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The Text Measurement and Optimization of China's Science and Technology Personnel Evaluation Policy Based on the Four-dimensional Analytical Angles

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Abstract: The evaluation of science and technology (S&T) talent is a crucial component of overarching S&T evaluation systems. Analyzing the policy texts of S&T talent evaluation facilitates the formulation of future policies and the advancement of related initiatives. From the perspective of quantitative policy analysis, this paper constructs a four-dimensional analytical framework comprising policy instruments, elements, targets, and effectiveness. Utilizing NVivo 11 Plus software, a longitudinal and departmental analysis is conducted on 115 S&T talent evaluation policy texts issued in China from 1978 to 2020. This is followed by single-dimension and cross-dimensional analyses anchored by policy instruments. The findings reveal several deficiencies in current S&T talent evaluation policies: the internal elements of policy instruments are incomplete, requiring enhanced operability; target settings and instrument selections are partially mismatched, necessitating clearer goal orientations; and interdepartmental cooperation is relatively lacking, leading to an unbalanced structure of policy instruments. To optimize future policies, improvements can be made across three matching dimensions (element-instrument, target-instrument, and effectiveness-instrument) to refine the proportion of policy elements, correct mismatches, and strengthen interdepartmental linkages. This paper

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analyzes S&T talent evaluation policies from a multi-dimensional perspective and proposes targeted optimization strategies. Future research could further explore these policies from the standpoint of policy synergy.

Keywords: Science and technology (S&T) talent evaluation; S&T talent evaluation policies; Policy instruments; Policy texts; Quantitative policy analysis

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1. Introduction

According to the definition in the National Medium and Long Term Science and Technology Talent Development Plan (2010-2020), S&T professionals refer to individuals who possess certain professional knowledge or specialized skills, engage in creative scientific and technological activities, and make contributions to the S&T enterprise and socio-economic development; they mainly include personnel engaged in scientific research, engineering design and technological development, S&T services, S&T management, S&T popularization, and other related S&T activities. S&T talents are the primary demographic of a nation's scientific and technological innovation and constitute a vital national human resource. Currently, countries worldwide regard S&T talents as a crucial strategic resource for participating in international economic and technological competition, placing great emphasis on their education, cultivation, motivation, and recruitment. Talent evaluation and motivation are the core of S&T talent policies, serving as a critical guiding force and barometer for S&T personnel and activities (Li Zhe, 2017).

In the establishment of the S&T talent policy system, evaluation policies, as a subset of talent policies, have increasingly attracted the attention of policy-making departments and scholars in recent years. For example, Liu Zhongyan (2018) utilized S&T talent evaluation as one of nine element dimensions to analyze S&T talent policies from 1978 to 2017, discovering that the elements of S&T talent cultivation, motivation, and evaluation appeared most frequently in the policy system and accounted for a substantial proportion. This indicates that S&T talent evaluation policy is a focal point in the formulation of S&T talent policies. Concurrently, some scholars, in their research on S&T talent evaluation policies, found that the development of China's S&T talent evaluation and motivation policies generally exhibits the characteristics of diversified

issuing entities, flattened power structures, diversified policy instruments, and a scientific policy system (Tan Yu, 2019). However, such studies have not yet conducted specific analyses of S&T talent evaluation policies from the perspectives of policy elements, policy targets, and policy effectiveness. Analyzing policy elements, targets, and effectiveness facilitates a more comprehensive understanding of how S&T evaluation policy instruments are utilized and what problems exist, thereby enabling the proposition of targeted recommendations. Furthermore, a critical question remains: have the policy instruments, elements, targets, and effectiveness of China's S&T evaluation policies been systematically aligned over time? Facing the new situations and demands of current S&T talent evaluation, how should S&T talent management departments build and optimize new, appropriate policy instruments based on the experience drawn from previous evaluation policies? These questions are worthy of our in-depth exploration.

2. Analytical Framework for S&T Talent Evaluation Policies

2.1 Policy Instrument Dimension

International scholars pioneered research on the classification of policy instruments relatively early. Rothwell and Zegveld (1985) classified policy instruments into supply-type, demand-type, and environment-type. Schneider and Ingram proposed five categories of policy instruments based on the behavioral assumptions of policy target groups: authority tools, incentive tools, capacity-building tools, symbolic and hortatory tools, and learning tools (Schneider A, 1990). Canadian scholars Howlett and Ramesh (2006) divided policy instruments into voluntary, compulsory, and mixed instruments based on the degree of government intervention. McDonnell and Elmore (2007) proposed a classification of policy instruments into mandates, inducements, capacity-building, and system-changing based on the expected role of the policies.

Regarding the classification of S&T talent policy instruments, some literature has already conducted relevant research. For instance, literature(Ma Xiangyuan, 2020) divided S&T talent policies into information, authority, organization, and financial policy instruments; literature(Gu Jinglei, 2017; Xu Nini, 2018) categorized S&T talent policies into five types of instruments: authority, hortatory, capacity, incentive, and system-changing; literature(Cao Shuai, 2019)classified S&T talent policy instruments into attraction, incentive, and cultivation tools; literature (Zhao Xingchen, 2018) categorized them into supply-type, demand-type, and environment-type policy instruments. This paper primarily studies S&T talent evaluation policies. With reference to the research of Schneider and Ingram and relevant domestic scholars, combined with the practical work of S&T talent evaluation, this paper classifies the basic policy instruments for S&T talent evaluation into five major categories: symbolic and hortatory tools, system-changing tools, authority tools, capacity tools, and incentive tools, in order to subdivide and analyze the specific policy instrument types under each major category.

In this paper, authority policy instruments for S&T talent evaluation refer to government departments utilizing government power and prestige to conduct work planning, content requirements, and directional

guidance for S&T talent evaluation. These mainly include specific tools such as talent planning, evaluation mechanisms, supervision and correction, classified evaluation, methods and approaches, regulatory control, procedures and cycles, and standard formulation. Incentive policy instruments refer to government departments recognizing, selecting, and providing spiritual and material rewards to S&T talents through relevant policies to achieve a motivating and promotional effect, including funding input, professional title assessment, talent selection and employment, income distribution, and reward and punishment systems. Capacity policy instruments refer to providing support for the development of specific professional capacities and talents in specific fields through relevant policies, including four specific tools: professional guidance, talent development in key fields, youth support, and talent cultivation. Symbolic and hortatory tools refer to establishing management services through policies, maintaining a fair and open evaluation environment, publicizing typical S&T talents, guiding social recognition, and jointly promoting S&T talent development; these can cover specific tools such as publicity and education, value orientation, management services, and Research integrity promotion. System-changing tools aim to transform the current status of S&T talent evaluation through mechanisms like innovation, reform, and competition, including specific tools such as encouraging innovation, perfecting systems, and reforming the current situation.

