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Research Article

Research on Parameter Estimation and Prediction of Sports Financial Market Volatility Model

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At present, the utility function of the financial system in the sports industry has not been brought into full play. Volatility reflects the uncertainty of asset price changes and plays an important role in asset pricing, portfolio, risk management, and asset allocation. Volatility has the characteristics of thick tail, leverage, market linkage, long memory, and aggregation. There are differences between different markets and countries. Therefore, according to the complex characteristics of volatility, this paper uses the feature-oriented research method to study several volatility prediction models, namely, random volatility model, realized volatility model, and multivariate volatility model. In order to promote capital formation and alleviate the financing constraints of sports finance, it provides reference value for reducing transaction costs, improving the quality and efficiency of sports industry, and realizing sustainable and rapid development.

1. Introduction

It is not only an important symbol of social development and human progress but also an important embodiment of a country's comprehensive national strength and national soft power [1]. At present, sports must be strong and prosperous, and the development of the sports industry is the main way [2]. The sports financial market refers to the content of large-scale comprehensive sports events [3]. Referring to international experience, to further transform China's huge population base into a potential sports consumption market, we need the coordinated promotion of sports culture, education, and venue construction.

Under the background of global finance, in the reality that the sports industry is developing day by day, it is urgent for every sports industry participant to control and avoid financial risks while ensuring its own development [4]. The research on the volatility of the returns of a single financial asset and the conditional covariance matrix between the returns of different financial assets is the main research content in the field of financial econometrics [5]. Today's economists believe that large-scale comprehensive sports events are no longer a simple sports competition but a comprehensive manifestation of society and economy [6]. There is a close relationship between sports economy and sports financial market [7]. On the one hand, developing sports financial market, raising funds, expanding financing channels, and making good use of idle funds provide favorable fund guarantee for the development of sports economy; on the other hand, it puts forward new requirements for the coordinated development of sports economy and increasing economic benefits. As the main driving force for the development of sports economy, the development of financial market directly affects the sports economic index and the holding of sports meetings [6]. On the other hand, the quality and quantity of investment can be directly affected by whether the sports economy is good or bad.

2. Related Work

The high-quality development of sports industry is related to the adjustment of national macroeconomic structure. Since the 19th CPC National Congress, China's extensive and high growth stage of economic development has basically ended. Instead, it entered a period of high-quality development aimed at maintaining sustained and healthy economic development [8]. To solve the problems of unbalanced, uncoordinated, and insufficient economic development, we must vigorously promote supply-side structural reforms and promote the optimization and upgrading of the industrial structure [9]. Emerging industries can effectively activate the mobility of social resources, accelerate the transformation of old and new power and the agglomeration of innovative elements, and are an important part of achieving high-quality economic development [10]. As the core of modern economy, finance plays a vital role in the development of real economy. At present, however, under the "three-phase superposition" effect, China's economic development began to show the trend of excessive financialization [11]. The scale and profit margins of the pan-financial sector exceed those of the real sector, asset prices are falsely booming, and shadow banking is massive [12]. There is a structural imbalance between the real economy and the virtual economy. Volatility, as a statistical concept, is often used to measure the volatility of the underlying asset price or return on investment by W, which plays an important role in derivative product pricing, portfolio, asset allocation, risk management, and hedging investment strategy.

Compared with foreign mature markets, country's financial market has the particularity of high risk, high leverage, and high volatility, and it is particularly important to analyze its characteristics [13]. However, it is worth affirming that with the further opening of China's market, it is very necessary to systematically and deeply use modern financial measurement methods to study the problems related to volatility [14]. According to the characteristics of volatility, this paper adopts stochastic process, realizes volatility model and multivariate GARCH, respectively, to describe the volatility, estimates the unknown parameters of the long memory stochastic volatility model under the continuous time frame, and establishes the realized volatility and multivariate volatility. Models are forecasted, and research on foreign exchange and stock markets, respectively, is applied.

