



Studying Long Memory of Tehran Stock Exchange

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Abstract

According to the efficient market hypothesis, prices in stock market follow the random walk theory. In such a market, data is published rapidly and affect the stock price. Thus a large proportion of financial theory is extended based on random walk models for assets prices and returns. Long memory is one of violation of efficient market that tells time series of capital market index does not follow the random walk theory. This study examined long memory as one of the properties of time series for Tehran dividend stock price index and industrial index to test the assumptions, Autoregressive Fractionally Integrated Moving Average (ARFIMA) model is used. The results indicated that the concept of long memory existed for two index in Tehran stock exchange. The result of this research shows that there is a conception of long memory in Capital Market of Iran. Not only capital market efficiency does not obey the random walk as Dickey Fuller test, but also it has long memory. Also its time series is not unstable, in other words it is steady.

Keywords: Random walk theory, Index, Time series, Long memory, Tehran stock exchange.

Introduction

Theoretically, investors are encouraged by profitable opportunity from securities that are assessed more or lower than the true value and it propels the security prices to the present value of future cash flows. Therefore, searching the securities which have been priced wrongly by investments analyzer and tracing them will make the market efficient. It will change the prices in the ways that reflect the true value of those securities. Since the data are randomly agreeable or against expectations, changes in security prices in efficient markets should be random that makes the security prices random. So, Investors would not be able to have extraordinary high returns in such efficient markets where the prices are the reflection of true values. However, over the past 20 years financial views are far from random base and study other field defects in efficient markets. The efficient market hypothesis cannot explain the reason of them.

Long memory is one of the defects in efficient markets that expresses time series of market index, do not follow the random walk theory. Over the past decade, processes of long memory assign the major part of time series analysis. Long memory reflects the existence of predictable parameter in a dynamic time series because it associates the assets future returns to previous returns. This theory does not reject the weakness of efficient market hypothesis. At this level of efficiency, the security prices reflect only data in previous prices and this data will be reflected in previous prices immediately. Future trend of security prices cannot be predicted by studying the historical trend of security prices because all of the previous data had affected the security prices. So, stock prices reach a level that encompasses all the useful information reflected in stock prices over the past. Therefore, the ability to predict stock prices using past prices is not possible. If stock market and security prices do not have random walk (the ability to predict prices using past prices is possible), prediction of stock prices

will be possible and it will reach excess return in this case the market efficiency cannot be expected. Resource allocation will not be optional in such a market and a utilitarian advantage of profitable strategy will be operational. Long memory in assets returns reflects correlation between observations with long time gap. So, past returns can be used in order to predict future returns.

Theoretical and background research

Long memory explains the correlation structure of time serious in large time gap (it is called long range dependence). Long memory in assets returns have important theoretical and practical aspects: first, because the long memory is special form of nonlinear dynamics, its modeling using the linear methods is not possible and development and use non-linear pricing models are encouraged. Second, despite of the long memory, using traditional methods for pricing of derivative securities will not be appropriate (Yakima, 1985). Finally, because long memory associates assets future returns with previous returns, it reflects predictable parameter in dynamic time series. This trait is the reason of rejecting the hypothesis weakness of efficient market. There are some definitions of the concepts of "long memory" in the econometrics literature. Two of the most important definitions will be expressed in this part:

McLeod and Hipel (1987) defined long memory as: suppose y_t is set of discrete time with self-correlation function ρ_j in j pause. A process with unlimited as shown in Eq.1 has long memory. While there is correlation in ARMA and it is limited to geometric. So this is a process with short memory.

