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Computational Analysis of Resource Allocation Optimization and Dynamic Planning for Continuing Education under Community Education Governance Framework

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ABSTRACT
In this paper, Kernel density estimation method is used to analyze the distribution characteristics of continuing education resources and reveal the distribution pattern of resources in different communities. On this basis, CCR model and BCC model are introduced to optimize the DEA model of data envelopment analysis and evaluate the resource allocation of continuing education institutions. The resource allocation optimization and dynamic planning system of continuing education is further constructed, and the system dynamics simulation method is used to simulate the optimization process of resource allocation, which provides a scientific basis for the governance of community education. The results show that: continuing education resource input is polarized in quantity, its performance level is not high, regional differences are significant, and scale efficiency is a key factor restricting quality improvement. This paper constructs a system dynamics model for the quality and user use of educational information resources, and in view of the difficulties of optimization and dynamic planning of the allocation of continuing education information resources, it is proposed that the managerial and digital educational resource platform construction-based inputs such as teachers' information technology application ability, assessment system construction, etc. should be improved to promote the high-quality and balanced development of continuing education informatization.

Keywords: Kernel density estimation, DEA model, Resource allocation, Continuing education, Dynamic modeling

1. Introduction

Colleges and universities as a school organization, the educational activities it carries out will inevitably consume a certain amount of educational resources, and continuing education in colleges and universities on the dependence of resources is more prominent [1-2]. Because, the degree of marketization of continuing education in colleges and universities, to be higher than the government-

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led, the autonomy and flexibility of schooling is higher, the scale of continuing education, quality, the economic and social benefits achieved and the occupation of continuing education resources are closely related [3-6]. The more educational resources invested in people, money and materials, the more significant the economic and social benefits achieved, the easier it is to form the corresponding scale effect and brand effect [7-9]. Educational resources are indispensable safeguard conditions for universities to carry out continuing education, and are the basis for the sustainable development of the cause of continuing education. Through the integration of educational resources, it can realize the rational allocation of resources, reduce duplication of construction, avoid idle and wasteful resources, and maximize the effectiveness of resources [10-13].

Resource integration is to optimize the allocation of resources, so that there are in and out, take and give, so as to obtain the overall optimal, at the same time, there should be a clear purpose, a correct and clear guiding ideology, to maintain the integration of the elements of the individuality of the characteristics, otherwise the integration is likely to fail [14-17]. Continuing education resource integration includes the integration of internal resources of continuing education in colleges and universities, the integration of continuing education resources in colleges and universities and undergraduate education resources, and the sharing and exchange of continuing education resources in colleges and universities and social resources [18-20]. How to effectively allocate limited resources to realize the maximum benefit and value is a challenge that continuing education needs to face and solve [21-22]. Dynamic programming, as a powerful mathematical optimization method, provides an effective solution for resource allocation [23-24]. By establishing a dynamic planning model, the continuing education program can be divided into multiple stages, with different educational decisions considered in each stage, and the optimal educational combinations can be calculated based on the current resource situation and educational needs, and the optimal plan for the whole continuing education can be obtained by progressing these stages step by step [25-28].

In this paper, Kernel density estimation is used to analyze the developmental dynamics and polarization phenomenon of each subsystem under the optimization of continuing resource allocation at each point in time. After that, DEA model, CCR model and BCC model, which are used for the performance evaluation of continuing education resource allocation and the process of analyzing the influencing factors, are introduced. Through empirical cases, the differences in the quantity and quality of continuing education resource allocation are analyzed, and on this basis, the resource allocation optimization system of continuing education is constructed by combining the SD system dynamics model. Finally, the dynamics of the resource allocation optimization system of continuing education is simulated with the teachers of five universities in Northwest China as the research object, which provides support and reference for the allocation optimization and dynamic planning of continuing education resources.

2. Metrics for optimizing the allocation of resources for continuing education

2.1. Kernel density estimation based on continuing education resources

Kernel density estimation [29-30] is investigated as follows, firstly the continuing education level function $f(g)$ is constructed as follows:

$$f(g)=\frac{1}{n\varphi}\sum_{i=1}^{n}K\left(\frac{G_i-\overline{g}}{\varphi}\right) \tag{1}$$

where n is the number of all observed individuals in the model, G_i is the independent identically distributed observations, φ is the bandwidth, and $\overline{g}$ is the mean. $K(\cdot)$ is the kernel function, and the kernel function expression is shown below:

$$K(g) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{g^2}{2}\right) \tag{2}$$

2.2. Research Methodology on Resource Allocation Performance in Continuing Education

2.2.1. CCR model. From the perspective of the production function, the CCR model is used to investigate whether the technical efficiency of a decision unit with multiple inputs and multiple outputs is effective under constant returns to scale. Assuming that there are n decision units, each decision unit has m inputs and s outputs, and the input and output indicators are represented by $x_{ik} = (i = 1, 2, \cdots, m)$ and $Y_{jk} = (j = 1, 2, \cdots, s)$, respectively.The CCR model is constructed with the following formula:

$$\min \theta s.t. \begin{cases} \sum_{k=1}^{n} X_k \lambda_k + s^- = \theta X_k \\ \sum_{k=1}^{n} Y_k \lambda_k - s^+ = Y_k \\ s^- \equiv 0, s^+ \equiv 0, \lambda_k \equiv 0, k = 1, 2, \cdots, n \end{cases} \tag{3}$$

X and Y represent input and output variables, respectively, and s^- and s^+ are slack variables that, when s^- and s^+ are not equal to 0, represent the specific values of input redundancy and output insufficiency of the indicators of the decision-making units, respectively. The λ represents the decision variable that can reconstruct the virtual decision unit. The value of θ can represent the efficiency value of the kth decision unit, when $\theta = 1$, it means that the kth decision unit is in an efficient state, when $\theta < 1$, it means that the kth decision unit is inefficient. The results of the CCR model are analyzed in the following two cases. First, when $\theta = 1$, $s^- = 0$ and $s^+ = 0$, it indicates that the kth decision unit resource allocation efficiency is effective and that input redundancy or output shortfalls do not arise. Second, when $\theta < 1$, s^- is not equal to 0 and s^+ is not equal to 0, it means that the kth decision unit is non-DEA effective, indicating that the resource allocation within this decision unit still needs to be improved to reach DEA effectiveness. The adjusted path is divided into two cases, the first case is improved by adjusting the inputs, the adjusted inputs can be expressed as s^-, the second case is improved by adjusting the outputs, the adjusted outputs can be expressed as s^+, and the adjusted decision-making unit is again subjected to the analysis of the efficiency of resource allocation, which is shown to be that the decision-making unit is efficiently allocated resources, and the realization of internal resource path optimization.

2.2.2. BCC model. The BCC model is an improvement of the CCR model in that, on the one hand, it is used to determine the effectiveness of the pure technical efficiency of the decision unit in the presence of variable returns to scale. On the other hand, the ratio of the technical efficiency obtained by the CCR model to the pure technical efficiency obtained by the BCC model is the scale efficiency, which is used to determine whether the state of scale is in increasing or decreasing returns to scale.The BCC model is constructed with the formula:

$$\min \theta s.t.\begin{cases} \sum_{k=1}^{n} X_k \lambda_k + s^- = \theta X_t \\ \sum_{k=1}^{n} Y_k \lambda_k - s^+ = Y_t \\ \sum_{k=1}^{n} \lambda_k = 1 \\ s^- \geq 0, s^+ \geq 0, \lambda_k \geq 0, k = 1,2,\cdots,n \end{cases} \tag{4}$$

The BCC model and the CCR model are mostly the same in terms of the relevant representations of variables, the similarity is that X and Y represent the input variables and output variables, respectively, s^- and s represent the relaxation variables, and λ represents the decision variables, except that the θ value represents the pure technical efficiency value or scale efficiency value of the decision unit.

