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Analysis of Evaluation and Cultivation System of Scientific and Technological Innovation Talents in Power Grid Enterprises Based on CIPP Model and Fuzzy AHP Model

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ABSTRACT

Science and technology innovation talents are the center of gravity of the national strategic power, which is crucial for promoting social development and scientific and technological progress. The purpose of this paper is to study the scientific and technological innovation talents of power grid enterprises, build the evaluation index system of scientific and technological innovation talents with reference to the CIPP model, select a power grid enterprise to analyze the examples, and use the fuzzy AHP model to evaluate its scientific and technological innovation talents training. Then build the role mechanism model of science and technology innovation talent cultivation, conduct regression analysis of the influence factors of science and technology innovation talent cultivation, and verify the research hypothesis. The evaluation results of the STI talents of the sample grid enterprises range from 3.6 to 4.0 points, and the evaluation grades are all good, confirming the practicality of the proposed STI talent evaluation method. Except for years of education, high focus in research field and teamwork, the selected personal factors, organizational factors and environmental factors have positive and significant effects on the quality of STI talents training. It is suggested that power grid enterprises improve and promote the development of the training system of scientific and technological innovation talents by building a training and development channel, developing a layered training model, innovating training methods as well as building a research platform.

Keywords: CIPP model, fuzzy AHP, evaluation index system, regression analysis, scientific and technological innovation talents

1. Introduction

During the "14th Five-Year Plan" period, the power grid is accelerating its upgrading to the energy Internet. Grid enterprises must comprehensively strengthen the construction of high-quality technical and skilled personnel, stimulate the enthusiasm, initiative and creativity of various types of

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high-quality technical and skilled personnel, in order to promote the high-quality development of enterprises, accelerate the construction of the international leading energy Internet enterprise with Chinese characteristics to provide a strong guarantee of talent and intellectual support [1-4].

Talent is the first resource, talent is an important asset of the enterprise, without people, performance is impossible to talk about. Scientific and efficient selection of talents, so that talents stand out and reasonable use, the reform and development of power grid enterprises is of great significance. Talent evaluation throughout the enterprise staff recruitment, cadre selection, team leader competition, technical skills expert selection and recruitment, job competency evaluation, technical skills level certification and other work, and its evaluation results will also directly affect the career development of employees [5-8]. Grid enterprises should change the traditional management concept, the talent as “the first resource of the enterprise, the development of competition”, the introduction of modern management theory and innovation talent management concepts, to create a good atmosphere for talent cultivation and development within the enterprise [9-12]. Through the evaluation means to quickly identify the talent in the enterprise, maximize the effectiveness of the use of enterprise talent, is the key to the development of the enterprise to excellence [13-15].

Seriously doing a good job in the training and management of talent evaluators is a new idea and new initiative for power grid enterprises to comprehensively improve their talent evaluation work, and it is also an important link to strengthen the talent advantages of power grid enterprises [16-18]. Taking the strategic objectives of the enterprise as the guide, taking the evaluation teacher ability quality model as the gripping hand, continuously optimizing and perfecting the management mechanism of the evaluation teacher can not only achieve the strategic objectives of the grid enterprise with great practical significance, but also lay a solid human resources foundation for the reserve and development of all kinds of talents of the enterprise [19-23].

Based on the CIPP model, the study selects specific indicators from background evaluation, input evaluation, process evaluation and outcome evaluation to complete the construction of the evaluation index system of science and technology innovation talents. The fuzzy AHP method is used to assign weights to the indicators, and the comprehensive scores of the three power grid enterprises are calculated as an example to evaluate the cultivation effect of their scientific and technological innovation talents. Subsequently, the model of the role mechanism of the influencing factors of the cultivation of scientific and technological innovation talents is constructed, and the relevant research hypotheses are put forward. The measured comprehensive score of scientific and technological innovation talents is taken as the dependent variable, and the factors in the hypothesis are taken as the independent variables, and the reasonableness of the research hypothesis is empirically tested through correlation analysis and regression analysis. On this basis, combining the results of the empirical research on the influencing factors, we discuss the cultivation path of scientific and technological innovation talents.

2. Methodology for analyzing the evaluation and training system for scientific and technological talents

Enterprises are the main body of economic development, and innovation is the inexhaustible power of enterprise development. In this paper, we study the scientific and technological innovation talents of power grid enterprises, adopt the fuzzy AHP model to evaluate the scientific and technological innovation talents, and use the multiple regression analysis method to analyze the influencing factors of scientific and technological innovation talents cultivation.

2.1. Fuzzy AHP model

Fuzzy concepts are widely found in daily life and scientific research. In order to better study and understand these fuzzy phenomena, fuzzy mathematics has been introduced and applied. Fuzzy hierarchical analysis is a comprehensive evaluation method in fuzzy mathematics. Due to the nature of the complex and comprehensive problem of the evaluation of scientific and technological innovation talents in power grid enterprises, which itself has characteristics such as vagueness, it is necessary to use a combination of qualitative and quantitative methods to get more scientific evaluation results when assessing their quality. This study chooses fuzzy hierarchical analysis as the main research method for the evaluation of scientific and technological innovation talents in power grid enterprises.

