Hindawi
Mobile Information Systems
Volume 2022, Article ID 9932083, 10 pages
https://doi.org/10.1155/2022/9932083

Research Article

Prediction of the Development Scale of Vocational Education Using Markov Algorithm and Countermeasures

Yi Zhang [1] and Xiaoding Yang [2]

[1] *Office of Educational Administration, Sichuan Winshare Vocational College, Chengdu 611330, China*
[2] *School of Marxism, Sichuan Winshare Vocational College, Chengdu 611330, China*

Correspondence should be addressed to Yi Zhang; 1931093202@siit.edu.cn

Received 16 April 2022; Revised 19 May 2022; Accepted 21 May 2022; Published 4 July 2022

Academic Editor: Liping Zhang

HVE (Higher Vocal Education) in China is developing rapidly. With the expansion of HVE enrollment, the scale has also expanded rapidly. However, with the great development of HVE, HVE also faces many problems. In this paper, the M_BPNN (Markov neural network-BP) model is constructed for the prediction of the development scale of vocational education. Using BPNN's powerful nonlinear mapping ability and error correction thought, the data information of the future development scale of vocational education is predicted. The results show that the prediction accuracy of the M_BPNN model is the best, and MSE (mean squared error) and MRE (mean relative error) are 10.184 and 5.017, respectively, which are lower than the other two prediction models. It shows that the prediction effect of the M_BPNN model is better than that of the pure Markov model. The forecast results show that the population of school age in H province will decrease from 3.36 million in 2020 at an average annual rate of nearly 700,000 to the lowest value of 2.06 million in 2022. After that, the population of school age will increase steadily. The result shows that there is a relative shortage of regional students, and the enrollment scale is developing well, but it is still not optimistic. It is necessary to coordinate the cross-regional development.

1. Introduction

Developing vocational education vigorously and accelerating human resource development are important steps in implementing the strategy of rejuvenating the country through science and education, strengthening the province through talents, and promoting economic structure optimization. The development model, job promotion and reemployment, and population change are all in the works. HVE (Higher Vocal Education) has both good and bad aspects. Education development must be based on the present and look to the future, which necessitates scientific planning, and understanding the population trend is critical in this process. Higher vocational education, secondary vocational education, vocational training centres, and amateur vocational education make up a comprehensive educational system that provides human resources for economic growth and expansion. A more precise forecast of HVE scale in China can improve the predictability of the government's HVE decision-making, provide theoretical support for the formulation of HVE development policies and strategic plans, and thus avoid HVE expansion blindness.

With the goal of building a well-off society in an all-round way, China's social and economic construction has entered a new stage of development. The government attaches great importance to the role of vocational education in social economy and human development. It is an important task for HVE researchers in China to predict the development of scientific higher vocational education and guide the development of HVE. Mcgrath made some preliminary explorations on the prediction parameters and methods of the development scale of vocational education by analyzing the existing achievements of vocational education prediction research and drawing lessons from the prediction ideas and methods of other types of education [1]. Trampusch combines the Markov model with the grey model and uses the grey Markov model to predict the changing trend of public attitude towards cloud education [2]. Prediger et al., based on the development and theoretical derivation of HVE in a province, used the grey model as the forecasting model, fitted the historical data, made a short-term forecast of HVE scale in a province, and analyzed its development trend [3]. Okoye et al. used quantile regression, linear regression, grey prediction, exponential smoothing, principal component analysis, and factor analysis to predict the talent demand and education scale of a city in the next few years [4]. As far as the research content is concerned, the proposal of educational investigation and experimental topics, the definition of content, the determination of object scope, the establishment of hypothesis, the conclusion, and analysis are not the research tasks of educational statistics, because these problems have to be solved by educational expertise related to the research content. Compared with the prediction research of other types of education, the overall level of systematic and scientific research on HVE development prediction in China is still quite weak.

China is undergoing a period of industrial restructuring and modernization, which has created new demands for HVE development as well as new challenges and opportunities. As a result, we must first gain a thorough understanding of the current state of HVE regional development in China and then work backwards from there to find a suitable path for our own development [5, 6]. China's vocational education has grown at an unprecedented rate, but the quality is uneven. This paper presents the problems and countermeasures of vigorously developing vocational education in H province, the research area, by establishing a prediction model of vocational education development scale based on the Markov model, with the goal of exploring and constructing a basic mode of vocational education teaching based on all-round quality education and ability, and providing reference for promoting the development of local vocational education in H province.

Main contributions of this paper are as follows:

(1) On the basis of the principle of the forecasting method based on the Markov model, the combination forecasting model of M_BPNN is established, which can accurately forecast the development scale of vocational education.

(2) According to the established combined forecasting model, this paper grasps the related factors that affect this result and the relationship between them and the forecasting result and then provides the basis for putting forward corresponding countermeasures.

2. Related Work

2.1. Vocational Education Development Research. There are two main bases for vigorously developing HVE: first, outside the educational system, that is, social industrialization, informationization, and modernization, and the corresponding changes in economic structure, industrial structure and technical structure. Secondly, in the education system, vocational education should be extended to a high level, and HVE should be enriched and improved. The development of basic education provides a solid foundation for vigorously developing HVE, and the continuing education system needs HVE to play an important role.

