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Research Article

Research on Dynamic Characteristics of Stock Market Based on Big Data Analysis

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The stock market is a real and continuously evolving extremely complex dynamic system. This paper analyzes the change of stock market efficiency from the perspective of dynamic evolution, and the recursive graph method is used to obtain the dynamic characteristics of stock price time series. For the sharp rise and fall of stock prices, this paper uses the heuristic segmentation algorithm of nonlinear time series mutation detection to study the detection of market dynamics characteristics before the stock market crash. Based on the above research results, this paper studies the dynamic evolution of financial markets and the construction of a complex network of dynamic characteristics between financial markets. The simulation results show that there are typical characteristics of small world network in stock market complex network, the stock market complex network shows stronger synchronization ability, and the transmission range of information between the stock markets in the complex network is significantly expanded.

1. Introduction

With the rapid development of nonlinear complex science, unbalanced system theory, and information processing technology, many new research ideas and analysis methods are applied to the study of the dynamic evolution of economic and financial systems. In particular, complexity science is committed to the exploration of new research paradigms of nonlinearity, heterogeneity, and disequilibrium. At present, using the theories and methods of complexity science to study the complex system of financial market mainly focuses on the exploration of the evidence of financial market complexity and the interpretation of financial market anomalies, and there is a lack of research on the quantitative extraction method and evolution law of financial market complexity features. The quantitative extraction method of financial market system dynamics characteristics, the dynamic process and mechanism of financial market system dynamics characteristics evolution, the monitoring of abnormal behavior of dynamic characteristics in financial market bubble, crisis and collapse process, and the dynamic process of financial crisis contagion are not enough.

Financial system is one of the most complex systems. Due to the large number of participants in the financial market, heterogeneity, and interaction, the financial system has more obvious complex characteristics such as emergence, chaos, and path dependence than other complex systems. The research on financial problems usually analyzes the one-dimensional price (price index) time series data formed after integrating various factors, these one-dimensional time series data contain the nonlinear and complex behaviour characteristics of the financial market, and the traditional linear analysis methods [1, 2] cannot effectively analyze these nonlinear characteristics. The main contribution of this paper is to use the recursive graph theory and the heuristic segmentation algorithm of nonlinear time series mutation detection to study the detection of the mutation time point of market dynamics before the overall collapse of the stock market. And the similarity measurement method of dynamic characteristics of complex systems in stock market is constructed, and on this basis, the adaptive market hypothesis is empirically studied.

At present, using the theories and methods of complexity science to study the problems of financial system mainly focuses on the search for the evidence of financial complexity and the interpretation of financial market anomalies, including the research on the nonlinearity, heavy tail, heteroscedasticity, long memory, fractal, and chaos of financial market. The quantitative analysis of the characteristics of financial market dynamics, the dynamic process and mechanism of financial market dynamics, the monitoring of abnormal behavior of dynamic characteristics in financial market bubble, crisis and collapse, and the dynamic analysis of financial contagion are not enough.

The empirical test of the effectiveness of the stock market is generally based on the linear model, and the stock market price time series is a chaotic time series. The linear research paradigm may no longer be applicable to the pseudorandom process determined by the nonlinear action of internal and external factors. The effectiveness of stock market should not be absolute and static, but relative and show dynamic changes over time. Campbell et al. [3] constructed the concept of market relative efficiency based on this idea. Using the idea of ecosystem evolution, Wimmer et al. [4] proposed the adaptive market hypothesis, and they believed that the effectiveness of the market would show dynamic evolution with the change of the external environment of the stock market. Koustas et al. [5] believed that we must re-examine most of the current test methods of market effectiveness, especially the random walk model, and thought about the effectiveness of the securities market from the perspective of the nonlinearity of price behaviour.

