Research Article

Preschool Education Resource Allocation Model for Index System Evaluation Based on Nonlinear Random Matrix

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Based on random finite sets and random matrices, this paper conducts research on ETT methods, focusing on solving key problems such as measurement set division, hybrid reduction, and target shape modeling, and provides theoretical and methodological support for ETT applications in complex environments. Evaluation is an activity to determine value, which is to judge the degree to which the object meets the requirements of the subject, that is, to judge against certain standards. Usually, the evaluation needs to go through a series of qualitative and quantitative combination; that is, subjective materials and objective statistical data are used together to judge and analyze to obtain the final evaluation result. The evaluation of preschool education resource allocation refers to qualitative and quantitative description of the relevant material and financial and human resources invested in the development of preschool education. This paper will study the preschool education resource allocation evaluation system from the aspect of the index system of the preschool education resource allocation evaluation system. The research results show that the average technical efficiency of preschool education resource allocation from 2019 to 2021 will increase steadily, and the combination of input elements in educational resources will be reasonable. In 2021, Spearman’s rho and Kendall’s tau correlation coefficients between overall technical efficiency and pure technical efficiency are as high as 0.958 and 0.841, which are higher than the correlation coefficients of 0.325 and 0.380 between overall technical efficiency and scale efficiency.

1. Introduction

Education is the cornerstone of social progress, national development, and national rejuvenation [1, 2]. Education is an important part of national public services, and its development direction, scale, speed, and quality are greatly affected by national policies. A large number of facts have proved that the more developed the public education, the higher the quality of the people, and the corresponding improvement in the level of social civilization, harmony, and economic development. Preschool education is the first stage of human beings receiving systematic education [3]. American pedagogical and psychologist Benjamin Bloom has tracked and studied more than a thousand children aged 0–17 and found that before the age of 5 is the best period for children’s intellectual development [4]. The research results of the UK’s “Effective Preschool Education Project” 2 also show that preschool education directly affects children’s primary school learning, which in turn affects their lifelong development. A large number of studies have proved that preschool education plays an important role in laying the foundation for people’s lifelong development [5, 6].

Educational balance is the equal distribution of educational resources under the domination of the idea of educational fairness and the principle of educational equality, so that educational institutions and educational groups are relatively balanced in terms of educational demand and educational supply, and ultimately realize that people are basically in the distribution and use of educational resources. Educational balance mainly involves the basic rights and guarantees of the educated, whose primary responsibility is the government. Education in any country and region inevitably has elite education and mass education. At present, the education balance mainly refers to the balanced development of 9-year preschool education in the basic education stage [7]. Material resources refer to the campus, buildings,
land, teaching equipment, and other fixed assets in the school, as well as related tangible properties of the school; financial resources are mainly public funds, including income expenditure, investment, and donation. Educational funds are invested in various fields of education through budget and other channels, and their total amount and distribution method will have a great impact on the effect of education [8, 9].

This paper starts from the concepts and theories related to the allocation of preschool education resources, based on the in-depth analysis of the purpose, content, and principles of the evaluation system to be constructed. Understanding and analyzing the allocation efficiency of educational resources in various provinces and cities, and adjusting the investment structure of educational resources will help to improve the allocation efficiency of preschool education resources and help to realize the transition of preschool education from “guaranteeing the basics and wide coverage” to providing better education. It helps to ensure a fairer and more effective investment in preschool education resources and also ensures that every student is provided with equal educational opportunities and the right to enjoy high-quality education, so that millions of families can rest assured. Through the overall evaluation of the efficiency of educational resource allocation in 31 provinces across the country, it analyzes the actual situation of insufficient investment in preschool education resource allocation, provides decision-making basis for the formulation of relevant policies in the preschool education stage, and provides decision-making reference for the decision-making of the education department. From the perspective of efficiency, it provides a new way to optimize the structure of educational resource allocation.

2. Related Work

The goal of global education balance is to achieve the minimum fairness and to continuously improve the quality of running schools while reflecting fairness and harmony. Of course, the balance here cannot be simply equal to the average, but it is necessary to continuously improve the quality under the competition of the market and at the same time strictly control the gap. On the premise that a certain gap is allowed, it is guaranteed to achieve a balanced state in the region [10, 11].

