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Original Paper

Efficiency Analysis of Private Lending Market in China—Based on Hurst Index

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Abstract

This paper explored the efficiency of the private lending market based on the fractal market theory. We used the rescaled range analysis method and the generalized Hurst exponent analysis method respectively, and we got that the private lending market had not yet reached the weakly efficient level and was anti-persistent. Then we further used the time-varying Hurst index to describe the dynamic changes in the efficiency of the private lending market and analyzed the Chinese stock market and foreign exchange market as a comparative analysis. We found that among the three markets, the efficiency of the private lending market was the lowest, and that there was a correlation between the efficiencies of the three markets, and its effectiveness was affected by the other two markets. Finally, based on the above analysis results, we put forward relevant suggestions on the development of the private lending market and provided a decision basis for investors in the private financing market.

Keywords

Fractal market theory, Private lending market, R/S method, GHE method, Time-varying Hurst index

1. Introduction

Economic development has always been the focus of research in the financial field, especially the development of the private economy plays an important role in the sustainable and stable development of the economy in China. And the development of the private economy is inseparable from the strong support of private finance (Li, 2020). After the reform and opening-up, China's private economy has developed rapidly, and the scale of private finance has continued to expand. Now it has become the main source of financing for China's private economy and plays an important role in the high-quality growth of China's economy (Sha & Li, 2020; Luo & Yin, 2006). The development of private finance

can provide financial support for small and medium-sized enterprises (SMEs), and effectively solve the "three rural" problems. It also promotes sustainable economic development, effectively adjusts China's industrial structure, and improves China's financial market (Sha & Li, 2020). Pan et al. (2018) established a VAR model to analyze that the development of private finance can significantly affect economic growth, and the interest rate of private finance can also significantly affect inflation. China is currently characterized by a typical dual economic structure, and this difference between urban and rural areas provides a huge development space for private finance (Mu, 2009). Private finance is mainly represented by private lending (Liao, Jia, & Lan, 2021). The early private lending in China was mainly based on social network relationship lending, including loans from relatives, loans from friends, etc. Nowadays, with the rise of small loan companies, guarantee companies, and Internet lending in the market, there are more and more forms of private lending. The diversity of private financial forms can effectively mobilize the enthusiasm of SMEs to invest and promote the development of the rural economy (Li & Sha, 2020). According to statistics and estimates, China's private lending market has developed rapidly in recent years. Excluding the impact of the epidemic, the total amount of lending has increased every year. As a developing country, China in the new era proposes to vigorously develop inclusive finance in the promotion of financial innovation and reform, and private financial services are an important supplement to inclusive finance (Li, Zhao, & Gou, 2021). Li et al. (2021) constructed a tail-dipping regression model from the capital supply side to empirically test that there are regional differences in private finance, and that the efficiency of the financial market needs to be improved. The efficiency of the financial market is mainly reflected in the equalization of the benefits and costs between the markets under the goal of the capital supply and demand parties pursuing the best benefits (He, Yang, & Chen, 2012). In the study of financial markets, the research on market efficiency is the most discussed issue by scholars at present (Fan & Zhang, 2002). The effectiveness of the financial market will directly affect the flow of funds, thereby affecting the effective allocation of resources in the real economy. The higher the effectiveness of the market, the stronger its role in supporting the development of the real economy and optimizing the allocation of capital resources (Zhu & Li, 2016). Therefore, it is of great practical significance to study the effectiveness of the private lending market.

2. Literature Review

At present, there are two important theories in the research on the efficiency of financial markets: the first one is the Efficient Market Hypothesis (EMH). It was first proposed by Cootner (1964) and Samuelson (2015), and later Fama (1965) extended the theory. The efficient market hypothesis believes that the market is a fair game process, and a market is called an efficient market if its prices fully reflect all available information. According to the degree of information reflected by the market, Fama divides the market types into three forms, namely weak form, semi-strong form, and strong form. The efficient market hypothesis theory assumes that investors in the market are rational and organized people. This theory is based on linear thinking that the entire market is static and equilibrium, and the changes in