2.2 Policy Element Dimension

To analyze the text content elements of S&T talent evaluation policies, based on the specific content elements of general talent evaluation policies, they are divided into five categories: evaluation subjects, evaluation methods, evaluation standards, evaluation guarantees, and evaluation applications. Evaluation subjects mainly refer to the implementing entities of S&T talent evaluation, such as employers, third-party organizations, market entities, and evaluation centers. Evaluation methods refer to the approaches, evaluation cycles, and classified evaluations utilized in implementing S&T talent evaluations. Evaluation standards refer to the criteria for implementing S&T talent evaluation, including the standard system, classification of standards, and specific evaluation indicators such as moral character, knowledge, capability, and performance contributions. Evaluation guarantees include management services, evaluation environments, mechanism building, institution building, financial guarantees, and other managerial, service-oriented, and supportive contents to ensure the smooth progress of S&T talent evaluation work. Evaluation applications refer to the utilization of S&T talent evaluation results, such as conducting professional title assessments and personnel selection based on evaluation indicators, and using the results for rewards and salary distribution.

2.3 Policy Target Dimension

Policy targets are the intended policy effects that the issuing entities aim to achieve by utilizing various policy instruments. Regarding the policy targets of talent policies, some scholars have conducted relevant analyses from different dimensions. For example, Ning Tiantian et al. (2014) analyzed the effectiveness of the National Medium- and Long-Term Talent Development Planning Outline (2010-2020) in promoting the strategy of strengthening the country through human resources from six dimensions: talent scale, talent quality, talent

investment, talent mobility, talent efficiency, and talent innovation. Yang Yan studied the synergy of Shanghai's talent policies using talent quality, talent scale, talent mobility, and talent efficiency as the dimensions of talent policy targets (Yang Yan, 2018). Furthermore, current policies, such as the Guiding Opinions on Classifying and Promoting the Reform of Talent Evaluation Mechanisms and the Opinions on Deepening the Reform of Project Review, Talent Evaluation, and Institutional Assessment issued by the General Office of the CPC Central Committee and the General Office of the State Council in 2018, also emphasized and clarified policy targets in their texts. Based on this, this paper references existing research findings and summarizes current policies to categorize the policy targets of S&T talent evaluation policies into five sub-targets: stimulating innovation, incentivizing through rewards and penalties, cultivating and supporting personnel, guiding evaluation orientations, and informing selection and appointment processes.

In this paper, the target of stimulating innovation in S&T talent evaluation policies mainly refers to activating the innovation momentum of S&T talents and enhancing innovation activities by utilizing talent evaluation tools and means. The target of rewarding and punishing for motivation is to commend or discipline S&T talents who meet or fail the evaluation requirements, in order to achieve positive incentive effects. Cultivating and supporting entails purposefully and preferentially training and assisting specific groups during the S&T evaluation process, such as cultivating and supporting young S&T talents to help them grow and succeed rapidly. The target of evaluation orientation is to guide the value orientation of S&T talent evaluation through directive policies to achieve predefined evaluation purposes. The target of selection, assessment, and appointment specifically refers to the application of S&T talent evaluation results, utilizing evaluations to guide talent selection and appointment.

2.4 Policy Effectiveness Dimension

Policy texts are generally formulated and issued by corresponding administrative authorities according to different policy types, and the effectiveness of policy texts issued by different levels of administrative authorities will also vary. Referring to the Regulations on Procedures for the Formulation of Administrative Regulations and the Regulations on Procedures for the Formulation of Rules, as well as the current formulation procedures for normative documents of state organs, and drawing on the classification and assignment standards of policy effectiveness by Peng Jisheng et al.(2008), this paper divides the effectiveness of S&T talent evaluation policies into 5 levels based on the issuing entities and policy types, as detailed in Table 1, to facilitate the quantitative analysis of the S&T talent evaluation policy effectiveness dimension.

Issuing Entities and Policy Types	Effectiveness Level
Laws and regulations promulgated by the National People's Congress and its Standing Committee	5
Plans, outlines, regulations, and opinions promulgated by the CPC Central Committee and the State Council, and ministerial orders of various ministries and commissions	4
Provisional regulations and trial measures promulgated by the CPC Central Committee and the State Council, and regulations and provisions of various ministries and commissions	3

Opinions, measures, and provisional regulations of various ministries and commissions	2
Notices and announcements of various ministries and commissions	1

Table 1 Rating table of policy effectiveness

3. Selection and Coding of S&T Talent Evaluation Policy Texts

3.1 Selection of Policy Texts

To comprehensively understand the longitudinal evolution of China's S&T talent evaluation policies, this paper analyzes national-level policy texts issued between 1978 and 2020. These texts were sourced through three primary channels: (1) Boolean searches using keywords such as "science and technology talents," "scientific and technological personnel," "scientific researchers," "S&T workers," "talent evaluation," "assessment," "evaluation," and "appraisal," and querying and collecting them in the PKULaw database and the policy database of the S&T Talent Center of the Ministry of Science and Technology; (2) Consulting the Selected Compilation of S&T Talent Policies and Regulations (Central Volume) and the Overview of China's S&T Policy Directories (1949-2010) compiled by the Talent Center of the Ministry of Science and Technology to supplement some policy entries and texts; (3) Obtaining the full texts of some policies through the policies and regulations columns on the websites of departments such as the Ministry of Science and Technology, the State Council, the Ministry of Human Resources and Social Security, and the Ministry of Education. Initially, 133 policy texts were obtained. After manual review, 18 texts with overlapping contents or weak relevance were removed, yielding a final analytical sample of 115 highly relevant policy texts for China's S&T talent evaluation policies.