Varghese et al. integrated urbanisation theory with regional economic development theory, human capital theory with vocational education development theory, and multiple intelligences theory with modern employment theory, and adopted the methods of normative and empirical combination, and qualitative and quantitative combination, supplemented by literature research and comparative research to discuss the development of vocational education in the process of urbanisation [7]. Allen et al. used modern econometric methods to establish a model reflecting the relationship between secondary vocational education and regional economic development [8]. Song et al. clarified the basic concept and theoretical thread of the coordinated development of vocational education and regional economy through literature retrieval and combing [9]. Chao-Hui and others analyzed the basic situation and characteristics of regional economic development [10]. Laurent et al. put forward seven measures for regional overall development of vocational education, specifically, joint enrollment between the east and the west, urban and rural areas, and cooperative education, vocational group education, HVE school financial aid policy system for students with financial difficulties [11].

Ryan et al. pointed out that the new role of the government should be reflected in that the government moves from manager to guide, from manager to coordinator, and from manager to supervisor [12]. Girgin et al. put forward that the development of China's regional vocational education should be based on serving the regional economic development, strengthening the relationship between colleges and enterprises, and strengthening the relationship between colleges and government. Randell et al. pointed out that the external environmental factors that affect the development of HVE are regional government's overall planning, regional economic development foundation, regional population structure, and regional educational structure background [13]. Rong et al. analyzed the factors of economic development and rural economic development from the perspective of rural HVE development; combined with the relevant vocational education policies issued by the state, according to the regional characteristics, this paper puts forward some countermeasures and suggestions to promote the development of HVE in rural areas [14]. Joyner puts forward development countermeasures from two dimensions: the policy orientation of the government and relevant administrative departments, the reform of management system, and deepening the reform of internal management system of secondary vocational schools [15].

2.2. Markov Model Theory. In recent years, the Markov model has been widely used in the field of economic management. One of its characteristics is that it has no consequences. In HMM (hidden Markov model), the hidden state of Markov chain can be inferred from external observation, so it is an ideal model to solve this kind of problems and an important reason for its wide application. HMM is a double-stochastic process of hidden states based on the Markov model, which is more realistic by adding a general stochastic process of generating observations from Markov chain states.

The vector Markov model is a Markov model with multiple probability transfer elements, which can deal with the probability transfer problem with multiple probability transfer elements. Spahn et al. applied the vector Markov model to the reliability prediction of supply chain distribution services, indicating that the vector Markov model has a broad application prospect [16]. Ezawa et al. put forward a new mixed density method in continuous mixed density HMM, which can achieve the balance of modeling accuracy and robustness [17]. Wu et al. applied semicontinuous HMM to the modeling and recognition of Arabic letters. In their research, they compared semicontinuous HMM with continuous HMM using Gaussian distribution, Besson distribution, and gamma distribution, which can greatly reduce the calculation amount while ensuring the recognition speed [18].

Baranwal et al. proposed a wavelet domain HMM, which can solve the problem of dependence among wavelet coefficients and is suitable for signal estimation, monitoring, classification, prediction, and other applications [19]. Wang HMM is introduced into the real-time monitoring of the running state of important equipment in the field of engineering management, processing signals from multiple sensors, diagnosing the running state of equipment, and predicting the remaining service life of equipment.

3. Methodology

3.1. The Basic Principle of Markov Prediction Method. The basic principle of the Markov forecasting method can be simply described as follows: if such a system exists, the state of the system can be transferred from one state to another according to the state transition matrix; that is, it can be derived from the current data and the latest data. If it is derived independently of historical data, then we call such a system Markov. This transfer process is called Markov process, and the set of this series of processes is called Markov chain. Markov process describes the state of a system and the theory of its transition from state to state. The mathematical description of Markov process is as follows.

Assuming that $\{X(t), t \in T\}$ is a random process, if the following conditions are met for any positive integer:

$$P\{X(t_n) \le x_n | X(t_{n-1}) = x_{n-1}, X(t_{n-2}) = x_{n-2}, \ldots, X(t_1) = x_1\} = P\{X(t_n) \le x_n || X(t_{n-1}) = x_{n-1}\}, \quad (1)$$

where $\{X(t), t \in T\}$ is called Markov process.

Markov process has two important properties, one is no aftereffect and the other is ergodicity. Aftereffect means that the state of the system at the next moment only depends on the current state and has nothing to do with the past state of the system.

Markov chain is a random process, which has no memory, also known as no aftereffect, that is, the state of t at any moment is only related to the state of the previous moment in the past, and has nothing to do with the state of other moments, namely,

$$P(j_t | j_{t-1}, j_{t-2}, \ldots, j_l) = P(j_t | j_{t-1}), \quad (2)$$

where j_t represents the state of t -time model and $P(j_t | j_{t-1})$ refers to the probability that the state of t time model is i_l under the condition that the state of $t-1$ time model is j_{t-1}, which is called the state transition probability.

Markov chain has the characteristics of stationarity, periodicity, interoperability, ergodicity, and reversibility, besides memoryless.

3.2. Markov Prediction Model Establishment. When a person's professional position changes in today's society, he must complete continuing education, acquire new professional skills, and obtain a new professional qualification certificate before starting a new job. HVE's connotation is fluid and evolving. It can range from basic college-level vocational education to college-level or even higher education. HVE will have greater flexibility and adaptability as modern science and technology, as well as the acceleration of vocational changes and skill renewal, continue to develop, and will provide people with lifelong diversified educational opportunities. Currently, the majority of China's professional and technical talents are concentrated in traditional industries, whereas emerging industries lack technical talent who are proficient in advanced technology as well as first-class professional and technical talents, and all of which must be trained and delivered through HVE.

