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Advancing the robustness of risk regulation for offshore drilling operations in China

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Robust regulation has become a pursuit in risk governance of offshore drilling operations over the recent decade. However, the idea of robust risk regulation has not been fully developed in China. This paper aims to explore what affects the robustness of risk regulation and how can a robust regulatory regime for offshore drilling operations be achieved in China. It begins with an identification of risks and values of the offshore petroleum industry, highlighting that robust regulation is the primary means to manage such risks in offshore drilling operations. It then discusses dimensions of regulatory robustness and assesses and compares regulatory regimes for this high-risk offshore petroleum industry in the United Kingdom, Norway, the United States and China. In specific, the Chinese paths to govern the risks of offshore operations are summarized. A key theoretical debate on regulating offshore drilling operations is which regulatory modes can better facilitate the robustness of risk regulation. The command-and-control regulation and self-regulation represent two primary regulatory modes of offshore risk regulation. The former is strongly dependent upon public enforcement while the latter emphasizes internal continuous improvement of the offshore petroleum industry. To develop robust offshore regulation in China, this paper suggests that a certain combination of the two modes is necessary to deliver optimal regulatory outcomes.

KEYWORDS

offshore drilling operations, offshore safety, risk regulation, regulatory robustness, regulatory regime

Introduction

Major accidents arising from offshore drilling operations are usually attributable to man-made hazards such as operation errors, technical problems, regulatory failures, or a combination of these. In China, how to regulate offshore drilling operations and manage risks of offshore accidents has become a crucial issue in marine economic development and environmental protection. Although an increasing number of Chinese laws and regulations address offshore safety and environmental issues, they have not comprehensively covered risk analysis and prevention. As such, this paper agrees that robust regulation is the primary means to promote offshore safety because it has a strong capacity to investigate and solve

specific problems and challenges and thereby prevent major accidents and minimize risks in the whole process of offshore operations (Baram and Lindøe, 2014; Renn, 2014). The paper intends to contribute to conceptualizing, designing and implementing a robust legal regime for preventing major offshore accidents and improving the health, safety and environmental performance of operators in China. Under this quest, the paper takes ex-ante regulation as the key part of the robust regime for offshore drilling operations.

The concept of robustness appeared early on in scientific fields such as ecology and engineering, which then inspired sociologists and policy researchers in their own analyses (Capano and Woo, 2017). The term "robust", from a risk perspective, is used to describe that a system can resist risks and has the capability to retain its functions in exceptional circumstances. A robust regulatory regime comes with a wide range of dimensions, including purpose and principles, modes of governance, regulatory approach and development, and balance between politics and regulation. In accordance with these dimensions, the paper mainly discusses three aspects regarding risk regulation of offshore drilling operations: (1) legal framework and principles; (2) regulatory modes and their setting of legal norms, authorities, inspections, compliance and enforcement; (3) non-legally binding norms, including industry standards, best practice and cultural aspects.

The paper adopts a comparative study approach by comparing China with the United Kingdom (UK), Norway and the United States (US) to investigate similarities and differences in their regulatory regimes for offshore drilling operations. Globally, the offshore petroleum industry in different countries faces common challenges in sustainable development and risk management. The UK, Norway, the US, and China have all had offshore disasters in the past decades and made a series of regulatory reforms afterwards. It is noteworthy that the regulatory reforms in the four jurisdictions have followed a similar trajectory, albeit the timing has been different (Bennear, 2015). That is, their risk regulation for offshore operations at first relies on a prescriptive approach, then shift towards more goal-based and performance-based regulatory approaches after major offshore accidents revealed the weaknesses of the command and control (CAC) regulatory regime. Nonetheless, each jurisdiction has its own legal system and regulatory context, which leads to different characteristics in offshore risk regulation. It is difficult to judge which regulatory mode is more effective in reducing the risks of offshore drilling operations. This study argues that the joint use of different regulatory approaches while keeping its own regulatory features in China will stand the best chance for catastrophic accident prevention and facilitate the robustness of offshore risk regulation in China.

