Text Analysis of Science and Technology Innovation Policies in the Guangdong Hong Kong Macao Greater Bay Area from the Perspective of Policy Tools

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Abstract. The construction of the Guangdong Hong Kong Macao Greater Bay Area International Science and Technology Innovation Center and the formulation of policy measures urgently require an innovative ecosystem view to promote the development of scientific and technological innovation. However, these policies have presented some problems and shortcomings in the specific implementation process. This study selected 63 science and technology innovation policy texts as the research objects, including local policies in Guangdong, Hong Kong, and Macao. From the perspective of policy tool theory, this study investigates the science and technology innovation policies in the Guangdong Hong Kong Macao Greater Bay Area from 2018 to 2023. Use UCINET software to code and analyze the key content of its policy text, as well as conduct co word analysis. Research and statistics on the use of various policy tools and the focus on key words. Analyze the specific deployment of different types of policy tools for technological innovation in the Guangdong Hong Kong Macao Greater Bay Area. Policy tools use three types: supply oriented, environmental oriented, and demand oriented. During the implementation process, government policies play a guiding role in the market and have achieved certain results. However, due to the small coverage area of policies and difficulties in adaptation, the ability to promote policies is limited. Therefore, by using various types of policy tools, the government can grasp the future trend of technological construction, thereby promoting stable and orderly economic and technological development in the Guangdong Hong Kong Macao Greater Bay Area.

Keywords: Technological Innovation, Policy Text Analysis, Co-word Analysis, Greater Bay Area.

1. Introduction

Against the backdrop of increasingly fierce global competition in technological innovation, regional technological innovation strategies are crucial for promoting the transformation and upgrading of regional economies[1]. This study focuses on the evolution and characteristics of science and technology innovation policies in the Guangdong Hong Kong Macao Greater Bay Area, aiming to explore the shaping of regional science and technology innovation ecology and its potential effects through in-depth analysis of policy texts[2]. Policy change is the logic of political or social change, and policy learning is an important driving force for promoting policy change[3]. This study selected 63 relevant policy texts published between 2018 and 2023 as the research subjects. UCINET software also helps this article reveal the key themes and internal connections of policies. Through in-depth analysis of science and technology innovation policies in the Guangdong Hong Kong Macao Greater Bay Area, it can help guide technology enterprises and research institutions in the region to better adapt to the policy environment.

2. Literature Review

As one of the representatives of Western scholars, Hood realized that policy tools have a certain effect in optimizing public management (Howlett, 1992) [4]. Elliott (2002) found in subsequent research that policy tools are only effective when they have policy tool characteristics as one side and policy objectives, environment, and audience as the other side [5]. Suchman constructed five policy measurement models based on policy input, policy implementation, policy performance, policy

efficiency, and policy process in his research [6]. Cisneros Montemayor et al. (2021) designed a logical model for policy evaluation, which is used to evaluate the effectiveness of public policy implementation[7]. In terms of policy tool analysis, Lyall and Tait (2005) classified policy tools into four categories: coping tools, control tools, impact tools, and induction tools. Rothwell and Zegvelad divided policy tools into three basic types: supply oriented, environmental oriented, and demand oriented [8]. Radin (1996) also divided policy tool groups into four categories: structural tool group, project-based tool group, behavioral tool group, and research and capacity building tool group [9]. The research results of relevant scholars provide a good reference for the research in this article. This article draws on the policy tools proposed by Rothwell and Zegvelad, including supply, environment, and demand, to analyze the scientific and technological innovation texts in the Hong Kong and Macao Greater Bay Area.