FAHP is a systematic analysis method combining qualitative and quantitative, which combines the characteristics of hierarchical analysis and fuzzy comprehensive evaluation method.The core idea of FAHP is to dismantle the problem layer by layer based on the characteristics of the multi-objective evaluation problem and the overall goal, forming a bottom-up hierarchical structure so as to carry out evaluation and analysis in a systematic way.

In the fuzzy hierarchical analysis, in the two-by-two comparison judgment between factors, the importance of one factor over another is quantitatively expressed to obtain the fuzzy judgment matrix and calculate the factor weights. Then for the objects in the program level, the fuzzy judgment matrix is established for calculation according to the factors in each factor level, and the weight vector obtained is used to form a weight matrix, and the final weight is obtained by combining the weight vector and weight matrix calculation, and finally the best object is selected by combining the principle of maximum affiliation.

2.1.1. Creating a comparative judgment matrix. First, indicators at the same level are compared and ranked according to their importance, so as to determine the weighting matrix for all level 1 and level 2 indicators. Let K_{ij} be the importance level of the ind indicator to the jrd indicator.

According to the significance of the above symbols, judgment matrix A is obtained:

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} \tag{1}$$

2.1.2. Consistency test. Due to the complexity of the objective and the existence of the subjectivity of the assignment, there are often unreasonable judgments, so it is necessary to carry out consistency tests on the change judgment matrix to determine whether the above weights are reasonably assigned.

1) Calculate the consistency index CI :

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{2}$$

$\lambda_{\max}$ is the largest characteristic root of the judgment matrix filled by each expert

2) Calculate the consistency ratio CR:

$$CR = \frac{CI}{RI} \tag{3}$$

When $CR < 0.1$, the judgment matrix is considered to have satisfactory consistency, indicating that the weights are reasonably assigned. Otherwise, the judgment matrix needs to be adjusted until satisfactory consistency is achieved, where RI is the average random consistency index of the judgment matrix.

The experts will determine the importance of the first-level and second-level indicators for the evaluation based on the comparison of the importance of the indicators. k experts will compare the importance of each first-level and second-level indicator, and the assessment value of the importance of the performance indicator will be K_{tmn} (K_{tmn} represents the assessment value of the nth expert on the importance of the mth second-level indicator in the tth first-level indicator), and the arithmetic average of the values will be taken:

$$\overline{K}_{tm} = \sum_{i=1}^{n} \frac{1}{n} K_{tmn} \tag{4}$$

The judgment matrix $\overline{A}$ obtained after processing the calculation:

$$\overline{A} = \begin{pmatrix} \overline{a}_{11} & \overline{a}_{12} \ldots & \overline{a}_{2n} \\ \overline{a}_{21} & \overline{a}_{22} & \overline{a}_{2n} \\ \vdots & \vdots & \\ \overline{a}_{n1} & \overline{a}_{n2} & \\ \overline{a}_{nn} & & \end{pmatrix} \tag{5}$$

The consistency test for this judgment matrix is also performed using the method described above.

2.1.3. Vector of indicator weights:

1) Single-level weight calculation. According to the judgment matrix A, according to the eigenvector method to find out each judgment matrix weight vector, that is, the importance of each evaluation factor ranking, that is, the weights are assigned. Under the condition of satisfying the consistency of the matrix, there are two simpler methods for finding the matrix weight vector: the sum method and the root method. The sum method is to sum the column vectors of the matrix, and then normalized to get the weight vector root method is to all the column vectors of the matrix to find the geometric mean of each quantity, normalized to get the weight vector. In this paper, the root method is used to find the weight vector $\overline{A}$ of the matrix, which is calculated as follows:

$$\overline{W_i} = \left(\prod_{j=f}^{n} \overline{a_{ij}} \right)^{\frac{1}{n}} \tag{6}$$

The normalized vector is the weight assignment of the indicator: $W = \left(W_1, W_2, W_m\right)^T$.

Among them:

$$W_i = \frac{\overline{W_i}}{\sum_{i=1}^{n} \overline{W_i}} \tag{7}$$

2) Comprehensive weight calculation. By the method of synthesizing the weight vector, the weight vector of the lower-level indicators (second-level indicators) to the upper-level indicators (first-level indicators) is derived, and each component of this vector is the comprehensive weight of the second-level indicators in the evaluation system. The formula is as follows:

$$Y_i = W_{X_i} \times W_{F_j} \left(i = 1, 2, \cdots\cdots, m \right) \tag{8}$$

Here n indicates the number of secondary indicators and m the number of primary indicators.

2.1.4. Standardized processing:

1) Treatment of quantitative indicator values. Two types of evaluation indicators Through the analysis of the evaluation indicator values, it can be seen that the evaluation indicator values consist

of the following two types of evaluation indicators: cost-type indicators, i.e., the smaller the indicator value, the better the evaluation indicators and benefit-type indicators, i.e., the larger the indicator value, the better the evaluation indicators.

