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# *Research on the Optimization and Coordination of Higher Education Resources Allocation Efficiency Based on Blockchain Technology*

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***Abstract:*** Under the circumstance that the total amount of educational resources that can be provided in a region is limited, the efficiency of resource use should be improved. Improving the efficiency and synergy of the optimal allocation of higher education resources can improve the utilization efficiency of educational resources and better achieve the sustainable development of higher education. However, due to the limitations of the traditional way of optimizing the allocation of educational resources in improving the efficiency and coordination of higher education resource allocation, based on blockchain technology, this paper built a collaborative sharing platform for higher education resources based on blockchain technology, and conducted experimental research on it from several aspects. The research showed that with the help of the collaborative sharing platform of higher education resources based on blockchain technology, the talent training output index of higher education institutions has increased by 4.9%, the scientific research output index has increased by 4.54%, the social service index has increased by 5.23%, and the coordination degree of resource allocation has increased by 4.91%. Under the circumstance that the investment level of educational resources is not much different, the resource allocation method based on blockchain technology can improve the efficiency of optimal allocation of educational resources.

## 1. Introduction

The traditional way of optimizing the allocation of educational resources has not kept pace with the development of the times, and has limited effect in improving the efficiency and synergy of the optimal allocation of higher education resources. The use of blockchain technology to improve the

efficiency of resource allocation and the degree of coordination can promote the effective use of educational resources and improve the output level of educational resources.

Cui D M evaluated the performance of teaching managers in the coordination of educational resource allocation, and put forward suggestions for promoting the integration of educational resources and establishing an educational resource sharing platform [1]. You L used the super-efficiency data envelopment analysis model to evaluate the allocation efficiency of educational resources, which improved the visualization of resource allocation efficiency [2]. Fang C studied the relationship between educational financial investment and educational resource allocation efficiency [3]. Zhang S J studied the current situation of educational resources, analyzed the limitations of the two resource allocation methods of government allocation and market allocation, and proposed some measures to promote the coordination of educational resource allocation [4]. Sun H P studied the current situation of higher education resource utilization in a province [5]. Aiming at the problem of the allocation of educational resources in higher vocational colleges, Li D Z put forward countermeasures to strengthen the construction of teachers and continuously update the allocation mode in combination with advanced technology [6]. Liu Y analyzed the feasibility of realizing the diversification of property rights in the higher education industry to improve the efficiency of educational resource allocation, and came to the conclusion that this method can improve the efficiency of educational resource allocation [7]. He P discussed the development prospects of blockchain technology, applied blockchain technology to the field of data security, and proposed measures for distributed management of data [8]. Li B applied blockchain technology to the power field and established a distributed intelligent power management system [9]. Liu L used blockchain technology to build a fresh supply chain risk identification system [10]. Yang Y Y has used blockchain technology in alcohol anti-counterfeiting [11]. Jiang H F applied blockchain technology to the financial field, and proposed some measures to use blockchain technology to reduce the cost of financial transactions and ensure the security of financial transactions [12]. Yu L S analyzed the characteristics of blockchain technology, and studied in detail the role of blockchain technology in reshaping the accounting field, including the reshaping of accounting data confirmation, the reshaping of accounting measurement, etc. [13]. Deng J G established a news report authenticity degree analysis system based on blockchain technology, and proved through experiments that this system can effectively distinguish the authenticity degree of news [14]. Although blockchain technology is widely used in many fields, it is rarely used in the field of education.

## 2. Application of Blockchain Technology in the Field of Education

(1) Realization of educational resource sharing

Blockchain technology can realize the sharing of educational resources. Although online educational resources provide people with many free and open digital resources, they also bring problems such as copyright protection, insufficient quality, and high sharing costs. However, blockchain-based educational resources have a significant openness feature, allowing students to learn and access information about all educational resource entities. In terms of solving quality problems, blockchain technology can utilize its smart contracts and consensus mechanisms to guarantee the quality of educational resources. The decentralization feature of blockchain technology can realize the sharing of educational resource data between nodes, and can reduce the management and sharing costs of educational resources. In addition, blockchain technology also has the characteristics of non-tampering. The nodes that store educational resources are distributed and the number is large. The modification of a single node cannot affect the educational resource data of other nodes, which ensures the data security of educational resources.

