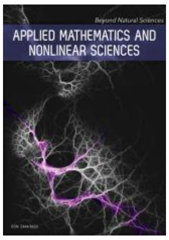
Applied Mathematics and Nonlinear Sciences, 9(1) (2024) 1-13



Applied Mathematics and Nonlinear Sciences

https://www.sciendo.com

Analysis of factors affecting the transformation of scientific and technological achievements in universities based on structural equation modeling

Weiman Wang[1], Shifeng Wang[2,†]

1. China Jiliang University, Hangzhou, Zhejiang, 310018, China.
2. Hangzhou Vocational & Technical College, Hangzhou, Zhejiang, 310018, China.

Submission Info

Communicated by Z. Sabir
Received December 14, 2022
Accepted May 22, 2023
Available online November 11, 2023

Abstract

Based on structural equation modeling, this paper measures and evaluates the transformation of scientific and technological achievements of colleges and universities in terms of implicit and explicit variables. The PLS algorithm is used to measure the intrinsic factor, which is designed to follow the Gaussian distribution and reach the expected value through iterative loops. The indicators and parameters of the explicit variables are evaluated by combining the principal component analysis and the great likelihood method. According to the results, the factors that are influenced by the policy environment account for 16.5%, while the problem of capital investment accounts for 36.3%. The number of invention patents increased by 8.93% after measuring and assessing them using the method presented in this paper. It demonstrates that universities can explore their technological achievements in depth and enhance their scientific research level.

Keywords: Structural equation modeling; Scientific and technological transformation; PLS algorithm; Principal component analysis; Great likelihood approach.
AMS 2010 codes: 97D60

†Corresponding author.
Email address: wwman2003@163.com

ISSN 2444-8656
https://doi.org/10.2478/amns.2023.2.01092

1 Introduction

While the technological innovation of industry-university-research cooperation is getting more and more attention and the cooperation between industry-university-research is getting more and more, the problem of the low rate of transformation and research institutes has not been effectively solved for a long time [1-3]. Due to the differences in economic system and resources, China's scientific and technological system is different from that of Western countries; most of the resources are concentrated in universities, and most of the SMEs cannot independent development. At present, although there are some industry-university-research cooperation docking and exchange meetings, the a lack of unified organization and policy coordination [4-6]. At the same time, due to the lack of scientific and technological management departments scientific and technological information consulting organizations to analyze, regulate, and information dissemination platforms, resulting in the university of the supply and demand of information exchange is not good. On the other hand, some scientific topics of universities lack market orientation, mainly focusing on theoretical analysis and evaluation, so the market research is not specific enough, so many research results or patents can not be articulated with the market and can not be developed and applied by enterprises, seriously affecting the effectiveness and popularizability of the results [7-10]. Therefore, we must vigorously promote the transformation of achievements into real productivity. It is necessary to think about the effectiveness of the way of transformation of scientific and technological achievements from a deep level, as well as the fundamental obstacle factors, and put forward policy recommendations to promote the cooperation between industry, academia and research, and the construction of an innovative country has important practical significance [11-12].

Based on structural equation modeling, this paper constructs an analysis platform to transform scientific and technological achievements in colleges and universities. Firstly, the PLS algorithm is used to measure the intrinsic variables of the factors that affect the transformation of scientific and technological achievements, and the complex relationships are standardized and analyzed. Then, after extracting the principal component weights of the indicators of scientific and technological achievements through principal component analysis, the great likelihood method is used to provide a comprehensive score for the transformation ability of scientific and technological achievements of high-level scientific and technological colleges and universities. Finally, the validity of the method of this paper is verified in the practical analysis through the results of the analysis of influencing factors and the effect of scientific and technological achievements transformation services. It is proved that after the precise analysis of the structural measurement model, the transformation market of scientific and technological achievements of universities is improved, and the profit of enterprises is also improved.

2 Literature review

Zhang, L used the location quotient method to measure industrial clusters, empirically analyzed the agglomeration status and development of high-tech industries in science and technology innovation platforms according to the principle of regional economics, estimated the location quotient as well as the agglomeration status, and provided a basis for the government to designate the relevant policies [13]. Liu, Q designed a scientific research information management system that provides convenient and fast scientific research and teaching tasks for university research management [14]. Dong, Z utilized data envelopment analysis and hierarchical analysis to assess the efficiency of marine science innovation in Zhejiang, firstly, the efficiency of technological innovation was analyzed from the aspects of dynamics and static, respectively, and secondly, in the selection of industrial advantages from the aspect of technological content, economic benefits are evaluated [15]. Li, W considered that the efficiency of the transformation of technological achievements is related to the development factors of the region, and the improvement of the transformation efficiency has a good effect on the promotion of ecological environmental protection [16].