2.2.3. DEA model. The DEA model [31] approach to resource allocation performance evaluation utilizes two models, the first is the CCR model, whose main function is to evaluate the technical efficiency of resource allocation, and the second is the BCC model, which decomposes technical efficiency into pure technical efficiency and scale efficiency. The DEA model method is used to determine whether each decision unit is effective or not, and the method is that when the efficiency value is 1, the efficiency value of the decision unit is effective, and when the efficiency value is less than 1, the efficiency value of the decision unit is invalid.

DEA model as some kind of universally applied non-parametric statistical method, which takes the concept of relative efficiency as the basic criterion, and uses mathematical planning model to evaluate the same type of multi-input, multi-output decision-making unit whether its technology and scale are effective or not, and focuses more on the performance management, i.e., seeking for improvement.The basic rule of DEA is to utilize scientific and measurable information as the basis of judgment, and to keep the decision-making unit (DMU) on the Under the premise of keeping the inputs or outputs of the DMUs unchanged, there is no need to set the weights for the decision-making units in advance, but only to set the production frontier of relative efficiency, and the production frontier of DEA will be projected on all DMUs, after which the deviation degree of the DMUs and the DEA production frontier will be utilized to judge the relative efficiency. In this paper, the DEA model method is used to assess the relative efficiency of informatization resource allocation in the continuing education stage under the decision-making units with the same input and yield indexes, and the input-output relationship of n decision-making units with m inputs and s outputs is as follows:

$$H_j = \frac{U^T y_i}{V^T x_j} = \frac{\sum_{r=1}^{S} U_r y_{rj}}{\sum_{i-1}^{mn} v_i x_{ij}}, j = 1,2,\ldots,n \tag{5}$$

For the above equation, the coefficients take values in the range of $h_j \leq 1, j = 1,\ldots,n$, and usually the closer h_{j0} is to l, the higher the value of the efficiency of the decision unit DMU_{j0} is, which represents the more optimal allocation of resources.

3. Empirical analysis of differences in the optimization of resource allocation for continuing education

The difference in the allocation of educational resources has become the key to the governance of community education, and the difference in allocation is mainly reflected in the quantity and quality. In order to illustrate the dynamic changes of the difference in the allocation of educational resources, this paper uses the average funding data of "double first-class" universities from 2013 to 2024 to plot the kernel density curves of different types of universities, and selects 2013, 2017 and 2024 as the study years. In the Kernel density estimation plot of funding, the vertical axis indicates the corresponding Kernel density value, in order to reflect the relative changes in the funding inputs of colleges and universities, the horizontal axis indicates the multiplier of the overall mean, and the value of 1 represents that the average per-student funding of the sample colleges and universities is equal to the overall average level.

3.1. Quantitative differences in educational resources

3.1.1. Differences in the amount of continuing education among different HEIs:

1) Among the comprehensive category of colleges and universities. The estimated distribution of the Kernel density of funding for the comprehensive category of colleges and universities is shown in Figure 1. The dynamics of the figure presents the following 2 features: first, the Kernel density curve shifts to the right overall during the sample examination period, indicating that its overall level of educational resources investment is relatively higher. Second, the right trailing tail of the Kernel density curve first lengthens and then shortens, the height of the wave crest rises, and the width of the wave crest decreases, reflecting the narrowing of the differences in the allocation of educational resources on the whole, and its extreme difference shows a trend of first increasing and then decreasing. It indicates that the allocation of educational resources among comprehensive colleges and universities is gradually balanced, and the polarization phenomenon is gradually weakening to disappearing.

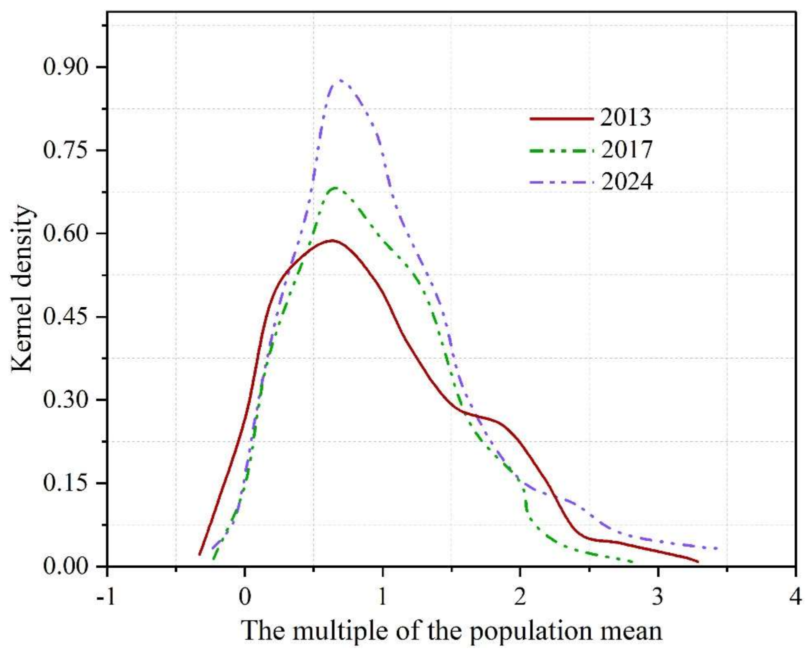

Fig. 1. The cost kernel density estimation distribution of the complex university

2) Between polytechnic colleges. The estimated distribution of Kernel density of funding among polytechnic universities is shown in Figure 2. The dynamics of the distribution presents the following three characteristics: First, the center of the Kernel density curve first moves to the right, and then the overall position remains stable, indicating that relative to the overall level, the investment of educational resources among polytechnic colleges and universities first increases and then remains stable. Secondly, during the sample period, the height of the main peak of the Kernel density curve rises sharply, the width of the main peak narrows gradually, and the right trailing tail of the Kernel

density curve shortens, which indicates that the concentration of educational resources in the high-input section increases, but the extreme difference is narrowing. Thirdly, the Kernel density curve gradually evolves into an obvious double-peak pattern, indicating that the allocation of educational resources among polytechnic colleges and universities is imbalanced and the degree of polarization is increasing.

