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Long Memory in Stock Markets: Empirical Study on Spot and Future Markets in Turkey

Abdullah YALAMA
Eskisehir Osmangazi University, Turkey

Sibel CELIK
Dumlupinar University, Turkey

Guven SEVIL
Anadolu University, Turkey

ABSTRACT

In this study, we examine the existence of long memory for return and volatility both in spot and future markets in Turkey. For this purpose, we apply modified GPH test of Smith (2005) to ISE-30 index and ISE-30 index futures for the period between 2005-2011. As a result, although we do not observe long memory for return series, we observe long memory for volatility both in spot market and future markets in Turkey. As volatility has long memory and is predictible, these two markets are not weak form efficient in Turkey.

Key words: Long memory, Fractal structure, ISE, Turkish Derivative Exchange, Return, Volatility, Modified GPH

INTRODUCTION

The behaviour of prices is of great importance for financial economists for many years. Although some of earlier studies investigating behaviour of prices are supportive of random walk theory (Fama 1965; Samuelson 1965), Mandelbrot and Taylor realize some fractal behaviour in stock market prices (Mandelbrot, 1963), (Mandelbrot and Taylor, 1967). Such behaviour is characterized by long memory and non periodic cyclical patterns. In case of long memory, linear pricing models and statistical inferences about asset pricing models based on standard testing procedures may not be appropriate (Yajima, 1985; Sowell, 1990). Several studies investigate long memory in spot market returns [*in stock exchange markets* : Greene and Fielitz,1977; Aydogan and Booth,1988; Lo,1991; Cheung and Lai, 1995; Barkoulas and Baum, 1996; Henry, 2002; *in bond markets* : Peters, 1989; *in Foreign Exchange Markets:* Cheung,1993; *in Commodity Markets:* Barkoulas et al., 1997] and in futures market returns [*in stock exchange markets:* Fung et al., 1994; Shieh , 2006; *in bond markets:* Fung and Lo, 1993; *in Foreign Exchange Markets:* Fang et al., 1994; *in Commodity Markets:* Helms et al., 1984; Corazza et.al, 1997]. Besides returns, long memory is investigated for volatility in spot markets [*in stock exchange markets:* Disario et al. 2008], in futures markets [*in stock exchange markets:* Tang and Shieh, 2006; *in Commodity Market:* Baillie et al., 2007] too. These studies apply different methods to examine long memory. The most widely used tests for long memory are classical rescaled range (R/S) analysis suggested by Hurst (1951), modified R/S analysis proposed by Lo; spectral regression method developed by Geweke and Porter- Hudak (GPH). However, the best method for testing long memory is controversial in the literature. Although classical R/S analysis is superiour to some other analysis for its robustness in capturing long range dependence in the presence of skewness and kurtosis in non- Gaussian distributions (Mandelbrot and Wallis, 1969), and detecting non periodic cycles (Mandelbrot, 1972), it has some shortcomings such as its sensitivity to short term dependence (Lo, 1991). To overcome some disadvantages of this shortcoming, Lo (1991) proposes modified R/S analysis. Lo(1991) indicates that while modified R/S is able to distinguish between short run and long run dependence, classical R/S can not. However, Teverovsky et al. (1999) show that Lo's modified R/S method is in tendency to accept the null hypothesis of no long range dependence, regardless of whether long range dependence is present or not. Thus, they do not suggest using Lo's modified R/S as the only technique to test for long range dependence, but using it with several graphical and statistical methods to check for long range dependence. Another method which is used the most in long memory studies is spectral regression method proposed by Geweke and Porter-Hudak (GPH). Superiority of GPH method results from its semiparametric structure, because semiparametric structure does not require assumption of the underlying distribution of the data and eventual short range dependencies (Sibbertsen, 2004). We present shortcomings and advantages of these three tests in table.1.

Table 1. Comparison of Classical R/S, Lo's Modified R/S and GPH Test

Method/ Features	Robustness to Short Range Dependence	Robustness to Small Sample	Robustness to Heteroskedasticty	Robustness to Multiple Scale	Robustness to Non-Gaussian Distributions	Robustness to Structural Breaks	Robustness to Level Shifts
Classical R/S	×	×	×	×	✓	×	
Lo's Modified R/S	✓	✓	✓		✓	×	×
GPH	✓	✓	✓		✓	×	×

Note: This table is formed by referring from following resources: Lo (1991); Ambrose et al. (1993); Cheung and Lai (1995); Nawrocki (1995); Barkoulas et al. (1997); Barkoulas et al. (1999); Teverovsky et al (1999); Hsu (2000); Henry (2002); Sibbertsen (2004); Carles (2005); Matteo et al. (2005).