The quest for robust risk regulation of offshore drilling operations in China

Offshore safety in China

Offshore oil and gas resources have been an important part of China's energy system. In line with the arrival of the fuel demand peak, China's domestic crude oil production is expected to reach the summit by 2030 and domestic natural gas by 2035 (Wang et al., 2021). This drives offshore petroleum exploration and exploitation to move from territorial waters to further and deeper areas in the Bohai Bay, the East China Sea and the South China Sea. Meanwhile, new offshore technologies are widely emerging in China, with the objective of improving the production efficiency of offshore petroleum resources and mitigating the tension between energy consumption and low-carbon development. For example, China's first self-run deep-sea field Shenhai-1 has started drilling since 2021, which can produce over 1 billion cubic meters of natural gas per year (CGTN, 2022). Accordingly, offshore oil and gas operations in China are facing new challenges caused by a harsher coastal ecosystem environment and more complex drilling facilities.

A number of hazards, risks and uncertainties in offshore drilling operations threaten human health, offshore safety and the marine environment. Typical hazards in offshore operations include oil and gas leakage and possible fires, explosions and blowouts in specific accidents. For instance, both the Deepwater Horizon explosion in the US and the 2011 Bohai Bay accident in China caused personnel deaths or injuries and inevitably resulted in oil pollution and coastal and environmental contamination. Compared with vessel-sourced oil pollution, pollution resulting from offshore drilling operations is more difficult to estimate and control, particularly in catastrophic accidents. Surveys have suggested that vessel-sourced oil pollution is in decline, while consequential oil spills in offshore drilling disasters are more costly (Jernelöv, 2010). According to incomplete statistics, about 57% of offshore accidents are distributed in the North Sea, 26% in the US Gulf of Mexico (GOM) and 17% in other areas (WOAD, 2019). This should explain why current research is mainly conducted on the safety regulation on the European and the US continental shelves.

Offshore drilling activities are highly risky, leading to different attitudes and measures towards risks from stakeholders. The understanding of risk is related to the probability of hazards and their real consequences that can be prevented by participants (Renn, 2014). Chinese coastal residents, at the moment, show low support and medium trust in offshore drilling activities (Chen and Martens, 2021). National and international petroleum companies engage in balancing production and health, safety and environmental performance of offshore drilling activities. Both regulators and the industry recognize that environmental risks should be minimized in each stage of offshore operations. Hybrid cooperation, as such, is recommended in risk regulatory measures of offshore drilling operations. That is, diverse stakeholders at multiple levels of government make efforts in institutional construction and regulation development (Osofsky et al., 2016).

Risk management can help offshore operators maintain safety performance while reducing hazards and limiting the consequences of offshore accidents. In a complex governance model, risk management is a key phase that links regulatory regimes to non-regulatory factors or measures, helping stakeholders make collectives decision involving uncertainty and keeping risks at an acceptable level (Renn, 2014). Risk analysis, as the crucial evaluation component of the risk management process, is required by both industrial practice and legal standards for offshore drilling operations in China (Yang, 2019). Information and data for risk analysis are usually shared within the Chinese offshore industry but

are not transparent to the public and decision-makers. This is because China currently lacks databases on offshore installations and related accidents and has not made legal rules on this issue at the national level (Chang et al., 2022). In 2018, China Search and Rescue (SAR) Centre was authorized to corporately establish an information-sharing platform on marine oil spills. The platform should collect and record data for a better understanding of risk and to improve offshore and marine safety. Until now there has been no further disclosure of detailed requirements or guidelines of the platform.

Offshore risk regulation and its robustness

Risk regulation refers to state action of risk management, which differs across regimes. Risk regulation for offshore drilling operations has a public nature and operates in various forms such as policies, principles and standards. Offshore risk regulation usually imposes requirements on the ex-ante behaviors of operators. Ideally, it can offer minimum safety standards and encourage all stakeholders to take comprehensive measures to prevent major accidents. A robust regulatory outcome, therefore, becomes the main goal of offshore risk regulation in different regimes (Baram and Lindøe, 2014).

