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Machine Learning Based Return Prediction for Digital Financial Portfolios

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ABSTRACT

With the continuous growth of the national economy and the expansion of market demand, traditional finance has gradually turned to digital transformation, and the emergence of digital finance has brought new breakthroughs to the economy. With the continuous development of the times, in order to meet the needs of the market, digital finance and commercial investment are constantly integrated. Therefore, this paper selects the returns and risks of digital financial investment as the research topic, and predicts the investment returns of the five major online banks by analyzing the digital financial portfolio investment return prediction system. The machine learning algorithm is introduced to optimize the digital financial portfolio investment return prediction system. The investment return rate is predicted by the optimized digital financial portfolio investment return prediction system, and then compared with the actual investment return rate. The experimental results show that the predicted value of the traditional digital financial portfolio investment return prediction system for the online bank financial management return rate differs from the actual return rate by 1%-2%, while the predicted value range of the digital financial portfolio investment return prediction system for the online bank financial management return rate is the same as the fluctuation range of the actual return rate. From the experimental data, it can be seen that the digital financial portfolio investment return prediction system based on machine learning can effectively improve the prediction ability of the digital financial portfolio investment return prediction system, making the predicted value closer to the actual value and increasing the reliability of the prediction. This paper provides reference value for the optimization and improvement of the digital financial portfolio investment return prediction system and contributes to the development of digital finance.

Keywords: Markowitz, Machine Learning, Digital Finance, Investment Income

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1. Introduction

For the financial investment, often has a strong time limit characteristics, investment performance on the performance of the timing of the performance is difficult to control [1-2]. This has caused the investor in the whole investment process in the existence of the risk of increasing, and secondly for the financial investment activities shown by the results, it is difficult to change through the will of the individual shown [3-5]. When investors continue to participate in the whole process of financial investment and activities, the performance of investment losses and later profit performance are difficult for investors to constraints, but also by the financial investment market has a different impact [6-8]. And these are in the financial investment risk exists, for the later financial investment activities have great risk, and second in the financial investment in the risk of obtaining income, investment risk also has uncertainty [9-11]. Financial investment performance does not exist in absolute loss or gain, and in the development trend is not stable, there is great flexibility [12-14]. In addition to this, financial investments can also have two different aspects of performance characterized negative and positive risk.

Asset returns in the financial market are often affected by macroeconomic conditions, financial policies, the financial situation of companies, the international environment and the psychological capacity of investors and other aspects, the changes are extremely complex and difficult to predict [15-16]. However, the analysis and prediction of asset returns can not only provide a basis for investors' investment decisions but also for the government to correctly formulate various macro policies. Therefore, how to more comprehensively grasp the characteristics of asset returns and make predictions is a subject of great interest to researchers and market analysts [17-19].

Literature [20] reveals based on empirical analysis that various international indicators show a strong correlation trend in the negative tails of the return distribution, and emerging markets show stronger dependence and portfolio optimization preference for gold. Literature [21] systematically reviews the technical tools of the stock market, which mainly involves stock return forecasting and risk analysis, and looks forward to the future development direction of the technical tools of the financial market. Literature [22] conceptualized a hybrid neuro-fuzzy controller based prediction model for daily price prediction of bitcoin, which outperformed two other intelligent models in numerical evaluation. Literature [23] envisioned a multi-timescale analysis (MTA) tool to decompose and combine the raw returns of financial investments and demonstrated good investment decision aids in simulated evaluations. Literature [24], to address the under-construction of decision-making and optimization of socially responsible portfolios, introduces a Deep Responsible Investment Portfolio (DRIP) model containing a multivariate bi-directional long and short-term memory neural network, which has a more positive impact in terms of financial performance and social impact than the traditional model. Literature [25] illustrated that the health news search index can be used as an important predictor of stock returns, and the accuracy of stock prediction can be further improved by considering the “asymmetric” effect, adjusting macroeconomic factors and relevant financial news. Literature [26] introduces an investment forecasting framework based on Tobin's q, operating cash flow and changes in return on net assets as forecasting indicators, which has good predictive and explanatory power in empirical analysis.

In order to reflect the positive role of machine learning in the application of digital financial portfolio investment income prediction system, this paper conducted a comparative experiment. The experimental results show that the risk assessment of China Construction Bank has the smallest difference with the actual risk value of the five banks based on machine learning digital financial portfolio investment income prediction system, with a difference of 0.0003, and the risk assessment of Industrial and Commercial Bank of China has the largest difference, with a difference of only 0.0029; the risk assessment of Bank of China has the smallest difference with the actual risk value of the five banks based on the traditional digital financial portfolio investment income prediction system, with a

difference of 0.0093, and the risk assessment of Bank of Communications has the largest difference, with a difference of 0.0378; This shows that machine learning can effectively improve the accuracy of risk prediction of the digital financial portfolio investment income prediction system and provide data support for risk avoidance.

2. Correlation Evaluation of Machine Learning and Digital Financial Investment Portfolio Return Prediction System

In the investment field of digital finance, if investors want to obtain stable returns, they must analyze the products of the investment market. Therefore, the corresponding analysis of investment products is also a guarantee for investors and their responsibility for the digital financial market. For different investment products, corresponding investment systems are required to analyze them. Figure 1 shows the structure of the traditional digital financial portfolio investment income prediction system.