In recent years, nonlinear time series analysis method [6, 7] has been introduced into the measurement of market effectiveness. Lee et al. [8] used Hurst index to measure the relative effectiveness of the stock market. However, the calculation of Hurst index generally requires the length of time series; otherwise, the calculation result is unreliable. Sun et al. [9] proposed the algorithm complexity theory to measure the market efficiency by measuring the degree to which the sequence deviates from the random walk sequence. Zunino et al. [10] believed that entropy can be used to quantify the degree of randomness of time series, so entropy can be used to quantify the degree of market effectiveness, and further use entropy to study the degree of market effectiveness of American market and Asian market during Black Monday and Asian currency crisis, respectively. Shi et al. [11] suggested to study the effectiveness of stock market from the perspective of information entropy. They believed that the market effectiveness changed with the passage of time and had a time scale effect. Niu et al. [12] used multiscale weighted permutation entropy and recursive quantitative analysis methods to study exchange rate fluctuations. The empirical results show that the yen/US dollar has higher complexity. Lee et al. [13] analyzed the multifractal of the US stock market based on the multifractal detrended fluctuation analysis method (MFDFA). The results show that the US stock market has multifractal. Cui et al. [14] used information entropy to quantify the effectiveness of the stock market and found that the effectiveness of the stock market has adaptive evolution behavior. Cao et al. [15] adopted data-driven research ideas on the evolution behavior of the stock market, which can effectively analyze the dynamic characteristics implied in one-dimensional time series and obtain a priori knowledge of the similarity and predictability of complex systems.

In this paper, the recursive graph method is introduced to study the evolution behavior of stock market. The financial time series usually obtained are one-dimensional time series, and the one-dimensional time series itself cannot show the multidimensional space characteristics of the prime mover system. Using the reconstructed phase space theory and recursive graph method, by embedding the one-dimensional stock price time series into the high-dimensional phase space. Furthermore, the dynamic characteristics of stock market system can be studied by analyzing the recursion of state vector trajectory in a high-dimensional phase space with equivalent topological properties. Compared with related works, this paper proposed the idea of recursive graph texture analysis, and the similarity measurement method of dynamic characteristics of complex systems in stock market is constructed by using local binary model.

2. Dynamic Evolution of Stock Market Efficiency Based on Recursive Graph Method

The stock market is a complex system with many influencing factors and extremely complex interaction relations. At present, it is impossible to construct the dynamic differential equation system of the evolution of the stock market, and even it is difficult for us to completely define the set of state variables affecting the stock market system. At present, the analysis of the dynamic characteristics of the complex system of the stock market is mostly from the static perspective, lack of research on the quantitative extraction method, and evolution law of the complexity characteristics of the financial market, and there is little literature on the internal mechanism between the financial crisis and the evolution of the dynamic characteristics of the stock market. In addition, the analysis of the dynamic characteristics of the stock market often focuses on individual markets, and there is a lack of analysis of the linkage relationship between the dynamic characteristics of each market.

The orderliness of complex systems is usually expressed by quasiperiodic behavior. Some similar behaviors have similar development modes and similar behaviors will occur under similar backgrounds. This phenomenon of state reproduction is called recursive behavior [16]. The recursive graph method [17] is used to reconstruct one-dimensional time series into high-dimensional phase space according to the phase space reconstruction theory and then study the dynamic behavior of the prime mover system generating time series in phase space.

The theoretical basis of recursive graph method is time-delay embedding theory [18]. One of the most essential ideas of recursive graph method is that reproduction is one of the most basic properties of dynamic complex systems. Some similar behaviors have similar development modes. This phenomenon of state reproduction is called recursive behavior. The theory holds that as long as the embedding dimension is not less than twice the attractor dimension of the original complex system generating the sequence, the reconstructed phase space can be topologically equivalent to the phase space of the original complex system. Therefore, according to the time-delay embedding theorem, the phase space reconstruction method can be used for one-dimensional time series $\{x_i | i = 1, 2, \ldots, n\}$ by selecting the appropriate phase space dimension m and delay time τ, the one-dimensional time series can be reconstructed into an m-dimensional phase space, and then a state vector set $R^m = \{\overrightarrow{X_i}\}$ can be obtained, where $\overrightarrow{X_1} = (x_i, x_{i+\tau}, \ldots, x_{i+(m-}\ 1)\tau)$, $i = 1, 2, \ldots, n^*, n^* = n - (m-1)\tau$.