3 Constructing a platform for analyzing the transformation of scientific and technological achievements in colleges and universities based on structural equation modeling

3.1 Structural equation modeling

Structural equation modeling verifies whether the model is reasonable and gives suggestions for optimization. The method focuses on estimating the degree of fit between the whole model and the sample data and determining which model as a whole is more consistent with the complex relationships presented by the data [17-19]. Structural equation modeling consists of measurement techniques and structural assessment techniques, where the basic purpose of measurement techniques is to describe the suitability of the observed marker variables as a test for latent variables or factors, while structural assessment techniques are used to assess the interrelationships between latent variables. Figure 1 illustrates the modeling of structural equations.

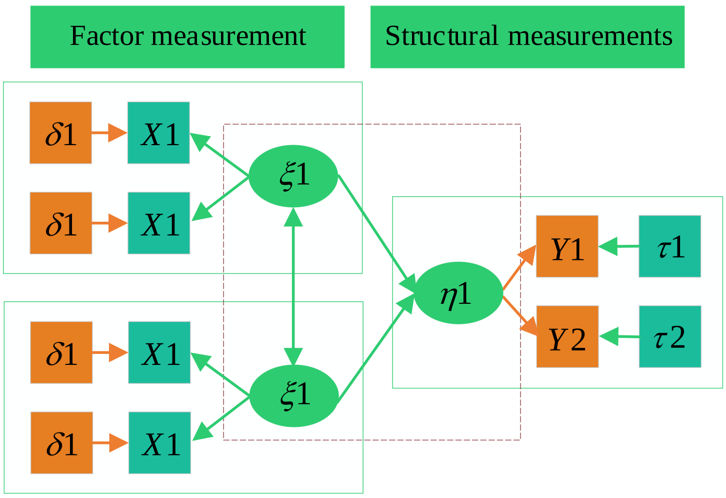


Figure 1. Structural equation model

Structural equation modeling variables include hidden and explicit variables. The hidden variables, also known as structural variables, include exogenous hidden variables ξ and endogenous hidden variables η. Explicit variables, also known as observed variables, are denoted by x, y. Each hidden variable corresponds to two systems of equations, the internal system and the external system, and the two systems of equations are utilized in an iterative loop to progressively approximate the true values of the hidden variables so that the formula for the transformable form of the i th sample is as follows:

$$B\eta_i + \Gamma\xi = \xi_i \tag{1}$$

The structural model describes the causal relationship between different stealth variables ξ_j of the form:

$$\xi_j = \sum\nolimits_{i \neq j} \beta_{ji}\xi_i + \varsigma_j \tag{2}$$

I.e.:

$$Y_j = (\sum_{h=1}^{p_j} w_{jh} x_{jh})^* = (X_j w_j)^* \tag{3}$$

In the above equation, w_j is a vector of weights and * represents the normalization of the estimates.

Scientific and technological results contain both tacit and explicit knowledge, and structural equation modeling allows not only to study the correlations between explicit variables, to estimate linear relationships between multiple and interrelated dependent variables, to deal with unobservable assumptions, to account for errors, and to analyze the structural relationships between latent variables.

3.1.1 Factor Measurement

In this paper, the PLS algorithm is utilized to derive an estimate of the hidden variable scores η_i, ξ, through which the samples are subdivided. The i th sample in class k is set to obey a Gaussian conditional distribution $f_i|_k(\eta_i|\xi B_k, \Gamma_k, \Psi_k)$, i.e.:

$$f_i|_k(\eta_i|\xi B_k, \Gamma_k, \Psi_k) = \frac{|B_k|}{(2\pi)^{M/2}|\Psi_k|^{1/2}} \exp(-\frac{1}{2}(B_k\eta_i + \Gamma_k\xi)'\Psi_k^{-1}(B_k\eta_i + \Gamma_k\xi)) \tag{4}$$

Where $k = 1,\cdots,K$ is the subdivided k nd category and $m = 1,\cdots,M$ refers to the m th endogenous internal system. The matrix of $B_k = (\beta_{mk})$, $M \times M$, refers to the path coefficients between endogenous internal systems in category k, where $r = 1,\cdots,M$. Ψ_k refers to the variance of the regression residuals for each endogenous internal system in category k. Then for any η_i, obeys the Gaussian conditional distribution of the finite mixture model, i.e:

$$\eta_i = \sum_{k=1}^{K} |\rho_k f_i|_k \left(\eta_i | \xi_i, B_k, \Gamma_k, \Psi_k\right) \tag{5}$$

In Equation (5), ρ_k is the weight of the class. The class to which the data point belongs before subdivision can be regarded as the hidden information in the data, so the subdivision problem can be regarded as a kind of incomplete data or residual data problem. The residual part of the data is denoted by z_{ik}. According to the full probability formula, the posterior probability that the i rd sample comes from the k th class, i.e:

$$p(z_{ik} = 1) \frac{|\rho_k f_i|_k(\eta_i|\xi_i B_k, \Gamma_k, \Psi_k)}{\sum_{k=1}^{K} |\rho_k f_i|_k(\eta_i|\xi_i B_k, \Gamma_k, \Psi_k)} \tag{6}$$

In the above equation, p_{ik} is the expected value of the residual part of the data, $p_{ik} = E(z_{ik}) = p(z_{ik} = 1)$.