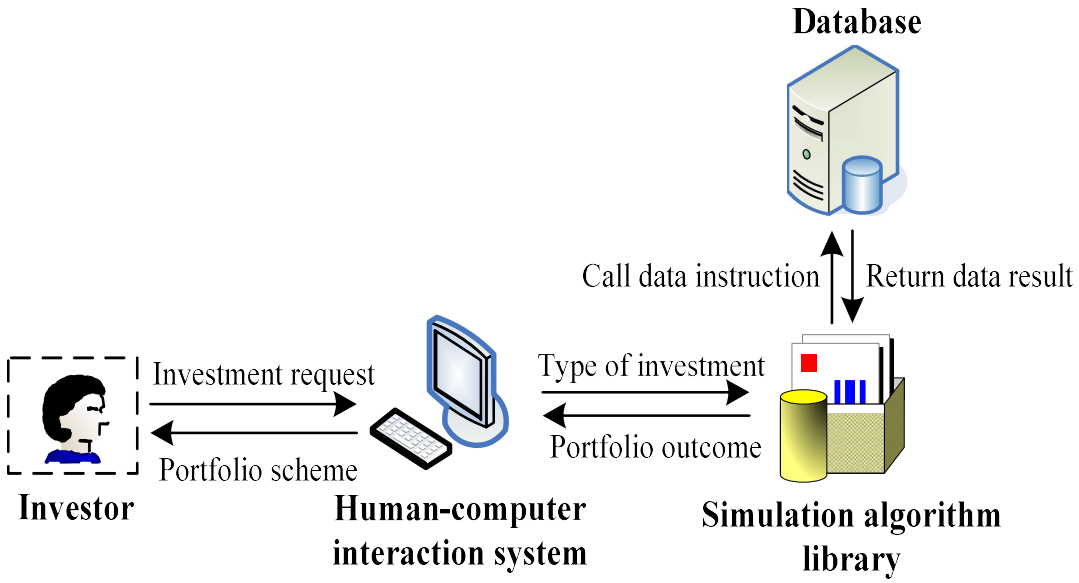


Fig. 1. Structure chart of traditional digital financial portfolio investment income forecasting system

In Figure 1, investors send investment requests to the human-computer interaction system. The system would analyze and calculate the data of the current digital financial market according to the actual situation of investors, and finally feed back the reasonable portfolio investment plan to investors. The traditional digital financial portfolio investment income prediction system has basic constraints, so its predicted return rate is not accurate. Therefore, it is necessary to optimize the traditional digital financial portfolio investment income prediction system. Therefore, it is proposed to use machine learning to improve the prediction function of the digital financial portfolio investment income prediction system. Its structure diagram is shown in Figure 2.

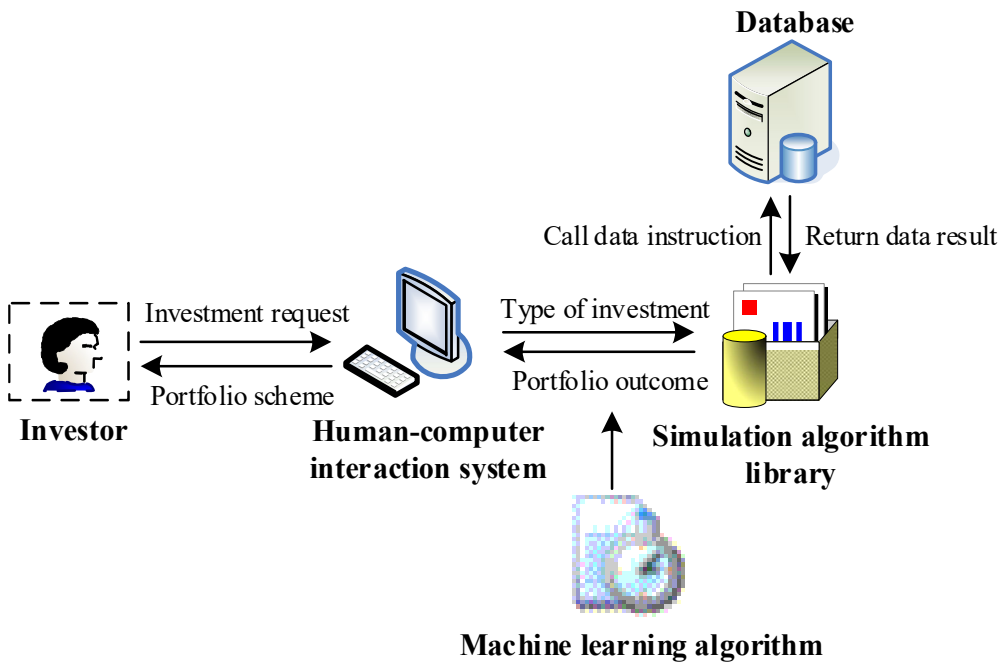


Fig. 2. Structure diagram of the digital financial portfolio investment income prediction system based on machine learning

Investment is risky, and the core of machine learning is to use algorithms to analyze data, learn from it, and make decisions or predictions about new data. Therefore, machine learning can analyze investment data and predict return values in the algorithm library, and then use the portfolio investment model to determine the rate of return.

Markowitz is the most classic portfolio investment model in the field of digital finance. If the Markowitz portfolio investment model is defined, the formula of the model can be obtained, as shown in Formula (1):

$$min\theta^2(P_i) = \sum\sum AW_m AW_n cov(P_m, P_n) \tag{1}$$

Among them, P_i represents portfolio investment income; P_m and P_n represent the income of the m and n assets; AW_m and AW_n represent the weights of the m and n assets, respectively.

