PRICE DISCOVERY IN THE ATHENS DERIVATIVES EXCHANGE: EVIDENCE FOR THE FTSE/ASE-20 FUTURES MARKET[(a)]

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Abstract: The FTSE/ASE-20 futures market, as the first organised Greek derivatives market, established in August 1999 and its operation rests with the Athens Derivatives Exchange (ADEX) and the Athens Derivatives Exchange Clearing House (ADECH). Cointegration tests are used and an error correction model is developed in order to examine the relationship between price movements of FTSE/ASE-20 three-month futures index and the underlying cash market in Athens Stock Exchange (ASE). The investigation of its price discovery mechanism has been motivated by the existing paucity of similar research in such newly established (emerging) futures markets and the growing importance of this market for both investors and the Greek capital market. The results show the presence of a bi-directional causality between stock index spot and futures markets, indicating that the newly established ADEX can provide futures contracts that serve as a focal point of information assimilation and fulfil their price discovery.

JEL Classification: G13, G14

Key words: Athens Derivatives Exchange, FTSE/ASE 20 futures contract, Price discovery, Cointegration analysis, Causality.

1. INTRODUCTION

The relationship between stock index spot and futures markets is still attracting the attention of academics, practitioners and regulators due to both the considerable volume of trading in these contracts and their role during periods of turbulence in financial markets. An important aspect of this relationship is the nature of the lead-lag relationship in the returns between equivalent assets traded in different markets or the predictive power of price movements in one market for those in the other market.

One of the economic functions of futures contracts is price discovery. Price discovery refers to the use of futures prices for pricing cash market transactions and its significance depends upon the above mentioned, close relationship between the prices of futures contracts and the underlying assets. The essence of the price discovery function of futures markets hinges on whether new information is reflected first in changes of futures prices or in changes of cash prices.

In other words, price discovery means whether price changes in futures markets lead price changes in cash markets more often than the reverse. If that is the case, there exists a lead-lag relationship between the two markets. Therefore, the futures prices may serve as the market's expectation of a subsequent delivery period cash price. The share of price discovery originating in the futures markets has important implications for hedgers and arbitrageurs who use these markets.

The first studies to test the price transmission process have used mainly the regression analysis. However, if price series are not stationary, a phenomenon typical in financial markets, then standard statistical tests of parameter restrictions are not reliable (Elam and Dixon, 1988). Thus, for overcoming the problems of non-stationary price series and due to the fact that price discovery deals with short-run and long-run departures from a presumed equilibrium relation, the introduction of cointegration analysis with error correction models is fortuitous.

An overwhelming number of studies have examined the price discovery process involving well established US, European and Asian futures markets providing different results. Notable studies using United States data and different econometric techniques (e.g., Ng, 1987; Kawaller, P. Koch and W. Koch, 1987; Stoll and Whaley, 1990; Chan, 1992; Antoniou and Garrett, 1993; Pizzi, Economopoulos and O' Neal, 1998) generally support the primacy of futures in the price discovery process. International evidence supporting the primacy of futures is not as strong. For instance, Grübichler, Longstaff and Schwartz (1994) and Booth, So and Tse (1999) report that the DAX index lags the price of its futures contract, a finding generally echoed by Tang and Ho (1989) for the SIMEX and Iihara, Kato and Tokunaga (1996) for the Japanese market. However, Shyy, Vijayraghavan and Scott-Quinn (1996) report the opposite for the French spot and futures prices. Moreover, Wahab and Lashgari (1993) report a uni-directional relationship among spot and futures prices of S&P 500 and FTSE-100 index, although the dominance of the spot prices has been found to be stronger.

The purpose of this paper is the examination of the information linkage between the FTSE/ASE-20 stock index and its three-month index futures contract and the role (lead or lag) that the futures market plays using daily closing futures and cash prices. This investigation is significant for two reasons. First, it is focused in an emerging futures market, such as is the case for Greece, given the existing paucity of research in such markets. The findings of this study may suggest if newly established futures markets can also provide futures contracts that fulfill their price discovery function. Second, given that there has been no prior investigation in ADEX due to its recent creation and short trading history and the FTSE/ASE-20 futures contract has the greater liquidity among the other derivatives products, this examination with more up-to-date econometric tests than were employed in the early literature on price discovery is certainly of concern to existing and future participants. Engle-Granger and Johansen cointegration tests are used and an error correction model (ECM) is developed in order to examine the causality relationship between the two markets.

This paper proceeds as follows: Section 2 gives a brief discussion of the Athens Derivatives Exchange and the FTSE/ASE-20 futures contract. Section 3 presents the methodology followed. Section 4 reports the sample data and presents the empirical results. Section 5 draws a summary and the conclusions referring the relationship between the FTSE/ASE-20 futures market and the underlying cash market.