The industrial structure determines that employment requires a large number of graduates from vocational colleges. Especially, HVE graduates are irreplaceable in production. However, the reality is that quite a few resources of HVE schools are idle, unable to recruit students, and the real demand is not strong. Therefore, technical and vocational schools lack the necessary sources of educational funds, and infrastructure investment is far from meeting the development needs of modern education. With the global economic integration, competition and talent flow are inevitable, and talent flow is also very common. Some provincial key technical schools lack students in this unfair competition, resulting in some first-class facilities and high-quality vocational education resources being idle and unable to perform their duties. All the above seriously hindered the sustainable development of HVE.

Markov process is a stochastic process theory that studies the state of an event and the transition rule between states. It studies the change trend of states at a certain time in the future by analyzing the initial probability of different states at a certain time and the transition probability relationship between states. This method of state division is based on the trend curve $\hat{y}(k)$ predicted by the grey model, and n parallel curves are made on its upper and lower sides. The area between every two adjacent curves is called a state.

For a nonstationary random sequence $\hat{y}(k)$ that conforms to the characteristics of Markov chain, it can be divided into states according to specific conditions, and any state $\otimes_i$ can be expressed as

$$\begin{aligned} &\otimes_i = [\otimes_{1i}, \otimes_{2i}], \ i = 1, 2, \cdots, n, \\ &\otimes_{1i} = \hat{y}(k) + A_i, \\ &\otimes_{2i} = \hat{y}(k) + B_i, \end{aligned} \quad (3)$$

because $\hat{y}(k)$ is a function of time k, the grey element $\otimes_{1i}$, $\otimes_{2i}$ also changes in time sequence; that is, the state $\otimes_i$ is dynamic. The number n of state divisions is the value of A_i, B_i which can be determined according to the amount and nature of data on the scale of vocational education development.

Let the state space of Markov chain $\{X_n, n \geq 0\}$ be E. For any two states $i, j \in C$, assume that the system starts from state i, and the moment when it reaches state j for the first time is represented as T_{ij}; that is,

$$T_{ij} = \min(n\colon X_0 = i, X_n = j, n \geq 1), \quad (4)$$

where T_{ij} is a random variable, referred to as "the first arrival time." Its value is that the system starts from state i and makes the smallest positive integer n of $X_n = j$. If such n does not exist, $T_{ij} = +\infty$ is specified.

The transition matrix, also known as the transition matrix, describes that the result of the n-th transition is only affected by the result of the $n-1$ th transition. Here, we let m_i represent the number of times that state s_i appears in different time periods, and m_{ij} represents the number of times that state s_i transits to state s_j. The transition probability p_{ij} is obtained by the following formula:

$$p_{ij} = p\{X(t+1) = j | X(t) = i\} = \frac{m_{ij}}{m_i}. \quad (5)$$

In the formula, p_{ij} plays a very important role in the whole prediction process. The more accurate the value of p_{ij} is, the more accurate our prediction method will be.

For example, a system has three states A, B, and C. The interworking can be simply described with Figure 1.

If each arrow indicates that there is a transition probability p_{ij} greater than 0 between the i state and the j state connected to it, it means that the i state can transition to the j state with a certain probability. Figure 1 shows that these three states are interconnected.

Considering that the ultimate goal of this topic is to predict the school-age population, their significance is to help us dig out isolated points, so as to accurately locate the wrong objects and repair the data of school-age population in the wrong objects. The correction formula of age-appropriate population x_i is

$$x_i = \frac{1}{2}(x_{i-1} + x_{i+1}). \quad (6)$$

The above repair methods are not only for erroneous data, but also for null data and redundant data. The steps of identifying and repairing abnormal data are shown in Figure 2.

When applying various Markov chain forecasting methods to analyze and solve practical problems, it is necessary to first check whether the random variable sequence has "Markov property." For random variables of discrete sequences, χ^2 statistics can be used to test them.

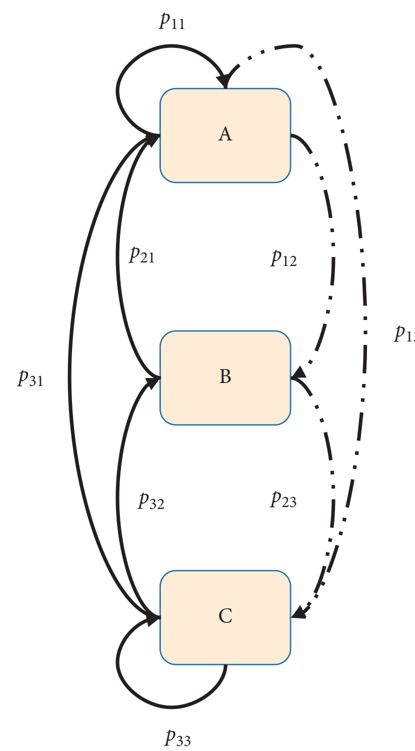

Figure 1: Schematic diagram of interoperability.