Smith (2005) indicates that when GPH method is applied to time series processes comprising occasional level shifts, GPH estimator often inaccurately finds long memory so derives an approximation to this bias. Considering the shortcomings of widely used models above and advantages of model derived by Smith (2005), we use modified GPH estimator of Smith (2005) to test long memory.

Table 4a-4c summarizes literature on long memory. One of the basic implication from table 4a-4c is that long memory is investigated mostly in stock markets and classical R/S, modified R/S and GPH estimation are the mostly preferred methods. The empirical results from applied methods mostly support common view regarding long memory analysis. The studies which apply classical R/S analysis mostly find long memory in financial markets (Greene and Fielitz, 1977; Helms et al. 1984; Peters, 1989; Cheung et al. 1993; Nawrocki, 1995). However, the findings of Lo's modified R/S analysis mostly indicate that there is no long memory in financial markets (Lo, 1991; Ambrose et al. 1993; Cheung and Lai, 1993; Cheung et al., 1993; Fung and Lo, 1993; Huang and Yung, 1995; Hiemstra and Jones, 1997). In addition, while some GPH test results support long memory (Cheung, 1993; Fang et al., 1994; Barkoulas and Baum, 1997; Barkoulas et al., 2000; Panas, 2001), some do not (Fung et al.,1994; Cheung and Lai,1995; Barkoulas and Baum,1996). In the literature, it is common view that volatility series have long memory (Crato and Ray, 2000; Du, 2004; Tang and Shieh, 2006; Baillie et al. 2007; Elder and Jin, 2007; Disario et al., 2008).

In Turkey, long memory is examined for spot market returns [*in stock exchange markets:* Kilic, 2004; Ozun and Cifter, 2007; Korkmaz et al., 2009] and for futures market returns [Korkmaz et al., 2009]. Besides returns, long memory in volatility is investigated in spot markets [*in stock exchange markets*: Disario et al., 2008; *in foreign exchange markets:* Turkyilmaz and Ozer, 2007].

Kilic (2004) analyses long memory in ISE by using GPH estimator, local Whittle estimator and FIGARCH model for the period 1988-2003. Their evidence show that daily returns do not have long memory, but they find evidence of long memory in the conditional variance supporting common literature.

Ozun and Cifter (2008) investigate long memory in ISE by applying Daubechies wavelet analysis and OLS estimator based on the Geweke and Porter-Hudak test. While the evidence form GPH test indicate that stock returns do not have long memory, fractional integration parameters based on the Daubechies wavelets find evidence of long memory in ISE.

Korkmaz et al. (2009a) examine long memory in Istanbul Stock Exchange (ISE) by applying structural break test in variance and ARFIMA-FIGARCH model. They use daily closing prices of ISE for the period from 1988 to 2008. As a result, they find no evidence of long memory in return series, however they detect long memory in volatility series. Thus, they indicate that ISE is not weak form efficient.

Korkmaz et al.(2009b) test existence of long memory for ISE-30 index, ISE-100 index, dollar and euro contracts traded in Turkish Derivatives Exchange by using unit root tests, structural break tests and long memory models. They find no evidence of long memory in Turkish Derivatives Exchange.

In this paper, we investigate long memory both in spot and futures markets to obtain comparable results. Although the most widely used methods are Hurst R/S, modified R/S of Lo and GPH test, due to shortcomings of these methods, different from previous literature we use modified GPH test of Smith to test long memory. In this respect, we believe that our study will contribute to the literature. Our study is organized as follows: section 2 describes the data and research method employed; section 3 emphasizes researched restriction, section 4 presents the empirical evidence and finally section 5 provides the summary and conclusion.

DATA AND RESEARCH METHOD

In this paper, we use daily closing prices of ISE-30 stock market index and ISE-30 stock index futures for the period between February 4 2005- March 22 2011. Data for ISE-30 stock market index is obtained from Central Bank of Republic of Turkey and data for ISE-30 stock index futures is obtained from Turkish Derivatives Exchange.