(2) Student classroom management

At this stage, college students' attendance and classroom performance are generally recorded manually by teachers before and after class. There is a risk of memory loss and misremembering in this kind of classroom management, and the accuracy of the records of student attendance and students' classroom performance is not high. In student classroom management, there may also be cases where students tamper with attendance and classroom performance, and even teachers modify the real situation of students' classroom performance for some reason. The combination of blockchain technology and student classroom management and the decentralization and immutability of blockchain technology can effectively ensure the security of students' classroom management information, so that teachers and teaching managers can more truly understand the classroom management situation.

(3) Guarantee of the authenticity of students' academic qualifications and degree information

Students' academic qualifications and degrees are important credentials for social recruitment and study abroad. The existing education management system is still mainly centralized to collect students' academic and degree information, and relies too much on the school's education information management system, making the issue of trust a barrier between students and enterprises, and between students and foreign universities. Distributed cloud storage of academic qualifications and degree information combined with blockchain technology can effectively reduce the risk of tampering with students' academic qualifications and degree information, can effectively guarantee the authenticity of students' academic qualifications and degree information, and also facilitate the access of relevant institutions.

## 3. Measures to Improve the Efficiency and Synergy of the Optimal Allocation of Educational Resources

(1) Evaluation index system of educational resource allocation efficiency

1) Principles of selection of evaluation indicators of educational resource allocation efficiency

When evaluating the allocation efficiency of educational resources, only by selecting scientific and reasonable evaluation indicators can the true and accurate evaluation results of the allocation efficiency be obtained. This paper analyzes the principles of selecting evaluation indicators, and the specific content is shown in Figure 1.

As shown in Figure 1, when evaluating the efficiency of educational resource allocation, the principles of scientific rationality, purpose, simplicity, data availability, and comprehensiveness should be adhered to. Adhering to the principle of scientific rationality means that the selected evaluation indicators should be able to truly and objectively reflect the efficiency of the allocation of educational resources. The principle of purpose emphasizes the selection of indicators on the efficiency of educational resource allocation according to specific research purposes. The principle of simplicity means that the evaluation indicators should reduce the number of evaluation indicators as much as possible on the basis of reflecting the nature of the evaluation object. The principle of data availability means that when selecting evaluation indicators, it is necessary to consider the difficulty of obtaining evaluation index data, and try to avoid selecting evaluation indicators that are difficult to obtain. The principle of comprehensiveness means that the selected evaluation indicators can fully reflect the input and output of higher education resources, and the comprehensiveness and authenticity of the evaluation results cannot be affected by the lack of a certain evaluation indicator.

2) Evaluation index system

Knowing the indicators for evaluating the efficiency of educational resource allocation can better evaluate the efficiency of educational resource allocation. This paper establishes an evaluation index system about the efficiency of educational resource allocation, and the specific content is

shown in Figure 2.