Formula (2) is as follows:

$$E(P_i) = \sum AW_m P_m \tag{2}$$

To solve the Markowitz portfolio investment model, the model is expanded to establish a new model. First, Formula (3) is defined as follows:

$$\sum_{r=0}^{i} I_r = 1 \tag{3}$$

Among them, I_r represents the investment result. The overall variance can be calculated by dividing the rate of return into expected rate of return and overall rate of return. The formulas are as follows:

$$R = \sum_{r=0}^{i} I_r P_m \tag{4}$$

$$E(R) = \sum_{r=0}^{i} E\left(I_r P_m\right) = \sum_{r=0}^{i} E\left(I_r P_m\right) \tag{5}$$

$$P_v = \sum_{r=0}^{i} r_{lr} I_r \tag{6}$$

Among them, r_{lr} represents risk loss rate. The expected rate of return can be subtracted from the overall rate of return by the transaction fee. In order to maximize the expected net rate of return, the original model can be converted:

$$\max R = \max[M(R_0) - \sum_{r=0}^{i} T_c \max(MI_r, U_l)] \tag{7}$$

$$\min \sum_{r=0}^{i} r_{lr} I_r = \max\{r_{lr}\} \tag{8}$$

Among them, T_c represents the transaction fee rate and U_l represents the maximum limit.

$$\begin{cases} \sum_{r=0}^{i} I_r = 1 \\ I_r > 0 \end{cases} \tag{9}$$

Formula (10) is as follows:

$$\min \sum_{r=0}^{i} r_{lr} I_r < \sum_{r=0}^{i} r_{lr} I_r \tag{10}$$

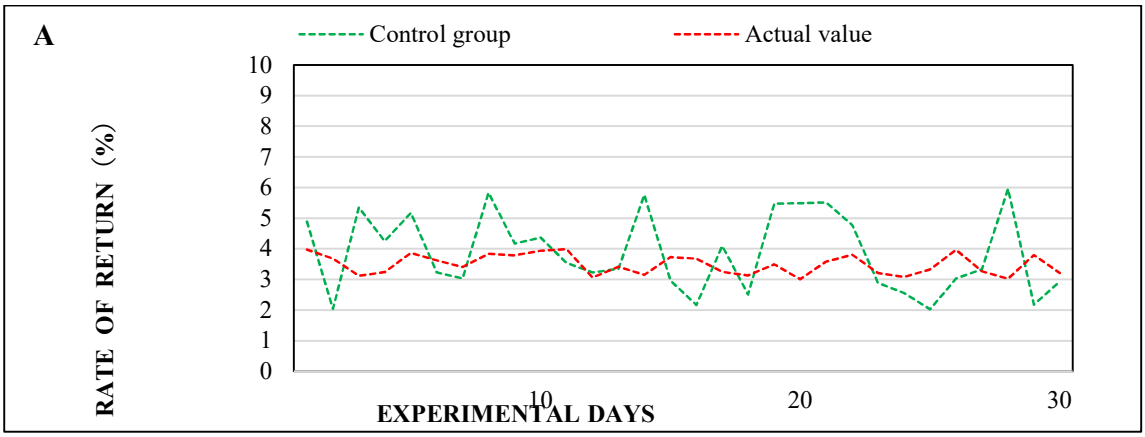
Therefore, the original model can be converted into a single-objective nonlinear programming model using computer algorithms and software.

3. Comparative Experiment on Digital Financial Portfolio Investment Income Prediction System

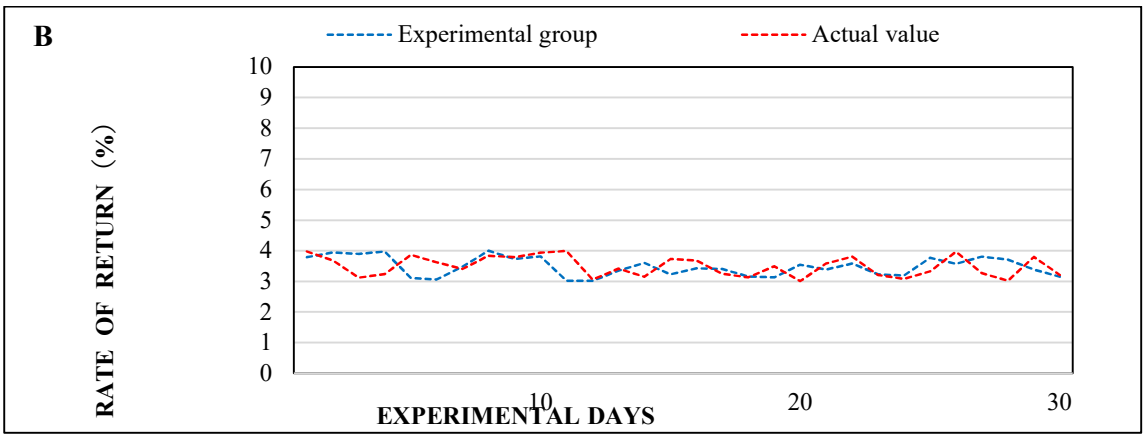
3.1. Experiment on the Effect of Machine Learning in the Digital Financial Portfolio Investment Income Prediction System

In order to test the effect of machine learning in the digital financial portfolio investment income prediction system, an experimental comparison was made on the online banking financial returns of five major Chinese banks in a month (30 days). The traditional digital financial portfolio investment income prediction system was used to predict the return rate of online banking financial management, and then the digital financial portfolio investment income prediction system based on machine learning was used to predict the return rate of online banking financial management. The results obtained by the two systems were compared with the actual rate of return. The traditional digital financial portfolio investment income prediction system was set as the control group, and the digital financial portfolio investment income prediction system based on machine learning was set as the experimental group to study the difference between the two systems and the actual rate of return.