transaction prices obey the random walk model (Zheng, 2011). But in reality, not every investor is rational, and not all behaviors in response to price changes are linear. Later, more and more scholars researched to prove that the return rate of the financial market is more of a "sharp peaks and fat tails" distribution pattern. However, the efficient market hypothesis is based on the normal distribution of returns, so this theory has been questioned by scholars. With the gradual introduction of nonlinear theory into the study of financial markets, scholars have reconsidered the issue of market efficiency with a brand-new way of thinking, and they subsequently put forward a series of research hypotheses, among which the fractal market hypothesis is the most famous. Since Mandelbort (1979) proposed the fractal analysis method, it has made a reasonable explanation for many complex phenomena. The capital market is a complex dynamic system, and its internal factors interact with each other, as well as many external factors that affect it, so the capital market has been difficult to understand deeply (Wan & Zhuang, 2007). Peter (1994) proposed the Fractal Market Hypothesis (FMH) by combining the fractal theory with the capital market theory, which provides a new perspective for us to better understand the financial market. The fractal market hypothesis is more complex but closer to the real market theory, so the analysis based on the fractal market theory is more universal than the efficient market theory (Tan, 2010). Discussing the effectiveness of a financial market requires analyzing whether the price changes in the market conform to the random walk process, that is to say, it is necessary to determine whether the market has a long memory. Long memory refers to the existence of significant autocorrelation between observations at two long intervals (Liu, Cheng, & Yang, 2019). At present, the research on the efficiency of China's financial market mainly focuses on whether it is weakly efficient. The fractal analysis method can judge whether the market has memory, and then judge that the market has fractal characteristics. The fact that the market has fractal characteristics means the denial of the efficient market hypothesis, which means that the market has not yet reached the weak-form efficient level (Liu, Cheng, & Yang, 2019). The rescaled range analysis method (R/S) is commonly used to study the efficiency of financial markets using the fractal market hypothesis. This method was proposed by British hydrologist H.E. Hurst on the basis of a large number of empirical studies to analyze the long memory and the period of time series (Hurst, 1951). The proposal of the Hurst index plays an important role in the theory of the fractal market hypothesis. It can reflect the fractal characteristics of the market, can describe the degree of market effectiveness, and is widely used in the study of financial markets. The Hurst index is a value between 0 and 1. When $0.5 < H < 1$, it indicates that the time series is persistent and the market has a long memory. When $H = 0.5$, it indicates that the time series is random, the market is efficient, and the future trend is unpredictable. When $0 < H < 0.5$, it indicates that the time series is anti-persistent and the market has the characteristics of mean reversion. Therefore, the more the Hurst index deviates from 0.5, the shows that the market is more ineffective and predictable. There are many methods for estimating the Hurst index, the original R/S analysis method requires a large sample size, and it is sensitive to short-term memory (Couillard & Davison, 2005). Based on these shortcomings, later scholars have made corrections and

supplements on the basis of this method. Cajueiro et al. (2005) proposed a new nonparametric statistical method for estimating the Hurst exponent, called rescaled variance analysis method (V/S). This method replaces the range of the cumulative dispersion of the sample series in the R/S analysis method with the variance of the series and compares the statistics of the two methods through the Monte Carlo model. The results show that the V/S analysis method is more robust and effective. Gu et al. (2008) used the V/S analysis method to study the nonlinear characteristics of China's Shanghai and Shenzhen stock markets. Peng et al. (1994; 1995) proposed the Detrended Fluctuation Analysis (DFA) method, which is a method for analyzing the relationship of power-law functions, and it can determine long-range correlations in non-stationary time series. On this basis, Kantelhardt et al. (2002) proposed the Multifractal Detrended Fluctuation Analysis Method (MF-DFA), which can estimate the multifractal spectrum from the time series through the Hurst exponent, and it can detect the short-term and long-term correlation of the time series. On the basis of the MF-DFA method, the generalized Hurst index can be obtained, and the generalized Hurst index is generally used in the research of financial markets. Many scholars have conducted empirical research on the application of fractal market theory in financial markets. Guo et al. (2020) used the R/S analysis method to analyze the effectiveness of seven pilot local carbon trading markets in China. This research shows that the seven carbon trading markets are not very active and have not yet reached the level of weak-form efficient markets. Liu (2019) studied the effectiveness of China's real estate market in different grades of cities based on a fractal perspective and showed that it is inefficient. There are also many studies on the effectiveness of foreign financial markets, including European stock markets (Onali & Goddard, 2011; Worthington &Higgs, 2004), Middle East and North African countries' stock markets (Ananzeh, 2021), Indian stock markets (Bhuyan, Patra, & Bhuian, 2020), Vietnam frontier markets (Mateus & Hoang, 2021), etc. In addition, the efficiency of the financial market changes when countries face major economic crises. Asem et al. (2017) indicated that a volatile market environment would increase the correlation between markets, so the market would become cross-inefficient. Some scholars have explored the behavior of financial market efficiency under crisis (Mynhardt & Plastun, 2014). There is also how different monetary regimes affect the price efficiency of exchange rates in the face of financial crises (Diniz-Maganini, Rasheed, & Sheng, 2021). Dias (2020) explored the market efficiency of the United States, China, and Europe in the context of the global pandemic of COVID-19. Sun (2021) studied the effectiveness of the US stock market during the global financial crisis and the spread of the new crown pneumonia epidemic. Other scholars have studied the efficiency of European and Asian stock markets during the 2008 financial crisis (Anagnostidis, Varsakelis, & Emmanouilides, 2016; Jin, 2016). At the same time, for the financial market that changes frequently, if we only calculate the static Hurst index and cannot accurately describe the behavior of this market, it is necessary to introduce a dynamic perspective. Zhao et al. (2011) used the dynamic Hurst index to judge the trend of the stock index in the actual stock market and the usable range of the dynamic Hurst index and believed that the index has a certain reference value. Qin et al. (2011) defined a concept of the time-varying Hurst index based on

the R/S analysis method, indicating that the time-varying Hurst index can successfully predict market reversals. Cajueiro and Tabak (2004) used the dynamic Hurst index to study the effectiveness of emerging markets, and the results showed that most markets, except Brazil, became more and more efficient over time. From the perspective of research methods, the conclusions drawn by different fractal analysis methods will be different. In this paper, we choose the classical R/S analysis method and the generalized Hurst exponent analysis (GHE) method for comparison with most of the research situations. And we add the sliding window method to obtain the dynamic Hurst index, and then judge the effectiveness of China's private lending market over time.