For the cost-type indicators, a dimensionless affiliation function is established as follows:

$$a_i = \begin{cases} 1 & f_i \le f_{\min} \\ \dfrac{f_{i\max} - f_i}{f_{i\max} - f_{imia}} & f_{i\min} \le f_i \le f_{i\max} \\ 0 & f_i \ge f_{i\max} \end{cases} \tag{9}$$

A dimensionless affiliation function is established for the benefit-based indicators as:

$$a_i = \begin{cases} 0 & f_i \le f_{\min} \\ \dfrac{f_i - f_{i\min}}{f_{i\max} - f_{i\min}} & f_{i\min} \le f_i \le f_{i\max} \\ 1 & f_i \ge f_{i\max} \end{cases} \tag{10}$$

$$a_i = \begin{cases} \dfrac{2\left(f_i - f_{i\min}\right)}{f_{i\max} - f_{i\min}} & f_{i\min} \prec f_i \prec \dfrac{1}{2}\left(f_{i\min} + f_{i\max}\right) \\ \dfrac{2\left(f_{i\max} - f_i\right)}{f_{i\max} - f_{i\min}} & \dfrac{1}{2}\left(f_{i\min} + f_{i\max}\right) \prec f_i \prec f_{i\max} \\ 0 & f_i \ge f_{i\max}; f_i \le f_{\min} \end{cases} \tag{11}$$

a_i is the value after normalization, f_i is the original data, $f_{i\min}$ and $f_{i\max}$ are the minimum and maximum values in the original data, respectively.

2) Processing of qualitative index values. The processing of qualitative index values using the expert scoring method. Qualitative analysis is a method of exploring problems by using human intuitive experience judgment and reasoning. In the comprehensive evaluation system for selecting cooperative enterprises, many indicators are evaluated using qualitative methods. Some indicators are very clear qualitatively and it is easy to determine their scores based on these criteria, but some rating indicators are not very clear and are a kind of fuzzy indicators that need to rely on expert ratings to determine their final scores. At this time it is necessary to synthesize the expert's preferences specifically by removing one of the highest and one of the lowest scores and then taking the average as the final score. In this paper, a five-level scoring system is used.

2.1.5. Comprehensive evaluation of indicators. Combining the standardized quantitative and qualitative index values, the judgment matrix of comprehensive evaluation is established, and then combined with the index weights, the judgment matrix is solved by vectors.

The so-called multi-indicator comprehensive evaluation refers to a certain mathematical model to “synthesize” multiple evaluation indicators into a holistic comprehensive evaluation value. There are many mathematical models that can be used for “synthesis”, and the problem lies in how to choose a more appropriate synthesis method according to the evaluation criteria and the characteristics of the evaluated system. In this paper, according to the characteristics of the evaluated object, we decide to use the linear weighted synthesis method to comprehensively evaluate the evaluation objects, obtain the comprehensive evaluation value through the comprehensive evaluation function and rank the evaluation objects according to the size of the value.

The linear weighted synthesis method applies a linear model:

$$y = \sum_{i=1}^{n} V_i x_i \tag{12}$$

To conduct a comprehensive evaluation of the candidate enterprises, where V_i refers to the weight coefficient corresponding to the evaluation index and y is the comprehensive evaluation value of the candidate enterprises.

2.2. Multiple regression methods

In view of the advantages of qualitative analysis in dealing with qualitative data, qualitative analysis methods have been continuously introduced into statistical analysis in many fields, which makes the problems that cannot be solved by traditional quantitative analysis solved one by one, and this paper adopts regression analysis methods to analyze the influencing factors of scientific and technological talent cultivation in power grid enterprises. Regression analysis method is a powerful tool to deal with the correlation between variables, which can not only provide the mathematical expression of the correlation between variables, that is, the so-called empirical formula, but also judge the validity of the established empirical formula to find out which dependent variables have a greater impact on the dependent variable, and which dependent variables have a smaller impact on the dependent variable.

According to the number of independent variables, there are two types of linear regression models: the univariate linear regression model and the multiple linear regression model. Simply put, when there is only one independent variable, the model is a univariate linear regression model, and when there are more than one independent variable, the linear regression is a multiple linear regression model.

A univariate linear regression analysis is used to explore the linear relationship between one dependent variable (also known as the resolved variable) one independent variable (or resolving variable). Its regression model expression is:

$$y_i = \beta_0 + \beta_1 x_i + u, i = 1, 2\cdots, n \tag{13}$$

Where y_i is the dependent variable (resolved variable), x_i is the independent variable (resolving variable), β_0 and β_1 are collectively called the parameters of the regression equation, β_0 is the constant term of the regression equation, β_1 is the regression coefficient, and u is the portion of the change in the y_i that is not resolved by the independent variable, called the random error term.

Multiple linear regression is used to study the linear relationship between a resolved variable and multiple resolved variables, and its model is generally expressed as:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i + u \tag{14}$$

Where y is the explained variable (dependent variable) $; x_1, x_2 \cdots x_i$ is the explanatory variable (independent variable) and β_0 is the constant term. $\beta_1, \beta_2 \cdots, \beta_i$ is the regression coefficient, and u is the random error term.

After n observations of y and x, n sets of observations $y_i, x_{i1}, x_{i^2} \cdots, x_{ik} \left(i = 1, 2\cdots n\right)$ are obtained, which satisfy the relationship equation:

$$y_i = \beta_0 + \beta_1 x_{i_1} + \beta_2 x_{i^2} + \cdots + \beta_k x_{ik} + u \tag{15}$$

Remember:

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, X = \begin{bmatrix} 1 & x_{11} & \cdots & x_{1k} \\ 1 & x_{21} & \cdots & x_{2k} \\ \vdots & \vdots & \vdots & \vdots \\ 1 & x_{n1} & \cdots & x_{nk} \end{bmatrix}, b = \begin{bmatrix} b_0 \\ b_1 \\ \vdots \\ b_k \end{bmatrix}, \mu = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_n \end{bmatrix} \tag{16}$$

where y is a $n\times 1$-dimensional observation vector, x is a $n\times(k+1)$-dimensional known design matrix, β is a $(k+1)\times 1$ -dimensional vector of unknown parameters, and u is an $n\times 1$ -dimensional vector of random errors. Then the model (14) can be written in the following form:

$$y = x\beta + u \tag{17}$$

Linear regression models need to satisfy the following assumptions:

1) The random error term u is a random variable whose distribution satisfies $u \sim N\left(0,\sigma^2\right)$, i.e., u satisfies the assumption of homoskedasticity.