1) Comparison of yield of ICBC. In order to verify the impact of machine learning in the digital financial portfolio investment income prediction system, the two systems in the experiment were used to predict the return rate of ICBC's online banking financial management in a month, and then the two prediction results were compared with the actual return rate of ICBC's online banking financial management in that month. The difference between the two systems in the digital financial portfolio investment income prediction was reflected, thus reflecting the effect of machine learning in the digital financial portfolio investment income prediction system. Figure 3 showed the comparison results of the online banking financial yield of ICBC.



A. The online banking financial yield of ICBC in the control group



B. The online banking financial yield of ICBC in the experimental group

Fig. 3. ICBC online banking yield comparison results

Looking at the data comparison chart in Figure 3, it could be seen that the digital financial portfolio investment income prediction system based on machine learning had a higher prediction accuracy for ICBC's online banking financial yield. Figure 3 showed that the actual rate of return of ICBC's online banking financing in this month remained between 3% and 4%.

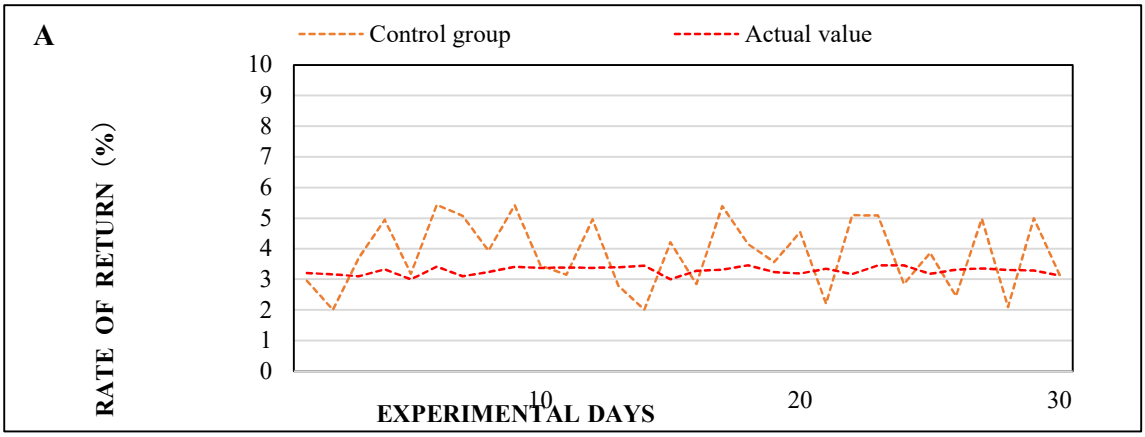
Figure 3A showed the return rate of ICBC's online banking financial management in the control group. It could be seen that the predicted value of the traditional digital financial investment portfolio investment income forecast system for ICBC's online banking financial management in the current month fluctuated between 2% and 6%, which was 1%-2% different from the actual return rate, with a large difference;

Figure 3B showed the return rate of ICBC's online banking financial management in the experimental group. It could be seen that the predicted value of the return rate of ICBC's online banking financial management in this month by the digital financial portfolio investment income prediction system based on machine learning fluctuated between 3% and 4%, which was the same as the fluctuation range of the actual return rate.

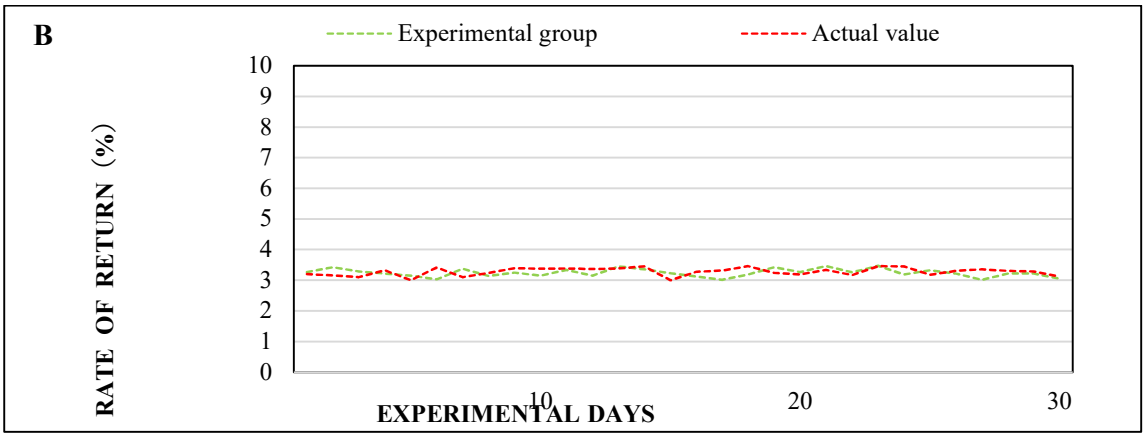
It could be seen that the digital financial portfolio investment income prediction system based on machine learning was more reliable in predicting the financial returns of ICBC's online banking.

