaysia, excl Norway, excl United Kingdom)
Norway: ("Digital Transformation" OR "Digitalization" OR "Digital Innovation")
AND ("Oil and Gas" OR "Petroleum Industry" OR "Energy Sector" OR "Hydrocarbon Industry")
AND ("Technology Adoption" OR "Industry 4.0" OR "Digital Technologies" OR "Smart Technologies" OR "IoT" OR "AI" OR "Big Data" OR "Cloud Computing")
Filters: Institution Country/Region = (excl Malaysia, Norway, excl United Kingdom)
United Kingdom: ("Digital Transformation" OR "Digitalization" OR "Digital Innovation")

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AND ("Oil and Gas" OR "Petroleum Industry" OR "Energy Sector" OR "Hydrocarbon Industry")
AND ("Technology Adoption" OR "Industry 4.0" OR "Digital Technologies" OR "Smart Technologies" OR "IoT" OR "AI" OR "Big Data" OR "Cloud Computing")
Filters: Institution Country/Region = (excl Malaysia, excl Norway, United Kingdom)

The period considered for the search (2010–2024) ensured relevance to contemporary research trends. After strict data cleaning steps, duplicate data entries, non-relevant datasets, and incomplete datasets were removed, resulting in 25 datasets for Malaysia, 39 datasets for Norway, and 162 datasets for the United Kingdom.

Following the cleaning process, the datasets were subsequently analyzed using VOSviewer (vosviewer. com), free software developed for the creation and visualization of bibliometric networks. We applied VOSviewer to map relationships among authors, keywords, and citations, and to identify thematic clusters in the literature (Van Eck & Waltman, 2010). The discussions centered on topics such as technological innovations, sustainability, and operational challenges.

Integrating the LENS. ORG database and VOSviewer, this study contributes to its methodological advancement, while also offering a comparative view of the oil and gas industry in Malaysia, Norway and the United Kingdom in terms of their digital transformation evolution. Besides, this methodology illustrates the relationship between research activities and thematic priorities in these countries. This study systematically maps research collaborations, identifies key knowledge clusters, and explores emerging trends in digital transformation. The comparative insights derived from Malaysia, Norway, and the UK will enable the Malaysian oil and gas sector to adopt best practices, accelerate digital adoption, and drive sustainable industry growth.

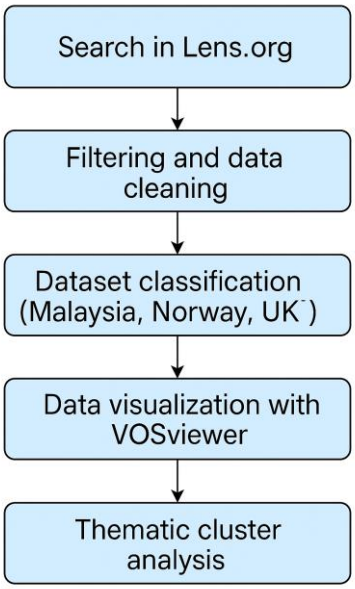

Figure 1: Flow Of Processes

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Results and Findings

Number of Publications (by Document and Source Type)

A comparative study on the publications on digital transformation in oil and gas generate the underpinning article cited in the UK is much higher than the number of articles cited in Malaysia and Norway. Significantly, the UK has a well-established corpus of 127 publications, as shown in the data. On the other hand, Norway has a moderate presence with 62 publications and Malaysia has a smaller yet growing research scene with 18 publications. This discrepancy indicates the UK possesses a much larger and diverse research community which is presumably supported by higher amounts of research funding as well as a wider pool of research fields. UK boasts substantially higher numbers of publications than all other countries, Norway has produced fewer publications overall but shows a strong journal article focus, suggesting a highly concentrated research effort in the field. This increase, however, mirrors a developing interest in leveraging digital transformation across the oil and gas sector in Malaysia which in turn shows Malaysia's increasing contributions to the industry.

Relative to publication type, most article types across the three countries consist of journal articles. Journal articles (78% of number of publications), conference proceedings (11% of number of publications), book chapters (6% of number of publications) and preprints (1% of number of publications) are the most common types of Malaysia's publications. In terms of publication types, Norway also has a strong emphasis on journal articles, which alone constituting 74% of the output, followed by conference proceedings 13%, book chapter 8% and preprints 5%. As can be seen in Table 1, the UK contains almost exclusively journal articles that account for 75% of the publications, 12 % are conference proceedings, 8% book chapters, and 5% preprints.