For the m rd endogenous internal system of the dependent variable, the dependent variable is $y_{mi} = \eta_n$ and the independent variable is $x_{mi} = ((\xi_{mi}), (\eta_{ni}))$. According to the method of least squares, the path coefficient is calculated as:

$$\tau_m = ((\beta_{mr}),(\nu_{mj})) = (x_m' x_m)^{-1} x_m{}' y_m \tag{7}$$

A given random sample $(x_1, x_2, \cdots, x_n)^T X$ for a n -dimensional random variable $X = (X_1, X_2, \cdots, X_p)$ follows a Gaussian distribution with mean μ and covariance $\sum$. If the ij th term of the covariance matrix $\sum$ is 0, then its counterparts X_i and X_j are conditionally independent given the other variables. Let $\Omega = \sum^{-1}$, S be the sample covariance matrix, the corresponding log-likelihood equation is obtained:

$$\ln L = |\Omega| + tr(\Omega S) - \rho \|\Omega\|_1 \tag{8}$$

Where Ω is a nonnegative positive definite matrix, tr denotes the trace of the matrix, and $\|\Omega\|_1$ is the norm of the sum l_1 of the absolute values of the $\sum^{-1}$ elements.

In order to achieve some kind of equilibrium or compromise between the target value and the degree of likelihood, this paper introduces the PLS algorithm to iteratively solve the fuzzy vectors in the results of scientific and technological transformations, as well as the expectations of each element in the vectors its.

3.1.2 Structural assessment

After the standardized analysis of the intrinsic factors of scientific and technological achievements conversion through PLS algorithm, this paper starts from this basis, this paper adopts the method of combining principal component analysis and great likelihood method.

Let the study of something involve p indicator, denoted by $X_1, X_2, \cdots, X_p$, respectively, and these p indicators form a p-dimensional random vector of $X = (X_1, X_2, \cdots, X_p)$.

A linear combination of X forms a new composite indicator, denoted by F, i.e., the new composite indicator can be linearly represented by the original variables, satisfying the following equation:

$$F_i = a_{i1}X_1 + a_{i2}X_2 + \cdots + a_{im}X_p, i = 1, 2, \cdots, k \tag{9}$$

The correlation coefficient matrix of the initial matrix is as follows:

$$X = \begin{bmatrix} X_1 & \cdots & X_p \\ \vdots & \vdots & \vdots \\ X_p & \cdots & X_{np} \end{bmatrix} \tag{10}$$

The correlation coefficient between the original variables X_i and X_j is:

$$r_{ij} = \frac{\sum_{s=1}^{n} (X_{si} - \bar{X}_i)(X_{sj} - \bar{X}_j)}{\sqrt{\sum_{s=1}^{n} (X_{si} - \bar{X}_i)^2 \sum_{s=1}^{n} (X_{si} - \bar{X}_j)^2}} \tag{11}$$

The formula for calculating the contribution rate to the variance of the original index data is as follows:

$$\omega_j = \frac{\lambda_j}{\sqrt{\sum_{j=1}^{p} \lambda_j}} \tag{12}$$

The cumulative variance contribution ratio $\frac{\sum_{j=1}^{k} \lambda_j}{\sum_{j=1}^{p} \lambda_j}$, indicates how much information has been extracted $X_1, X_2, \cdots, X_p$ cumulatively from the previous k principal components. The relationship between the principal component loading matrix a_{ij} and the factor loading matrix b_{ij}, is shown below:

$$a_{ij} = \frac{b_{ij}}{\sqrt{\lambda_{ij}}} \tag{13}$$

Suppose there is a data table for a certain moment t, denoted by H. Here, H there are n sample points $e_1, e_2, \cdots, e_n$ and each sample point is described by $2p$ indicator variables, i.e., x_1, x_2, K, x_p where x_1, x_2, K, x_p are p exogenous explicit variables, again constituting a set of endogenous explicit variables. At the tth moment, the data for the n sample points in the $2p$ -dimensional space can be represented by a $n \times 2p$-dimensional data table H:

$$H = \left[x_1 \; K \; x_p \; K \; x_p \right]_{n \times 2p} \tag{14}$$

Standardize all the significant variables in H, viz:

$$\tilde{x}_{ij} = \frac{x_{ij} - \overline{x_j}}{S_j} \quad i = 1, 2, K, n; \; j = 1, 2, K, p \tag{15}$$

Where $\overline{x_j} = \frac{1}{n} \sum_{i=1}^{n} x_{ij}$, $S_j = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_{ij} - \overline{x_j})^2}$, the standardized data removes the effect of the variable's magnitude, notation $\tilde{H} = (\overline{x}_{ij})_{n \times 2p}$.