Regulatory robustness can be understood as a regime that is explicitly able to cope with all possible risks, adapt to changing situations while keeping basic functionalities, and achieve a stable balance of power and trust between stakeholders (Hale, 2014). The term 'robustness' has a somewhat similar meaning as the now more popular term 'resilience', although a resilient framework is more aimed at addressing sudden shocks and thus more likely to enable a fundamental shift in a company's core activities so as to adapt to arising internal and external challenges (Levin and Lubchenco, 2008). Considering that different legal regimes have their own values, norms, institutions and cultures, this paper uses 'robustness' to discover various regulatory regimes for offshore drilling operations that keep their basic functionality even under some component failures (Klau and Weiskircher, 2005). The scope of robust risk regulation for offshore drilling operations, according to the existing point of view, mainly comprises legally binding norms and offshore petroleum industry norms (see Figure 1). On one side, legally binding norms consist of laws, regulations and regulatory authorities based on "state control", which usually imposes mandatory inspections and sanctions on offshore operators. On the other side, industry standards, best practices and safety culture compose industry norms, which are more consistent with "internal control" of risk management systems of offshore drilling operations (Lindøe and Engen, 2013). Determining factors of the robustness of offshore risk regulation also include information disclosure and trust between regulators, inspectors and operators. Offshore risk regulation usually has two distinct modes, namely CAC regulation and self-regulation. The former heavily relies on legally binding norms, applying the prescriptive approach to safety inspections and enforcement. The latter is based on industry norms and having capable of keeping track of technological development and innovation in the offshore petroleum industry (Hart, 2010). In regulatory practice, different countries may integrate the elements of the two modes and maximize their advantages, such as the responsibility allocation and the role played by public and private sectors, in risk mitigations (Coglianese and Mendelson, 2010). This study, therefore, examines four countries' regulatory regimes governing offshore petroleum activities, with the aim of evaluating their robustness and providing paths for China to develop robust offshore risk regulation.

Regulatory regimes for offshore drilling operations: The UK, Norway, the US and China

The UK health and safety regulation

The 1988 Piper Alpha disaster was a booster of UK regulatory reforms for offshore drilling operations. With a public inquiry into the disaster, the UK Government initiated a research program on offshore safety and fundamentally changed the prior regulatory regime. First, instead of the UK Department of Energy, the Health and Safety Executive (HSE) took the responsibility of assessing the integrity and safety of offshore installations and developing the environmental regulatory framework for the United Kingdom Continental Shelf (UKCS). Second, new offshore safety regulations were developed based on a goal-setting approach, which means instead of the regulator, those who cause major accidents and manage hazards must be responsible for controlling the risks. For instance, a safety case must be prepared and submitted to the HSE for assessment and acceptance, before owners and operators start an offshore drilling program in the UKCS. This became a key rule afterwards and was developed into Offshore Installation (Safety Case) Regulations in 2005. The Safety Case Regulations abandoned the prescriptive approach and rationalized and simplified UK offshore health and safety legislation, with the aim of reducing risks of major accidents and hazards to workers' health and workplace safety on offshore installations or related activities (HSE, 2006).

The fundamental idea of the Safety Case Regulations is to have a living document that can be updated as required throughout the lifetime of the installation (Paterson, 2016). To achieve this life-cycle goal, safety cases must be made and carried out from designing an offshore installation to the operations until its modification or abandonment. The new offshore safety regulations are supposed to cover the whole process of offshore drilling operations, particularly those factors that could bring about a major accident. The safety case regime shows a performance-based characteristic that incorporates economic and safety benefits to provide incentives for operators. The HSE, under the regime, sets the general goal but leaves the details to duty holders to formulate. For example, operators take the obligation of formal safety assessments with independent verification (Acheampong and Akumperigy, 2018). Through the systematic risk analysis, the safety cases for offshore installations attempt to reduce the risks and hazards to as low as is reasonably practicable (ALARP) (HSE,