$$\lim_{n \rightarrow \infty} \sum_{j=-n}^n |\rho_j| \quad (1)$$

Ding *et al.* (1993) described long memory with the correlation diagram. The correlation time series graphs with long memory reduce with slower rate of decline and



hyperbolically unlike time series that reduces exponential. So according to the above definitions of long memory, minor cumulative process (Fractal) is a process with long memory as the above equation. y_t Process will be a minor cumulative from position d if equation is $(1-L)^d y_t = u_t$. Where L is stop operator, $-0.5 < d < 0.5$ and u_t is a process and all of the frequencies includes positive spectrum if there is cumulative u_t from null position with minor, $0 < d < 0.5$ y_t process will have long memory with positive correlation and it will reduce hyperbolically as the second definition. Long memory shows in-linear structure of stock market consequently linear is efficiency in explaining the true nature. In-linear structure of stock market makes its prediction impossible (Charfeddine & Guegan, 2011). Examinations and models have investigated long memory in time series such as GPHR/S (Rescaled Range Analysis) MRS (Modified Rescaled Range), DFA (Detrended Fluctuation Analysis) most of which are among the semi-parametric methods. The most famous and flexible model in econometrics is autoregressive fractionally integrated moving average. This is one the parametric methods that has prediction ability in time series. In fact time series can be predicted if long memory verifies through this model. It can be estimated via OX metrics software. Mandelbrot and Wallis (1969) introduced process of ARFIMA (0, d, 0) which is Brownie Fractal moving. This model is able to describe and explain potentially the changes in the most of markets because more popular process ARFIMA (p, d, and q) includes process with auto aggressive long memory process and moving average and also process with long memory. This model will explain the recent decade's hypothesis over Fractals markets which has been proposed by expanding and extending the conventional models. The model of ARFIMA (p, d, q) has the following form in Eq.2:

$$\phi(L)(1-L)^d (y_t - \mu) = \Theta(L)\varepsilon_t, \varepsilon_t \approx iid(0, \sigma^2) \quad (2)$$

Where d is difference parameter, μ can be any particular function of time and L is stop operator so that $y_{t-1} = Ly_t$. So polynomial $\Theta(L)$ and $\phi(L)$ shows in order the rank of correlation and (AR) moving average series. If roots in $\Theta(L) = 0$ and $\phi(L) = 0$.

Are out of the unite circle and they do not have the same roots and also $d \in [0.5]$. Process can be stationary and reversed. In fact there is $-0.5 < d < 0.5$. the series includes long memory for $-0 < d < 0.5$, according to the first above definition of long memory, in ARFIMA model. In other words, these processes reflect more stability and their correlation lead slower than correlation function of ARFIMA. The series has long memory or short memory when there is $d \in (-0.5, 0)$. In ARFIMA regression moving average accumulated minor will be estimated precisely.

Mandelbrot (1971) was the first person who considered the existence of long memory in asset return. Greene and Fielitz (1977) studied daily return of New

York Exchange by classic statistic R/S. Low questioned their research's result and rejected it that has been adjusted statistic R/S. he changed R/S statistic in a way that dynamic statistic includes long memory. He concluded there is not obvious evidence on existence of long memory in index of New York Exchange. Crato and Lima (1994) searched the existence of long memory in index of New York Exchange with GPH that was invented by other researchers and they also confirmed this trait in both return and conditional variance.

Barkoulas and Baum (1996) examined the existence of long memory in Dow Jones index and the stocks of some Subset of firms. Although they did not find any evidence for existence of long memory in this index but they saw long memory in five companies returns and medium memory in three companies returns.

Berg (1998) examined the existence of long memory in daily, weekly, monthly index return in Swedish Stock Exchange using adjusted R/S, GPH and Autoregressive Fractionally Integrated Moving Average (ARFIMA). The adjusted R/S method and ARFIMA represented lack of long memory in index return of Swedish Exchange. Grau-Carles (2000) studied the behavior of daily return in five indexes in Dow Jones stock, FTSE, NIKKEI and Madrid Stock Exchange Index. They used R/S test, adjusted R/S test and GPH test to consider long memory and found weak evidence on existence of long memory, but their researches on second square and absolute returns show the strong evidence on pulsation persistence. Olan, (2002) searched the existence of long memory in returns of nine international stock index return using parametric and semi-parametric methods and presented evidences on existence of long memory in Germany, Japan, South Korea and Taiwan's markets; whereas there is no evidence in U.S, England, Hong Kong, Singapore and Australia's markets.

