Research on Computer Assisted Performance Intelligent Evaluation Model of Achievements Transformation through Principal Component Analysis

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Abstract. Based on the principal component analysis method, an evaluation system for the transformation of scientific and technological achievements in universities was established, and 42 universities in Guangdong Province were used as examples for verification. The research results show that this method can scientifically quantify the level of scientific and technological achievements transformation in universities, and formulate corresponding improvement suggestions based on the evaluation results, which can provide a reference for improving the level of scientific and technological achievements transformation in universities.

1. Introduction
The effective transformation of scientific and technological achievements into productive forces will effectively promote the progress of science and technology and promote the rapid development of economy and society. As the country's main R&D institution, universities are important birthplaces of scientific and technological achievements. Therefore, promoting the effective transformation of scientific and technological achievements in universities can provide a strong impetus for the high-quality development of our economy and society. Since 2015, China has revised the law on the transformation of scientific and technological achievements and formulated policies for the transformation of scientific and technological achievements, which have enabled the quantitative transformation of scientific and technological achievements in Chinese universities and research institutes. According to statistics, in 2017, the total amount of science and technology achievements conversion contracts of public universities and research institutions in the country reached 12.1 billion yuan, achieving high economic value [1]. However, the conversion rate of scientific and technological achievements in Chinese universities is still not high. In 2016, the number of patents granted to universities in China reached 144,375, but the number of patents sold was only 4,803, accounting for 3.3% [2]. This means that the rate of patent achievement conversion in universities is low, scientific and technological achievements cannot be effectively transformed into productivity and economic benefits are generated, and there is a waste of resources. Therefore, to promote the effective transformation of scientific and technological achievements in universities, and to analyze the performance of scientific and technological achievements is particularly critical. Carrying out the evaluation of the transformation efficiency of scientific and technological achievements in universities can help to understand the problems existing in the transformation of scientific and technological achievements in colleges and universities and propose targeted improvements.
The existing university scientific and technological achievements transformation performance evaluation has a good research foundation, but there are still shortcomings. The current research on the transformation of scientific and technological achievements is mainly concentrated at the regional level, and the research on individual colleges and universities needs to be further studied. Therefore, this paper uses the principal component analysis method to establish a university science and technology achievement transformation system, and proposes optimization suggestions based on the analysis results. At the same time, this article takes 42 universities in Guangdong Province as case studies. The results obtained can provide references for the transformation of scientific and technological achievements of universities in Guangdong Province, and promote the high-quality development of the economy and society in the Guangdong-Hong Kong-Macao Bay Area.

2. Evaluation method
This article adopts the principal component analysis method to establish the evaluation system for the transformation of scientific and technological achievements in universities. Principal component analysis is a dimensionality-reducing multivariate statistical method that examines the correlation between multiple variables [3]. The basic idea is to derive a few unrelated principal components from the original multi-index variables as comprehensive indicators. And the indicators contains most of the information of the original multiple indicators and is not related to each other.

The principle of principal component analysis is as follows: there are \( n \) samples and \( p \) indicators, and the matrix is \( X = (X_{ij})_{n \times p}, \) where \( i = 1,2,\ldots,n; j = 1,2,\ldots,p; X_{ij} \) is the \( j \)-th index value of the \( i \)-th sample. The specific calculation steps are as follows:

1. Normalize the matrix \( X \) to obtain a standardized matrix \( X' \). The calculation process is \( X'_{ij} = (X_{ij} - \bar{X}_i) / \sigma_i \) \((i = 1,2,\ldots,n; j = 1,2,\ldots,p)\), where \( \bar{X}_i \) and \( \sigma_i \) are the first sample mean and standard deviation of \( i \) indicators;

2. Calculate the correlation coefficient matrix \( R \) of the normalized matrix \( X' \), where \( R_{ij} = \frac{\sum_{i=1}^{n}(X_{ij} - \bar{X}_i)(X_{ij} - \bar{X}_j)}{\sqrt{\sum_{i=1}^{n}(X_{ij} - \bar{X}_i)^2}\sum_{j=1}^{n}(X_{ij} - \bar{X}_j)^2} \). \( R \) is the correlation coefficient of the original variables \( X_i \) and \( X_j \);