2) The different observations between the random error terms are uncorrelated, i.e:

$$E\left(u_i u_j\right) = 0 (i \neq j) \tag{18}$$

The random error terms u_i are independent of each other, subject to the assumption of normality. The value of error term u taken in one period is independent of the value taken in any other period, which in econometrics is called the absence of autocorrelation or serial independence of u.

3) The analytic variable x is uncorrelated with the random error term u, viz:

$$Cov\left(x_i, u_i\right) = 0 \tag{19}$$

4) x is a non-random matrix with full rank. Classical assumptions such as those mentioned above are known as Gauss-Markov conditions, but these assumptions are not always fully satisfied with respect to real economic problems.

3. Evaluation of science, technology and innovation talent development

3.1. Evaluation modeling

3.1.1. CIPP evaluation model. CIPP model consists of four parts: background evaluation, input evaluation, process evaluation, and outcome evaluation. The essence of CIPP model is to focus on improvement rather than proof by evaluating the whole process of training program. This paper applies the CIPP model to the evaluation of talent training quality of power grid enterprises, which can systematically connect each link of the training system as a whole, not only for a certain part of it. The dynamic characteristics of the CIPP model can scientifically reflect the whole picture of the whole talent training system.

3.1.2. System of evaluation indicators. Based on the definition of CIPP model constitutes the evaluation model of this paper, and 4 first-level indicators and 16 second-level indicators are set around the background evaluation, input evaluation, process evaluation and outcome evaluation in CIPP model. The evaluation indicators of scientific and technological innovation talents in power grid enterprises are shown in Table 1. The background evaluation involves the policy environment, cultivation objectives, cultivation plan and talent selection mechanism. Input evaluation is to analyze the resources that electric power enterprises plan to invest in order to achieve the established talent cultivation goals, and three indicators are set in this part: faculty strength, input funds and cultivation facilities. Process evaluation sets four indicators: training content, training management, training assessment and teaching methods. Outcome evaluation is carried out from two aspects: outcome and impact, with two indicators set for outcome evaluation: competence level and comprehensive quality, and three indicators set for impact evaluation: enterprise recognition, talent satisfaction and the degree of promotion of the training program.

Table 1. The evaluation index of the innovation talents of the power grid enterprise

Primary indicator	Secondary indicator

Background evaluation	Policy environment A1
	Culture target A2
	Culture plan A3
	Talent training mechanism A4
Input evaluation	Funding A5
	Training facilities A6
	Faculty member A7
Process evaluation	Culture content A8
	Culture management A9
	Training assessment A10
	Teaching method A11
Achievement evaluation	Ability level A12
	Comprehensive quality A13
	Enterprise recognition A14
	Talent satisfaction A15
	Training program extensibility A16

3.2. Empirical studies

In the previous section, the evaluation model of science and technology innovation talents was constructed, and in this section, an arithmetic example analysis will be carried out to verify the practicality of the model. Three power grid enterprises (PGE 1~ PGE 3) are selected, from which a team of experts is formed to evaluate the level of their scientific and technological innovation talent cultivation. The indicators are assigned according to the fuzzy AHP method and the scores are calculated for the grid enterprises.

3.2.1. Indicator weights. Using the fuzzy AHP analysis method for expert scoring, according to the definition of judgment matrix, this paper takes the quality of enterprise science and technology innovation talent cultivation as the target layer, sets the background evaluation, input evaluation, process evaluation, and outcome evaluation as the criterion layer, and then sets the downward 16 secondary indicators as the indicator layer. The weight coefficients of enterprise science and technology innovation talent evaluation are finally obtained as shown in Figure 1. The weight values of background evaluation, input evaluation, process evaluation and outcome evaluation are 0.2232, 0.1996, 0.2589 and 0.3183, and the weight value of outcome evaluation is the largest among the first-level indicators. Among the second-level indicators, competence level A12 and cultivation content A8 have the greatest influence on STI talents, with weight values of 0.0945 and 0.0930, respectively.