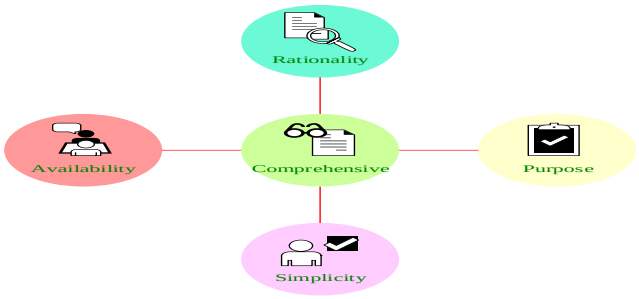


Figure 1: Selection principles of efficiency evaluation indicators

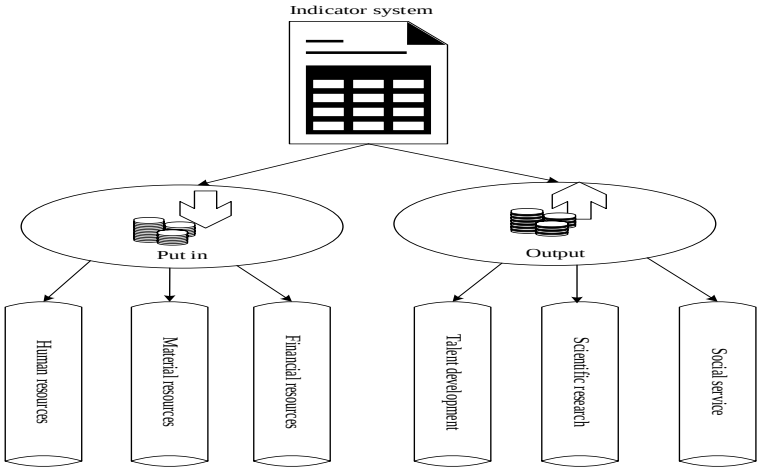


Figure 2: Efficiency evaluation index system

As shown in Figure 2, the efficiency evaluation index has two aspects: educational resource input index and educational resource output index. Input indicators include human resource input indicators, material resource input indicators and financial resource input indicators, and output indicators include talent training output indicators, scientific research output indicators and social service output indicators. Human resources in the field of education include teachers, teaching assistants, administrative and scientific research personnel, etc. The human input indicator generally selects the number of teachers, teaching assistants, etc. In addition, the input of material resources refers to the input of teaching equipment, books and other teaching resources, and the input of financial resources generally refers to the expenditure of institutional education funds. The output indicators of talent training are generally expressed by the number of students in school, the number of graduates, and the number of effective employment. The scientific research output indicator is generally expressed by the number of academic papers, scientific and technological reports, invention patents, and other scientific research achievements.

(2) Implementation process of efficiency evaluation of educational resource allocation

There are four steps in the implementation of educational resource allocation efficiency evaluation, and the specific content is shown in Figure 3.

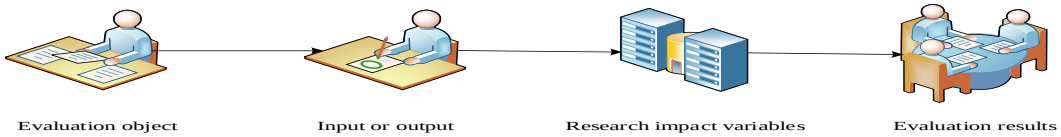


Figure 3: Implementation process of efficiency evaluation

As shown in Figure 3, first, the evaluation object should be determined, and which schools

should be evaluated for resource allocation efficiency; second, it should be determined whether to evaluate resource allocation input or resource allocation output in combination with the evaluation object; third, the input and output indicators are determined according to the evaluation objectives, and the variables that affect the input and output indicators are studied; fourth, the input and output indicators of educational resources and related variables are analyzed to obtain efficiency evaluation results.

(3) Collaborative sharing platform for higher education resources based on blockchain technology

Blockchain technology can promote the sharing of educational resources and effectively ensure information security. The overall architecture of the higher education resource collaborative sharing platform based on blockchain technology has four modules, and the specific contents are shown in Figure 4.

