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An empirical study on the driving factors and pathways of research talents innovation capability

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Abstract

This study designed a survey questionnaire encompassing three levels: research institutions, research environment, and research talents, with 19 specific measurement indicators. The questionnaire was distributed to research personnel from over 20 research institutes, universities and related enterprises in China. Based on 537 valid responses, a structural equation model (SEM) was constructed to analyze the relational effects of the driving factors. The findings are as follows: (1) The innovative capability of research talents is a composite outcome of the interaction between multiple "external-internal" factors. Effective organizational support from research institutions and a favorable research environment, both soft and hard, are indispensable elements in enhancing this capability. (2) A key factor in enhancing innovation capability is the proper resolution of effective supply and scientific utilization of research resources by research institutions, along with the improvement of research satisfaction. (3) Research institutions should establish an integrated research mechanism that combines "environment-organization-talent" to achieve the generation and effective transformation of high-quality research outputs.

Keywords: research talents; research institutions; research environment; innovative capability; driving factors.

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1. Introduction

Research talent, as the most active and important resource in innovation activities, is increasingly valued in enhancing innovation capacity [1]. The innovation ability is gradually improved with the development of people's understanding and practical ability, and is restricted by a variety of factors. Lei et al. (2011) pointed out that innovative practical ability is one of the most important skills in cultivating the innovation capacity of research talent, encouraging research talent to actively participate in science and technology competitions is also one of the most effective ways to enhance their creative practical abilities [2]. According to Yang and Qian's (2017) research, emphasizes the importance of bolstering interdisciplinary awareness, broadening knowledge, fostering emotional intelligence, and cultivating innovation to enhance overall creativity. Moreover, a deep understanding of flaws in our elementary education and the current scientific research landscape is crucial [3].

In terms of the classification of scientific and technological innovation ability, scholars have also carried out multi-dimensional exploration. For example, Meng (2015) categorized innovative ability into multiple practical abilities, including innovative consciousness, research ability, practice ability, spirit, thinking, methods and skills, quality, personality and wisdom, technical application, organization, and teamwork abilities [4]. Pan (2018) categorized the dual-innovation capability of high-level talents in colleges and universities into exploratory and utilization innovation abilities, emphasizing their strong correlation with scientific research, subjective, and objective performances [5]. Yang et al. (2022) believed that scientific and technological innovation ability is mainly reflected in experimental design thinking and creative thinking [6].

In terms of the research on the index system of scientific research talents' innovation ability, Lan (2017) analyzed the components of talent's innovation ability and formulates an evaluation index system encompassing innovation thinking, insight, self-confidence, and learning ability, structured around 4 primary and 17 secondary indicators [7].

Building on existing research, we must consider: (1) What internal and external factors influence the formation and evolution of research talent's innovative capabilities? (2) What are the interaction relationships among these factors? (3) What are the key factors impacting research talent's innovative abilities? (4) How can negative factors be mitigated and positive factors enhanced?

To explore these questions, we developed a "Research Talent Innovation Capability Driving Factors" questionnaire, distributed to researchers from over 20 domestic research institutes, universities and enterprise research institutions, yielding 537 valid responses. This empirical study aims to gather insights and perceptions on various driving factors in the research environment and institutions. We will use statistical methods to test the reliability and validity of the results, and employ Structural Equation Modeling (SEM) to construct a relationship model of the driving factors. This model will explore the relationships between endogenous and exogenous variables, providing crucial insights for research institutions to further enhance the innovative capabilities of the research talents.

2. Study Design

2.1. Theoretical framework construction

Based on relevant theories and previous research, this study holds that: The innovation ability of research talents refers to the creative ability and innovative thinking demonstrated by research talents in the field of science and technology, utilizing their knowledge, skills, and experience during their research endeavors. This capability is a core resource of research institutions, characterized by its dynamic and adaptable nature. It is crucial for creatively solving real-world problems and advancing technological development, serving as a key indicator of the proficiency level of research talent.

The innovation ability of research talents is a kind of social ability produced by the combination of science and technology and innovative talents. Generally speaking, the innovation ability of research talents is a possible evaluation standard for the degree of mastery of specialized knowledge and skills, whether they have high creativity, and whether they can make great contributions to scientific and technological progress.