3.2 Coding of Policy Texts

NVivo 11 Plus, a robust and widely adopted qualitative data analysis software, was employed to analyze the collected texts. Upon importing the 115 documents, all clauses and sentences related to 'S&T talent evaluation' were queried, coded, and subsequently categorized according to the aforementioned dimensions of instruments, elements, targets, and effectiveness. Taking policy instrument coding as an example, the coding examples are shown in Table 2. It should be noted that the reference points extracted during the coding process all reflect the information of policy instruments and can be classified under the categories of policy instruments; however, not every policy instrument coding reference point can correspondingly reflect the information of the policy element and policy target dimensions. Therefore, the total number of reference points in the policy element and target dimensions is not equal to that in the policy instrument dimension. After coding, a total of 1238 reference points were obtained for the policy instrument dimension, 1004 for the element dimension, and 455 for the target dimension. To ensure coding reliability, simultaneous cross-coding was conducted by independent groups of doctoral and master's students. Before coding, they fully discussed and determined the dimensions and directions of coding; when coding directions were inconsistent, consistency was ensured through thorough discussion and negotiation.

Policy Instruments	Content Description	Policy Source
Value orientation	Establish an evaluation orientation centered on innovation quality and academic contribution.	Notice of the State Council on Printing and Distributing the "13th Five-Year" National Science and Technology Innovation Plan (Guo Fa [2016] No. 43)
Publicity and education	Strengthen the publicity of typical deeds and figures in S&T innovation, strive to create a social public opinion environment that encourages S&T workers to start careers, supports them in achieving success, and helps them do their jobs well, and promote the formation of a good social atmosphere where everyone pursues innovation and contributes to it.	Several Opinions of the Organization Department of the CPC Central Committee, the Ministry of Education, the Ministry of Science and Technology, etc., on Mobilizing and Organizing the Broad Masses of Scientific and Technological Workers to Make New Contributions to Building an Innovative Country (Ke Xie Fa Ban Zi [2007] No. 6)
Encouraging innovation	Innovate mechanisms for the cultivation, utilization, mobility, evaluation, and motivation of S&T talents.	Notice of the Ministry of Science and Technology, the Ministry of Human Resources and Social Security, the Ministry of Education, etc., on Printing and Distributing the National Medium- and Long-Term S&T Talent Development Plan (2010-2020) (Guo Ke Fa Zheng [2011] No. 353)
Supervision and correction	Improve the supervision mechanism, and perfect the credit encouragement and accountability mechanism associated with professional evaluation results. Strengthen the assessment of various talent special projects and selectees, and strictly implement the exit system for those who fail the assessment.	Notice of the Ministry of Science and Technology on Printing and Distributing the "13th Five-Year" National S&T Talent Development Plan (Guo Ke Fa Zheng [2017] No. 86)
Professional guidance	Strengthen support for young S&T innovation talents. In task delegation, post employment, and professional title assessment, break away from seniority, focus on development potential, and boldly appoint young S&T talents to take on heavy responsibilities.	Opinions of the Leading Party Members' Group of the Ministry of Science and Technology on Implementing the Spirit of the Fifth Plenary Session of the 18th CPC Central Committee and Deeply Implementing the Innovation-Driven Development Strategy (Guo Ke Dang Zu Fa [2016] No. 1)
Income distribution	Reform and perfect enterprise distribution and incentive mechanisms, support enterprises in attracting S&T talents, and allow state-owned high-tech enterprises to implement incentive policies such as stock options for technical and management backbones.	Notice of the State Council on Printing and Distributing Several Supporting Policies for the Implementation of the Outline of the National Medium- and Long-Term Program for Science and Technology Development (2006-2020) (Guo Fa [2006] No. 6)

Table 2 Examples of coding for science and technology talents evaluation policy

4. Quantitative Analysis of S&T Talent Evaluation Policy Texts

4.1 Descriptive Statistics of Policy Texts

4.1.1 Longitudinal Distribution of Policy Texts

Based on the annual distribution of S&T talent evaluation policy texts in Figure 1, between 1978 and 2020, except for the years 1983, 1984, 1992, 1993, and 1994 when the national level did not issue policies related to S&T talent evaluation, relevant policies were issued in all other years. Adapting Li Yanping's chronological framework for S&T talent policies, this study categorizes the evaluation policies into four historical phases: the recovery and adjustment period (1978-1984), the in-depth reform period (1985-1994), the strategic orientation period (1995-2005), and the innovative development period (2006-2020) (Liu Zhongyan, 2018).

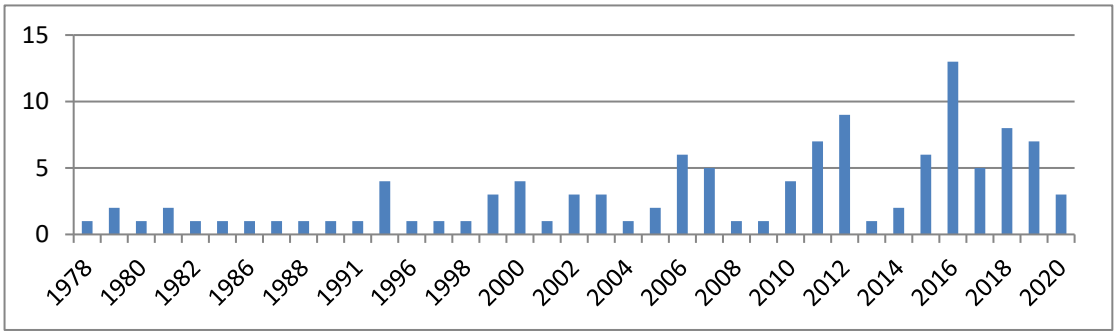

Figure 1 Annual distribution of science and technology personnel evaluation policies in China from 1978 to 2020

From the perspective of policy quantity distribution, fewer S&T talent evaluation policies were issued during the recovery and adjustment period and the in-depth reform period; there was a certain growth in the number of policies during the strategic orientation period, but it was relatively unstable; during the innovative development period, the number of policies showed a relatively stable upward trend with significant growth.

4.1.2 Statistics of Policy Issuing Departments

Given the numerous administrative restructuring efforts in China since the reform and opening up, which involved the renaming and merging of various ministries and commissions, historical departments were reclassified under their current designations. This reclassification was based on functional continuity and departmental transfers to ensure statistical consistency. The 115 S&T talent evaluation policy documents were issued by a total of 50 units, among which 75 were issued by a single department (accounting for 65%), and 40 were issued jointly by multiple departments (accounting for 35%). Among the 50 units, 32 departments issued 2 or more S&T talent evaluation policies (see Table 3), and 9 departments — namely the Ministry of Science and Technology, the Ministry of Human Resources and Social Security, the Ministry of Education, the National Development and Reform Commission, the State Council, the Ministry of Finance, the China Association for Science and Technology, the General Office of the State Council, and the Ministry of Natural Resources — issued more than 10 documents. As the national competent department for science and technology, the Ministry of Science and Technology issued the most S&T talent evaluation policies. Departments such as the Ministry of Human Resources and Social Security, the Ministry of Education, the

Ministry of Finance, the National Development and Reform Commission, the State Council, the China Association for Science and Technology, the Chinese Academy of Sciences, and the General Office of the State Council also jointly issued a large number of related policies.