According to the complex characteristics of volatility, this paper uses the feature-oriented research method to study several volatility prediction models, namely, random volatility model, realized volatility model, and multivariate volatility model. The research is divided into five parts. The first part expounds the financial background of sports industry. The second part analyzes and supplements the relevant literature. The third part analyzes the materials and methods and analyzes the volatility model of sports finance. At the same time, the application of the multivariate prediction model in volatility research is evaluated. The fourth part analyzes and discusses the results. Finally, it summarizes the full text, realizes cross period smoothing, wealth effect, and risk prevention, and stimulates the development of sports financial consumption.

3. Materials and Methods

3.1. Sports Finance. With the continuous development of academic research and business practice, all walks of life have gradually formed a more consistent understanding of the sports industry. That is, "sports industry refers to the collection of the same type of economic activities that provide sports products for the society and the synthesis of similar economic sectors." Among them, the sports industry in a broad sense refers to all production and operation activities related to sports, including sports material products and sports services. The sports industry in a narrow sense refers to the sports service industry or the marketable part of the sports industry [15]. In China, since the marketization of sports industry, scholars began to explore how to establish the investment and financing system of sports industry and give full play to the role of finance, so as to promote the better and faster development of sports industry. Under the leadership of national sports government agencies, we will establish relatively independent sports industry financial institutions in conjunction with relevant national financial departments. In view of this, they put forward a series of tentative plans on establishing the investment and financing system of China's sports industry. It can be summarized into two basic paths, one is to strengthen the guiding role of the government in the investment and financing system of the sports industry, improve the investor system, establish a reasonable decision-making mechanism, and make full use of the financial credit function; the other is to actively introduce market forces to enrich the sports industry [16]. The main body of investment and financing participants and the channels for investment and financing of the sports industry are expanded. It can be seen that in the early stage of sports industry development, the government's direct participation plays a leading role in the financial support activities of sports industry.

3.2. Volatility. Volatility, as a statistical concept, is often used to measure the volatility of underlying asset prices or investment returns [17]. It plays an important role in derivative product pricing, investment portfolios, asset allocation, risk management, and hedging investment strategies. In the market, volatility is defined as a statistical measure of the return dispersion of financial underlying assets, generally expressed as the second-order moment of the financial return series. Generally, the higher the volatility, the greater the risk of the asset.

3.2.1. Analysis of Volatility Characteristics. A remarkable feature of financial fluctuations different from other fluctuations is the instability or abnormal operation of financial institutions. It not only affects their own survival and development but also leads to the loss or failure of many savers and investors, resulting in social unrest. This is financial volatility. A large number of experimental data and research

show that financial assets are volatile. Among them, the persistence of volatility is a remarkable feature [18]. The fluctuation of financial assets has a clustering phenomenon; that is, a large fluctuation is often followed by a large fluctuation. Similarly, a small fluctuation will be followed by a small fluctuation, which is tested by relevant empirical tests [19]. An economic explanation for this kind of clustered volatility is that the current volatility impact can continue to affect the volatility expectation for a considerable period of time in the future.

Let P_t denote the asset price at time t and $r_t = \ln(P_t) - \ln(P_{t-1})$ be the logarithmic rate of return from $t-1$ to t. Define the conditional mean and conditional variance as

$$\begin{aligned} m_t &= E_{t-1}[r_t], \\ h_t &= E_{t-1}[r_t - m_t]^2. \end{aligned} \tag{1}$$

The variance forecast for forward k periods is as follows

$$h_{t+k|t} = E_t[r_{t+k} - m_{t+k}]^2. \tag{2}$$

According to the understanding of volatility persistence, its mathematical definition is as follows

$$\theta_{t+k|t} = \frac{\partial h_{t+k|t}}{\partial r_t^2}. \tag{3}$$

Since $h_{t+k|t}, r_t^2$ is the same unit here, $\theta_{t+k|t}$ is dimensionless. The corresponding measure represents the persistence of this accumulation, which represents the arithmetic mean of $\theta_{t+k|t}$ from time t to $t+k$, which can be expressed as follows:

$$\varphi_{t+k|t} = \frac{1}{k}\left(\sum_{i=1}^{k} \theta_{t+i|t}\right). \tag{4}$$

