Research on technology policy protection space of China's deep-sea carrying equipment

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Abstract. The development of disruptive technologies in the Marine field is an important means to seize the commanding heights of international scientific and technological competition and requires policy support from the government. Based on the concept of strategic niche management, this study quantitatively studied the construction and evolution of policy protection space during the development of China's deep-sea carrier equipment technology from 2001 to 2018. The research shows that: (1) from 2001 to 2018, three different types of policy tools were used in relevant technology policies, with the proportion of "expect establishment" 62.50%, "network construction" 6.58% and "learning and experiment" 30.92%, but the use of policy tools was not balanced. (2) on the whole, the growth trend of the number of deep-sea submersible development is lower than the trend of the use of policy tools, indicating that the use of policy tools has a certain impact on the development of deep-sea vehicle technology, but the effect is limited. From 2010 to 2018, the number of deep-sea vehicles developed and the number of policy tools used increased by three times and four times respectively compared with that from 2001 to 2009, indicating that the use of policy tools after 2010 has a significant role in promoting the development of deep-sea vehicle technology and industry. (3) China's deep-sea delivery equipment industry is still in the stage of technological niche, and the use of protective policy tools such as network construction should be strengthened.

1. Introduction

The new material technology, high-energy-density, life support system (manned), high-fidelity sampling device and information remote transmission technology contained in deep-sea carrier equipment all belong to the subversive technology category in the field of marine science and technology in the world today. The "disruptive technology" was put forward by Christensen in 1997 which can replace existing technologies, have a significant impact on technology paradigm, business model, competitive situation, and turn the existing market and consumer expectations to new performance. However, its development is confronted with “innovation dilemma”, most disruptive technologies cannot quickly occupy the market, and the growth space is squeezed by mainstream technologies [1]. Disruptive technologies are characterized by long cycle, high investment and high risk, which requires the government to provide lasting guidance and support, build a policy protection space, and form an innovation ecosystem to accelerate the emergence of disruptive innovations [2]. Promoting disruptive technological innovation in deep-sea transport equipment industry through protective policies is of great strategic significance to China's marine military security, rights and interest protection, resource development and utilization and marine environmental protection.
In the research of technological innovation policy, a theory focusing on the endogenous process of technological development - "strategic niche management" (SNM, theory for short), provides a new perspective and analysis method for the research of disruptive technology innovation. In 1992, Rip and Schott, Dutch scholars, introduced the concept of ecology into the field of technological innovation and proposed the concept of technological niche, which is “a protective void created by sustainable and breakthrough technological innovation to avoid competition with the mainstream”\(^3\). On this basis, a new theoretical analysis framework - SNM theory is proposed to explain the change of technology paradigm, the path from the technical niche to the formation of technology regime through the niche market\(^4\). With regard to the application of SNM, Hoogma, Kemp and Geels \(^5-\)6\) have studied it from the logical and temporal dimensions. According to Hoogma et al., SNM based on logical dimension is an internal process of technology, including three processes: expect establishment, network construction, learning and experiment \(^5\). Kemp and Geels based on time dimension will be SNM process is divided into technology niche, market niche and paradigm niche \(^6\), which believes in technology niche stage, mainly around the choice of technology, the experiment and experimental set up and implement. Then the new technology is pushed to the market niche through experiment expansion, when the main performance of the new technology product is comparable to that of the old technology product in the market requirement, and the old technology product has incomparable advantages, the protective policy is withdrawn and the market niche enters the paradigm niche stage\(^7\).

At present, research on disruptive technology innovation based on SNM theory is mainly focused on new energy automobile industry\(^8-\)10\), and research on policy protection space of disruptive technology of China’s deep-sea delivery equipment is still blank. Based on the theory of SNM, a two-dimensional analysis framework of policy protection space is constructed with the technical policies related to deep-sea transport equipment in China from 2001 to 2018. Quantitative analysis is made on the use of 12 policy tools and niche transition contained in the three processes of internal process of SNM- expected establishment, network construction, learning and experiment. To explore the evolution of policy protection space in the process of technological development, and to analyze the niche stage of China’s deep-sea transport equipment industry, to provide useful reference for the adjustment and optimization of subversive technological innovation policies.