2) Comparison of yield of Agricultural Bank of China. Now, the two systems in the experiment were used to predict the return rate of online banking of Agricultural Bank of China in a certain month. The two prediction results were compared with the actual rate of return of online banking financing of Agricultural Bank of China in the month, which reflected the difference between the two systems in

the digital financial portfolio investment income prediction, thus reflecting the effect of machine learning in the digital financial portfolio investment income prediction system. Figure 4 showed the comparison results of online banking financial returns of Agricultural Bank of China.



A. The online banking financial yield of Agricultural Bank of China in the control group



B. The online banking financial yield of Agricultural Bank of China in the experimental group

Fig. 4. Agricultural Bank of China online banking yield comparison results

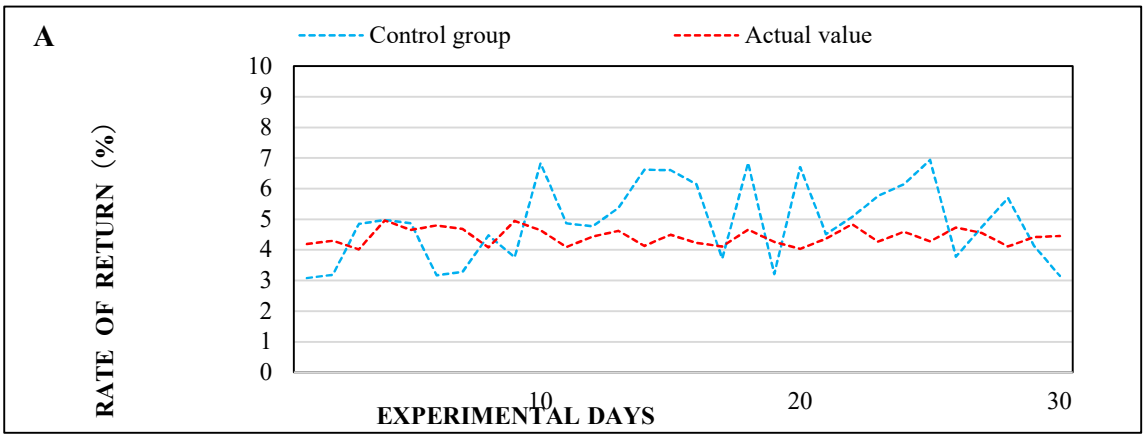
Looking at the data comparison chart in Figure 4, it could be seen that the digital financial portfolio investment income prediction system based on machine learning had a higher prediction accuracy for the online banking financial yield of Agricultural Bank of China. Figure 4 showed that the actual rate of return of online banking financing of Agricultural Bank of China in this month remained between 3% and 3.5%.

Figure 4A showed the return rate of online banking financial management of Agricultural Bank of China in the control group. It could be seen that the predicted value of the return rate of online banking financial management of Agricultural Bank of China in the current month by the traditional digital financial investment portfolio investment income prediction system fluctuated between 2% and 5.5%, which was 1%-2% different from the actual return rate, with a large difference;

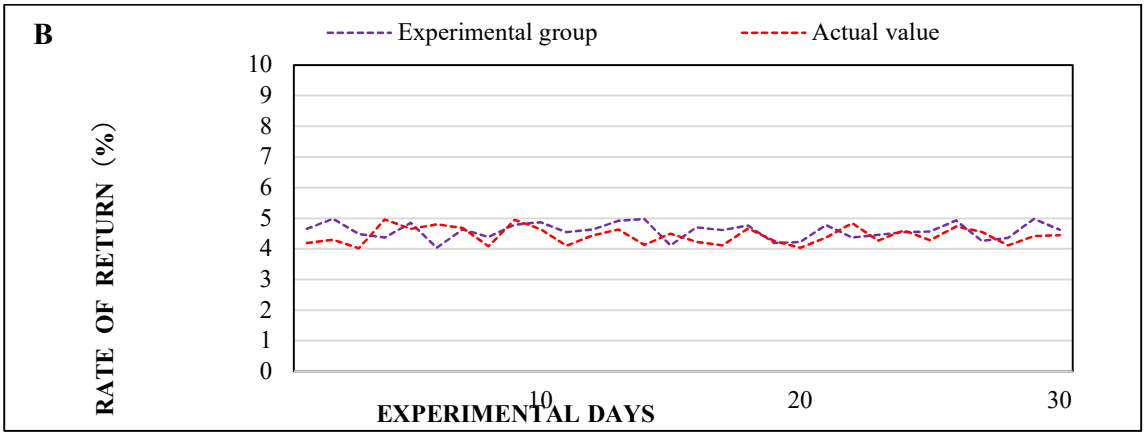
Figure 4B showed the return rate of online banking financing of Agricultural Bank of China in the experimental group. It could be seen that the predicted value of the return rate of online banking financing of Agricultural Bank of China in this month by the digital financial portfolio investment income prediction system based on machine learning fluctuated between 3% and 3.5%, which was the same as the fluctuation range of the actual return rate.

It could be seen that the digital financial portfolio investment income prediction system based on machine learning was more reliable in predicting the return rate of online banking of Agricultural Bank of China.

3) Comparison of yield of Bank of China. Now, the two systems in the experiment were used to predict the online banking financial yield of Bank of China in a certain month. The two prediction results were compared with the actual rate of return of online banking financing of Bank of China in this month, which reflected the difference between the two systems in the digital financial portfolio investment income prediction, thus reflecting the effect of machine learning in the digital financial portfolio investment income prediction system. Figure 5 showed the comparison results of the return rate of online banking wealth management of Bank of China.