3. Calculate the eigenvalues \( \lambda_k (k = 1,2,\ldots,a) \) of \( R \), and the normalized orthogonal eigenvectors \( a_k = (a_{k1}, a_{k2}, \ldots, a_{kp})^T \) corresponding to each eigenvalue. The principal component corresponding to \( \lambda_k \) is the \( k \)-th principal component. The variance contribution rate of each component is \( \eta_k = \frac{\lambda_k}{\sum_{i=1}^{a} \lambda_i} \).

According to the requirement of cumulative variance contribution rate \( \geq 85\% \), the principal components corresponding to the first \( m \) eigenvalues are selected, and the corresponding principal component is \( F_k = a_k^T X' \).

3. Evaluation system construction and data source
The selection of university scientific and technological achievements transformation performance evaluation index needs to consider the scientific, typical and measurable principles. Scientificity means that the evaluation indicators can objectively and truly reflect the characteristics and status of the transformation of scientific and technological achievements. Typicality means that the evaluation indicators can comprehensively reflect the comprehensive characteristics of the transformation of scientific and technological achievements and reduce the number of indicators. Measurability means that the evaluation index can be directly quantified, and the value is easy to obtain, which improves the operability of the evaluation system. Based on the current status of university scientific and technological achievements transformation and existing literature research, the selected indicators include two primary indicators of scientific and technological achievements input and scientific and technological achievements output, of which there are six secondary indicators of scientific and
technological achievements input and seven secondary indicators of scientific and technological achievements output. The specific evaluation system is shown in the following table:

Table 1. Performance evaluation indicators for the transformation of scientific and technological achievements.

| No. | Primary indicator | Secondary indicator | Unit   |
|-----|------------------|---------------------|--------|
| 1   | Input of scientific and technological achievements (X1) | Teaching and Research Staff (Y1) | People |
| 2   |                           | Research and Development Staff (Y2) | Man-year |
| 3   |                           | Total funding input (Y3) | Thousand yuan |
| 4   |                           | Government funding (Y4) | Thousand yuan |
| 5   |                           | Entrusted capital investment by enterprises and institutions (Y5) | Thousand yuan |
| 6   |                           | Basic Research Project (Y6) | Item |
| 7   |                           | Number of monographs (Y7) | Item |
| 8   |                           | Published Papers (Y8) | Item |
| 9   |                           | Number of identification results (Y9) | Item |
| 10  | Output of scientific and technological achievements (X2) | Achievement Award (Y10) | Item |
| 11  |                           | Number of patents declared (Y11) | Item |
| 12  |                           | Number of technology transfer contracts (Y12) | Item |
| 13  |                           | Technology transfer income (Y13) | Thousand yuan |

This article selects 42 universities in Guangdong Province as the research object, of which 9 are 211 colleges and 33 are non-211 colleges. The data source of all indicators is the Compilation of Scientific and Technological Statistics of Higher Education in 2017 [2].

4. Performance evaluation analysis of university scientific and technological achievements transformation

4.1. Correlation analysis of evaluation indicators
Correlation analysis is performed on each evaluation indicator, and the correlation matrix obtained is shown in Table 2. As can be seen from the table, the relationship between the indicators of the evaluation system established is strong, and there is basically a significant correlation phenomenon. This means that there is overlap in the information of the indicators. It can be seen that the original data of the evaluation system should not be directly used in the evaluation and analysis of the performance of scientific and technological achievements.