In addition, volatility also has mean reversion. Mean reversion is usually described as a normal level of volatility. Under this normal level, no matter what the fluctuation trend is, it will eventually tend to this normal level. In this nature, the long-term prediction of the volatility model should return to the same normal level. In fact, the volatility mean reversibility indicates that the current information does not explain the significant characteristics of the long-term prediction of the future. Therefore, for any t, there are

$$\begin{aligned} &P \lim_{k \longrightarrow \infty} \theta_{t+k|t} = 0, \\ &\qquad \text{or} \\ &P \lim_{k \longrightarrow \infty} \theta_{t+k|t} = \sigma_t^2 < \infty. \end{aligned} \tag{5}$$

This definition is also extensible, for example, in the process of nonfinite variance. The option price is often regarded as consistent with the average recovery. If the option exercise date is short, its implied volatility is more active. On the contrary, its implied volatility is often lower, which is closer to the average of the long-term volatility of asset prices. Volatility is also asymmetric.

This asymmetry, also known as the risk premium effect or the leverage effect, corresponds to the two theories of the asymmetric mechanism, respectively [20]. The asymmetry of volatility will not only cause the bias of price prediction but also cause the bias of option implied volatility. Therefore, the implied volatility of virtual value put options is often higher than that of parity options and real value options.

3.3. Volatility Model. Building a volatility model that can accurately and quantitatively measure the volatility and dynamic characteristics of financial markets is one of the core contents of modern finance, and it also has a significant impact on sports finance [21]. Volatility plays an important role in the research of financial market, and it has important theoretical and practical significance for the selection of optimal portfolio, the design of derivatives pricing and hedging strategy, and the measurement and management of financial market risks. However, the real volatility in the real market cannot be observed directly, so it is necessary to build a reasonable Volatility Measurement Method and model in order to better estimate the real volatility. Figure 1 shows the change trend of China's sports industrial structure in recent years.

In recent years, due to the rise of domestic sports consumption market and the guidance of sports industry policy, the sports industry structure has been greatly influenced. On the one hand, the sports service industry dominated by sports competition and performance, sports fitness, and leisure has sprung up, and the output scale has expanded rapidly and has driven the rapid development of surrounding business forms such as sports media, sports education, and training, and further improved the sports industry system. On the other hand, the old sporting goods manufacturing industry either withdraws from the market or seeks technological transformation and innovation and upgrading, transforming to intensive, capital, and technology-intensive.

For the stock index futures market, we introduce additional explanatory variables to obtain the extended model of ms-har, which is recorded as ms-har-y model. Its specific form is as follows:

$$RV_{t+h} = \beta_{0,s_t} + \beta_{1,s_t} + \beta_{2,s_t} + \beta_{3,s_t} + \beta_{4,s_t} + \varepsilon_{t+h}. \tag{6}$$

Here, $\varepsilon_{t+h}|\Omega_t \sim N(0, \sigma^2_{s_{t+h}}), h = 1, 5, 10.$

3.3.1. IC-BP Prediction Network Model Based on Volatility. There are a large number of models that can describe the prediction problem of time series, and most of these models are linear models. However, the factors affecting time series are diverse and complex, and the traditional linear model cannot truly reflect the true relationship between time series and its influencing factors, so the prediction accuracy is not high. BP neural network is a multilayer forward one-way propagation network. By storing and learning a large number of input-output mode mapping relationships, a nonlinear mapping of input and output can be established. It is an advantageous tool for approximation and modeling of nonlinear systems. Figure 2 shows the structure of the BP neural network.

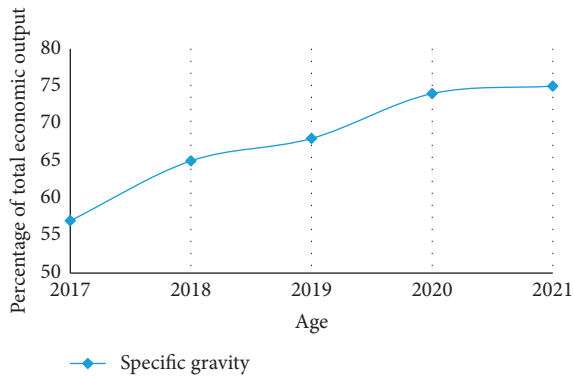

Figure 1: Change trend of sports industry structure.