A. The online banking financial yield of Bank of China in the control group



B. The online banking financial yield of Bank of China in the experimental group

Fig. 5. Bank of China online banking yield comparison results

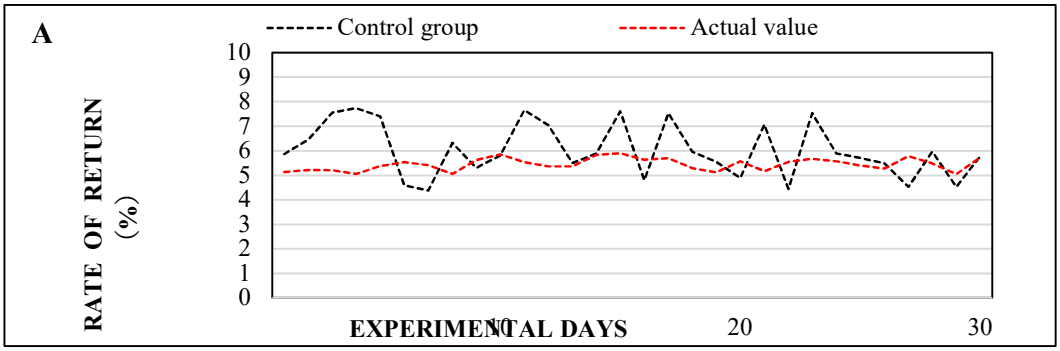
Looking at the data comparison chart in Figure 5, it could be seen that the digital financial portfolio investment income prediction system based on machine learning had a higher prediction accuracy for the online banking financial yield of Bank of China. Figure 5 showed that the actual rate of return of online banking financing of Bank of China in this month remained between 4% and 5%.

Figure 5A showed the return rate of online banking financial management of Bank of China in the control group. It could be seen that the predicted value of the return rate of online banking financial management of Bank of China in this month by the traditional digital financial portfolio investment income prediction system fluctuated between 3% and 7%. This was 1%-2% lower than the actual rate of return, and the difference was large;

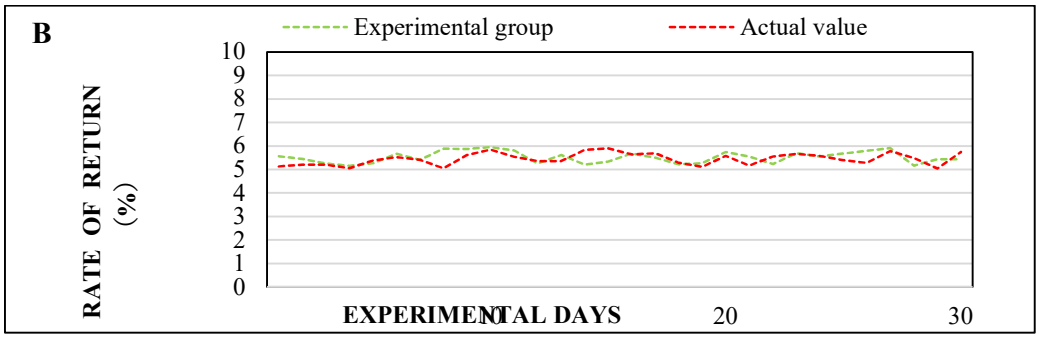
Figure 5B showed the return rate of online banking financial management of Bank of China in the experimental group. It could be seen that the predicted value of the return rate of online banking financial management of Bank of China in this month by the digital financial portfolio investment income prediction system based on machine learning fluctuated between 4% and 5%, which was the same as the fluctuation range of the actual return rate.

It could be seen that the digital financial portfolio investment income prediction system based on machine learning was more reliable in predicting the return rate of online banking of Bank of China.

4) Comparison of yield of China Construction Bank. Now, the two systems in the experiment were used to predict the online banking financial yield of China Construction Bank in a certain month. The two prediction results were compared with the actual rate of return of China Construction Bank's online banking financing in the month, which reflected the difference between the two systems in the digital financial portfolio investment income prediction, thus reflecting the effect of machine learning in the digital financial portfolio investment income prediction system. Figure 6 showed the comparison results of China Construction Bank's online banking financial returns.



A. The online banking financial yield of China Construction Bank in the control group



B. The online banking financial yield of China Construction Bank in the experimental group

Fig. 6. China Construction Bank online banking yield comparison results

Looking at the data comparison chart in Figure 6, it could be seen that the digital financial portfolio investment income prediction system based on machine learning had a higher prediction accuracy for China Construction Bank's online banking financial yield. Figure 6 showed that the actual rate of return of online banking financing of China Construction Bank in this month remained between 5% and 6%.