We test long memory by applying Fractional differencing ARFIMA model. ARFIMA model is developed by Granger and Joyeux (1980) and Hosking (1981). A general class of fractional process can be defined as;

$$A(L)(1-L)^d x_t = B(L)u_t \qquad [Equation\ 1]$$

where $A(L)=1-a_1L-.....-a_pL^p$ *and* $B(L)=1+b_1L+....+b_qL^q$ are polynomials in the lag operator L, all roots of $A(L)$ and $B(L)$ are stable, and u_t is a white-noise disturbance term. d is fractional parameter. Fractional parameter, d may take any real value. ARMA process is discussed which is a special case of ARFIMA, if $d=0$. If $d \geq 1/2$ the variance of the process is infinite and process is nonstationary, if $d \leq 1/2$ the variance is finite and process is stationary (Granger and Joyeux, 1980). To estimate fractional parameter d , Geweke and Porter- Hudak (1983) procedure can be applied. This GPH estimate of d equals the least squares coefficent in the regression of the log periodogram, $\log(f_j)$ on $H_j = -\log\left(2-2\cos\left(w_j\right)\right) \approx -\log w^2{}_j$ for $j=1,2,....,J$ where $w_j = 2\pi j/T$, T is sample size and $J \langle T$ (Smith, 2005). GPH estimate is;

$$\hat{d} = d_* + \frac{\sum_{j=1}^{J}\left(H_j - \overline{H}\right)\log\left(\hat{f}_j / f_j\right)}{\sum_{j=1}^{J}\left(H_j - \overline{H}\right)^2} \qquad [Equation\ 2]$$

where $\hat{f}_j$ refers to the periodogram evaluated at w_j and f_j refers to the spectrum evaluated at w_j and

$$d_* \equiv \frac{\sum_{j=1}^{J}\left(H_j - \overline{H}\right)\log f_j}{\sum_{j=1}^{J}\left(H_j - \overline{H}\right)^2} \qquad [Equation\ 3]$$

Smith (2005) suggests a modification to the GPH estimator and indicates that modified GPH is implemented by adding an extra regressor, $-\log(p^2+w^2)$ to GPH regression. In this way the bias is caused by level shifts is reduced. However, since p is unknown, Smith (2005) derives an estimator by establishing $p_T = kJ/T$ for some constant k >0 and run following regression;

$$\log \hat{f}_j = \alpha + dH_j + \beta Z_{kj} + \hat{u}_j \qquad [Equation\ 4]$$

where $Z_{kj} = -\log\left(\frac{(kJ)^2}{T^2} + w_j{}^2\right)$, and $H_j = -\log\left(2-2\cos\left(w_j\right)\right)$ as before.

The modified GPH estimator is;

$$\hat{d}^k = d_*{}^k + \left(\tilde{H}'M_Z\tilde{H}\right)^{-1} \tilde{H}'M_Z \log\left(\hat{f}/f\right) \qquad [Equation\ 5]$$

where $\tilde{H} = H - \overline{H}$, $M_Z = I - \tilde{Z}_k\left(\tilde{Z}_k{}'\tilde{Z}_k\right)^{-1}\tilde{Z}_k{}'$, $\tilde{Z}_k \equiv Z_k - \overline{Z}_k$, $\overline{H} = J^{-1}\sum_{j=1}^{J} H_j$, $\overline{Z}_k = J^{-1}\sum_{j=1}^{J} Z_{kj}$ and $d_*{}^k$ denotes the estimator computed from the spectrum rather than the periodogram.

As a result, Smith (2005) compares the standard and modified GPH estimates of d. If the standard estimate of d is larger than the modified estimate of d long memory may arise from level shift. If the modified estimate of d is larger, long memory does not arise from structural shifts.

RESEARCH RESTRICTIONS

This study is applied only to daily closing prices of the ISE-30 stock index futures contracts and ISE-30 index for the period between February 4 2005- March 22 2011. So the results may not generalize in other countries.

EMPIRICAL RESULTS

We present GPH and modified GPH estimates of the d parameter for return series in Table 2. Smith (2005) indicates that modified GPH estimates perform well for k=3 and J selected by using plug-in method. If $0 \leq d \leq 1/2$ we can say that series have long memory. In table.2, although d parameters are between 0 and 1/2 , they are not significant. Thus, there is no evidence of long memory in return series for ISE-30 index and ISE-30 index futures. This result is consistent with Kilic (2004) and Korkmaz et al. (2009a) who find no long memory in ISE.