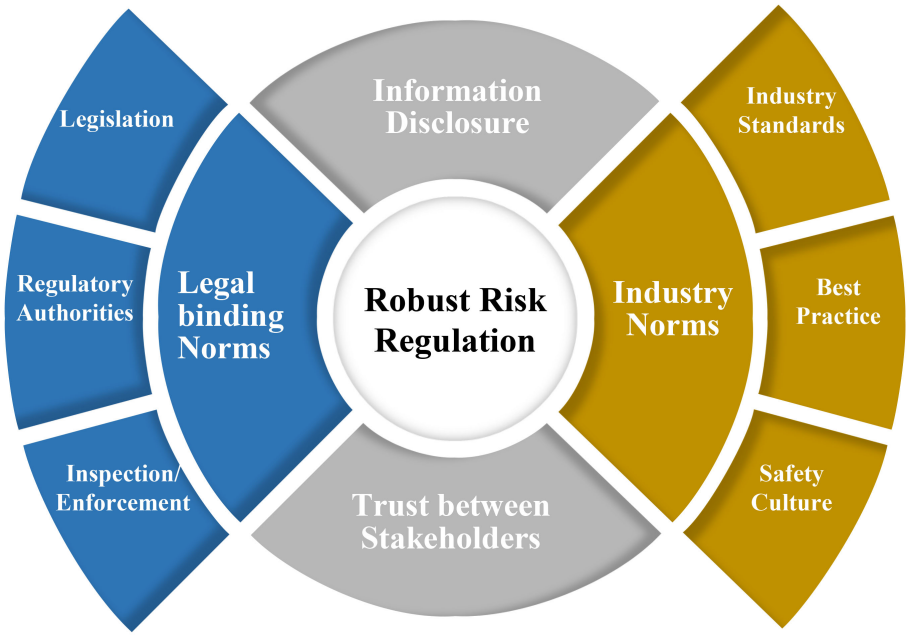

FIGURE 1
The scope of robust risk regulation of offshore drilling operations.

2006; Paterson, 2016). Although there are doubts about the thorough implementation of safety cases, empirical studies show that the regime has greatly facilitated the controlling of major offshore accident hazard risks (Acheampong et al., 2021).

Inspired by the UK regulatory practices, the European Commission (EC) enacted the Offshore Safety Directive (OSD) in 2013, which is in fact a further development of the Safety Case regulations. The OSD highlights the need to frame minimum safety standards for offshore operations and to limit the consequences of major accidents across European waters (OSD, 2013). Based on the precautionary principle, the OSD stipulates more comprehensive and rigorous standards for the safety of offshore operations for all Member States. Specifically, it separates the functions of safety maintenance and environmental protection from the economic development of offshore resources. A performance-based approach is applied to regulate risks in offshore drilling operations. The liability for environmental damage caused by offshore accidents is clarified. Major hazard reports and internal and external emergency response plans are required to be submitted. To implement the OSD, the UK issued the Safety Case Regulations 2015 (SCR 2015) which extends the application to petroleum operations from internal waters to external waters. The competent authority is responsible for regulating offshore major hazards, which is known as the Offshore Safety Directive Regulator (OSDR) at first, and then has become the Offshore Major Accident Regulator (OMAR) since the UK left the European Union (EU).

The Norwegian offshore risk regulation

The evolution of Norwegian risk regulation for offshore drilling operations is also largely driven by offshore disasters in the country. Norway has been dedicated to developing a consistent, integrated legal regime for regulating offshore safety since the 1980s. Norwegian laws such as the Petroleum Act, Working Environment Act and relevant regulations provide the legal and administrative basis for the state's offshore safety management. The Petroleum Safety Authority (PSA) as the main regulatory authority holds the responsibility for regulation-making and enforcement in terms of workplace safety and the environment of offshore drilling platforms and associated land facilities. Similar to the UK HSE, the PSA's function covers all stages of offshore drilling operations but sets overall goals and leaves detailed safety management to the industry (PSA, 2015). This is because petroleum companies usually have the necessary knowledge, decision-making mechanism and compliance resources, while detailed regulation from the government could undermine the perception by individual companies of their responsibility.