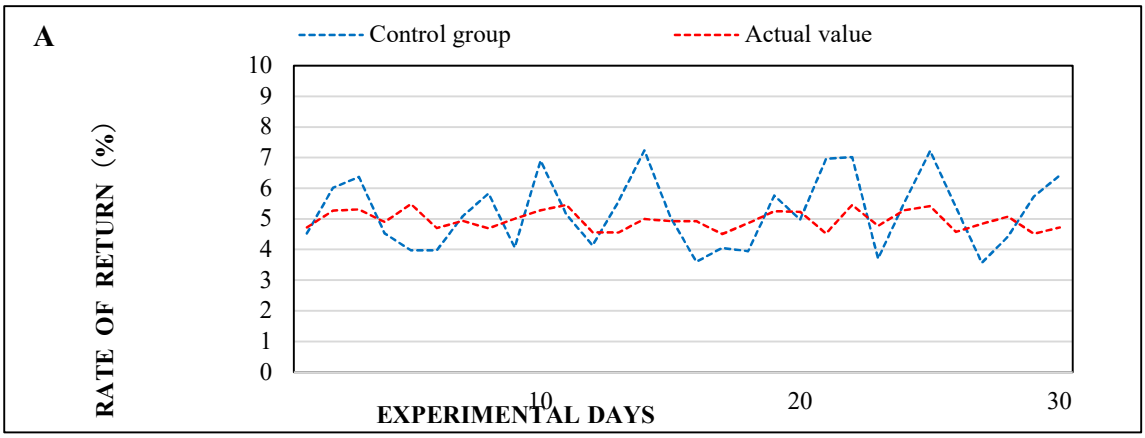
Figure 6A showed the return rate of online banking financial management of China Construction Bank in the control group. It could be seen that the predicted value of the return rate of online banking financial management of China Construction Bank in the current month by the traditional digital financial portfolio investment income prediction system fluctuated between 4% and 8%, which was 1%-2% different from the actual return rate, with a large difference;

Figure 6B showed the return rate of China Construction Bank's online banking financial management in the experimental group. It could be seen that the predicted value of the return rate of China Construction Bank's online banking financial management in this month by the digital financial portfolio investment income prediction system based on machine learning fluctuates between 5% and 6%, which was the same as the fluctuation range of the actual return rate.

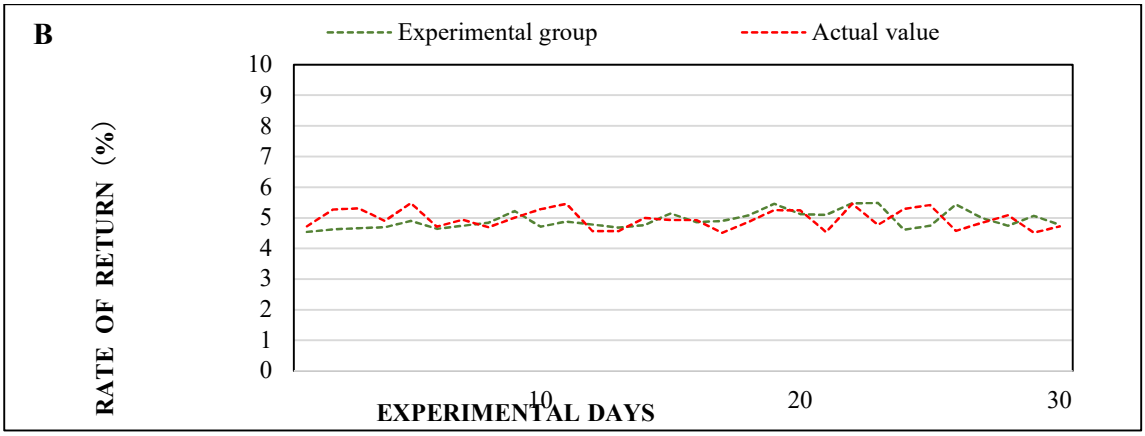
It could be seen that the digital financial portfolio investment income prediction system based on machine learning was more reliable in predicting the financial yield of China Construction Bank's online banking.

5) Comparison of yield of Bank of Communications of China

Now, the two systems in the experiment were used to predict the online banking financial yield of Bank of Communications of China in a certain month. The two prediction results were compared with the actual rate of return of online banking financing of Bank of Communications of China in this month, which reflected the difference between the two systems in the digital financial portfolio investment income prediction, thus reflecting the effect of machine learning in the digital financial portfolio investment income prediction system. Figure 7 showed the comparison results of online banking financial returns of Bank of Communications of China.



A The online banking financial yield of Bank of Communications of China in the control group



B The online banking financial yield of Bank of Communications of China in the experimental group

Fig. 7. Bank of Communications online banking yield comparison results

Looking at the data comparison chart in Figure 7, it could be seen that the digital financial portfolio investment income prediction system based on machine learning had a higher prediction accuracy for the online banking financial yield of Bank of Communications of China. Figure 7 showed that the actual

rate of return of online banking financing of Bank of Communications of China in this month remained between 4.5% and 5.5%.

Figure 7A showed the return rate of online banking financing of Bank of Communications of China in the control group. It could be seen that the predicted value of the return rate of online banking financing of Bank of Communications of China in this month by the traditional digital financial portfolio investment income prediction system fluctuated between 3.5% and 7.5%. This was 1%-2% lower than the actual rate of return, and the difference was large;

Figure 7B showed the return rate of online banking financial management of Bank of Communications of China in the experimental group. It could be seen that the predicted value of the return rate of online banking financial management of Bank of Communications of China in this month by the digital financial portfolio investment income prediction system based on machine learning fluctuated between 4.5% and 5.5%, which was the same as the fluctuation range of the actual return rate.

It could be seen that the digital financial portfolio investment income prediction system based on machine learning was more reliable in predicting the return rate of online banking of Bank of Communications of China.