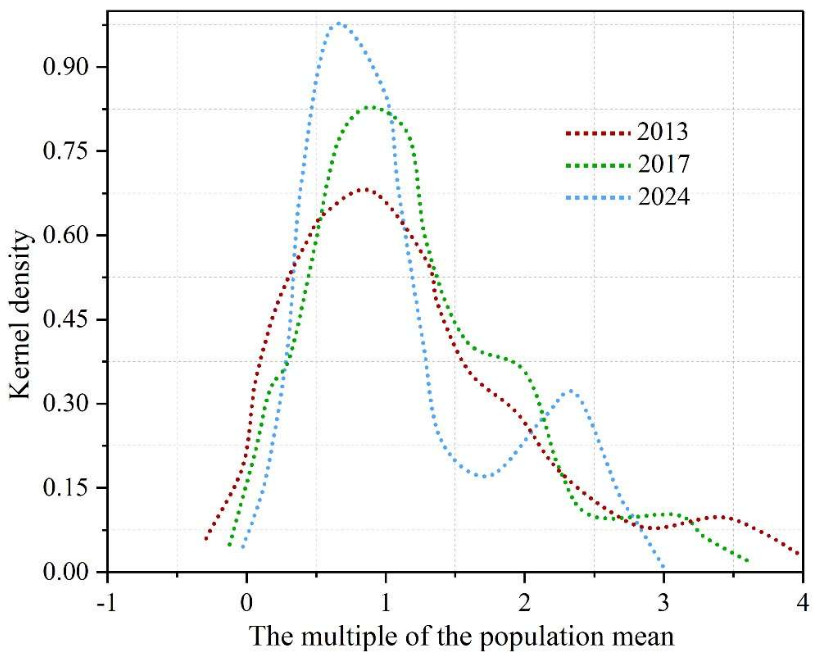

Fig. 2. The funding kernel density of the technical colleges and universities

3) Between Agricultural and Forestry Colleges and Universities. The estimated distribution of Kernel density of funding among colleges and universities in the agricultural and forestry category is shown in Figure 3. The dynamics of its distribution still presents three features: First, during the sample examination period, the Kernel density curve of the low-input segment of educational resources moves to the left, the Kernel density curve of the high-input segment moves to the right, and the right trailing tail gradually expands, indicating that there is a tendency for the input gap of educational resources to gradually increase in its whole. Secondly, the height of the main peak of the Kernel density curve rises and the width of the main peak decreases, indicating that the concentration of educational resources in the low-input segment increases. Thirdly, the Kernel density curve shows a trend from a double-peak pattern to a clear multi-peak pattern, indicating that the allocation of educational resources among agricultural and forestry colleges and universities is imbalanced, with obvious polarization and a gradual multi-polarization trend.

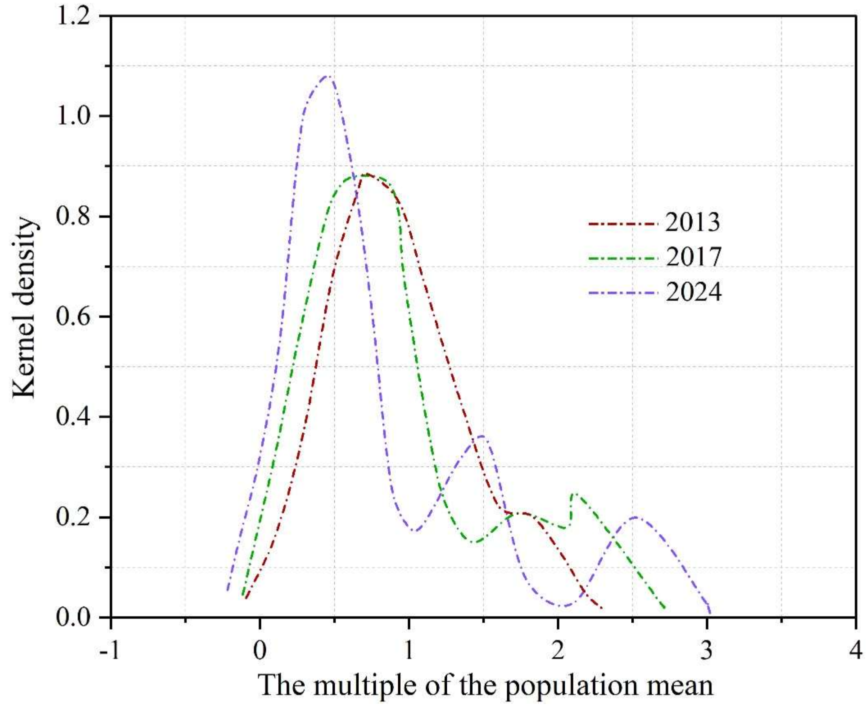

Fig. 3. The distribution of the kernel density of the agricultural forest class

3.1.2. Measuring and explaining the imbalance in education resources. In order to further explore the difference status of educational resource allocation, according to the original grouping, the ER index, EGR index and LU index which measure the degree of polarization are obtained, and the polarization index of funding input is shown in Table 1, and 2013 is taken as the base period year, and the value of the polarization index is taken to be 100.It can be seen that the polarization indexes have ups and downs in part of the period but the overall tendency is still decreasing, and taking 2013 as the base period, during the period 2014-2024, the average values of ER index, EGR index and LU index of educational resource allocation decreased by 9.91%, 2.91% and 5.24%, respectively, compared with that of 2013. Since the above three indices are more sensitive to the degree of polarization, it can be obtained that while the homogeneity among colleges and universities of the same category is increasing and the degree of aggregation is rising, the heterogeneity among colleges and universities of different categories is decreasing , the degree of confrontation between groups is decreasing. The differences in resource allocation between different categories of colleges and universities are gradually narrowing, and the horizontal boundaries are becoming less and less obvious, and the degree of decline in the differences between different categories of colleges and universities is greater than the degree of increase in the homogeneity between the same categories of colleges and universities, which results in a downward trend in the three polarization indices.

Table 1. Investment polarization index

Year	Extinction log			Relative number		
	ER index	EGR index	LU index	ER index	EGR index	LU index
2013	0.0632	0.0438	0.0496	100.0000	100.0000	100.0000
2014	0.0624	0.0448	0.0514	100.5195	105.0412	102.7595
2015	0.0603	0.0474	0.0505	97.0608	109.1899	103.6878
2016	0.0515	0.0375	0.043	85.7881	85.6699	88.3099
2017	0.0616	0.0461	0.0481	97.6667	101.6703	100.6696
2018	0.0623	0.0468	0.0486	97.0195	101.8504	100.6397
2019	0.0647	0.0517	0.054	106.436	114.101	109.941
2020	0.0665	0.0513	0.0546	110.0723	117.7009	113.162
2021	0.0598	0.0468	0.0485	94.9614	99.1491	99.1405
2022	0.0481	0.0353	0.0413	79.6605	79.561	83.8489
2023	0.0464	0.0319	0.0399	68.4708	72.1311	76.3511
2024	0.0427	0.0282	0.0371	65.3115	69.8791	71.0898

3.2. Differences in the quality of continuing education resources in different regions

Taking the key regions of China's “One Belt, One Road” construction as an example, the performance of continuing education in different regions is calculated to illustrate the quality differences in the allocation of continuing education resources, and the evaluation results of the DEA model include three parts: comprehensive efficiency (C), technical efficiency (V), scale efficiency (S) and returns to scale (R). The difference in the quality of educational resources is shown in Table 2. It can be seen:

1) The quality of the allocation of educational resources is not high, and there are significant differences between regions. In 2017, the comprehensive efficiency of the Belt China region (including the 13 provinces of Xinjiang-Chongqing) was 0.94236, i.e., only 94.236% of the optimal level, and due to the significant improvement in the overall technical efficiency of the region, the comprehensive efficiency in 2024 grew to 0.96212, reaching 96.212% of the optimal level. The combined efficiency of the “All the Way” China region (including five provinces, including Shanghai and Hainan) was 0.99274 in 2017, and its efficiency value declined in 2024, to as low as 96.224% of the optimal level. As the “One Belt” China region is a developed coastal province, rich in educational resources, with a relatively high level of continuing education, and with a better infrastructure than the western region, the level of allocation quality in the “One Belt” China region is higher than in most of the This has led to a higher level of configuration quality in the “One Belt” regions than in most of the “One Road” regions of China.