3. Methodology

3.1 Rescaled Range Analysis Method

The rescaled range method can perform fractal analysis on time series through the Hurst index, and judge whether a time series has a long memory according to the range of the index. It means that events in the past affected the present, and events in the present affect the future, thereby denying the assumptions of the market hypothesis. The principle is as follows:

i. Given a time series $\{x_1, x_2, ..., x_N\}$, its total length is N, divide the time series into A consecutive subsequences of length n, at this time $N = A \times n$. Note that each divided subinterval is I_a, where $a = 1, 2, ..., A$, denote the elements in a subinterval as x_{ak}, where $k = 1, 2, ..., n$. The interval mean of I_a is defined as:

$$E_a = \frac{1}{n}\sum_{k=1}^{n} x_{ak} \tag{1}$$

ii. Define the cumulative intercept of the mean in subinterval I_a as:

$$Y_{ak} = \sum_{i=1}^{k}(x_{ai} - E_a), \quad i = 1, 2, ..., N \tag{2}$$

iii. The range of subinterval I_a is defined as:

$$R_{I_a} = max(X_{ak}) - min(X_{ak}) \tag{3}$$

iv. The standard deviation of subinterval I_a is defined as:

$$S_{I_a} = \sqrt{\frac{1}{n}\sum_{k=1}^{n}(x_{ak} - E_a)^2} \tag{4}$$

v. Calculate R_{I_a} / S_{I_a} to obtain the rescaled range result for each subsequence, which is defined as:

$$(R/S)_n = \frac{1}{A}\sum_{a=1}^{A}\frac{R_{I_A}}{S_{I_a}} \tag{5}$$

vi. Increase the length of the subinterval and repeat the above steps until $n = N$, sequence $[(R/S)_n]_{n=1}^{N}$ can be obtained.

vii. Then perform linear regression with $log(n)$ as the independent variable and $log(R/S)$ as the dependent variable, according to the equation:

$$log(R/S) = logC + H \cdot log(n) + \varepsilon \tag{6}$$

Using the least-squares method to estimate the slope H is the estimated value of the Hurst exponent.

3.2 V-Statistic

The V-statistic is extended by Peters (1994) to estimate the average period of time series, it can judge whether the sequence has an aperiodic cycle, and get the average cycle length, its expression is:

$$V_n = \frac{(R/S)_n}{\sqrt{n}} \tag{7}$$

Observe the trend of the curve by drawing the $V_n \sim ln(n)$ curve graph, If the curve is a horizontal line, the time series is random, that is $H = 0.5$, the market is efficient at this time. If the curve slopes downward, the time series process is anti-persistent, that is $0 < H < 0.5$. If the curve slopes upward, the time series is a long memory process, that is $0.5 < H < 1$. We can not only judge market efficiency with V-statistic, but also find out the long memory length of time series. When the curve has an obvious turning point, it indicates that the influence of the past on the future disappears, and the time length n at this time corresponds to the average cycle length of the sequence.

3.3 Generalized Hurst Exponent Analysis Method

The generalized Hurst exponent is a q-order moment of an incremental distribution, which can obtain the scaling behavior of different fluctuation orders. This method was originally proposed by Di Matteo et al. (2003). For a random variable $X(t)$, where $t = 1,2,...,k,...,T$, defined as follows:

$$F_q(\tau) = \frac{\left\langle \left| X(t+\tau) - X(t) \right|^q \right\rangle}{\left\langle \left| X(t) \right|^q \right\rangle} \tag{8}$$

where τ varies from 1 to τ_{max}, $\langle ... \rangle$ represents the sample mean within the time window. If $X(t)$ is scaled, the following power-law relationship exists:

$$F_q(\tau) \propto \tau^{qH(q)} \tag{9}$$

where $H(q)$ is the generalized Hurst exponent of order q.

In order to further study the relationship between $H(q)$ and q, taking the natural logarithm of both sides of the above formula, the obtained relationship is as follows:

$$(1/q) ln F_q(\tau) \propto H(q) ln \tau \tag{10}$$

For different values of q, $H(q)$ describes different characteristics of the time series. If the trend change is continuous, then $H(q) > 0.5$. If it is anti-persistent then $H(q) < 0.5$. If it is a random walk process, then $H(q) = 0.5$. According to Di Matteo et al. (2003), we set τ range from 1 day to τ_{max} = 19 days. In this paper, the result of $q = 2$ is selected as the generalized Hurst exponent value.

