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RESEARCH ARTICLE

Research on Policy-Oriented Technology Forecasting of China's Offshore Platform Based on Multidimensional Information

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Abstract

The development and utilization of offshore platforms have significantly enhanced the efficiency of energy extraction and have become crucial for national energy security and the stable operation of marine energy social systems. Consequently, offshore platform technology is not merely a marker of scientific and technological progress but also a key element of national strategic layout and marine industrial policy formulation. This paper combines text mining with expert evaluation and integrates multidimensional data from academic papers, patents, and industry reports to develop a novel policy decision-support technology forecasting model. Data on China's offshore platform technology from 2004 to 2023 are analyzed to assess its current state through comparative technology curves and to explain the mapping relationship between technological evolution and industrial policy adjustment. Furthermore, topic clustering of papers and patents is used to construct a hierarchical structure that clarifies the relationships among different technological areas and the operation logic of the marine industry. On this basis, the trajectories of technological evolution derived from papers and patents are compared, and future trends are projected to identify potential areas of innovation and policy optimization. The findings provide actionable insights and strategic guidance for Chinese corporations and government decision-makers on the development and optimization of offshore platform technology, thereby supporting the long-term coordinated governance of marine energy social systems.

Keywords: technology forecasting model, offshore platform technology, multidimensional information, topic analysis, marine energy policy.

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1 Introduction

Offshore platforms, as crucial facilities for the development and utilization of marine resources, are significant not merely in economic terms but also in areas such as national strategy, environmental protection, and technological advancement. Offshore platform technology continues to evolve rapidly; for example, floating offshore wind platforms have progressed from small-scale prototypes to full-scale devices deployed at sea [1]. On the one hand, as onshore oil and gas resources gradually deplete, oceans, particularly deep-sea regions, emerge as new frontiers for energy exploration; offshore platforms facilitate the extraction of these deep-sea oil and gas reserves, substantially enhancing human energy resources and bolstering national energy security. On the other hand, these platforms also function as monitoring centers, enabling the immediate assessment of marine pollution and ecosystem variations, predicting marine disasters, and safeguarding maritime territorial integrity. Therefore, offshore platforms serve not only as infrastructure for marine resource exploitation but also as critical components of national strategic initiatives. These platforms play an instrumental role in fostering technological advancement, reinforcing national security, and promoting environmental sustainability.

The development of offshore platforms relies heavily on advanced technology. Offshore platforms include diverse fixed and floating types, such as jacket, gravity-based, tension leg, spar, and semi-submersible platforms, which are applied in oil and gas production, offshore wind energy, and other marine activities [2]. Their development involves the in-depth application of traditional engineering sciences such as structural mechanics, materials science, ocean engineering, and electrical automation, and actively incorporates the latest advancements in cutting-edge fields including modern information technology, artificial intelligence, and new energy technology. Consequently, the evolution of offshore platform technology greatly depends on cross-disciplinary technological innovation and integration. Accurately predicting the development trends of offshore platform technology is crucial for guiding the development of the offshore engineering sector, fostering technological innovation, protecting the ecological environment, enhancing international competitiveness, optimizing resource allocation, and ensuring operational safety. This holds profound significance for achieving sustainable development of marine resources.

Although technological development is fraught with uncertainties, historical evidence reveals consistent patterns, cycles, and trends [3]. For example, the technology life cycle theory suggests that new technologies generally progress through stages of emergence, growth, maturity, and decline, which are observable across various technologies. Concurrently, a broad spectrum of technology-related data, including R&D investments, patent application counts, and publication data of scientific papers, demonstrates regular patterns. Such patterns are instrumental in modeling and forecasting future technological trends accurately.

Numerous scholars have proposed various methods for technology forecasting. Technology forecasting methods can generally be categorized into qualitative and quantitative approaches based on their reliance on data [4]. Qualitative methods predominantly utilize the experience and knowledge of experts, which often renders the conclusions subjective [5]. With advances in computer technology, quantitative methods such as statistical and machine learning methods based on patent indicators [6] and text mining [7] have increasingly been employed in this field. Compared to indicator-based methods, text mining excels at extracting useful information from a vast corpus of textual documents, thus becoming a mainstream method in technology forecasting [8]. However, text mining faces challenges in filtering out irrelevant and meaningless information [9], and discovering the linkages between topics extracted from scientific papers and patents remains a complex task [10], which underscores the valuable contributions of experts' wisdom. Consequently, it is essential to integrate text mining with expert insights to effectively predict technological trends and enhance the reliability of the outcomes.

The foundation of text mining lies in the text. Patent analysis can be conducted on the basis of patent citations, International Patent Classification (IPC) codes, or keywords and other textual content extracted through text mining [11, 12]. Previous studies have predominantly relied on patent data, for example, to forecast the development of defense technologies [13] and to model the temporal patterns of patent counts for technology analysis [14]. However, patents alone do not fully represent the development of a technology. Academic papers, as vital products of research, also mirror technological advancement.

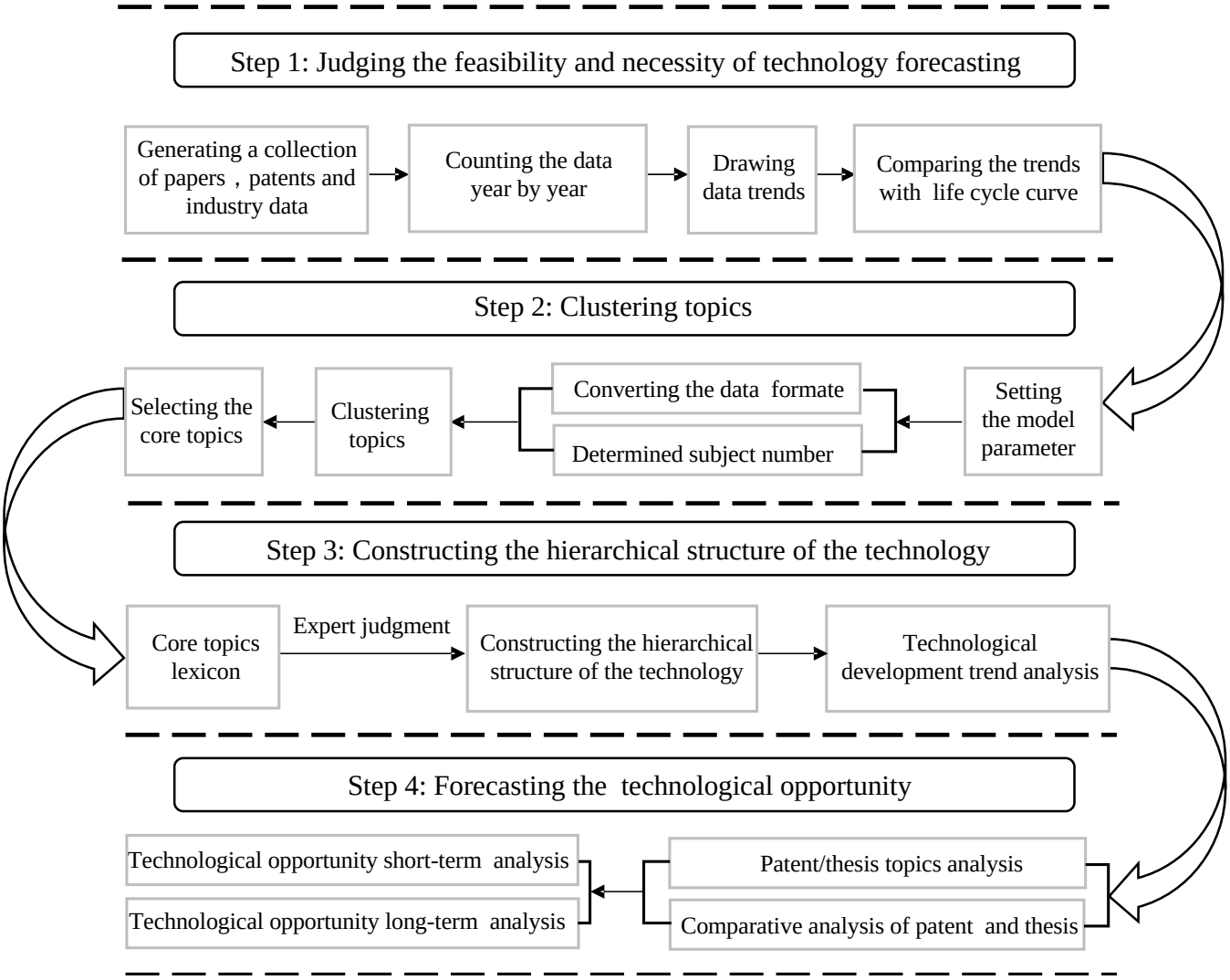


Figure 1. Framework of technology forecasting.