Table 2. Correlation analysis of various indicators.

|   | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 | Y8 | Y9 | Y10 | Y11 | Y12 | Y13 |
|---|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|
| Y1| 1.00 |    |    |    |    |    |    |    |    |     |     |     |     |
| Y2| 0.92* | 1.00 |    |    |    |    |    |    |    |     |     |     |     |
| Y3| 0.71* | 0.87* | 1.00 |    |    |    |    |    |    |     |     |     |     |
| Y4| 0.72* | 0.89* | 0.99* | 1.00 |    |    |    |    |    |     |     |     |     |
| Y5| 0.52* | 0.68* | 0.90* | 0.89* | 1.00 |    |    |    |    |     |     |     |     |
| Y6| 0.80* | 0.93* | 0.97* | 0.97* | 0.85* | 1.00 |    |    |    |     |     |     |     |
4.2. Analysis of the principal component analysis method of the evaluation system

Principal component analysis is performed on the evaluation system for the transformation performance of scientific and technological achievements of universities, and the contribution rate of the scientific and technological achievements transformation index method is obtained, as shown in Table 3. As can be seen from the table, the cumulative variance contribution rate of the second component has reached 88.56%, exceeding 85%. Therefore, selecting the first two principal components can represent the original data of the data for evaluation and analysis.

Table 3. Principal component method contribution rate.

| Principal component | Eigenvalue Variance | Contribution rate/% | Cumulative/% |
|---------------------|---------------------|---------------------|--------------|
| F1                  | 9.4478              | 72.68               | 72.68        |
| F2                  | 2.0647              | 15.88               | 88.56        |
| F3                  | 0.4798              | 3.69                | 92.25        |
| F4                  | 0.4303              | 3.31                | 95.56        |
| F5                  | 0.2318              | 1.78                | 97.34        |
| F6                  | 0.1388              | 1.07                | 98.41        |
| F7                  | 0.0718              | 0.55                | 98.96        |
| F8                  | 0.0595              | 0.46                | 99.42        |
| F9                  | 0.0379              | 0.29                | 99.71        |
| F10                 | 0.0195              | 0.15                | 99.86        |
| F11                 | 0.0135              | 0.10                | 99.96        |
| F12                 | 0.0043              | 0.03                | 100.00       |
| F13                 | 0.0004              | 0.00                | 100.00       |

Note: * indicates significant correlation at the 0.05 level.

Table 4 shows the correlation coefficient between each principal component and the corresponding index. The principal component F1 has a significant correlation with Y1 ~ Y10 indicators, and F2 has a significant correlation with Y11 ~ Y13 indicators. Therefore, the two main component indicators F1 and F2 can be used instead of the original 13 evaluation indicators. The calculation process of F1 and F2 is as follows:

F1 = 0.256×Y1+0.296×Y2+0.317×Y3+0.315×Y4+0.290×Y5+0.317×Y6+0.290×Y7+0.314×Y8+0.25×Y9+0.314×Y10+0.229×Y11+0.205×Y12+0.188×Y13;

F2 = -0.272×Y1-0.258×Y2+0.003×Y3-0.048×Y4+0.185×Y5-0.072×Y6-0.237×Y7-0.086×Y8-0.311×Y9+0.020×Y10+0.425×Y11+0.521×Y12+0.452×Y13.
Table 4. Principal component analysis matrix.

| Evaluation index | F1   | F2  |
|------------------|------|-----|
| Y1               | 0.256| -0.272|
| Y2               | 0.296| -0.258|
| Y3               | 0.317| 0.003|
| Y4               | 0.315| -0.048|
| Y5               | 0.290| 0.185|
| Y6               | 0.317| -0.072|
| Y7               | 0.290| -0.237|
| Y8               | 0.314| -0.086|
| Y9               | 0.225| -0.311|
| Y10              | 0.314| 0.020|
| Y11              | 0.229| 0.425|
| Y12              | 0.205| 0.521|
| Y13              | 0.188| 0.452|

5. Comprehensive Evaluation of University Scientific and Technological Achievements Transformation

In order to quantify the transformation performance of scientific and technological achievements in universities, this article calculates their respective weights based on the variance contribution rate of the principal component F1 and principal component F2. The specific calculation process is as follows:

- Weight of principal component F1: \( w_1 = \frac{72.68}{72.68+15.88} = 0.821 \);
- Weight of principal component F2: \( w_2 = \frac{15.88}{72.68+15.88} = 0.179 \).