Furthermore, from the distribution of policy-issuing departments, it can also be seen that S&T talent evaluation policies are scattered among various S&T policies or talent policies issued by different departments, and there are relatively few policies exclusively focused on the topic of S&T talent evaluation.

Issuing Department	Independent Issuances	Joint Issuances	Total Issuances
Ministry of Science and Technology	11	22	33
Ministry of Human Resources and Social Security	7	17	24
Ministry of Education	6	17	23
National Development and Reform Commission	1	10	11
State Council	6	5	11
Ministry of Finance	0	11	11
China Association for Science and Technology	3	8	11
General Office of the State Council	3	7	10
Ministry of Natural Resources	8	2	10
General Office of the CPC Central Committee	1	7	8
Chinese Academy of Sciences	0	8	8
CPC Central Committee	2	5	7
Organization Department of the CPC Central Committee	1	5	6
Chinese Academy of Engineering	0	6	6
National Natural Science Foundation of China	0	5	5
State-owned Assets Supervision and Administration Commission of the State Council	3	2	5
State Administration for Market Regulation	2	3	5
National Health Commission	1	4	5
National Administration of Traditional Chinese Medicine	1	4	5
Ministry of Industry and Information Technology	2	2	4
Ministry of Ecology and Environment	2	1	3
Ministry of Civil Affairs	2	1	3
National Food and Strategic Reserves Administration	2	1	3
Ministry of Agriculture and Rural Affairs	1	2	3
Ministry of Culture and Tourism	0	2	2
Central Leading Group for Professional Title Reform	2	0	2
State Power Corporation	2	0	2
Ministry of Public Security	0	2	2
State Taxation Administration	0	2	2
Ministry of Transport	2	0	2
Ministry of Commerce	0	2	2
General Administration of Sport	0	2	2

Table 3 Department statistics of science and technology talents evaluation policy

4.2 Analysis of Individual Policy Dimensions

4.2.1 Analysis of the Policy Instrument Dimension

Based on the classification of policy instrument types determined previously, the S&T talent evaluation policy instruments are categorized. The analysis reveals that the policy instruments employed in China's S&T talent evaluation policies can be categorized into five primary dimensions and 24 specific subcategories, as shown in Table 4.

Authority tools	Incentive tools	Capacity tools	Symbolic and hortatory tools	System-changing tools
Talent planning	Funding input	Professional guidance	Publicity and education	Encouraging innovation
Evaluation mechanism	Professional title assessment	Talent development in key fields	Value orientation	Perfecting systems
Supervision and correction	Talent selection and employment	Youth support	Management services	Reforming the status quo
Classified evaluation	Income distribution	Talent cultivation	Research integrity promotion	
Methods and approaches	Reward and punishment system			
Regulatory control				
Procedures and cycles				
Standard formulation				

Table 4 Policy instruments of science and technology talents evaluation policy

The distribution of policy instruments exhibits significant variation (see Figure 2). The three most frequently used policy instruments are "standard formulation, encouraging innovation, and management services," among which "standard formulation" accounts for the highest proportion at 14.1%; policy instruments such as "methods and approaches, talent cultivation, youth support, income distribution, classified evaluation, and reward and punishment systems" also have relatively high frequencies, ranging between 5% and 7%; whereas the least frequently used are "professional guidance, talent planning, and talent development in key fields," all of which are below 1%.

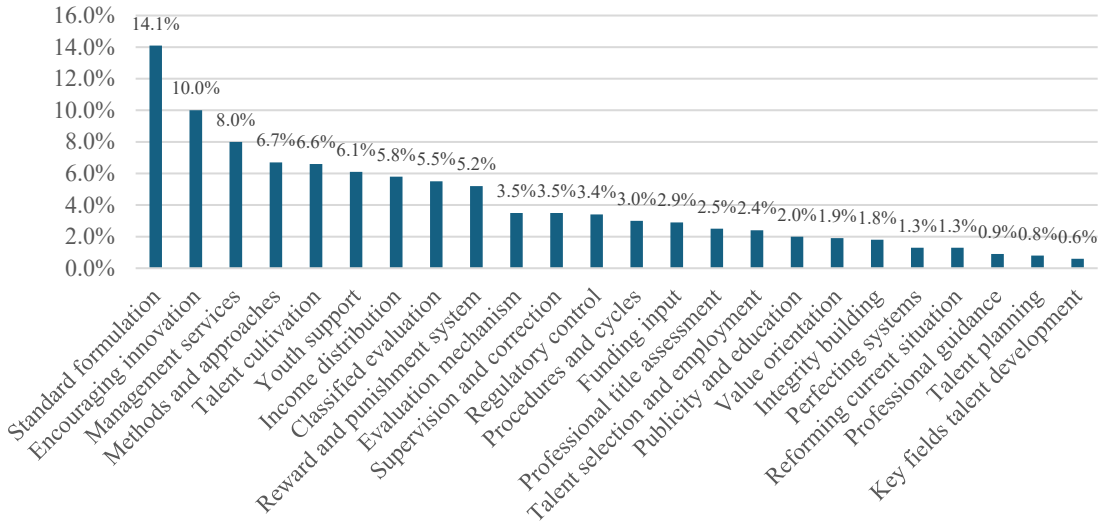

Figure 2 Proportion of policy instruments

From the perspective of the historical stages of S&T talent evaluation policies (Figure 3), policy instruments were used significantly less frequently during the recovery and adjustment period (1978-1984) and the in-depth reform period (1985-1994). As time progresses and the number of policies increases, the number of policy instruments also gradually rises. Overall, authority tools account for the highest proportion in each stage, reaching 36.8%, followed by symbolic and hortatory tools (17.0%) and incentive tools (16.9%), while system-changing tools (15.2%) and capacity tools (14.1%) are used least frequently.