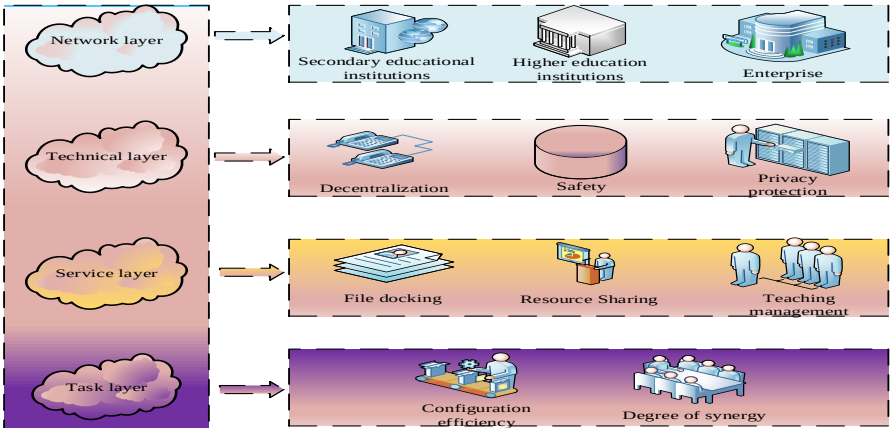


Figure 4: Higher education resource collaborative sharing platform

As shown in Figure 4, the overall architecture of the collaborative sharing platform has four modules: network layer, technology layer, service layer and task layer. At the network layer, higher education institutions establish consortium chains with secondary education institutions and enterprises in the form of peer-to-peer network connections. As the student source provider of higher education institutions, secondary education institutions would record students' performance in the blockchain, including students' grades, awards, classroom performance evaluation, teacher evaluation, etc. Similarly, higher education institutions can show students' comprehensive school performance to relevant companies when students are doing internships or formally participating in work, so as to achieve higher and more accurate docking efficiency. The functions of the technical layer mainly include the decentralization, security and privacy protection of blockchain technology. The service layer includes student file docking, collaborative sharing of educational resources, and efficient teaching management. The content of the task layer is to improve the efficiency and coordination of educational resource allocation.

The collaborative sharing platform improves the efficiency and degree of collaboration of educational resource allocation mainly in two aspects. First, the collaborative sharing platform can promote the transformation of higher education resources from dispersion and isolation to convergence and integration, and improve school resource allocation capabilities and collaboration levels. From the perspective of the society as a whole, the school's collaboration with scientific research institutes can improve the level of discipline specialization and increase the amount of school's scientific research output. The school's collaboration with enterprises can provide students with more employment channels and increase the employment rate of students. From the perspective of the school, the collaborative sharing platform can try to avoid the problem of

duplication of resources within the school. Through the collaborative sharing platform, the school can realize the sharing of resources among different departments. The number and location of books and equipment can be sorted into categories, the database can be integrated synchronously, the integration of resources can be better achieved, and the output of educational resources can be increased on the basis of appropriate educational resource input. Second, the collaborative sharing platform can better maintain the balanced development of the three educational resource allocation forces of the government, higher education institutions, and enterprises.

## 4. Algorithms for Evaluating the Efficiency and Synergy of Educational Resource Allocation

(1) Neutral DEA (Data Envelope Analysis) efficiency evaluation method

Taking the educational resource system as the decision-making unit, if there are j decision-making units in total, the input type of each decision-making unit is *i*, and the output type is *t*. For the qth decision-making unit, its *p* input is $\chi_{pq}$, the *u* output is $\gamma_{pq}$, and then the efficiency calculation formula of the decision-making unit is:

$$t_{\bullet}\ s_{\bullet}\quad \vartheta_{cc}=\frac{\sum_{u=1}^{t} r_{uc}\gamma_{pq}}{\sum_{p=1}^{i}\omega_{pc}\chi_{pq}}\le 1 \tag{1}$$

$$t_{\bullet}\ s_{\bullet}\quad \vartheta_{cc}=\frac{\sum_{u=1}^{t} r_{uc}\gamma_{uq}}{\sum_{p=1}^{i}\omega_{pc}\chi_{pq}}\le 1 \tag{2}$$

Among them, $r_{uc}$ and $\omega_{pc}$ are the weights used when evaluating the decision-making unit, and $\vartheta_{cc}$ is the maximum efficiency value obtained.