After the phase space reconstruction, how to judge whether the two states in the phase space are recursive and the critical distance ε is a very key parameter. At present, there is no general method for its selection, which is usually set as 5–10% of the standard deviation of time series or limited to 10%–30% of the recurrence rate [19, 20]. When the distance between two state vectors in phase space is less than the critical distance ε, the two states are considered to show the behavior of state recursion.

$$R_{ij} = \theta\left(\varepsilon - \overrightarrow{X_i} - \overrightarrow{X_j}\right), \quad \overrightarrow{X_i}, \overrightarrow{X_i} \in R^m, \tag{1}$$

where θ is Heaviside function and m represents the number of dimensions.

$$\theta(x) = \begin{cases} 1, & x \geq 0, \\ 0, & x < 0, \end{cases} \tag{2}$$

The value of R_{ij} represents the recursive relation of state vectors $\overrightarrow{X_i}$ and $\overrightarrow{X_j}$ in phase space. All R_{ij} will form a matrix $\mathbf{R}$ composed of 0 and 1, which is called recursive matrix.

In order to study the evolution behavior of a system, we first need to determine which factors may affect the system and the interaction relationship between factors according to a priori knowledge. Then, following certain principles, the most essential and important factors are selected as the state variables of the research system. Then, according to the corresponding theory, the dynamic differential equation system controlling the evolution of these state variables is constructed.

Supposing a system can be determined by m state variables, each state variable is a function of time t, that is, $y_i = y_i(t)$, then the following differential equations can be constructed to describe the evolution behavior of the system:

$$\begin{cases} \dfrac{\mathrm{d}y_1}{\mathrm{d}t} = f_1(\gamma, y_1, y_2, \ldots, y_m), \\ \dfrac{\mathrm{d}y_2}{\mathrm{d}t} = f_2(\gamma, y_1, y_2, \ldots, y_m), \\ \cdots \\ \dfrac{\mathrm{d}y_m}{\mathrm{d}t} = f_m(\gamma, y_1, y_2, \ldots, y_m). \end{cases} \tag{3}$$

With the evolution of time, a series of system state vectors $Y_i = (y_1, y_2, \ldots, y_m)$ can be obtained, these state vector points will form the state trajectory of the system in m-dimensional phase space, and the change of state trajectory represents the dynamic behavior of system evolution. However, the stock market is different from the research object in our natural science. It is difficult for us to completely define the set of state variables affecting the stock market system, so we cannot construct the differential equation system of the evolution of the stock market system. In the study of stock market system, usually only one-dimensional time series of stock price can be obtained, and this series is obtained from the projection of points in m-dimensional phase space to one-dimensional space. On the one hand, such one-dimensional time series data can directly provide us with very limited information about the dynamic characteristics of the stock market; on the other hand, all the information about the dynamic characteristics of the stock market is hidden in the one-dimensional time series. Therefore, in the study of the stock market system, we can use the method of reconstructing the phase space in physics to embed the one-dimensional time price series into the high-dimensional phase space, so that the dynamic behavior characteristics of the stock market evolution can be reflected in a high-dimensional phase space with unchanged topological properties through the change of the running trajectory of the state vector in the phase space.

This paper makes a quantitative comparative study on the effectiveness of stock markets in 10 developed countries (regions) and 6 emerging countries (regions) by using recursive graph method and recursive entropy. Due to the different cardinality of stock market indexes in various countries, in the next analysis, the daily returns of major stock market indexes in various countries are used for analysis. Firstly, the recursive graph method is used to analyze the daily return series of Dow Jones Industrial Average (January 6, 2015, to September 27, 2019). The embedding dimension can be determined as 6 by using the false neighbor point method. The variation of nearest neighbor error rate of Dow Jones industrial index with embedding dimension is shown in Figure 1.