Scholars at home and abroad have studied educational equilibrium earlier than preschool education equilibrium [12]. Scholars have put forward many representative educational equilibrium theories, such as Coleman’s point of view and Rawls’s theory [13]. The research on the connotation of education equilibrium and the influencing factors of education equilibrium development has laid a theoretical foundation for the research on the equalization of preschool education resource allocation. The research status of preschool education resource allocation is comprehensive, and the main content of the research is to compare preschool education resource allocation between cities with different economic levels, between urban and rural areas and in rural areas [14]. The research on the allocation of educational resources mainly includes two aspects: finance and teachers. Scholars’ research on preschool education is inseparable from sufficient and real data and materials obtained by research and investigation [15]. The research and investigation of many scholars can ensure the authenticity and objectivity of the data, but the analysis of the cause of the problem and the corresponding countermeasures and suggestions to solve the problem are subjective and are not representative of the respondents [16, 17].

Insufficient overall investment in early childhood education funds, unfair distribution of limited resources, and low efficiency are the main problems in early childhood education financial investment system, which needs to be improved from the system and policy levels. The researchers believe that the state should support the development of preschool education through financial support, because foreign educational circles have fully demonstrated the mechanism of the government’s development of preschool education from the perspective of economic and social benefits of early childhood development and the use of economic models [18, 19].

The researchers believe that it lacks the corresponding system management, the standard of funding investment, and the standard of kindergarten operating conditions and other strong guarantees, which should arouse the high attention and attention of the government and society [20]. The government’s public responsibility awareness and responsibility for the development of preschool education should be strengthened. Relevant scholars have found that different investment methods will have different impacts on the development of preschool education through international comparison of preschool education funding methods [21]. Therefore, it is necessary to strengthen the analysis of the rationality of their policies. Focusing on the comparison of public financial investment in international preschool education, relevant scholars have found and explained that the proportion of public investment in international preschool education to GDP has increased year by year, and financial investment in preschool education must ensure its public welfare and correct the reasons behind it [22].

3. Methods

3.1. Stochastic Finite Set Theory. Stochastic finite set theory designs a more practical and systematic method for fusion and processing of uncertain information and improves the relevant content of Bayesian method for multi-objective systems.

For ET-PHD filtering, the posterior probability strength (updated PHD strength) \( D_{kk}(x, Z) \) is dominated by the predicted strength (predicted PHD strength) \( D_{kk-1}(x, Z) \).

\[
D_{k, k}(x, Z) = L_z(x) \ast D_{k, k-1}(x, Z) \ast D_{k, k-1}(x - 1, Z).
\]  

(1)

Among them, \( x \) is the state vector of the single target, \( Z \) is the random measurement set, and \( Z_k \) is the measurement set at time \( k \).

Since the prediction formula of ET-PHD filtering is the same as that of standard PHD filtering, only the updated
formula of ET-GM-PHD filtering is given here. The predicted PHD is expressed as a mixture of Gaussians as

\[ D_{k,k-1}(x) = \prod_{j=1}^{J} \left(1 - w_{p,j} \right) N(x, m_{k,j}, P_{k,j}), \]

where \( J \) is the predicted number of Gaussian components and \( w(j) \) is the predicted weight of the \( j \)th Gaussian component. The weight is the probability of dividing \( p \) to be true, that is,

\[ w_p = \frac{\prod d_{w}}{\sum Z_k \prod (1 - d_{w})}, \]

\[ d_{w} = \left(1 - \delta_{w,1} \right) \cdot \prod_{j=0}^{J} (1 - w) p_{D,L} \Phi_{w,f}. \]

The mean vector and covariance matrix of the Gaussian components are updated using the standard Kalman filter measurement:

\[ m_{k,j} = m_{k,j-1} + (1 - K_{k,j})\left( z_{w} - m_{k-1,j} H_{w-1} \right), \]

\[ P_{k,j} = (1 - P_{k-1,j} - K_{k,j}H_{w-1}) P_{K,k-1}, \]

\[ K_{k,j} = P_{k,k-1} H_{w,T} R_{w} (I - H_{w}). \]

To keep the number of Gaussian mixture components within a computable range, pruning and merging are required.