Table 1: Number Of Publications By Documents And Sources Type.

Publication Type	Malaysia	Norway	United Kingdom (UK)
Journal Article	14 (78%)	46 (74%)	95 (75%)
Conference Proceedings	2 (11%)	8 (13%)	15 (12%)
Book Chapter	1 (6%)	5 (8%)	10 (8%)
Preprints	1 (5%)	3 (5%)	7 (5%)
Total	**18**	**62**	**127**

This highlights that journal articles are still the dominant form of dissemination of scholarly work for the three countries in digital transformation. While none of these comparisons is precisely the same population, what we do see is the broad regularity of both differences in output and the importance of journal publications in the common narrative of regularity documented both in the research literature and library and bibliometric literature.

Publication Trends by Year

Subsequently, we analysed the number of publications per year on digital transformation in the oil and gas industry, for Malaysia, Norway and the United Kingdom from 2000 to 2024. The data shows some interesting trends and differences, offering insight into the research landscape in these countries over the years as shown as Table 2

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Table 2: Number of Publications by Year.

Year	Malaysia	Norway	United Kingdom (UK)
2000 - 2014	1	6	18
2015 - 2019	5	14	21
2020	2	10	13
2021	0	8	10
2022	4	7	19
2023	5	9	21
2024	1	10	25

Research activity in Malaysia although appears to be low but shows a gradual and consistent increase over time. Between 2000 and 2014, there was a very modest number of contributions in scholarly literature, indicating the limited interest in the phenomenon of digital transformation. Starting in 2015, however, research appeared to accelerate, reflecting rising interest in the field. This growth peaked in 2022, marking the highest publication output to date, highlighting the flourishing interest and research on digital transformation in the Malaysian oil and gas sector both academically and industrially. 2023 continued this upward trend, but 2024 saw a dip, indicating slight changes in academic output.

Norway, in contrast, has a more stable growth path. Publications were limited from 2000–2014, yet there was a clear increase in this number from 2015 onwards, with 2019 being a year of exponentially more research activity. The prominence in 2020 reflects the impact of the COVID-19 pandemic, which hastened the transition to digital solutions and increased scholarly interest. While 2023 experienced a slight decline, 2024 rebounded with strength, demonstrating Norway's continued dedication to digital transformation, especially in the spheres of sustainability and renewable energy.

United Kingdom displays a steady and strong growth trajectory in the research output. There was a gradual increase from 2000 to 2014 and a sharp rise post-2015. Surges in publication activity were present in 2022 and 2024, focusing on operational efficiency, change management, and big data application in digital transformation all areas where the UK is adapting. Such raw and consistent output also emphases the UK's continued leading role and supporting academia, especially in the digital and sustainable transition of the oil and gas sector.

Most Active Source Titles

This is the section which identifies the journals and publishers favored by researchers on the topic of digital transformation in the oil and gas sector in Malaysia, Norway and the UK. Analyzing publication data for these countries shows different preferences and patterns of researchers as shown at Table 3.

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Table 3: Three Most Active Publishing.

Source Title - Malaysia	Qty	Source Title - Norway	Qty	Source Title - UK	Qty
Springer Science and Business Media	6	Springer Science and Business Media	29	Springer Science and Business Media	75
AIP Publishing	1	Elsevier BV	6	Elsevier BV	15
Allerton Press	1	IEEE	5	SPE	6

On Malaysia side, 6 publications are from Springer Science and Business Media, hence the first choice. AIP Publishing and Allerton Press also make a smaller contribution–1 publication each. This pattern reflects that Malaysian scholars are not only actively publishing in internationally recognized publishers but also more oriented towards technical and applied research related to digital transformation.

Similar findings can be observed at the Norwegian level, where researchers have a strong preference for Springer Science and Business Media (29 publications). Norway's proclivity towards multidisciplinary research is underscored by the 6 publications from Elsevier BV. Norway's emphasis on technical and engineering pursuits in terms of digital transformation is reflected in its five IEEE publications.

The UK leads in total number of publications, with 75 led by Springer Science and Business Media. The leading journals by number of publications include Elsevier BV (15 publications) and SPE (6 publications), indicating a varied interest in high-impact journals. This contributes to a rich research environment in the UK, with contributions to technology, energy and social sciences.

Malaysia has a concentrated preference towards publishers, but Norway has a more balanced approach with interest in specialized and multidisciplinary journals. In contrast, the UK displays a very diverse and mature research ecosystem that feeds into many high-impact sources. These trends, however, reflect similarities like example, the dominance of Springer Science and Business Media and differences in thematic focus and research interests in the three countries.