Let the index value sequence of random variables contain m possible states, and use f_{ij} to indicate the frequency, $i, j \in E$, of the index value sequence $x_1, x_2, \ldots, x_n$ from state i to state j after one step transition. The value obtained by dividing the sum of the j-th column of the transition frequency matrix by the sum of each row and column is called "marginal probability" and marked as p_j; that is,

$$p_j = \frac{\sum_{i=1}^{m} f_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{m} f_{ij}}. \quad (7)$$

Then, when n is large enough, the statistic obeys the χ^2 distribution with the degree of freedom $(m-1)$, where p_{ij} is the transition probability:

$$\chi^2 = 2\sum_{i=1}^{m}\sum_{j=1}^{m} f_{ij}\left|\log\frac{p_{ij}}{p_j}\right|. \quad (8)$$

The value of statistic χ^2 is obtained after calculation. If $\chi^2 > \chi_a^2((m-1)^2)$, it can be considered that $\{m_i\}$ conforms to Markov property [18, 19]; otherwise, it can be considered that the sequence cannot be processed by Markov chain.

3.3. Improved Markov Prediction Model for the Development Scale of Vocational Education. The process of population concentration in cities is known as urbanisation. The greater the proportion of urban population and the better the development conditions for vocational training, the higher the

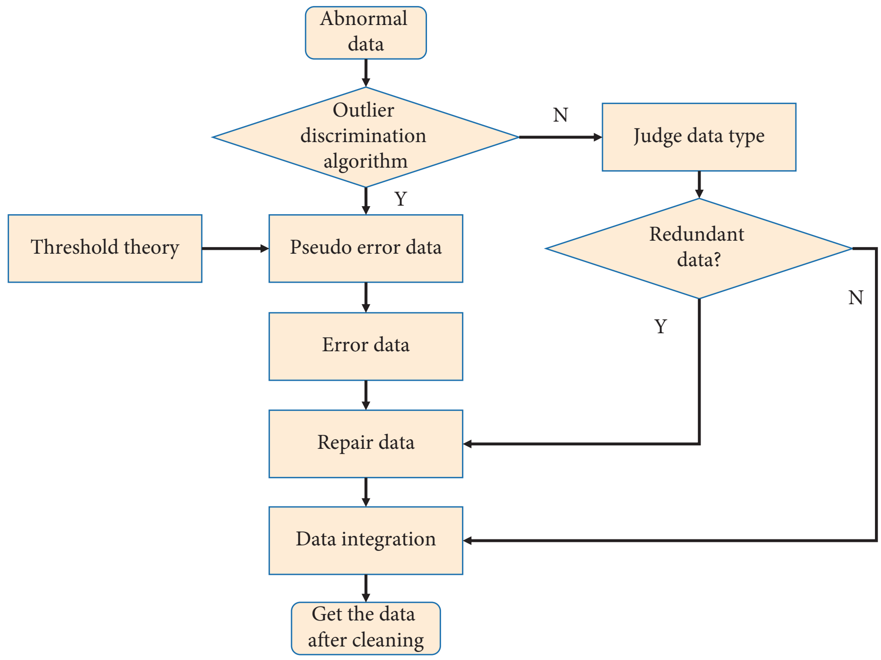

Figure 2: Identification and repair steps of abnormal data.

rate of urbanisation. Without taking other factors into account, the rate of urbanisation is positively correlated with the development of an ultrahigh pressure relationship [8]. To improve the talent structure, we must not only focus on overall quality improvement, but also on the training and development of a diverse range of professionals. The demand for social structural talents is stratified, and so should the training of those talents in colleges and universities. Undergraduate, let alone graduate, study is impossible and unnecessary. As a result, we should adhere to the coordinated development of HVE college, undergraduate, and graduate education on a university scale. For a series of random variables, it is a traditional Markov chain forecasting method to calculate the absolute distribution of the future period by using the Markov chain model with step 1 and the initial distribution. Therefore, this paper uses the increment of performance index before and after as the input of the Markov prediction model.

Let the performance index sequence be $y_1, y_2, \ldots, y_i$, then the increment of the front and back items is

$$\operatorname{inc}(i) = y(i+1) - y(i), \quad i = 1, 2, \ldots, n-1. \tag{9}$$

Through one-step prediction by the Markov prediction model, the absolute increment $\operatorname{inc}(n)$ of the next moment relative to y_n is obtained, and the predicted value of the next moment is calculated by the following formula:

$$y_{n+1} = y_n + \operatorname{inc}(n). \tag{10}$$

Because of the distributed information storage and parallel computing performance of the neural network, it has the associative memory ability of external stimulus information and input patterns. This ability is realized through the cooperative structure between neurons and the collective behavior of information processing. Especially, BP neural network (BP neural network) [20] is an important tool to study forecasting problems because of its nonlinear mapping, self-organization, error feedback adjustment, generalization, and fault tolerance. Therefore, this section puts forward a combined prediction model of vocational education development scale-M_BPNN (Markov-BP neural network). The idea is as follows:

(1) The Markov model is used to get the prediction results under the condition of analytic mathematics.

(2) The relative sequence of errors between the predicted results obtained by the Markov model and the real school-age population is obtained. Establish BPNN, and use the relative sequence of errors as the input data of BPNN, so as to fit the nonlinear function.

(3) The prediction value obtained by the Markov model is superimposed with the relative sequence of errors obtained by BPNN, and the final prediction result is obtained.

For the prediction of this age-appropriate population, the principle of choosing the number of nodes in the hidden layer is to reduce the number of nodes as much as possible and simplify the network model without affecting the accuracy of network prediction. In this document, the number of nodes in the hidden layer is determined according to the following function [16] and adjusted appropriately after the training starts:

$$M = 2N + 1, \tag{11}$$

where M is the number of hidden layer nodes and N is the number of input layer nodes. Therefore, we adopt 3-8-1 BPNN, that is, the number of input layer nodes is 3, the number of hidden layer nodes is 8, and the number of output layer nodes is 1.