2) From the viewpoint of the effectiveness of educational resource allocation, the clustering effect of resources plays an important role. 2017 DEA effective “one belt” China region has 5, respectively Shaanxi, Gansu, Liaoning, Qinghai, Liaoning and Guangxi; “one road” China region has 4, respectively Shanghai, Fujian, Guangdong and Zhejiang, scale efficiency is a key factor affecting the level of resource allocation. There are four Chinese regions, namely Shanghai, Fujian, Guangdong and Zhejiang, and scale efficiency is a key factor affecting the level of resource allocation.

3) From the perspective of scale compensation, the sharing of educational resources will greatly improve the allocation level and reduce the inter-regional differences. Compared with the key regions in “One Road” China, most of the regions in “One Belt” China are in the stage of increasing returns to scale, i.e., appropriately increasing the investment of educational resources in higher education will get a higher proportion of output.

Table 2. Education resource quality difference

Region	2017	2024

	C	V	S	R-S	C	V	S	R-S
Xinjiang	0.7998	0.9796	0.8167	irs	0.9852	1.0000	0.9856	irs
Shanxi	1.0000	1.0000	1.0000	-	1.0000	1.0000	1.0000	-
Gansu	1.0000	1.0000	1.0000	-	1.0000	1.0000	1.0000	-
Ningxia	0.9801	1.0000	0.9806	irs	1.0000	1.0000	0.9833	irs
Qinghai	1.0000	1.0000	0.9995	-	1.0000	1.0000	1.0000	-
Neimenggu	0.9007	0.9086	0.998	irs	0.8075	0.9009	0.8983	irs
Heilongjiang	0.9595	0.9831	0.9784	irs	0.9679	1.0000	0.9704	irs
Jilin	0.7902	0.8029	0.9883	irs	1.0000	1.0000	1.0000	-
Liaoning	0.9998	0.9973	1.0000	-	0.9405	1.0000	1.0000	-
Guangxi	1.0000	1.0000	1.0000	-	1.0000	1.0000	1.0000	-
Yunnan	0.8798	0.9809	0.9	irs	0.9345	1.0000	0.9363	irs
Xizang	0.9803	0.9986	0.9802	irs	0.872	1.0000	0.8717	irs
Chongqing	0.9605	0.9668	0.9988	irs	1.0000	1.0000	1.0000	-
Shanghai	1.0000	1.0000	1.0000	-	1.0000	1.0000	1.0000	-
Fujian	1.0000	0.9992	1.0000	-	0.8112	0.8499	1.0000	-
Guangdong	1.0000	1.0000	1.0000	-	1.0000	1.0000	1.0000	-
Zhejiang	1.0000	0.9994	1.0000	-	1.0000	1.0000	1.0000	-
Hainan	0.9607	1.0000	0.9701	irs	1.0000	1.0000	1.0000	-

4. Optimization of resource allocation and construction of a dynamic planning system for continuing education

4.1. Causal characterization of resourcing mechanisms for continuing education

The Continuing Education Resource Sharing System consists of three modules, namely, resource development and quality improvement, user utilization and regional education authorities, and the improvement of resource quality, user incentives and government funding allocations all revolve around resource utilization rates. The overall operation mechanism process of the system can be briefly described as follows:

As the organizer of the development and use of regional continuing education resources, the education authority is mainly responsible for adjusting the prices of resources and services, formulating the annual allocation of special funds for continuing education, building a cloud service platform for the use of continuing education resources, and giving incentives according to the performance of users and resources in a scientific and reasonable manner.

According to the users' demand for resources and the government's commissioning or customization requirements, the software development enterprises give full play to their technical and financial advantages to produce continuing education resources that meet the corresponding technical standards, and provide services such as quality improvement and technical support at a later stage, and sometimes they also have to develop new products.

Currently, users selectively use high-quality continuing education resources according to the purpose of teaching and learning. Schools are responsible for the construction of informatization environments, encouraging teachers and students to actively utilize them and make reasonable evaluations and suggestions for improvement according to the teaching effect and satisfaction during the process of using them, and the feedback information is transmitted to the software development enterprises through the education authorities in a timely manner to facilitate the improvement of resource quality.

Causality is a basic tool for qualitative analysis of system dynamics. Causality assumes that complex phenomena occurring in socio-economic systems are usually caused by dynamic complexity. The base model analysis of resource quality and user usage dynamics is shown in Figure 4.