The formula for calculating the indicators of the transformation of scientific and technological achievements is shown below:

$$B_{ij} = \frac{\lambda_{ij}}{\sum_{1}^{n} \lambda_{ik}} \tag{16}$$

$$W_k = B_{ij}{}^{*} A_i (k = 1, 2, \cdots, 13 | i = 1, 2, 3) \tag{17}$$

$$M = \sum_{k=1}^{14} C_k * W_k \tag{18}$$

In the above formula, C_k indicates the specific value of each index, and M is the maturity score of scientific and technological achievements transformation.

3.2 Construct a platform for analyzing the transformation of scientific and technological achievements

Promoting scientific and technological achievements in universities is an important guarantee for promoting the national innovation and development strategy. Achievement transformation is a complex scientific and technological economic activity, scientific and technological achievements conversion performance is a dynamic accumulation of dynamic results, scientific and technological achievements into economic and social value, often need years, it is not easy to measure with a single indicator, must first construct the university scientific research quality evaluation index system [20-21]. In this paper, the intrinsic factors of converting scientific and technological achievements are standardized and analyzed using the PLS algorithm.

The overall structure of the university's scientific and technological achievements transformation analysis platform is shown in Figure 2. Colleges provide technical patents or information for the government as a source of knowledge and information, and the government acts as the information control center of the whole system, formulates corresponding policies and systems, channels scientific achievements, and grasps the direction and development trends of the market. Enterprises are the direct actors in the transformation of scientific achievements, the applicators of achievements, and the executors of the industrialization of achievements. They are able to respond quickly to market changes and demands. Their main roles are to track the world's advanced technology, collect information about enterprises and the market, carry out scientific research activities according to the needs of the market, and then provide enterprises with patents and technologies to improve the productivity of the enterprises. Colleges have rich human resources and high-level scientific with intellectual advantages, academic advantages, multidisciplinary comprehensive advantages, and talent training advantages, and they are the main body of scientific and technological innovation in the system of scientific and technological achievements transformation. The goal of university scientific research institutes is to select and realize the technologies with specific purposes, to provide the enterprises with the technologies, and to promote the development of the enterprises.

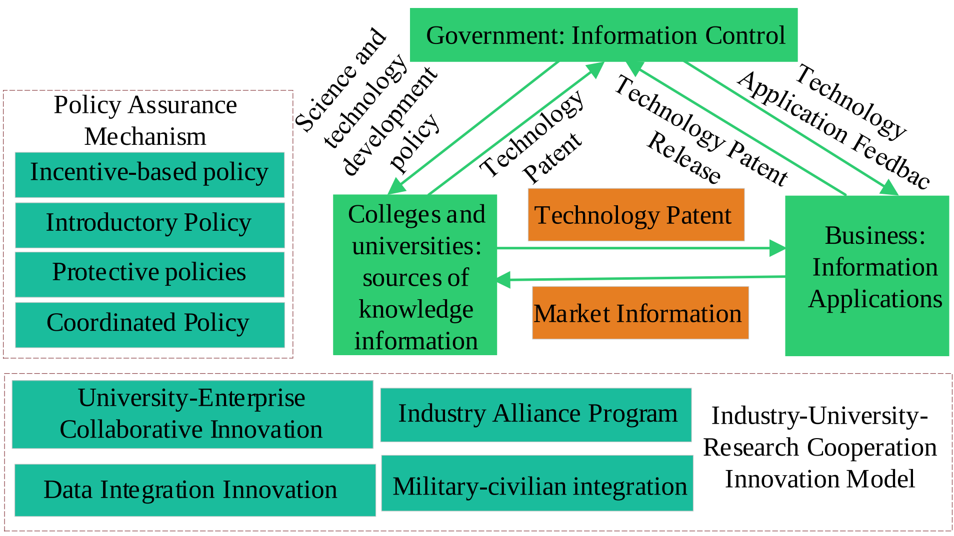


Figure 2. Analysis of scientific and technological achievements in flat

This paper is based on the structural equation modeling constructed by the university scientific and technological achievements transformation analysis platform. The method is measured from the intrinsic and extrinsic factors, respectively, and then comprehensively formulate the policy to guide the development of innovation. It constantly promotes technology innovation and product upgrading by occupying the market or exploring new markets to achieve the virtuous circle of university work. Conduct an adequate market analysis to ensure that the achievements are adapted to market demand. After achieving the achievement, please choose the appropriate time to transform it and realize its value. In terms of actively exploring new mechanisms, it can ensure that the direction of technological development of enterprises transforming the results does not deviate from the right track, which enhances the scale and level of scientific research of university organizations.