Norwegian regulatory regime for offshore drilling operations relies on a self-regulation mode that provides an "internal control" system for preventing and responding to major offshore accidents (Braut and Lindøe, 2010). The system adopts a tripartite approach, taking labor, industry, and government as equal participants to make regulations and solve problems. In the tripartite regime, labor

unions play a mandatory role in monitoring and ensuring safety compliance in the Norwegian offshore industry. Representatives from labor unions not only have the legal right to represent employees to discuss with the employer and authorities health, safety or welfare issues, but also conduct the duties of assessing risks, investigating complaints and relevant documents, and carrying out workplace inspections (Hovden et al., 2008).

One crucial element in the Norwegian tripartite system is the trust between regulators (e.g., Ministry, PSA) and petroleum companies and industry partners (e.g., labor unions, industry associations). "Trust" means that participants interact with each other and act in expected ways. Norwegian regulators believe that a function-based regime can motivate operators and other stakeholders to make decisions concerning risk governance in an open and trusting way that maximizes the role of regulation. Although displaying trust could be vulnerable since one stakeholder might not act as expected, Norway makes use of power to reduce such vulnerability while emphasizing a balance between trust and power exercise. "Power" can be understood as government control. In the Norwegian regulatory regime, regulatory authorities like the PSA reduce vulnerability by power means such as making legally binding rules and imposing sanctions on offshore operators. Governmental controls can bind up companies and suppliers and thereby narrow down the scope of legal standards. Accordingly, keeping a balance between power and trust enables the regulator to take control of the industry while being willing and capable to collaborate upon an update of accepted norms and standards (Engen et al., 2017). This is an effective way to develop the robustness of offshore risk regulation in the face of industry development and changes.

The US regulatory regime

In the US, offshore safety and environmental regulations used to be based on a CAC culture with heavy prescriptions on inspection and enforcement (Baram, 2014). In the post-Deepwater Horizon era, the US makes a series of administrative reforms and regulatory changes. First, the Mineral Management Service (MMS) is restructured into the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), which consists of three regulatory authorities: the Bureau of Ocean Energy Management (BOEM), the Bureau of Safety and Environmental Enforcement (BSEE) and the Office of Natural Resources Revenue (ONRR). The BSEE focuses on safety and environmental regulation of offshore drilling operations in the US waters and is accountable to the government. Second, new regulations are implemented to prevent major offshore accidents and to improve the safety and environmental performance of the US petroleum industry. For instance, the Drilling Safety Rule imposes strict criteria on safety equipment, well control systems and blowout prevention of offshore operations (BOEMRE, 2010). The Workplace Safety Rule introduces the safety and environmental management system (SEMS) to legal standards, which together with the SEMS II Final Rule supplements operators' SEMS plans with worker training and strengthens decision-making and independent verification related to safety management (BSEE, 2013).

The new regulations require offshore operators to take main responsibility for the implementation and oversight of the SEMS. This makes the US regulatory regime for offshore operations develop towards a hybrid approach that combines a performance-based approach with prescriptive standards, which is notable progress in the US offshore risk regulation (Marine Board et al., 2012). To enhance the safety level of operations and minimize the consequences of major accidents, the BSEE has also tested a Risk-based Inspection Program to complement prescriptive inspections and examine the financial resources of diverse agencies. However, the regulatory reforms have not established a comprehensive framework and changed the prescriptive and compliance feature of the US regime. This does not mean that the new regime is not proactive and cannot achieve better safety performance of the industry, while the regime seems to hardly guarantee the effectiveness of its implementation because the US offshore drilling policy may constantly change. In addition, uncertainties such as political intervention and data collection challenge the robustness of the US offshore safety regulation and the development of the SEMS of the offshore petroleum industry.