The cross-efficiency evaluation value of the decision-making unit is:

$$\vartheta_{co}=\frac{\sum_{u=1}^{t} r_{uc}^{*}\gamma_{uo}}{\sum_{p=1}^{i}\omega_{pc}^{*}\chi_{po}} \tag{3}$$

The adversarial crossover efficiency model of the decision unit is:

$$\min\ D=\sum_{u=1}^{t} r_{uo}\left(\sum_{q=1,q\neq 0}^{j}\gamma_{uq}\right) \tag{4}$$

$$t_{\bullet}\ s_{\bullet}\ \sum_{p=1}^{i}\omega_{po}\left(\sum_{q=1,q\neq 0}^{j}\chi_{pq}\right)=1 \tag{5}$$

$$\sum_{u=1}^{t} r_{uo}\gamma_{uc}-\vartheta_{cc}^{*}\sum_{p=1}^{i}\omega_{po}\chi_{pc}=0 \tag{6}$$

The benevolent cross-efficiency model of the decision-making unit is:

$$\max \quad R = \sum_{u=1}^{t} r_{uo} \left( \sum_{q=1, q\neq 0}^{j} \gamma_{uq} \right) \tag{7}$$

$$\sum_{u=1}^{t} r_{uo} \gamma_{uc} - \sum_{p=1}^{i} \omega_{po} \chi_{pq} \leq 0 \tag{8}$$

The average adversarial and benevolent crossover efficiency can be expressed as:

$$\overline{\vartheta_o} = \frac{1}{j} \sum_{c=1}^{j} \vartheta_{co} \tag{9}$$

The neutral DEA crossover efficiency evaluation model is:

$$\max \quad \varepsilon = \min_{u \in \{1,2,\ldots t\}} \left\{ \frac{r_{uo} \gamma_{uo}}{\sum_{p=1}^{i} \omega_{po} \chi_{po}} \right\} \tag{10}$$

$$t. s. \ \vartheta_{cc}^{*} = \frac{\sum_{u=1}^{t} r_{uo} \gamma_{uc}}{\sum_{p=1}^{i} \omega_{po} \chi_{pc}} \tag{11}$$

(2) Evaluation of the degree of coordination in the allocation of educational resources

The formula for calculating the index correlation degree of the subsystems in the educational resource system is:

$$k_q = \varsigma_q \sum_{q=1}^{j} \left(1 - u_{pq}\right) \tag{12}$$

Among them, $k_q$ is the influence degree of the qth index on the educational resources subsystem, $\varsigma_q$ is the standard deviation of the qth index, and $u_{pq}$ is the correlation coefficient between the pth index and the qth index.

The weight calculation formula for the indicators of the educational resources subsystem is:

$$\nu_q = \frac{k_q}{\sum_{q=1}^{j} k_q} \tag{13}$$

The formula for calculating the order degree of the educational resources subsystem is:

$$FD(r_{qp})=\begin{cases}\dfrac{\chi_{qp}-b_{qp}}{a_{qp}-b_{qp}}\\ \dfrac{a_{qp}-\chi_{qp}}{a_{qp}-b_{qp}}\end{cases} \tag{14}$$

$$FD_q(r_q)=\sum_{q=1}^{j}v_{pFD}(r_{qp}) \tag{15}$$

Among them, $FD(r_{qp})$ is the order degree of the educational resource subsystem.

The collaborative evaluation formula of the educational resource system is:

$$TE=\sqrt{\left|FD_1^{s1}(r_1)-FD_1^{s0}(r_1)\right|}\times\ldots\times\sqrt{\left|FD_q^{s1}(r_q)-FD_q^{s0}(r_q)\right|} \tag{16}$$

$$TE=\sqrt{\left|FD_q^{j}(r_q)-FD_q^{z}(r_q)\right|} \tag{17}$$

Among them, $FD_q^{s0}(r_q)$ is the order degree of the educational resource subsystem at time $s_0$, $FD_q^{z}(r_q)$ is the order degree of a certain educational resource subsystem, and $FD_q^{j}(r_q)$ is the order degree of the educational resource system other than this educational resource subsystem.