Thus, an integration of papers and patents reflects the research level and market acceptance of the technology, with papers indicating the fundamental R&D status and patents demonstrating practical applications [15]. Moreover, data beyond scientific and technical documents, such as social media data, can reflect market and public attention to a technology and complement patent analysis in monitoring its development trends [16]. Similarly, industry data, such as investments, elucidate the market acceptance and potential of a technology, influencing its future trends and directions. Consequently, this study posits that merging patents, papers, and industry data into a multidimensional informational base text can comprehensively capture the current state of technological development and enhance the accuracy of future predictions.

In this study, a technology forecasting model that integrates text mining with expert knowledge is developed and applied to predict trends in offshore platform technology in China. The remainder of this paper is organized as follows: Section 2 outlines the details of the technology forecasting model; Section 3 provides a detailed analysis of offshore platform technology in China from 2004 to 2023 and forecasts future development trends; Section 4 presents the conclusions.

2 Methods

Based on the text mining method, a framework for technology forecasting is developed in this paper. This framework can be considered an enhancement to that proposed by Li et al. [17]. In that work, the authors combine topic text mining methods that use scholarly and patent documents with expert judgment methods for predicting trends in technology. In this study, additional industry data are included to enrich the text source. Furthermore, a preprocessing step to evaluate

the feasibility and necessity of technology forecasting is performed. Finally, the framework is divided into four steps, as shown in Figure 1.

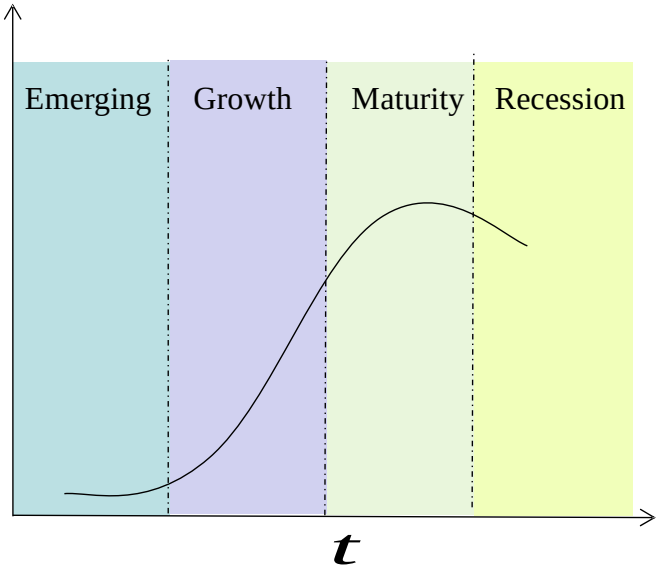


Figure 2. Technology life cycle curve.

Step 1: Judging the feasibility and necessity of technology forecasting. This study employs the Web of Science (WOS) and Derwent Innovations Index (DII) databases to gather scientific articles and patent data, while industry reports are used as the source for industry data. Search terms related to the target technology are formulated, with data compiled annually from 2004 to 2023. To evaluate the feasibility and necessity of forecasting trends, growth curves for patent, paper, and industry data are generated. The method involves fitting these growth curves to a technology life cycle curve to determine the technology's current phase, as illustrated in Figure 2 [18]. Typically, technology development exhibits a "slow-fast-slow" trajectory. It is usually represented by an S-shaped life cycle curve, encompassing four phases: emergence, growth, maturity, and decline. If this technology has reached the decline phase, technology forecasting may be deemed unnecessary.

Step 2: Clustering topics. The textual content from papers and patents, sourced from WOS and DII, is archived annually. CiteSpace is used for analysis to convert these files into XML format [19]. Subsequently, the Lingo algorithm of Carrot2 is adopted to cluster topics for both papers and patents through a three-step process (Figure 3):

(1) Constructing a user dictionary and a stop-word list, incorporating domain experts' insights to prevent technical jargon from fragmentation and to eliminate textual noise;
(2) Determining the optimal number of topics by calculating perplexity;
(3) Estimating the probability of each topic in the texts and enumerating the topic words.

Step 3: Constructing the technology hierarchy and analyzing technological development trends. The technology tree is a branching diagram that represents the relationships between technologies [20]. It provides a technology map that illustrates the relationships among product components, technologies, or technological functions within a specific technology field. Similarly, technology roadmaps built on bibliometric and text mining analyses can depict the structure and development of emerging technologies [21]. Decomposing a technology into its structural dimensions and constituent elements, as in morphology analysis, helps to systematically identify technology fields with development potential for in-depth analysis [22]. Using the clustered technology topic words as objective evidence for decision-making, we utilize the results and expert knowledge in the thematic analysis process. Ultimately, the hierarchy of technologies is constructed.

Step 4: Forecasting technological opportunities. According to the research of Shibata et al. [23], topics present in academic papers but absent in patents are identified as opportunities. Identifying such opportunities provides direction for future technological development; for example, patent mining has been applied to identify technological innovation opportunities for floating liquefied natural gas systems on offshore platforms [24]. Thus, it is essential to identify technological opportunities to anticipate technological trends. We perform a differential analysis of the topics with high growth rates in scientific papers versus patents. We compare the technological evolution paths delineated in both papers and patents to project future technological development trends.

3 Offshore Platform Technology Forecasting in China

3.1 Data collection and preprocessing

In this section, the developed model is used to forecast offshore platform technology in China. The data sources for papers, patents, and industry data are the WOS, the DII, and publicly available industry reports

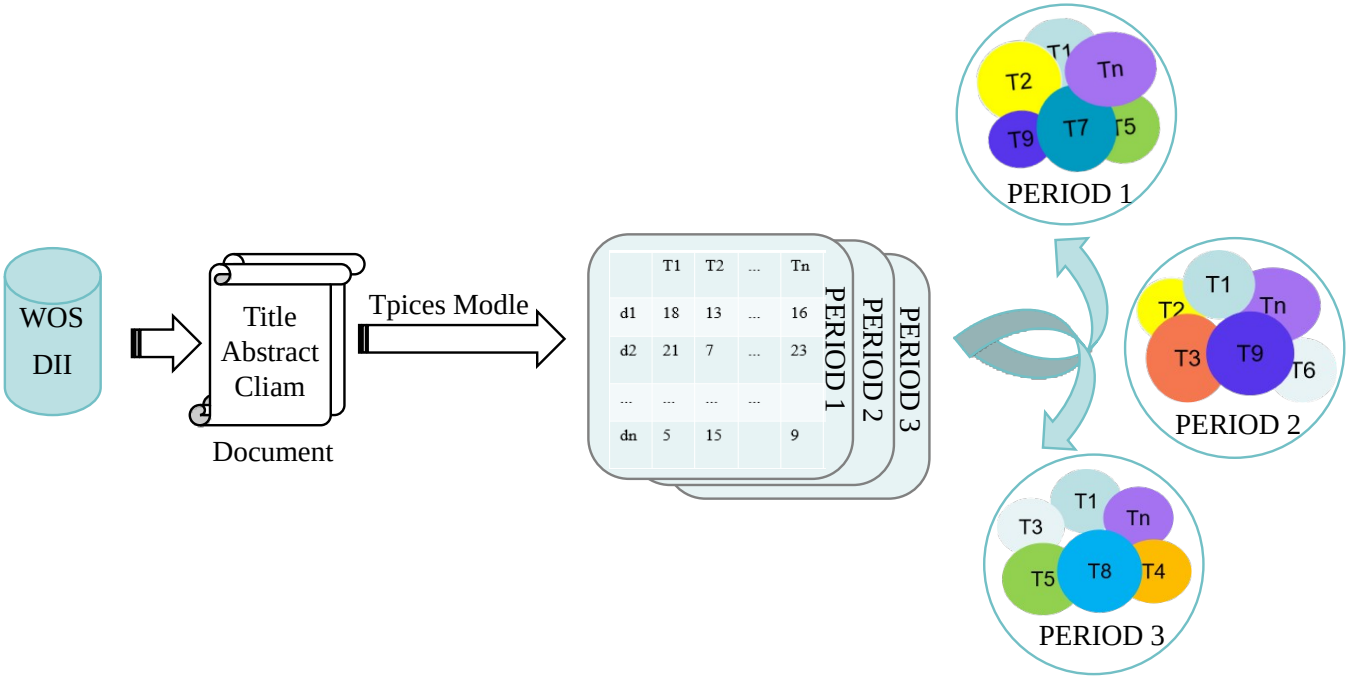


Figure 3. Flowchart of the topic clustering process.