Citation Analysis

This section presents the findings for Malaysia, Norway, and the United Kingdom most cited articles on the digital transformation on oil and gas industry. The information is useful in shedding light on the per article title basis frequency of its citation, showing the impact it has on the academic community. Results for Malaysia, Norway, and the United Kingdom are presented in Tables 4, 5, and 6.

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Table 4: Most Cited Articles (Malaysia).

No	Author (Years)	Title Sources	Journal	Freq
1	(Ng & Ghobakhloo, 2020)	Energy sustainability and industry 4.0	IOP Publishing	13
2	(Satar et al., 2019)	Exploring Internet of Things Adoption in Malaysian Oil and Gas Industry	IEEE	11
3	(Khaleel et al., 2023)	Towards Sustainable Renewable Energy	Allerton Press	9
4	(Adumene et al., 2022)	Offshore oil and gas development in remote harsh environments: engineering challenges and research opportunities	Springer Science and Business Media LLC	9
5	(Said et al., 2020)	Integrating Cloud in Engineering, Procurement and Construction Contract	American Scientific Publishers	4

Data in Table 4 shows the frequency of citations of single article titles by researchers in the Malaysian oil and gas industry, with a total of 46 citations distributed among five key studies. The most frequently cited articles are Ng & Ghobakhloo, (2020), "Energy Sustainability and Industry 4.0", published in IOP Publishing, with 13 citations. This highlights its significant impact on discussions about sustainability and technological advancements in the oil and gas sector.

A notable study, Satar et al., (2019), "Exploring Internet of Things Adoption in Malaysian Oil and Gas Industry", published in IEEE, has 11 citations, emphasizing the growing importance of IoT adoption in enhancing operational efficiency. Another prominent work, Khaleel et al., (2023), "Towards Sustainable Renewable Energy", published in Allerton Press, has 9 citations, underlining the relevance of renewable energy transition in the industry.

Additionally, Adumene et al., (2022), "Offshore Oil and Gas Development in Remote Harsh Environments: Engineering Challenges and Research Opportunities", published in Springer Science and Business Media LLC, also received 9 citations, showcasing the importance of overcoming challenges in offshore operations. Lastly, Said et al., (2020), "Integrating Cloud in Engineering, Procurement, and Construction Contract", published in American Scientific Publishers, has 4 citations, indicating interest in leveraging cloud technologies in the sector.

The varying citation frequencies reflect Malaysian researchers' engagement with a diverse range of topics, including sustainability, technological adoption, renewable energy, and operational challenges, demonstrating their contributions to advancing the industry.

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Table 5: Most Cited Articles (Norway).

No	Author (Years)	Title Sources	Journal	Freq
1	(Munim et al., 2022)	Assessing blockchain technology adoption in the Norwegian oil and gas industry using Bayesian Best Worst Method	Elsevier BV	29
2	(Sharma et al., 2017)	The Dawn of the New Age of the Industrial Internet and How it can Radically Transform the Offshore Oil and Gas Industry	OTC	15
3	(Geekiyanage et al., 2020)	Drilling data quality improvement and information extraction with case studies	Springer Science and Business Media LLC	12
4	(Idries et al., 2022)	Challenges in platforming and digitizing decentralized energy services	Springer Science and Business Media LLC	12
5	(Løken et al., 2020)	Data-driven approaches tests on a laboratory drilling system	Science and Business Media LLC	9

Table 5 highlights the citation frequencies of key works authored by researchers in Norway, showcasing a total of 77 citations distributed across five significant studies. The most frequently cited work is Munim et al., (2022), "Assessing Blockchain Technology Adoption in the Norwegian Oil and Gas Industry Using Bayesian Best Worst Method," published by Elsevier BV, with 29 citations. This study underscores the critical role of blockchain in advancing technological innovation in the oil and gas sector.

Another influential work, Sharma et al., (2017), "The Dawn of the New Age of the Industrial Internet and How It Can Radically Transform the Offshore Oil and Gas Industry," published by OTC, has 15 citations, emphasizing the transformative potential of the Industrial Internet for offshore operations. Two studies, Geekiyanage et al., (2020), "Drilling Data Quality Improvement and Information Extraction with Case Studies," and Idries et al., (2022), "Challenges in Platforming and Digitizing Decentralized Energy Services," both published by Springer Science and Business Media LLC, have each received 12 citations, reflecting the significance of data quality and digitalization challenges in energy services.