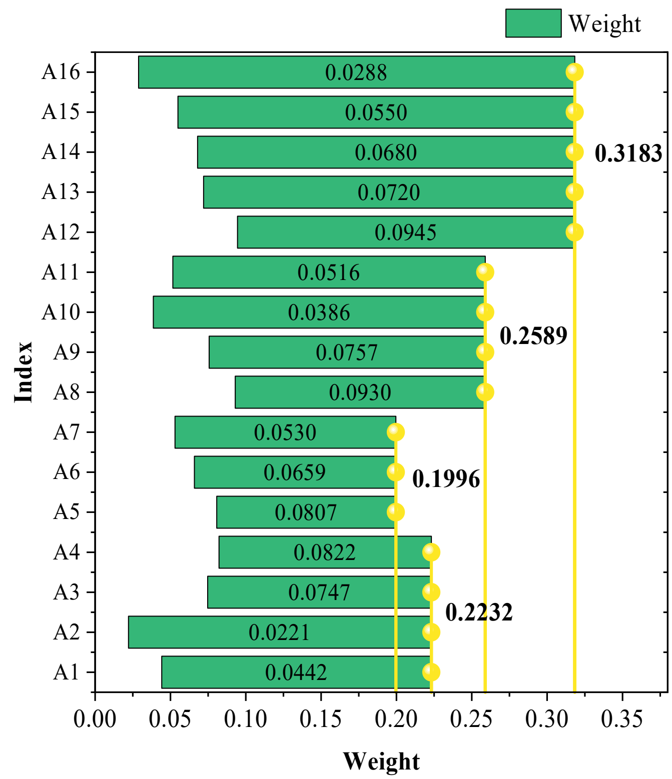
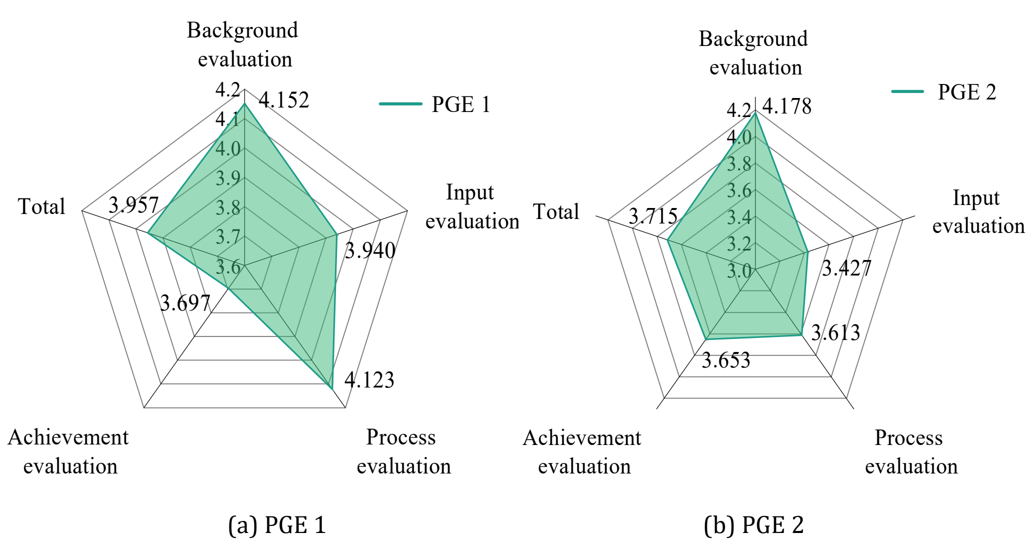
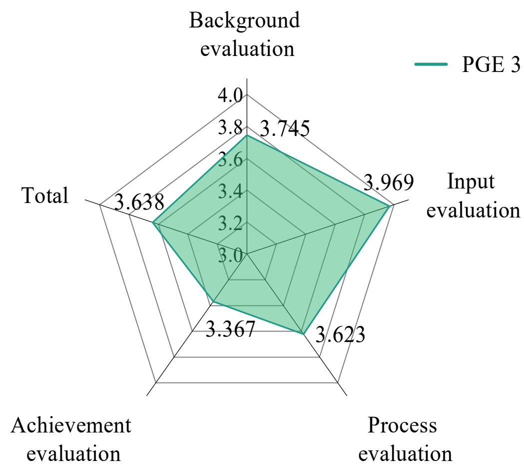


Fig. 1. The weight factor of scientific and technological innovation talents evaluation

3.2.2. Comprehensive evaluation:

1) Comprehensive index evaluation. A comprehensive assessment of the cultivation of scientific and technological innovation talents of the three power grid enterprises is conducted, and the evaluation results of scientific and technological innovation talents are shown in Figure 2, with scores from 0 to 5 corresponding to very poor, poor, medium, good and excellent levels. In terms of the total score of the three grid enterprises, enterprise PGE 1 has the highest score of 3.957, enterprise PGE 2 has the second score of 3.715, and enterprise PGE 3 has the third score, with an average value of 3.638, and their comprehensive scores are all in the dimension of "good", which indicates that all three grid enterprises have a good capacity to innovate in terms of science and technology innovation and talent training. This indicates that the three grid enterprises have good innovation ability in terms of science and technology innovation and talent cultivation quality.





(c) PGE 3

Fig. 2. The evaluation results of scientific and technological innovation talents

2) Evaluation of secondary indicators. In addition to the comparative analysis of the comprehensive score of each grid enterprise, it is also possible to analyze the characteristics of each dimension according to the score of the second-level indicators of the grid enterprises, and put forward targeted suggestions on the specific situation of the scientific and technological innovation talents of each grid enterprise, which can improve its comprehensive innovation ability more efficiently and is conducive to the long-term development of the company. The ability of each secondary indicator of the three grid enterprises is analyzed in a horizontal comparison, and the results of the scores of the secondary indicators are shown in Figure 3. For enterprise PGE 1, its secondary indicator scores are distributed in [2.98, 4.53], and the evaluation scores of teaching method A11 and talent selection mechanism A4 are the highest, both greater than 4.5 points. The secondary indicator scores of enterprise PGE 2 and enterprise PGE 3 are distributed at [2.78, 4.51] and [2.65, 4.41], which are slightly lower than the evaluation scores of enterprise PGE 1. Both of them have the highest evaluation scores on cultivation plan A3 and input funding A5, respectively.