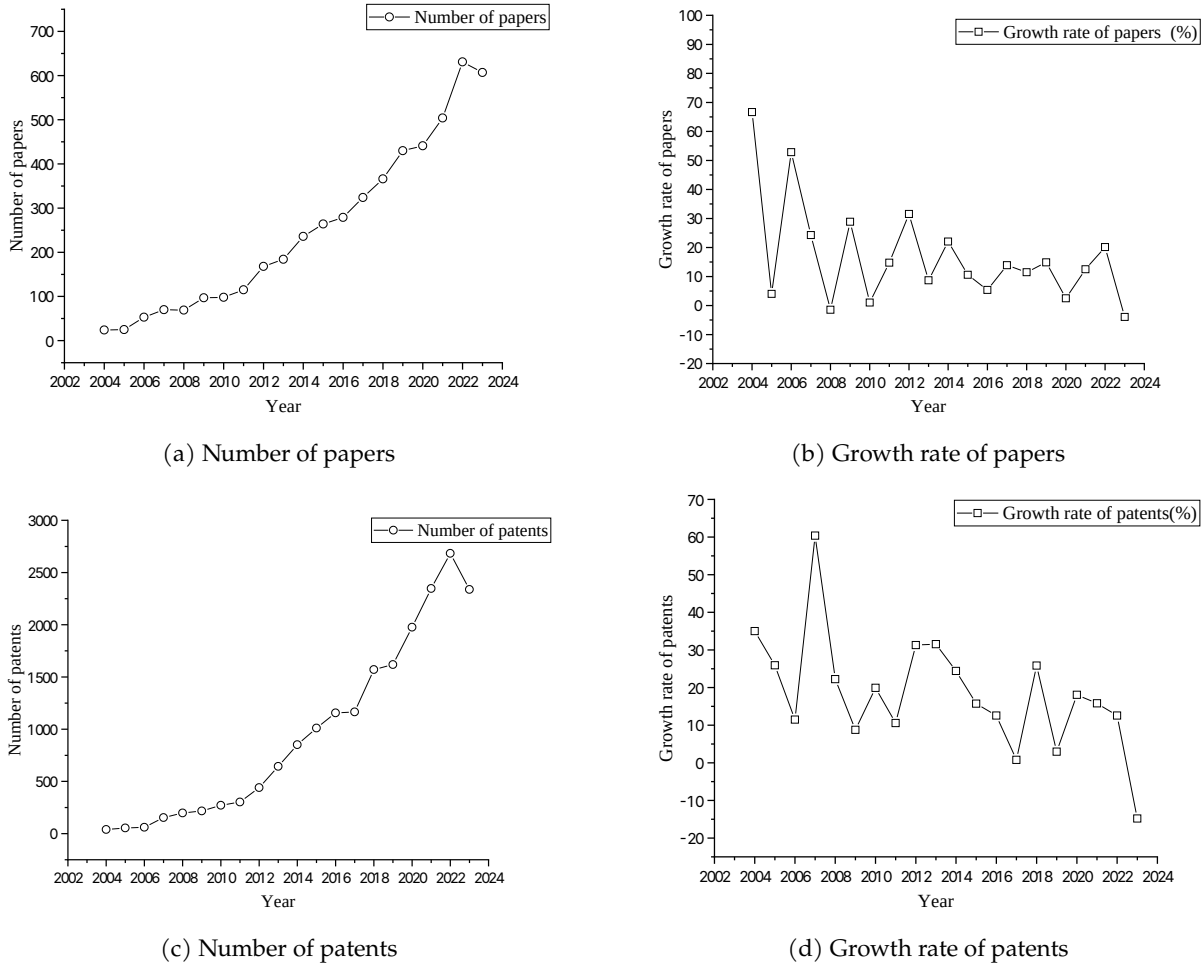


Figure 4. Number and growth rate of papers and patents per year on offshore platform technology.

released by authoritative institutions, respectively. "TS=(Offshore platform) AND CU=(China)" was

used as the query to search for papers, retrieving 4,985 papers from the WOS database between 2004 and 2023. As of 14 November 2024, "TS=(Offshore platform) AND PN=(CN*)" was used as the query to retrieve patent data from the DII, with 19,102 granted patents retrieved from the database between 2004 and the end of 2023. The industry data were extracted from annual reports published by the China Offshore Oil Engineering Corporation (COOEC), the Ministry of Natural Resources of the People's Republic of China, and the China Petroleum and Chemical Industry Federation (CPCIF) from 2004 to 2023.

All data were subjected to an identical preprocessing protocol: (1) deduplication using DOI/patent-number matching; (2) format standardization (PDF-to-text conversion via the open-source tool CERMINE for papers and patents); (3) removal of extraneous content such as headers, footers, references and copyright notices.

3.2 Overall analysis

An overall analysis of the number of papers and patents was conducted, with the annual figures shown in Figure 4. The data illustrate a rapid, synchronized growth in the number of papers and patents related to offshore platform technology, which began to increase rapidly around 2012. This surge indicates heightened activity in research and development in this field in recent years. To quantitatively illustrate the growth rate, Figures 4(b) and 4(d) show the corresponding trends over time. Initially, the growth rate exhibited significant fluctuations due to the low base numbers of papers and patents. However, from 2008 onwards, the extreme growth rates seen earlier (above 50%) disappeared, and before 2023 the annual growth rates fluctuated roughly between -2% and 32%. Logistic growth-curve fitting yielded $R^2 > 0.95$ ($p < 0.001$, Levenberg–Marquardt (L-M) fitting). Despite a decrease in 2023 (about 4% for papers and 13% for patents), the overall trend in the number of papers and patents remains upward, underscoring the continued vibrancy of the offshore platform technology sector.

The most intuitive change in the development of industries related to offshore platform technology is the change in the sea area used in the offshore engineering field. A larger sea area indicates more prosperous industry development. Therefore, this section uses the sea area used in the offshore engineering field as a proxy for industry data related to offshore platform technology. The extent of sea area used in the offshore engineering field over the years is shown in Figure 5. It can be seen that since 2004, the sea area used in the offshore engineering field grew slowly (logistic fit $R^2 = 0.96$, $p < 0.001$). Starting in 2019, influenced by national policies, the growth rate of the sea area used in the offshore engineering field accelerated: the annual increase rose from about 16,000 hectares in 2018 to about 76,000 hectares in 2020, and although it moderated to about 48,000 hectares in 2022, the area continued to expand, reaching 856,903 hectares in 2022.

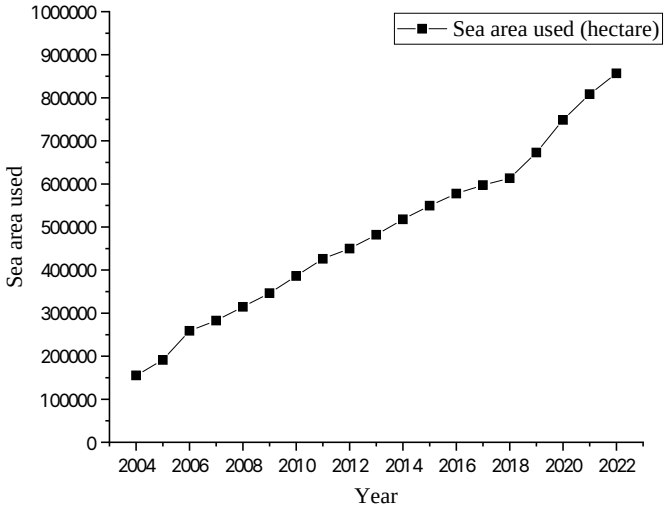
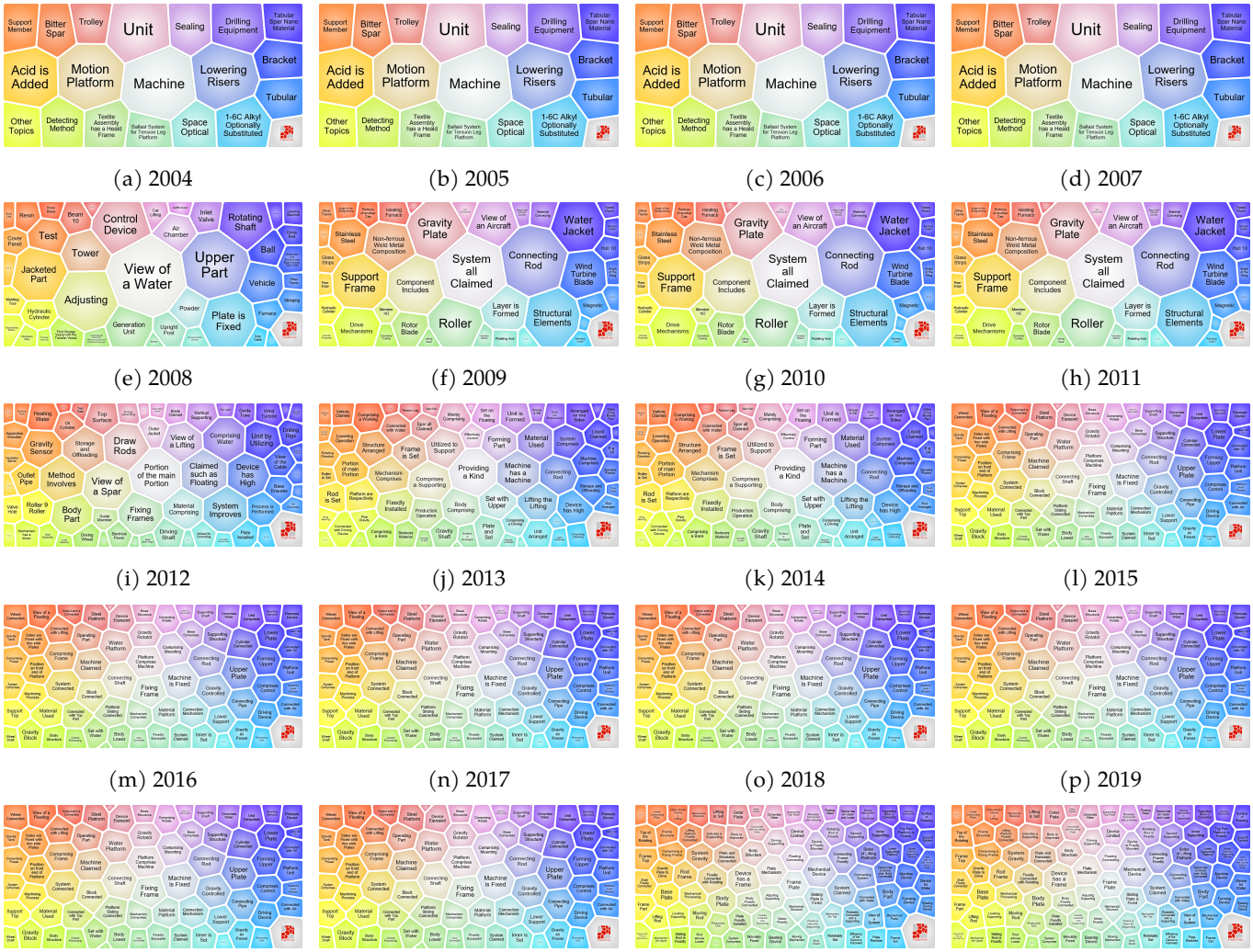