## 5. Experimental Purpose and Design of Higher Education Resource Optimal Allocation Efficiency and Synergy

(1) The purpose of the experiment

This paper studies the efficiency and coordination degree of blockchain technology and the optimal allocation of educational resources, and proposes a collaborative sharing platform for educational resources based on blockchain technology. Through the simulation experiment research on the collaborative sharing platform of educational resources based on blockchain technology, it is proved that blockchain technology can promote the efficiency and synergy of the optimal allocation of educational resources.

(2) Experimental design

In order to ensure the accuracy of the experimental data, this paper investigates and collects the optimal allocation efficiency and coordination degree of educational resources in a certain region. A simulation mathematical model about the optimal allocation efficiency and coordination degree of educational resources in a certain region is constructed by using artificial intelligence algorithm and computer technology. In this paper, two colleges and universities are set up in the mathematical model. One school uses a collaborative sharing platform of educational resources based on blockchain technology to realize the optimal allocation of educational resources. This school is called school B. Another school uses the traditional way of optimizing the allocation of educational resources to achieve the optimal allocation of educational resources. This school is school T. A six-year study was conducted on these two schools from five aspects: educational resource input index, talent training output index, scientific research output index, social service index and the degree of coordination of resource allocation. Appropriate use of computer technology can be used to speed up the experimental process, and the experimental results can be observed and analyzed after the experiment is over.

## 6. Experimental Results of the Efficiency and Synergy of Higher Education Resource Optimal Allocation

(1) Educational resource investment indicators

The educational resource investment indicators include human, material and financial resource indicators. This paper records the number of teachers in the two schools over a 6-year period, and the results are shown in Table 1.

As shown in Table 1, the number of teachers in school B has been increasing, and the number of teachers in the sixth year has increased a lot compared to the number of teachers in the first year. However, the number of teachers in school T has increased and decreased, and the number of teachers in the sixth year is not much different from the number of teachers in the first year, which shows that the collaborative sharing platform of educational resources based on blockchain technology can effectively guarantee the investment of teachers.

Table 1: Number of teachers in two schools

| | School B | School T |
|---|---|---|
| 1 | 4526 | 4523 |
| 2 | 4535 | 4501 |
| 3 | 4569 | 4521 |
| 4 | 4575 | 4536 |
| 5 | 4579 | 4523 |
| 6 | 4591 | 4528 |

Material resources can be calculated together with financial resources. The unit of annual investment is 100 million yuan. The specific results are shown in Table 2.

Table 2: Annual investment of two schools

| | School B | School T |
|---|---|---|
| 1 | 11.326 | 12.156 |
| 2 | 11.314 | 11.936 |
| 3 | 11.305 | 11.912 |
| 4 | 11.213 | 11.873 |
| 5 | 11.103 | 11.753 |
| 6 | 11.029 | 11.526 |

As shown in Table 2, the material and financial investment of school B has been in a state of decline, and the investment index of the sixth year has dropped a lot compared with the investment index of the first year. However, the material and financial investment of school T is also gradually declining in the simulation experiment environment, but the final effect is not as good as that of school B, which shows that the collaborative sharing platform of educational resources based on blockchain technology can effectively reduce the investment of material and financial resources.

(2) Talent training output indicators

The output indicators of talent training include the number of students in school, the number of graduates, the number of effective employment, etc. This paper records the talent training output indicators of school B and school T, and the index value ranges from 1 to 100. The results are shown in Figure 5.