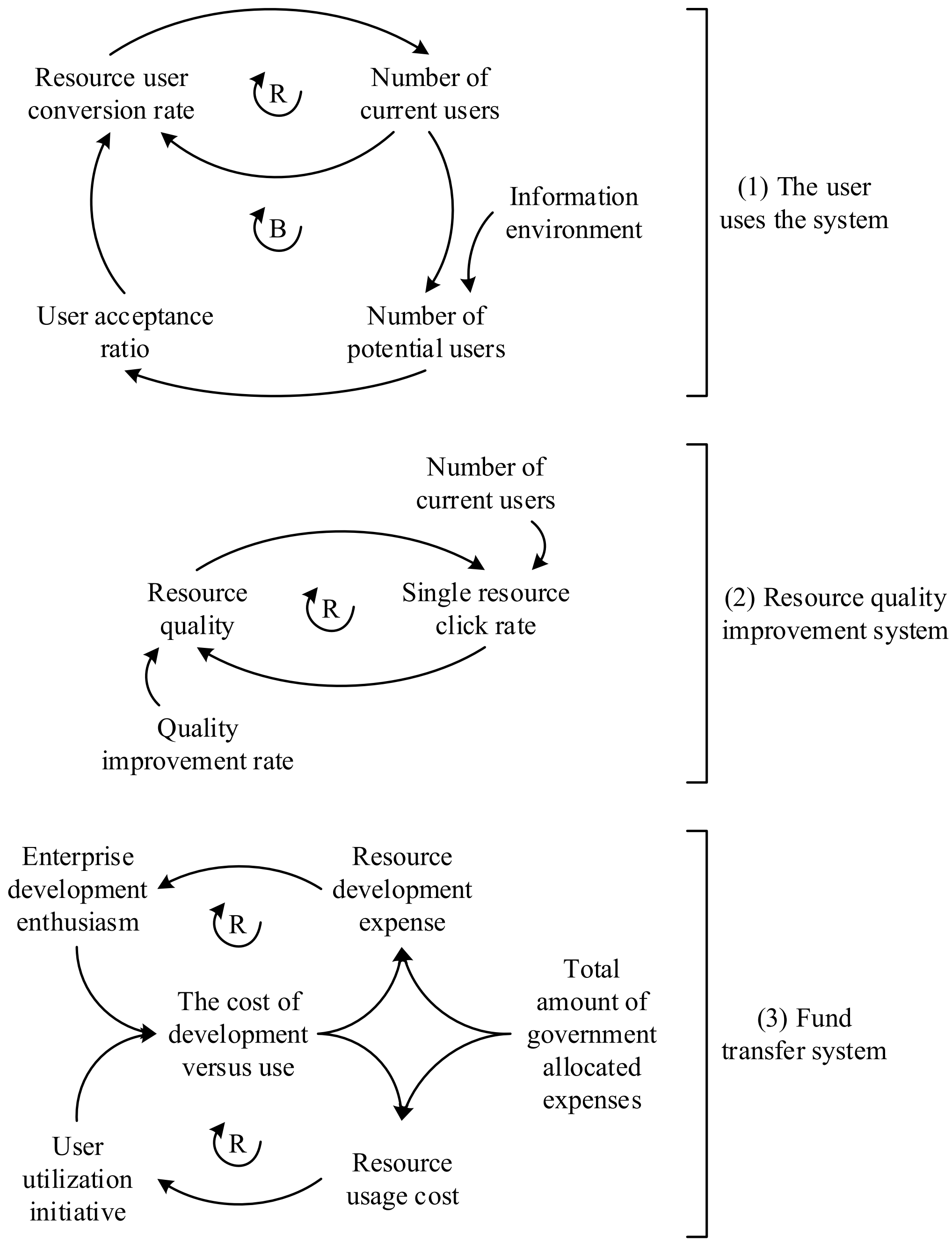

Fig. 4. Causal relationship between resource quality and user usage

4.2. System Dynamics Model for Optimizing the Allocation of Continuing Education Resources

1) Stock flow model of the system. In this paper, in the construction of the system stock flow diagram (referred to as flow diagram), the quality of continuing education resources and user utilization of the system flow stock is shown in Figure 5. The flow diagram further distinguishes the nature of variables on the basis of causality analysis, portrays the relationship between system elements with more intuitive symbols, and accurately illustrates the cumulative changes of the system with quantitative data. System dynamics categorizes variables into four types: state variables, rate variables, auxiliary variables and constants. This model flow diagram has a total of 26 variables, including five state variables such as single resource clicks, number of current users, number of potential users, resource

use development input costs, and resource use input costs; three rate variables such as click rate, user conversion rate, and cost conversion rate; eight auxiliary variables such as actual sharing, resource use ratio, and utilization incentive regulation parameters; and ten auxiliary variables such as quality improvement time, average user 10 constants such as quality improvement time, average user contact rate, and environmental impact factor.

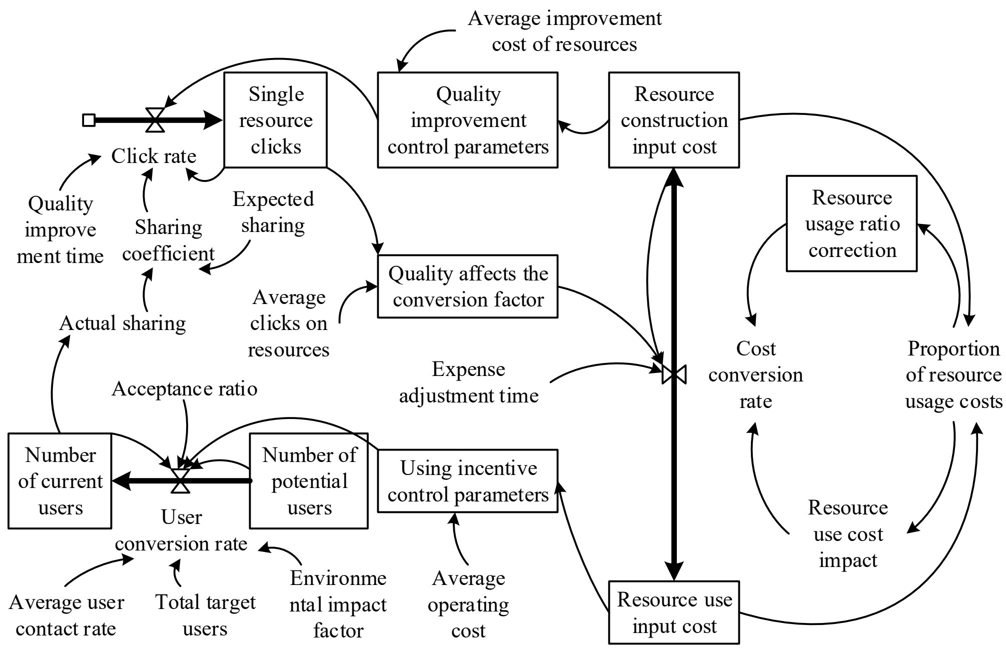

Fig. 5. Continue education resource quality and user utilization system flow stock

2) Causal feedback loop analysis of the model. Feedback loops make the interactions between variables show dynamic complexity, and their analysis can provide a deeper understanding of the operational mechanisms and behavioral characteristics of the actual system. The following major feedback loops exist in the model of the system of quality and user utilization of continuing education resources:

(1) Single Resource Hits → Quality Impact Conversion Factor → Cost Conversion Rate → Resource Use Input Cost → Utilization Incentive Regulation Parameter → User Conversion Rate → Number of Current Users → Actual Sharing → Sharing Factor → Hits Rate → Single Resource Hits.

(2) Current number of users → actual sharing → sharing factor → click rate → clicks on a single resource → quality impact conversion factor → cost conversion rate → cost of resource use inputs → utilization incentive regulation parameter → user conversion rate → current number of users.

(3) Resource construction input costs → quality improvement regulation parameter → click rate → single resource clicks → quality impact conversion factor → cost conversion rate → resource construction input costs.

(4) Resource use input costs → utilization incentive regulation parameter → user conversion rate → number of current users → actual sharing → sharing factor → click rate → single resource clicks → quality impact conversion factor → cost conversion rate → resource use input costs.

3) System Dynamics Equations of the Model. The equations are quantitative relationships between the elements in the system model. The equations of system dynamics are mainly composed of level equation (L), rate equation (R), auxiliary equation (A), constant (C) and initial value (N). Combining the idea of continuing education resources sharing and the above analysis of the system operation

mechanism and causal feedback structure, according to the nature of the variables in the model, this paper comprehensively applies the trend extrapolation method, the gray prediction method, and the function of the table function, and establishes the system's dynamics equations using the equation editor provided by Vensim PLE. Continuing education resources and system dynamics model equation expressions are shown in Table 3.

Table 3. Continue the education resources and system dynamics model equation

Serial number	Variable equation	Dimension	Type
1	Single resource click quantity = INTEG(click rate, initial value = 100)	Every time	L
2	The current number of users is equal to INTEG(the user conversion rate, the initial value = 20)	Per Person	L
3	The number of potential users is equal to the user conversion rate, Initial value = 480)	Per Person	L
4	Resource use input cost = INTEGg (cost conversion rate, initial value = 2000yuan)	Yuan	L
5	The cost of resource construction is called INTEG(- the cost conversion rate, the initial value = 8000yuan)	Yuan	L
6	Click rate = rate = (quality improvement control parameter × sharing coefficient × single resource click quantity)/quality improvement time/month	Every time/one month	R
7	User conversion rate = environmental influence factor × by using incentive control parameter × user average contact rate × acceptance ratio (current user number/target user total)	Person/one month	R
8	Cost conversion rate = "" (resource construction input cost = 1000. quality affects conversion factor × resource construction expense (1 - resource usage ratio correction) (usage ratio of resource usage)/cost adjustment time, critical value)	Yuan/one month	R
9	Shared coefficients = actual Shared/expected sharing	Dmnl	A
10	Use incentive control parameter = WITH LOOKUP(resource use expense/mean usage, table function adjustment)	Dmnl	A
11	Actual sharing = single resource click quantity/current user number	Every time/person	A
12	Quality influence conversion factor = WITH LOOKUP (single resource click quantity/resource average click quantity, table function adjustment)	Dmnl	A
13	Quality improvement control parameter = WITH LOOKUP (resource construction input cost/resource average improvement cost, table function adjustment)	Dmnl	A
14	The resource use ratio is fixed to the = WITH LOOKUP(usage ratio, table function adjustment)	Dmnl	A
15	Use of resource usage ratio = resource usage ratio	Dmnl	A
16	Resource usage ratio = resource use input fee/(resource use input fee + resource construction expense)	Dmnl	A
17	The total number of target users = the number of current users and the number of potential users	Person	C

5. Dynamic simulation of a system for optimizing the allocation of resources for continuing education

This study was conducted on the teachers of five universities in Northwest China, and 500 questionnaires were distributed with 493 valid questionnaires by using the method of stratified sampling distribution. After exploratory factor analysis to test the validity of the data, the value of KMO and Bartlett's ball test was obtained as 0.9902, the cumulative variance explained rate was 87.65%, and the Cronbach's alpha value of all the question items on the reliability test was 0.9941, which indicated that the data had good reliability and validity, and could be used to carry out the next step of the dynamics model of the system of the high-quality and balanced development of continuing education resources construction and simulation analysis.