Figure 5. Sea area used in the offshore engineering field.

Based on the analysis of the trends in academic papers, patents, and industry data related to offshore platform technology (Figures 4(a), 4(c), and 5), as well as the technology life cycle curve (Figure 2), it is possible to ascertain the current phase of research, application, and industrialization of this technology. The stage of paper development is in the late growth phase, indicating that the research and development of offshore platform technology is in a rapid growth phase with high innovation vitality. The stage of patent development is in the mid-growth phase, indicating that the application of offshore platform technology is in a high-speed growth phase. The quantity of sea area used is in the transition phase from the emergence phase to the growth phase, indicating that the commercialization of offshore platform technology is still in its early stages. The above analysis indicates that offshore platform technology is not yet fully mature, and the emergence of new technologies in this field may have a significant impact on industry development. Therefore, accurate predictions of these trends are essential.



(a) 2004 (b) 2005 (c) 2006 (d) 2007

(e) 2008 (f) 2009 (g) 2010 (h) 2011

(i) 2012 (j) 2013 (k) 2014 (l) 2015

(m) 2016 (n) 2017 (o) 2018 (p) 2019

(q) 2020 (r) 2021 (s) 2022 (t) 2023

Figure 6. Topic clustering of offshore platform technology.

3.3 Topic clustering and hierarchical structure construction

3.3.1 Topic clustering

The Lingo algorithm in Carrot2 is used to cluster topics related to offshore platform technology by year. The clustered themes related to offshore platform technology over the years are shown in Figure 6.

The top 20 technology topics are extracted from the overall text corpus, and a word frequency graph visualizes the important technologies in the offshore platform field, as shown in Figure 7.

3.3.2 Hierarchical structure construction

On the basis of the above, twelve offshore-platform experts (6 academia, 4 industry, 2 regulators) selected by snowball sampling validated topics, built the hierarchy and adjudicated gaps through a two-round Delphi until $\kappa = 0.78$ agreement was reached. As depicted in Figure 8, offshore platform technology consists of three main categories: "Fixed Platforms", "Compliant Platforms", and "Floating Platforms". "Fixed Platforms" include "Jacket Platform", "Gravity Platform", and "Jack-up Platform"; "Compliant Platforms" are composed of "Guyed Tower Platform", "Articulated Tower", and "Tension Leg Platform"; "Floating Platforms" consist of "Semisubmersible", "Floating Production Unit (FPU)", "Floating Storage and Offloading (FSO)", "Floating Production, Storage, and Offloading System (FPSO)", and "Spar Platform".

3.3.3 Analysis of the technological development trends

The offshore platform technology topics are analyzed over different time periods to form a timeline graph, as shown in Figure 9. As illustrated, offshore platform technology exhibits the following characteristics:

(1) Interdisciplinary integration. The technological fusion of marine oil and gas development equipment involves multiple disciplines, such



Figure 7. Word frequency graph of core topics in offshore platform technology.

as engineering mechanics, material science, and information technology. The intersection and integration of different disciplines promote technological innovation and breakthroughs.

(2) Intelligentization. With the development of artificial intelligence and big data technologies, marine oil and gas development equipment is becoming increasingly intelligent. Intelligent control systems and intelligent monitoring devices are becoming important directions for technological breakthroughs.

(3) Greening. The enhancement of environmental awareness drives the development of marine oil and gas development equipment towards greening. Energy-saving, emission reduction, and environmentally friendly technologies are becoming key elements in technological development.

3.4 Technology comparison and forecasting

3.4.1 Comparison analysis

Based on the hierarchy diagram, an analysis of the evolution trends of technology topics was conducted, starting with the first level of the offshore platform technology hierarchy, namely, "Fixed Platforms", "Compliant Platforms", and "Floating Platforms".

The number of occurrences of the three themes–"Fixed Platforms", "Compliant Platforms", and "Floating Platforms"–in papers and patents in the offshore platform field is shown in Figures 10(a) and 10(b). It can be observed from the figures that before 2012, the number of papers on the three topics in the offshore platform field was relatively low, remaining below 100. After 2012, the number of papers on the "Fixed Platforms" and "Floating Platforms" topics showed a growth trend, with the rate of growth also increasing. Before 2012, the number of patents on the "Fixed Platforms" and "Floating Platforms" topics in the offshore platform field grew slowly and remained at a comparable level, while that on the "Compliant Platforms" topic remained far lower. Since 2012, the number of patents on the "Fixed Platforms" topic has shown a significant growth trend, and the growth rate of patents on the "Floating Platforms" topic has also increased. However, the number of patents on "Floating Platforms" no longer keeps pace with that of "Fixed Platforms". The number of patents on the "Fixed Platforms" topic reached about 1,750 in 2023 (with a peak of about 1,970 in 2022), while that on the "Floating Platforms" topic was about 500 and that on the "Compliant Platforms" topic was fewer than 100.

To provide a more intuitive analysis of the focus of offshore platform technology in basic research and development and its application, the relative proportions of the annual counts of the three topics–"Fixed Platforms", "Compliant Platforms", and "Floating Platforms"–in papers and patents are statistically analyzed, as depicted in Figures 10(c) and 10(d). For papers, the relative proportions of the three topics are relatively stable, with only slight fluctuations. The "Floating Platforms" topic has the largest share, followed by "Fixed Platforms", while "Compliant Platforms" accounts for a very small proportion. For patents, the proportion of "Floating Platforms" topics has been on a continuous decline, while the proportion of "Fixed Platforms" topics has been on a continuous rise, quickly occupying more than half of the total proportion.

From this, it can be concluded that, in terms of basic research and development, the development of offshore platform technology is relatively stable across different categories, with "Floating Platforms" having the largest share. In terms of applied research, the focus of offshore platform technology has shifted from "Floating Platforms" to "Fixed Platforms".

Below is the analysis of the second level of the offshore platform technology structure, namely the respective sub-topics of "Fixed Platforms", "Compliant Platforms", and "Floating Platforms".