Table 2. Estimates of the Long Memory Parameter for Return Series

	GPH	*Modified GPH*		
		k=2	*k=3*	*k=4*
	Daily returns on ISE-30 index			
Plug-in	-0.0177	0.0432	0.0266	0.0532
	(0.0534)	(0.0971)	(0.0820)	(0.0728)
	[-0.3315]	[0.4453]	[0.3245]	[0.7320]
$J = T^{1/2} = 39$	0.1906	0.0547	0.0559	0.0561
	(0.1194)	(0.2992)	(0.2590)	(0.2394)
	[1.5960]	[0.1831]	[0.2160]	[0.2345]
	Daily returns on ISE-30 index futures			
Plug-in	0.0051	0.0486	0.0309	0.0746
	(0.0534)	(0.0971)	(0.0820)	(0.0728)
	[0.0964]	[0.5005]	[0.3775]	[1.0260]
$J = T^{1/2} = 39$	0.1822	0.0061	0.0072	0.0067
	(0.1194)	(0.2992)	(0.2590)	(0.2394)
	[1.5260]	[0.0207]	[0.0279]	[0.0283]

Note: The table includes estimates of d , long memory parameter of GPH and Smith's (2005) Modified GPH with standart errors are in ( ) and t values are in [ ]. *** indicates significance at 1%, ** indicates significance at 5%, * indicates significance at 10%. Following Smith (2005), we use both rule-of- thumb value of $J = T^{1/2}$ and the plug-in method of Hurvich and Deo (1999) to select J . k represents a scalar between 1 and 5. We choose three different k values as 2,3,4, following Connolly et al. (2007). However, our main focus is on k=3, and J selected using plug-in method, following Smith (2005).

After investigating long memory in return series, we also examine long memory in volatility series. In the literature, different studies used different measures as proxy of volatility. For example, while Lobato and Savin (1998) used squared returns, Granger and Ding (1996) used absolute returns and Breidt, Crato and de Lima (1998) used log-squared returns. Bollerslev and Wright (2000) used all three of these volatility measures. In this study, we used squared returns and absolute returns as a proxy of volatility.

We report results for long memory in volatility in table.3. Table.3 shows that both ISE-30 index and index futures volatility series have long memory and since GPH estimate is smaller than modified GPH estimates, level shifts are not source of long memory. This result is consistent with that of Disario et al. (2008), Kilic (2004) and Korkmaz et al.(2009a)

Table 3. Estimates of the Long Memory Parameter for Volatility Series

	Volatility Series of Squared Returns				*Volatility Series of Absolute Returns*			
	GPH	***Modified GPH***			***GPH***	***Modified GPH***		
		k=2	***k=3***	***k=4***		***k=2***	***k=3***	***k=4***
	Volatility on ISE-30 Index				***Volatility on ISE-30 Index***			
	0.5478***	0.6808***	0.6722***	0.6340***	0.4292***	0.5848***	0.5107***	0.4756***
Plug-in	(0.0927)	(0.1831)	(0.1512)	(0.1325)	(0.0936)	(0.1852)	(0.1528)	(0.1338)
	[5.9070]	[3.7180]	[4.4460]	[4.7850]	[4.5830]	[3.1570]	[3.3430]	[3.5550]
	0.5378***	0.4659	0.5081**	0.5320**	0.4333***	0.5002*	0.4939*	0.4939**
J=T1/2=39	(0.1194)	(0.2992)	(0.2590)	(0.2394)	(0.1194)	(0.2992)	(0.2590)	(0.2394)
	[4.5040]	[1.5570]	[1.9610]	[2.2220]	[3.6290]	[1.6720]	[1.9070]	[2.0630]
	Volatility on ISE-30 Index Futures				***Volatility on ISE-30 Index Futures***			
	0.3903***	0.5719***	0.5214***	0.5099***	0.3410***	0.5102***	0.4881***	0.4824***
Plug-in	(0.0534)	(0.0971)	(0.0820)	(0.0728)	(0.0534)	(0.0971)	(0.0820)	(0.0728)
	[7.3080]	[5.8900]	[6.3520]	[7.0050]	[6.3850]	[5.2550]	[5.9460]	[6.6270]
	0.5581***	0.4868	0.5226**	0.5434**	0.5125***	0.5143*	0.5173**	0.5224**
J=T1/2=39	(0.1194)	(0.2992)	(0.2590)	(0.2394)	(0.1194)	(0.2992)	(0.2590)	(0.2394)
	[4.6740]	[1.6270]	[2.0170]	[2.2700]	[4.2930]	[1.7190]	[1.9970]	[2.1820]