In the prediction of multivariate time series, we often face the problem of input selection, which is an important problem to determine the prediction space complexity and algorithm time dimension. The rapid development of ICA technology makes it possible to solve this problem. Based on the technology, the independent and stable features of the original data can be extracted, which is helpful to improve the anti-interference ability of prediction. Based on this, the design idea of IC-BP prediction network is to use ICA technology as the pre-system of index attribute feature extraction and combine it with BP prediction network. Specifically, the features of the data are extracted by ICA technology, and then the input of the prediction network is designed. The input satisfies the principle of maximizing the extraction of sequence statistical features and taking into account the principle of convenient input, using a three-layer prediction network and a suitable transfer function. This design can realize the integration and complementarity of the advantages of feature extraction and nonlinear network prediction in order to improve the accuracy and complexity of model prediction. Figure 3 shows the network flow chart of IC-BP.

Figure 3 is divided into three steps. The first step is data collection and division. Using two years of data for training can establish a relatively satisfactory prediction accuracy. According to the similarities and differences of input variable attributes, there can be two types of inputs: similar and heterogeneous. It should be noted that when dealing with financial time series such as exchange rate, the similar network model selects multiple historical data of the same type as the input vector, and the data have autocorrelation and partial correlation, which reflects the linkage between markets and is helpful for BP network to learn the prediction law of the exchange rate series itself. Therefore, similar input is considered as an input method that performs well in short-term prediction.

3.3.2. Development Analysis of Sports Finance. Throughout various economic growth theories, capital formation or capital accumulation plays a very key role in economic growth. The Harrod–Domar model is a typical representative of capital determinism. On the basis of Keynesian income determinism, it is concluded that the actual growth rate of economy is determined by the actual savings rate and the actual capital output ratio, so the savings rate becomes the only source of power for economic growth. That is, as long as the capital accumulation rate of an economy is maintained at a high level, the economy will generate rapid growth. Therefore, the "savings investment" conversion rate is proposed in the field of sports finance, which can promote the capital circulation rate and improve the level of capital accumulation. Suppose there is $I = sY$ in a Fenbid economy, where I is the level of domestic investment, Y is the total economic output, and s is the savings rate. In the dimension of per capita output, we can see

$$y = Ak^a, \tag{7}$$

y, k, and a represent per capita output, per capita capital input, and output distribution ratio, respectively, which can be obtained through the capital accumulation equation:

$$\begin{aligned} sy &= (g + \sigma + n)k \\ K'(t) &= sf[k(t)] - (g + \sigma + n)k(t). \end{aligned} \tag{8}$$

Among them, n, g, and σ are the labor growth rate, the steady growth rate of implied technological progress, and the depreciation ratio of fixed assets, respectively.

When we assume that scale revenge is unchanged, the time axis becomes short-term, as shown in Figure 4.

It can be seen from Figure 4 that when the savings rate rises, the actual investment curve moves upward, and the per capita capital investment begins to rise, tilting more resources to the investment side to reach a new balance. In this process, the financial system mainly acts on the savings rate parameter, and by changing the proportional relationship between consumption and savings in economic output, individual financial resources are integrated into group investment, and finally capital accumulation and economic growth are expanded.

3.4. Application of Multivariate Forecasting Model in Volatility. Among the multivariate prediction models, the GARCH model is representative. We assume that $\{y_t\}$ is a $k \times 1$ dimensional vector, F_t is the information filter family of $\{y_t\}$ at time $[0, t]$, and θ is an unknown parameter, and then we get

$$\varepsilon_t = M_0 z_t. \tag{9}$$

Here, $M_0 = V\Lambda^{1/2}$.