Similarly, for the daily return series of Shanghai Composite Index (January 6, 2015, to September 27, 2019), the embedding dimension can be determined as 7 by using the false neighbor point method. The variation of nearest

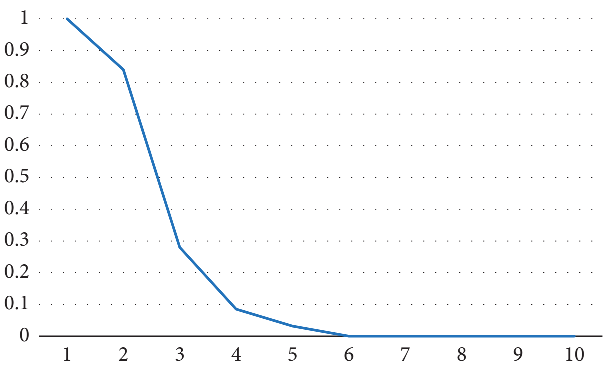

Figure 1: The variation of nearest neighbor error rate of Dow Jones industrial index with embedding dimension.

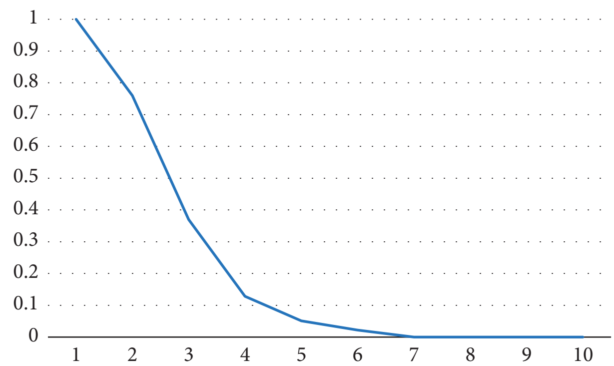

Figure 2: The variation of nearest neighbor error rate of Shanghai Composite Index with embedding dimension.

neighbor error rate of Shanghai Composite Index with embedding dimension is shown in Figure 2.

It can be seen from the recursive graph data of the daily return of the Dow Jones Industrial Average and the daily return of the Shanghai Composite Index that the recursive graphs of both show certain regularity, which are obviously different from the recursive graphs generated by random number sequences, and their recursive graphs have fractal like self-similarity structure. Therefore, the daily return sequences of the two market indexes are not random walk sequences.

The recursive entropy of the daily return series of the US Dow Jones industrial average is 0.4371 and that of the Shanghai composite index is 0.4663, indicating that the order of the daily return series of the US Dow Jones industrial average is weaker than that of the Shanghai Composite Index, indicating that the effectiveness of the US stock market is stronger than that of the Chinese stock market during this time period. This is consistent with the research results obtained in most research literature, which shows that recursive entropy can effectively measure the effectiveness of the stock market.

Through the comparative analysis of the recursive entropy of the daily return series of 16 major stock market indexes in the world and the recursive entropy of the daily return series of the same stock market index in each time stage, the following conclusions can be obtained:

(1) The effectiveness of stock markets in various countries will fluctuate within a certain range different from each other. The recursive entropy of stock market indexes in most developed countries (regions) is greater than 2 in the first three years, while the recursive entropy of stock market indexes in emerging market countries (regions) is less than 1.

(2) Social unrest in a country (region) will affect the effectiveness of the country (region) stock market. In countries with relatively stable social situation, the effectiveness of the stock market is relatively stable without large fluctuations.