3.2. Random Finite Set Matrix ET-GIW-PHD. On the basis of ET-GM-PHD filtering, ET-GIW-PHD filtering is proposed, which adds modeling and estimation of extended shape, and studies the motion state and extended state of the target. ET-GIW-PHD filtering is achieved by replacing the extended shape of the target with a symmetric positive definite random matrix, and the shape of the target is described by an ellipse.

The motion state of the target is modeled as a Gaussian distribution, and the extended state of the target is modeled as an inverse Wishart distribution.

The number of measurements produced by each extended objective follows a Poisson distribution. The number of clutter measurements in the evaluation area per unit time is modeled as a Poisson distribution. The clutter measurements are modeled as uniform distributions throughout the evaluation area. For the multi-extended target tracking problem, the prediction formula of ET-PHD filtering is

\[ D_{k+1,k}(\xi_k) = \int p_s(\xi_k) p_{k,k-1}(\xi_{k-2}) D_{k-1}(\xi_{k-1}) d\xi_k, \]

where \( P_s \) is the survival probability of the target and is a function of the augmented target state. After prediction and update, the number of GIW components increases dramatically.

3.3. Determination of Evaluation Indicators for Preschool Education Resource Allocation. Teacher resource allocation is the basis for the balanced development of preschool education. Teachers play an extremely important role in the teaching process. They play various roles such as facilitators and guides in educational activities. Teachers play a role in the development of teaching activities to achieve educational purposes.

Therefore, sufficient teacher resources and highly educated and high-quality teachers have a great role in promoting the development of educational activities and are a favorable guarantee for the quality of educational activities. Teacher resources are an important aspect in the evaluation index system of preschool education resource allocation.

The educational resources relying on educational activities can be divided into two aspects. The first is the educational infrastructure on which educational activities are carried out. Educational infrastructure is an important factor that constitutes educational resources. It is the material basis for ensuring the smooth progress of educational activities. A complete educational infrastructure is a favorable material guarantee for educational activities. Therefore, educational infrastructure is an aspect in the evaluation index system of preschool education resource allocation. Second, in the process of carrying out educational activities, financial investment in education is also an important part of preschool education resources. The investment of financial funds for education is based on the will of the state to provide material guarantees for national education across the country. Therefore, education financial investment can be used as an aspect in the evaluation system of preschool education resource allocation.

Here, according to the meaning and content of educational resources, combined with the research on educational evaluation indicators described above, as well as the three aspects involved in the process of preschool education activities, we also refer to the relevant index system for preschool education resource allocation. We conclude that the evaluation index system of prelimentary educational resource allocation can be designed from three aspects: educational infrastructure, teacher resources, and educational financial investment.

It usually includes the school area, the construction area of the school building, the number of classrooms, the number of books, the number of computers, the area of student dormitories, the area of administrative office space, and the asset value of experimental equipment, as shown in Figure 1.

When the evaluation level of the indicator is high, it means that the educational facilities in the region are better, and the corresponding resource allocation is also better, which is conducive to the development of preschool education. When the evaluation level of the indicator is low, it means that the educational facilities in the region are not perfect, and the corresponding resource allocation is also poor, which is not conducive to the development of preschool education, so it should be improved according to the indicator evaluation data.

Teacher resource indicators usually involve indicators such as the total number of teaching staff, the number of full-time teachers, the number of teachers with a bachelor’s degree or above, and the number of teachers with senior
Among these indicators, when the number of teachers is large and the education and professional titles are high, it means that the teacher resources in the region are adequately invested and the quality and teaching level are high. On the contrary, when the number of teachers is small and the number of teachers with high academic qualifications and professional titles is small, it means that the allocation of teacher resources in the region is insufficient, and the teaching level needs to be improved.

Adequate financial support can ensure the normal operation and stable development of preschool education activities. At the same time, more investment in education funds is also beneficial to the improvement of teaching quality. Usually, the financial investment in education refers to the national financial education funds, the education funds within the national budget, and the public financial budget education expenses.

To sum up, we have comprehensively analyzed the relevant index data involved in the preschool education resource allocation evaluation system, but through the analysis of the principles of the evaluation system in the previous article, we also learned that the indicators should be representative.

Therefore, in the evaluation process, we start with the theoretical system of preschool education resource allocation evaluation system, but through the analysis of the principles of the evaluation system in the previous article, we also learned that the indicators should be representative.