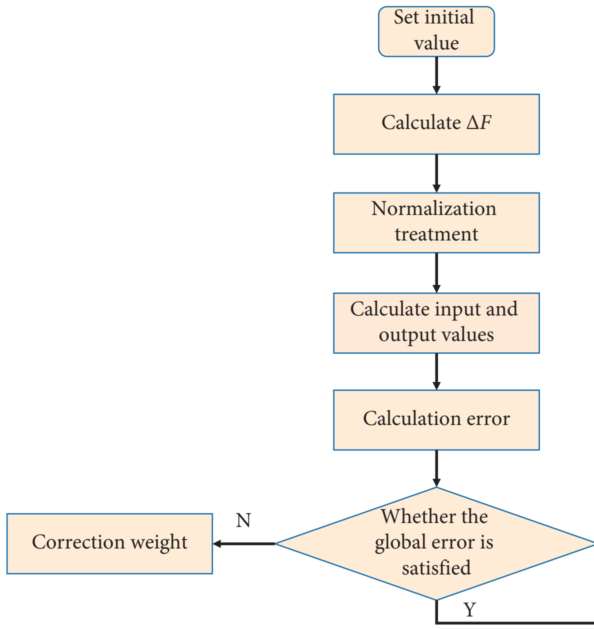

Figure 3: Flowchart of the M_BPNN algorithm.

The forecast data $\hat{Y}$ has been obtained by using the Markov model. Here, we do not take $\hat{Y}$ as the final forecast result, but we continue to work out the relative sequence of errors between the forecast data $\hat{Y}$ and the real data Y, that is, the population difference ΔF:

$$\Delta F = Y - \hat{Y}, \quad (12)$$

where we take the population difference ΔF as the input data of BPNN and use the rolling prediction structure to predict the future ΔF.

The weight vector adjustment is

$$\Delta W_j = \eta\left(d - W_j^T X\right)X. \quad (13)$$

The components of ΔW_j are

$$\Delta \omega_{ij} = \eta\left(d_j - W_j^T X\right)x_i, \quad i = 0, 1, \ldots, n. \quad (14)$$

The learning rules have nothing to do with the transfer function adopted by neurons, so there is no need to calculate the derivative of the transfer function, which not only has fast learning speed but also has high accuracy. The weight can be initialized to any value.

The specific algorithm flow of the combination model of M_BPNN is shown in Figure 3.

The specific algorithm is described as follows:

(1) Set the initial value

(2) Calculate the Markov model to get the population difference

(3) Determine the input data and ideal output data of BPNN

(4) Normalize the input data of BPNN

(5) Train BPNN and predict the next age-appropriate population difference

(6) Whether the fault meets the accuracy requirements, and if not, make error correction

4. Experiment and Results

The M_BPNN model introduces the BPNN algorithm, which breaks the fixed pattern of traditional mathematics. By using its own structural mechanism and learning and training of historical data, we can adjust the law to adapt to future changes. Therefore, the introduction of BPNN has nonlinear characteristics, which is of great help to adjust the characteristics of population data. Sim function is used to predict the future population difference, and the predicted population difference is superimposed with the prediction result of the Markov model to get the future population (HVE enrollment) of school-age HVE. The expected results are shown in Figure 4.

In order to further evaluate and compare the prediction performance of the models, we introduce the following indicators to compare and analyze the models proposed in this paper, MSE (mean squared error) and MRE (mean relative error). The evaluation results of the prediction performance of the model are shown in Table 1.

We can see that the M_BPNN model has the best prediction accuracy, and MSE and MRE are 10.184 and 5.017, respectively, which are lower than the other two prediction models. The second one is the BPNN model, and the last one is the pure Markov model. The Markov model is a model based on mathematical analysis. It uses statistical knowledge to construct state transition matrix, so as to achieve the purpose of predicting the age-appropriate population. However, it can only predict the general trend of the school-age population, and the prediction results are rough.

The M_BPNN model makes use of the ability of BPNN to process nonlinear signals and indirectly predicts the time

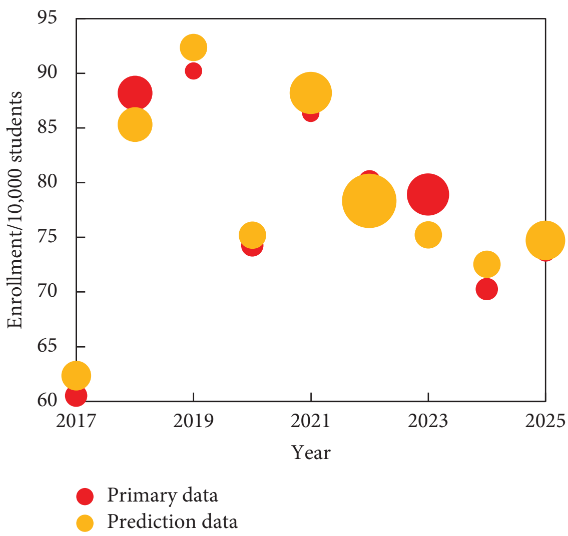

Figure 4: Prediction result.

Table 1: Evaluation of prediction performance of the model.

Prediction model	MSE	MRE
Markov	28.324	6.832
BPNN	13.069	5.561
M_BPNN	10.184	5.017

series of future population data through the relative sequence of prediction errors. Therefore, compared with the Markov model alone, the prediction accuracy is improved. In this way, the information contained in the time series of population data can be described more accurately and completely. Finally, the BPNN is used to predict the age-appropriate population. Experiments show that the M_BPNN model has the best prediction result. Based on the survey data of H Provincial Bureau of Statistics in 2020, the total number of school-age population aged 20–22 in 2020–2025 is predicted. The prediction results are shown in Table 2 and Figure 5.