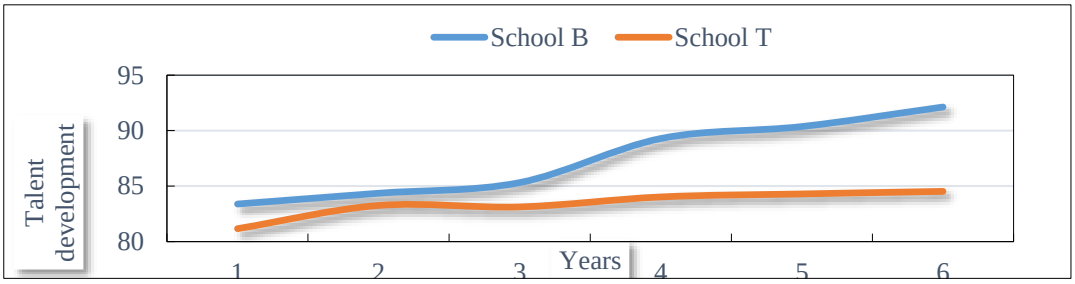


Figure 5: Talent training output indicators

As shown in Figure 5, from the perspective of the change trend of the talent training output index, the talent training output index of school B is on the increase, and the talent training output index of school T has declined in the third year. Judging from the specific data results, the talent training output index of school B in the sixth year was 92.13, and the talent training output index of school T in the sixth year was 84.52. In the sixth year, the talent training output index of school B was 7.61 higher than that of school T. The average talent training output index of school B was 87.48, and the average talent training output index of school T was 83.39. The average talent training output index of school B was 4.9% higher than that of school T.

(3) Scientific research output indicators

The scientific research output indicators include academic papers, scientific research reports and other scientific research results. The scientific research output indicators of school B and school T are recorded, and the index value ranges from 1 to 100. The results are shown in Figure 6.

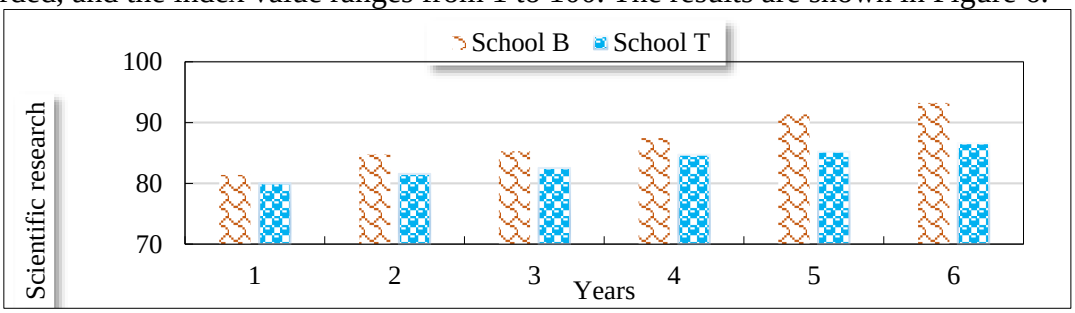


Figure 6: Scientific research output indicators

As shown in Figure 6, during the six-year period, the scientific research output indicators of both school B and school T have gradually increased. In the first year, the scientific research output index of school B was 81.39, and the scientific research output index of school T was 80.02. In the sixth year, the scientific research output index of school B was 93.25, and the scientific research output index of school T was 86.61. The average scientific research output index of school B was 87.24, and the average scientific research output index of school T was 83.45. Compared with the average scientific research output index of school T, the average scientific research output index of school B increased by 4.54%.

(4) Social service indicators

The social service indicators of school B and school T are recorded, and the value range of social service indicators is 1-100. The social service indicators of school B and school T are shown in Figure 7.