Lastly, Løken et al., (2020), "Data-Driven Approaches Tests on a Laboratory Drilling System," published by Science and Business Media LLC, has garnered 9 citations, highlighting the value of data-driven innovations in drilling operations. These results underscore Norway's contribution to advancing digital transformation with a focus on blockchain, data quality, and energy system digitalization, enhancing sustainability and operational efficiency in the oil and gas industry.

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Table 6: Most Cited Articles (United Kingdom).

No	Author (Years)	Title Sources	Journal	Freq
1	(Sovacool et al., 2019)	Decarbonization and its discontents: a critical energy justice perspective on four low-carbon transitions	Springer Science and Business Media LLC	235
2	(Al-Shabandar et al., 2021)	A deep gated recurrent neural network for petroleum production forecasting	Elsevier BV	34
3	(Ali et al., 2024)	Evaluation the effect of wheat nano-biopolymers on the rheological and filtration properties of the drilling fluid: Towards sustainable drilling process	Elsevier BV	17
4	(Hamed et al., 2007)	Optimization of Deepwater Drilling With Real-time Operations	SPE	5
5	(Perrons, 2021)	How digital technologies can reduce greenhouse gas emissions in the energy sector's legacy assets	Elsevier BV	5

Table 6 presents the citation frequencies of key articles prepared in the UK, with a total of 296 citations across five significant studies. The most frequently cited article is Sovacool et al., (2019), "Decarbonization and Its Discontents: A Critical Energy Justice Perspective on Four Low-Carbon Transitions," published by Springer Science and Business Media LLC, with an impressive 235 citations. This highlights its pivotal contribution to discussions on energy justice and sustainable transitions.

Another notable contribution is Al-Shabandar et al., (2021), "A Deep Gated Recurrent Neural Network for Petroleum Production Forecasting," published by Elsevier BV, with 34 citations, emphasizing the integration of advanced machine learning techniques in petroleum production. Additionally, Ali et al., (2024), "Evaluation of the Effect of Wheat Nano-Biopolymers on the Rheological and Filtration Properties of the Drilling Fluid: Towards Sustainable Drilling Process," also published by Elsevier BV, has received 17 citations, reflecting its relevance to sustainable drilling innovations.

Two additional studies, Hamed et al., (2007), "Optimization of Deepwater Drilling with Real-Time Operations," published by SPE, and Perrons, (2021), "How Digital Technologies Can Reduce Greenhouse Gas Emissions in the Energy Sector's Legacy Assets," published by Elsevier BV, have each garnered 5 citations, showcasing the UK's focus on both drilling optimization and digital transformation in reducing greenhouse gas emissions.

These citation frequencies underscore the UK's emphasis on innovative energy technologies, sustainability, and the integration of digital solutions to address global energy challenges.

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Top Field of Study

The Top Field of Study table includes the main areas of research focus of academic researchers in Malaysia, Norway, and the UK regarding digital transformation in the oil and gas sector. The field of study is an area of concentrated academic effort. We provide an overview of the frequencies of research activities in these fields as Figure 1, 2 and 3.