This study divides the innovative capabilities of research talent into two levels: intrinsic innovative capabilities and explicit innovative capabilities. Intrinsic innovative capability is the foundation and prerequisite for cultivating and

enhancing explicit innovative capability, while explicit innovative capability is the external manifestation of research talent's intrinsic innovative capability in the transformation and application of research outcomes.

2.2. Demonstration of driving factors

Many scholars have studied the index system to stimulate the innovation vitality of research talents from the three dimensions of individual factors, organizational factors and environmental factors. Among them, the most obvious incentive effects are: thinking consciousness incentive and health incentive in individual factors, leader incentive and system incentive in organizational factors, policy incentive and industrial development potential incentive in environmental factors.

Based on the organic combination of process theory and system theory, scientific and technological innovation can be regarded as a system process of continuous improvement [9]. The innovation ability system of research talents is a kind of creative activity that takes the relevant scientific research personnel engaged in scientific and technological innovation in scientific research institutions as the main body, uses hardware and software resources, and takes knowledge creation and technology development as the goal in a certain environment. This paper studies the driving factors of the innovation ability of research talents from three levels: research talents, research institutions and research environment.

2.2.1. Analysis of driving factors at the level of research talents

The relevant driving factors mainly include the following: Professional and academic level factors; Independent research and development level factor; Team cooperation level factor; Transformation factors of innovation achievements.

2.2.2. Analysis of driving factors at the level of research institutions

The factors of research institutions refer to the influence of the hierarchical structure and target orientation of research institutions on the implementation of research activities and innovation of research talents, including the organizational structure and functions of research institutions. The optimization of the organizational structure of research institutions and the play of the functions of research institutions have an important impact on the formation and improvement of the innovation ability of research talents.

2.2.3. Analysis of driving factors at the level of research environment

The research environment factors referred to in this study refer to the direct impact or indirect driving factors of the external environment of research talents on their innovation ability, which can be divided into four aspects, including research culture environment, research work environment, research policy environment and research collaborative environment.

2.3. Research methods and data acquisition

Structural equation (SEM) model is used to clearly depict and describe the causal relationship and action path between variables by mathematical expression, which has brought great help to the causal research between complex and abstract variables. With the continuous research on the theory of structural causality model [10], the path of analyzing actual causality based on structural equation has gradually evolved [11,12]. Structural equation model (SEM) is a multivariate data analysis method for analyzing complex relationships among constructs and indicators.

It should be pointed out that the essence of the innovation ability of research talents is a complex system composed of three levels of factors, namely, research talents, research institutions and research environment. Each element in the system will inevitably be directly or indirectly affected by other elements. All elements of the innovation ability of scientific research talents exist together and interact with each other. As shown in Fig. 1.

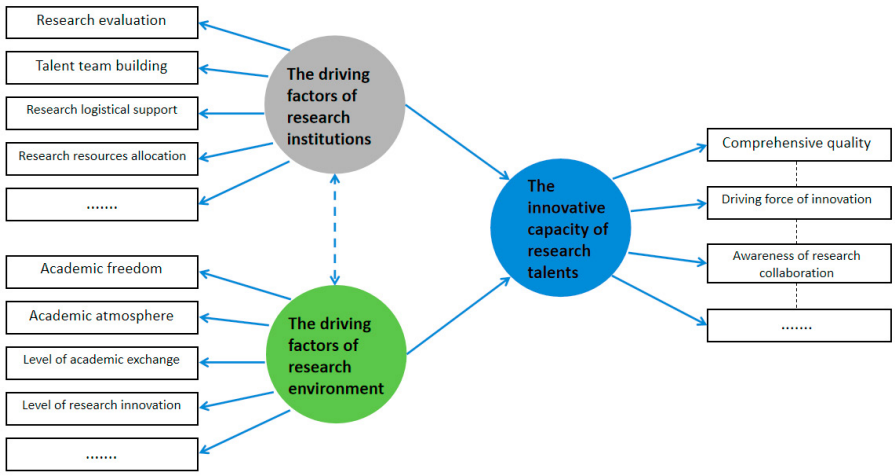

Fig. 1. Causal diagram of the innovation capability of research talents

Based on the concept of structural equation, the figure above shows the driving relationship between the two factors, such as research institutions and research environment, on the innovation factors of research talents, and the two factors will also interact with each other. In order to measure the relationship between the three types of factors, it is necessary to design corresponding measurement indicators to describe the relationship.