2. Data used and research method

2.1 Data Sources
Due to the strategic and overall nature of the technical policy on deep-sea carrier equipment, this paper only selects the text of the policy on deep-sea carrier equipment promulgated by China at the national level for research. the policy text is collected in the database of the ‘Beida Fabao- Laws & Regulations Chinese’ Database, ‘http://www.pkulaw.cn/’. The original policy texts were retrieved by searching the entries of "deep-sea carrier equipment", "deep-sea submersible" and "underwater robot" from 2001 to 2018, and 135 relevant policy literatures were sorted out on this basis.

2.2 Construction of technical policy analysis framework for deep-sea carrier equipment
On the basis of Huang Ziyang’s establishment of policy protection spatial analysis model\(^10\), this paper conducts local adjustment and modification according to the characteristics of deep-sea carrier equipment technical policy. The analysis framework of policy protection space was constructed from the two dimensions of Y-axis (policy tools) and X-axis (niche transition), and the Y-axis was divided into three categories and 12 policy tools, as shown in table 1. The X-axis is divided into three stages in the endogenous process of technology development: technological niche, market niche and paradigm niche.

According to SNM theory, there is an interactive mechanism among the three endogenous processes of disruptive technology growth (expect establishment, network construction, learning and experiment), and the policy tools contained in the three processes also exert influence on different stages of niche transition, with continuity and relevance, as shown in figure 1.
Table 1. Formatting sections, subsections and subsubsections.

| Types of policy tools            | The intension of Policy Tools                                                                 |
|----------------------------------|----------------------------------------------------------------------------------------------|
| Magnificent Tactic               | National macro vision guidance and encouragement, such as development strategy and guiding principles |
| Industry Planning                | Specific industrial planning policies, such as technology development, industrialization objectives and planning |
| Expect establishment             | Strictly standardize the relevant policies of technology, products and markets, such as laws and regulations, market access, technical standards and equipment standards. |
| Standard management              | Encourage the circulation of technology, market and other information and provide related services, such as providing project guides, guidance catalogues, and establishing information databases. |
| Information Service              |                                                                                               |
| Fiscal Support                   | Direct financial support to relevant actors, such as tax relief, loan discounts and subsidies |
| Financial Support                | Indirect financial support to relevant actors, such as loan guarantees and concessions         |
| Intellectual Property Protection | Protection and guidance of intellectual property rights in legislation, publicity and enforcement |
| Strategic Policies               | Assistant measures to assist industrial development, such as the construction of national emergency response system, deep-sea knowledge publicity, etc. |
| Research on Science and Technology | The government directly or indirectly encourages the development of science and technology, such as independent innovation, research investment, major projects, and innovation incubator construction. Encourage learning and cooperation platforms among actors and organize demonstration projects, such as the establishment of national key laboratories, the establishment of production, education and research platforms, the development of demonstration projects, the development of pilot cities and the establishment of industrial alliances. To lay the foundation of human resources for the development of technology and industry, such as talent cultivation and talent incentive |
| Platform Construction and Demonstration Pilot | Encouraging the study of foreign advanced technologies and strengthening cooperation and exchanges between technologies and industries, such as the introduction of foreign capital and foreign cooperation |
| Learning and experiment personnel training |                                                                                               |
| international co-operation       |                                                                                               |
2.3 Research Methods

The 135 selected policy documents were coded in the first round according to year-number by content analysis method. Then, according to the content of the policy clauses, it is classified into 12 policy instruments, and the second round of coding is conducted for the policy instrument-specific clauses/chapters, such as 2003-2-10, indicating that the policy is the policy text no. 2 of 2003 and belongs to the policy clause 10 of the 12 policy instruments (international cooperation). 152 policy items selected from 135 policy literatures were classified into 12 policy tools as the analysis objects. Finally, the function period of each coding policy tool was determined, and the construction, evolution and application of policy tools for policy protection space of China's deep-sea vehicle technology were quantitatively analysed from the two dimensions of policy tool and niche transition.

3. Quantitative Analysis of Policy Texts

3.1 Dimension analysis of policy tools

3.1.1 Overall analysis. The frequency and proportion of using policy tools can reflect the importance of policy tools in different stages of the whole ecological niche. Statistics are made on the policy tools used in the technical policies on deep-sea delivery equipment issued from 2001 to 2018, as shown in table 2.