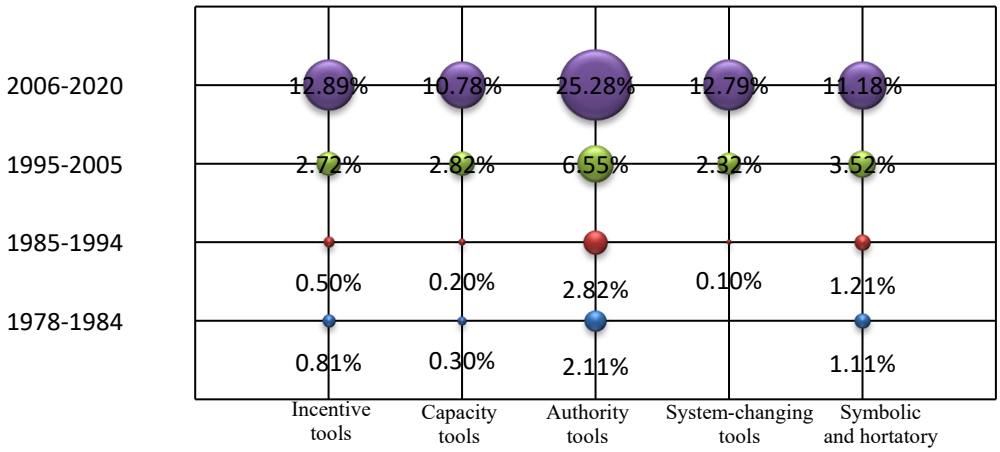

Figure 3 The distribution of policy instruments at different stages

4.2.2 Analysis of the Policy Element Dimension

As shown in Figure 4, during the recovery and adjustment period (1978-1984) and the in-depth reform period (1985-1994), evaluation standards and evaluation methods accounted for a large proportion of the S&T talent evaluation policy elements. This was mainly because the number of policies during these two periods was limited and policy support was insufficient, leading the policies at that time to focus more on the standardization of evaluation standards and methods. During the strategic orientation (1995-2005) and

innovative development (2006-2020) phases, evaluation support mechanisms accounted for the largest proportion, and the proportions of evaluation standards, evaluation methods, and evaluation applications also saw substantial growth, making the ratio of various evaluation elements more balanced. Looking at the overall proportions, the evaluation guarantee element was mentioned most frequently, accounting for 33.3%, followed by evaluation standards (23.3%), evaluation methods (17.7%), and evaluation applications (16.7%), while evaluation subjects only accounted for 9.1%.

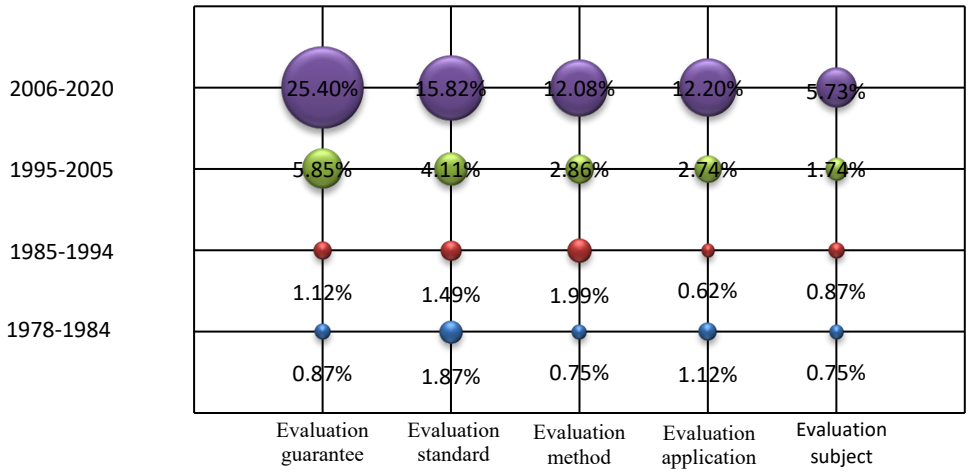

Figure 4 The distribution of policy elements at different stages

4.2.3 Analysis of the Policy Target Dimension

In the distribution of S&T talent evaluation policy targets (Figure 5), the main targets during the recovery and adjustment period (1978-1984) were selection, assessment, and appointment, as well as rewarding and punishing S&T talents, lacking the orientations of stimulating innovation and evaluation orientation. Policies during the in-depth reform period (1985-1994) began to pay attention to the target of evaluation orientation but still lacked the orientation of stimulating innovation. Policies during the strategic orientation period (1995-2005) and the innovative development period (2006-2020) mentioned all five categories of targets, among which the cultivating and supporting target became a primary policy target starting from the strategic orientation period (1995-2005). This shift was primarily driven by the 'Talent-Strong Country Strategy' proposed in the 2002 National Outline, prompting the state to attach increasing importance to the education and cultivation of talents to provide talent guarantees and intellectual support for building a moderately prosperous society in all respects and realizing the great rejuvenation of the Chinese nation.

The 18th National Congress of the Communist Party of China in 2012 proposed implementing the "innovation-driven development strategy," emphasizing adherence to the path of independent innovation with Chinese characteristics and the implementation of the innovation-driven development strategy. This is reflected not only in industry and S&T development policies but also in S&T talent evaluation policies. As can be seen from Figure 5, the target of stimulating innovation reached a very high proportion during the innovative development period, second only to the cultivating and supporting target, indicating that during

this period, policy-making departments increasingly emphasized the orientation of stimulating innovation in S&T talent evaluation policies.