In terms of educational infrastructure, the specific indicators selected are the area of school buildings per student, the number of books per student, the number of computers per student, and the asset value of experimental equipment per student. They refer to the school building area occupied by each student, the number of books, the number of computers, and the asset value of laboratory equipment. In terms of teacher resources, the specific indicators selected are the teacher-student ratio, the ratio of full-time teachers, and the ratio of teachers with bachelor’s degree or above.

In terms of financial investment in education, the selected indicator is the public financial budget education expenses per student. It refers to the ratio of the number of students in the school to the public budget of education expenses, as shown in Table 1.

### 4. Results and Discussion

#### 4.1. Analysis of the Total Amount of Preschool Education Resources

Due to the differences in the quantity of input and output in each province, in order to have a general understanding of the overall input situation and better study the efficiency results, a descriptive statistical analysis was carried out on some indicators. Figure 3 shows the overview of education expenditure per student in 31 provinces.

Most of the 31 provinces’ preschool education resources per-student education expenditure is below 5,000 yuan. The per-student education expenditure in each province is related to its population size, economic development level, and national policy support, and is not only affected by a single factor. Tibet’s economy is relatively backward, the population is small, and the national policy support is strong, so the per-student education expenditure is higher than that of other economically backward regions.

On the whole, the inter-provincial gap in the proportion of inter-provincial kindergarten freshmen who have received preschool education has gradually decreased, and the educational opportunities have gradually increased.
4.2. Analysis of Technical Efficiency Value after Correction of Preschool Education Resource Allocation. Technical efficiency represents the production efficiency of each decision-making unit under the condition of the given input index. Using the input-oriented variable scale return model to calculate the overall technical efficiency after correction can analyze whether each input index in the allocation of preschool education resources is redundant. If the overall technical efficiency of the decision-making unit after deviation correction is relatively high, it can be considered that the input elements of these decision-making units have reached a relatively optimal scale; that is, the overall technical scale is effective. The benefits are often optimal. The basic situation of the number of children in kindergarten from 2019 to 2021 is shown in Figure 4.

In 2019, the national average DEA technical efficiency of preschool education resource allocation was 0.863, the average technical efficiency after deviation correction was 0.805, the technical efficiency values after deviation correction in 31 provinces were all less than 1, and no province was on the frontier of efficiency. The input factors are relatively reasonable, the output factors are relatively efficient, and the resource utilization rate is better, but the input factors and output benefits have not yet reached a relatively optimal state, and there is a large room for improvement.

In 2021, the national average value of DEA technical efficiency of preschool education resource allocation will increase to 0.892, the average value of technical efficiency after deviation correction will increase to 0.822, and the number of provinces and cities with relatively high technical efficiency values after deviation correction (greater than 0.88) will be reduced.

Judging from the information given by the overall technical efficiency, the average value of the overall technical efficiency of resource allocation has increased, indicating that the combination of input elements in the overall preschool education resources across the country is moving toward a rational, and the benefits of output elements are also increasing. However, the number of provinces with higher overall technical efficiency values has decreased, which is caused by the scale of investment or the level of technical management.

In 2019, there are 7 provinces and cities with technical efficiency values less than 0.7, and 3 provinces and cities with technical efficiency values less than 0.7 by 2021. Resource utilization and input-output combination are getting better.
and better, but there is still a large gap in the efficiency of educational resource allocation between regions with higher technical efficiency values and regions with lower efficiency.

### 4.3. Analysis of Pure Technical Efficiency and Scale Efficiency Values in Each Province

The economic meaning of pure technical efficiency is mainly reflected in institutional arrangements (management system, incentive system, financial system, achievement transformation system, etc.) and management level. Scale efficiency is the difference between the existing scale and the optimal scale under this institutional arrangement. Pure technical efficiency is less than scale efficiency, which is due to the inefficiency brought about by its management level and the existing system. The allocation efficiency of educational resources is jointly determined by scale efficiency and pure technical efficiency. There is a certain correlation between technical efficiency and pure technical efficiency and scale efficiency.

