Efficiency Tests of the Greek Futures Market

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Abstract

Futures market present high trading volume during the last decade. Greek futures market presents upward trading volume, especially on FTSE/ASE-20, FTSE/ASE-40 indexes and on three stocks, Hellenic Telecommunications Organization, Public Power Corporation, Intracom. This paper examines the difference in volatility during trading and non-trading periods, using several econometric methods, Serial correlations, ADF test and Durbin- Watson test. Test results from these methods provide evidence that futures on FTSE/ASE-20 and Public Power Corporation are stationary series while the other three series depend on the season meaning that the Efficient Market Hypothesis is rejected.

Keywords: Futures Market, ADF test, Durbin- Watson, Market Efficiency, Greece.

JEL Classification: C22;C52;C87;G13;G14

Introduction

Risk management has never been an easy task, moreover today that prices of financial assets have become much more volatile and the main way to reduce risk is the use of appropriate financial derivative products available in the market (Floros and Vougas, 2006). During the last two decades, the most common used derivative product is futures contracts, which are expanding into many new markets such as energy, currencies, interest rates and stock indexes (Ward, n.d). The main purpose of trading futures is the so called hedging, meaning that price movements of the hedged item and the hedging derivative product offset each other (Yang, 2001).

A futures contract is an agreement to buy (or sell) a specified amount of underlying assets delivered on a future date at an agreed price upon entering the contract – futures price (Wang, 2004). Futures market was established in Greece on 1999, trading only futures on FTSE/ASE-20 index. Later on in the year 2000, futures on FTSE/ASE-40 index were introduced and progressively several stock futures were introduced in the market (Hellenic Telecommunications Organization, National Bank of Greece, Coca-Cola Hellenic Bottling Company, Vodafone-Panafon, Alpha Bank, Intracom, OPAP, Public Power Corporation, EFG Eurobank Ergasias). Nowadays futures on two indexes, FTSE/ASE-20, FTSE/ASE-40 and three stock futures, Hellenic Telecommunications Organization, Intracom and Public Power Corporation represent 71,2% of the whole Greek futures market (see appendix, table 11). Because of the vast development and popularity of this market, it is essential to search whether this market is efficient or not.

The concept of efficient markets exists for decades since Bachelier (1967) and since then several researches, Working, 1934; Cowles and Jones, 1937; Kendall, 1953; Fama, 1965 cited by Lee, Gleason, and Mathur, 2000, examined the efficient market hypothesis (EMH) and the random walk hypothesis (RWH). The most common used tests for testifying whether EMH and RWH exist are the serial correlation test, the unit root test, the Augmented Dickey- Fuller (ADF) test and the Phillips- Perron (PP) test. The purpose of this paper is to test the futures market in Greece so as to show whether it is efficient or not and whether time series are stationary or not, using the above statistical tests. In order to highlight these issues, this paper is divided into the following sections. The first part is the introduction to the topic which is followed by the indication of the corresponding background. Thirdly, the data description is mentioned and fourthly the methodology followed. The empirical results are placed in the fifth section and the final section is the report of the conclusions.

Literature Review

Lee, Gleason and Mathur (2000), tried to prove that French futures market is efficient. They tested the four bigger future products (CAC 40 Index Futures, ECU Bond Futures, National Bond Futures and PIBOR 3-Month Futures) because the whole futures market is depending on these our contracts. They took daily opening and closing prices from the foundation of the market (February, 1986) till 30 April 1997. They tested them for stationarity, serial correlation and variance ratio and they concluded that these contracts do not depart from a random walk, confirming the pricing efficiency of the contracts. Hoque, Kim and Pyun, (2006), tested the market efficiency of eight different Asian emerging markets (Hong Kong, Indonesia, Malaysia, Korea, Singapore, Philippines, Taiwan and Thailand). They took weekly closing prices from April 1990 to February 2004. They used variance ratio test to find out whether these eight markets prove to be mean-reverting or not. The basic findings were that five markets (Indonesia, Malaysia, Philippines, Singapore and Thailand), show specific mean- reverting and predictive behavior of stock prices while two markets (Taiwan and Korea) show some mean- reverting and unpredictable patterns in the time series. Park and Switzer (1995), examined the performance of three types of stock index futures, S&P 500 Index Futures, Major Market (MM) Index Futures and Toronto 35 Index Futures. The data come from the period 8 June 1988 to 18 December 1991. They used Unit Root Test, Cointegration Tests and Variance Ratio Test in order to find out the hedging effectiveness of the products. They identified that using the bivariate GARCH model, estimation of hedging prices are becoming more reliable. It is important to notice that this method produces equal results for within and out-of sample prices. Yang (2001), applied different econometric methods in order to find the optimal variance ratio in the Australian futures market during the period 1 January 1988 to 12 December 2000. Specifically, he used the OLS Regression, the Bivariate Vector Autoregressive model (BVAR), the Error Correction model (ECM) and the multivariate diagonal VEC GARCH model. It was generally found that GARCH time varying hedge ratios provide the greater portfolio risk reduction but they do not produce the greater profit return. So, it is obvious that is a matter of investor to decide in which product to invest, the less risky or the more profitable. Lypny and Powalla (1998), evaluated the hedge effectiveness of the DAX stock index futures using weekly closing prices during the period July 1991 to July 1994. They applied a dynamic hedge strategy using the GARCH model combining with an error