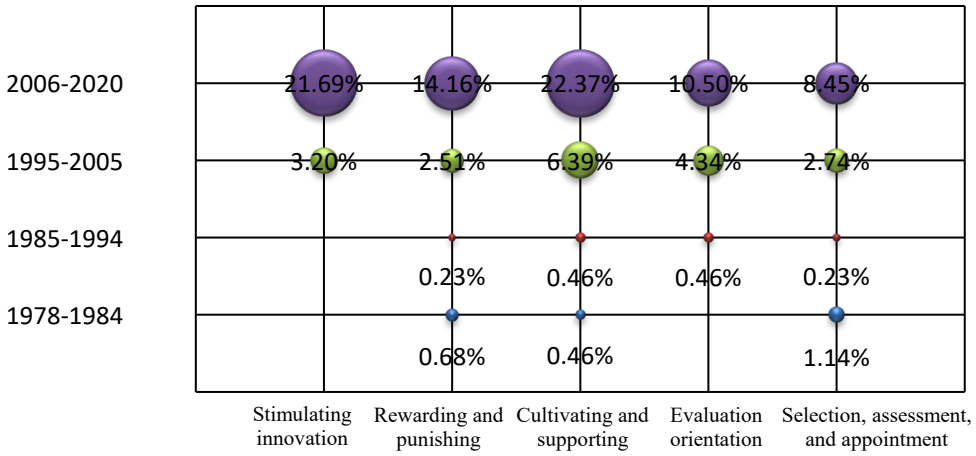

Figure 5 The distribution of policy targets at different stages

4.2.4 Analysis of the Policy Effectiveness Dimension

Judging from the distribution of policy effectiveness (Figure 6), the number of policies during the recovery and adjustment period (1978-1984) was relatively small, and the policy types were mainly opinions, provisional regulations, trial rules, and trial measures from various departments. During the in-depth reform period (1985-1994), the number of regulations and rules with an effectiveness level of 4 experienced a certain growth. During the strategic orientation period (1995-2005) and the innovative development period (2006-2020), policy documents mainly featured an effectiveness level of 2, and the proportion of policy documents with effectiveness levels of 3 and 4 was also significant. Notably, the Higher Education Law of the People's Republic of China, adopted at the fourth meeting of the Standing Committee of the Ninth National People's Congress in 1998, as a policy law with the highest legal effectiveness, mentioned the academic evaluation and educational evaluation systems for teachers in its provisions. It stipulated "assessing the ideological and political performance, professional ethics, professional level, and work achievements of teachers, management personnel, teaching support personnel, and other professional and technical personnel, with the assessment results serving as the basis for appointment or dismissal, promotion, reward, or punishment."

In terms of policy quantity and proportion, the proportion of level-5 policy effectiveness is only 0.9%, indicating a shortage of S&T talent evaluation policy documents with high policy effectiveness. The quantities and proportions of documents with policy effectiveness levels of 4, 3, 2, and 1 are 48 documents (41.7%), 35 documents (30.4%), 23 documents (20.0%), and 8 documents (7.0%), respectively, showing a generally reasonable distribution overall.

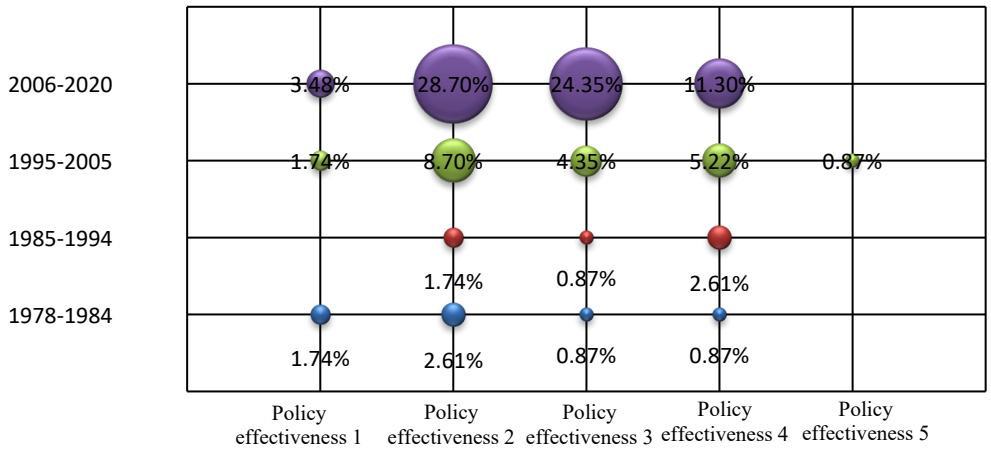

Figure 6 The distribution of policy effective at different stages

4.3 Four-dimensional Cross-analysis of Policy Texts

Using policy instruments as the foundational dimension, matrix coding in NVivo 11 Plus was employed to conduct a cross-analysis across policy elements, targets, and effectiveness. It calculates the proportion of reference points for each dimension and analyzes the characteristics and deficiencies presented by each dimension.

4.3.1 Element-Instrument Intersection: Incomplete Internal Elements and the Need for Enhanced Operability

The element-instrument cross-dimensional analysis (Table 5) shows that regarding S&T talent evaluation policy elements, only the evaluation guarantee element generally covers all five major categories of policy instruments and their specific subcategories; the three elements of evaluation standards, evaluation methods, and evaluation applications cover the five major categories of policy instruments, but do not fully cover all instrument subcategories; the evaluation subject element does not involve system-changing tools. This demonstrates that the incomplete inclusion of policy elements will, to a certain extent, affect the completeness of various policy components and result in reduced operability of policy instruments. For example, a lack of evaluation subject elements will lead to unclear rights and responsibilities of evaluation subjects, making it difficult to specify rights and obligations.

Furthermore, a careful study of China's S&T talent evaluation policies reveals that the policies issued in our country mainly focus on top-level national design and top-down guidance, lacking detailed operational elaborations. For instance, in recent years, various S&T talent evaluation policies have frequently mentioned conducting S&T talent evaluations by "leveraging the role of specialized peer review," "establishing an industry evaluation mechanism based on peer review," and "emphasizing the introduction of international peer review." This is a beneficial summary of China's S&T talent evaluation practices and a highly recognized evaluation method. However, peer review and expert review also have their shortcomings: first, there are no unified procedures and norms; second, phenomena of favoritism, violations of professional ethics, and seeking improper benefits still occur in peer reviews. How to ensure that peer reviews are open, fair, and just, and how

to regulate the responsibilities and obligations of review experts still require continuous summary and innovation in China's S&T talent evaluation work. Currently, in the issued policies, ensuring the credibility of peer review is still primarily required from an overall design perspective. For example, while policies require "establishing expert responsibility systems, information disclosure systems, accountability systems for effectiveness and responsibility, and credit systems for evaluation," these are mostly mentioned in individual clauses and sentences in the policy texts, lacking detailed guidance on institutional building and sample references.