2.3.2. Data acquisition

Based on the analysis and summary of the aforementioned driving factors and simulated the Likert 5-point scale, this study designed a three-level framework consisting of research talent, research institutions, and research environment (first-level indicators), 10 driving factors (second-level indicators), and 19 specific measurement variables (third-level indicators). A total of 45 single-choice questions were designed to correspond with these measurement indicators. After four rounds of pilot testing and extensive interaction and communication with researchers from various institutions, the final survey questionnaire was developed.

From April to June 2023, formal survey questionnaires were distributed to researchers at multiple universities, research institutes and enterprises in China, with a particular focus on researchers from various research institutes. The distribution and collection process lasted three months, yielding a total of 593 questionnaires. After excluding invalid and non-compliant responses, 537 valid questionnaires were collected, representing 90.5% of the total distributed questionnaires.

Given that the data obtained are based on the subjective evaluations and judgments of research institutions and researchers, which are difficult to measure directly and accurately, this study will employ a Structural Equation Modeling (SEM) approach to construct a model of the driving factors influencing research talent's innovative capabilities.

3. Measurement variables and model construction

3.1. Measurement variables and hypothesis setting

The driving factors and measurement index system of the innovation ability of research talents are shown in Table 1.

Table 1. Measurement index system of driving factors of innovation ability of research talents

Level of driving factors	Symbols	Specific measurement indicators	Level of driving factors	Symbols	Specific measurement indicators

Research environment level	ε_1	Degree of academic freedom	Level of research institutions	ε_8	Satisfaction with research evaluation system
	ε_2	Degree of team coordination		ε_9	Talent team building satisfaction
	ε_3	Degree of academic atmosphere		ε_{10}	The adequacy of research time
	ε_4	A sense of responsibility and mission		ε_{11}	Research logistics support
	ε_5	Level of research and innovation		ε_{12}	Level of and technological resource sharing
	ε_6	Level of academic exchanges		ε_{13}	Incentives for research and innovation
	ε_7	Level of research and breakthrough		ε_{14}	Salary distribution satisfaction
Level of research talents	η_1	Comprehensive quality of research	Level of research talents	η_4	Driving force of research innovation
	η_2	Awareness of research collaboration		η_5	Influence of research level
	η_3	Research implementation capability			

As the carrier of research ability, research talents' ability will be affected by external environment variables and research institutions. Therefore, this questionnaire takes the measurement index of research talents' level (internal cause) as the endogenous latent variable (affected party), and the measurement index corresponding to the level of research institutions and research environment as the exogenous variable (influencing party). Based on the results of the questionnaire and the characteristics of research talents and research institutions, this study makes the following assumptions about the possible relationship between the endogenous latent variables and the exogenous latent variables involved in the model:

(1) The initial hypothesis of the relationship between endogenous variables.

The endogenous latent variables are "η_1 comprehensive research literacy", "η_2 awareness of research collaboration", "η_3 driving force of research innovation", "η_4 research implementation ability" and "η_5 influence of research level".

Based on the analysis of the characteristics of endogenous latent variables, the specific hypotheses are as follows:

H_{11}:"η_2 Awareness of research collaboration" has a positive impact on "η_3 driving force of research innovation".

(2) The initial hypothesis of the relationship between exogenous variables and endogenous variables.

The specific measurement indexes of exogenous latent variables are shown in Table 1. Based on the research of relevant scholars, five hypotheses are established for the model, which are as follows:

H_{21}: Analysis of exogenous variables that have a positive impact on "η_1 comprehensive research literacy"

H_{22}: Analysis of exogenous variables that have a positive impact on "η_2 awareness of research collaboration"

H_{23}: Analysis of exogenous variables that have a positive impact on the "η_3 driving force of research innovation"

H_{24}: Hypothesis: Analysis of exogenous variables affecting "η_4 research implementation capacity"

H_{25}: Analysis of exogenous variables influencing the "η_5 research level influence"

3.2. Model construction and revision

LISREL8.8 software was used to analyze the structural equation model and further explore the influence path of research environment on the innovation ability of research talents.