The results show that the application of the M_BPNN model is quite successful. After testing, the deviation ratio of the two groups of data is very small, which indicates that the prediction is credible.

The population of HVE stage in H province is at the minimum stage. The age-appropriate population will drop from 3.36 million in 2020, with an average annual decline of nearly 700,000 to the lowest value of 2.06 million in 2022. After that, although the age-appropriate population will increase steadily, the total amount will not exceed 2.3 million. To sum up, after 2020, the total population of HVE stage in H province will not fluctuate much (see Figure 6).

Generally speaking, the demand for full-time teachers is related to two factors. First, the number of students in school, the demand for full-time teachers is directly proportional to the number of students in school; the other is the teacher-student ratio, and there are differences between schools at all levels. Based on the above forecast of HVE students' enrollment, the demand for full-time HVE teachers is expected from 2020 to 2025. The results are shown in Figure 7.

The forecast shows that from 2020 to 2025, the demand for full-time teachers will increase first and then decrease, and will rise slightly after 2020. Although the overall trend of full-time teachers shows a downward trend from 2020 to 2025, the demand for full-time teachers still shows a downward trend, and teachers at that time are increasing. With the demand for high-quality talents in China's economic and social development, in order to improve the teaching quality of HVE, the teacher-student ratio of HVE has to be reduced, so the demand for teachers will continue to increase.

This forecast uses two methods to forecast the education funds in HVE budget. First, it is calculated based on the per capita education expenditure in HVE budget in 2020; second, it is based on the education funds in HVE budget in 2020, and it is measured by the standard of the synchronous growth with China's GDP. According to the above prediction of the number of students in this paper, the education funds in the budget are predicted. See Figure 8 for the results.

The forecast results show that if the education budget expenditure is predicted according to a fixed standard, it will show a trend of first decreasing and then increasing slightly, and it will drop to the bottom of 40.125 billion yuan in 2024, 12.238 billion yuan less than 52.363 billion yuan in 2020, and 40.936 billion yuan in 2025, an increase of 811 million yuan over 2024. According to the GDP growth, the growth trend will continue from 2020 to 2025, from 66.393 billion yuan in 2020 to 2025, 113.627 billion yuan for the whole year, up by 71.14%. The development of HVE needs the support of government policies and funds, the support of society, and of course the efforts of professional associations themselves. That is to say, the development of vocational training needs the joint efforts of the government, society, and schools, which are indispensable. H province can take the following countermeasures to develop HVE.

Strengthen reform: first, HVE was established as the initiator, with direct involvement from the labour and industrial departments, as well as appropriate participation from relevant management departments and institutions. The second step is to overhaul the management of public HVE schools. We will actively attract private capital and external funds by adopting various forms such as "sharing cooperation," "nongovernmental public assistance," and "project financing," and introduce private school-running mechanisms in public schools by deepening the reform of system and mechanism. Third, continue to reform the HVE public school personnel distribution system. We should scientifically set up internal institutions and posts in schools, implement flexible management methods, fully implement the teaching and administrative staff employment system, and improve the salary structure in schools, according to the reform direction of public institutions.

Establish and improve the vocational education fund's guarantee mechanism: establishing a financial input system that is compatible with the scale of operating schools and training needs and implementing a diversified investment

Table 2: Comparison between preview value and actual value of HVE students from 2020 to 2025.

Years	School-age population (10,000 people)	Number of students in senior high school (10,000 people)	Prediction value of HVE students (10,000 people)	Actual value of HVE students (10,000 people)
2020	443.21	41.36	34.25	34.69
2021	433.23	40.22	33.65	34.01
2022	421.68	40.86	33.74	32.99
2023	426.35	39.67	32.13	31.68
2024	406.98	38.21	30.69	31.67
2025	389.27	37.27	31.32	31.07

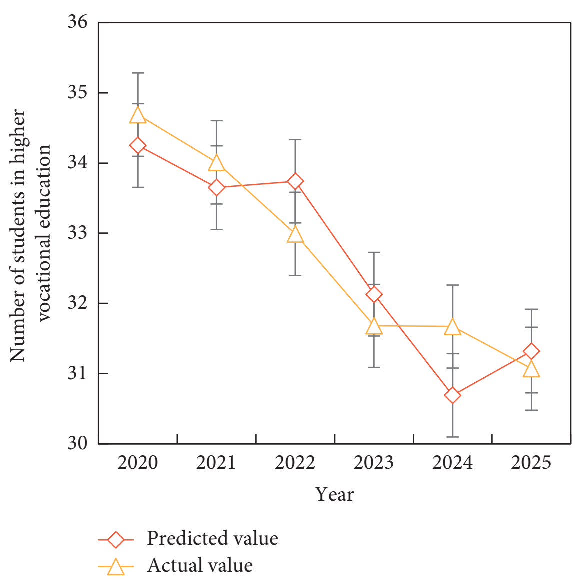

Figure 5: Comparison between actual and predicted number of HVE students.