The frequency (proportion) of policy tools used by the related technical policies of deep-sea transport equipment was 95 times (62.50%), 10 times (6.58%) and 47 times (30.92%) of "expect establishment", "network construction" (6.58%) and "learning and testing" (30.92%) respectively. Among them, the top four are "standard management" (39 times), "industry planning" (30 times), "magnificent tactic" (17 times) in "expect establishment" and "platform construction and demonstration pilot" (25 times) in learning and experiment. However, the use of policy tools is not balanced. "Expect establishment" and "industry planning" tools are overused and do not form policy synergy. The tools of "network" construction" are inadequately used. Among them, "strategic policy" (3.29%) to assist the development...
of technology and industry is less, and "fiscal support" (1.32%) policy, such as direct tax relief and subsidies, is also less used by the government for technology research and development. The disruptive technology of deep-sea transport equipment of "intellectual property protection" (1.32%) has not been given due protection of rights and interests, and financial funds have not participated in the cultivation and development of technology and industry. To some extent, it has affected the improvement of independent innovation ability.

Table 2. Analysis and statistical results of policy tools from 2001 to 2018.

| Types of policy tools       | Number | Proportion (in total) | Proportion (in Similar Action Surfaces) | total number | total Proportion |
|-----------------------------|--------|-----------------------|----------------------------------------|--------------|------------------|
| Expect establishment        |        |                       |                                        |              |                  |
| Magnificent Tactic          | 17     | 11.18%                | 17.89%                                 |              |                  |
| Industry Planning           | 30     | 19.74%                | 31.58%                                 |              |                  |
| Standard Management         | 39     | 25.66%                | 41.05%                                 | 95           | 62.50%           |
| Information Service         | 9      | 5.92%                 | 9.47%                                  |              |                  |
| Network construction        |        |                       |                                        |              |                  |
| Fiscal Support              | 2      | 1.32%                 | 20.00%                                 |              |                  |
| Financial Support           | 1      | 0.66%                 | 10.00%                                 |              |                  |
| Intellectual Property       | 2      | 1.32%                 | 20.00%                                 | 10           | 6.58%            |
| Protection Strategic Policies| 5      | 3.29%                 | 50.00%                                 |              |                  |
| Learning and testing        |        |                       |                                        |              |                  |
| Research on Science and Technology Platform | 5 | 3.29% | 10.64% | | |
| Construction and Demonstration Pilot | 25 | 16.45% | 53.19% | 47 | 30.92% |
| Personnel Training          | 8      | 5.26%                 | 17.02%                                 |              |                  |
| International Co-operation  | 9      | 5.92%                 | 19.15%                                 |              |                  |
| Total                       | —      | 152                   | 100%                                   | —            | 152              |

3.1.2 Analysis of frequently used policy tools. The most frequently used policy tool from 2001 to 2018 was "standard management", which shows the policy intensity of regulating industrial development. Its content mainly includes three aspects: (1) Establish "new" standards. For example, in November 2011, the Standardization Administration of China issued the 12th five-year plan for standardization development, which required the formulation of "key technical standards for manned deep-sea submersible, deep-sea operation and transportation system". (2) Revising the "old" standards. For example, in June 2013, the Ministry of Industry and Information Technology promulgated the Notice of the Second Revision Plan of Industry Standards in 2013, which compiled the revision plan of industry standard including "pacification for light shell of composite materials for deep-sea submersible". (3) To promulgate laws and regulations, administrative licensing and other access standards. For example, in February 2016, the Standing Committee of the National People's Congress promulgated the “Law of the People's Republic of China on Exploration and Development of Deep Seabed Regional Resources”, and in April 2017, the State Oceanic Administration promulgated the “Measures for the Administration of Exploration and Development Licenses for Deep Seabed Regional Resources”, in order to "strengthen the management of exploration and development activities in deep seabed areas and standardize deep seabed areas". The application, acceptance, examination, approval and supervision and management of regional resources exploration and development activities.
The extensive use of "industry planning" tools has played a positive role in guiding and promoting the development of technology and industry. For example, in December 2005, the State Council promulgated the "National Outline for Medium-and Long-term Scientific and Technological Development (2006-2020)". The "deep-sea operation technology" in ocean technology (such as large-depth underwater transportation technology, deep-sea operation equipment manufacturing technology and deep-sea space station technology) was included in the sixth "frontier technology" of national planning and development. In July 2012, The State Council promulgated the "12th Five-year Plan for the Development of National Strategic Emerging Industries", "deep-sea transportation, emergency operations and other equipment and key supporting equipment and systems" were listed as national strategic emerging industries to be supported. In May 2015, the State Council promulgated "Made in China 2025", vigorously promoting the development and engineering of deep-sea space stations and large floating structures, and mastering the core technology of integrated, intelligent and modular design and manufacture of key supporting equipment.