For the London Stock Exchange Lillo and Farmer (2004) demonstrated that the signs of orders obey a long-memory process. The autocorrelation function decays roughly as a power law with an exponent of 0.6, corresponding to a Hurst exponent $H = 0.7$. This implies that the signs of future orders are quite predictable from the signs of past orders; all else being equal, this would suggest very strong market inefficiency. Lillo and Farmer demonstrated, however, that fluctuations in order signs were compensated for by anti-correlated fluctuations in transaction size and liquidity, which were also long-memory processes that act to make the returns whiter. They showed that some institutions display long-range memory and others don't.

Bilel and Nadhem (2009) applied a new test for fractionally integrated (FI) processes designed as Fractional Dickey-Fuller (1981) FD-F test. Also they applied the log-period gram regression and rescaled rang

analyses (R/S) to a wide range of G7 market stock returns and finds some evidence for positive long memory in 5 of the 7 series considered.

Siow-Hooi et al. (2010) investigated the characteristic of long memory in Melissa Stock Exchange. They investigated efficient of market in weak level using GPH method by separation of market-using Bry and Boschian (1971) algorithm into two parts ascent and descent. Their research period has been since 1985 to 2009. The result shows Malaysia Stock Exchange does not include long memory; it has short memory so it is not possible to be modeled for future prices.

Research methodology

Table 1. Time delimitation of research

Index	Date of start	End date	Number of data
Industry index	October 1997	August 2011	3268
Price index and cash return	August 1999	August 2011	2830

The present study has been attempting to examine the phenomenon of long memory. So, this study is a descriptive study of correlation according to the aim of application type and the way of applying to find the correlation between variables to eventual method. In this study, library method has been used for gathering the dates. Tehran Stock Exchange database has used different methods for having sufficient dates. Statistical society in this research is Iran Stock Market and the time delimitation of research is shown in Table 1. Because research's variable includes the price index of time series and cash returns (CR) and industry index. So there is no sampling in this research and every index is examined in the respective time territory.

Research hypothesis are formulated as follow:

H 1: Price index and cash return (CR) of Tehran Stock Exchange have long memory.

H 2: Tehran Stock Exchange industry index has long memory.

Results

The result of this research has been presented in two sections: 1. Data features include normalization and stationary Tests. 2. The existence of long memory test in time series with the ARFIMA model. The descriptions of data are shown in Table 2.

Above table represents and describes the standards of daily index returns. Price index and industry returns index both have elongated to the right and includes more elongations than standards. Therefore, based on this statistic, Tehran Stock Exchange daily returns do not

Table 2. Description of returns index

Index	Mean	Mode	Crooked	Elongation
Industry index	0.000919	0.00067	0.801042	19.34361
Price index and cash return	0.001352	0.001001	1.644074	24.23846

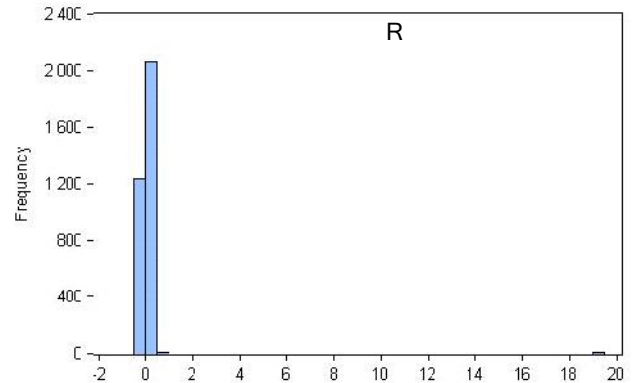
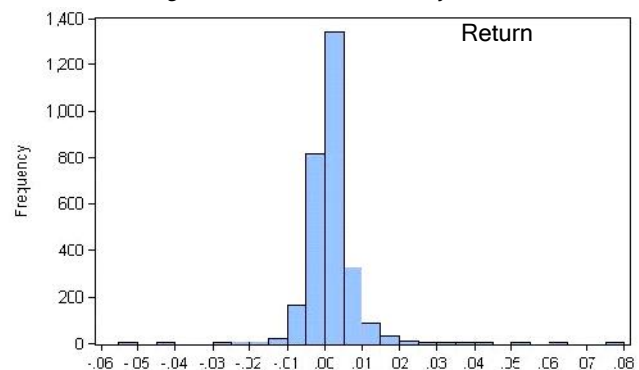


Fig 2. Distribution of industry index and CR



include normal distribution. The Fig. 1 and 2 presents the distribution of each index.