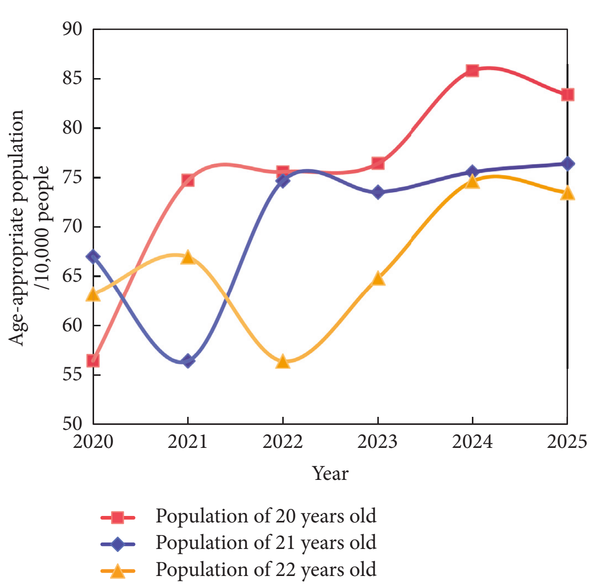

Figure 6: Forecast of HVE age population in H province from 2020 to 2025.

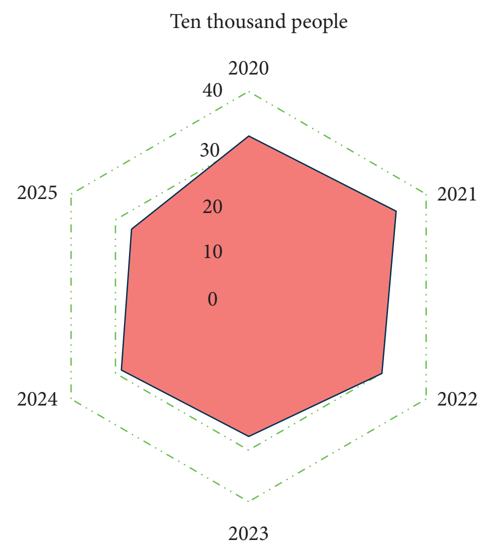

Figure 7: Demand forecast of HVE teachers from 2020 to 2025.

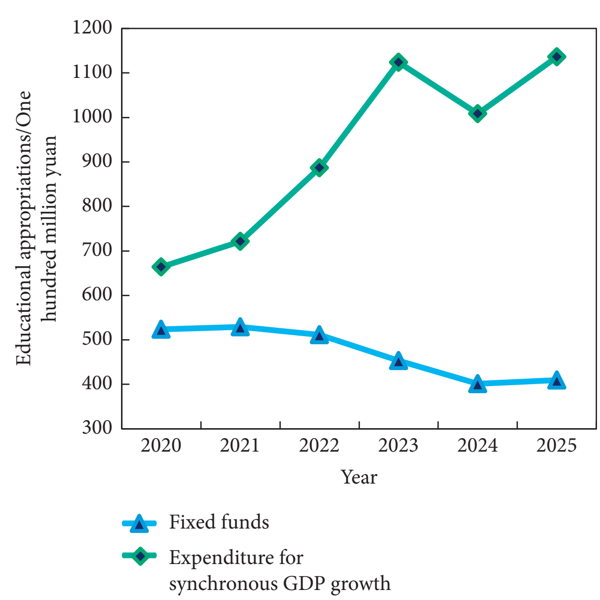

Figure 8: Forecast of education expenditure in HVE budget from 2020 to 2025.

system for education based on public finance are both necessary. According to the needs of industrial upgrading and economic transformation, we will continue to strengthen the basic capacity building of vocational education, improve the conditions for running vocational schools, and increase experiential and practical training and teaching equipment. In addition, strengthen and improve teacher management in vocational schools. Improve the vocational teacher education and training system on a continuous basis, and establish vocational education teacher training bases that rely on universities both within and outside the province. And establish a series of professional titles and evaluation systems for teachers in specialised schools, as well as improve and refine the professional title system of teachers in specialised schools.

Implement strategic management: from the above forecast results, vocational education in H province has achieved a leap-forward development and will enter a relatively stable and connotative development path in the future. Therefore, vocational education in H province should seek the best combination of development direction, scale, quality, and speed and make overall strategic planning and design accordingly. The advantages of HVE economies of scale are not absolute. If the scale exceeds a certain range, it will increase the cost and reduce the overall advantages. If the development scale of HVE is not large enough, it will lack competitiveness. Of course, the high quality and high speed of development cannot be mentioned. HVE makes scientific and reasonable decisions in time, implements strategic management, and keeps the development direction, scale, quality, and speed in harmony, which is the key to its strategic success.

Strengthen the teaching staff's structure: the improvement of the HVE level is largely dependent on the overall quality of the teachers. However, HVE colleges and universities in H province suffer from a teacher shortage, poor quality, an arbitrary structure, a lack of practical ability, and a scarcity of academic leaders and backbone teachers. H province should also spend a significant amount of money to establish training centres for teachers in technical and professional education. Vocational colleges should develop teacher training plans based on the school's current situation and send teachers to the training on a regular basis. Teachers can be encouraged to participate in various training programmes on the one hand. The teacher training centre, on the other hand, can organise some of the best teachers and scholars in related fields to impart subject knowledge and develop teachers' innovative abilities. A teacher training network with top-down connections, left-right communication, division of labour, and cooperation will be formed as the key construction base of vocational education covering the entire province, with provincial vocational teacher training as the leader, skill training of enterprises and institutions as the supplement, and school training of vocational colleges as the main body.