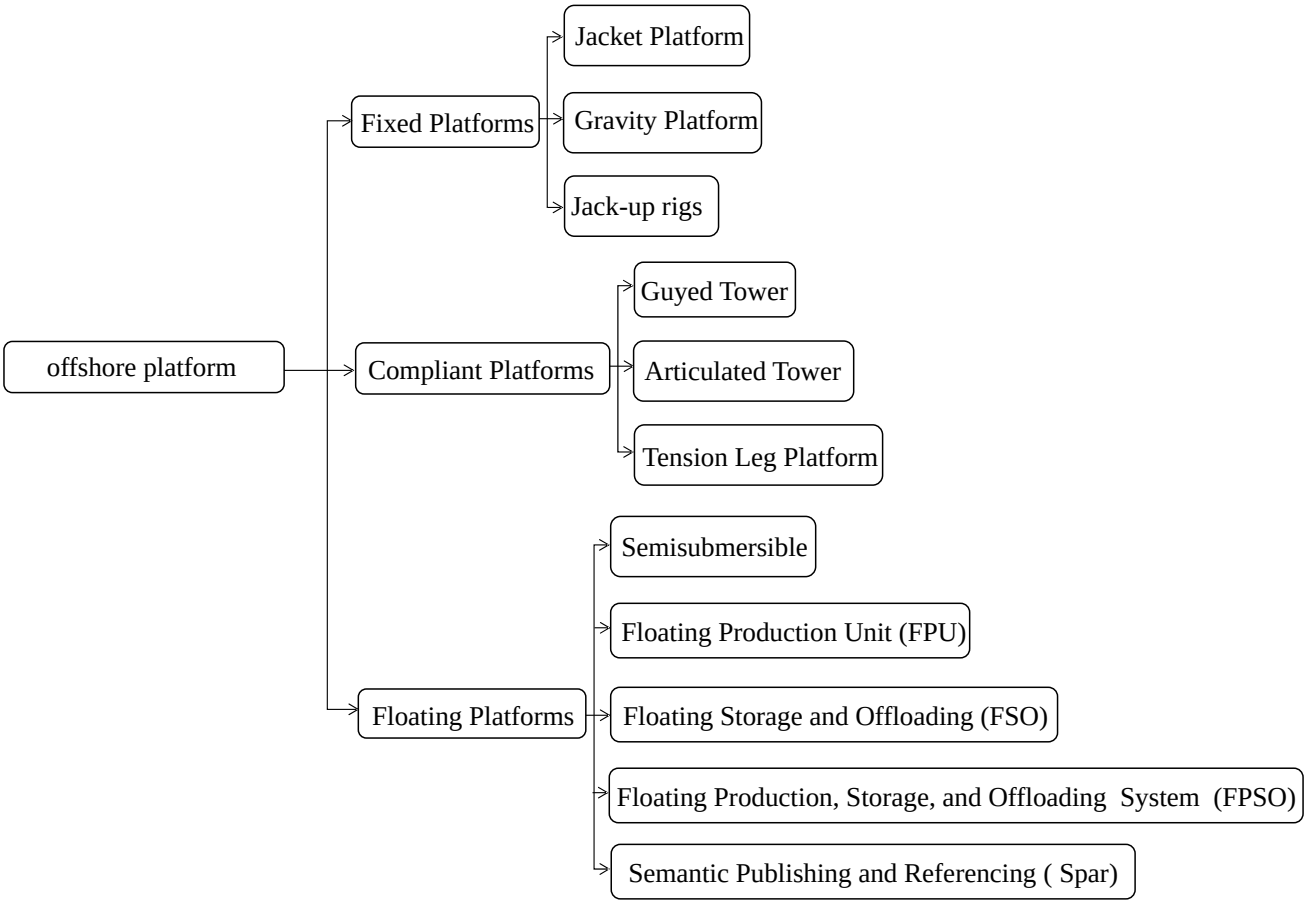


Figure 8. Offshore platform technology tree.

In the papers, under the topic of "Fixed Platforms", the sub-topics include "Jacket Platform", "Gravity Platform", and "Jack-up Platform". Figure 11 shows the changes in the numbers and proportions of different sub-topics over the years. It can be observed that before 2010, the "Jacket Platform" topic had a larger share, and since 2010, the proportion of the "Jacket Platform" topic has been continuously declining. The proportion of the "Jack-up Platform" topic has always been relatively small. Since 2012, the proportion of the "Gravity Platform" topic has generally increased and has remained at or above half of the sub-topic total, reaching about 70% by 2023.

From this, we can conclude that the "Gravity Platform" is a hot topic in the current basic research and development within the "Fixed Platforms" category of offshore platform technology, while the technology related to the "Jacket Platform" is mature and gradually losing research interest.

The sub-topics under the "Fixed Platforms" topic in patents are quite different from those in academic papers. Figure 12 shows the changes in the numbers and proportions of different sub-topics over the years. It can be seen from the figure that in the field of "Fixed Platforms", the "Matthew Effect" is evident in the number of patents in various sub-topics, with the "Gravity Platform" theme having a larger share and showing continuous growth. Meanwhile, the proportion of the "Jacket Platform" and "Jack-up Platform" topics has always been relatively small and continues to decline.

From this, we can conclude that the application research in "Fixed Platforms" in offshore platform technology currently focuses on "Gravity Platform", and this trend is becoming more pronounced.

In the papers, the "Compliant Platforms" topic is divided into three categories: "Guyed Tower Platform", "Articulated Tower", and "Tension Leg Platform". Figure 13 shows the changes in the numbers and proportions of different sub-topics over the years. It can be seen from the figure that the number of "Tension Leg Platform" related topics has a clear advantage, with "Guyed Tower Platform" and "Articulated Tower" appearing in only a few years.