The instability is usually caused by lack of a fixed level of outputs. In time series literature, such time series is called unstable time series with unit root. Generalization Dike-Folder test has been used for examining unit root of series returns which is one of the most used tests for examination of existence of unit root. In this test, Null hypothesis is single root and against hypothesis is the lack of single root in time rang. The unit root is based on this logic that when the regression process explains the first level of $y_t = \rho y_{t-1} + u_t$ is unsteady, this regression can be fitted using the ordinary least squares but ordinary least squares of regression are not under the terms of t distribution even in long samples. Hence, the generalization Dike-Folder test is used. In this test hypothesis is null and this claim is presented as follow:

$$H_0 : \rho = 1 \tag{3}$$

$$H_1 : \rho < 1$$

The tests statistic is according to Eq. 3:

$$\hat{\tau} = \frac{\hat{\rho} - 1}{\hat{se}(\hat{\rho})} \tag{4}$$

If the absolute value of τ is more than critical point of an absolute value τ presented by Dike-Fouler, null hypothesis will be rejected and it means time series is unsteady and it calculated absolute value τ is less than

a critical point of absolute value, $H_0: \rho=1$ hypothesis will be accepted in this case time series will have unsteady random walk. Analyzing the time series, steadiness is used for time series reaction to impulse response. Momentum effect on variable over time can be permanent, long-term, and short-term. If momentum effect is permanent, that time series will have complete long term memory. If momentum effect remains for relatively long periods, the series will be fraction and will have long memory. If momentum effects lose, the series will have short memory. Dike Folder Generalized test for

Table 3. Null Hypothesis: $D(\text{Price Index})$ has a unit root

Exogenous: Constant			
Lag Length: 1 (Automatic - based on SIC, Maxlag=14)			
Augmented Dickey-Fuller test statistic		t-Statistics	Prob.*
		-6.799004	0.0000
Test critical values:	1% level	-3.463576	
	5% level	-2.876047	
	10% level	-2.574581	

*MacKinnon (1996) one-sided p-values.

price and index and cash return are shown in Table 3.

According to the research result with 95% confidence, it can be expressed that price index series and cash return and industry index series are stationary and this result expresses that daily market return is not random and model for it behavior can be provided. Dickay Fuller (1981) generalized test for industry index is shown in Table 4.

Table 4. Null Hypothesis: $D(\text{SANAT-Index})$ has a unit root

Exogenous: Constant			
Lag Length: 2 (Automatic - based on SIC, Maxlag=15)			
Augmented Dickey-Fuller test statistic		t-Statistics	Prob.*
		-6.370356	0.0000
Test critical values:	1% level	-3.451561	
	5% level	-2.870774	
	10% level	-2.571761	

*MacKinnon (1996) one-sided p-values.

According to the research result with 95% confidence, it can be expressed that price index series and cash return and industry index series are stationary and this result expresses that daily market return is not random and model for it behavior can be provided.

Table 5. Test for studying long memory in price index and cash return

Description	Coefficient	The amount of t	Significance Level
Latitude of Origin	0.00149160	1.08	0.279
First Level Correlation	0.450982	5.97	0.000
Second Level Correlation	0.650625	7.42	0.000
Third Level Correlation	-0.942240	-5.76	0.000
First Level Moving Average	-0.471506	-5.09	0.000
Second Level Moving Average	-0.677678	-6.58	0.000
Third Level Moving Average	0.629193	5.98	0.000
D parameter	0.344981	5.78	0.000

Table 6. Test for studying long term memory in industry index

Description	COEFFICIENT	The amount of t	Significance level
Latitude of Origin	0.000797	0.853	0.394
First Level Correlation	.0588943	22.2	0.000
Second Level Correlation	0.575209	16.9	0.000
Third Level Correlation	-0.937082	-36.3	0.000
First Level Moving Average	-0.577042	-17.1	0.000
Second Level Moving Average	-0.576371	-14.3	0.000
Third Level Moving Average	0.894001	28.0	0.000
D Parameter	0.292218	18.0	0.000

The existence of long memory in time series with ARFIMA model is as follow. ARFIMA (3, d, 3) test for studying long memory in price index and cash return is shown in Table 5.