5. Conclusions

Vocational education is an important part of national education, and the development of vocational education is an important foundation and educational strategic policy to promote economic and social development. It is an important task for Chinese vocational education researchers to predict the future development scale of vocational education with scientific methods. In this paper, Markov theory is applied to predict the development scale of vocational education, and the state transition matrix is obtained by using statistical knowledge. Because the time series of population data is nonlinear, this paper combines Markov theory with BPNN to construct M_BPNN. The research shows that the prediction accuracy of the M_BPNN model is the best and MSE and MRE are 10.184 and 5.017, respectively, which are lower than the other two prediction models. The experiment proves that the prediction result of the M_BPNN model is the best. The prediction results show that the age-appropriate population in HVE stage of H province is in the trough stage, and the age-appropriate population will decrease from 3.36 million in 2020 to the lowest value of 2.06 million in 2022 at an average annual rate of nearly 700,000. After that, the age-appropriate population will increase steadily, but the total number will not exceed 2.3 million. After 2020, the total age population of HVE stage in H province fluctuates little.

Data Availability

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

Conflicts of Interest

The authors do not have any possible conflicts of interest.

References

[1] S. Mcgrath, "Vocational education and training for development: a policy in need of a theory?" *International Journal of Educational Development*, vol. 32, no. 5, pp. 623–631, 2012.

[2] C. Trampusch, "Employers, the state and the politics of institutional change: vocational education and training in Austria, Germany and Switzerland," *European Journal of Political Research*, vol. 49, no. 4, pp. 545–573, 2010.

[3] D. J. Prediger and W. E. Brandt, "Project CHOICE: validity of interest and ability measures for student choice of vocational Program," *The Career Development Quarterly*, vol. 40, no. 2, pp. 132–144, 2011.

[4] P. I. Okoye and K. Okoye, "Enhancement and innovation in higher education in nigeria through technical vocational education and training (tvet) and entrepreneurship education," *Journal of Mixed Methods Research*, vol. 2, no. 5, pp. 116–174, 2015.

[5] Y. Robert, "Historical antecedents as precedents for nanotechnology vocational education training and workforce development," *Human Resource Development Review*, vol. 10, no. 4, pp. 417–430, 2011.

[6] C. Pan, W. Dai, L. Chen, L. Chen, and L. Wang, "Driving range estimation for electric vehicles based on driving condition identification and forecast," *AIP Advances*, vol. 7, no. 10, p. 105206, 2017.

[7] F. P. Varghese, J. Nolan, S. R. Ali, E. Anderson, and R. Southerland, "Vocational psychology and the future: the role of telepsychology in shaping research," *Journal of Career Development*, vol. 47, no. 4, pp. 363–379, 2020.

[8] J. Allen and S. B. Robbins, "Prediction of college major persistence based on vocational interests, academic preparation, and first-year academic performance," *Research in Higher Education*, vol. 49, no. 1, pp. 62–79, 2008.

[9] B. Song, D. W. Kim, and K.-H. Lee, "Contextual influences on Korean college students' vocational identity development,"

Asia Pacific Education Review, vol. 17, no. 1, pp. 175–184, 2016.

[10] X. U. Chao-Hui and X. T. Xie, "Research overview on the higher vocational education of yunnan province," *Journal of Bei Jing Institute of Technology*, vol. 121, no. 1, pp. 125–130, 2014.

[11] C. Laurent, J. M. Robert, and J. Grambert, "The european forum of technical and vocational education and training," *Basin Research*, vol. 23, no. 3, pp. 332–345, 2011.

[12] C. Ryan and M. Sinning, "Skill matches to job requirements. a national vocational education and training research and evaluation program report," *Mendeleev Communications*, vol. 10, no. 4, pp. 134-135, 2009.

[13] S. Randell, "The participation of youth and non-government organisations in non-formal vocational education and training for employment enterprise in Papua New Guinea," *IEICE - Transactions on Electronics*, vol. 94, no. 1, pp. 55–58, 2011.

[14] Z. Rong and C. Zhao, "Research on the correlation model of vocational talents, population structure and economic development," *Wireless Personal Communications*, vol. 102, no. 2, pp. 1–12, 2018.

[15] R. Joyner, "AERA vocational education special interest group proceedings. american educational research association annual meeting," *Journal of Applied Biomechanics*, vol. 28, no. 5, pp. 502–510, 2012.

[16] P. N. Spahn, A. H. Hansen, H. G. Hansen, J. Arnsdorf, H. F. Kildegaard, and N. E. Lewis, "A Markov chain model for N-linked protein glycosylation - towards a low-parameter tool for model-driven glycoengineering," *Metabolic Engineering*, vol. 33, pp. 52–66, 2016.

[17] K. Ezawa, "General continuous-time Markov model of sequence evolution via insertions/deletions: are alignment probabilities factorable?" *BMC Bioinformatics*, vol. 17, no. 1, p. 304, 2016.

[18] B. Wu, B. G. Hu, and Q. Ji, "A coupled hidden markov random field model for simultaneous face clustering and tracking in videos," *Pattern Recognition*, vol. 64, no. 2, pp. 361–373, 2016.

[19] L. You, H. Jiang, J. Hu et al., "GPU-accelerated faster mean shift with euclidean distance metrics," *Computer Vision and Pattern Recognition*, vol. 7, 2021.

[20] L. Huang, G. Xie, W. Zhao, Y. Gu, and Y. Huang, "Regional logistics demand forecasting: a BP neural network approach," *Complex & Intelligent Systems*, vol. 1, pp. 1–16, 2021.