Research on synergy of science and technology policy types and policy tools based on analysis of policy text

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Abstract. The development of the times has brought about a new form of policy formulation from single targeting to multi-policy coordination. It has put forward new requirements for the science and technology policy system, and how to formulate scientific and reasonable science and technology policy has become the most important problem. In order to explore the approached to this problem, this paper, combining different periods of data characteristics for comparative analysis, starts with the classification of policies and the synergistic effect of policy types and policy tools, constructing a collaborative analysis model of policy function to study the collaborative research between science and technology policy types and policy tools. Finally, it is suggested that the formulation of science and technology policy should closely combine the background of the times with the characteristics of policy types, and the corresponding policy tools should be synthetically selected to match its applicability.

1. Introduction
Since the 21st century, China has attached great importance to the development of scientific and technological innovation, and 19th CPC National Congress has proposed the establishment of a highly integrated technological innovation system to help China build an innovative power. Science and technology policy is a series of measures [1] to intervene and guide science and technology innovation activities in order to realize the development goal of science and technology innovation. Effective science and technology policy has positive significance to improve the ability [2] science and technology innovation and encourage innovation activities. The implementation of science and technology policy needs to rely on the collocation of various policy tools. Therefore, it is of great theoretical and practical significance to study the synergistic effect between policy types and policy tools.

2. Research status
Policy making is the most important channel for the government to embody its function, and most of the policies formulated by different government departments as the main body are based on the characteristics of the department's business management, which has certain limitations. To address the issue of policy coherence, Governments are seeking ways to classify policies based on some form of perception, as are science and technology policies. Science and technology related policies first appeared before the second World War [3] until 1963 Brooks introduced dichotomy, established the science and technology policy government support, the science guidance system [4]. Then according
to their different perspectives, the research on policy classification is carried out, which is more representative: Morosin from the point of view of centralization and decentralization, the policy is divided into task-oriented and diffusion-oriented[5]; Ekboir science and technology policy is divided into direct investment policy, indirect support policy and peripheral promotion policy[6]. Zhang Yongan and others divide science and technology policy into authority, guidance, urgency and stage.

Policy classification is to distinguish the policy itself through some cognitive forms, and the policy tool is the [7] concrete measures and means taken by the government to achieve the policy goal. Whether the application of policy tools and policy types match, to some extent, determines the effect of policy objectives, and policy tools are not isolated [8]. Therefore, the research on science and technology policy classification is accompanied by the research on policy tool classification. Using government participation as a benchmark, Canadian scholars divide policy tools into voluntary, hybrid and mandatory [9]; similarly, American Lowi and others divide policy tools into regulatory and non-regulatory tools; most typically, Rothwell and Zegveld divide policy tools into demand, supply and environmental at the impact level.

At present, experts and scholars have carried out extensive and in-depth research on the application of science and technology policy classification or policy tools, but the government has gradually changed from the targeted application of single policy to the comprehensive dialectical treatment of various policies in the process of science and technology management practice. China has developed good innovation policy tools covering all policy areas related to innovation. However, there are many researches on science and technology policy classification and policy tools mining but lack of empirical research, and most of them stay in unilateral research on policy types or policy tools, and the formulation of science and technology policy needs to rely on the implementation of policy tools, and there is an inherent relationship between the two. Therefore, the author will start with some scientific and technological policy texts, and dig into the synergy between various types of policies and policy tools.

3. Research ideas and methods

3.1. Research thought

3.1.1. Science, technology and innovation policy classification design. The policy is information expressed and stored in text. The analysis method of text mining overcomes the problems of large text data, hidden information, and difficult classification. At the same time, text mining is more objective than artificial classification. The analysis should choose the text mining method. The specific process is shown in Figure 1.

![Figure 1. Text mining process.](image)

3.1.2. Classification and design of policy tools. Rothwell and zegveld [10] divide the science and technology policy tools into supply type, demand type and environment type from the impact level, and classify them through the measures and tools used in the policy. Each type of policy tool has clear characteristics, strong maneuverability, practicability and guidance, so it is regarded as the classification standard of science and technology policy tools in this paper.
3.1.3. Collaborative analysis model for types of policy needs and application of policy tools. Quality house model is a method to transform customer demand into technical index, and to show the [13] degree of customer demand satisfaction with technical index. By deeply understanding the connotation of the quality house model, this paper regards the policy type as the customer demand, the application of the policy tool as the technical index, and establishes the cooperative analysis model of the policy type demand and the application of the policy tool. The (Policy Function Synergy Deployment model, as shown in figure 2 below.

![Figure 2. QFD model.](image)

3.2. Data sources
In order to deeply explore the mechanism of various types of science and technology policies and policy tools, this paper selects the science and technology policy from 1990 to 2018 as the research object from Wanfang database. Select 2200 policy texts, select 1992 effective policy texts.

