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Quantitative Analysis Of China's Application-Oriented Talents Cultivation Policies

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ABSTRACT

Faced with a new wave of scientific and technological revolution and industrial transformation, the Chinese government has implemented policies to cultivate application-oriented talents. Application-oriented talents utilise engineering theories and technical methods to achieve engineering objectives. Cultivating such talents

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enables Chinese engineering education to meet better the needs of local economic and social development, promoting the differentiated development of Chinese higher education. We use quantitative methods to analyse China's application-oriented talents cultivation policies. The analysis focuses on the changes in policy contents and characteristics of policy responses to capture the developmental trends and critical stages of these policies. Findings from our study indicate that China's policies and measures are more and more specific according to the practical demands. There has been a shift in emphasis from scale expansion to quality improvement in application-oriented talents cultivation. The evolution of these policies follows a path-dependent pattern with gradual changes over time. Most provinces have actively responded to the Chinese central government's policies. However, there is a specific time lag in their responses. The number of response policies formulated by a single policymaker is higher than those formulated jointly by multi-policymakers. Our study can provide educators and policymakers with a clearer understanding of the critical focuses and characteristics of cultivating application-oriented talents and references for formulating and implementing engineering talent cultivation.

1 INTRODUCTION

1.1 Research Background

Given the current inadequacy of China's talent-cultivating structure and quality to meet the demands of economic structural adjustment and industrial upgrading (Ma 2023), along with the pressing issue of prominent structural contradictions and severe homogenisation tendency in higher education, as well as the need to promote the classified development and management of higher education, theoretical research on the cultivation of application-oriented talents in China has long been discussed in the academic community. Furthermore, the Chinese government has also extensively explored policy formulation and implementation.

Based on the positioning of talent cultivation, Chinese higher education can be broadly classified into three main types: research-oriented, application-oriented, and skill-oriented. Application-oriented talents primarily utilise engineering theories and technical methods to achieve engineering objectives (Xia and Yi 2016). Specialised higher education institutions in many countries have been established specifically to cultivate such talents (Schüll 2018; Lepori and Kyvik 2010; Teuscher 2019). Notably, the distinguishing feature between application-oriented and research-oriented talents lies in their practical engineering skills (Yuan and Zheng 2002). Application-oriented talents, closely related to practical engineering and societal issues, are integral to China's engineering talent pool. The cultivation of application-oriented talents also addresses the long-standing scientific-oriented cultivating model in Chinese engineering education (Luo et al.2008). It ensures a better alignment between talents nurtured by higher education institutions and industry job requirements, thus enabling engineering education to meet better the practical needs of local economic and social development and promoting social and academic integration (Tarazona and Rosenbusch 2019).

Existing research papers primarily explore the connotation (Wu and Huang 2014), historical origins (Pan and Shi 2009), case studies (Zhuang and Zhou 2004), and evaluation systems (Wu 2006) of application-oriented talents in China. However, there needs to be more quantitative analysis concerning relevant policies. Furthermore, research has not been found regarding provincial-level governments' responses to the central government's policies on this topic. Policies fundamentally reflect governments' social management endeavours (Huang 2016). Quantitative analysis and computation of policies offer valuable insights into their characteristics, current status, and temporal changes. Analysing the policies for cultivating application-oriented talents in China provides a deeper insight into the dynamic policy objectives and thematic changes in higher engineering education. Moreover, it allows us to comprehend the shift in the government's governing philosophy and the implementation and diffusion of the central government's policies at the provincial level, offering valuable references for cultivating engineering talents and higher engineering education in China and globally.

1.2 Research Questions

The research questions addressed in this study are as follows:

1) How have the application-oriented talents cultivation policies the Chinese central government issued evolved?

2) What is the response of provincial-level governments to the central government's policies for cultivating application-oriented talents?

To address these questions, we systematically utilise policy text analysis and quantitative methods of policy literature to examine the application-oriented talents cultivation policies in China. It analyses the current status and changes in the policies issued by the central government and the responses of provincial-level governments. The study aims to gain insights into policy development trends and critical stages, providing valuable references for policy design and research on developing application-oriented talents cultivation.

It is worth noting that although China has expanded the scale of application-oriented talents by cultivating professional degree postgraduates (which differ from academic degrees, such as Master of Engineering and Doctor of Engineering), most application-oriented talents in China are still undergraduate students. Therefore, this study focuses on analysing the policies for cultivating undergraduate-level application-oriented talents.