correction of the mean return. They found out that the combination of GARCH and Error Correction can satisfy both criteria, risk reduction and profit returns better than each model on its own.

Data Decription and Methodology Followed

The period under study is from 8 August 2004 till 9 August 2006. The data are limited to this period because the Athens Derivatives Exchange (ADEX) database provides daily opening and closing prices of futures prices only from 2004 and not before. Spot and Futures prices were obtained from the Athens Stock Exchange (ASE) database and Athens Derivatives Exchange (ADEX) database respectively. FTSE/ASE-20 comprises 20 Greek companies quoted on the Athens Stock Exchange (ASE), with the largest market capitalisation (blue chips), while the FTSE/ASE-40 comprises 40 mid-capitalisation Greek companies. Hellenic Telecommunications Organisation, Public Power Corporation and Intracom represent half of the turnover of the stock futures. Futures contracts on index are quoted in ADEX and their price is measured in index points multiplied by the contract multiplier which is €5 while stock futures' price calculated by multiplying the futures price by the contract size (100 shares)(www.adex.ase.gr). In testing the efficiency of the market, it is essential to require synchronous observations of both futures' and the underlying asset's prices.

Based on Lee, Gleason and Mathur, 2000, the examination of differences in volatility during the trading and non trading periods close-to-close (Rc-c) and open-to-open (Ro-o) returns are used and calculated as follows:

$Rc\text{-}c_t = Ln\ (Pc_t / Pc_{t-1})$ and $Ro\text{-}o_t = Ln\ (Po_t / Po_{t-1})$.

The appliance of Jacque- Bera test examines whether disturbances are normally distributed. Serial correlations and unit root tests are used to test for the efficiency of the financial futures contracts and by employing all of them, the robustness of the conclusions can be better established. ADF tests for efficiency of the series. With a Unit Root I(1) as the null hypothesis, the following regression on the natural logarithm of prices is computed:

$$\Delta p_t = \eta_0 + \eta_1 T + \eta 2p_{t-1} + \sum_{i=1}^{L} \gamma_i \Delta p_{t-i} + \mu_t$$

where: t is the number of observations.

Empirical Results

Basic Statistics

Table 1 presents the basic statistics of log daily returns. The returns are not normally distributed (JB high), rather are characterised by significantly high skewness and kurtosis.

The open-to-open returns present higher standard deviation than the close-to-close returns, which mean higher volatility during trading hours for FTSE/ASE-40, DEI (Public Power Corporation) and INTKA (Intracom). OTE (Hellenic Telecommunications Organisation) presents lower volatility during trading hours while FTSE/ASE-20 presents the same standard deviation for both open-to-open and close-to-close returns. Volatility varies by contract, with OTE being the most volatile and FTSE/ASE-40 and FTSE/ASE-20 the less volatile.

Table 1: Basic Statistics for Returns

	FTSE/ASE-20		FTSE/ASE-40		DEI		INTKA		OTE	
	O-O	C-C	O-O	C-C	O-O	C-C	O-O	C-C	O-O	C-C
Mean	8,674	8,219	53,919	50,639	-2,56	-2,524	95,77	90,739	10312	10011
St. Dev.	122,57	122, 53	125,33	34,593	195,21	191,54	251,3	189,77	237,46	309,06
Skewness	-0,202	-0,781	0,38	0,635	-0,634	-0,266	-0,01	1,031	0,095	7,359
Kurtosis	3,948	7,699	1,495	1,503	51,281	53,693	1,814	2,236	1,274	220,52
Jacque-Bera	29,285	674,41	78,239	106,15	61136,2	67357	38,606	132,90	82,707	13052
Obs.	661	661	661	661	629	629	659	659	659	659

Mean and St. Dev. are multiplied by 10^3.