3. Category Analysis of Science and Technology Innovation Policy Texts in the Greater Bay Area based on Policy Tools

This article is based on a classification perspective of policy tools, by consulting the Guangdong Hong Kong Macao Greater Bay Area portal website (https://www.cnbayarea.org.cn/) And the central government website(https://www.gov.cn/) From the technology innovation column on the website, all 63 policy documents related to technology innovation were downloaded as the focus of this study's policy text. The research entry point of the paper is to analyze the content of policy texts and the distribution characteristics of text quantity. Use keyword extractors and manual filtering to obtain standardized policy keywords. Next, draw a co-occurrence matrix for the extracted keywords and present a social network diagram of co-occurrence analysis. Through this article's analysis, we explore the overall hotspots and changes in science and technology innovation policies in the Guangdong Hong Kong Macao Greater Bay Area in the past six years, revealing the evolution of policy requirements for science and technology innovation in the Guangdong Hong Kong Macao Greater Bay Area and the central government in recent years. Through the study of science and technology innovation policy texts in the past 6 years, this study explores the distribution characteristics of policy texts in the Guangdong Hong Kong Macao Greater Bay Area, proposes the changing trends of government science and technology innovation policies at different stages, and points out the key development directions of the government in recent years. In response to this, this article proposes suggestions such as a policy transmission mechanism for scientific and technological innovation policies.

3.1. Policy Content

The selected Greater Bay Area portal website and the central government's policy on technological innovation have a time range of 2018-2023, with a time span of 6 years. The listing method used in this article is in the form of "policy number serial number". As mentioned earlier, Rothwell and Zegvelad's classification of policy tools can be divided into three categories: supply oriented, environmental oriented, and demand oriented [10]. The keywords involved in the three policy tools include: supply oriented - infrastructure, human resources, capital investment, information technology, and public services; Environmental - laws and regulations, special planning, finance and taxation, financial supervision and security measures, etc; Demand oriented - government procurement, outsourcing, market regulation, opening up to the outside world, and public facilities.

Table 1. Part of Science and Technology Innovation Policies

No.	Document Name	Document No.
1	Implementation Opinions of the People's Government of Guangdong Province on Accelerating the Construction of Innovative Leading Areas for the General Artificial Intelligence Industry	Yue Fu [2023] No. 90
2	Notice of Guangzhou Local Financial Supervision and Administration Bureau, Guangzhou Science and Technology Bureau, People's Bank of China Guangdong Branch Business Management Department, State Administration of Financial Supervision and Administration Guangdong Regulatory Bureau, China Securities Regulatory Commission Guangdong Regulatory Bureau on Issuing "Several Measures for Guangzhou to Increase Efforts to Support Financing of Science and Technology Enterprises"	Sui Financial [2023] No. 19
…	… …	… …
63	Notice of the Ministry of Science and Technology and the All China Federation of Industry and Commerce on Issuing the Guiding Opinions on Promoting the Innovative Development of Private Enterprises	Guoke Fazi [2018] No. 45

3.2. Frequency statistical analysis

This research sample consists of 57 policies related to scientific and technological innovation from the Guangdong Hong Kong Macao Greater Bay Area portal website and 6 policies related to scientific and technological innovation from the central government website. The quantity of these 63 policies over the past 6 years is preliminarily organized according to three types of policy tools. As shown in Figure 1, the number of science and technology innovation policies issued between 2018 and 2023 has shown a continuous upward trend. The number of policies reached its peak in 2022, but there was a significant decrease in 2023. The quantity of supply oriented policies accounts for the majority among the three types of policy tools, followed by environmental policies, and the quantity of demand oriented policies accounts for the least. From a time perspective. The number of supply and environmental policies also reached a peak in 2022, indicating that in 2022, the Greater Bay Area and the central government increased their efforts to promote scientific and technological innovation after the COVID-19 epidemic, while steadily creating a benign environment for scientific and technological innovation and development. In 2023, all three types of policy tools have slightly decreased.