China's regulatory regime

The regulation structure for offshore drilling operations in China is primarily formed by legally binding rules and standards and encompasses the subjects of development, health, safety and environment. In the Bohai Bay accident, Chinese offshore drilling laws and regulations were criticized for fragmentation and lacking unified goals and principles (Mu et al., 2014; Yang, 2018). Overlapping functions of regulatory authorities indirectly led to non-compliance and weak enforcement then. In response, China made an institution integration and stipulated risk rules to improve the consistency of the regulatory regime and cooperation between participants of the offshore petroleum industry. Nationally, the Ministry of Natural Resource (MNR), the Ministry of Ecological Environment (MEE) and the Ministry of Emergency Management (MEM) took the responsibility for the development, environmental and safety issues of the exploration and extraction of all mineral resources, respectively. The MNR issues licenses for offshore drilling activities and the MEE assesses marine environmental impact reports and emergency response plans submitted by operators. The documents are required to incorporate risk assessment, particularly to analyze environmental risks before carrying out offshore operations. The Office of Offshore Oil Safety Operations (`the Office' hereafter) as a department of the MEM is in charge of inspections of workplace safety, employee training and education, and production facility of the offshore petroleum industry. Both the inspections and enforcement show a prescriptive feature based on limited risk rules and standards, which illustrates that China has not fully established offshore risk regulation.

The industry norms of Chinese offshore regulation are mainly promoted by China National Offshore Oil Corporation (CNOOC)

which has the exclusive right to cooperate with foreign petroleum enterprises pertaining to offshore oil and gas exploration, extraction, production and sales. Failed to manage risks and to share responsibilities with foreign operators in the Bohai accidents, the CNOOC made self-regulatory reforms and more strictly comply with the Work Safety Law, the Regulation on Offshore Oil Safety Operations and its Detailed Rules, and the Safety Rules for Offshore Fixed Platforms and relevant laws and regulations. Specifically, the CNOOC strengthens health, safety and environmental culture and develops internal risk management systems to prevent risks and promote compliance. The CNOOC also issued operation guidelines to provide standards and guarantees for equipment integrity and well control throughout the life cycle (CNOOC, 2021). Since China adopts a state-control model to regulate offshore drilling operations, industry norms of risk regulation to some extent lack the foundation to be incentivized. As a result, whether the regulators and operators can effectively cooperate in risk governance of offshore drilling operations may influence the robustness of Chinese offshore risk regulation.

Comparison of regulatory robustness

Table 1 sorts out the key aspects of offshore risk regulation in the UK, Norway, the US and China, from which this study compares different traits and levels of regulatory robustness in these countries (see Table 1). The analysis of different regulatory regimes for offshore drilling operations facilitates the identification of the requirements and opportunities for improving offshore risk regulation in China.

Overall, the UK and Norway have successfully transferred the main burden of risk governance to petroleum companies through the safety case and a tripartite system, respectively. Given the degree of development of offshore health and safety regulation in the UK and Norway, it could have been assumed that there was a robust regime in place that would not require much further attention from the regulator. Under the comparison, the US and China lack targeted and comprehensive mechanisms to regulate the risks of offshore drilling operations. This could be the reason that offshore regulatory standards in the UK safety case regime were superior to that in the US and Chinese regimes at the time of their offshore disasters. The EU OSD afterwards is precaution-based and likely to be applied where risks possibly occur even when no precise proof exists, whereas offshore drilling laws and regulations in the US and China have not fully applied the precautionary principle, which easily leads to lower safety standards for offshore operations. The Environmental Protection Law of China has identified the precautionary principle in hazardous activities, and to what extent China can translate the principle into specific laws and regulations and implement it in practice remains to be seen.

The regulatory authorities play a vital and proactive role in designing robust regulation. The UK HSE takes risk-based and performance-based approaches to carry out inspections, enforcement and investigations in relation to safe offshore operations. Norway's PSA motivates petroleum companies to view safety and security collectively. Operators, under the PSA's advice, conduct maintenance work as planned, meanwhile, to keep sufficient capability to deal with unexpected events. The HSE and the PSA also cooperate with the industry and established mechanisms to review and assess lessons learnt so that

TABLE 1 Key aspects of offshore risk regulation in the UK, Norway, the US and China.