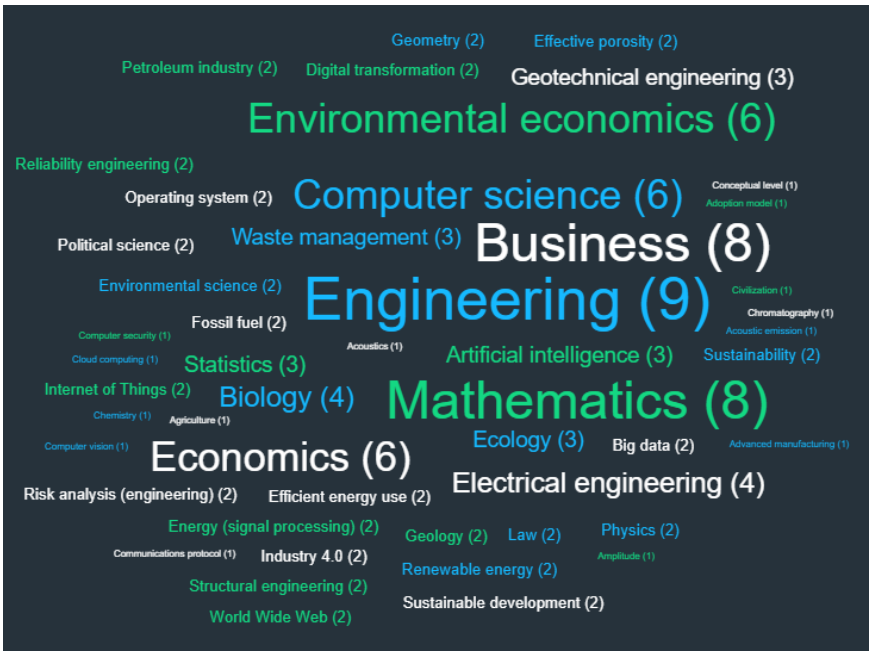

Figure 2: Top Field of Study (Malaysia).

Malaysian scholars exhibit a strong interdisciplinary focus, with prominent representation in Materials Science and Computer Science (8), alongside Engineering (7). Fields such as Economics, Political Science, and Business (5) further highlight the diverse research landscape addressing the digital transformation of the oil and gas industry. Significant contributions are also observed in Law (4), Mechanics, Sustainable Development, and Biology (3 each), reflecting the regulatory, environmental, and technical dimensions of the sector. Additional specialized areas, including Thermodynamics, Reliability Engineering, and Environmental Economics, emphasize targeted solutions for industry challenges. This broad research spectrum underscores Malaysia's commitment to integrating technological, socio-economic, and environmental considerations into its academic and industrial endeavours.

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Figure 3: Top Field of Study (Norway).

Norwegian researchers exhibit a strong focus on Computer Science (36), Engineering (27), and Business (16), emphasizing technological innovation and strategic management within the context of digital transformation in the oil and gas industry. Supporting this focus are fields like Computer Security (11), Risk Analysis (10), and Knowledge Management (7), reflecting efforts to address security, operational efficiency, and organizational insights. Additional contributions come from areas such as Petroleum Industry (7), Process Management (6), and Environmental Economics (6), showcasing Norway's dedication to process optimization, energy sector advancements, and sustainability. Further engagement in disciplines such as Artificial Intelligence (8), Economics (9), and Environmental Science (6) highlights the interdisciplinary approach adopted by Norwegian researchers to tackle diverse challenges in the sector. This broad yet strategically aligned research framework underscores Norway's commitment to driving innovation and addressing industry-specific needs comprehensively.

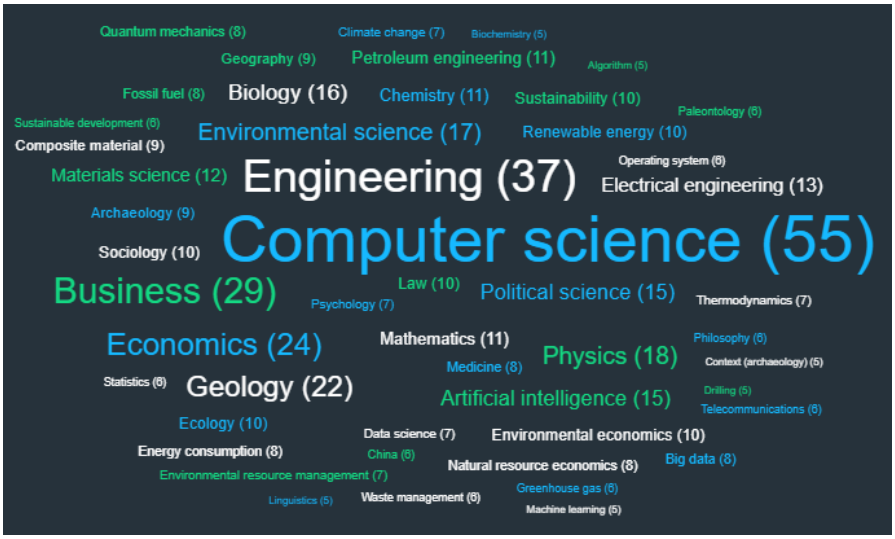

Figure 4: Top Field of Study (United Kingdom).

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Researchers from the United Kingdom place significant emphasis on Computer Science (55) and Business (29), reflecting their importance in advancing both technological innovation and strategic business processes for digital transformation in the oil and gas industry. Supporting disciplines such as Engineering (37), Economics (24), and Environmental Science (17) highlight the UK's focus on operational efficiency, resource management, and sustainability. Other notable areas, including Geology (22), Physics (18), and Artificial Intelligence (15), demonstrate a diverse research approach aimed at addressing technical challenges and fostering innovation. Fields like Petroleum Engineering (11), Materials Science (12), and Political Science (15) further underline the UK's commitment to addressing sector-specific policy, operational, and technological needs. This comprehensive and interdisciplinary research landscape showcases the UK's strategic efforts to drive innovation and sectoral growth in digital transformation.