The comprehensive score of each university is \( S = S_1 \times w_1 + S_2 \times w_2 \), where \( S_1 \) and \( S_2 \) are the scores of F1 and F2 of each university. The higher the university's overall score, the stronger the university's scientific and technological achievements in terms of transformation strength, and the better its conversion performance. The specific scores of 42 universities in Guangdong Province are shown in Table 5. As can be seen from the table, Sun Yat-sen University ranks first in the transformation performance of scientific and technological achievements of universities, second is South China University of Technology, and third is Southern Medical University. The comprehensive scores of Sun Yat-sen University and South China University of Technology are relatively close, but the third place of Southern Medical University's comprehensive score is far lower than that of South China University of Technology. This shows that the gap in the strength of the transformation of scientific and technological achievements of universities in Guangdong Province is very wide.

The reason why Sun Yat-Sen University and South China University of Technology have higher comprehensive scores is that these two universities have begun to carry out the transformation of scientific and technological achievements earlier. Both the personnel of scientific and technological achievements, funding input and the output of scientific and technological achievements are ahead of other universities. For South China University of Technology, the transformation of scientific and technological achievements has formed a unique mode of scientific and technological achievements transformation. At the same time, the transformation system of scientific and technological achievements of South China University of Technology has also been improved day by day. In addition, the transformation of scientific and technological achievements of South China University of Technology has also formed a "point-line-plane" pattern to achieve an effective allocation of scientific and technological achievements transformation resources. Sun Yat-sen University has not only established a scientific and technological achievements transformation system, but also established an intellectual property transformation platform to promote the scientific and technological achievements of university teachers to enterprises for application in a timely manner, and to obtain higher scientific and technological achievements transformation benefits.
Table 5. Comprehensive scores of university scientific and technological achievements transformation.

| No | University name                                    | F1     | F2     | Score  |
|----|----------------------------------------------------|--------|--------|--------|
| 1  | Sun Yat-sen University                             | 13.988 | -4.487 | 10.674 |
| 2  | South China University of Technology               | 9.690  | 7.122  | 9.229  |
| 3  | Southern Medical University                        | 4.074  | -1.933 | 2.997  |
| 4  | Guangdong University of Technology                 | 2.599  | 1.887  | 2.472  |
| 5  | South China Agricultural University                | 2.373  | 0.137  | 1.972  |
| 6  | Shenzhen University                                | 1.871  | 0.340  | 1.597  |
| 7  | Jinan University                                   | 1.889  | 0.039  | 1.557  |
| 8  | Guangzhou Medical University                       | 1.222  | -1.218 | 0.875  |
| 9  | Guangzhou University of Chinese Medicine           | 0.847  | -1.429 | 0.439  |
| 10 | GuangZhou University                               | 0.397  | 0.282  | 0.376  |
| 11 | South China Normal University                      | 0.468  | -0.084 | 0.369  |
| 12 | Shantou University                                 | 0.058  | -1.068 | -0.144 |
| 13 | Foshan University                                  | -0.339 | 0.040  | -0.271 |
| 14 | Guangdong Pharmaceutical University                | -0.357 | -0.104 | -0.311 |
| 15 | Guangdong Medical University                       | -0.308 | -0.690 | -0.377 |
| 16 | Dongguan University of Technology                  | -0.525 | 0.138  | -0.406 |
| 17 | Guangdong Ocean University                         | -0.501 | -0.189 | -0.445 |
| 18 | Southern University of Science and Technology      | -0.739 | -0.107 | -0.625 |
| 19 | Guangdong Polytechnic Normal University            | -0.957 | 0.617  | -0.675 |
| 20 | Guangdong University of Petrochemical Technology  | -1.053 | 0.039  | -0.857 |
| 21 | Zhongkai University of Agriculture and Engineering | -1.084 | -0.156 | -0.917 |
| 22 | Lingnan Normal University                          | -1.078 | -0.192 | -0.919 |
| 23 | Wuyi University                                    | -1.267 | 0.056  | -1.030 |
| 24 | Zhaoqing University                                | -1.320 | -0.167 | -1.113 |
| 25 | Guangdong University of Science and Technology     | -1.494 | 0.398  | -1.155 |
| 26 | Zuhai College of Jilin University                  | -1.416 | -0.296 | -1.215 |
| 27 | Tianhe College of Guangdong Polytechnical Normal University | -1.611 | 0.415  | -1.248 |
| 28 | Guangdong Polytechnic College                      | -1.593 | 0.305  | -1.253 |
| 29 | Shaoguan University                                | -1.600 | -0.039 | -1.320 |
| 30 | Guangzhou College of South China University of Technology | -1.658 | 0.156  | -1.332 |
| 31 | University of Electronic Science and Technology of China, Zhongshan Institute | -1.620 | -0.035 | -1.336 |
| 32 | Huizhou University                                 | -1.636 | 0.035  | -1.336 |
| 33 | Guangdong University of Education                  | -1.660 | 0.136  | -1.338 |
| 34 | Jiaying University                                 | -1.633 | -0.078 | -1.354 |
| 35 | Guangzhou Maritime University                      | -1.650 | -0.060 | -1.365 |
| 36 | Hanshan Normal University                          | -1.698 | 0.042  | -1.386 |
| 37 | South China Institute of Software Engineering, Guangzhou | -1.726 | 0.137  | -1.392 |
| 38 | Beijing Institute of Technology, Zhuhai             | -1.757 | 0.010  | -1.440 |
| 39 | Neusoft Institute Guangdong                        | -1.775 | 0.000  | -1.475 |
| 40 | Guangdong Ocean University Cunjin College           | -1.782 | -0.024 | -1.467 |
| 41 | Huali College Guangdong University of Technology   | -1.789 | -0.013 | -1.470 |
| 42 | Zhujiang College of South China Agricultural        | -1.854 | 0.041  | -1.514 |
6. Suggestions for the transformation of scientific and technological achievements in universities