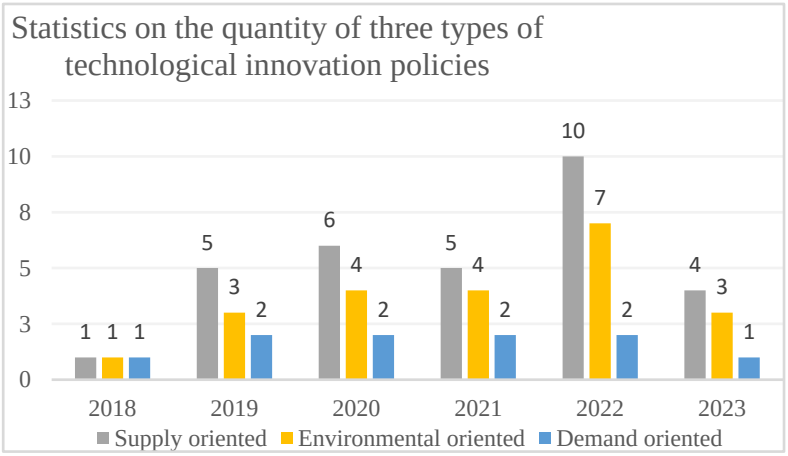

Figure 1. Statistics on the quantity of three types of scientific and technological innovation policies in the Guangdong Hong Kong Macao Greater Bay Area over a period of 6 years

The usage and frequency statistics of three types of "technological innovation" policy tools are shown in Table 2.

Table 2 Frequency statistics of the use and main keywords of science and technology innovation policy tools in the Greater Bay Area and the central government

Policy tool types	Keyword 1 and word frequency	Keyword 2 and word frequency	Keyword 3 and word frequency	Keyword 4 and word frequency	Keyword 5 and word frequency
Supply oriented	Infrastructure	human resources	Capital investment	information technology	public service
	108	50	7	41	56
Environment oriented	law	Special planning	Finance and taxation	Financial regulation	Safeguard measures
	29	10	3	41	18
Demand oriented	government procurement	outsource	Regulation	Opening up to the outside world	Public facilities
	8	5	26	17	2

From the data in Table 1, it can be seen that,

(1) The use of the three basic policy tools is uneven. Supply oriented policy tools are most commonly used, accounting for 62.23%. The proportion of environmental policy tools is 24.0%. Demand based policy tools are the least used, accounting for 13.8%. The above data reflects the excessive use of supply oriented policy tools in the science and technology innovation policy system, while the use of demand oriented policy tools is slightly insufficient. This indicates that the technological innovation activities in the Guangdong Hong Kong Macao Greater Bay Area are mainly driven by the government, and there is a serious lack of technological innovation momentum and demand from the market. Firstly, as a newly established administrative region, the Greater Bay Area faces enormous risks and challenges in its technological innovation policies. In recent years, during the COVID-19 pandemic, the market is facing the pressure of economic transformation and economic slowdown. Therefore, the Greater Bay Area government has introduced 19 policies in 2022, hoping to stimulate social vitality through technological innovation activities.

(2) There are significant differences in the use of policy tools. The Greater Bay Area of Guangdong, Hong Kong, and Macao shows a clear tendency towards the central government's "technological innovation" policy tools, reflected in the frequency of use of different policy tools. The frequency and focus of use of policy tools vary from supply oriented, environmental oriented to demand oriented, reflecting significant differences in the choice of policy tools by policy makers at different stages of their lifecycle. In supply oriented policy tools, policy makers attach great importance to providing sufficient material and technological foundations, talent support, and financial guarantees for scientific and technological innovation. The extensive use of these policy tools is closely related to the characteristics of innovation and entrepreneurship activities, aiming to provide a good starting point and supporting environment for technological innovation. Compared to the significant investment in supply oriented policy tools, the use of environmental policy tools is relatively conservative. This means that in the middle and later stages of technological innovation, more mature and comprehensive laws, regulations, and policy planning are needed to maintain the sustainable development of "technological innovation" activities, but the current support is insufficient. The frequency of use of demand based policy tools is generally low. This result indicates that the current

use of policy tools has been more effective in encouraging initial innovation and entrepreneurship, but insufficient in maintaining and supporting mid to late stage development.