4. Empirical study on classification of science, technology and innovation policy

4.1. High-frequency word list and common word matrix
This paper uses ROSTCM6 software to process the selected 1992 policies, statistics the word frequency of the completed word segmentation document set, eliminate the invalid words, and act as the basic work of the next keyword network analysis. The high-frequency words are formed into a common word matrix with ROSTCM6 software as shown in Table 1.

|        | Technique | Develop | Service | Construct | Country | Institution | Resource |
|--------|-----------|---------|---------|-----------|---------|-------------|----------|
| Technique | 11275     | 9943    | 11834   | 8681      | 6729    | 6914        | 5672     |
| Develop  | 11275     | 9943    | 8890    | 6206      | 5672    |             |          |
| Service  | 8782      | 9943    | 8575    | 6178      | 6729    |             |          |
| Construct| 8575      | 11834   | 8890    | 6206      | 5672    |             |          |
| Country  | 6178      | 8681    | 6206    |           |         |             |          |
| Institution | 6914    |         |         |           |         |             |          |
| Resource | 6729      |         |         |           |         |             | 5672     |

4.2. Keyword network
Based on the effective high-frequency vocabulary and common word matrix obtained above, the policy text is analyzed by keyword network, and the semantic network diagram is formed through the social network and semantic network analysis function of ROSTCM6 software.

4.3. Central and small group analysis
The analysis of keyword networks relies on complex network thinking. The two most important indicators are "network centrality" and "point centrality". Table 3-3 shows the centrality of the policy samples used in this article and the centrality of the network. The centrality of the network is 7.67%, which means that the nodes in the network are not tightly concentrated, and there are still many elements that have no commonality. Now, it shows that the content of science and technology innovation policy is more complex and scattered. In order to display the centrality more intuitively, use the NetDraw function of UCINET software to adjust the size of each node in the keyword network according to the centrality value, and the result is shown in Figure 3.

| 1  | development | 10 | establish | 19 | Technology | 28 | unit |
|----|-------------|----|-----------|----|------------|----|------|
| 2  | mechanism   | 11 | strengthen| 20 | management | 29 | Supervisor |
| 3  | accelerate  | 12 | Develop   | 21 | project    | 30 | Autonomously |
| 4  | promote     | 13 | Entrepreneurship | 22 | platform  | 31 | Transform |
| 5  | system      | 14 | country   | 23 | research   | 32 | R&D |
| 6  | economic    | 15 | Construction | 24 | encourage | 33 | mechanism |
| 7  | ability     | 16 | Innovation | 25 | Results    | 34 | funds |
| 8  | policy      | 17 | service   | 26 | Method     | 35 | department |
| 9  | promote     | 18 | technique | 27 |           |    |       |

Figure 3. Point centric degree.

4.4. Cluster analysis
According to the keyword network structure, the key words of science, technology and innovation policy text are clustered and analyzed, and all keywords are clearly divided into two groups. Group 1 mainly includes: development, innovation, construction, country, etc. Group 2 mainly includes: management, service, technology, science and technology, etc. The analysis holds that the words "development, construction, state" in group 1 have strong authority and compulsion, and the words "strengthen, develop, promote and speed up" have strong urgency. The words "management, service, technology, science and technology" in group 2 mainly reflect certain guidance and guidance. According to the research of many scholars on the classification of science and technology innovation policy, this paper divides the science and technology innovation policy into authority, urgency and guidance, among which there is some overlap between authority and urgency.

5. Analysis on the synergy effect between the type of science and technology innovation policy and the policy tool based on QFD

5.1. Data specification
According to the classification results, all science and technology policies are classified. There are 984 authoritative policies, of which 636 apply supply-based policy tools, accounting for 64.63% of the total number of authoritative policies. 240 apply environmental policy tools, accounting for 24.39%. 108 applications of demand-oriented policies, accounting for 10.98%. There are 924 guiding policies, of which 480 are applying supply-based policy tools, accounting for 51.95% of the total number of guiding policies. 372 are applying environmental policy tools, accounting for 40.26%. 72 are applying demand-based policy tools, Accounting for 7.79%. There are 84 urgent policies, of which 48 apply supply-based policy tools, accounting for 57.14% of the total number of guiding policies. 24 apply environmental policy tools, accounting for 28.57%. 12 apply demand-based policy tools, Accounting for 14.29%.
5.2. Analysis of synergies between different types of policy needs and policy tools

The synergetic degree model of the application of policy tools is based on the quality house model. In this paper, the right wall of the quality house is designed as the classification intensity of the policy type, which is limited by the research conditions. This paper only takes the quantitative relationship as the criterion of classification strength. This part mainly presents the distribution of various types of policy formulation, as well as the types of policy tools applicable to policy types.

The left wall is the classification and relative weight of the policy type. Assuming that the importance of the policy type is described by the semantic variables of five grades, the corresponding triangular fuzzy number of the semantic variables of five grades is \((0.0, 0.1, 0.2), (0.2, 0.3, 0.4), (0.4, 0.5, 0.6), (0.6, 0.7, 0.8), (0.8, 0.9, 1)\). According to the score of the four policy types by experts, the fuzzy weight of the policy type is obtained.