In the O-GARCH model, we can take a further assumption, and in the dynamic change modeling, we get

$$\lambda_{i,t} = c_i + \alpha_i z_{i,t-1}^2. \tag{10}$$

Therefore, under the conditional covariance of ε_t, the following formula is satisfied:

$$H_t = M_0 \Lambda_t M_0'. \tag{11}$$

Among the above models, the volatility modeling method based on a factor extraction has been widely used. However, due to the irrelevance of the above model in the assumption of

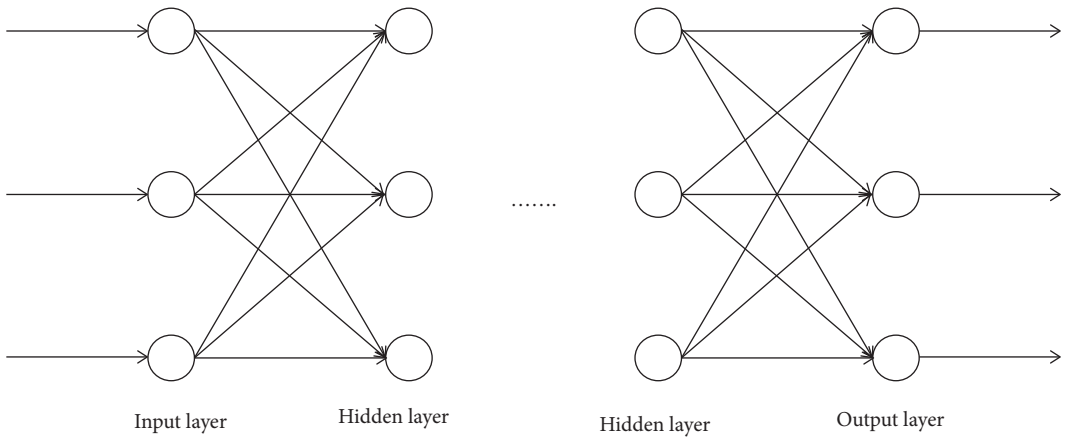

Figure 2: Structure diagram of BP neural network.

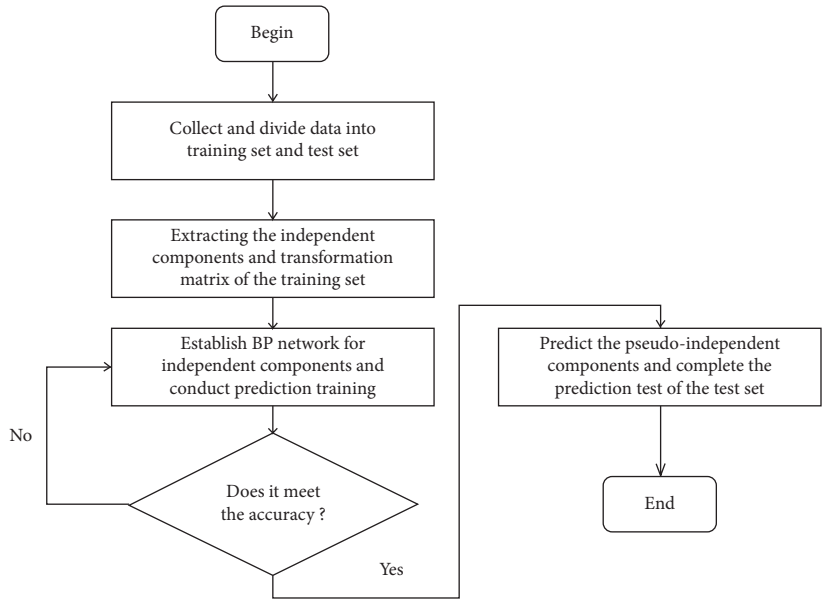

Figure 3: IC-BP network flow chart.

principal component conditions, the conclusion is wrong. Therefore, the IC-GARCH model is established, and within the assumption that the conditions are not correlated, the independent component decomposition technique combined with the multivariate GARCH model can be established. Then, there are

$$v_{i,t}^2 = w_i + \sum_{u=1}^{p} \alpha_{i,u} s_{i,t-u}^2 + \sum_{u=1}^{Q} \beta_{i,u} v_{i,t-u}^2. \quad (12)$$

Finally, combined with the transformation matrix, we can get the conditional covariance of ε_t:

$$H_t = CV_t C'. \quad (13)$$

In the above formula, $V_t = \mathrm{diag}(v_{1,t}, \ldots, v_{k,t})$.