Policy Instrument Category	Policy Instrument	Policy Elements				
		Evaluation guarantee	Evaluation standard	Evaluation method	Evaluation application	Evaluation subject
Capacity tools	Reward and punishment system	0.7%	1.2%		31.9%	
	Income distribution	0.8%	0.9%		43.2%	
	Talent selection and employment	0.7%	1.4%	2.1%	5.2%	1.8%
	Professional title assessment	0.3%			7.9%	0.7%
	Funding input	8.9%			0.6%	
Capacity tools	Youth support	2.6%	0.4%	1.6%	2.3%	
	Talent cultivation	2.6%	1.8%	2.4%	0.7%	
	Talent development in key fields	6.2%		7.3%		6.0%
	Professional guidance	5.4%	0.8%			
Authority tools	Standard formulation	1.9%	59.7%	5.6%	2.9%	2.4%
	Procedures and cycles	4.3%	0.3%	13.1%	0.8%	2.8%
	Regulatory control	5.5%			1.4%	
	Methods and approaches	0.7%	2.4%	18.9%		0.3%
	Classified evaluation	4.3%	7.9%	42.1%		5.5%
	Supervision and correction	8.0%	0.4%			0.4%
	Evaluation mechanism	6.4%	1.8%	1.4%		
	Talent planning	2.4%				
System-changing tools	Reforming the status quo	4.3%	2.2%	2.4%	0.3%	
	Encouraging innovation	3.3%	3.1%	1.7%	2.0%	
	Perfecting systems	3.9%	0.8%		0.2%	

Symbolic and hortatory	Research integrity promotion	10.8%	0.3%	0.4%		0.5%
	Management services	9.9%	1.0%	0.9%	0.5%	79.7%
	Value orientation	1.2%	13.4%	0.2%		
	Publicity and education	4.9%	0.3%		0.2%	

Table 5 Node coding coverage of policy element - policy instrument cross analysis (%)

4.3.2 Target-Instrument Intersection: Goal Mismatches and the Need for Clearer Orientations

The target-instrument cross-dimensional analysis (Table 6) shows that the five major categories of policy instruments generally cover the five policy targets. The target of stimulating innovation is mainly paired with system-changing tools; the target of rewarding and punishing for motivation is primarily paired with incentive tools; the target of cultivating and supporting is largely paired with capacity tools; the target of evaluation orientation is mainly matched with symbolic and hortatory tools and authority tools; and the target of selection, assessment, and appointment is mainly paired with incentive tools. Fundamentally, a general alignment between target settings and policy instruments has been achieved. However, there are some mismatches between target setting and instrument selection. For instance, the target of rewarding and punishing for motivation is mismatched with the reforming the status quo tool under system-changing tools, and the target of evaluation orientation is mismatched with the evaluation mechanism tool under authority tools. Mismatches between target setting and instrument selection will lead to ambiguous targets during the application of policy instruments, and targets may also fail to be achieved due to incorrect instrument choices.

Policy Instrument Category	Policy Instrument	Policy objectives				
		Stimulating innovation	Rewarding and punishing	Cultivating and supporting	Evaluation orientation	Selection, assessment, and appointment
Capacity tools	Reward and punishment system	2.6%	61.1%	2.3%		
	Income distribution	0.8%		0.2%		1.5%
	Talent selection and employment	2.7%		1.7%	1.1%	34.2%
	Professional title assessment		0.6%			22.0%
	Funding input		1.1%	0.2%		
Capacity tools	Youth support		3.6%	45.0%	1.3%	3.7%
	Talent cultivation	2.9%	0.5%	33.0%	6.8%	4.8%
	Talent development in key fields			1.8%		

	Professional guidance	0.2%		3.1%		0.5%
Authority tools	Standard formulation	3.4%	6.7%	1.2%	3.7%	6.2%
	Procedures and cycles		0.6%			2.1%
	Regulatory control					
	Methods and approaches	0.6%	0.6%	0.7%	2.3%	1.5%
	Classified evaluation	1.9%	3.3%	2.6%		2.8%
	Supervision and correction					
	Evaluation mechanism	2.0%		2.2%	34.7%	1.2%
	Talent planning			1.5%		12.7%
System-changing tools	Reforming the status quo	0.7%	18.0%			0.9%
	Encouraging innovation	76.1%	3.6%	1.7%	5.5%	4.4%
	Perfecting systems	0.6%		1.7%		
Symbolic and hortatory	Research integrity promotion					
	Management services	1.3%				1.5%
	Value orientation	1.7%		1.2%	44.6%	
	Publicity and education	2.6%	0.4%			

Table 6 Node coding coverage of policy target - policy instrument cross analysis (%)

4.3.3 Effectiveness-Instrument Intersection: Insufficient Interdepartmental Cooperation and Unbalanced Instrument Structure

The distribution results of the issuing units for S&T talent evaluation policies mentioned above show that 65% of the 115 policy documents were issued by single departments, and 35% were jointly issued by multiple departments, indicating a relative lack of jointly issued policy documents. At the same time, the policies issued by departments such as the General Office of the State Council, the General Office of the CPC Central Committee, the Ministry of Science and Technology, the Ministry of Education, and the Ministry of Finance are overly concentrated, which is equally detrimental to interdepartmental cooperation. S&T talents are spread across various industries, involving numerous departments, broad sectors, and complex job types. Furthermore, S&T talent evaluation also involves personnel management, education and training, finance, and other departments. Effectively executing S&T talent evaluation necessitates robust interdepartmental collaboration,

rather than relying solely on science and technology or personnel management authorities.

In the pairing of policy effectiveness and policy instruments (Table 7), capacity tools and system-changing tools with policy effectiveness levels of 1 and 2 account for a small proportion, and symbolic and hortatory tools and system-changing tools with policy effectiveness levels of 3 and 4 also make up a small percentage. Overall, the proportion of system-changing tools is relatively low. This is precisely the reason for the continuous calls from academic and industrial circles in recent years to reform S&T talent evaluation. It is also the underlying context for the Opinions on Deepening the Reform of Project Review, Talent Evaluation, and Institutional Assessment issued jointly by the General Office of the CPC Central Committee and the General Office of the State Council in 2018.