Note: The table includes estimates of d , long memory parameter of GPH and Smith's (2005) Modified GPH with standart errors are in ( ) and t values are in [ ]. *** indicates significance at 1%, ** indicates significance at 5%, * indicates significance at 10%. Following Smith (2005), we use both rule-of- thumb value of $J = T^{1/2}$ and the plug-in method of Hurvich and Deo (1999) to select J . k represents a scalar between 1 and 5. We choose three different k values as 2,3,4, following Connolly et al. (2007). However, our main focus is on k=3, and J selected using plug-in method, following Smith (2005).

SUMMARY AND CONCLUSION

Different from common literature, our study investigates long memory for return and volatility series both in spot and futures markets to obtain comparable results. In addition, different from Turkish literature on long memory, we use different method which is adjusted for level shifts. Our results indicate that return series of ISE-30 index and ISE-30 index futures have no long memory. This result is consistent with Kilic (2004), Korkmaz et al. (2009a) who find no long memory in ISE and Korkmaz et al.(2009,b) who find no long memory in ISE-30 index futures return series. We also investigate long memory in ISE-30 index and ISE-30 index futures volatility series. It is common view in the literature that volatility series have long memory. Our results show that both ISE-30 index and ISE-30 index futures volatility series have long memory and level shifts are not source of this long memory.

Existence of long memory in volatility series implies that distant observations of the ISE-30 index and ISE-30 index futures volatility are related to each other. In other words, both spot and futures market do not forget large volatility shocks quickly. Since volatility have long memory in Turkey, risk analysing methods which include volatility component, such as Value at Risk model or volatility forecasting models which consider long memory will give more efficient results. In addition, long memory in return volatility is not consistent with market efficiency. So, regulators should analyse the sources of long memory in stock market to improve efficiency.

REFERENCES

Ambrose B.W., Ancel E.W., Griffiths M.D. (1993), "Fractal Structure In The Capital Markets Revisited", Financial Analysts Journal, Vol.49, No.3, pp.73-77

Aydogan K. and Booth G.G., "Are There Long Cycles in Common Stock Returns?", Southern Economic Journal, Vol.55, pp.141-149

Baillie R.T., Han Y.W., Myers R.J. and Song J.,2007. "Long Memory Models For Daily And High Frequency Commodity Futures Returns", The Journal of Futures Markets, Vol.27, No.7, pp.643-668

Barkoulas J.T. and Baum C. F.,1996. "Long Term Dependence in Stock Returns", Economics Letters, Vol.53, Issue.3, pp.253-259

Barkoulas J.T. and Baum C.F.,1997. "Long Memory and Forecasting in Euroyen Deposit Rates", Financial Engineering and the Japanese Markets, 4, pp.189-201

Barkoulas J., Labys W.C.,and Onochie J., 1997. "Fractal Dynamics in International Commodity Prices", The Journal of Futures Markets, Vol.17, No.2, pp.161-189

Barkoulas J., Labys W.C.,and Onochie J., 1999. "Long Memory in Future Prices", The Financial Review, 34, pp.91-100

Barkoulas J., Baum C.F., Travlos N. 2000. "Long Memory in the Greek Stock Market", Applied Financial Economics, 10, pp.177-184

Bollerslev, T. and J.H. Wright, 2000. "Semiparametric estimation of long memory volatility dependencies: the role of high frequency data", Journal of Econometrics, 98, 81-106

Breidt, F.J., N. Crato and P.de Lima, 1998. "The detection and estimation of long memory in stochastic volatility", Journal of Econometrics, 83, 325-348

Cajueiro D.O. and Tabak B.M., 2004. "Evidence Oflong Range Dependence in Asian Equity Markets: The Role of liquidity and Market Restrictions", Physica A, Vol.342, pp. 656 – 664

Cavalcante J., and Assaf A., 2004. "Long Range Dependence in the Returns and Volatility of the Brazilian Stock Market", European Review of Economic and Finance, Vol 4, pp. 1-19

Cheung Y.W., 1993. "Long Memory in Foreign Exchange Rates", Journal of Business & Economic Statistics, Vol.11, No.1, pp.93-101