1.3 Data Sources

The data sources for this study include application-oriented talents cultivation policies at both the Chinese central and provincial levels, which have authority.

The policy text data for this study are obtained from the following sources, with the policy retrieval cutoff date being May 2023:

1) The primary source of policy texts was the "Peking University Law Information Retrieval System" (http://www.pkulaw.cn), China's most authoritative legal information retrieval system. The policy texts are retrieved using the keyword "application-oriented," and irrelevant policies unrelated to application-oriented talents cultivation or the construction of application-oriented universities were excluded. The full text of the policies is downloaded to form the foundational dataset.

2) Additional policies referenced or cited within each policy are collected as supplementary data based on the foundational dataset.

3) The official websites of the Chinese central government and provincial-level governments were searched using the keyword "application-oriented" to collect and supplement other policies related to application-oriented talents cultivation.

4) Texts from internal working meetings of various institutions with minimal substantive contents are excluded to ensure the accuracy of the dataset's analysis results.

5) Some of the collected policies may have become obsolete. However, these expired texts are also included in the analysis dataset to reflect the dynamic nature of legal regulations and policy releases over the years and analyse policy content changes.

2 METHODOLOGY

2.1 Data and Methodology for the Evolution of the Central Government's Policies Contents Analysis

In order to identify the critical contents of China's application-oriented talents cultivation policies, we analyse the policy content changes in general and in different stages. On October 23, 2015, the Chinese Ministry of Education, National Development and Reform Commission, and Ministry of Finance jointly issued the policy *"Guiding Opinions on Guiding Some Provincial-level (non-key) Undergraduate Universities to Transform into Application-oriented Universities"*, which marked the establishment of specific policy guidelines for the transformation and development of provincial-level undergraduate universities and provided clear guidance for the cultivation of application-oriented talents in China. After the promulgation of this policy, the specific measures for cultivating application-oriented talents in China showed significant improvement. Therefore, this policy is symbolic of cultivating application-oriented talents in China. Consequently, this study categorises the application-oriented talents cultivation policies at the central level in China as follows:

Stage 1: Exploration of Application-oriented Talents Cultivation

Stage 2: Guiding Some Provincial-level (non-key) Undergraduate Universities to Transform into Application-oriented Universities

Stage 3: Construction and Development of Application-oriented Universities

2.1.1 Policy Text Segmentation

Chinese Word Segmentation in this study is performed using the Jieba segmentation tool (https://github.com/fxsjy/jieba). Four widely used Chinese stop-word libraries are loaded for stop-word processing.

2.1.2 Keyword Extraction and Evolution Analysis

In this study, keyword extraction was performed on the segmented results of policy texts using the TF-IDF algorithm. We collected statistics and analysed the changes in keywords in the central government policy in general and different stages.

For the overall analysis of the central government's policies (covering all policies), the following steps were taken: Firstly, the TF-IDF algorithm was used to filter out keywords from all texts, and nominal terms such as "should" "establish" were removed, resulting in the selection of the top 20 keywords. Next, the TF-IDF values of these top 20 keywords were computed for each time slice within the three stages, reflecting their importance in each stage. Finally, line graphs were used to illustrate the changes in these general keywords in the three stages.

The following steps were taken to analyse keywords by stage: Firstly, we segment the policies. Then, the TF-IDF algorithm was applied to each stage to extract keywords, and the top 20 keywords were selected. Finally, a comparison was made to analyse the variations of these keywords across different stages.

2.2 Data and Methodology for the Provincial-level Governments' Policies Analysis

As mentioned earlier, the importance and significance of the policy "*Guiding Opinions on Guiding Some Provincial-level (non-key) Undergraduate Universities to Transform into Application-oriented Universities*" is significant. Therefore, We took this policy as the core foundation to explore provincial-level governments' responses. We measure the response time (T_i) of provincial-level governments' response to the core central policy. The calculation formula is as follows:

$$T_i = Y_{Response} - Y_{Publication} \tag{1}$$

In this regard, T_i stands for the response time, measured in months; $Y_{Response}$ represents the year of the province i's first response to the core central policy, and $Y_{Publication}$ is the year of publication of the core central policy.

3   RESULTS AND DISCUSSION

3.1 Content Changes in Application-Oriented Talents Cultivation Policies Based on Keywords Analysis

In this section, we analyse the overall contents and its changes in application-oriented talents cultivation policies at the central level in China.