From this, we can conclude that in offshore platform

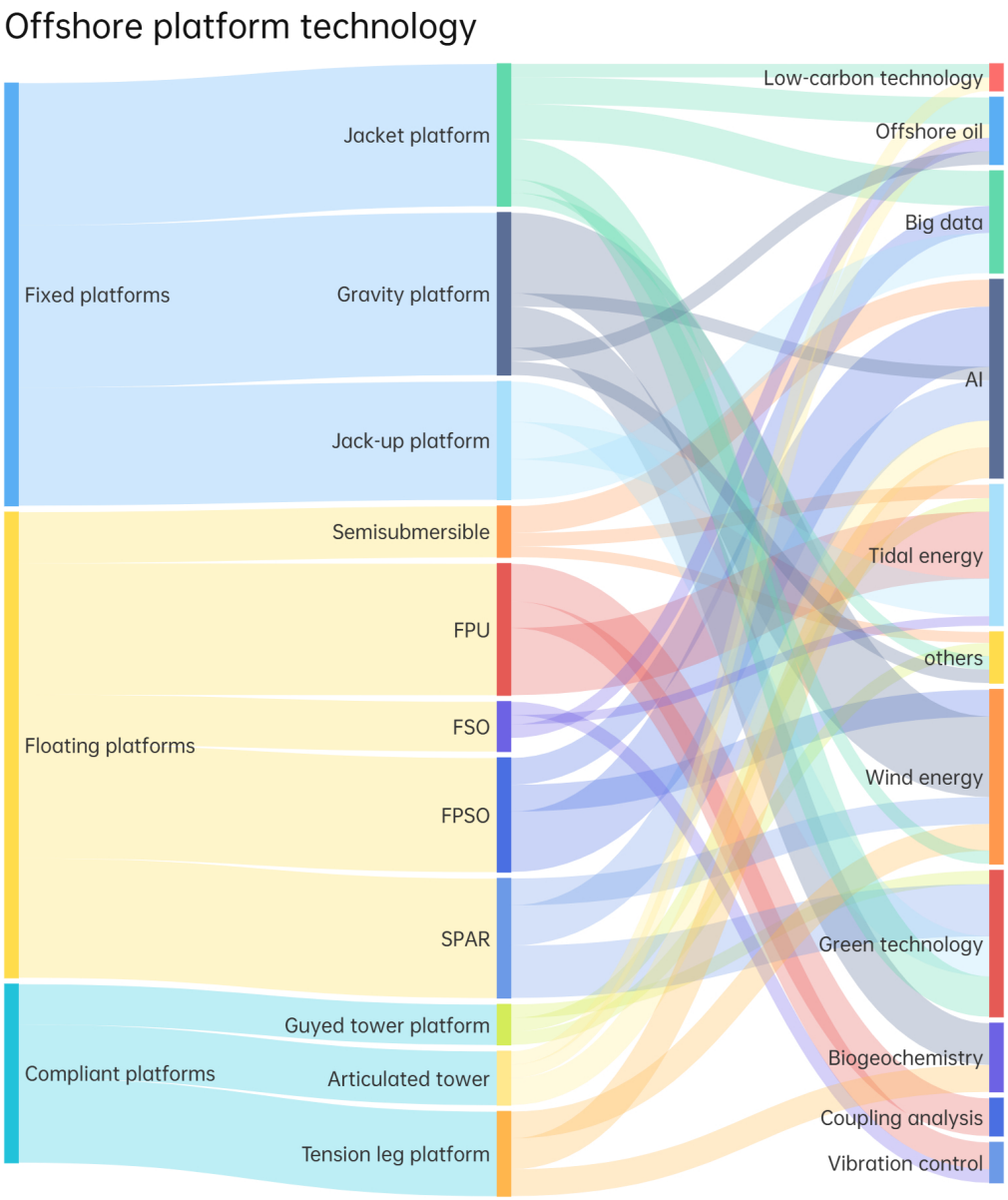


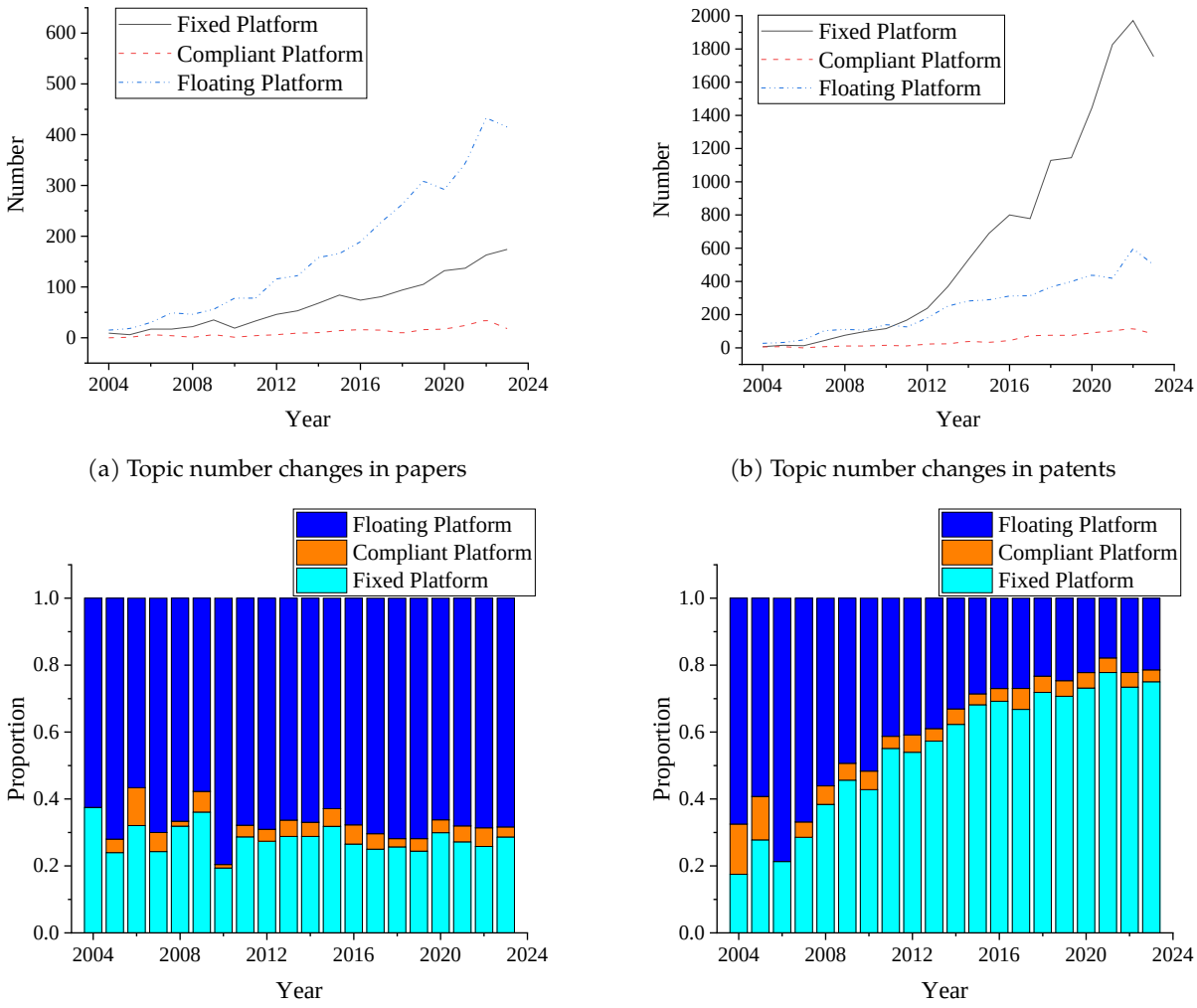
Figure 9. Offshore platform technology topics flow chart.

technology, the basic research and development of various sub-topics within the "Compliant Platforms" category are mainly focused on "Tension Leg Platform".

The distribution of sub-topics under "Compliant Platforms" in patents is similar to that in academic papers. Figure 14 shows the changes in the numbers and proportions of different sub-topics over the years. It can be seen from the figure that after 2012, the proportion of "Tension Leg Platform" related topics increased; before 2012, "Articulated Tower" had a dominant share, while after 2012, the proportion of "Articulated Tower" related topics decreased.

From this, we can conclude that in offshore platform technology, the application research of the various sub-topics within "Compliant Platforms" has shifted from a focus on "Articulated Tower" to a focus on "Tension Leg Platform".

In the papers, the "Floating Platforms" topic is divided into five categories: "Semisubmersible", "FPU", "FSO", "FPSO", and "Spar". Figure 15 shows the changes in the numbers and proportions of different sub-topics over the years. It can be seen from the figure that since 2008, the proportion of "Spar" related topics



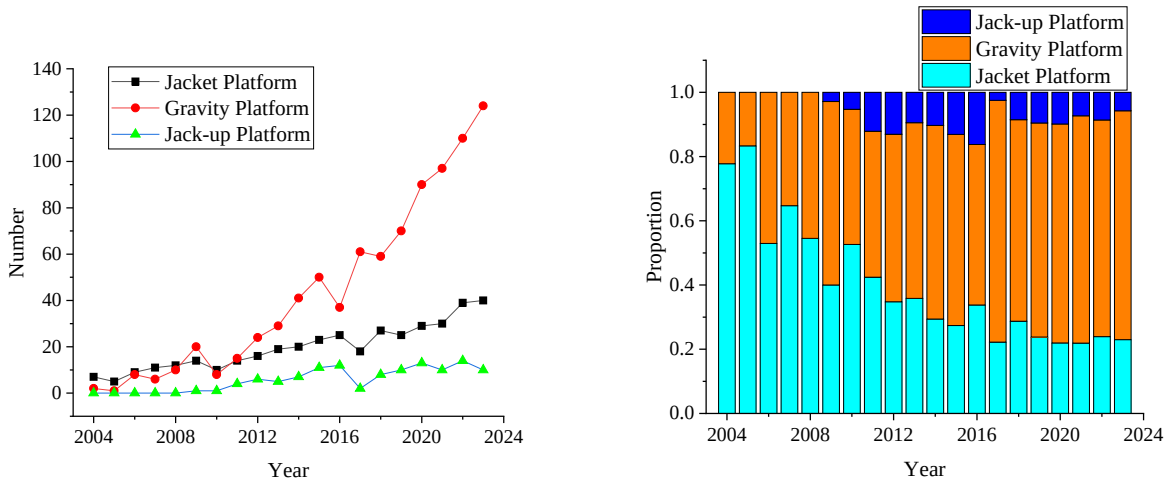
(a) Topic number changes in papers

(b) Topic number changes in patents

(c) Topic proportion changes in papers

(d) Topic proportion changes in patents

Figure 10. Annual changes in the "Fixed Platforms", "Compliant Platforms", and "Floating Platforms" topics in papers and patents.