(3) There is a significant difference in the frequency of using sub tools of the same type of policy tools. In supply oriented policy tools, the frequency of infrastructure use is as high as 108 times, far higher than the 41 times of capital investment, indicating that policies tend to support technological innovation by improving infrastructure, and relatively less directly incentivize innovation activities through capital investment. Similarly, in environmental policy tools, the frequency of use of financial regulation (41 times) is significantly higher than that of fiscal and tax policies (3 times), reflecting that policies focus more on regulation rather than fiscal incentives in creating a favorable innovation environment. The difference in the frequency of use of these sub tools reveals the focus and priority of policy makers in their specific implementation, while also suggesting potential issues of uneven resource allocation. Further optimization of the policy tool portfolio is needed to support various aspects of scientific and technological innovation activities in a more balanced manner.

3.3. Quantitative Analysis of Technological Innovation Policies

3.3.1 Keyword Extraction and Normalization Processing

For this study, co word analysis can deeply explore the trends of technological innovation policies. This study is based on the definition of co word strength by Lou Wenlong, Liu Qing, and Liang Chenghui (2023) [11]. Co word strength refers to the number of policy documents that contain both keyword A and keyword B. Count the number of documents where two keywords appear simultaneously in the same policy document. This article selects the top 30 keywords in terms of word frequency to form a 30 * 30 high-frequency keyword matrix. Import the co word matrix into UCINET and visualize it through the NETDRAW function, resulting in a keyword network as shown in Figure 2. The thickness of the line segment between two keywords represents the frequency of keywords appearing simultaneously in the same policy document. The size of network nodes represents the centrality of each keyword.

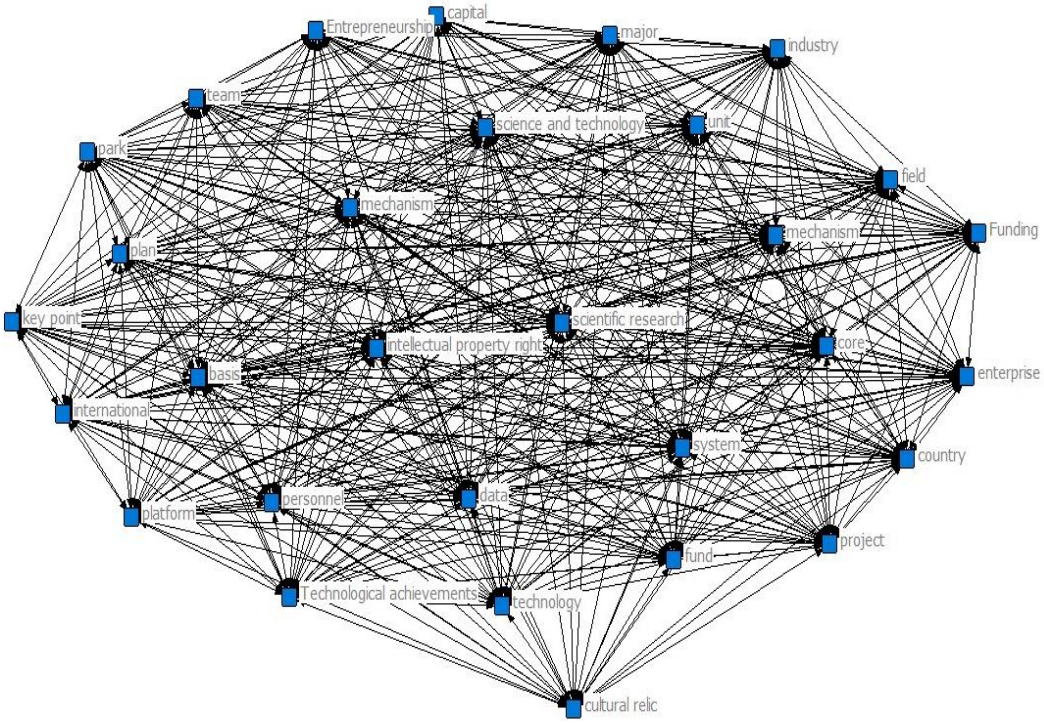

Figure 2. Social network diagram of keywords

From Figure 2, it can be seen that the degree centrality of "project", "technology", "enterprise", and "unit" is relatively high. Therefore, the keywords "project", "technology", "enterprise", and "unit" are at the core of the co word network, indicating that the Greater Bay Area and the central government have focused on supporting technology enterprise project activities in the past five years.