Autocorrelations (AC) and Partial Autocorrelations (PAC) and Augmented Dickey Fuller (ADF) Test

In table 2, the AC and PAC are summarised of all five series. It is easily understood from this table that FTSE/ASE-20 and DEI series are stationary while the other three series seem to be non stationary. But even the non stationary series can be easily turned to stationary series by calculating their first differences.

Table 2: Autocorrelations (AC) and Parial Autcorrelation (PAC)

Lag	FTSE/ASE-20		FTSE/ASE-40		DEI		INTKA		OTE	
	O-O	C-C	O-O	C-C	O-O	C-C	O-O	C-C	O-O	C-C
1	0,009[a]	-0,040	-,0499	-0,500	-0,271	-0,235	-0,715	-0,191	-0,071	-0,335
	0,009[b]	-0,040	-0,499	-0,500	-0,271	-0,235	-0,715	-0,191	-0,071	-0,335
	0,058[c]	1,0813	165,10	165,37	46,570	34,841	338,67	24,063	3,3047	74,205
2	-0,044	0,069	-0,499	-0,498	0,027	0,027	0,433	-0,618	-0,857	0,000
	-0,044	0,067	-0,995	-0,997	-0,050	-0,029	-0,161	-0,679	-0,866	-0,126
	1,3415	4,2167	330,75	329,75	47,042	35,317	462,82	277,21	489,91	74,205
3	-0,021	-0,096	0,995	0,995	-0,043	-0,082	-0,714	-0,188	-0,070	-0,012
	-0,020	-0,091	0,372	0,079	-0,053	-0,087	-0,989	-0,993	-0,980	-0,063
	1,6263	10,370	990,75	987,75	48,210	39,562	801,76	300,78	493,13	74,308
4	0,001	0,026	-0,496	-0,498	-0,004	-0,003	0,994	0,994	0,994	0,001
	-0,001	0,015	-0,162	-0,007	-0,031	-0,045	0,419	0,203	0,390	-0,029
	1,6265	10,821	1155,1	1152,4	48,219	39,567	1458,7	957,77	1150,1	4,308
5	0,019	-0,033	-0,497	-0,496	-0,020	0,002	-0,711	-0,190	-0,070	0,020
	0,018	-0,019	0,073	0,002	-0,033	-0,012	0,191	-0,194	-0,257	0,010
	1,8752	11,540	1320	1316	48,464	39,569	1795,3	981,69	1153,4	74,580
6	-0,040	0,053	0,991	0,991	0,019	-0,056	0,430	-0,614	-0,851	-0,031
	-0,041	0,041	-0,034	-0,001	0,003	-0,069	-0,247	0,081	0,169	-0,023
	2,9596	13,449	1977	1971	48,704	41,535	1918,7	1233,3	1637	75,208
7	0,045	-0,026	-0,494	-0,495	-0,056	0,023	-0,710	-0,187	-0,069	0,002
	0,048	-0,016	0,015	-0,001	-0,057	-0,011	0,017	-0,050	-0,113	-0,017
	4,3423	13,895	2140,6	2134,9	50,728	41,885	2255,6	1256,7	1640,2	75,212
8	0,028	0,042	-0,495	-0,493	-0,021	0,026	0,988	0,988	0,988	-0,021
	0,024	0,031	-0,006	0,001	-0,059	0,028	0,104	0,025	0,077	-0,034
	4,8542	15,095	2304,7	297,7	51,010	42,319	2908,6	1909,7	2293,2	75,513
9	-0,026	-0,069	0,986	0,986	0,025	-0,019	-0,707	-0,188	-0,070	0,013
	-0,025	-0,056	0,001	-0,001	0,000	-0,017	-0,049	-0,016	-0,055	-0,010
	5,3220	18,300	2958,7	2949,7	51,400	42,543	3243,1	1933,5	2296,5	75,624
10	-0,024	0,027	-0,492	-0,493	0,039	-0,037	0,427	-0,610	-0,846	0,003
	-0,020	0,014	-0,001	-0,001	0,043	-0,049	-0,028	0,008	0,039	0,001
	5,7139	18,791	3121,6	3112,9	52,392	43,407	3365,7	3183,5	2777,2	75,631
11	0,003	-0,024	-0,492	-0,491	-0,028	0,025	-0,706	-0,186	-0,069	-0,013
	0,004	-0,007	0,001	0,001	-0,010	0,009	0,036	-0,003	-0,025	-0,013
	5,7215	19,188	3285	3275	52,896	43,802	3700,5	2206,8	2780,4	75,752
12	0,031	0,024	0,982	0,982	-0,016	-0,032	0,982	0,982	0,982	0,037
	0,025	0,006	-0,002	-0,001	-0,030	-0,033	-0,003	0,001	0,017	0,032
	6,3897	19,561	3936	3924	53,061	44,451	4349,5	2855,8	3429,3	76,656