Policy Instrument Category	Policy effectiveness 1	Policy effectiveness 2	Policy effectiveness 3	Policy effectiveness 4	Policy effectiveness 5
Incentive tools	27.8%	19.3%	22.9%	19.0%	24.7%
Capacity tools	6.0%	15.5%	21.1%	17.1%	12.0%
Authority tools	33.0%	37.8%	32.0%	30.1%	63.2%
System-changing tools	9.3%	10.0%	12.3%	12.3%	
Symbolic and hortatory	23.9%	17.4%	11.7%	21.6%	

Table 7 Node coding coverage of policy effective - policy instrument cross analysis (%)

5. Optimization Strategies for S&T Talent Evaluation Policies

5.1 Element-Instrument Alignment: Optimizing Element Proportions to Enhance Policy Operability and Guidance

Regarding policy element inclusion, the formulation of S&T talent evaluation policies must not only sustain the use of evaluation support mechanisms and standards but also appropriately increase the proportion of elements related to evaluation methods, applications, and subjects. The two guiding documents on the reform of talent evaluation mechanisms issued by the General Office of the CPC Central Committee and the General Office of the State Council in 2018 basically covered the policy elements of evaluation standards (e.g., overcoming the "five only" [evaluating solely on the basis of papers, titles, degrees, awards, or designations], and highlighting the orientation of moral character, capability, and performance), evaluation methods (e.g., classified evaluation, diversified evaluation, etc.), evaluation subjects (e.g., strengthening the principal status of employers in talent evaluation), evaluation applications (e.g., correcting the utilization orientation of talent evaluation), and evaluation guarantees (e.g., improving the market-oriented and socialized management service system). However, whether the local reform policies specifically formulated by provinces and municipalities based on the State Council's guiding documents contain relatively complete policy elements, and whether the implementation and advancement of the reforms are effective, relevant departments such as the State Council should conduct supervision and inspections to ensure the reforms are fully implemented.

Furthermore, in the formulation of S&T talent evaluation policies, the state should not only focus on top-

level national design and top-down guidance, but also provide more detailed specific operational guidance to enhance the guidance and operability of the policies. For instance, regarding the peer review mentioned above, when requiring the establishment of evaluation expert "responsibility systems, information disclosure systems, accountability systems, credit systems, and exit mechanisms," guidance on the construction of these systems should be strengthened. Specifically, this involves how to ensure through relevant institutional constraints that review experts possess the required professional capabilities before the review; and how to enable review experts to strictly abide by professional ethics, conduct evaluation work independently, objectively, and impartially, comply with work regulations such as confidentiality and recusal, refrain from abusing power for personal gain during the review, and be subject to the constraints of relevant laws, regulations, and credit systems throughout the process, as well as the supervision of the whole society and the subjects and objects of the evaluation.

5.2 Target-Instrument Alignment: Rectifying Goal Mismatches and Strengthening Policy Support Measures

During policy formulation, government entities must carefully align specific targets with appropriate policy instruments, ensuring that S&T talent evaluation goals are effectively realized through the use of appropriate policy instruments. It is necessary to avoid situations where policy targets cannot be achieved due to the improper selection of policy instruments, or where the targets of using policy instruments are ambiguous.

Perfect policy instruments require not only a complete variety of tools and complete policy elements, but also the joint collaboration of their relevant surrounding supporting tools and measures. Therefore, when formulating S&T talent evaluation policies, relevant national departments should focus on how to achieve the targets of the policy instruments mentioned in the policy texts or the supporting policy instruments needed to exert their efficacy. When formulating such policy instruments that require the coordination of relevant supporting measures, comprehensive consideration and overall control should be taken: on the one hand, emphasis should be placed on considering whether the relevant supporting policy instruments already exist or are perfected, and whether they can be used; on the other hand, attention should be paid to uniting multiple departments and utilizing the favorable business conditions of other departments to form a multi-departmental policy synergy and policy support network. By improving the supporting measures of policy instruments, the scientific nature, practicability, feasibility, and target accessibility of the policy instruments will be further enhanced.

5.3 Effectiveness-Instrument Alignment: Fostering Interdepartmental Synergy and Optimizing Instrument Structure

S&T talent evaluation policies need to apply various types of policy instruments, such as authority tools, incentive tools, capacity tools, symbolic and hortatory tools, and system-changing tools, while also including policy elements like evaluation subjects, evaluation applications, evaluation methods, evaluation standards, and evaluation guarantees. Policies issued by a single department are inherently constrained by its specific functions, responsibilities, and jurisdictional scope, making it difficult to comprehensively integrate all

necessary policy instruments and elements, making it difficult to form a policy document that encompasses all aspects of S&T talent evaluation work. Therefore, when formulating relevant S&T talent evaluation policies, the competent departments for S&T talents need to pay attention to uniting with relevant business departments, coordinating the various contents and relationships of talent evaluation work, and jointly issuing policy texts with strong operability and complete content elements, forming a working and policy synergy among departments.

Judging from their intrinsic attributes, policy instruments each have their own functions, advantages, and disadvantages, and they also have their respective applicable targets and conditions when applied. Therefore, in the process of formulating S&T talent evaluation policies, national S&T and talent management departments need to pay special attention to the attribute characteristics of the policy instruments themselves, use them in a scientific and reasonable combination, and optimize the overall structure of policy instruments. While attaching importance to the use of authority tools and symbolic and hortatory tools, attention should also be paid to the use of incentive tools, system-changing tools, and capacity tools. China's S&T talents involve numerous industries, the number of talents is large, the evaluation methods are diverse, and the evaluation content covers a wide range. The effectiveness of authority tools and symbolic and hortatory tools in S&T talent evaluation is mainly concentrated at the management and service levels. However, the purpose of S&T talent evaluation policies is to cultivate, discover, and motivate S&T talents to continuously contribute to scientific and technological development through evaluation. This requires the participation of more incentive tools, system-changing tools, and capacity tools. Through the participation of these tools, the talent evaluation systems and mechanisms that do not adapt to the requirements of the times can be continuously reformed, and the methods and approaches of S&T talent evaluation can be continuously innovated to guide the professional development and capability enhancement of S&T talents. Therefore, among authority tools, the application proportion of the "talent planning" tool should be increased; meanwhile, the usage proportions of incentive tools, system-changing tools, and capacity tools should be increased overall.

6. Conclusion

By utilizing a four-dimensional framework encompassing policy instruments, elements, targets, and effectiveness, this study conducted a multi-dimensional analysis of China's S&T talent evaluation policies since the reform and opening-up period. It systematically identifies existing deficiencies within both individual dimensions and cross-dimensional instrument applications, offering valuable insights for the future formulation of S&T talent evaluation policies in China. However, a limitation of this study is its exclusive reliance on policy instruments as the primary baseline for cross-analysis. Future research should broaden this scope by conducting cross-analyses among policy elements, targets, and effectiveness, or by examining the policies through the lens of policy synergy. In the future, attempts can be made to conduct cross-analyses among policy elements, policy targets, and policy effectiveness, or to further analyze from the perspective of

policy synergy, such as policy instrument synergy, policy target synergy, and policy element synergy, in order to carry out a quantitative analysis of S&T talent evaluation policies from multiple angles and provide a more comprehensive reference for policy formulation.

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