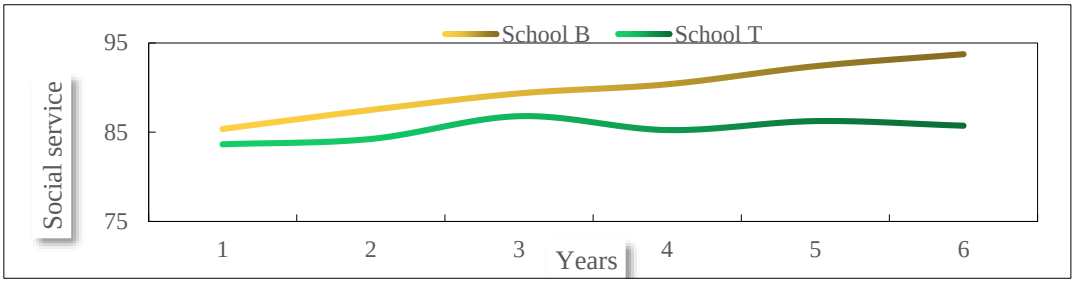


Figure 7: Social services indicators

As shown in Figure 7, the social service index of school B has been increasing, while the social service index of school T has declined in the fourth and sixth years. From the results, the social service index of school B in the sixth year was 93.73, and the social service index of school T in the sixth year was 85.73. In the sixth year, the social service index of school B was 8 higher than that of school T. The average social service index of school B was 89.78, the average social service index of school T was 85.32, and the average social service index of school B was 85.32. Compared with school T, the average social service index has increased by 5.23%.

(5) The degree of coordination of resource allocation

This paper analyzes and records the coordination degree of resource allocation of school B and school T. The value range of the index of coordination degree is 1-100. The specific results are shown in Figure 8.

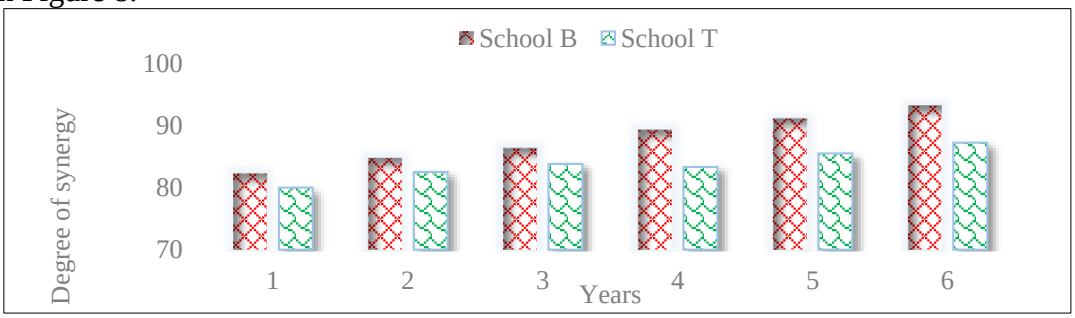


Figure 8: Resource allocation coordination degree

As shown in Figure 8, the coordination degree of resource allocation in the first year of school B was 82.29, and that in the sixth year was 93.23. The coordination degree of resource allocation in the sixth year of school B was 10.94 higher than that in the first year. The coordination degree of resource allocation in the first year of school T was 79.99, the degree of coordination in resource allocation in the sixth year was 87.27, and the degree of coordination in resource allocation in the sixth year of school T was 7.28 higher than that in the first year. The resource allocation coordination degree index of school B has been on the rise, and the resource allocation coordination degree of school T has declined in the fourth year, indicating that the collaborative sharing platform of educational resources based on blockchain technology can stably maintain the improvement of the degree of coordination of resource allocation. The average resource allocation coordination degree of school B was 87.85, and the average resource allocation coordination degree of school T was 83.74. The average resource allocation coordination degree of school B was 4.91% higher than that of school T.

## 7. Conclusions

In order to improve the efficiency and synergy of the optimal allocation of higher education resources, this paper established an evaluation index system for the efficiency of educational

resource allocation and a collaborative sharing platform for educational resources based on blockchain technology. Combined with the neutral DEA efficiency evaluation method and the synergy degree evaluation method, an experimental study was carried out on the five aspects of educational resource input index, talent training output index, scientific research output index, social service index and resource allocation synergy degree. The results showed that the resource allocation method combined with blockchain technology can significantly increase the output level of educational resources, improve the optimal allocation efficiency and coordination degree of educational resources, and improve the utilization level of educational resources.

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