Cheung Y.W, Lai K.S, and Lai M., 1993. "Are there Long Cycles in Foreign Stock Returns", Journal of International Financial Markets, Vol 3 (1), pp.33-47

Cheung Y.W. and Lai, K.S., 1993. "Do Gold Market Returns Have Long Memory", The Financial Review, Vol.28, No.2, pp.181-202

Cheung Y.W, and Lai K.S, 1995. "A Search for Long Memory in International Stock Market Returns", Journal of International Money and Finance, Vol.14, No.4, pp.597-615

Corazza M., Malliaris A.G., Nardelli C., 1997. "Searching for Fractal Structure in Agricultural Futures Markets", The Journal of Future Markets, Vol.17, No.4, pp.433-473

Crato N. and Ray B.K.,2000. "Memory in Returns and Volatilities of Futures' Contracts", The Journal of Futures Markets, Vol.20, No.6, pp.525-543

Disario R., Saraoglu H., McCarthy J. and Li H., 2008. "Long Memory in the Volatility of an Emerging Equity Market: The case of Turkey", International Financial Markets, Institutions and Money , 8, pp.305-312

Du K. , (2004), "Fractal Analysis Of Chinese Stock Market: Some Findings", Journal of Business, Vol. 38, pp.1-11

Elder J. and Jin H.J., 2007. "Long Memory in Commodity Futures Volatility: A Wavelet Perspective", The Journal of Futures Markets, Vol.27, No.5, pp.411-437

Fama, E. F. 1965. "The behavior of stock market prices" , Journal of Business, Vol. 38, No. 1, pp.34-105

Fang H., Lai K.S., Lai M., 1994. "Fractal Structure in Currency Futures Price Dynamics", The Journal of Futures Markets, Vol.14, No.2, pp.169-181

Fung H.G., Lo W.C., Peterson C.E.,1994. " Examining the Dependency in Intra-day Stock Index Futures", The Journal of Future Markets, Vol.14, No.4, pp.405-419

Fung H.G.and Lo W.C., 1993. "Memory in Interest Rate Futures", The Journal of Futures Markets, Vol.13, No.8, pp.865-872

Granger, Clive W.J. &Ding, Zhuanxin, 1996. "Varieties of long memory models", Journal of Econometrics, 73(1), 61-77

Greene M. T.and Fielitz, B.D, 1977. "Long Term Dependence in Common Stock Returns", Journal of Financial Economics, Vol.4, Issue.3, pp.339-349

Grau P.and Carles.,2005. "Tests of Long Memory: A Bootstrap Approach", Computational Economics, 25, pp. 103–113

Helms B.P., Kaen F.R., Rosenman R.E., 1984. "Memory in Commodity Futures Contracts", The Journal of Futures Markets, Vol.4, No.4, pp. 559-567

Henry O. T, 2002. "Long memory in stock returns: some international evidence", Applied Financial Economics, Vol.12, pp.725-729

Hiemstra and Jones,1997. "Another Look at Long Memory in Common Stock Returns", Journal of Empirical Finance, 4, pp.373-401

Huang B.N, Yang C.W, 1995. "The Fractal Structure in Multinational Stock Returns", Applied Economics Letters, Vol. 2, No. 3, pp.67–71

Kılıc R., 2004. "On the Long Memory Properties of Emerging Capital Markets: Evidence From Istanbul Stock Exchange", Applied Financial Economics, 14, pp.915-922

Koong C.S., Tsui A.K.C., and Chan W.S., 1997. "On Tests For Long Memory in pacific Basin Stock Returns", Mathematics and Computers in Simulation, Vol.43, Issue.3-6, pp.445-449

Korkmaz T., Cevik E.I., Ozatac N., 2009a. "Testing for Long Memory in ISE Using ARFIMA-FIGARCH Model and Structural Break Test", International Research Journal of Finance and Economics, 26, pp.186-191

Korkmaz T., Erdoğan S. And Cevik I., 2009b. "Testing Existence of Long Memory in ISE indexes and Currencies Futures Contracts Returns Which are Traded at The Turkish Derivatives Exchange", İktisat İşletme ve Finans, Vol.22, No.259, pp.99-113

Lo, A.W., 1991. "Long Term Memory in Stock Market Prices", Econometrica, Vol.59, No.5, pp.1279-1313