Based on the realized volatility, which is widely used to measure the fluctuation of securities price, the realized volatility converges to the integral volatility of price uniformly without micro noise and price jump in the market. In reality, the market will have price jumps. To this end, many scholars have successively proposed three

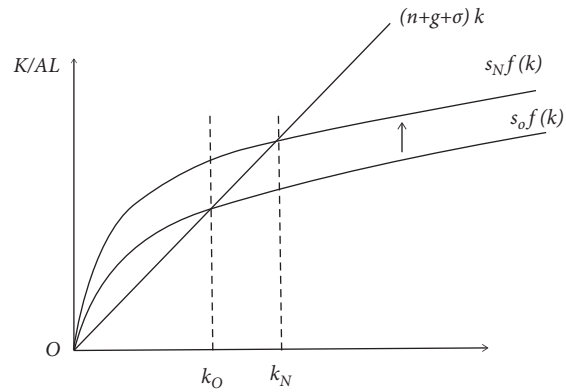

Figure 4: Solow's capital accumulation function and savings rate.

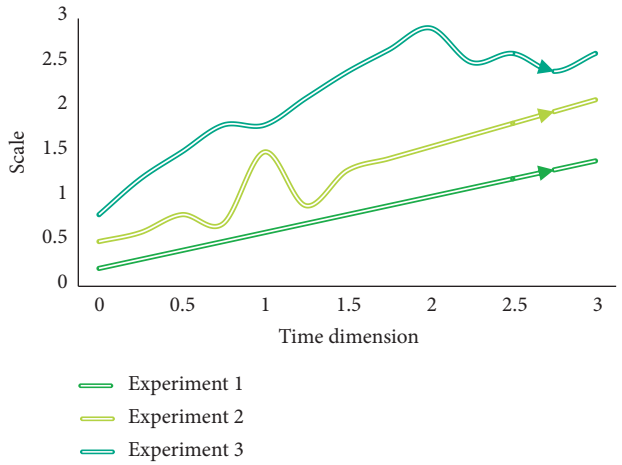

Figure 5: Experimental results of sports finance scale variables at different time lengths.

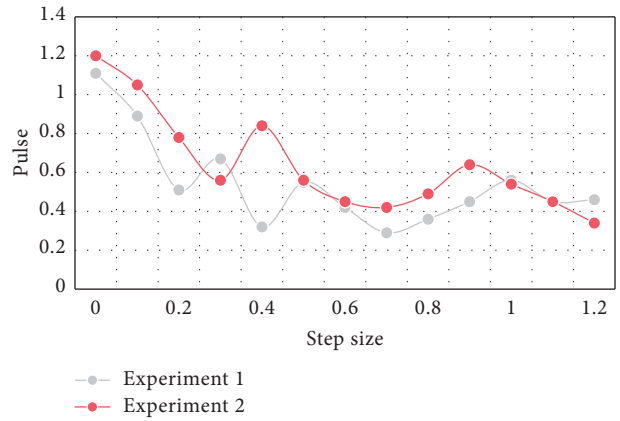

Figure 6: Volatility impulse response.

volatility measures of market noise. This paper uses the realized kernel volatility estimate which takes the form as follows:

$$RV_t = \sum_{j=-H}^{H} k\left(\frac{H}{H+1}\right)\gamma_j, \tag{14}$$

where $\gamma_j = \sum_{i=|j|+1}^{n} r_{t,i} r_{t,i-|j|}$ and $k(x)$ represents the kernel function, which can be expressed as follows:

$$k(x) = \begin{cases} 1 - 6x^2 + 6x^3, & 0 \le x \le \frac{1}{2}, \\ 2(1-x)^3, & \frac{1}{2} \le x \le 1, \\ 0, & x > 1. \end{cases} \tag{15}$$

Because in the presence of market noise, in order to obtain the consistent estimation of the quadratic variance of the price, the value of H must increase with the increase in the sample. Therefore, multiperiod volatility can be expressed as follows:

$$RV_{t,t+h} = h^{-1}\left[RV_{t+1} + RV_{t+2} + \cdots + RV_{t+h}\right]. \tag{16}$$

Among them, $h = 1, h = 5, h = 10$, and $h = 22$ represent the realized volatility of daily, weekly, semimonthly, and one-month, respectively.