Table 2. Main test parameters of the initial model of the structural equation

χ^2/df	RMSEA	SRMR	NFI	NNFI	CFI	GFI	AGFI
1.561	0.060	0.096	0.94	0.97	0.98	0.73	0.67

Table 2 summarizes the key parameters of the LISREL model fit, indicating that all technical indices are at ideal levels. Specifically, the Comparative Fit Index (CFI), Goodness of Fit Index (GFI), and Adjusted Goodness of Fit Index (AGFI) are 0.98, 0.73, and 0.67, respectively, demonstrating a good fit between the measurement data and the evaluation model. Overall, the quality of this structural equation model is good.

Through simulation calculations, T-values and Modification Indices (MI) were obtained. Based on these values and the logical relationships between items and factors, adjustments to the model parameters were made according to the MI suggestions and variable logical relationships. Following these modification steps, the final SEM model depicting the relationships among the driving factors for research talent is shown in Figure 2, with the model fit parameters summarized in Table 3.

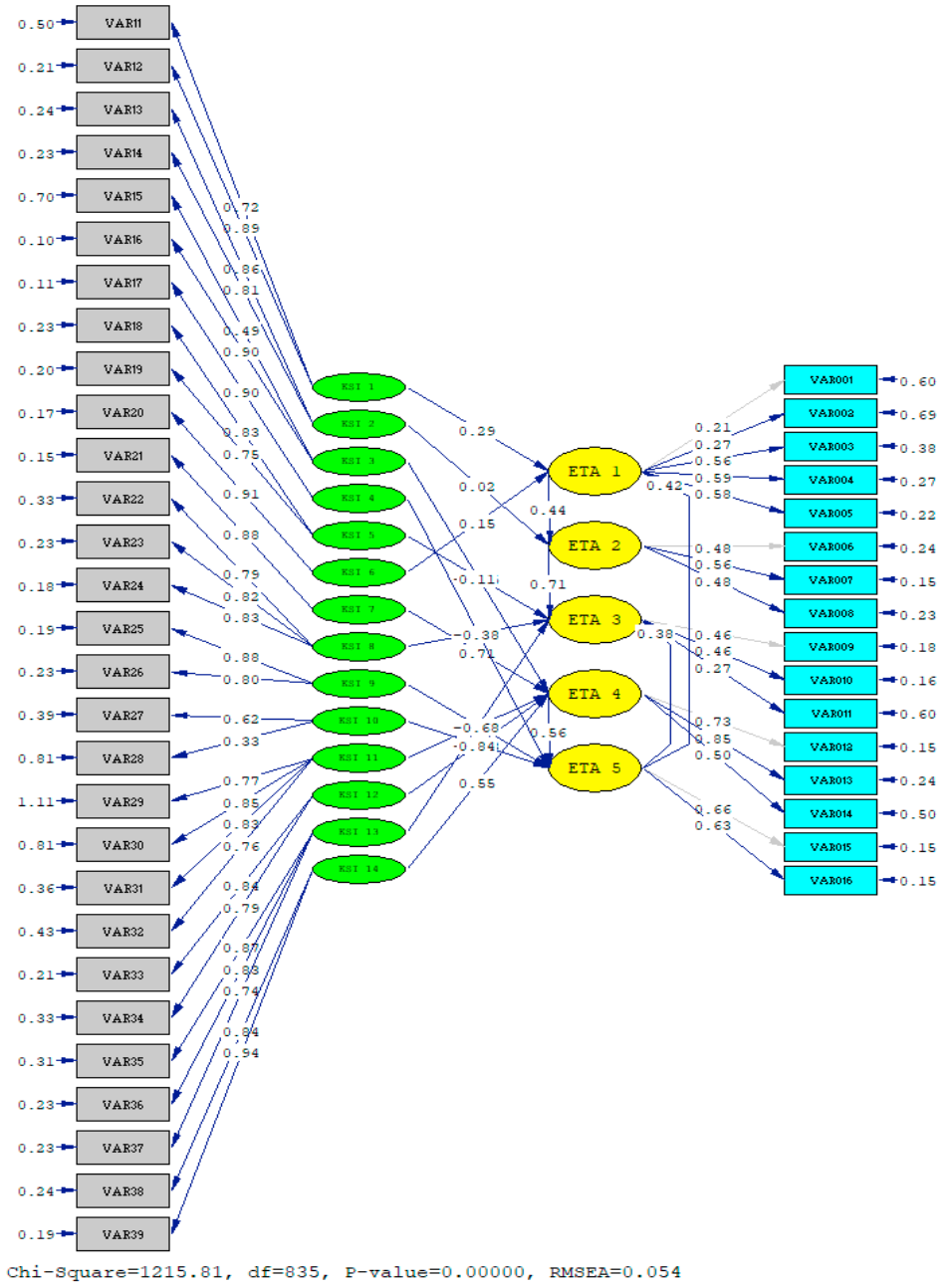

Fig. 2. Final SEM model of driving factors of innovation ability of research talents