4 Practical analysis of the analysis platform for the transformation of scientific and technological achievements

4.1 Analysis of influencing factors

4.1.1 Data acquisition

1) Relevant data from universities and enterprises in the region were collected to obtain an assessment of the intrinsic and extrinsic factors of the transformation of scientific and technological achievements in universities.

2) Relevant interviews were designed for the intrinsic factors of information communication mechanism between universities and enterprises, intellectual property rights attribution issues, teachers' evaluation, and transformation service capacity to understand the perceptions and experiences of relevant participants. Scale scores or qualitative analyses were used to obtain the average values and correlations of these factors.

3) Data on the government's financial input and related policy documents were collected for the extrinsic factors that affect the transformation of scientific and technological achievements, such as financial input and policy environment. In addition, interviews with representatives of universities, enterprises, or relevant stakeholders were conducted to obtain qualitative feedback and views on these factors.

4) Following the data collection phase, data were analyzed using structural equation modeling.

4.1.2 Analysis of results

Table 1 shows the results of the analysis of influencing factors. From the perspective of intrinsic factors, the information communication mechanism between universities and enterprises has a high influence, with a mean value of 3.29 and a marginal probability occupying 10.1%, followed by intellectual property rights attribution issues, occupying 9.5%. Faculty evaluation and transformation service capacity have mean values of 3.35 and 3.38, respectively. From the external perspective, the influence of the financial investment problem on the transformation of scientific and technological achievements is high, reaching 36.3%, and the policy environment accounts for 16.5%.

Table 1. Results of the analysis of influencing factors.

Variable	Explanation	Total	Mean	Marginal probability
Intrinsic Factors	Intellectual Property Attribution	1085	3.32	9.5%
	Teacher Evaluation	1085	3.35	6.2%
	Transformation Service Capability	1085	3.38	7.3%
	Corporate Information Communication	1085	3.29	10.1%
External Factors	Financial Support	1085	3.79	36.3%
	Policy Environment	1085	3.56	16.5%
	Service System	1085	3.45	11.2%

This paper uses the structural analysis model to evaluate and count the research personnel invested by the universities in this region in the past 10 years so as to analyze the influencing factors of the transformation of scientific and technological achievements in universities more obviously. Figure 3 shows the results of analyzing the input of scientific research personnel. There have been relatively more teaching and scientific research personnel in colleges and universities in the region over the years, with an average of about 4,500 per year, followed by research and development personnel, which reached a maximum of 3,800 in 2011 and an average of about 2,000 per year after that. However, the number of research results applications and service personnel is relatively small. The average number of personnel is only 861 people. The region's scientific and technological achievements application and service full-time personnel in 2011 there are 3,500 people. In 2022, 800 people, in the second place, are in its scientific and technological personnel structure to occupy a large proportion. The structural equation model analyzes the factors influencing the transformation of scientific and technological achievements in this university at a deeper level and, therefore, reacts to the fact that university researchers must have the appropriate knowledge transfer capacity in order to transfer the transferred results to the enterprises in the appropriate form, manner, and way.