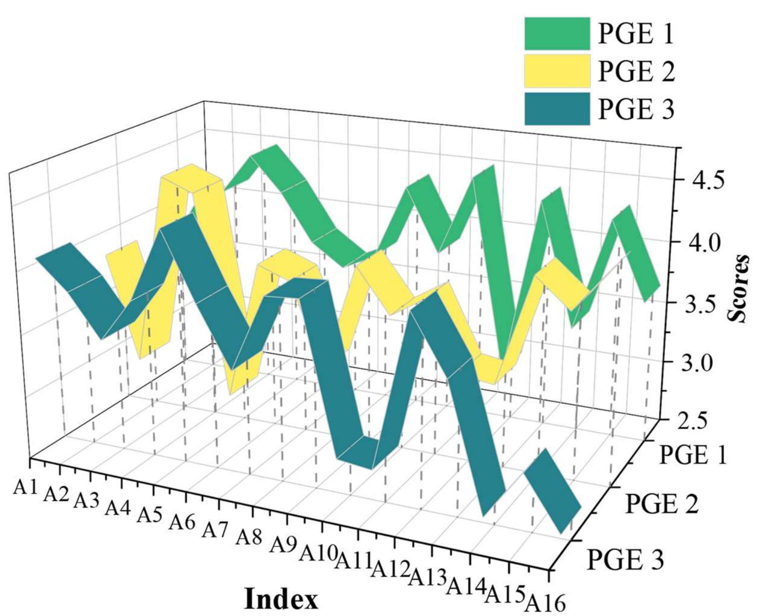


Fig. 3. Scoring results of the secondary index

4. Factors influencing the development of STI talent

After measuring the comprehensive score of STI talents of power grid enterprises, this chapter focuses on the empirical analysis of the influencing factors of STI talents of power grid enterprises to provide theoretical support for the proposal of more effective enhancement of the cultivation of STI talents.

4.1. Empirical research model and hypotheses

4.1.1. Mechanism of action model. Human behavior is the result of dynamic interaction between internal factors, behavior itself and external environment. Based on the above analysis, this paper will combine relevant literature and theoretical foundations to build a model of the influence mechanism of science and technology innovation talent cultivation from the individual factors at the micro level, the organizational factors at the meso level and the environmental factors at the macro level, and the model of the mechanism of the role of science and technology innovation talent cultivation is shown in Fig. 4, to explore the influence of the three levels on the cultivation of scientific and technological innovation talent.

Fig. 4. The model of the development of scientific and technological innovation talents

4.1.2. Research hypotheses. Under the framework of the model of the role mechanism of factors influencing the cultivation of scientific and technological innovation talents, combined with the theoretical basis and previous research, this paper puts forward the following hypotheses:

1) Personal factors:

Hypothesis 1: The personality characteristics of science and technology innovation talents have a significant positive impact on the quality of enterprise talent training.

Hypothesis 2: The personal pre-accumulation of scientific and technological innovation talents has a significant positive impact on the quality of enterprise talent cultivation.

Hypothesis 3: The scientific research interest of scientific and technological innovation talents has a significant positive influence on the quality of enterprise talent cultivation.

Hypothesis 4: Teamwork significantly affects the cultivation of scientific and technological innovation talents.

2) Organizational factors:

Hypothesis 5: Innovation atmosphere has a significant positive effect on the cultivation of science and technology innovation talents.

Hypothesis 6: Institutional prestige has a significant positive effect on the cultivation of scientific and technological innovation talents.

3) Environmental factors:

Hypothesis 7: Institutional norms have a significant positive effect on the cultivation of scientific and technological innovation talents.

4.2. *Impact Factor Indicator Collection*

Using the literature factor collection method to select and construct indicators for personal factors, organizational factors and environmental factors, four primary indicators, seven secondary indicators and 12 tertiary indicators were finally obtained. The influencing factor indicator system is shown in Table 2, with control variables added to the first-level indicators, consisting of personality characteristics such as age, age of employment, job title, and the number of years in which the highest title has been obtained.

Table 2. Impact factor index system

Primary indicator	Secondary indicator	Tertiary index
Control variable	Personality characteristics B1	Employment age C1, age C2, title C3 and maximum title time C4
Personal factor	Personal accumulation B2	The period of education C5 and academic communication activity C6
	Teamwork B3	Research cooperation number C7
	Research interest B4	High focus in research C8, cross disciplinary research experience C9
Organizational factor	Creative atmosphere B5	Laboratory level C10
	Institutional prestige B6	Inaugural enterprise C11
Environmental factor	Institutional specification B7	Innovation policy support C12

4.3. *Validation of Impact Factors*

After the collection of relevant index data on 150 research samples according to the determined index system of influencing factors of scientific and technological innovation talent cultivation, hypothesis testing was carried out with the comprehensive score of scientific and technological innovation talent cultivation determined through the previous chapter as the dependent variable, and the indexes of operationalization of each influencing factor as the independent variable.