4. Empirical Analysis

4.1 Data

Wenzhou is an experimental area for the comprehensive reform of the private economy and a key area for private financial activities in China. Private finance is very active (Shi, 2019). The Wenzhou Index ensures the orderliness of private financing to a certain extent that generated during the reform period, and makes up for the blank of the market price representation of private financing. The Wenzhou Index is the most representative and typical of all private financing interest rate indexes in China, and it is also a relatively mature index so far. The paper explores that the Wenzhou index can help us deeply understand the information value of China's private financing interest rate index (Shi, 2019). The Wenzhou Index is based on the statistical index and statistical evaluation theory, and it is compiled using a hierarchical weighted synthesis method. This paper selects the Wenzhou private comprehensive interest rate index data from January 4, 2013 to December 20, 2021. We study the Wenzhou index (WI) as a private lending market data. In order to have a deeper understanding of the factors affecting the effectiveness of the private lending market, this paper also selects the foreign exchange rate data (FER) and the Shenzhen stock exchange composite index (SSECI) for comparison, which is the epitome of China's stock market, and the date range is the same. (The data comes from the Wind database)

In order to eliminate the possible heteroscedasticity in the time series and obtain a more stationary time series in the statistical sense, let the composite index of the private lending market be P_t on that day, we log-linearize the sequence. Use $r_t = ln(P_{t+1}/P_t)$ to take the logarithmic rate of return on the daily data and convert the price series into a return series.

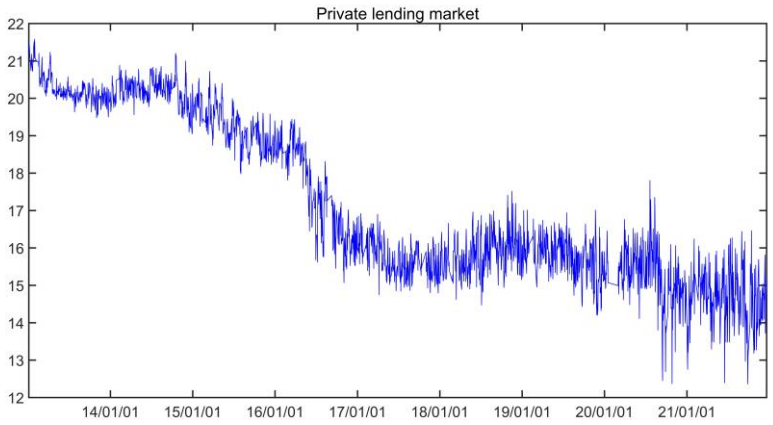

Figure 1. Original Price

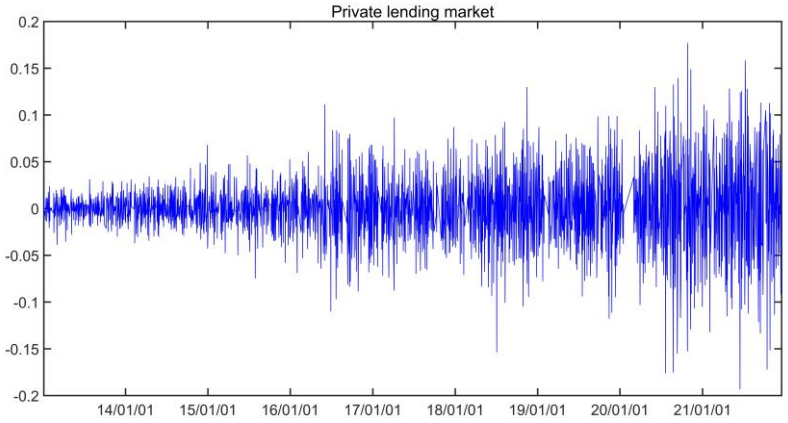

Figure 2. Return Series

From Figure 1, we can see that the overall trend of private comprehensive interest rates in Wenzhou is downward. There is a clear downward trend during 2016, and there is also a small downward trend in 2020. In order to ensure the healthy and stable development of the private lending market, China has been adjusting interest rates. In 2015, the Supreme People's Court promulgated and implemented the "Regulations on Several Issues Concerning the Application of Law in the Trial of Private Lending Cases", which adjusted the upper limit of the interest rate to four times the upper limit of the one-year LPR (Loan Prime Rate). In 2020, the Supreme People's Court issued the "Decision on Amending (Regulations on Several Issues Concerning the Application of Law in the Trial of Private Lending Cases)", and continued to lower private lending interest rates. This reduces the financial cost of SMEs and can reduce a series of social problems caused by high interest rates (Meng & Zhang, 2021). Figure 2 shows that the two time series have large fluctuations in some intervals, but they are basically stable. The yield sequence can better reflect the changes in market information, so we will use the yield sequence for the research below.

Table 1. Descriptive Statistics Results

Name	Max	Min	Mean	Standard Deviation	Skewness	Kurtosis	Jarque-Bera	Probability
WI	0.1766	-0.1932	-0.0002	0.0385	-0.1278	5.2064	440.9516***	0.0000

Note. *** 1% significance level

This paper uses Eviews10 to carry out descriptive statistics on the private lending market return rate series. From the descriptive statistics in Table 1, it can be seen that the distribution of this series is not zero with respect to the standard normal distribution, and the kurtosis is greater than 3. It belongs to the distribution pattern of "sharp peaks and fat tails", which is the case for most return series in the

financial market. It can also be seen from the Jarque-Bera statistic results of this series that the statistic is much greater than zero, and the data does not conform to a normal distribution.