(3) From the perspective of time dynamic evolution, the quantitative analysis of the effectiveness of stock markets in various countries at various stages can be concluded that the effectiveness of stock markets presents more complex dynamic evolution characteristics and fluctuates repeatedly in relative effectiveness and relative ineffectiveness.

3. Complex Network Construction of Dynamic Characteristics between Financial Markets

3.1. Detection Algorithm of Market Dynamics Characteristics before Stock Market Crash. In recent years, the sharp rise and fall of stock prices are frequent, especially the sharp fall of stock market has brought great challenges to the stability of financial market. The stock market crash destroys market confidence and causes great panic among investors and society, which reduces the overall resource allocation efficiency of the stock market, while the traditional financial theory cannot make an effective explanation for the stock market crash. Kim et al. [21] defined stock price crash according to three criteria: first, the stock price suddenly drops sharply without warning. Second, the change of stock price is negative and asymmetric. Third, the stock price crash is contagious.

In this paper, recursive quantitative analysis (RQA) and heuristic segmentation algorithm for mutation detection of nonlinear time series are used to study the detection of mutation time points of market dynamics characteristics before stock market crash.

The laminar flow index of recursive quantitative analysis method describes the ratio of recursive points in vertical structure to all recursive points and reflects the probability of laminar flow state in complex system. The calculation formula of laminar flow index is defined as follows:

$$\text{Laminar} = \frac{\sum_{V=V_{\min}}^{N} vP(v)}{\sum_{V=1}^{N} vP(v)}, \tag{4}$$

where $P(v)$ represents distribution function of segment length in recursive graph.

Financial time series data are generally nonlinear and nonstationary series. When the external environment changes, it will lead to structural mutations and new characteristics of financial time series. The understanding of these structural mutations is helpful to study the evolution law of financial market. The stock market is a complex system. Due to the complex and changeable external environmental factors and the influence of people's psychological activities, the structural characteristics of stock time series often change with time, and the series presents nonlinearity and nonstationarity.

The heuristic segmentation algorithm effectively solves the problem that the previous time series mutation detection methods are based on the assumptions of stationary and linear processes. At the same time, due to the use of the multi-iterative algorithm, the amount of detection calculation is greatly reduced. Not only the method is practical, but also the white noise and peak noise have little impact on the anomaly detection results.

This paper chooses Dow Jones industrial average as the research object to analyze the collapse process of American stock market when the financial crisis occurs. A total of 9165 trading days of four major global financial and economic crises were collected for analysis. The results show that the previous stock market crashes seem to occur without warning, but the dynamic characteristics of the market have changed suddenly before the market crash. It provides a new method for studying and warning the collapse of the stock market. Through the analysis, it can be seen that during each financial crisis, the Laminar series of American stock market showed fractal like self-similarity structure, and the series showed complexity characteristics. There are blank bands in the recursive graph, indicating that there is phase transition in Laminar sequence, and abnormal mutations of Laminar sequence occur at these phase transition points. These mutation points correspond to the abnormal mutation of the dynamic characteristics of the stock market.

3.2. Dynamic Evolution Research of Financial Markets. Efficient market hypothesis (EMH) [22] is the basis of modern classical financial theory. It is a linear research paradigm of static and equilibrium convergence, and the assumption of linear behavior of financial market deviates from the actual situation, resulting in many difficulties for efficient market hypothesis. A large number of empirical studies [23–26] show that the price fluctuation of financial market has the behavioral characteristics of scale invariance, self-similarity, and long-term memory. The existence of these characteristics shows that the financial market has nonlinear and fractal characteristics and is a complex dynamic system composed of multiple factors.

In recent years, the research of financial market shows a new trend from linear paradigm to nonlinear paradigm and from equilibrium analysis to unbalanced analysis. The adaptive market hypothesis (AMH) based on the idea of biological evolution has emerged. AMH believes that financial markets are dynamically evolving, with common periodicity, panic, market bubble, and collapse. These market states show complex dynamic evolution. The researches results show that AMH can better describe the dynamic change behavior of market return than EMH.