4. Result Analysis and Discussion

At different time intervals, the values of various indicators of the system vary greatly, which shows that the scientific stability of the system structure is poor and it is difficult to undertake the task of describing objective reality. Due to the financial support for the high-quality development of the sports industry, the system contains many variables. Considering the influence strength and constituent elements of the variables, the scale output variables of the sports industry in the model are selected for testing. The changes of this variable in different equal step lengths with time intervals of 0.2 years, 0.6 years, and 1 year were investigated, respectively. As shown in Figure 5, the current curve represents a time step of 1 year. When three different time steps are input to the model, the changes in the output results of the sports industry scale are not large, indicating that the model is in a relatively stable state.

Secondly, the stock index futures market has a strong leverage effect, and the overnight rate of return has a significant negative impact on the volatility, which similarly indicates that the overnight rate of return captures the additional leverage effect. Thirdly, we analyze the impact of stock index spot market on the volatility of stock index futures market, in order to explore whether it has the role of volatility transmission. Surprisingly, it is found that the medium-term and long-term stock index spot market volatility has a significant positive impact on the stock index futures market volatility while the short-term volatility has a negative impact, but it is not statistically significant. Combined with the above analysis, the volatility of the stock spot market will bring risks to the whole market in a sense, and the risk of long-term volatility is greater than that of short-term volatility. Figure 6 shows the volatility impulse response.

The changes of stock index spot and futures have a lagging positive effect on itself. With the increase in lag period, the positive effect decreases gradually. Comparatively speaking, the lag effect of stock index spot volatility is longer and more obvious, and it is positive, while the lag positive effect of stock index futures volatility is short-lived and the long-term lag effect is negative. At the same time, the positive shock from the external stock index spot volatility will cause the stock index futures volatility to rise significantly, and the lagging effect of this shock is strong and long-lasting. On the other hand, the change of stock index futures volatility will cause the reverse change of stock index spot volatility, and the lag effect of stock index futures volatility is long and significant.

The calculation example shows that the prediction accuracy of the IC-BP network model is higher than that of multivariate BP network, SVR model, and PC-BP model. The IC-BP network model in the case of dimensionality reduction can effectively reduce the training burden of the

model and still has good prediction accuracy. When the research object of the model is high-dimensional time series, the model has a greater application advantage.

5. Conclusions

Volatility reflects the uncertainty of asset price changes and plays an important role in asset pricing, portfolio, risk management, and asset allocation. Therefore, the research on parameter estimation and prediction of the volatility model has become a hot issue in the field of sports finance and sports financial investment in recent years. Government financial support and market financial support are of great significance to sports finance and play different roles in the process of high-quality development of sports finance. With the continuous upgrading of the financial demand for sports finance, the government departments' understanding of sports finance activities continues to deepen, and the policy tools and state-owned capital are gradually active. A continuous multifractal volatility model based on stochastic process product is proposed. The ubiquitous existence of multifractal features in financial markets indicates that the distribution features of volatility in financial markets will show a nonlinear trend with time scale changes. First, the financial system can expand capital accumulation, promote capital formation, and alleviate the financing constraints of sports finance. Second, it can reduce transaction costs, optimize resource allocation, disperse innovation risks, and promote sports financial technology and model innovation. Third, it can achieve cross period smoothing, wealth effect, and risk protection and stimulate the development of sports financial consumption. However, there are still some problems in this paper that need to be modified. Some contents were not discussed. For example, due to the "memory effect" of volatility, its influence will last for a period of time before it disappears. This part of the effect needs to be further analyzed in future research.

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 declare that they have no conflicts of interest.

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