Research Publication: Co-Occurrence Results for Malaysia, Norway, and the United Kingdom

Co-occurrence analysis explores connections among key terms and concepts within a dataset, visually illustrating their associations to reveal meaningful knowledge structures, the significance of concepts, and thematic proximities between various terms. In this study, co-occurrence analysis was applied using a structured methodological approach to uncover thematic connections specifically within digital transformation research in the oil and gas industry for Malaysia, Norway, and the United Kingdom.

The methodological process involved five primary steps:

1. Data Extraction and Preparation: Relevant publications from Malaysia, Norway, and the UK spanning from 2010 to 2024 were retrieved from Lens.org using specific keyword strings tailored to digital transformation in the oil and gas sector.
2. Data Cleaning and Organization: The dataset underwent rigorous refinement by removing duplicates, irrelevant publications, and incomplete records, culminating in a final dataset comprising 258 entries.
3. Uploading and Processing Data in VOSviewer: The cleaned dataset was uploaded to VOSviewer, specialized software for bibliometric visualization and analysis.
4. Setting Co-occurrence Parameters: Parameters were established to identify keyword co-occurrences, including defining a minimum occurrence threshold to ensure significant thematic linkages were clearly visualized. Only terms meeting or exceeding these thresholds were selected for co-occurrence mapping.
5. Generating Thematic Maps and Interpretation: VOSviewer generated visual maps illustrating thematic clusters and keyword interconnections. Each cluster was subsequently analyzed to interpret primary research focuses and thematic concentrations.

The resulting co-occurrence maps for Malaysia, Norway, and the UK are depicted in Figure 4. Each country exhibited three distinct clusters, clearly revealing the thematic concentrations and proximities among terminologies used by authors in digital transformation research.

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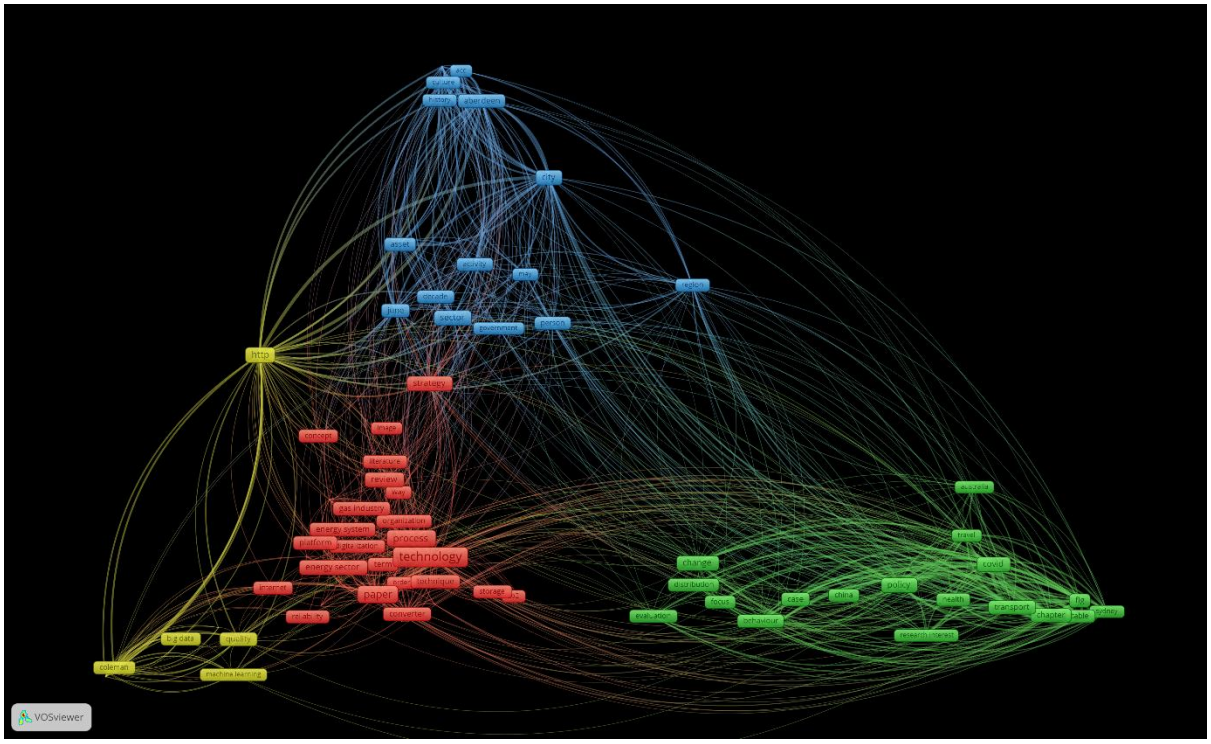