After adjustment, the value decreased to 1215.81, the model value decreased from 1.561 to 1.456, the RMSEA value was 0.054, the RMR value was 0.058, and the other main parameters were also quite ideal. The adjusted parameter values show that the model fit is quite good. As shown in Table 3.

Table 3. Main test parameters of the final model of the structural equation

χ^2/df	RMSEA	RMR	SRMR	NFI	NNFI	CFI	GFI	AGFI
1.456	0.054	0.058	0.073	0.95	0.98	0.98	0.74	0.68

3.3. Empirical results and findings

Statistical parameter values show that the adjusted model supports the positive relationship between "comprehensive research literacy" and "awareness of research collaboration", that is, the "comprehensive research literacy" of research talents will have a significant relationship with "awareness of research collaboration", and the direction of effect is positive. It shows that the higher the comprehensive quality of research talents is, the better logical thinking and problem-solving ability are conducive to the improvement of research collaboration consciousness.

The statistical parameter values show that the model supports the original hypothesis of the influence of " research collaboration consciousness" on "research innovation driving force", that is, the " research collaboration consciousness" of research talents will have a significant positive effect on their " research innovation driving force", and the direction of effect is positive. It shows that the stronger the awareness of research collaboration is, the more conducive it is to the promotion of research driving force. Research institutions need to focus on guiding and cultivating the collaborative ability of research talents.

Statistical parameter values show that the adjusted model supports the positive relationship between " research implementation ability" and " research level influence", that is, " research implementation ability" will have a significant relationship with " research level influence", and the direction of effect is positive. It shows that the stronger the research implementation ability of research talents is, the more they can promote the transformation and application of research results, and the final influence of research level will be greatly improved.

The statistical parameter values show that the adjusted model supports the positive relationship between "research level influence" and "comprehensive research literacy" and "driving force of research innovation", that is, "research level influence" will have a significant relationship between "comprehensive research literacy" and "driving force of research innovation", and the direction of the effect is positive. It shows that the higher the influence of research level is, the higher the degree of application of research achievements, the higher the recognition of research institutions and the society, and the higher the conversion rate of research achievements, which in turn can drive the initiative of research learning and innovation of research talents.

4. Conclusions

Based on the aforementioned data of investigation and analysis on the driving factors of research environment on the innovation ability of research talents, five secondary driving factors in the indicators of "basic ability level", "innovation ability level" and "application ability level" are determined as the endogenous latent variables of the model. Taking 14 secondary indicators such as " research cultural atmosphere", " research implementation support", " research management efficiency" and " research support" as exogenous latent variables, the structural equation model (SEM) and LISREL program software were used to analyze the interaction between endogenous latent variables and exogenous latent variables. The relationship model of the driving factors of research environment on the innovation ability of research talents was constructed. The following conclusions are drawn:

(1) In the relationship between endogenous latent variables, "awareness of research collaboration" has a particularly significant positive relationship with "driving force of research innovation"; "Comprehensive research literacy" has a particularly significant positive relationship with "awareness of research collaboration"; "Research implementation ability" has a particularly significant positive effect on " research level influence"; "Research level influence" has a particularly significant positive relationship with "comprehensive research literacy" and "driving force of research innovation".

(2) In the relationship between internal and external latent variables, "research breakthrough level" will have a direct and significant effect on " research implementation ability", and the direction of effect is positive. "Research

time adequacy" has a direct and significant effect on "research level influence", and the effect direction is positive. "Research and innovation incentive" will have a direct and significant effect on "Research innovation driving force", and the effect direction is positive. "Salary distribution satisfaction" will have a direct and significant effect on " research implementation ability", and the effect direction is positive.

To sum up, there are positive interactions between endogenous latent variables and between endogenous latent variables and exogenous latent variables. The conclusions of the model can provide relevant reference for strategies and measures to further improve the innovation ability of research talents.

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