4.2 Hurst Index Analysis

This paper uses Matlab software to carry out R/S analysis on the private lending market rate of return series, and the results are as follows:

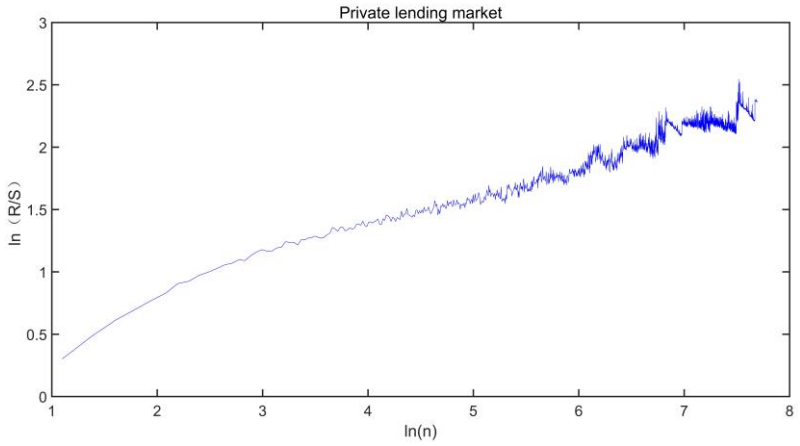

Figure 3. $ln(R/S) \sim ln(n)$ **Graph of Private Lending Market**

Table 2. Hurst Results for Private Lending Market

Private lending market	H	H (shuffled)	H (Fourier transform)
R/S	0.2637	0.0540	0.3160
GHE	0.1357	0.0815	0.1863

Figure 3 shows the curve $ln(R/S) \sim ln(n)$ of the comprehensive interest rate of private lending, and its slope is the Hurst index value of the private lending market. Table 2 shows the results of the R/S analysis method, the Hurst index is 0.2637, indicating that the return series has anti-persistent. That is to say, the future trend is likely to be opposite to the current trend. Since volatility is predictable, some investors will use it to obtain abnormal returns in the market. In addition, the deviation of the value of 0.5 is large, which indicates that the market has not reached the weak-form efficient level. Since the long-term correlation between return series and the thick-tailed distribution of volatility are the causes of multifractal features (Wan & Zhuang, 2007; Zhou, 2009), we perform shuffled transformation and Fourier phase randomization on the data to obtain the factors that affect the multifractal characteristics. Table 2 shows that the results obtained after data shuffled and Fourier phase randomization are all different from the original values. The multifractal degree of $\Delta H = 0.2097$ after the shuffled and transformation of the yield sequence is greater than the multifractal degree of $\Delta H = 0.0523$ after the Fourier phase randomization. It shows that the long-term correlation of the series has a greater impact

on the multifractal characteristics than the fluctuating thick-tailed distribution.

The Hurst index calculated by the classical R/S method is often larger than the true value. The GHE method can avoid false detection of time series and is more robust. Therefore, we also use the GHE method to calculate the Hurst index value to ensure the accuracy of the results. Table 2 also gives the results of the comparative analysis of the two methods. The Hurst index calculated by the GHE method is 0.1357. The series also shows anti-persistent, and the market still has not reached the weak-form efficient level, which is consistent with the results obtained by the R/S analysis method.

In order to further test the validity of the Hurst index results, this paper also uses the unit root test and the Wild Bootstrap variance ratio test to analyze the efficiency of the private lending market. These methods are used to test the properties of random walks in financial time series, so that the weak-form efficiency of the market can be judged. The method is implemented with Eviews 10.

Table 3. Unit Root Test Results

		t-statistic	Probability
ADF test statistic		-21.7615***	0.0000
	1%	-3.4332	-
Test critical values	5%	-2.8627	-
	10%	-2.5674	-

Note. *** 1% significance level

Table 4. Wild Bootstrap Variance Ratio Test Results

Joint tests	Test value	Df	Probability
MV	17.3337***	2144	0.0000
Individual tests			
period	VR	z-statistic	Probability
2	0.3527	-17.3337***	0.0000
4	0.1844	-12.6822***	0.0000
8	0.0846	-9.7209***	0.0000
16	0.0443	-7.2090***	0.0000

Note. *** 1% significance level

The unit root test results in Table 3 show that the return sequence does not follow a random walk process. And the results of the Wild Bootstrap variance ratio test are shown in Table 4. The variance ratio test statistic is the VR value, and the MV value represents the joint test statistic of the variance ratio. The number of test repetitions was 1000 times, and the lag cycle times were 2, 4, 8, and 16 days. It can be seen from the results that the MV value of the joint test statistic is 17.3337, and the

corresponding probability is 0.0000, which also indicates that the sequence does not follow the random walk process. Therefore, the private lending market has not yet reached the weak-form efficient level, and this result is also consistent with the result of the Hurst index calculated above.