	UK	Norway	US	China
Regulatory Authority	Health and Safety Executive (HSE) and Offshore Major Accident Regulator (OMAR)	The Petroleum Safety Authority (PSA)	Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) and Bureau of Safety and Environmental Enforcement (BSEE)	Ministry of Natural Resource (MNR), Ministry of Ecological Environment (MEE) and Ministry of Emergency Management (MEM). The Office of Offshore Oil Safety Operations (Office) of the MEM is particularly responsible for the safety of the offshore petroleum industry.
Regulatory regime	Safety Case Regulations (2005/2015)	Statutes: Petroleum Act, The Working Environment Act, et al.; and decrees and health, safety and environmental regulations	BOEMRE and BSEE regulations, such as Drilling Safety Rule, Workplace Safety Rule (Safety and Environment System rule), et al.	Safety laws and regulations, such as Regulation on Offshore Oil Safety Operations and its Detailed Rules, Regulation on the Safety of Fixed Offshore Platforms, et al.
Key Approach	Goal-based and performance-based	Self-regulation	Prescriptive	Prescriptive
Safety and Environmental regulatory responsibility	The HSE makes assessments on the integrity and safety of offshore installations. The Department of Energy and Climate Change (DECC) develops environmental regulations for offshore operations.	The PSA helps operators maintain safety in all phases of the petroleum industry and prevent environmentally harmful incidents arising from offshore operations and prepare emergency response plans for a leak or blowout.	BSEE manages and coordinates inspection programs or programs related to the safety and environmental performance on the continental shelfs. BOEMRE carries out environmental assessments at the stage of leasing, exploration plans and development plans.	The MEM conducts inspections on workplace safety, employee training and education and production facilities. The MEE assesses marine environmental impact reports and emergency response plans in respect of offshore operations.
Cultural Aspects	Health, safety and environmental culture	Safety culture, egalitarian and trust values	Safety culture	CNOOC health, safety and environmental culture

recommendations on well control and safe operations can be made to operators. The US BSEE and China MEM, since their establishment, have issued a series of offshore safety laws and regulations, which can maintain a certain risk level of offshore operations through operators complying with legally binding rules and mandatory inspections (Baram, 2014). Different from the U.K and Norway, regulatory authorities in the US and China basically adopt a prescriptive approach, which may cause the expertise of regulators to lag behind that of petroleum companies and public organizations in the face of new economic conditions and technological advantages (Barua et al., 2016). Hence, how to work together with the petroleum industry and dynamically track risks of offshore drilling operations challenges regulators of the two countries.

In terms of the regulatory regime for offshore operations, the Norwegian regime is assumed highly coordinated as it incorporates governmental mandates with a great deal of self-regulation that is promoted and enforced by the PSA (Engen and Lindøe, 2017). This is also called "the Nordic model". Highlighting the egalitarian value and a balance between power and trust from different participants, this model is considered to meet the most criteria of the robustness of offshore risk regulation (Hale, 2014). The UK regulatory regime has not been sufficiently proven to be robust, since its implementation of the safety case is not as long enough as the Norwegian regime is and its effectiveness needs to be further evaluated. Based on the prescriptive approach, the US regulatory regime used to be described as the least balanced in the way of working. Chinese regulatory regime for offshore operations shows a higher level of "state control", which relies more on industry regulatory compliance than the US regime does. To optimize the CAC regime, both the US and China introduce risk management systems to offshore drilling regulations. For China, developing risk regulation for offshore operations also conflicts with its CAC regulatory environment, since a "top-down" strategy may lead to inflexibility of offshore risk regulation with respect to information gathering, standard setting and enforcement. Under this situation, how to balance input from the different parties becomes a crucial issue in improving the flexibility and robustness of China's offshore risk regulation.

Shaping robust risk regulation for offshore drilling operations in China

By comparing and analyzing possible dimensions of the robustness in multiple regulatory regimes, this paper finds that robust risk regulation for offshore drilling operations in China is hampered by a threefold problem: (1) ununified principles, legislation and regulatory standards; (2) weak cooperations and trust between stakeholders; (3) imbalanced regulatory regime. Based on the regulatory deficiencies and requirements, reforms should be continuously made to enhance the robustness of offshore risk regulation in China.