It is noteworthy that the 30 industrial planning departments are composed of 12 departments (State Council, Ministry of Science and Technology, National Development and Reform Commission, Ministry of Commerce, National Intellectual Property Office, National Defense Science, Technology and Industry Commission, National Energy Bureau, Ministry of Industry and Information Technology, Ministry of Finance, Ministry of Transport, Maritime Bureau, Land and Land). Ministry of Resources and Industry Commission, National Energy Development (2006-2020) National Outline for Medium and Long-term Scientific and Technological Development (2006-2020) Integrated into the Ministry of Natural Resources) issued separately or jointly. Among them, 23 plans were published separately and 7 plans were published jointly. The above departments separately released "industry planning" with the same or similar content related to deep-sea carrier equipment technology and industrial development, accounting for up to 76.7%. Compared with other policy systems, this is a relatively high figure. On the one hand, it shows that various departments attach great importance to deep-sea science and technology; on the other hand, it also reflects the lack of coordination between different departments with multiple policies, which is prone to the overlapping of "industry planning" policies, waste of administrative resources and low administrative efficiency.

3.1.3 Time-evolution characteristics of policy tool use. From 2001 to 2018, the distribution of node usage varies from time to time, as shown in Figure 2. The size and intensity of the circle reflects the change of policy protection at each time point. Overall, the use of policy tools is gradually increasing with the change of time.

From 2001 to 2005, at the beginning of the Technical niche, only one type of policy tool was used - magnificent strategy and industry planning in "expect establishment". From 2006 to 2009, policy tools involved three types of expect establishment, network construction, learning and experiment, but the number of them was relatively small. Still, it mainly uses policy tools such as Industry Planning, standard management and information service in "expect establishment". The government actively constructs the common vision, norms and information service of technological innovation to guide industrial development. From 2010 to 2018, the use of policy tools covers three types, and the number of them is significantly increased compared with the previous period. "Learning and experiment" (30.92%) policy tools are widely used. The government provides relevant policy support to encourage the learning and exchange of actors at all levels of technology, industry, products and markets, including platform construction and demonstration pilot, personnel training and international cooperation, to promote the continuous optimization of new technologies. During this period, "expect establishment" tools have taken a back seat, while network construction, fiscal support, financial support and intellectual property protection tools remain less used during this period, reflecting adjustments and changes in the space for policy protection.
3.2 Dimension Analysis of Niche Transition

3.2.1 The influence of policy tools in different periods on the number of deep submersibles. Combined with the cumulative use of policy tools of the three major functional surfaces (considering the timeliness of policy tools) and the development quantity of China's deep-sea submersible in the same period (subject to the built quantity)\(^{[11]}\), the influence of these tools was comprehensively analysed, as shown in figure 3.