4.3 Average Period Test

The Hurst index calculated by R/S analysis can judge the future trend of the time series, but it is not known how long this trend will last. V-statistics can determine whether a sequence has aperiodic cycles, and it can measure the average cycle length through breakpoints. To this end, we further draw a V-statistic graph of the private lending market, as follows:

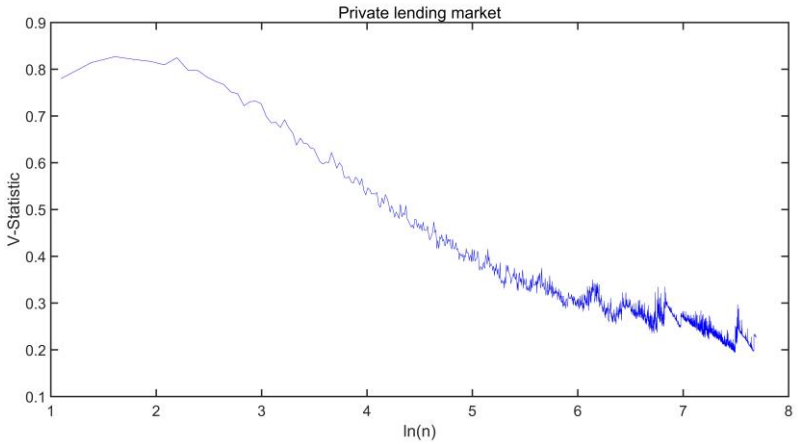

Figure 4. V-statistics of Private Lending Market

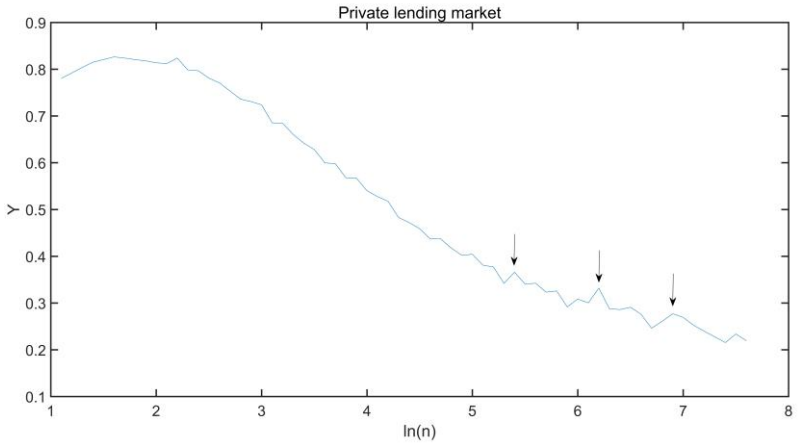

Figure 5. Linear Interpolation of V-Statistics

The V-statistic graph shown in Figure 4 is a downward sloping curve, which also illustrates the anti-persistence characteristics of the time series. If the current trend is up, then it is likely to be down in the future, and vice versa. Therefore, the private lending market is not an efficient market and is anti-persistent. Figure 5 shows the curve after V-statistic linear interpolation, the curve has many

breakpoints. When the major turning points are $ln(n) = 5.4$, 6.2, and 6.9, the corresponding times are 230, 491, and 1087 days, respectively. The average period test is performed on these breakpoints. From the test results in Table 5, the H value after the breakpoint is still less than 0.5, and the time series is still anti-persistent. That is to say, the private lending market is not an efficient market, and the market efficiency has not reached the weak-form efficient level.

Table 5. Average Period Test Results

Time(days)	H value before breakpoint	H value after breakpoint
230	0.2127	0.1357
491	0.1927	0.1359
1087	0.1797	0.1295

4.4 Time-varying Hurst Index Analysis

From the results of the R/S analysis method and the GHE analysis method, it is concluded that the private lending market is not an efficient market, and the inefficiency of the market means that the participants can profit from it. The market is predictable, and the anti-persistent of the time series shows that the current trend is upward, and the next trend is likely to be downward. This can achieve a macro-expected effect for investors. But predictable patterns also change over time (Lim & Brooks, 2011). Financial crises caused by various dynamic economic events that continue to emerge can cause market efficiency to switch between different points in time. Therefore, we use the time-varying Hurst index to detect the evolution of time series data over time. In this paper, the time-varying Hurst index is obtained by setting a window on the GHE method for rolling calculation. The time-varying Hurst index can not only reflect current market changes, but also serve as an indicator for judging future trends and investor sentiment. There are many lengths of window selection, but generally speaking, the window selection cannot be too large or too small. If the window is too large, part of the information can easily be missed. If it is too small, the result of the Hurst index calculation lacks meaning. According to the criteria for selecting windows in some articles (Mateus & Hoang, 2021; Anagnostidis, Varsakelis, & Emmanouilides, 2016), this paper selects a window with a length of 500 observations for rolling calculation. At the same time, we also calculated the Hurst index results with a window of 1000 observations, and the results showed little difference, so they are not listed in detail in this article. The result of window scrolling with 500 observations selected looks like this:

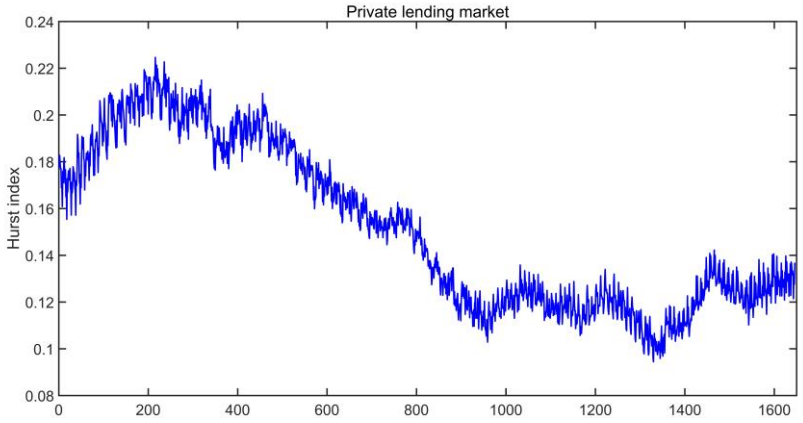

Figure 6. Time-varying Hurst Index of Private Lending Market

From the results in the above figure, we can see that the Hurst index of the private lending market has been below 0.25, which is far from 0.5, and the market inefficiency has not changed. Although there are obvious fluctuations over time, it also shows that the private lending market has always been anti-persistent. An anti-persistent means that the system often reverses itself, and it also implies some profit opportunities. Market fluctuations are unstable, but there are certain rules. When the Hurst index is less than 0.5, on the one hand, it means that the range of price changes is not large, and there are many identical data in the yield series. On the other hand, it means that there is no artificial and regular operation in the market (Ye & Cao, 2001). From Figure 6, we can see that between 2015 and 2021, there are two significant fluctuations in the Hurst index value of the private lending market. Once at the end of 2015, the Hurst index moved significantly closer to 0.5, and the market efficiency increased. Another time, the market efficiency continued to decline from the second half of 2016, and it gradually stabilized at a low value until the first half of 2019. The Hurst index deviates further from the direction of 0.5, and the market inefficiency continues. The reason for the increase in the efficiency of the private lending market at the end of 2015 may be that the central bank continued to implement the monetary policy of “cutting interest rates and reserve requirements” to provide liquidity to the market, thereby reducing the financial cost of the entire market. From the second half of 2016 to the first half of 2019, the efficiency of the private lending market continued to decline for a long time, which was caused by various reasons. First, in the second half of 2016, the government issued a real estate purchase restriction policy to comprehensively limit the rapid rise in real estate prices. In the case that residents cannot afford the high real estate prices, the increase in private lending has also been suppressed to a certain extent. Secondly, at the end of 2016, the Federal Reserve raised interest rates, which made the US dollar appreciate. It also causes capital outflow and currency devaluation, which intensifies the volatility of China’s financial market and reduces the efficiency of the private lending market. Part of the reason is due to the Sino-US trade friction. The economic and trade war between China and the United States began at the end of March 2018. Due to the imbalance of trade between the two countries,

the friction caused serious impact on the economic market of each country, which reduces the market liquidity, and the asymmetric market information leads to the continuous inefficiency of the private lending market.

In order to further understand the reasons for the changes in the efficiency of the private lending market, we use the Shenzhen stock exchange composite index and the spot exchange rate data of USD/RMB for a comparative analysis, which represent China's stock market and foreign exchange market respectively. We use the EI index (Gu, Shao, & Wang, 2013; Wang & Hu, 2015; Sukpitak & Hengpunya, 2016) to more accurately judge the relationship between the private lending market and the efficiency of China's stock market and foreign exchange market. The expression is as follows:

$$EI = |H - 0.5| \tag{11}$$

It can be seen from the above formula that the smaller the EI index, the higher the market efficiently. The results in Table 6 show the results of the Hurst index analysis and the corresponding EI index results using the GHE method for the three markets. From the table, we can see that the efficiency of both the stock market and the foreign exchange market is greater than 0.5, which indicates that the series has a long memory. And it is generally believed that the H value is in the range of 0.45 to 0.55, indicating that the market has reached the weak effective level. The Hurst index value of the foreign exchange market is just within this range, which can indicate that the foreign exchange market has reached the weak effective level. From the EI indices of these three markets, it can be seen that the private lending market has the lowest efficiency, while the foreign exchange market has the highest efficiency. And the Hurst index results show that the private lending market is anti-persistent. The reason may be that the Wenzhou index has not been released for a long time, and the private lending market is not mature enough. It is not common for financial markets have anti-persistence, and most of them indicate the existence of long memory in time series. However, some scholars have studied the effectiveness of financial market is anti-persistent. For example, Aslam et al. (2021) found that markets in Kenya, Morocco, Romania, and Serbia exhibit anti-persistent behavior when studying the efficiency of frontier markets. Diao et al. (2020) explored the efficiency of the five ASEAN countries' markets and found that the Chinese market has anti-persistent and so on.

Table 6. Hurst Index Analysis Results

Series type	Hurst index	EI index
WI	0.1357	0.3643
SSECI	0.5763	0.0763
FER	0.5251	0.0251

Table 7. Correlation Analysis of Three Market Efficiencies

Correlation coefficient	Pearson correlation coefficient	Spearman correlation coefficient
WI-SSECI	-0.704**	-0.495**
SSECI-FER	0.571**	0.468**
FER-WI	-0.581**	-0.552**