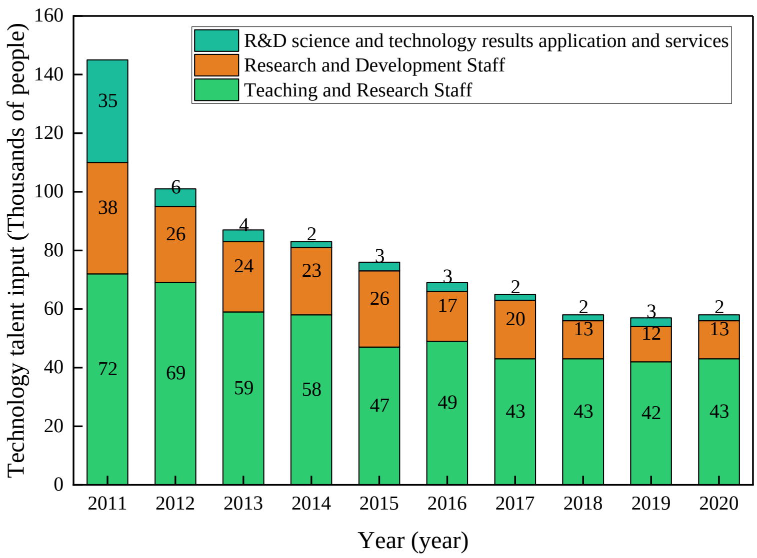


Figure 3. Results of researcher input analysis

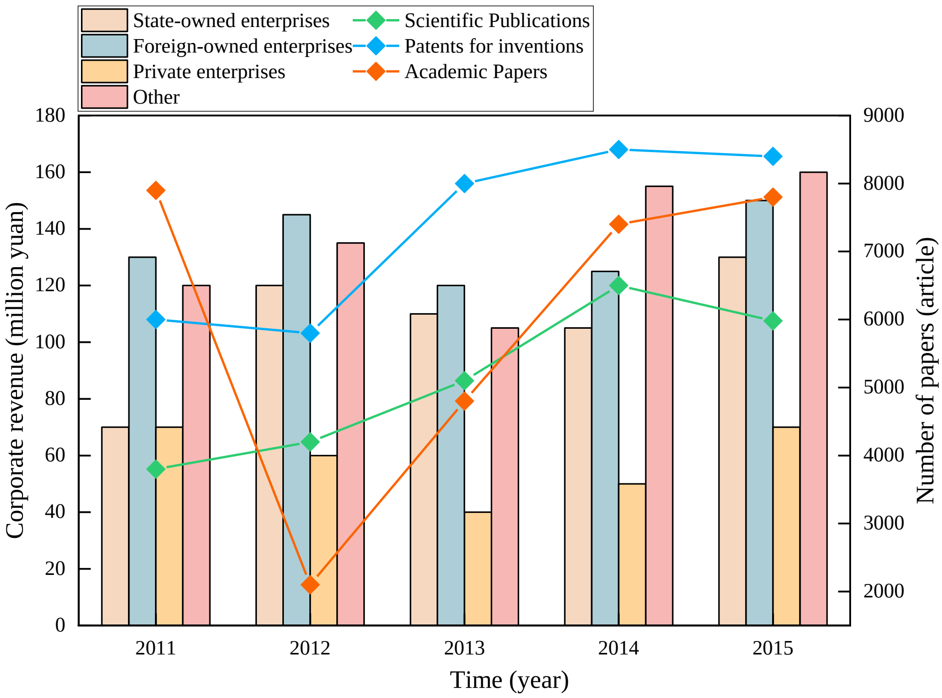
4.2 Effectiveness of services for the transformation of scientific and technological achievements

4.2.1 Efficiency of services

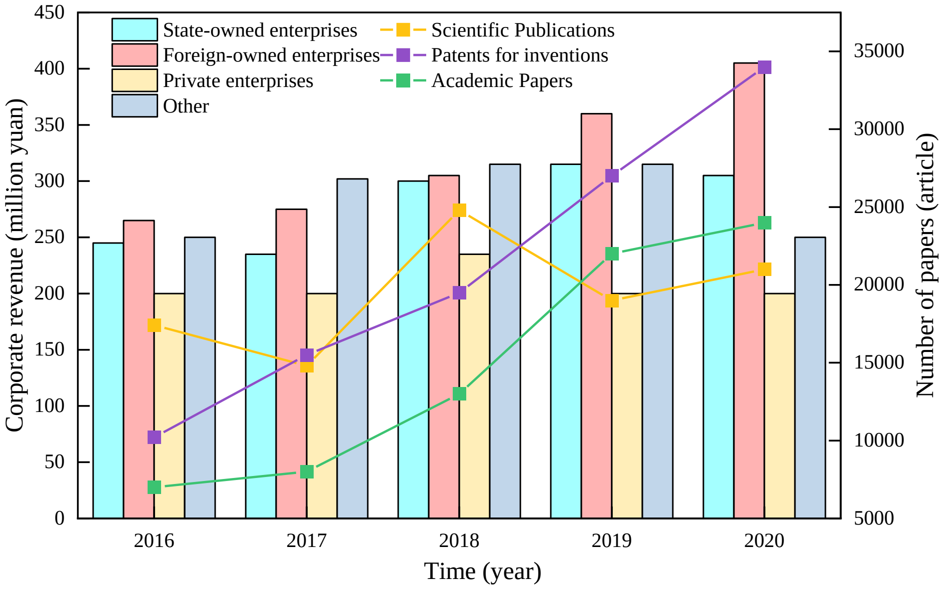
The most important criteria for consideration in the scientific and technological achievements of universities are the number of academic papers published, the number of patents authorized, and the achievements in the transformation of scientific and technological achievements are inseparable from the role played by the technology transfer and intellectual property management departments. Through the analysis of the above-influencing factors, therefore, in 2016, the scientific and technological achievements transformation analysis platform was used to analyze the scientific and technological transformation achievements of the universities in the region, as well as to evaluate the benefits of the transfer of the achievements to enterprises, so as to improve the efficiency of the service of scientific and technological achievements transformation in universities. The service efficiency of the transformation of scientific and technological achievements of universities in the region from 2011 to 2020 can be seen in Figure 4.