Figure 5: Co-Occurrence Map For Malaysia, Norway And United Kingdom.

The co-occurrence analysis depicted in the figure provides a comprehensive overview of the thematic structure in research on the digital transformation of the oil and gas industry. The visualization reveals distinct clusters that underline key research areas, demonstrating how interconnected themes are advancing the sector.

Cluster 1 (Red): Technology Implementation and Process Optimization
This cluster centers on the integration of technology, processes, and systems within the oil and gas industry. Keywords such as "technology," "process," "platform," and "energy sector" highlight the emphasis on improving operational efficiency and system reliability. The research in this cluster addresses challenges like organizational preparedness, resource allocation, and the seamless adoption of advanced technologies into existing workflows. The strong connectivity within this cluster underscores the pivotal role of technological innovation as a cornerstone of digital transformation in the sector.

Cluster 2 (Green): Sustainability and Policy
The green cluster focuses on the industry's response to sustainability challenges and policy requirements. Keywords such as "change," "sustainability," "policy," and "health" reflect efforts to align the sector with global environmental goals, such as reducing carbon emissions and adopting renewable energy technologies. Regional-specific terms like "China," "Australia," and "transport" point to geographically diverse strategies and adaptations to both local and international regulatory demands. This cluster underscores the growing emphasis on integrating environmental sustainability into the oil and gas industry's strategic priorities.
Cluster 3 (Blue): Socioeconomic and Historical Context

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The blue cluster explores the intersection of digital transformation with historical, cultural, and socioeconomic dimensions. Keywords like "history," "sector," "government," and "region" suggest an analytical focus on how digital advancements influence regional economies, governance, and societal dynamics. This cluster reflects the industry's increasing awareness of the broader implications of technological innovation, including economic transformations and community-level impacts.

Cross-Cluster Interconnections

Visualization also highlights significant cross-cluster connections, illustrating the holistic nature of research in this field. For instance, the relationship between sustainability (green cluster) and technology implementation (red cluster) emphasizes the need for operational efficiency that also addresses environmental concerns. Similarly, links between policy and socioeconomic themes (blue and green clusters) underline the importance of informed decision-making that integrates regional and global perspectives.

Evolution of Research Themes

The temporal progression of research themes reveals an adaptive industry responding to shifting priorities. Initial research predominantly focused on addressing technical and implementation challenges (red cluster). Over time, the scope has expanded to include sustainability considerations (green cluster) and socioeconomic impacts (blue cluster), indicating a dynamic evolution in research focus areas. This progression reflects the industry's growing commitment to tackling multifaceted challenges through innovative, interdisciplinary solutions.

Conclusion

The co-occurrence analysis unveils a rich and interconnected research landscape in the digital transformation of the oil and gas industry. While technological innovation continues to dominate, emerging themes around sustainability, policy, and socioeconomic dimensions are becoming increasingly prominent. Future research should prioritize exploring synergies between these clusters, such as leveraging technological advancements for sustainability goals or using policy frameworks to facilitate digital tool integration. This integrated, cross-disciplinary approach will be vital for driving meaningful transformation in the sector, enabling it to meet global environmental, societal, and operational challenges.

Discussion

There is a clear divergence in the thematic focus of research regarding the digital transformation of the oil and gas industry, as evidenced by the unique clusters identified within the co-occurrence analysis. This clustering reflects the variety of digital transformation challenges and opportunities, influenced by differences in technology adoption, resource allocation, and strategic priorities across studies.

The red cluster focuses on challenges and implementation barriers related to digitalization. Keywords such as "technology," "process," and "system" reveal an emphasis on overcoming practical obstacles like resource limitations and organizational readiness. This cluster underscores the industry's efforts to integrate cutting-edge technologies into operational frameworks, aiming for enhanced efficiency and reliability amidst economic pressures.