ARFIMA (3, d, 3) test for studying long term memory in industry index is shown in Table 6. Above table shows that first order correlation is positive and significant, it shows that there is positive and significant relation between today and yesterday returns. The second correlation is also positive and significant relation between today return and 2 days ago. The third level correlation shows that there is inversely relation between today return and 3 days ago. D-parameter is positive and less than 0.5 for both time series price index and cash return and industry index; and because it is statically significant, shows that the time series has long term memory. Interrupted level for correlation process and moving average has been identified by Akaike information criterion. When model has less Akaike criterion, with interruption, that level remains in the model. For different interrupted levels $p>6$ and $q>6$ will be estimated for finding the appropriate level of Autoregressive Moving Average (ARMA) (p, d). Between 36 different estimated equations, the best model is one which has less Akaike and Showers criterion. According to the result of RFIMA model, hypothesizes of existence of long memory in time series price index and cash return and industry index will be confirmed with the high confidence.

In addition, according to the second definition, it will have long memory if the correlation diagram decreases with the increasing of the interrupted level with the rate of hyperbolically decline slows.

A slow decline in Fig. 3 and 4 show the existence of long memory. The results indicate the existence of long memory in time series index returns that confirmed both hypothesizes. Also, sub results express that there is a

Fig 3. AFC Diagram for 500 interruption of price index and CR

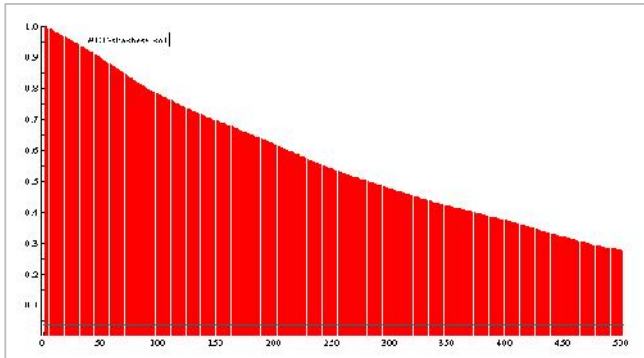
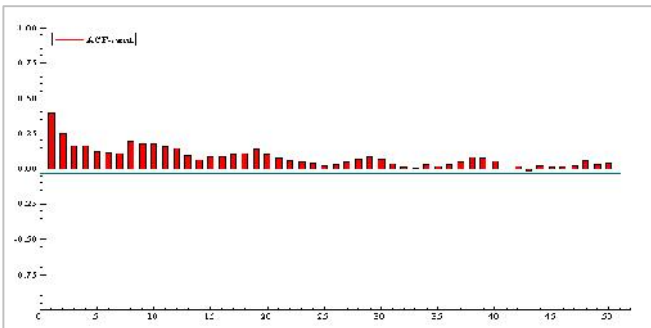


Fig .4. AFC Diagram for Industrial index and CR



direct relationship between today result and yesterday and 2 days ago, and inverse relation with 3 days ago. It can be explained with this strategic result of investment.

Conclusion and Recommendation

According to the efficient market hypothesis, prices in stock market follow the random walk theory. In such a market, data is published rapidly and affected the stock price, so stock returns cannot be predicted based on past prices. So a large proportion of financial theory is extended based on random walk models for assets prices and returns. Long memory is one of violation of efficient market that tells time series of capital market index do not follow from random walk theory.

Since both hypothesis were confirmed and had the same result, conclusion solely based on both theories because the indexes are the general criterion of capital market. The conception of long memory expresses that the effects and events influence on time series and this effect can be observed for long time. For example, the war in the country can influence the capital market efficiency that its effects can be seen for many years in capital market. In fact conception of long memory has been derived from the statistical basis for predicting and explaining the characteristics of time series. The result of this research shows that there is a conception of long memory in Capital Market of Iran. Not only capital market

efficiency does not obey the random walk as Dickey Fuller test, but also it has long memory. Also its time series is not unstable, in other words it is steady.

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