6.1. Creating an environment conducive to the transformation

Creating a good environment for the transformation of scientific and technological achievements with innovative thinking and an open form can promote the transformation process of scientific and technological achievements in universities. The first is to create an open and strong academic atmosphere. Universities should encourage scientific researchers to carry out original innovations in the process of basic research and create a research environment that can tolerate failure. The second is to establish an open selection and employment mechanism. In the mechanism for the appointment of scientific research personnel and the evaluation of professional titles, the scoring weight of indicators such as the conversion rate of scientific and technological achievements and the ability to innovate scientific and technological research shall be strengthened to effectively guide scientific researchers to transform the obtained scientific and technological achievements in a targeted manner. At the same time, universities can optimize the existing staffing mechanism, actively introduce personnel who have achieved high achievements in the transformation and application of scientific and technological achievements in enterprises, and combine the introduction and the go-out to optimize the structure of university scientific research personnel.

6.2. Promote the reform of scientific research management mechanisms and models in universities

The orderly implementation of the transformation of scientific and technological achievements requires scientific and reasonable management mechanisms as support. Universities should combine with their own actualities, and constantly optimize and improve the management mechanism and mode for the transformation of university scientific and technological achievements. Universities should break away from the traditional management mode of scientific research, strictly implement all aspects of project establishment, research and development, and project conclusion, and integrate the concept of scientific and technological achievements into the entire process of project research. First of all, universities should attach importance to being market-oriented and extensively researching the market and the needs of enterprises in project selection, so as to achieve targeted scientific research. Second, in the process of project research and development, universities should fully integrate existing scientific research conditions and resources and introduce relevant enterprises. The subject participates in the research process so that the results obtained will be more applicable. Finally, in the project conclusion, the university should focus on the acceptance indicators of the patent achievements, software copyrights, etc. for applied research projects. At the same time, universities should pay attention to the economic benefits generated by the application and promotion of the project.