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The green cluster emphasizes sustainability and policy-driven themes. Keywords like "change," "sustainability," and "policy" highlight the industry's increasing alignment with global environmental goals and its adoption of renewable energy technologies. Example like the findings from Haouel and Nemeslaki (2024), our analysis confirms Norway's strong emphasis on sustainability. However, contrary to the findings of Prestidge (2021), our analysis highlights a higher concentration on infrastructure challenges rather than digital innovation readiness within Malaysia's context. This cluster shows a focus on integrating sustainable practices and addressing environmental concerns through strategic policy frameworks and innovative approaches.

The blue cluster explores the socioeconomic and historical dimensions of digital transformation. Keywords such as "history," "sector," and "region" reflect research that examines the broader impact of technological advancements on communities, regional economies, and governance. This cluster underscores the industry's awareness of the need for a balanced approach that considers societal and economic implications alongside technological innovations.

The evolution of research themes over time reveals a progressive transition. Earlier studies predominantly addressed implementation challenges (red cluster), while recent publications have expanded to focus on data-driven decision-making (green cluster) and the socioeconomic impacts of technology adoption (blue cluster). This evolution demonstrates the industry's adaptability in addressing emerging challenges and leveraging new opportunities.

The co-occurrence map also highlights the interconnectedness of themes across clusters, such as the influence of digitalization on fostering innovation and enhancing operational efficiency. These connections underscore the holistic nature of digital transformation as an end-to-end process encompassing technical, operational, and strategic dimensions.

The bibliometric analysis enabled us to identify dominant research themes and gaps within Malaysia's context, directly addressing our objective of benchmarking Malaysia's progress against Norway and the UK. It highlights specific areas needing strategic attention, such as infrastructure improvement and digital skill enhancement. These findings have practical implications for policymakers and industry stakeholders, providing a clear direction for targeted interventions to accelerate digital transformation in alignment with the best global practices.

The findings illustrate the breadth and depth of research priorities within the oil and gas industry, with clusters reflecting a mix of complementary and divergent themes. This segmentation highlights the industry's journey toward balancing resilience and innovation. Future research could explore synergies between clusters, such as leveraging data-driven insights to address implementation challenges or using emerging technologies to enhance operational efficiency, further advancing the industry's digital transformation journey.

Conclusion

This bibliometric analysis provides a comprehensive assessment of the research landscape on digital transformation in the oil and gas sector, successfully benchmarking Malaysia's efforts against Norway and the United Kingdom, thereby clearly achieving the stated research objectives. Specifically, the analysis identified and compared key trends, influential

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publications, thematic clusters, and regional priorities within the digital transformation literature across these three countries.

The findings reveal distinct regional differences and priorities: Malaysia primarily emphasizes infrastructure development, digital skill enhancement, and regulatory adaptation; Norway leads in sustainability-driven digitalization, particularly focusing on renewable energy integration and emissions reduction while the UK prioritizes innovation-driven competitiveness and technological integration across upstream and downstream operations.

Key themes emerging from the analysis underscore the critical role of innovation capability, workforce competency, and technological readiness as essential drivers of digital transformation. By mapping top authors, leading publications, and collaborative research networks, the study highlights the intellectual structure of this evolving field and provides valuable insights into how regional policies, industry dynamics, and technological advancements shape digital adoption strategies across diverse regulatory and economic landscapes.

Practically, the insights derived from this study serve as strategic resources, enabling policymakers, industry practitioners, and researchers to develop targeted, evidence-based strategies tailored to specific regional contexts. This structured comparative analysis contributes to both academic and practical knowledge by offering strategic recommendations for resource allocation, infrastructure improvement, and capacity-building initiatives.

However, limitations of this study include its reliance solely on bibliometric data, which may not fully capture qualitative nuances or practical industry implementations. Therefore, future research should integrate qualitative methods and case studies for deeper insights into practical digital transformation applications. Additionally, exploring cross-border collaboration strategies, shared innovation frameworks, and policy harmonization could further enhance the effectiveness and sustainability of digital transformation efforts.

In conclusion, by identifying regional strengths and gaps, this comparative bibliometric analysis enhances understanding of the global digital transformation landscape in the oil and gas industry. It provides a robust foundation for fostering strategic collaboration, accelerating digital adoption, and ensuring long-term sustainable growth and resilience, aligning closely with Malaysia's National OGSE Industry Blueprint (2021–2030) objectives of enhancing technological capability, closing digital skill gaps, and fostering global competitiveness (Malaysia Petroleum Resources Corporation, 2021).

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