Lobato I.N. and Savin N.E., 1998. "Real and Spurious Long Memory Properties of Stock Market Data", Journal of Business &Economic Statistics, Vol.16, No.3, pp.261-268

Mandelbrot, B.B.,1963. "The Variation of Certain Speculative Prices", Journal of Business, 36., pp.394-419

Mandelbrot, B.B., and Taylor, H., 1967. “On the Distribution of Stock Price Differences”, Operations Research, 15, pp.1057-1062

Mandelbrot, B.B. and Wallis J.R., 1969. “Robustness of Rescaled Range R/S in the Measurement of Noncyclic Long Run Statistical Dependence” Water Resources Research , pp.967-988

Mandelbrot, B., 1972. “Statistical methodology for non-periodic cycles: from the covariance to R/S analysis”, Annals of Economic and Social Measurement, 1, pp. 259–90.

Nawrocki D.,1995. “R/S Analysis and Long Term Dependence in Stock Market Indices”, Managerial Finance, 21,7, pp.78-91

Ozun and Cifter, 2008. “Modeling Long-Term Memory Effect in Stock Prices: A Comparative Analysis with GPH Test and Daubechies Wavelets”, Studies in Economics and Finance, Vol.25, Issue.1, pp.38-48

Panas E., 2001. “Estimating Fractal Dimension Using Stable Distributions and Exploring Long Memory Through ARFIMA Models İn Athens Stock Exchange”, Applied Financial Economics, 11, pp.395-402

Peters E.E., 1989. “ Fractal Structure in The Capital Markets”, Financial Analysts Journal, Vol. 45, No. , pp.32-37

Sadique S. and Silvapulle P., 2001. “Long -Term Memory in Stock Market Returns: International Evidence, International Journal of Finance and Economics, 6, pp.59-67

Samuelson, P. 1965. “Proof that properly anticipated prices fluctuate randomly” Industrial Management Review, 6, 2, pp.41-49

Shieh S.J., 2006. “Long Memory and Sampling Frequencies: Evidence in Stock Index Futures Markets”, International Journal of Theoretical And Applied Finance ,Vol.9, No.5, pp. 787–799

Sibbertsen P., 2004. “Long memory in volatilities of German stock returns”, Empirical Economics, Vol.29, No.3, pp.477-488

Smith A., 2005. “Level Shifts and the Illusion of Long Memory in Economic Time Series”, Journal of Business and Economic Statistics, 23 (3), pp.321-335

Sowell, F. (1990): "The Fractional Unit Boot Distribution," Econometrica, 58, pp.495-505

Tang T. and Shieh S.J., 2006. “Long-memory in Stock Index Futures Markets: A Value-at-Risk Approach”, Physica A, Vol.366, pp.437-448

Teverovsky V., Taqqu M.S. and Willinger W., 1999. “A Critical Look at Lo’s Modified R/S Sttaistic”, Journal of Statistical Planning and Inference , 80, pp.211-227

Willinger W., Taqqu M.S., and Teverovsky V., 1999. “Stock Market Prices and Long Range Dependence”, Finance Stochast., 3, pp.1-13

Yajima, Y. (1985): "On Estimation of Long-memory Time Series Models," Australian Journal of Statistics, 27, pp. 303-320

Table 4a.Summary Literature on Long Memory in Financial Markets

Study	*Period*	*Spot Market*	*Futures Market*	*Method*	*Evidence*
Greene and Fielitz (1977)	1963-1968	Stock Market	-	Classical R/S	+
Helms et al. (1984)		-	Commodity Market	Classical R/S	+
Aydogan and Booth (1988)	1962-1980	Stock Market	-	Classical R/S	-
Peters (1989)	1950-1988	Stock Market	-	Classical R/S	+
		Bond Market			+
Lo (1991)	1962-1987	Stock Market	-	Modified R/S	-
Ambrose et al. (1993)	1950-1988	Stock Market	-	Classical R/S	-
				Modified R/S	-
Cheung (1993)	1974-1987	Foreign Exchange Market	-	GPH Test	+
Cheung and Lai(1993)	1973-1987	Gold Market	-	Modified R/S	-
Cheung et al. (1993)	1957-1990	Stock Market	-	Classical R/S	+
				Modified R/S	-
Fung and Lo (1993)	1982-1991	-	Bond Market	Classical R/S	-
				Modified R/S	-
Fung et al. (1994)	12 Trading Days	-	Stock Market	Classical R/S	-
				Modified R/S	-
				GPH Test	-
Fang et al. (1994)	1982-1991	-	Foreign Exchange Market	GPH Test	+
Cheung and Lai (1995)	1970-1992	Stock Market	-	Modified R/S	-
				GPH Test	-
Huang and Yung(1995)	1988-1992	Stock Market	-	Modified R/S	-
Nawrocki (1995)	1926-1992 /1962-1991	Stock Market	-	Classical R/S	+
				Modified R/S	+
Barkoulas and Baum (1996)	1947-1995*	Stock Market	-	GPH Test	-
Corazza et.al (1997)	1981-1991	-	Commodity Market	Pareto- Levy stable parameters	+
				Classical R/S	+
				Modified R/S	+