First, a precaution-based law or regulation with wide safety standards will better help China prevent major offshore accidents and limit their consequences. Such a law or regulation should be established based on the precautionary principle and designed to minimize risks in each phase of offshore operations, involving prevention policy, safety requirements on operators as well as information disclosure. There is no doubt that ex-ante precautions rather than ex-post inspections facilitate the better performance of offshore operations. Since "all risk reduction measures are the precaution to some degree" (Trouwborst, 2009), China should take operators rather than regulators as the main liable party and make them prove that their drilling activities comply with health, safety and environmental criteria and will not cause major accidents. For instance, strict rules on licensing, competent authority and document preparation should be made and optimized, and risk management systems and offshore emergency plans should be implemented to adapt to innovative technologies and the changing environment. Even if the offshore industry faces fewer scientific and environmental uncertainties, precaution-based regulation can ensure that either regulators or the industry apply rigorous regulatory standards to offshore drilling operations.

Second, Chinese regulatory authorities and the offshore petroleum industry should develop a more equal and effective way to cooperate in regulating the risks of offshore operations. Balancing power and trust between stakeholders can be a determinant of the robustness of offshore risk regulation (Lindøe et al., 2013). Currently, the degree of trust between Chinese regulators and regulated industry has not resulted in more flexible regulatory measures. To change this situation, the Chinese regulatory authority - the Office of the MEM - should play a more functional role in regulating offshore safety and making positive interactions with the offshore petroleum industry. Since 2022, the MEM has planned to establish a regulatory mechanism so that enterprises are fully responsible, with the intervention of third-party independent verification and government precise supervision (MEM, 2022). This reflects that petroleum companies, particularly the Ministry of Emergency Management (CNOOC), 2021 have a wide space to manage offshore risks in their own ways. Referring to the UK and Norway practice, labor unions can contribute to information sharing and free-flow communication in a collaborative mechanism, which should also be strengthened in the Chinese offshore industry.

Third, an integrated regulatory regime that combines different approaches may increase the robustness of risk regulation for offshore drilling operations. There is little empirical evidence that either CAC regulation or self-regulation is significantly superior in risk mitigation for the offshore petroleum industry (Bennear, 2015). As such, it is unnecessary and unrealistic to change a country's regulatory environment. However, to facilitate a robust yet flexible regulatory regime, China needs to reform its CAC regulatory regime by introducing goal-oriented and performance-based approaches like the HSEMSs in offshore drilling laws and regulations. Self-regulation and market reform are also feasible ways to improve competition and performance among petroleum companies (Ho, 2012; Leutert, 2016). China therefore should motivate both state actors (e.g., government and CNOOC) and non-state actors (e.g., foreign oil companies, labor unions and public organizations) to ensure regulatory compliance and enforcement on safe drilling operations.

Conclusion

This paper reveals the main characteristics and deficiencies of risk regulation for offshore drilling operations in China. By comparing regulatory regimes in the UK, Norway, the US and China, we argue that robust offshore risk regulation may integrate both legally binding norms and industry norms and maximize their advantages. We propose a precaution-based regulatory framework supervised and enforced by a key functional authority, namely the Office of the MEM, with joint implementations by stakeholders that would significantly advance the regulatory robustness in China. Under the framework, China can, on one hand, convert industrial practice to rule compliance so that minimum safety standards are complied with offshore operators, on the other hand, strengthen the autonomy of the petroleum industry in risk management to achieve a regulatory state of balance and flexibility. Self-regulation should be taken as a supplementary approach in the CAC environment. This will facilitate information disclosure and transparency in decision-making and allow private sectors to make more contributions to minimize risks and hazards and improve the health, safety and environmental performance of petroleum companies (Lin et al., 2015; Damagh and Faure, 2016). The CNOOC as a state company has the exclusive rights to cooperate with regulatory authorities, foreign operators, as well as employees, which can be seen as an internal control capability. China accordingly should provide a legal foundation or mechanism for not only the CNOOC but all contractors and operators to have greater autonomy in regulating risks of offshore drilling operations, which should be based on appropriate trust between regulated industry and regulatory authorities.

Author contributions

The author confirms being the sole contributor to this work and has approved it for publication.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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