Figure 4(a) shows the earnings of enterprises and the number of papers published from 2011 to 2015. From the point of view of the earnings of enterprises, foreign-funded enterprises compared to state-owned and private enterprises, the earnings situation is higher, on average, reaching 1.34 million yuan per year, followed by the state-owned enterprises in 2011 earnings of only 900,000 yuan, although after a few years of an upward trend, but the number of earnings are for about 1.1 million yuan. Private enterprises are less, with an average gain of less than 800,000 yuan per year. In terms of the number of papers published, in these five years, the number of scientific and technical papers published by universities in the region was small, although there was an upward trend. Among them, the papers about scientific and technological works are only 5,116 per year on average, and the papers about the number of invention patents are 7,340 on average. It can be seen that the lower number of scientific and technological research of the universities in the region has led to the enterprises investing less in the universities, and therefore, they will lose the ownership, advantage, and privileged position of knowledge.

Figure 4(b) shows the enterprise earnings and the number of papers published from 2016 to 2020. The number of patents authorized for scientific and technological achievements in colleges and universities grows rapidly, and the proportion of invention patents is higher than others. From 2016, the total number of patents authorized for scientific and technological achievements of universities is 17,418, of which 10,216 are invention patents, accounting for 49.72% of the proportion of all patents authorized, and rising to 2020, the total number of patents authorized for scientific and technological achievements of universities is 68,971, of which the invention patents rise to 34,294, accounting for 58.65% of the proportion of all patents authorized. And the enterprise revenue increases with the growth of invention patents, which averages 1.23 million yuan per year. It shows that the number of university scientific and technological achievements that have been authorized for patents has rapidly grown in recent years, as measured by the resultant equation model. Compared with the other two patent types of utility model and design, the invention patent requires the highest technological content, especially the requirement of novelty and inventiveness is more. The patent authorization of scientific and technological achievements of universities is not only abundant in quantity but also guaranteed in quality.



(a) Corporate revenue and number of papers published from 2011-2015



(b) Corporate revenue and the number of papers published from 2016-2020

Figure 4. Service efficiency of science and technology transformation

4.2.2 Patent classification

Colleges and universities are of different types and have different specialized fields of expertise, so there are significant differences in their patent classification. Selecting representative colleges and universities in different regions and classifying them by group according to the 2016-2020 patent authorization data can show the specific distribution of the patent technology field of a particular college or university. Table 2 shows the number of patents in the field of technology in universities. From the data in the table, it can be seen that different universities have different fields of scientific and technological research. This paper, after structural equation modeling, analyzed the transformation of scientific and technological achievements of each university and screened out the key disciplinary areas of scientific and technological innovation activities, in which the university A for the study of line faults has a higher number of patents of 283, and the school B and the school C are respectively on the preparation of the regeneration and catalytic methods The research on copper refining patents. The number of patents on copper refining research is 123, mainly in the research area of school D. The research of University E is about the fabrication of nanostructures, with 105 patents. This shows that structural equation modeling can focus on the layout and mining of the patent technology field to form the core patents with high patent value so as to improve the scientific research level of universities.

Table 2. Number of patents in the field of university technology

School Number	Technology Type	Number of patents
A	Line failure	283
B	Recycled Manufacturing	170
C	Catalytic methods	132
D	Copper refining	123
E	Fabrication of nanostructures	105

5 Conclusion

With the goal of analyzing the factors affecting the transformation of scientific and technological achievements in universities, this paper analyzes the regional, hierarchical, and quantitative characteristics of the transformation of scientific and technological achievements in universities in detail based on the structural equation model. The transformation of scientific and technological achievements in colleges and universities can be analyzed through statistical analysis, data correlation analysis, and factor analysis. Firstly, the PLS algorithm is used to analyze the expected value of intrinsic variables obeying the Gaussian distribution. Then, the index system of scientific and technological achievements transformation of high-level scientific and technological colleges and universities is constructed by objectively assigning weights to the evaluation index system with the use of the principal component analysis method. The model parameters are estimated with the use of the great likelihood method. Finally, the effectiveness of the method presented in this paper is verified through practical analysis. The results show that the factors affecting the transformation of scientific and technological achievements are influenced by the policy environment, which occupies 16.5%, and the problem of capital investment, which occupies 36.3%. After a thorough analysis, the percentage of patents authorized by universities reached 58.65%. It is an annual increase of 1.23 million yuan in corporate earnings and mining of research fields of different schools to form core patents with high patent value and improve the scientific research level of colleges and universities.