4.3.1. Correlation analysis. In order to further explore whether there is a correlation between each influencing factor and the cultivation of scientific and technological innovation talents, the correlation analysis will be used to test the correlation between all influencing factor variables and the quality of scientific and technological innovation talents cultivation (TIT) firstly, the correlation is tested by using Pearson's correlation coefficient in SPSS22.0, and the descriptive and correlation statistical results of the variables are shown in Fig. 5, and the yellow circle indicate significant correlation at least at the 0.05 level (two-sided).

The results of correlation analysis show that the quality of science, technology and innovation talent cultivation is significantly and positively correlated with age, job title, academic exchange activity, cross-disciplinary research, current unit of employment, laboratory, and innovation policy support ($p<0.05$), and negatively correlated with the number of research collaborations, years of education, and high focus on research fields but not significantly, and did not show any significant correlation with the age of hiring, and the years of obtaining the highest title, and whether these variables are significantly correlated with one another, or not. Whether there is a causal relationship between these variables needs to be further tested by regression analysis.

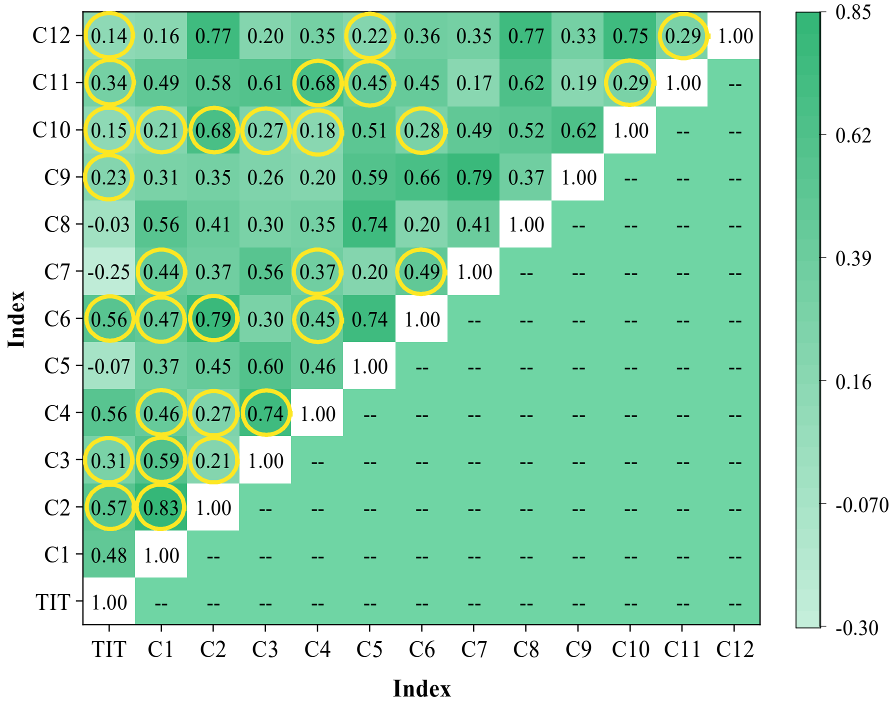


Fig. 5. Statistical results of descriptive and related relationships of variables

4.3.2. Analysis of control variables. Regression analysis of the impact of each control variable, i.e., personality trait dimension, was conducted, and the analytical results of the regression of control variables are shown in Table 3, with ***, **, and * representing 1%, 5%, and 10% significance levels, respectively. The age of STI talents C1, the age of employment C2, the job title C3, and the number of years of obtaining the highest title C4 all have a significant positive impact on the quality of STI talents training. Among them, age is significant at 1% level with age of employment and years of highest title, and job title is significant at 5% level, and each factor passes the multiple covariance test, and hypothesis 1 is confirmed.

Table 3. Control Variable Regression Analysis Results

Variable	Nonnormalized coefficient	Normalized coefficient	P	R2	Adjusted R2	F
C1	0.424	0.567	0.002***	0.287	0.245	F=37.452 P=0.008***
C2	0.301	0.471	0.005***	0.214	0.209	F=31.544 P=0.002***
C3	0.264	0.246	0.028**	0.102	0.089	F=8.437 P=0.011**
C4	0.344	0.509	0.0001***	0.293	0.275	F=34.936 P=0.004***

4.3.3. Analysis of influencing factors. The results of regression analysis of each influence factor are shown in Table 4, ***, **, * represent 1%, 5%, 10% significance level respectively. Personal pre-accumulation B2 can explain 53.5% of the variance of the quality of science and technology innovation talent cultivation, in which academic communication activity C6 has a significant positive impact on the quality of science and technology innovation talent cultivation, with an impact coefficient of 0.702, and the education level C5 has a negative but insignificant impact on the quality of science and technology innovation talent cultivation, and Hypothesis 2 is partially confirmed.

The results of research interest dimension B4 show that, on the one hand, cross-disciplinary research experience C9 has a direct positive effect on the quality of cultivation of scientific and technological innovation talents, with a regression coefficient of 0.401, i.e. the richer the experience of cross-disciplinary research of scientific and technological innovation talents, the stronger the quality of cultivation of their talents. On the other hand, the high focus of research field C8 does not have a significant effect on the cultivation quality of STI talents, and even shows a certain negative tendency, and Hypothesis 3 is partially confirmed. Teamwork C7 has a significant effect on the quality of science and technology innovation talent cultivation, and it is a significant negative effect, hypothesis 4 is confirmed.