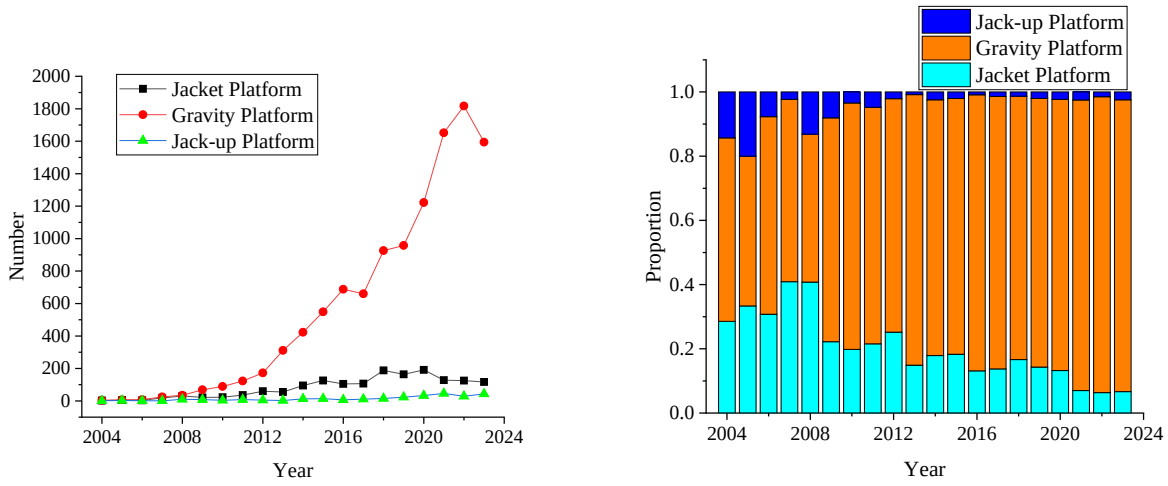


(a) Sub-topic number changes

(b) Sub-topic proportion changes

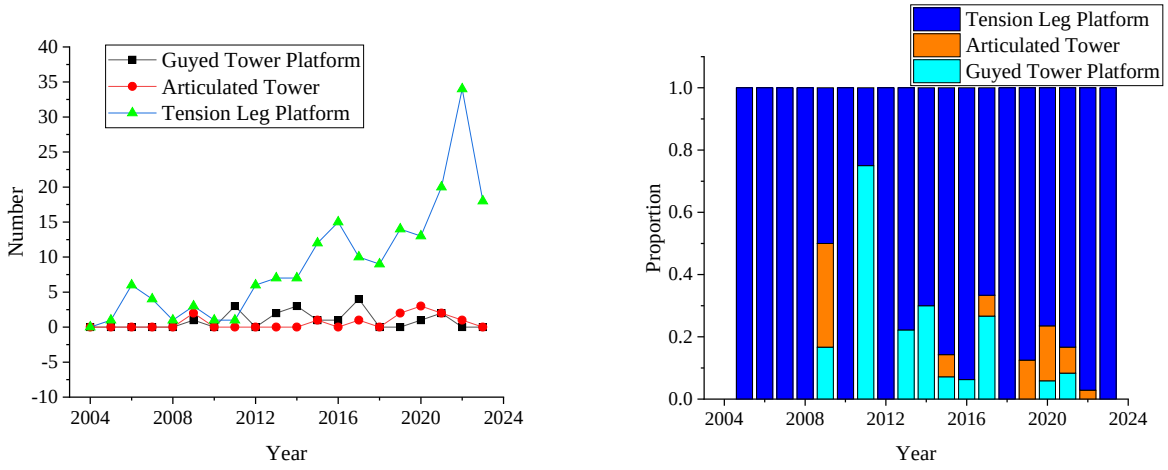
Figure 11. Annual changes in sub-topics under "Fixed Platforms" in papers.

has been on a continuous downward trend, and has remained relatively stable from 2014 to 2023. Since 2010, the number and proportion of "FSO" related topics have been on a continuous upward trend, and its



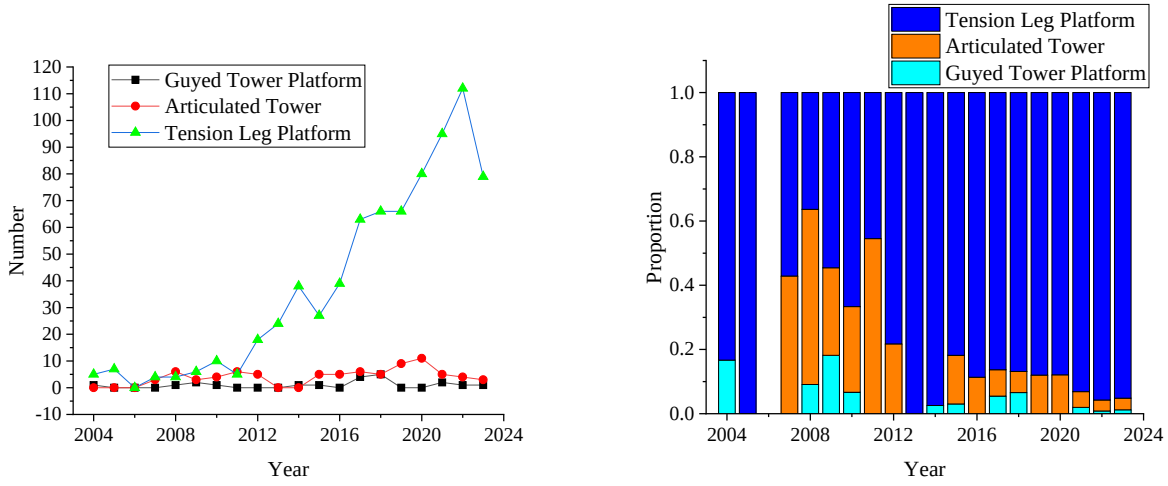
(a) Sub-topic number changes (b) Sub-topic proportion changes

Figure 12. Annual changes in sub-topics under "Fixed Platforms" in patents.



(a) Sub-topic number changes (b) Sub-topic proportion changes

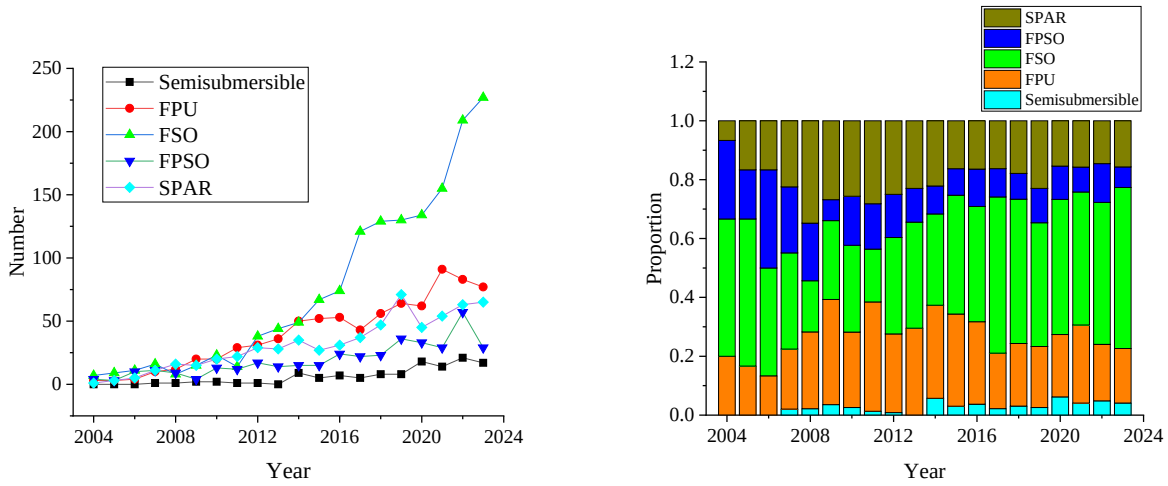
Figure 13. Annual changes in sub-topics under "Compliant Platforms" in papers.



(a) Sub-topic number changes (b) Sub-topic proportion changes

Figure 14. Annual changes in sub-topics under "Compliant Platforms" in patents.

proportion exceeded half in 2023. The proportions of the other three themes have remained relatively stable.



(a) Sub-topic number changes (b) Sub-topic proportion changes

Figure 15. Annual changes in sub-topics under "Floating Platforms" in papers.

From this, we can conclude that in offshore platform technology, the basic research and development of various sub-topics under "Floating Platforms" are making continuous progress, the interest in "Spar" topics is declining, and "FSO" related topics are starting to gain some attention.

The proportion of "Floating Platforms" topics in patents has been relatively stable. Figure 16 shows the changes in the numbers and proportions of different sub-topics over the years. It can be seen from the figure that "Semisubmersible" related topics rarely appear in the data. "Spar" and "FPSO" related topics are declining with fluctuations. "FPU" and "FSO" related topics are rising with fluctuations.

From this, we can conclude that in offshore platform technology, the application research of various sub-topics under "Floating Platforms" rarely includes "Semisubmersible" platforms, the interest in "Spar" and "FPSO" platforms is declining, and "FPU" and "FSO" related topics are starting to gain some attention.