As shown in Figure 3, the growth trend of the number of deep-sea vehicles in the research period is lower than that of policy tools, which reflects that the use of policy tools has a certain impact on the development of deep-sea transport equipment technology, but the effect is limited. The impact around 2010 is quite different. From 2001 to 2009, the number of deep submersible research and development and the number of policy tools used are relatively small. The policy objectives mainly focus on "technology selection, experimental selection" to use "expected establishment". In 2010, the government issued the "Decision on Accelerating the Cultivation and Development of Strategic Emerging Industries" and issued a series of supporting policies after that. The policy goal was shifted to the cultivation of technology centring on "experimental establishment and implementation". Massive use of platform construction and demonstration pilot, personnel training and international co-operation in "learning and experiment" (30.92%), and the use of "network construction" tools (6.58%), which have played a role in promoting and pulling policy. Statistics show that the number of deep-sea vehicles developed and the number of policy tools used in 2010-2018 increased by three times and four times respectively compared with the previous period, indicating that the use of policy tools after 2010 has a significant role in promoting the development of deep-sea vehicle technology and industry.
3.2.2 Niche analysis of China's deep-sea vehicle equipment industry. According to the three important symbols commonly used in the world to measure industrial marketization: (1) independent market subject, with autonomy and independence; (2) price determined by the market; (3) expansion of private consumption scope. Comparing the current situation of China's deep-sea transport equipment industry: (1) There is no independent market body yet. The deep-sea transport equipment industry belongs to the disruptive and technology-intensive strategic emerging industry. The main body of comprehensive technology competition which relies on the government for the establishment, research, production, experiment and use of products, planning and deployment. (2) The price is fixed by the government, R&D investment, price determination and product procurement are all covered by the government. (3) Although China's deep-sea transport equipment has taken an important step in industrialization, such as the completion of a fully penetrated passenger submersible "Huandao Jiaolong 1" for sightseeing and tourism in December 2015, which is invested by China Chengtong Holding Group, a central enterprise. However, the private consumer market has not been officially opened and the scope of consumption has not been expanded. In addition, the current China's deep-sea vehicle equipment in the whole structure of deep sea manned space technology, high-performance materials technology, long life time of power technology, etc, and the United States, Russia, Japan and other Marine technology developed countries still there is a big gap, the key technology is not yet fully realized "subversion", its development also did not reach a certain number of market size (the cumulative number of research and development in 2001-2018 is only 32), and the conditions for the transition from technical niche to market niche are not yet available.

At present. The niche of China's deep-sea transport equipment industry is still in the first stage - technical niche, which is still far from the next market niche. At the same time, deep sea transport equipment and spaceflight technology level are similar, belong to the vertical direction of technical innovation, compared with the new energy automobile and electronic industries, such as the more disruptive technology, and the use of products is more specific (scientific research, military purposes, etc.). It is urgent for the government to continue to construct policies and measures to improve day by day. "protecting space" should be supported and specially protected in order to improve the ability of independent innovation and international competitiveness.
4. Conclusion
Based on SNM, this paper quantitatively studies the policy protection space of deep-sea transport equipment, and draws the following conclusions: (1) From 2001 to 2018, three different types of policy tools were used in China's technology policy for deep-sea delivery equipment, the proportions of which were 62.50% of expected establishment, 6.58% of network construction, 30.92% of learning and experiment, indicating that the use of policy tools is not balanced. The overuse of magnificent tactic and industry planning tools in the expected establishment has not resulted in policy synergy, resulting in waste of administrative resources and low administrative efficiency. The tools of "network construction" are inadequately used, such as "fiscal support" (1.32%), "intellectual property protection" (1.32%) and "financial support" (0.66%) are less used, has affected the improvement of independent innovation ability to some extent. (2) The increasing trend of the number of deep-sea vehicles is lower than that of policy tools on the whole, which indicates that the use of policy tools has a certain impact on the development of deep-sea transport equipment technology, but the effect is limited. In 2010 the government issued " Decision on Accelerating the Cultivation and Development of Strategic Emerging Industries " and after intensive released a series of supporting policies, the policy should play the role of push and pull in 2010-2018, the number of vehicle development and policy tools use the number of three and four times more early growth, respectively, after the show that in 2010 the use of policy tools for nurturing deep sea transport equipment and technology of China and industrial development has a significant role in promoting. (3) The market-oriented conditions of China's deep-sea transport equipment industry are not yet available, the key technologies have not yet been completely "disruptive" and the number of research and development has not reached a certain market scale (only 32), the industry is still in the technical niche stage, e protective policies should not be reduced and should continue to strengthen. Especially should pay attention to use the "network (the network construction)" tool to promote the development of the industry, in addition to direct financial support or fiscal support, creating a favourable investment environment to guide social capital investment, attract more producers, form a complete set of producers and consumers (such as adventure tourism, salvage, etc.) to join and steady to participate in the cultivation and development of technology and industry. At the same time, we should increase support for independently innovative technologies or products, strengthen intellectual property protection, get rid of the disadvantage of being controlled by others of disruptive key technologies as soon as possible, and realize the scientific and technological strategic goal of "hindering blocks ".

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