5.1. Impact of increased total inputs on the resource allocation system

Increasing the total input of resources for continuing education contributes to the early realization of resource allocation. The impact of the total input of the balanced development of resources on the evolution of the system's behavior is shown in Figure 6. Overall, when the total input ratio is 5, the quality and balanced development of regional continuing educationization will be realized after the 9th year; when the input increases to 2 times~5 times of the current one, the quality and balanced development of regional continuing educationization will be realized after the 6th~8th year. This shows that as the proportion of total inputs for quality and balanced development of continuing education resources continues to expand, the spacing of years for continuing education to achieve quality and balanced development gradually decreases, which, to a certain extent, indicates that high inputs for continuing education can dissolve the imbalanced development of continuing education.

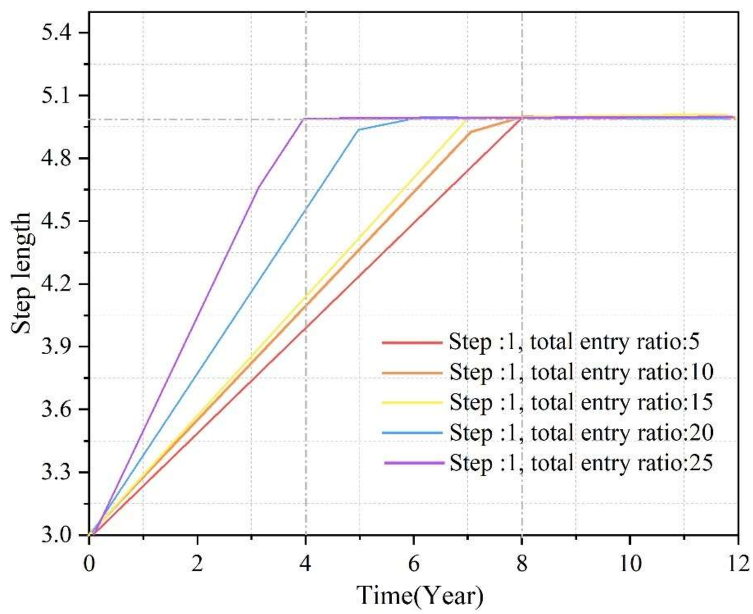

Fig. 6. The influence of total investment on the evolution of system behavior

5.2. Impact of information technology on the system for optimizing the allocation of continuing education resources

The effects of different inputs on the allocation of continuing education resources are shown in Figure 7. By individually increasing the input proportion of five subsystems in the limited input proportion, it is found that the influence effect on the quality and balanced development of continuing education resources is in the following order: informatization application>informatization organization and management>informatization guarantee mechanism>average distribution of the proportion of each input factor>continuing education resources and platform construction>informatization infrastructure construction, which shows that only through the optimization of informatization hardware and software resource allocation This shows that only through the optimal allocation of information technology hardware and software resources, the effect of quality and balanced development of continuing education can not be greatly improved. The real solution to the imbalanced development of continuing education mechanism lies in: the exact implementation of information technology protection and incentive mechanism, the formation of information technology organization and management team centered on the digital learning needs of the educational subject, in the orderly digital education field to make the process and results of information technology applications have value.

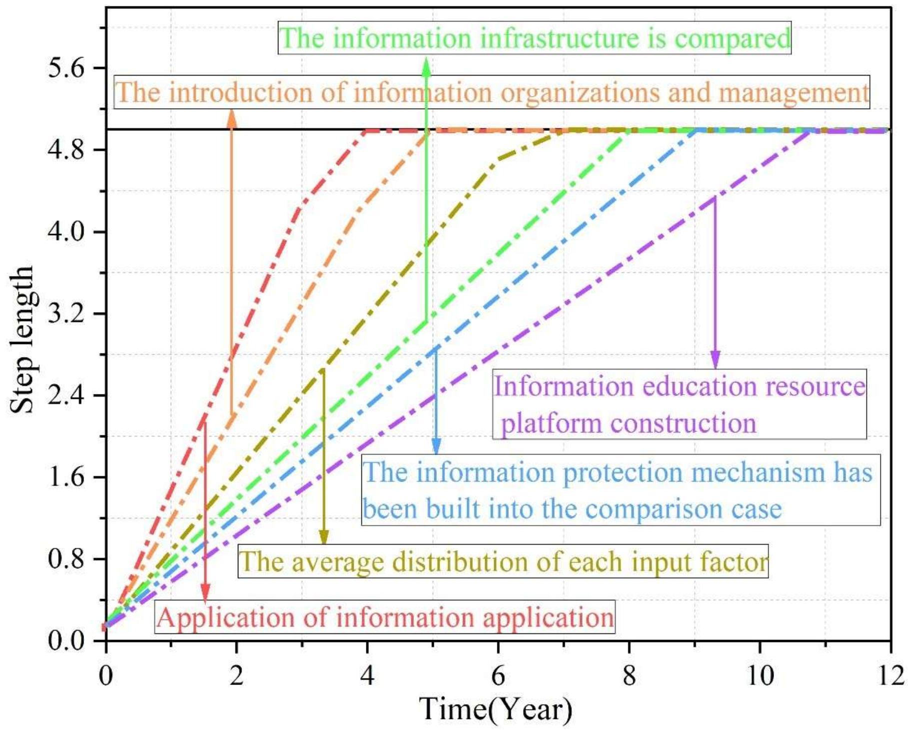

Fig. 7. Different inputs affect the continued education resource allocation

5.3. Pluralistic and structural character of the system's development dynamics

5.3.1. Increased satisfaction with the development of a resource platform for continuing education. In the subsystem of quality and balanced development of continuing education resource platform, improving satisfaction with the construction of continuing education resource platform is the most effective strategy to promote quality and balanced development. The influence of the allocation of the three-level indicators on the balanced development of the system is shown in Figure 8. In the subsystem of quality and balanced development of continuing education resource platform, each construction input factor and the average allocation of three-level indicators > input of satisfaction with the construction of continuing education resource platform > input of the construction of continuing education resources and platform. Continuing education resource platform can only build satisfactory resources from the actual needs of school education and teaching in order to promote the quality and balanced development of each obligatory continuing educationization more quickly.