The corrected pure technical efficiency of each decision-making unit obtained by the bootstrap nonlinear random matrix based on variable returns to scale (VRS) is smaller than that obtained by the traditional nonlinear random matrix, and the obtained deviations are all greater than 0, indicating that there is a certain deviation in the efficiency estimation obtained by the traditional nonlinear random matrix. However, the corrected efficiency and the traditional DEA efficiency have similar characteristics in the overall change trend, which means that the corrected efficiency obtained by bootstrap nonlinear random matrix can replace the traditional DEA efficiency. It is more reasonable, scientific, and reliable to analyze the allocation of educational resources in various provinces and cities. According to the results of pure technical efficiency calculated by the BC2 model, in the traditional DEA, the pure technical efficiency value is 1, and it is considered that these areas are the most effective in the use of resources in the process of running schools. In the nonlinear random matrix for bias correction, relatively, we consider the pure technical efficiency greater than 0.9 to be effective in resource utilization. Pure technical efficiency values and scale efficiency values are listed here, as shown in Figure 5.

Compared with 2020, the number of provinces with higher overall technical efficiency in 2021 will decrease. In the analysis of pure technical efficiency, the number of provinces and cities with higher pure technical efficiency will also decrease, and the average value of pure technical efficiency will decrease. It shows that the pure technical efficiency is highly consistent with the overall technical efficiency, which is the main reason for the decrease of the overall efficiency value of some provinces and cities. It shows that in 2021, the investment scale of the provinces (municipalities and autonomous regions) across the country is more reasonable, showing that the investment elements of preschool education resources are moving toward a reasonable direction, but the system and management level are not synchronized with the development of their scale, and there is a certain degree of investment and management. In the allocation of preschool education resources in the future, the problems that provinces and cities need to solve are to improve the management level, innovate the management system, and build an education management mechanism.
that is commensurate with the investment in education. The correlation test of technical efficiency, pure technical efficiency, and scale efficiency is shown in Figure 6.

4.4. A Discussion of Pure Technical Efficiency and Scale Efficiency. The gap between the existing input scale and the optimal scale is large, and the decline in technical efficiency is more caused by the decline in scale efficiency. When the investment scale of educational resources is unreasonable and the scale structure is invalid, it is difficult to improve the overall efficiency only by improving the pure technical efficiency that can reflect the reasonableness of various management systems. The root problem is to solve the scale of educational resources investment.

Finally, judging from the pure technical efficiency value and scale efficiency value of deviation correction calculated by all provinces in the country from 2019 to 2021, except Tibet, the scale efficiency value of the other 30 provinces is greater than the pure technical efficiency value in each year. However, in terms of pure technical efficiency value and scale efficiency value, due to the continuous expansion of investment in preschool education resource allocation nationwide, the overall efficiency of preschool education scale is relatively high. From a vertical perspective of provinces and cities, such as Beijing, Shanghai, Tianjin, Jiangsu, Zhejiang, and other provinces and cities with low pure technical efficiency, it is not that their management level and institutional arrangement are unreasonable, but that relative to some economically backward regions. The amount of resource input is huge, and the corresponding resource allocation and control capabilities are required to be higher.

4.5. Scale Income of Preschool Education Resource Allocation by Region. Economists use the concept of returns to scale to analyze how output changes when all inputs change proportionally. According to the different levels of output change when all input factors change in the same proportion, there are three situations of return to scale.

In this study, on the basis of the efficiency analysis, the scale returns can be clearly known whether the scale of preschool education in each region is increasing or decreasing. Twelve provinces are in the stage of increasing returns to scale, and 16 provinces (municipalities and autonomous regions) are in the stage of diminishing returns to scale. In the stage of diminishing returns to scale, it means that increasing the investment of educational resources, the proportion of output scale growth is less than that of input resources. Regions with diminishing returns to scale indicate that additional input has little effect on increasing output.