3.4.2 Technological opportunities forecasting

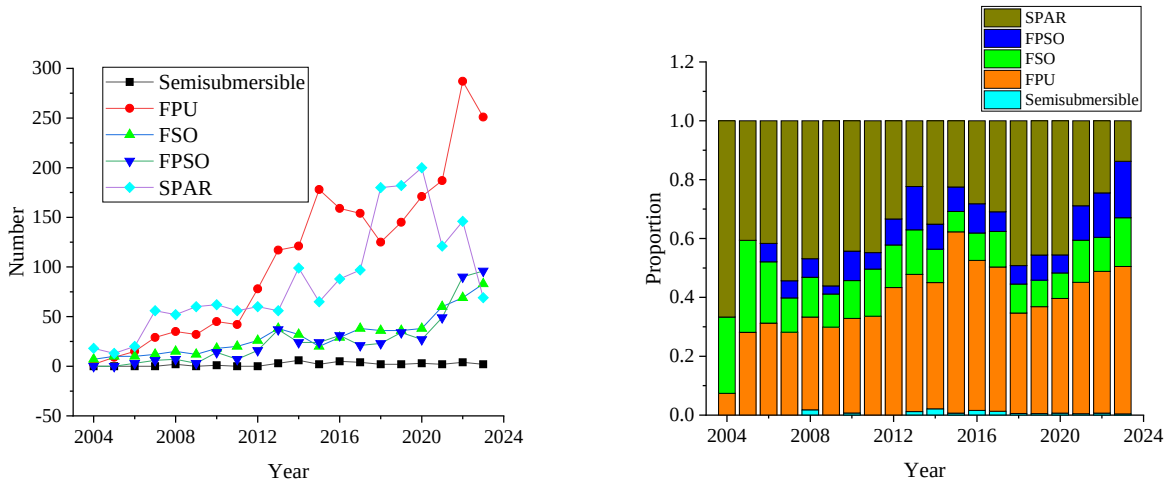
Based on the previous analysis of the themes in papers and patents, predictions for emerging technological opportunities in offshore platform technology have been made. The comparison of the results of related topics in papers and patents is shown in Figure 17. The trends of sub-topics under "Fixed Platforms" and "Compliant Platforms" in papers and patents are relatively consistent, forming a synergistic trend, with "Gravity Platform" and "Tension Leg Platform" being the mainstream. The sub-topics under the "Floating Platforms" topic show consistent directions but different proportions in papers and patents. The "FSO" sub-topic shows an upward trend and a clear advantage in proportion in papers (about 55% in 2023), while in patents it also rises with fluctuations but remains behind "FPU", which accounts for about half of the floating-platform patents in 2023. The "Spar" sub-topic shows a downward trend and a clear loss of proportion advantage in papers, while in patents it also declines with fluctuations.

The following predictions for offshore platform technology are provided: (1) In the near future, "Gravity Platform" and "Tension Leg Platform" will continue to be the mainstream in offshore platform technology research; (2) In the long term, the "FSO" and "FPU" topics will become hot spots in application research; (3) The basic research on the "Spar" topic appears to be nearing saturation, and the enthusiasm for application research is also expected to continue declining in the near future.

4 Conclusions

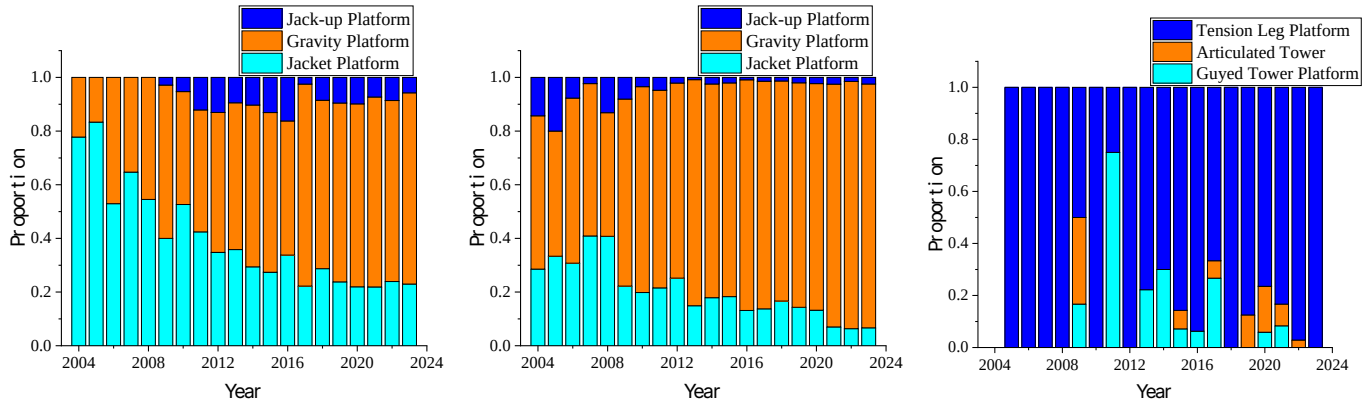
In this paper, a technology forecasting model is developed to predict the development trends of offshore platforms in China. To enhance both efficiency and accuracy, a combination of topic-based text mining and expert judgment was employed. Multidimensional information, including scientific papers, patents, and industry data from 2004 to 2023, was analyzed to improve the reliability of the results. The findings are summarized as follows:

(1) Research and application of offshore platform technology are currently experiencing a period of explosive growth, although industrialization

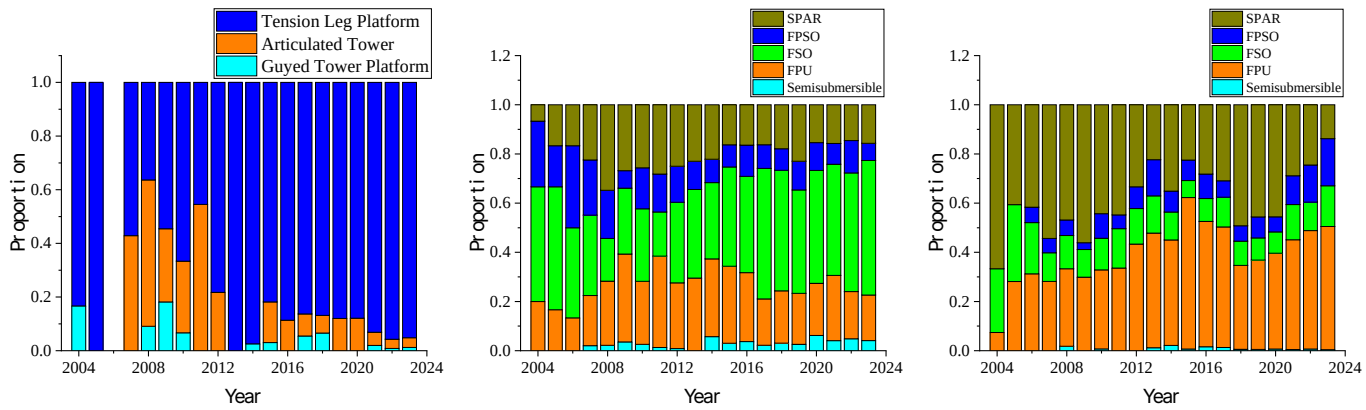


(a) Sub-topic number changes (b) Sub-topic proportion changes

Figure 16. Annual changes in sub-topics under "Floating Platforms" in patents.



(a) "Fixed Platforms" sub-topics in papers (b) "Fixed Platforms" sub-topics in patents (c) "Compliant Platforms" sub-topics in papers



(d) "Compliant Platforms" sub-topics in patents (e) "Floating Platforms" sub-topics in papers (f) "Floating Platforms" sub-topics in patents

Figure 17. Comparison of topics in papers and patents.

remains in its nascent stages. An analysis of the development trends across research papers, patents, and industry data related to offshore platform technology, aligned with the life cycle curve, confirms this rapid growth phase. This period is characterized by swift advancements in technology, increased research activities, rising patent applications, and substantial industry demand for new innovations. However, despite the significant potential for expansion

and development, the industrialization of offshore platform technology faces challenges in technological adaptation and market acceptance.

(2) The development trend of offshore platform technology is characterized by multidisciplinary integration, intelligence, and greening. An analysis of technology topic timelines reveals that these trends align with the goals of constructing a modern industrial system. By synergizing intelligence, greening, and multidisciplinary integration, a comprehensive, advanced, and secure modern maritime industry system is established. This approach not only enhances the efficiency of ocean resource development but also supports the sustainable development of the marine environment.

(3) In the near future, the "Gravity Platform" and "Tension Leg Platform" will remain the focal points of research in offshore platform technology. Concurrently, the "FSO" and "FPU" topics are poised to become prominent areas in application research. Meanwhile, the bibliometric data from 2004 to 2023 reveal that Spar fundamentals are nearing saturation: the number of Spar-related papers grew by only about 3% in 2023, the share of Spar patents among all offshore-platform patents fell from about 11% in 2018 to about 3% in 2023, and applied-research interest keeps falling.

However, the proposed model has several limitations. First, the forecasting framework is inherently shaped by historical patterns extracted from papers, patents and industry data. It may underestimate the emergence of disruptive technologies that, by definition, break existing trajectories and lack antecedent signals in the data. Second, expert judgment–used to interpret topic clusters and construct the technology hierarchy–can introduce subjective bias, especially when the experts are more familiar with incremental than radical innovations. Third, the current keyword-based retrieval strategy might miss cross-domain or out-of-scope inventions that could suddenly redefine offshore platform concepts. Future work will explore anomaly-detection techniques and weak-signal scanning on broader text corpora (e.g., pre-print repositories, standard drafts, and social media) to enhance sensitivity to potential disruptions.

Data Availability Statement

The data used to support this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest

Yan Zhou served as an Associate Editor of the *Journal of Social Systems and Policy Analysis* at the time of manuscript submission. To ensure the integrity of the peer-review process, Yan Zhou was not involved in the editorial handling, peer review, or decision-making process for this manuscript, which was handled independently by another editor. The remaining authors declare no conflicts of interest.

AI Use Statement

The authors declare that no generative AI was used in the preparation of this manuscript.

Ethical Approval and Consent to Participate

Not applicable.

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