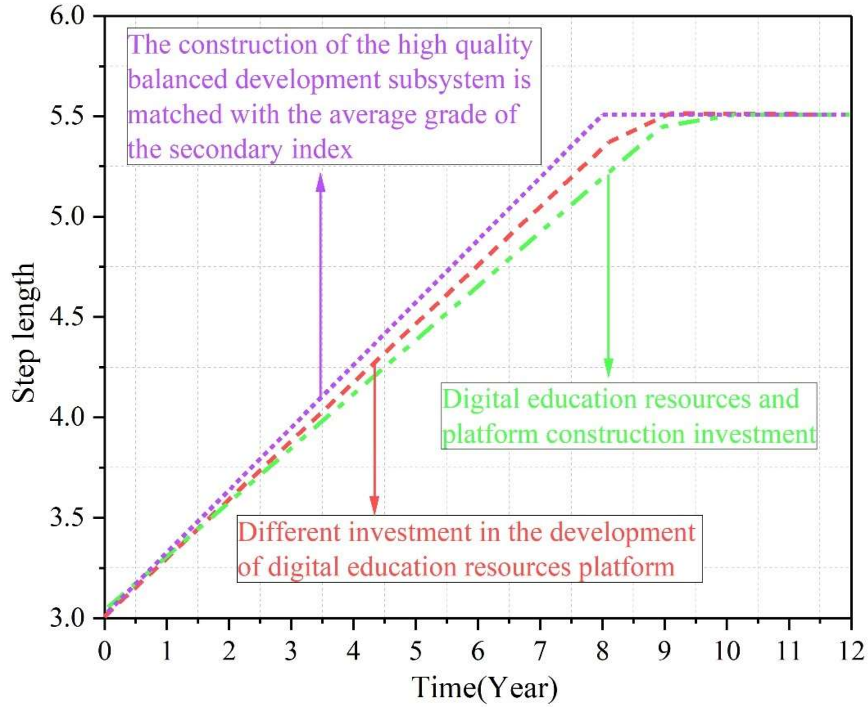

Fig. 8. The effect of the third level index on the balanced development of the system

5.3.2. Strengthening the Incentive and Evaluation System for Informatization. In the subsystem of quality and balanced development of informatization guarantee mechanism, strengthening the construction of informatization incentive and evaluation system is the most effective strategy to promote quality and balanced development. The effects of the three-level index allocation on the balanced development of the system are shown in Figure 9. The analysis found that the order of magnitude of the effect of promoting the quality and balanced development of compulsory continuing educationization is in the following order: the input of informationization incentive and appraisal system construction (year 6) > the input of informationization safeguard mechanism construction satisfaction (year 7) > the average distribution of the various construction input factors and the second-level indicators (year 8). In the subsystem of quality and balanced development of informatization guarantee mechanism, strengthening the construction of informatization incentive and evaluation system is the most effective strategy to promote quality and balanced development.

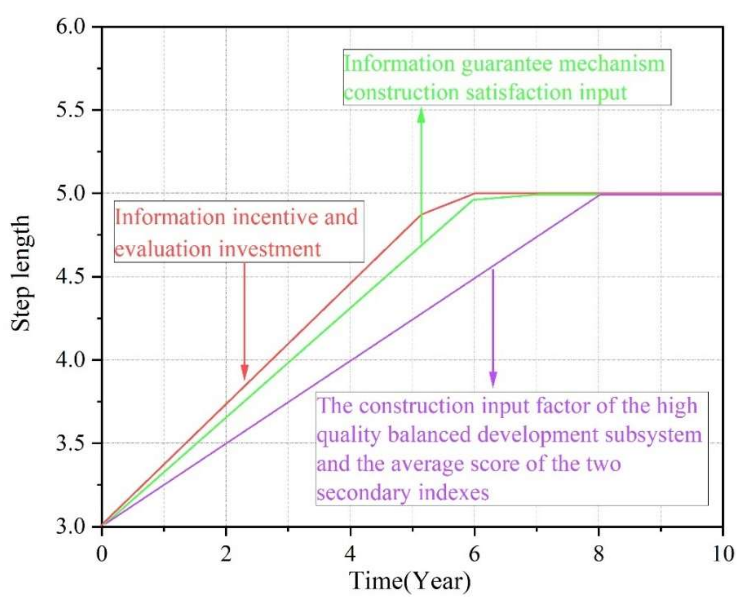

Fig. 9. The effect of the third level index on the balanced development of the system

5.3.3. Enhancement of teachers' IT application capacity. In the subsystem of quality and balanced development of information technology application, improving teachers' information technology application ability is the most effective strategy to promote quality and balanced development. The effects of the three-level indicator allocation on the balanced development of the system are shown in Figure 10. The order of magnitude of the effect of promoting the quality and balanced development of compulsory continuing educationization is in the following order: input of teachers' information technology application ability (year 3) > input of satisfaction with information technology application (year 3) > input of information technology learning application (year 4) > application of information technology resource platform (year 4) > the average distribution of each construction input factor and the second-level indicators (year 8). It can be seen that improving both teachers' IT application ability and satisfaction of IT application can realize the quality and balanced development of compulsory continuing educationization the fastest.

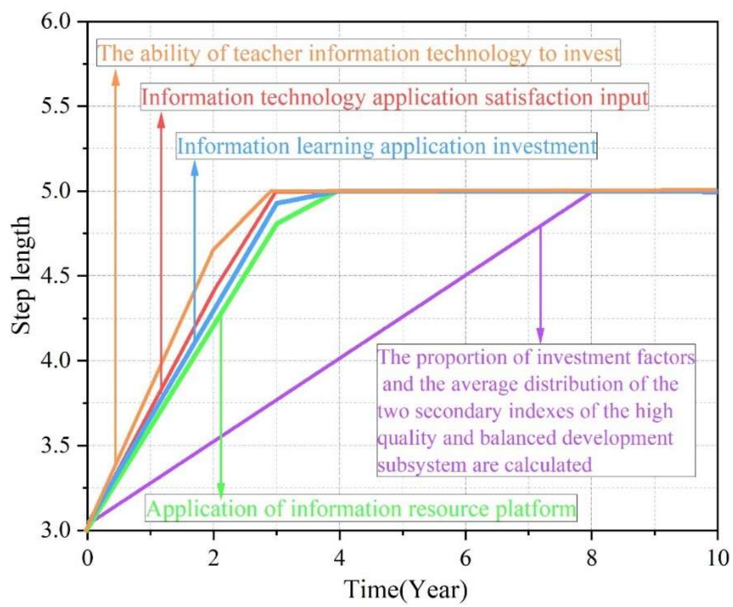

Fig. 10. The influence of index distribution on the balanced development of system

6. Conclusions and recommendations

6.1. Conclusion

Taking the community education governance framework as the research background, this paper focuses on the optimization of continuing education resource allocation, uses Kernel density estimation and DEA model to measure the current resource allocation efficiency of continuing education, constructs a resource allocation optimization and dynamic planning system, and simulates the simulation effect of system dynamics.

1) Comprehensive colleges and universities are gradually balanced among themselves in the allocation of educational resources, and the polarization phenomenon is gradually weakening to disappearing. On the other hand, the configuration between polytechnic colleges and agricultural and forestry colleges is imbalanced, the degree of polarization increases, and it gradually shows a multi-polarization situation. In addition, there are great differences in the quality of continuing education resources in different regions.

2) This paper constructs a system dynamics model of the quality and user use of continuing education information resources, and carries out simulation and policy simulation from different sides and

influencing factors for the utilization rate of education information resources, and puts forward some countermeasures and suggestions.