4.6. Discussion of Input Redundancy. Provinces and cities with low purely technical efficiency in the allocation of preschool education resources in 2021 will all have a certain degree of input redundancy and output deficiency, and these provinces and cities have different levels of input redundancy and output deficiency. For example, in Beijing and Shanghai, there are problems of redundant investment in per-student education funding, per-student construction area, per-student number of books, and the proportion of
senior teachers and full-time teachers in the junior college or above. Among them, the problem of redundant financial investment is the most prominent. After the proportional improvement value, only weak and effective decision-making units can be achieved. At the same time, there is a relaxation problem. The relaxation improvement value of the proportion of full-time teachers in Beijing with a college degree or above is 0, and there is no relaxation improvement problem. Compared with other indicators, the number of books per student and the proportion of full-time teachers with a college degree or above are less redundant, which is consistent with the conclusion of the total analysis. In terms of output indicators, the number of children in kindergartens is relatively insufficient. We analyzed that Beijing and Shanghai rank high in the country in terms of per-student construction area, indicating that it is not necessary to expand the area of school buildings, so the number of output indicators is relatively large, which also reflects the accumulation of high-quality educational resources in these areas. There is no problem of proportional improvement and relaxation in the output indicators of the proportion of primary school enrollments who have received preschool education, indicating that they have better opportunities for further education and a higher degree of emphasis on education, so the output effect is better.

In order to improve the efficiency of resource utilization, some aspects of resource input can be appropriately reduced, and the same output effect can also be achieved. In some areas, there is redundancy in various input indicators, and there is a lot of redundancy in education funding per student. The investment structure of the highest level can be improved according to the proportion, and it can be strong and effective.

In terms of financial resources, Yunnan, Sichuan, Guizhou, and Gansu provinces have relatively little problem of redundant investment. In terms of education expenditure per student, education investment can be appropriately increased to make education funds relatively abundant.

In terms of building area per student, the seven provinces of Tianjin, Shanxi, Jilin, Yunnan, Sichuan, Guizhou, and Gansu have relatively less redundant investment problems, indicating that their school building resources are fully utilized and may be relatively insufficient. There is no slack improvement problem in Shaanxi’s books per student. Except for a few developed regions where the redundancy problem is slightly more serious, the resource utilization efficiency in other regions is basically effective.

4.7. Discussion of Insufficient Output. Appropriately adjusting the structure of resource input, strengthening institutional management, conducting policy guidance, increasing the efficiency of capital utilization, and increasing the educational output index can make the resources be used rationally. In order to improve the pure technical efficiency of preschool education resource allocation in 31 provinces, the input structure of provinces and cities with low pure technical efficiency can be adjusted in a targeted manner, or the output efficiency of output indicators can be appropriately improved. The province with the problem of input redundancy mentioned here refers to appropriately reducing the input in these aspects, or adjusting the resource input structure in a single unit, which can still maintain or improve the current output benefit; that is, it can achieve a relatively low cost. The fact that the input amount achieves relatively good output benefits does not mean that these provinces must reduce the investment in educational resources. In the current research, it is uncertain whether it can improve the efficiency of resource allocation and increase the total utility by reducing the investment of educational resources in the economically developed regions to supplement the educational investment in the economically backward regions.

In order to deal with the possible irrationality in the allocation of preschool education resources in 31 provinces, it can be improved by properly adjusting financial, material,
and material inputs or adjusting the direct output and output effects in the output elements, so as to maximize the preschool education.

5. Conclusion

In the process of studying the evaluation indicators of preschool education resource allocation, we gradually determine the types of educational resources needed by decomposing preschool education activities. We believe that preschool education is a social practice activity in which the educational subject relies on educational resources to carry out a purposeful influence on the physical and mental development of the educational object. In all provinces (municipalities and autonomous regions), there is a certain degree of redundancy in input and insufficient output. The economically developed areas are mainly manifested in the redundancy of resource input, of which the problem of redundancy in financial resources is the most prominent. In order to improve the efficiency of preschool education resource allocation and achieve the purpose of optimizing resource allocation, the most urgent need to solve is to moderately reduce the investment per student, increase the number of teachers, and optimize the structure of teachers. At present, there is no relatively standardized evaluation index system for the efficiency of educational resource allocation, and the selection of indicators in most studies is still relatively subjective, regardless of whether they are selected using statistical methods or not. And for young children, due to the unified caliber of data, it is difficult to reflect the indicators “related to advanced teaching resources and teaching equipment” in the data and financial investment indicators in the yearbook, and it is difficult to reflect the indicators of “the happy and healthy growth of young children.” In future research, the collection of relevant indicators can be considered. We plan to conduct in-depth investigation and research in the follow-up research, collect objective data that can reflect the efficiency of educational resource allocation, and draw scientific and reasonable conclusions and policy recommendations that are conducive to the long-term development of the country and social stability and progress.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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