Innovation atmosphere B5 and institutional prestige B6 both have significant predictive power on the quality of science and technology innovation talent cultivation, and the regression coefficients of the two are 0.363 and 0.188, indicating that the stronger the innovation atmosphere of the organization where the science and technology innovation talent is located and the higher the institutional prestige are, the more significant is the enhancement effect on the cultivation of the talent, which means that hypothesis 5 and hypothesis 6 are confirmed.

Among the environmental factors, innovation policy support C12 has a significant positive effect on the quality of science and technology innovation talent cultivation, with a regression coefficient of 0.163, indicating that innovation policy support has a significant positive effect on the quality of science and technology innovation talent cultivation, and hypothesis 7 is confirmed.

Table 4. Regression analysis results of various influencing factors

Variable		Normalized coefficient	P	VIF	R2	Adjusted R2
B2	C5	-0.042	0.734	1.544	0.577	0.535
	C6	0.702	0.001***	1.235		
B3	C7	-0.249	0.002***	1.066	0.084	0.059
B4	C8	-0.002	0.159	1.233	0.265	0.192
	C9	0.401	0.003***	1.051		
B5	C10	0.363	0.007***	1.331	0.334	0.288
B6	C11	0.188	0.085*	1.351	0.313	0.274
B7	C12	0.163	0.061*	1.230	0.183	0.164

4.4. Science, technology and innovation talent cultivation path

Combined with the above analysis of the influencing factors of scientific and technological innovation talent cultivation, the path of scientific and technological innovation talent cultivation in power grid enterprises is proposed from the following dimensions.

4.4.1. Establishment of training and development pathways. Grid enterprises should do a good job of cultivating scientific and technological innovation talents, and should do a good job of scientific and technological innovation talent career development channel and talent inventory and other basic work. First, we should plan the core positions, screen the key cultivation objects with cultivation potential, and concentrate resources on key breakthroughs. The second is to do a good job of science and technology innovation talent fine class job competency model, clear different sequences, different levels of science and technology innovation talent professional knowledge and skills, experience, ability to competency elements, professional contribution, work motivation and so on.

4.4.2. Development of a tiered training model. In the process of building a hierarchical and categorized cultivation system, it is necessary to clarify the suitable cultivation modes for different levels and categories of scientific and technological innovation talents, and then to clarify the specific cultivation methods and cultivation contents. With the help of the learning navigation formed by the learning map, the employees make their personal learning and development plan according to the direction of the competence they need to develop and after counseling by the superior manager. On the basis of the job competency model, form the improvement measures corresponding to the ability quality. Retrieve the existing training resources and build the whole training system.

4.4.3. Focus on innovative training methods. Explore some time-flexible and effective ways of conducting STI training. Knowledge and experience accumulation training can adopt the traditional course mode or the emerging community learning. For the training of science and technology innovation talents at the level of practical operation, enterprises should establish practical training and operation bases, so that young scientific and technological talents can learn with the subject, learn with the project, and apply what they have learned.

4.4.4. Establishment of scientific research platforms. According to the law of scientific research talent development, the cultivation of scientific research and innovation talents requires a stable scientific research environment and scientific research platform. On the basis of the scientific research platform, stable scientific research resources should be provided, such as expert guidance and project experience. School and enterprise “dual tutor system” can be implemented to promote the deep integration of industry, academia, research and utilization. Through the establishment of projects with top scientists in the industry, young researchers can deeply understand the research methods of top scientists and conduct innovative research in combination with the needs of enterprises.

5. Conclusion

This paper constructs the evaluation index system of scientific and technological innovation talents based on the CIPP model, and utilizes the fuzzy AHP method to evaluate the scientific and technological innovation talents of the selected grid enterprises. It establishes a research model for the cultivation of scientific and technological innovation talents, utilizes regression analysis method, clearly presents the relevant factors affecting the quality of cultivation of scientific and technological innovation talents through empirical analysis and proposes the path of cultivation of talents.

1) The evaluation index system of science and technology innovation talents with background evaluation, input evaluation, process evaluation and result evaluation as the first-level indexes is constructed, and the weight values are 0.2232, 0.1996, 0.2589 and 0.3183, respectively. The cultivation of science and technology innovation talents of the three power grid enterprises is at a good level, and the comprehensive scores are between 3.6 and 4.0, among which, the grid enterprises with the highest scores are in the areas of outstanding performance in teaching methods and talent selection mechanism.

2) In addition to years of education, high focus in research field and teamwork, all the factors selected in this paper have a significant positive impact on the quality of science and technology innovation talent cultivation, in which teamwork has a certain negative and significant impact on talent cultivation, and the positive impact of academic communication activity has the largest effect, with an impact coefficient of 0.702. Hypotheses 1 and 4-7 in the paper have been verified, while hypotheses 2 and 3 have been partially verified.

3) Grid enterprises should study the growth law of scientific and technological talents, build hierarchical and personalized cultivation and development channels, do a good job in the development of scientific and technological talents stratified and classified cultivation mode, pay attention to the development of innovative training methods, enhance the cultivation effect, and build a platform for the cultivation of different levels of scientific and technological talents with the use of a platform suitable for hierarchical development, and cultivate scientific and technological innovation talents with the potential for development.

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