AMH hypothesis regards the stock market as a complex adaptive system. Under different external conditions, the market characteristics show dynamic evolutionary behavior. At present, few studies directly study the dynamic evolution of market dynamics. This paper studies the adaptive market hypothesis from the perspective of complexity science and constructs a method system to quantify the dynamic evolution behavior of the dynamic characteristics of the stock market.

A basic theory of system dynamics is that each system must have its own structure. The system structure determines the function of the system. Different system structures determine that the system has different dynamic behavior and shows different dynamic behavior characteristics.

In this paper, the recursive graph texture similarity measure (EMD) is used to analyze the dynamic evolution of the dynamic characteristics of 16 major market indexes in the global stock market, and the specific results are shown in Table 1.

It can be seen from Table 1 that the minimum EMD between the dynamic characteristics of each market and the dynamic characteristics of random system is concentrated at about 5.0, and the difference is small. It shows that there is a stable upper limit of similarity between each market dynamic characteristic and the stochastic system in the process of adaptive evolution. However, there are great differences between the dynamic characteristics of each market and the maximum EMD of the dynamic characteristics of stochastic system, which shows that the dynamic characteristics of each market have varying degrees of volatility in the process of adaptive evolution, and different markets make different adaptive changes to the same external environment. For example, at the beginning of its establishment, the EMD distance of China's Shanghai stock market was as high as 56.72, which was larger than that of other stock markets, indicating that the market effectiveness of China's stock market was low at the beginning of its establishment.

3.3. Complex Network Construction and Analysis between Financial Markets. This paper uses the processing idea of symbolic time series to symbolize the logarithmic return series of EMD series in each stock market, then constructs the linkage model composed of five symbols, and constructs the directional weighted complex network of the linkage model of stock market dynamic characteristics from the transformation relationship between the linkage models. This paper analyzes the evolution of the dynamic characteristics of the stock market and the changes of the linkage mode during the financial crisis from 2008 to 2012. It is divided into three stages: precrisis, subprime mortgage crisis, and European debt crisis, and constructs the directed weighted complex network of the linkage mode of the market dynamic characteristics in each time period. Through some statistical characteristics of the complex network and the changes of the composition of important nodes, the changes of the market linkage model structure in each stage of the financial crisis is analyzed in this paper.

Table 1: EMD distance statistics data of each market index.

Market index	Maximum value	Minimum value	Mean value	Variance
AS30	18.52	4.76	7.28	4.59
SMI	23.08	4.86	7.31	4.61
FCHI	14.73	4.87	6.92	2.36
GDAXI	18.76	4.98	7.12	3.76
HSI	19.02	5.11	7.36	4.03
N225	34.38	5.12	7.49	7.25
STI	17.68	5.11	7.62	5.06
FTSE	17.66	4.87	6.98	3.52
DJI	21.32	4.71	7.58	5.03
IXIC	27.92	5.23	9.16	15.12
P500	18.914	4.92	7.65	4.59
SH	56.72	5.12	8.97	42.36
SZSE	34.25	5.17	8.38	13.98
SENSEX	21.86	5.21	7.59	5.68
JKSE	16.63	5.36	7.82	4.73
KS11	18.43	5.02	7.39	5.12

Table 2: EMD distance statistics data of each market index.

Market index	Network diameter			Modularity		
	Precrisis	Subprime crisis	European debt crisis	Precrisis	Subprime crisis	European debt crisis
AS30	17	19	16	0.601	0.643	0.625
SMI	16	17	13	0.536	0.649	0.611
FCHI	21	19	15	0.603	0.626	0.608
GDAXI	20	18	16	0.626	0.638	0.621
HSI	18	18	12	0.606	0.629	0.598
N225	18	17	16	0.612	0.628	0.611
STI	15	20	13	0.616	0.652	0.606
FTSE	22	22	15	0.618	0.636	0.605
DJI	18	19	12	0.636	0.626	0.611
IXIC	20	25	16	0622	0.636	0.615
P500	18	20	20	0.639	0.641	0.635
SH	16	20	16	0.616	0.626	0.608
SZSE	17	16	13	0.612	0.623	0.609
SENSEX	16	18	15	0.619	0.622	0.606
JKSE	16	22	17	0.618	0.631	0.598
KS11	18	19	16	0.612	0.617	0.605