According to the comparison of five groups of data in Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7, it could be seen that the predicted value of the traditional digital financial portfolio investment income prediction system for the online banking financial management yield was 1%-2% different from the actual yield. The range of the predicted return of the digital financial investment portfolio investment based on machine learning for online banking financing was the same as the fluctuation range of the actual return. It showed that machine learning could help improve the prediction accuracy of the digital financial portfolio investment income prediction system by 1%-2%, and could prove that machine learning can effectively enhance the prediction function of the digital financial portfolio investment income prediction system and optimize the digital financial portfolio investment income prediction system. As the digital financial portfolio investment income forecasting system was a forecasting system, it could only roughly estimate the value of the rate of return. In order to predict the actual rate of return, it was necessary to rely on reliable digital models for computer calculation.

3.2. Experiment on The Role of Machine Learning in Digital Financial Portfolio Return Prediction System

In order to examine the role of machine learning in the digital financial portfolio investment return prediction system, the average risk of online banking wealth management of the five major banks in that month was evaluated, the risk assessment averages obtained by the two systems were compared with the actual risk averages, and the differences between the assessment values and the actual values of the two systems were studied to reflect the role of machine learning in the digital financial portfolio investment return prediction system. The comparison results were shown in Table 1.

Table 1. Risk mean comparison chart

	Average risk assessment of the control group	Actual mean risk	Average risk assessment of the experimental group
Industrial and Commercial	0.0974	0.0763	0.0734
Bank of China	0.0621	0.0714	0.0701
Agricultural Bank of China	0.0664	0.0837	0.0816
China Construction Bank	0.0711	0.0916	0.0913
Bank of Communications	0.123	0.0852	0.0825

It can be seen from the data in Table 1 that, overall, the average assessment value of the online banking financial management risk by the digital financial portfolio investment return prediction system based on machine learning is closer to the actual risk value.

When using the traditional digital financial portfolio investment income prediction system for evaluation, the average value of risk assessment for ICBC was 0.0974, and the average value of risk assessment for Bank of China was 0.0621. The average value of risk assessment for Agricultural Bank of China was 0.0664, and the average value of risk assessment for China Construction Bank was 0.0711. The average risk assessment of Bank of Communications was 0.123;

When evaluating the digital financial portfolio investment income prediction system based on machine learning, the average risk assessment of ICBC was 0.0734, the average risk assessment of Bank of China was 0.0701; the average risk assessment of Agricultural Bank of China was 0.0816, the average risk assessment of China Construction Bank was 0.0913; the average risk assessment of Bank of Communications was 0.0825;

The actual risk values of ICBC, Agricultural Bank of China, Bank of China, China Construction Bank, and Bank of Communications were 0.0763, 0.0714, 0.0837, 0.0916, and 0.0852, respectively. It can be seen that the risk assessment of China Construction Bank has the smallest difference with the actual risk value of the five major banks in the digital financial portfolio investment income prediction system based on machine learning, with a difference of 0.0003. The risk assessment of ICBC has the largest difference, with a difference of only 0.0029;

The smallest difference between the traditional digital financial portfolio investment income prediction system and the actual risk value of the five banks is the risk assessment of the Bank of China, with a difference of 0.0093. The largest difference is the risk assessment of the Bank of Communications, with a difference of 0.0378. The smallest difference in the control group is much larger than the largest difference in the experimental group. Obviously, machine learning plays an obvious role in the digital financial portfolio investment income prediction system, which can effectively improve the accuracy of risk prediction of the digital financial portfolio investment income prediction system and provide data support for risk avoidance.

The application research of machine learning in the digital financial portfolio investment income prediction system found that the traditional digital financial portfolio investment income prediction system has unreasonable aspects, and machine learning can solve these problems well. Especially in today's rapidly changing technology, if the digital financial portfolio investment income prediction system wants to keep up with the trend of the times, it must introduce new science and technology as a source of power. Machine learning can improve the prediction ability of the digital financial portfolio investment income prediction system, make the yield prediction of the digital financial portfolio investment income prediction system closest to the trend of the actual yield, and can effectively

calculate the risk value, thereby avoiding risks and improving the judgment ability of the digital financial portfolio investment income prediction system. The experimental data also proves that the promotion of machine learning in the digital financial portfolio investment return prediction system fully demonstrates its advantages and has very practical significance for the development of digital finance.

4. Conclusions

The research on the digital financial portfolio investment income prediction system based on machine learning is of great significance. Experimental data show that it is an inevitable trend to introduce machine learning into the digital financial portfolio investment income prediction system. Through the comparison of experimental data, it can be seen that machine learning can effectively improve the prediction ability of the digital financial portfolio investment income prediction system, adjust the predicted rate of return and the actual rate of return to the closest state, thereby avoiding risks, minimizing the risk value, and maximizing the advantages of the digital financial portfolio investment income prediction system. However, while this study has achieved certain results, there are also some problems. First, due to time constraints, the duration of this experiment is short, and there may be certain errors in the experimental results; secondly, in terms of experimental data collection, this paper only selects the income data of online banks as experimental data, without considering the situation in other digital financial fields, and the experimental data capacity is small and not representative; finally, with the in-depth development of society, what changes and challenges will digital finance encounter in the future is still unknown. How to achieve sustainable economic development is the focus of human attention and research. The digital financial portfolio investment income prediction system based on machine learning proposed in this paper can only contribute a small part to the development of digital finance. In order to explore the role of machine learning in the field of digital financial prediction, it is still necessary to invest a lot of time and energy in research. In order to have a deeper understanding of the impact of machine learning in the digital financial portfolio investment income prediction system, subsequent research will explore their potential and further improve the analysis results for these issues.

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