3.1.1 Contents in the Central Government's Application-oriented Talents Cultivation Policies

To understand the overall essential content units, we analysed the top 20 keywords in terms of importance in the policy texts. These essential keywords and their variations across the three stages are presented in Table 1 and Figure 1, respectively.

Table 1. Top20 Keywords in the Central Government's Policies

| Number	Keywords	TF-IDF	Number	Keywords	TF-IDF
1	Technology	0.2473	11	Teacher	0.0561
2	Pilot	0.1451	12	Standard	0.0528
3	Major	0.1286	13	Teaching	0.0528
4	Enterprise	0.1187	14	Practice	0.0495
5	Innovation	0.1154	15	Characteristic	0.0462
6	Industry	0.0923	16	Training	0.0462
7	Admission	0.0791	17	Level	0.0396
8	Evaluation	0.0791	18	Strategy	0.0396
9	Area	0.0693	19	Course	0.0396
10	Classification	0.0660	20	Base	0.0396
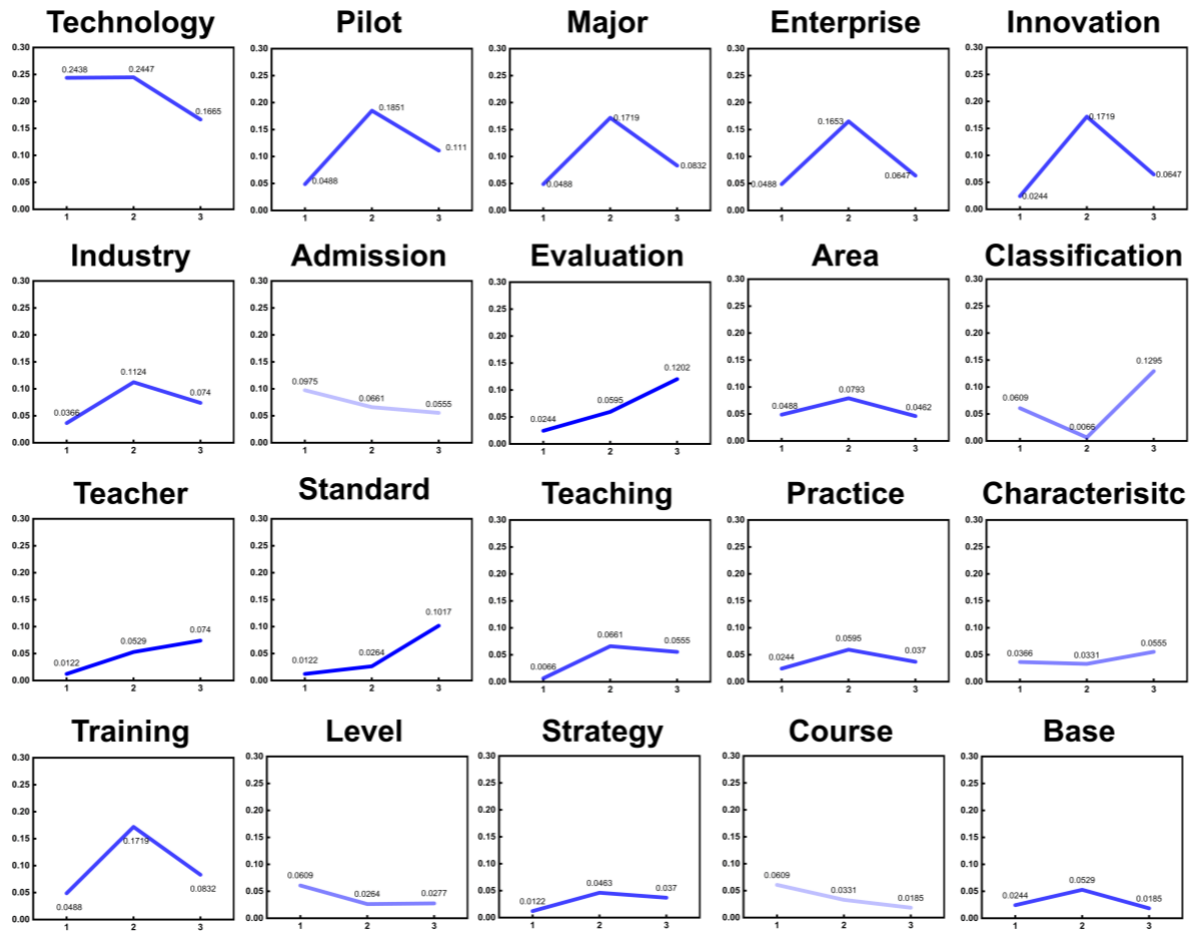
Fig. 1. Changes in TF-IDF values of Top 20 Keywords in Central Policies