Reference

[1] Zheng, X. (2017). Evaluation of transformation of scientific and technological achievements in enterprise. Ship Building of China, 58, 714-718.

[2] Xu, J., Chen, D., Liu, R., Zhou, M., & Kong, Y. (2021). Environmental regulation, technological innovation, and industrial transformation: an empirical study based on city function in china. Sustainability, 13. 12512

[3] Marta Magadán Díaz, & Jesús I. Rivas García. (2021). The role of kibs on digital transformation and technological changes in the spanish publishing industry. Malaysian Journal of Library and Information Science, 26(1), 83-101.

[4] Zhao, X., Ding, X., & Li, L. (2021). Research on environmental regulation, technological innovation and green transformation of manufacturing industry in the yangtze river economic belt. Sustainability, 13. 1-15

[5] Wang, X. (2017). Research on financing problems and countermeasures of intellectual property rights of small and medium sized scientific and technological enterprises. Boletin Tecnico/Technical Bulletin, 55(15), 633-637.

[6] Sagalevich, A. M., & Sagalevich, V. D. (2020). Outstanding achievements in ocean technology and science in the 20 th century. Marine Technology Society Journal, 54(4), 68-80.

[7] Tabatabaei, M., Soltanian, S., Aghbashlo, M., & Nizami, A. S. (2019). Fast pyrolysis of biomass: advances in science and technology: a book review. Journal of Cleaner Production, 213.1411-1413

[8] Jia, W., Xie, Y., Zhao, Y., Yao, K., & Chong, D. (2021). Research on disruptive technology recognition of china's electronic information and communication industry based on patent influence. Journal of Global Information Management, 29(2), 148-165.

[9] Kai, S., Zhijian, L., Xiangwei, Y Agricultural machinery automatic guidance technology based on patent map., Qiufei, Q., & Yeqing, W. (2017). International Agricultural Engineering Journal, 26(2), 1-11.

[10] Ma, J., Zhang, Y., & Qiu, X. (2017). Construction of interdisciplinary research platform in agricultural universities. Boletin Tecnico/Technical Bulletin, 55(18), 639-644.

[11] Lei, K., & Zhang, M. (2021). Research on transformation mode of scientific and technological achievements with different transaction costs: taking the electric power industry as an example. MATEC Web of Conferences, 336(1), 09016.

[12] Zhang, Q., Zhao, X., Qiao, W., Zou, Y., & Yao, Y. (2019). Research on scientific gas extraction technology in paper engineering. Paper Asia, 2(3), 66-70.

[13] Zhang, L. (2017). Analysis on the development of high-tech industry cluster in harbin scientific and technological innovation platform. Revista de la Facultad de Ingenieria, 32(2), 342-348.

[14] Liu, Q. (2017). Design and implementation of scientific research information management system for universities. C e Ca, 42(3), 1014-1019.

[15] Dong, Z. (2019). A study on the transformation and upgrading of zhejiang marine economic industrial structure based on the analysis and evaluation of scientific and technological innovation. Journal of Coastal Research, 98(sp1), 231-234.

[16] Li, W., & Zhang, P. (2020). Developing the transformation of scientific and technological achievements in colleges and universities to boost the development of low-carbon economy. International Journal of Low-Carbon Technologies.305-316

[17] Karani, A., Deshpande, R., Jayswal, M., & Panda, R. (2021). Work-life balance and psychological distress: a structural equation modeling approach. Human Systems Management(4), 1-15.

[18] Xu, Y., & Xu, N. (2021). Fpga autotuning optimization based on structural equation modeling. Procedia Computer Science, 183(2), 132-138.

[19] Yang, L., Wang, J., & Zhou, G. (2017). An influence effectiveness model for rural finance demand based on structural equation modeling. Revista de la Facultad de Ingenieria, 32(16), 23-29.

[20] Subia, G. S., Marcos, M. C., Pascual, L. E., Tomas, A. V., & Liangco, M. M. (2020). Cognitive levels as measure of higher-order thinking skills in senior high school mathematics of science, technology, engineering and mathematics (stem) graduates. Technology Reports of Kansai University, 62(3), 261-268.

[21] Wagner, C. S., Roessner, J. D., Bobb, K., Klein, J. T., Boyack, K. W., & Keyton, J., et al. (2017). Article in press g model approaches to understanding and measuring interdisciplinary scientific research (idr): a review of the literature article in press g model. Journal of Informetrics, 5(1), 14-26.