[a] *Autocorrelations*
[b] *Partial Autocorrelations*
[c] *Q- Statistic*

The previous statement is only confirmed for OTE series while the other two series remain non stationary even after the application of second differences. Although AC shows non stationarity, PAC mentions that when lag increases, FTSE/ASE-40 and INTKA become stationary.

In order to confirm the above statements about stationarity or non stationarity, it is important to apply the ADF test for 1 lag. Running a regression on equation (1), see methodology, table 3 summarizes that all series are stationary at a 99% confidence level except from FTSE-40. Specifically, all series are stationary even when the ADF test is applied without any lag. Also, the same results are mentioned with the similar to ADF test called Phillips-Perron (PP) test except from FTSE/ASE-40 series that are stationary too (see appendix, table 1-12). The residuals of the regression are stationary for FTSE/ASE-20,DEI, close-to-close returns of OTE, as Durbin- Watson test is close to 2, which mentions that there is no autocorrelation indicating that the series are stationary. It is important to mention that these series are stationary because they are logged and usually log series tend to be more stationary (Dimeli, 2002, p.35). These results are totally different than those produced by Lee et al. (2000) who tested the French derivatives market and they concluded the market is efficient and the series perform as the random walk theory.

Table 3: Unit Root Test

		FTSE/ASE-20	FTSE/ASE-40	DEI	INTKA	OTE
O-O	Test Statistics	-18,84294	-5,86 E+16	-20,93540	-27,92474	-70,70220
	Durbin Watson	1,99850	2,955455	2,005231	2,318544	3,735941
C-C	Test Statistics	-17,25574	-1,41 E+16	-20,22262	-45,35265	-23,87653
	Durbin Watson	1,985047	2,966413	2,001735	3,362106	2,020878

Critical values are -3,4428, -2,8663 and -2,5693 at the 90%, 95% and 99% respectively. The null hypothesis is rejected if the test statistic is smaller than the critical value.

Another interesting topic is the relationship between open-to-close and close-to-open prices. Running a regression on equation (1) and adjusting for heteroskedasticity, it is easily understood that FTSE-20 and open-to-close of OTE series are again stationary as its residuals, while the other series are non stationary. Using the forecasting ability, it is mentioned that almost all forecasts are far from the actual series as their Variance Proportion which says how far the variation of the forecast is the variation of the actual series are close to 1 (worst case) and only open-to-close of OTE series has a reliable forecasting ability (see appendix, table 12).

Table 4: Stationarity Test of Open-to-Close and Close-to-Open Prices

		FTSE/ASE-20	FTSE/ASE-40	DEI	INTKA	OTE
O-C	Test Statistics	-6,882010	-0,389971	5,234391	-0,187297	-3,123796
	Durbin Watson	20457215	2,992134	2,920101	3,434787	2,138362
C-O	Test Statistics	-5,776963	-0,389496	5,106275	-1,188424	-3,127178
	Durbin Watson	2,053149	2,999040	2,845893	2,387982	2,166429

Critical values are -3,4428, -2,8663 and -2,5693 at the 90%, 95% and 99% respectively. The null hypothesis is rejected if the test statistic is smaller than the critical value.

Conclusion

This paper tried to investigate whether the 5 most common traded future contracts present pricing efficiency. In order to prove whether this efficiency exists, were used Jacque- Bera (JB) test, serial correlations and Unit Root Test (ADF). According to the results, the series are not normally distributed due to the high skewness and kurtosis. FTSE/ASE-40,DEI and INTKA present higher standard deviation during open-to-open prices than close-to-close prices, meaning higher volatility during trading hours. OTE presents lower volatility during trading hours while FTSE-20 presents the same standard deviation for both open-to-open and close-to-close returns. The AC test confirmed that only FTSE/ASE-20 and DEI are stationary while the other series are non stationary. Unit Root Test (ADF) proved that all series are stationary except from FTSE/ASE-40. Finally studying the relationship between open-to-close and close-to-open prices, it is mentioned that FTSE/ASE-20 and open-to-close prices are stationary. These results are totally different than those produced by Lee, Gleason and Mathur (2000) in the French derivatives market providing evidence that the random walk hypothesis cannot be rejected for this market.