In Figure 1, we present the changes in TF-IDF values of the Top 20 keywords and distinguish different categories using blue lines with varying transparency. The horizontal axis denotes distinct stages, whereas the vertical axis signifies TF-IDF values. Overall, the central policies for cultivating application-oriented talents revolve around "technology", "pilot", "major", "enterprise", and "innovation". The term "technology" is essential in all stages, indicating that China's policy for cultivating application-oriented talents focuses on specific technological innovation and integration with enterprises. With the significant increase in the importance of "evaluation" and "practice" and a relatively gradual decrease in the importance of "admission", "level", and "course", it can be inferred that China is gradually emphasising the optimisation of the evaluation system for application-oriented talents cultivation, shifting from the initial focus on course levels and professional licensing to the enhancement of practical operational abilities. In the third stage, the importance of the term "teacher" also continues to increase, indicating that China is increasingly emphasising the impact of teachers' capabilities on talent cultivation and gradually expanding the scale of teachers with rich practical experience from the business sector.

3.1.2 Changes in the Central Government's Application-Oriented Talents Cultivation Policies

To further understand the policy changes across different stages, we analyse the Top 20 keywords in three stages (as shown in Table 2). We use colour blocks to indicate the variation of these keywords. Each grey block in the table represents the keywords that will disappear in the subsequent stage, orange blocks represent newly introduced keywords in the current stage, and blue blocks represent keywords that are introduced in the current stage but will disappear in the subsequent stage.

Table 2. Top 20 Keywords in Different Stages

Number	Stage 1 Keywords	TF-IDF	Stage 2 Keywords	TF-IDF	Stage 3 Keywords	TF-IDF
1	Technology	0.2438	Technology	0.2447	Technology	0.1665
2	Scale	0.1097	Pilot	0.1851	Classification	0.1295
3	Admission	0.0975	Innovation	0.1719	Evaluation	0.1202
4	Graduate	0.0731	Major	0.1719	Pilot	0.1110
5	Classification	0.0609	Enterprise	0.1653	Training	0.1110
6	Level	0.0609	Industry	0.1124	Standard	0.1017
7	Course	0.0609	Area	0.0793	Major	0.0832
8	Area	0.0488	Entrepreneurship	0.0661	Teacher	0.0740
9	Major	0.0488	Admission	0.0661	Industry	0.0740
10	Pilot	0.0488	Teaching	0.0661	Advanced-level	0.0740
11	Enterprise	0.0488	Evaluation	0.0595	Enterprise	0.0647
12	Characteristic	0.0366	Experiment	0.0595	Innovation	0.0647
13	Guidance	0.0366	Practice	0.0595	Qualified	0.0555
14	Demand	0.0366	Internship	0.0595	Teaching	0.0555
15	Industry	0.0366	Employment	0.0529	Characteristic	0.0555
16	Mutual Recognition	0.0366	Government	0.0529	Admission	0.0555
17	philosophy	0.0244	Base	0.0529	industry-education integration	0.0462
18	Innovation	0.0244	Teacher	0.0529	Area	0.0462
19	Communication	0.0244	Strategy	0.0463	Certificate	0.0462
20	Practice	0.0244	Frontliner	0.0463	Conditions of Universities	0.0370

From the perspective of content changes in each stage, we can intuitively observe that the critical focus of policies has changed over time. The significant changes in each stage indicate the evolving hot issues in application-oriented talents cultivation. Moreover, during this stage, the guidance role of policies is still emphasised. The government highlights the recognition of credits between vocational and general education, which helps establish a bridge for two-way communication between vocational and general education.

In stage 1, the central government emphasise expanding the scale of application-oriented talents cultivation. It attaches importance to expanding the channels for universities to admit graduates from vocational schools. It encourages some universities to simultaneously admit outstanding in-service technical and skilled talents, graduates from vocational schools, and graduates from general and comprehensive high schools.