The fuzzy weight is triangular fuzzy number representation, that is, \(a=(a_1, a_2, a_3)\), and the \(\lambda\) is introduced as the risk bias index of policy type fuzzy weight deblurring. The formula is \(E(a)=[(1-\lambda)]\) to maintain objectivity. In this paper, the \(\lambda\) value is classified as policy type deblurring calculation is carried out.

The roof is designed as the autocorrelation matrix of policy tools, and the part of house is the correlation matrix of policy types and policy tools, which is based on the application of policy tools under different policy types. Reflect the quantitative relationship and correlation between policy types and policy tools. The basement mainly calculates the application intensity of the policy tool and the application weight of the policy tool, and uses the data and the plan matrix of the right wall to calculate the synergy of the application of the policy tool.

The satisfaction of the requirements of the policy type with the application of policy tools is mainly used to indicate whether the classification intensity of the policy type matches the relative weight of the policy type. Expressed by \(S\), \(S = \sum_{i=1}^{m} W_i S_i(y_i), S_i(y_i) = 0.25(y_i - 1)\), Among them, \(y_i\) is a value of 1-5, which is obtained by comparing the classification intensity of the policy type with the relative weight of the policy type. Above 0-0.2 and 2, \(y_i\) takes the value of 1, 0.2-0.4 and 1.6-1.8, and \(y_i\) takes the value of 2. , 0.4-0.6 and 1.4-1.6, the value of \(y_i\) is 3, 0.6-0.8 and 1.2-1.4, the value of \(y_i\) is 4, 0.8-1.2, the value of \(y_i\) is 5, which represents the level of customer satisfaction, \(W_i\) is the relative weight of the policy type. The calculation results are shown in Figure 4.

![Figure 4. QFD model.](image-url)
5.3. Data analyse

5.3.1. Collaborative analysis of corporate policy types and policy tools. The coordination degree of the overall policy type classification intensity is 0.755, which barely meets the good standard. Combined with the policy tools, the policy type classification is analyzed. (1) The overall application intensity of urgent policy is low, the policy of applying supply-oriented policy tools and environmental-oriented policy tools is not up to the requirement, and the proportion of application of demand-oriented policy tools is more important than its power. (2) The overall application intensity of authoritative policy is slightly higher, which basically meets the requirements. The proportion of policy applied to supply policy tools and demand policy tools is normal, but the proportion of policy applied to environmental policy tools is low. (3) The proportion of policies applying demand-based policy tools in guiding policies is fully in line with the requirements, but the proportion of policies applying supply-based policy tools is low, and the proportion of policies applying environmental policy tools is high.

5.3.2. Comparative analysis of synergy in different periods. Figure 4 shows that the synergy between policy types and policy tools is different in different periods. Combined with the key words of the 12th Five-Year Plan period and the 13th Five-Year Plan period, the synergy degree of science and technology innovation policy and policy tools in the two periods is analyzed. "Development" has been the top priority in both periods, especially during the 13th Five-Year Plan period, when the central degree of "development" has reached the highest level; during the 12th Five-Year Plan period, the proportion of guiding policies has reached a more appropriate level; during the 13th Five-Year Plan period, the promotion of "technology and management" has represented more application of guiding policies." Development and innovation "is still the theme of this period.

6. Conclusions

Through the classification research of policies, this paper puts forward the collaborative development analysis model of policy functions to build connections, and analyzes the characteristics and results of data in different periods, ending up in drawing the following conclusions:

(1) When policies are formulated, corresponding policy tools should be matched according to the characteristics of the policies to improve the effect of collaborative application. The application proportions of different types of science and technology policies in various science and technology policy tools show the same trend, indicating that when the government formulates science and technology policies, they don't pay enough attention to the characteristics of various types of science and technology policies and their matching with different science and technology policy tools. Many are based on experience and conventions, thus failing to be matched with appropriate technology policy tools based on characteristics.

(2) Different science and technology policy tools have different applicability to different types of science and technology policies. Although different types of science and technology policies show the same trend in the application proportions of various science and technology policy tools, there are still certain differences, showing that different science and technology policy tools are applicable to different types of science and technology policies to different degrees.

(3) Different policy types should be adjusted in the application of policy tools. The degree of synergy between policy types and policy tools in the House of Quality model is 0.755. The analysis believes that the overall number of urgent policies cannot meet the needs, and urgent policies using supply-based policy tools and environmental policy tools should be increased. The overall number of authoritative policies is higher than that. Therefore, authoritative policies that apply supply-oriented policy tools and demand-oriented policy tools should be appropriately reduced. The overall number of guiding policies is relatively high, and the number of policies that apply supply-oriented policy tools cannot meet demand, so those who apply supply-oriented policy tools should basically remain at the current level, while guidance policies that apply environmental policy tools should be greatly reduced.
(4) Policy tools should be formulated and used in accordance with the background of the times when policies are made in different periods. Through the comparative analysis of the three periods before the Twelfth Five-Year Plan, the Twelfth Five-Year Plan and the Thirteenth Five-Year Plan, the proportions of policy types in different periods are obviously different, with characteristics presented consistently with the centrality of the theme of the era, reflecting the influence of policy making in the context of the times.

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