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Appendix

Table 1: PP for Open-to-open FTSE/ASE-20

PP Test Statistic	-25.41660	1%	Critical Value*	-3.4428
		5%	Critical Value	-2.8663
		10%	Critical Value	-2.5693

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 2: PP for Close-to-close FTSE/ASE-20

PP Test Statistic	-26.65650	1%	Critical Value*	-3.4428
		5%	Critical Value	-2.8663
		10%	Critical Value	-2.5693

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 3: PP for Open-to-open FTSE/ASE-40

PP Test Statistic	-54.99250	1%	Critical Value*	-3.4428
		5%	Critical Value	-2.8663
		10%	Critical Value	-2.5693

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 4: PP for Close-to-close FTSE/ASE-40

PP Test Statistic	-54.88100	1%	Critical Value*	-3.4428
		5%	Critical Value	-2.8663
		10%	Critical Value	-2.5693

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 5: PP for Open-to-open INTKA

PP Test Statistic	-65.89258	1%	Critical Value*	-3.4428
		5%	Critical Value	-2.8663
		10%	Critical Value	-2.5693

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 6: PP for Close-to-close INTKA

PP Test Statistic	-31.54943	1%	Critical Value*	-3.4428
		5%	Critical Value	-2.8663
		10%	Critical Value	-2.5693

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 7: PP for Open-to-open DEI

PP Test Statistic	-33.11374	1%	Critical Value*	-3.4432
		5%	Critical Value	-2.8665
		10%	Critical Value	-2.5694

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 8: PP for Close-to-close DEI

PP Test Statistic	-31.80466	1%	Critical Value*	-3.4432
		5%	Critical Value	-2.8665
		10%	Critical Value	-2.5694

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 9: PP for Open-to-open OTE

PP Test Statistic	-27.58414	1%	Critical Value*	-3.4428
		5%	Critical Value	-2.8663
		10%	Critical Value	-2.5693

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 10: PP for Close-to-close OTE

PP Test Statistic	-36.61805	1%	Critical Value*	-3.4428
		5%	Critical Value	-2.8663
		10%	Critical Value	-2.5693

**MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 11: Derivatives Market Volume

-ΣΜΕ επί μετοχών - Stock Futures					
Alpha Τράπεζα - Alpha Bank	85.440	459	457	386	
COSMOTE - COSMOTE Mobile Telecommunications	18.886	102	96	50	
EEEK - EEEK	16.274	87	115	76	
Εθνική Τράπεζα - National Bank of Greece	161.942	871	990	1.272	
Eurobank - Eurobank	54.843	295	305	271	
EXAE - Hellenic Exchanges Holding S.A.	33.903	182	102	134	
Γερμανός - Germanos	11.204	60	3	1	
OTE - Hellenic Telecommunication Organization	272.997	1.468	1.351	1.142	
Ιντρακόμ - Intracom	314.945	1.693	1.075	2.157	
ΟΠΑΠ - OPAP	91.226	490	408	397	
ΔΕΗ - Public Power Corporation	217.970	1.172	1.137	1.865	
Εμπορική Τράπεζα - Emporiki Bank	93.734	504	262	191	
TITAN - TITAN Cement Company	9.090	49	51	50	
Τράπεζα Πειραιώς - Piraeus Bank	80.768	434	409	281	
ΓΕΚ - GEK	149.774	805	575	717	
HYATT Regency - HYATT Regency	5.553	30	4	1	
Μαρφίν - Marfin	41.097	221	144	301	
Attica - Attica	58.429	314	267	263	
Ελληνική Τεχνοδομική - Elliniki Technodomiki	166.995	898	575	910	
Ιντραλότ - Intralot	29.004	156	108	102	
Μυτιληναίος - Mitilinaios	61.409	330	207	270	
Σύνολο - Total	**1.975.483**	**10.621**	**8.640**	**10.837**	**25,4%**

Source: Athens Derivatives Exchange

Table 12: Forecasting (OTE) OLS METHOD

Forecast: OOOTEF
Actual: OOOTE
Forecast sample: 1 662
Adjusted sample: 1 659
Included observations: 658

Root Mean Squared Error	263.9748
Mean Absolute Error	250.9304
Mean Absolute Percentage Error	159.4549
Theil Inequality Coefficient	0.435115
Bias Proportion	0.000000
Variance Proportion	0.189325
Covariance Proportion	0.810675