6.3. Cultivate a full-time achievement transformation team

Cultivating a professional team specializing in the transformation of scientific and technological achievements is an important support for accelerating the process of scientific and technological achievements transformation in universities. The composition of managers for the transformation of scientific and technological achievements must be scientific and reasonable. They must understand both business development and business operations professionals. The responsibilities of the scientific and technological achievements transformation team should be highly market-sensitive. The team needs to collect market and enterprise demand information for the university as an important basis for project approval; at the same time, it should regularly promote the university's scientific and technological achievements to the market to maximize its economic benefits. Therefore, managers of scientific and technological achievements transformation must not only have a long-term scientific research concept, but also have a high market insight, and have a pioneering and pragmatic spirit.

6.4. Improve incentives and innovate ways of profit distribution

Universities should innovate the distribution of benefits to stimulate the results to transform the enthusiasm of various stakeholders. The first is to adjust the focus of rewards and focus more on
economic rewards in the "late stage" of achievement transformation. The existing rewards for patents and other achievements in universities are basically in the early stage of achievement transformation, and scientific researchers have already received corresponding rewards during the stage of title review and appointment. Therefore, universities should change the original reward mechanism, attach importance to rewards for the transformation of achievements, and guide scientific researchers to work towards the transformation of achievements from an economic perspective. The second is to increase reward objects. None of the university's existing results translation documents clearly mention the personnel incentives of the “Technology Transfer Center”. When improving the relevant incentive measures, the university may specify the “technological achievements promotion staff” (or technology intermediary agency) commissions. If the promoter is the person who completes the project, the commission belongs to the person who completes the project. At the same time, public methods are adopted to prevent the transmission of benefits.

6.5. Optimize transformation pathways and carriers, and build bridges for achievement transformation

The transformation of scientific and technological achievements from the theoretical stage to the actual application stage cannot be separated from the related role of the intermediary platform. Therefore, universities should continuously improve and optimize the channels and carriers of scientific and technological achievements transformation, and promote the establishment of a good scientific and technological achievements transformation service system and technical system. It is found through research that university researchers expect universities to form a platform for the transformation of results. Universities should take advantage of the wealth of information to build bridges for joint transformation of research results, and introduce technology intermediary service agencies familiar with science and technology policies and industry development, socialization, marketization, and professionalism. Universities can build bridges for achievement transformation in the following ways: The first is to introduce scientific and technological achievements to transform the relevant subjects of the whole chain. Universities can attract high-tech companies, financial institutions, evaluation agencies, legal consulting agencies, research institutes, etc. to gather in science and technology parks and research institutes abroad. This can fully integrate resources, complement each other's advantages, and organically integrate the management advantages of enterprises, the financial service advantages of venture capital institutions, and the scientific research advantages of universities. At the same time, it also improves the quality of talent training and provides an open innovation platform for accelerating the transformation of scientific and technological achievements. The second is to establish a sound technology intermediary service system. According to the scientific research reality of universities, universities can establish market-oriented professional science and technology service companies, guide relevant personnel to enter the market to conduct scientific and technological achievements transformation and transactions, and establish a scientific and technological market system that integrates transformation and industrialization as soon as possible. These can create a good environment for fair transactions between supply and demand of scientific and technological achievements.

7. Conclusion

Based on the principal component analysis method, this paper establishes a university science and technology achievement transformation performance evaluation system, and establishes a comprehensive score to scientifically quantify the university science and technology achievement transformation performance, and analyzes 42 universities in Guangdong province as cases. The main conclusions are as follows:

(1) The scientific and technological achievements transformation performance evaluation system based on the principal component analysis method can scientifically measure the scientific and technological achievements transformation strength of universities and has good operability.

(2) The top three scientific and technological achievements of universities in Guangdong Province are: Sun Yat-sen University, South China University of Technology and Southern Medical University.
The scientific and technological achievements of Guangdong universities are highly diversified and there are obvious gaps.

(3) Based on the results of performance analysis, the corresponding optimization suggestions are proposed from the five parts of environmental construction, mechanism establishment, personnel team, and reward mechanism and transformation platform.

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