6.2. Recommendations

For the resource allocation optimization and dynamic planning calculation of continuing education, this paper puts forward the following suggestions:

1) Enhancing teachers' information technology application ability and application input of information technology application subsystem is the optimal strategy to promote the quality and balanced development of information technology of continuing education resources.

2) To carry out the management input of information technology organization and management and information technology protection mechanism subsystem is a solid strategy to build information technology organization and management team, information technology incentive and evaluation system.

3) Increasing the investment in the construction of digital education resource platform and informationization infrastructure subsystem is the most basic strategy to improve the satisfaction of digital education resource platform and the satisfaction of informationization infrastructure construction.

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References

[1] Jokhan, A., Chand, A. A., Singh, V., & Mamun, K. A. (2022). Increased digital resource consumption in higher educational institutions and the artificial intelligence role in informing decisions related to student performance. Sustainability, 14(4), 2377.

[2] Berbegal-Mirabent, J., Gil-Doménech, D., & de la Torre, E. M. (2021). Examining strategies behind universities’ technology transfer portfolio: how different patterns of resource consumption can lead to similar technology transfer profiles. Competitiveness Review: An International Business Journal, 31(3), 571-593.

[3] Adamo, C. E., Esper, M. T., Bastos, G. C. F. C., Sousa, I. F. D., & Almeida, R. J. D. (2017). University of the Third Age: the impact of continuing education on the quality of life of the elderly. Revista brasileira de Geriatria e Gerontologia, 20, 545-555.

[4] Gómez, G. Á., Moya, J. V., Ricardo, J. E., & Sanchez, C. B. V. (2020). Evaluating Strategies of Continuing Education for Academics Supported in the Pedagogical Model and Based on Plithogenic Sets (Vol. 37). Infinite Study.

[5] de Lima Ferreira, J., & Bertotti, G. R. (2016). Continuing education for professional development in higher education teaching. Creative Education, 7(10), 1425-1435.

[6] Qi, J. (2024). The Role of Continuing Education in Lifelong Learning: A Quantitative Study in Two Universities in China. Pacific International Journal, 7(2), 190-196.

[7] Matkin, G. W. (2022). Reshaping university continuing education: Leadership imperatives for thriving in a changing and competitive market. American Journal of Distance Education, 36(1), 3-18.

[8] Alkhimenko, O. N., Asaliev, A. M., & Kuksova, O. D. (2014). Human capital on the knowledge economy: the role of continuing education. Rev. Eur. Stud., 6, 277.

[9] Cendon, E., Schulte, D., & Mörth, A. (2021). University continuing education as an innovation lab for future education–potentials and limitations. European Journal of University Lifelong Learning, 5(1), 15-25.

[10] Ayyıldız, P., & Yılmaz, A. (2024). 'Quality'Service to Society? Continuing Education and Training Centers in Universities: Insider Views. Bayburt Eğitim Fakültesi Dergisi, 19(41), 1635-1649.

[11] Hou, A., & Rogers, L. M. (2017). Lessons in university continuing education: A 25-year perspective. The Journal of Continuing Higher Education, 65(1), 3-12.

[12] Makarovaa, A., & Pavlichevab, E. N. (2020). Development of information resources to ensure continuing education and knowledge transfer in chemical universities. CHEMICAL ENGINEERING, 81.

[13] Martel, J. (2023). College continuing education: invisible and unrecognized?. Canadian Journal for the Study of Adult Education, 35(1), 29-40.

[14] Bocconcelli, R., Carlborg, P., Harrison, D., Hasche, N., Hedvall, K., & Huang, L. (2020). Resource interaction and resource integration: Similarities, differences, reflections. Industrial Marketing Management, 91, 385-396.

[15] Sklyar, A., Kowalkowski, C., Sörhammar, D., & Tronvoll, B. (2019). Resource integration through digitalisation: a service ecosystem perspective. Journal of Marketing Management, 35(11-12), 974-991.

[16] Eriksson, E., & Hellström, A. (2021). Multi‐actor resource integration: a service approach in public management. British Journal of Management, 32(2), 456-472.

[17] Luo, T., Hostetler, K., Freeman, C., & Stefaniak, J. (2020). The power of open: Benefits, barriers, and strategies for integration of open educational resources. Open Learning: The Journal of Open, Distance and e-Learning, 35(2), 140-158.

[18] Silva, V. B. D., Mendes, V. A., Lima, S. C. F. D., Gonçalves, T. L. P., Paes, G. O., & Stipp, M. A. C. (2021). Continuing education in nursing practice: integration between education and service. Cogitare Enfermagem, 26, e71890.

[19] Kotlyarova, I. O., Voloshina, I. A., Volchenkova, K. N., & Batina, E. V. (2020, September). On-line education resources for the optimization of on-line continuing professional education. In 2020 International Conference Quality Management, Transport and Information Security, Information Technologies (IT&QM&IS) (pp. 588-592). IEEE.

[20] Qiao, X. (2021). Integration model for multimedia education resource based on internet of things. International Journal of Continuing Engineering Education and Life Long Learning, 31(1), 17-35.

[21] Zheng, X. (2024). Research on the Key Educational Competencies for Continuing Education in Vocational and Technical Colleges. International Journal of Educational Teaching and Research, 1(2).

[22] Basri, H., & Hasri, S. (2024). Modern Education Management: Challenges, Strategies Towards a Future of Continuing Education. Munaddhomah: Jurnal Manajemen Pendidikan Islam, 5(3), 260-269.

[23] Haskell, W. B., Jain, R., & Kalathil, D. (2016). Empirical dynamic programming. Mathematics of Operations Research, 41(2), 402-429.

[24] Liu, D., Xue, S., Zhao, B., Luo, B., & Wei, Q. (2020). Adaptive dynamic programming for control: A survey and recent advances. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 51(1), 142-160.

[25] Muzapparovna, N. G. (2024). ADVANCEMENTS IN CONTINUING EDUCATION: EXPLORING INNOVATIVE APPROACHES TO TEACHING IN THE MODERN ERA. International Journal of Advance Scientific Research, 4(04), 89-96.

[26] Khan, I. U., & Aftab, M. (2022). Dynamic programming approach for fuzzy linear programming problems FLPs and its application to optimal resource allocation problems in education system. Journal of Intelligent & Fuzzy Systems, 42(4), 3517-3535.

[27] Amuji, H. O., Onwuegbuchunam, D. E., Okoroji, L. I., Nwachi, C. C., & Mbachu, J. C. (2023). Development/Application of Dynamic Programming Model for Students' Academic Planning and Performance in the Universities. Greener Journal of Science, Engineering and Technological Research, 12(1), 20-25.

[28] Han, X., & Wang, D. (2025). Gradual Optimization of University Course Scheduling Problem Using Genetic Algorithm and Dynamic Programming. Algorithms, 18(3), 158.

[29] Zhiyi Li,Songtao Zhang,Zihan Fu,Fanlei Meng & Lijuan Zhang. (2025). Confidence-Feature Fusion: A Novel Method for Fog Density Estimation in Object Detection Systems. Electronics,14(2),219-219.

[30] Soumita Modak. (2024). A new interpoint distance-based clustering algorithm using kernel density estimation. Communications in Statistics - Simulation and Computation,53(11),5323-5341.

[31] Muren ,Ma Zhanxin & Li Hao. (2024). A new parallel framework algorithm for solving large-scale DEA models. Expert Systems With Applications,241,122687-.