The policy "Guidelines on Guiding Some Provincial-level (non-key) Undergraduate Universities to Transform into Application-oriented Universities" provides more explicit and specific regulations regarding establishing application-oriented universities, which are the main entities for cultivating such talents. In terms of student engineering practical ability development, in addition to the previous emphasis on "practice", specific measures were further divided into "experiment", "practice", and "internship". Furthermore, this policy's significant significance is

reflected in its precise requirements for teaching and teachers, making the cultivation more actionable. Additionally, the policy explicitly specifies various evaluation systems during the transformation process of provincial-level undergraduate universities into application-oriented universities, reflecting the guiding principle of "using evaluation to promote transformation".

In stage 3, it can be observed that the cultivation of application-oriented talents in China has become more standardised and specific in policy formulation. It can be confirmed by the appearance of the term "standard" in this stage and its relatively high TF-IDF value. Furthermore, adding the term "advanced-level" and "conditions of universities" indicate that this stage no longer focuses on expanding the scale but emphasises improving the quality. In stage 3, the central government has been exploring establishing a warning mechanism and exit mechanism, requiring higher education institutions that fail to meet the standards to rectify within a specified period.

Moreover, in terms of the university operating model, there is a growing emphasis on industry-education integration. The appearance of some specific terms also reflects critical events in this stage. For example, "certificate" reflects China's initiative to adapt to the demand for high-quality and multi-skilled technical personnel in response to the new technological revolution and industrial transformation. Since 2019, pilot programs for the "diploma plus certificates of vocational skills" have been launched in application-oriented undergraduate universities.

In addition, during stage 1, the central government emphasise establishing a classification system for different types of higher education institutions in China and differentiated levels for universities and talents. However, during stage 3, the emphasis shifts from hierarchical distinctions to more focus on types, reflecting the gradual equalisation of the status of application-oriented and research-oriented talents at the central policy level in China, with increasing attention given to engineering talents. Application-oriented talents and research-oriented talents are merely different types without hierarchical distinctions.

On the whole, the evolution of China's policy for cultivating application-oriented engineering talents follows gradual changes and is characterised by path dependence. At various stages, the central government has consistently placed great importance on the technical proficiency requirements of application-oriented talents. It has paid considerable attention to admission and majors' development. Application-oriented talents primarily utilise engineering theories and technical methods to achieve engineering objectives. Meeting the practical needs of local economic and social development has always been an important goal for application-oriented talents cultivation and Chinese engineering education. In terms of stakeholders, besides universities themselves, the role of enterprises has also been emphasised in the policies. In addition, pilot programs have been important initiatives for China to explore and implement application-oriented talent cultivation, serving as demonstrations through summarising good experiences. The term "innovation" has been consistently emphasised because innovation capability is a

requirement for engineering talents and a significant response to China's strategy of promoting innovation-driven development through measures related to application-oriented talent cultivation and university construction.

3.2 the Provincial-level Governments' Responses to the Central Government's Policies

Given that China has a vertically decentralised political system, provincial-level governments have substantial autonomy in economic and social development. Therefore, provincial-level governments and their actions are essential for transforming and developing application-oriented talents cultivation. After the central government issues policies, provincial-level governments need to cooperate and implement them to achieve the desired cultivation and transformation, establishing a talent cultivation mechanism that meets the requirements of economic restructuring and industrial upgrading. We plot a figure of response time and the number of response policymakers (as shown in Figure 2).
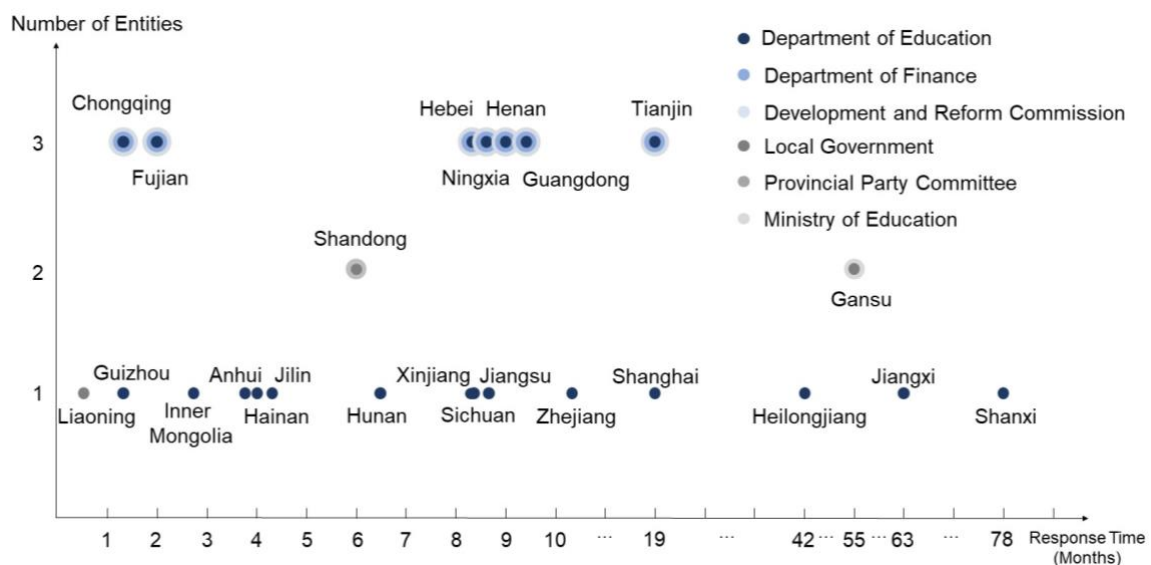