Firstly, the logarithmic return of EMD series of each market index is calculated. In order to reduce the impact of noise, when the absolute value of logarithmic return is less than 0.5%, the change of dynamic characteristics of stock market is very small, and the return is recorded as 0. Then, using the idea of symbolic time series analysis, the dynamic characteristic linkage model of American Standard and Poor's 500 index and other market indexes is symbolized. Suppose that the logarithmic return of EMD of Standard and Poor's 500 index in period t is R_t, and the logarithmic return of EMD of other market indexes in period t is r_t, then the linkage symbol f between other market indexes in period t and Standard and Poor's 500 in period $t-1$ shall be determined according to the following rules:

$$F_t = \begin{cases} 2, & r_t * R_{t-1} > 0, \\ 1, & r_t * R_{t-1} = 0, \\ 0, & r_t * R_{t-1} < 0. \end{cases} \quad (5)$$

Because the stock market trades five days a week, we design the stock market linkage mode into a linkage mode composed of five symbols, so there are 243 linkage modes in total. Finally, the linkage mode is regarded as the node of the complex network, and the number of changes from one mode to another mode is regarded as the weight.

Before the specific data analysis, a 1000 length random time series satisfying lognormal distribution is generated as the comparison basis of the similarity of market dynamics characteristics. Then, using the similarity measurement method of stock market dynamic characteristics based on EMD, this paper analyzes the dynamic evolution and linkage mode of the dynamic characteristics of 16 major market indexes in the global stock market during the 2008–2012 financial crisis.

The analysis of the overall structural characteristics of the complex network of each stock market linkage mode is shown in Table 2.

It can be seen from Table 2 that the dynamic characteristics of the stock market and the modularity of the complex network of linkage modes are very small, which shows that the aggregation phenomenon between the linkage modes is not obvious. During the European debt crisis, the network diameter decreased significantly, the stock market linkage mode was complex, and the small world characteristics of the network were enhanced, indicating that the conversion between various fluctuation modes was accelerated, the linkage between national stock markets and American stock markets was enhanced, and the stock markets showed the phenomenon of crisis contagion. In addition, the impact of the subprime mortgage crisis makes investors in various countries more sensitive to external information, especially crisis signals, resulting in the instability of the dynamic structure of the global stock market. The instability of this system dynamic structure will further accelerate the infection of the financial crisis and amplify the negative impact of the financial crisis. The actual market situation is that during the European debt crisis, the stock markets of various countries experienced extreme market phenomena of sharp rise and fall.

4. Conclusions

The dynamic characteristics of stock market show dynamic evolution. In this paper, the periodic evolution behavior of the effectiveness of the stock market and the hidden law behind this phenomenon is studied. This paper makes an empirical study on the adaptive market hypothesis from the perspective of the evolution of the dynamic characteristics of the stock market. This paper only analyzes the changes of the basic statistics of the network structure for the dynamic evolution of the complex network with the dynamic characteristics of the stock market and does not further analyze the evolution of the community structure of the complex network in the process of the financial crisis. In the future, it will analyze the relationship between the evolution of the community structure of the complex network with the dynamic characteristics of the stock market and the contagion of the financial crisis from a more microperspective. In the future, multilayer complex networks will be further used to further analyze the linkage between financial markets during the financial crisis, so as to provide new research ideas and empirical methods for the study of financial crisis contagion.

Data Availability

The basic data used in this paper are downloaded from https://cn.stockq.org/.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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