"+" indicates long memory for all (most) of sample, "-" indicates no long memory for all (most) of sample "~" indicates long memory for some of sample
* represents generalized period in the study.

Table 4 b.Summary Literature on Long Memory in Financial Markets

Study	*Period*	*Spot Market*	*Futures Market*	*Method*	*Evidence*
Barkoulas et al. (1997)	1960-1994	Commodity Market	-	GPH Test	~
Koong et al. (1997)	1975-1994	Stock Market	-	Modified R/S	-
				GPH Test	-
				Modified GPH Test	-
Barkoulas and Baum (1997)	1985-1994	Eurocurrency Deposits	-	GPH Test	+
Hiemstra and Jones (1997)	1962-1991	Stock Market	-	Modified R/S	-
Lobato and Savin (1998)	1962-1994	Stock Market	-	Semiparametric procedure of Lobato and Robinson	-
Willinger et al. (1999)	1962-1987	Stock Market		Graphical R/S method	+
			-	Whittle's estimate	+
				Modified R/S with corresponding Vq -vs-q-plots	+
Barkoulas et al. (1999)	1968-1993*	-	Commodity Market	GPH Test	+
			Foreign Exchange Market		+
			Stock Market		-
Barkoulas et al. (2000)	1981-1990	Stock Market	-	GPH	+
Crato and Ray (2000)	1977-1997	-	Commodity Market	Modified R/S	- /+
			Currency Market	Nonparametric Spectral test of Lobato and Robinson	- /+
			Stock Market Returns / Volatility	GPH	- /+
Sadique and Silvapulle (2001)	1983-1998	Stock Market	-	Classical R/S	~
				Modified R/S	~
				GPH	~
				The frequency domain score test	+
				Time domain counterpart	~
Panas (2001)	1993-1998	Stock Market	-	Estimation of Levy Index	+
				GPH Test	+
Henry (2002)	1982-1998	Stock Market	-	KPSS test	-
				GPH	~
				Gaussian semiparametric estimator of Robinson	-
				Frequency domain maximum likelihood estimator	-

"+" indicates long memory for all (most) of sample, "-" indicates no long memory for all (most) of sample "~" indicates long memory for some of sample
* represents generalized period in the study.

Table 4 c. Summary Literature on Long Memory in Financial Markets

Study	*Period*	*Spot Market*	*Futures Market*	*Method*	*Evidence*
Cajueiro and Tabak (2004)	1992-2000	Stock Market	-	Classical R/S analysis	+
Du (2004)	1990-2001	Stock Market Returns	-		+
		Trading Volume		Classical R/S	+
		Volatility			+
Grau Carlas (2005)	2003-2003/	Stock Market	-	Classical R/S analysis	-/-
	1999-2003			Modified R/S analysis	+/-
				GPH	+/-
				DFA	-/-
Shieh (2006)	1982-2001	-	Stock Market	Modified R/S	-
					-
				DFA	-
				ARFIMA	
Tang and Shieh (2006)	1997-2005*	-	Stock Market Volatility	FIGARCH	+
				HYGARCH	+
Baillie et al. (2007)	1980-2000	-	Commodity Market	FIGARCH	+
			Volatility	Local Whittle estimation	+
Elder and Jin (2007)	1983-2000	-	Agricultural Commodity	Wavelet methodology	+
			Market Volatility		
Disario et al.(2008)	1988-2004	Stock Market Volatility	-	Wavelet method	+
				Variance method	+
				Absolute Value Method	+

"+" indicates long memory for all (most) of sample, "-" indicates no long memory for all (most) of sample "~" indicates long memory for some of sample
* represents generalized period in the study.