Note. ** 5% significance level

Next, we use the same window length to roll the Chinese stock market and foreign exchange market to obtain the corresponding time-varying Hurst index. In order to verify the correlation between the three market efficiencies, we conduct a correlation analysis of the time-varying EI indices of the three markets, and the results are shown in Table 7. The results show that the three markets are all significantly correlated when the confidence level is 0.01, and there are negative correlations between the private lending market and the stock market, private lending market and foreign exchange market. Then the time-varying graph of the Hurst index of the other two markets is drawn as follows. It can be seen from Figure 7 that the Hurst index of the stock market is not stable, and there are large fluctuations. Especially between the second half of 2015 and the second half of 2017, the Hurst index value increased and deviates significantly from 0.5, the stock market became inefficient, the reason for the inefficiency may be related to the turmoil in the stock market. 2015 was a turbulent year for China's stock market. From the beginning of the year, the stock market continued to rise until it reached its highest level in the middle of the year, and then began to plummet. The volatility of the stock market is too large and the investors' mood is unstable, which causes the stock market to become less efficient. Then, starting in 2016, the Fed rate hike event also caused shock in the global financial market, and the stock market experienced two circuit breakers, and there is panic in the market, and these are the reasons for the inefficiency of the stock market. In addition, it can also be seen from Figure 8 that the efficiency of the foreign exchange market fluctuated greatly during this period. It is not only related to the effect of stock market linkage, but also to the occurrence of global economic events. Affected by the Fed rate hike event, global financial markets have been impacted. The turbulence in the financial market led to exchange rate sensitivity and increased pressure on the foreign exchange market, so the foreign exchange market became less efficient during this period. From the time-varying Hurst index results of the three markets, it is not difficult to see that the affected sub-ranges overlap more or less, and the reasons for the lower market efficiency are overlapping.

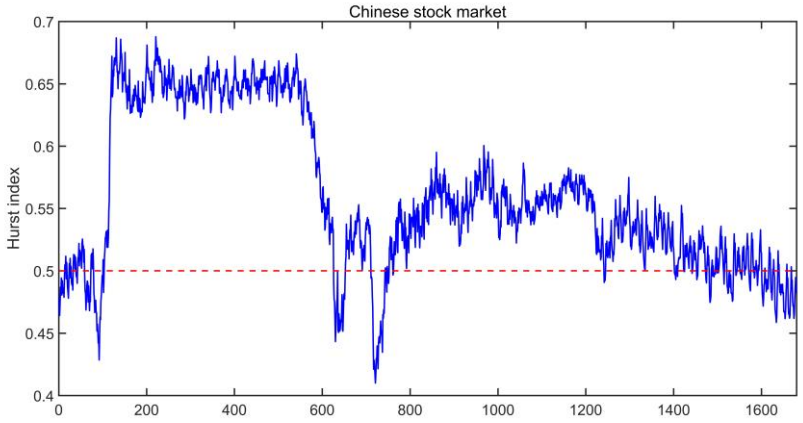

Figure 7. Time-varying Hurst Index of Chinese Stock Market

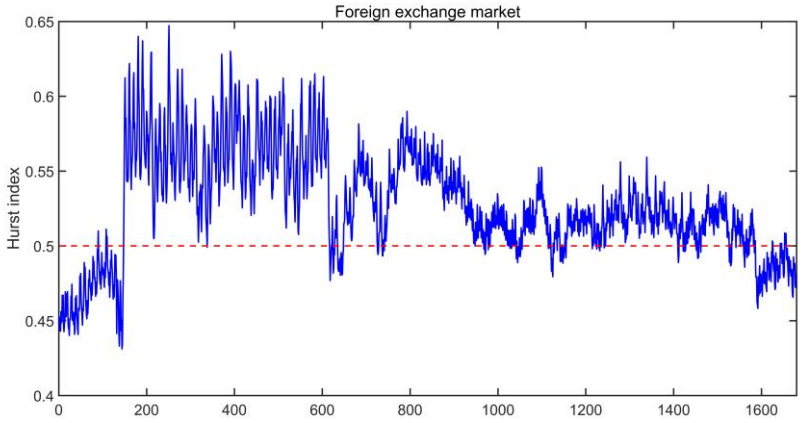

Figure 8. Time-varying Hurst Index of Foreign Exchange Market

5. Conclusion and Suggestion

This paper uses the classical R/S analysis method and the generalized Hurst exponent analysis method to explore the effectiveness of the private lending market. The results all show that the private lending market is not an efficient market and is anti-persistent. Then we further use the rolling window to calculate the time-varying Hurst index of the private lending market, which more clearly describes the dynamic change process of the efficiency of the private lending market, and makes a comparative analysis with China's stock market and foreign exchange market. The results show that compared with the stock market and foreign exchange market, the private lending market is the least efficient. In addition, there is a correlation between the three market efficiencies. The decline of market efficiency is related to the occurrence of some domestic and foreign economic events, and the causes of changes in market efficiency have cross effects.

Based on our research results, this paper proposes relevant suggestions for the development of the private lending market and investment decisions. First of all, the private lending market has not yet reached the weakly efficient level, indicating that the development of the market is not mature enough,

the trading system is not perfect enough, and there are still problems in the supervision system, etc. Therefore, the government should propose relevant policies to effectively intervene, and supervise the transaction and supervision of the private lending market to strengthen the construction of the effectiveness of the private lending market. Secondly, through the comparative analysis of the stock market and foreign exchange market, it can be seen that the efficiency of various financial markets affects each other. The government should take macro-control measures and not blindly focus on the development of a market. In conclusion, this paper explores how the efficiency of the private lending market can better adapt to the financial inclusion policy and better understand the price trends in the private financing market, and then better guide the pricing of private capital, which is conducive to the stable development of the national financial market.

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