Fig. 2. Responses of Provincial-level Governments to Central Government's Policies

Overall, 24 provinces, autonomous regions and municipalities responded to the core central policies, accounting for 80% (excluding Hong Kong, Macao, and Taiwan). The median response time is 8.16 months, and the average is 15.84 months. It means that the distribution of response time data is right-skewed, with response times concentrated in a small range of values but with some provinces having extreme values, resulting in longer overall response times. Specifically, the response time of each province varies significantly. Liaoning province has the shortest response time, 0.52 months, while Jiangxi province has the longest at 78.83 months. Beijing, Hubei, Yunnan, Shaanxi, Qinghai, and Tibet Autonomous Region do not have corresponding response policies. Among the response policymakers, the provincial-level education department is the most frequent single policymaker, while the situation of the three departments of "education department-finance department-development and reform commission" jointly formulating response policies is also

common, and the situation in which two departments formulate the response policy is the least common. Shandong province is the only province in which the response policy was jointly issued by the provincial party committee and the provincial-level government, and Gansu province's response policy was jointly issued by the Ministry of Education and provincial-level governments, making it the only province in which a central government department formulates a provincial-level response policy. Seven provincial-level governments formulate response policies through the three departments of "education department-finance department-development and reform commission". On the whole, the number of response policies formulated by a single policymaker is higher than those formulated jointly by multi-policymakers.

4 SUMMARY

This study collects policies about cultivating application-oriented talents issued by the Chinese central and provincial-level governments. We analyse the policies' contents, changes and response characteristics using policy text analysis methods.

We found that:

1) Measures for cultivating application-oriented talents were mentioned in China as early as 2010 but required further specificity. In recent years, the Chinese government has demonstrated a more determined stance towards cultivating application-oriented talents, resulting in increasingly specific policy tools and measures. China has progressively shifted its emphasis from expanding scale to enhancing quality in cultivating application-oriented talents.

2) The evolution of China's policy for cultivating application-oriented talents follows gradual changes and is characterized by path dependence.

3) Most Chinese provincial-level governments have actively responded to the central government's policies and taken measures to cultivate application-oriented talents and construct application-oriented universities. However, there is a specific time lag in their response. Formulating response policies involving multi-policymakers can ensure the progress and implementation of policies to a certain extent. However, when it comes to the measures of Chinese provincial-level governments in application-oriented talents cultivation, the number of response policies formulated by a single policymaker is still higher than those formulated jointly by multi-policymakers.

There are some limitations in the current research:

1) The source of policy data needs to be enriched, and more data on some provincial-level governments' policy responses may affect the conclusions.

2) Due to the limited amount of provincial-level response data, the current study needs to differentiate between policy dissemination, policy reference and implementation, and the implicit responses of provincial-level governments, which may lead to deviations from the actual situation.

3) Further research is needed to investigate the underlying reasons and impacts behind the results presented in this study. For example, whether the response

speed of provincial-level governments and the number of policymakers would impact the quantity and quality of application-oriented talents cultivation.

To overcome these limitations, we will concentrate on the following enhancements: broadening the range of data sources through web scraping and other methodologies to gather a more extensive collection of pertinent policy and distinguishing various types of provincial-level governments' policy responses to gain deeper insights. Additionally, we will conduct more field research to thoroughly investigate the factors that influence the phenomenon.

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