Secondly, the centrality of "talent" and "technology" is also relatively high, indicating that policies are also strongly supporting relevant technical talents. The centrality of "funding", "scientific research", "intellectual property", and "scientific and technological achievements" also appears in the above figure, indicating that the government has increased its investment in funds to attract scientific and technological innovation talents and produce scientific and technological achievements. With the rise of artificial intelligence technology, although the keyword "artificial intelligence" has not been included in the top 30. "Science and technology", "talent", "scientific research", and "technology" also emphasize the importance of talent and technology in scientific and technological innovation policies. The government may cultivate and attract talents in the field of technology through corresponding policies and measures. Intellectual property protection is also aimed at stimulating more innovative activities. Economic incentives and resource allocation play important roles in promoting innovation and technological development. This may reflect the activities of the government or other organizations in terms of funding, incentive mechanisms, and resource introduction. "Technological achievements" imply significant attention to the transformation and application of scientific research achievements.

3.3.2 Distribution of Policy Types for Technological Innovation

Based on the research of Xiong Ye and Zhao Qun (2021) [12] on supply oriented policy tools, this article also analyzes the relevant policies of science and technology innovation policy from the perspective of supply oriented policy tools. Liu Yana, Dong Qiyuan, and Tan Xiaoting [13] conducted a similar study on the Beijing Tianjin Hebei region in 2019, pointing out that talent policies are a sustained driving force for regional technological innovation and development. Yang Yuting (2022) [14] evaluated the talent policies in Shanghai's connection with the Yangtze River Delta region and concluded that improving the synergy between policies can facilitate the smooth flow of talent policies on a large scale[15]. From the provided data, it can be seen that the current innovation and entrepreneurship policies mainly focus on direct financial support, especially on investment in innovation projects[16]. However, these data also reveal that policies in infrastructure construction and talent cultivation are relatively weak, which may limit long-term innovation potential.

4. Main Research Findings

From the keyword analysis of technological innovation policies, it can be seen that the core of the policy is focused on "technology" and "enterprises", indicating a strong tendency of the government to promote enterprises to carry out technological activities. This is reflected in the emphasis on scientific research, technological development, and intellectual property protection, where "scientific research", "technology", and "intellectual property" are high-frequency keywords. Significantly, government strategies not only focus on providing financial support for the technology sector, such as the frequent emergence of "funds" and "funds".

From the analysis of keyword frequency, it can be seen that the connection between science and technology policy and talent policy is not significant, reflecting a certain degree of separation between science and technology policy and talent policy[17]. For example, the frequency of the term "technology" is extremely high, indicating an emphasis on scientific and technological development in enterprises. However, compared to the specific frequency of words related to "talent", the direct correlation between the two is not prominent. In addition, although "technology" has a high frequency of words, the degree of integration with "talent" seems to be not close enough, suggesting that there may be a lack of sufficient strategic integration between technological development and talent innovation incentives. Talents are the fundamental basis for the survival of technology. The development of all technologies cannot be separated from the assistance and support of talents.

5. Countermeasures and Suggestions

In order to strengthen the continuity of science and technology innovation policies, the government first needs to formulate a long-term and stable science and technology development strategy to transcend short-term political cycle changes and provide a predictable development framework for scientific research institutions and enterprises. Secondly, the government should establish effective communication and coordination mechanisms between different government departments and levels to ensure policy consistency and synergy, and avoid policy fragmentation.

Financial support should be diversified, in addition to direct government financial investment, private sector participation and the introduction of venture capital should also be encouraged. Talents are the core driving force of technological innovation. Special programs and scholarships should be established to strengthen the cultivation of local talents. The promotion of industry university research cooperation is also crucial. Finally, the continuous investment in basic scientific research by the government cannot be ignored. Basic research is the foundation of all technological innovation, ensuring long-term stable investment in basic science, and is of great significance for cultivating innovative thinking and theoretical exploration.

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