2. ATHENS DERIVATIVES EXCHANGE (ADEX) AND THE FTSE/ASE-20 FUTURES CONTRACT

Until the late years of the last decade, and prior to the creation of the institutional framework for the operation of the organized derivatives market in Greece, transactions on derivatives existed on a limited scale, over-the counter, mainly between financial institutions and companies. The development of the organized derivatives market in Greece, similarly with other developed European countries, was a result of the growth of the Greek capital market and economy in general[1]. The establishment of the Athens Derivatives Exchange (ADEX) and the Athens Derivatives Clearing House (ADECH) in accordance with Law 2533/1997 offers a majority of standardized products to an

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[1] The Greek capital market seemed ready to support an organised market on financial derivatives. The turnover ratio is over 30% since 1994 whilst, in 1998, it increased 62%. Accordingly, the total capitalisation has been over 20 billion dollars since 1996, reaching 81 billion dollars in 1998. Finally, the ratio of capitalisation to GDP has increased continuously from 1996. In 1998 it had doubled compared to it for 1997 and was well above 120% in 1999.

enlarging number of participants (corporations, individual investors, banks, mutual funds, state enterprises, investment companies), contributes to the efficiency of the capital market and has positive influence on the national economy.

ADEX and ADECH were founded in April 1998 as autonomous companies. ADEX's purpose is to organize and support trading in the derivatives market. It is organized along two main axes. The first is the development of business and the second is related to the execution of transactions. The purpose of ADECH is to act as counterparty in all trades concluded on ADEX, the clearing of transactions that are effected, the settlement of the transactions, the ensuring of the fulfillment of obligations arising from these transactions, and co-operation with members and banks, to ensure the safe commitment and disengagement of margins, the financial settlement of transactions and every related activity. The electronic system provided by ADEX is part of the Integrated Automated Electronic Trading System (OASIS). All transactions on standardized derivatives are effected through this system, creating an electronic market in which access is via a computer installation at every member's location.

Direct access to ADEX and ADECH is restricted to those organizations, which have been accepted as members, having fulfilled the legal requirements and submitted the details required by the membership application. There are two types of membership in ADEX. The first category is the single members who act as broker-agents and are not allowed conducting transactions for their own account and the second category is the market makers.

The FTSE/ASE-20 blue chip index was the first underlying asset of the futures contract, followed by the FTSE/ASE-40 midcap index, the ten year Greek bond, the three-month ATHIBOR, and selected "blue-chip" stocks much later, while American style options contracts on major Greek “blue-chip” stocks and the above FTSE indexes and stock lending contracts have been launched recently.

The trading on ADEX began on 27/8/1999 and the first traded product was the FTSE/ASE-20 futures contract. The FTSE/ASE 20 index has been chosen as the most suitable due to the high liquidity, and turnover of its constituent shares. The futures on the FTSE/ASE-20 are cash settled and quoted in index points. At any point in time, there are six index futures contracts listed, corresponding to the associated expiration months: the three nearest consecutive months from the monthly cycle and the three nearest months from the March, June, September and December quarter cycle, not included in the consecutive months. The expiration day and the last trading day on the FTSE/ASE-20 futures is the third Friday of the expiration month. Open positions on futures are subject to daily settlement (marking to market). Table 1 displays the main specifications of the FTSE/ASE-20 futures contract.

TABLE 1: Specifications of the FTSE/ASE- 20 Futures Contract

PRODUCT	- FTSE/ASE-20 INDEX FUTURES
SETTLEMENT	- Cash settlement
MINIMUM LOT SIZE	- Single Market: 1, Block Market: 100
CONTRACT SIZE	- 5 EURO per index point
QUOTE UNIT	- Index points
MINIMUM TICK	- 0.25 index points
TICK VALUE	- 1,25 EURO
PRICE LIMIT	- No price limit
TRADING HOURS	- Monday to Friday: 10:45 am to 16:15 pm (local time)
MARGIN REQUIREMENTS	- 12% of the position
MARGINING SYSTEM	- RIVA (Risk Valuation) per end client
POSITION LIMITS	- No position limits
LAST TRADING DATE	- 3rd Friday of the expiration month
SETTLEMENT DATE	- First working day following the last trading day
LISTING RULES	- 3 closest consecutive months plus 3 closest from the Mar-Jun-Sep-Dec quarter cycle. On the working day following the last trading day, a new series is introduced
SETTLEMENT OF FEES	- Fees are settled on the working day that follows the trade day (T+1)
EXCHANGE FEE	- 0,15-0,55 EURO (Market Makers B) / 1,30-1,80 EURO (Others Members)
MARGIN	- Collateral using RIVA (Risk Valuation) at end client level by Clearing House

Source: ADEX

3. METHODOLOGICAL ISSUES

3.1 Stationarity

The existence of unit roots is firstly tested using the Augmented Dickey-Fuller test (ADF) (Dickey and Fuller, 1981) through the following relationship:

$$\Delta S_t = \alpha + \beta \mathrm{T} + \rho S_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta S_{t-i} + u_t \tag{1}$$

where $\Delta S_t = S_t - S_{t-1}$, S_t is the index of the spot market, and k is chosen so that the deviations u_t to be white noise. The same relationship is used to determine the order of the futures price index (F_t). The null and the alternative hypothesis for the existence of unit root in S_t and F_t is H_0: $\rho = 0$, H_1: $\rho < 0$. If the null hypothesis of only a unit root cannot be rejected, then the stock prices follow a random walk.

Phillips and Perron (1988) have modified the ADF test (based on Equation 1 without lagged differences), as the ADF tests are only valid under the crucial assumption of i.i.d. processes. In practice, it may be more realistic to allow for some dependence among the u_t*'s*. In that case, the asymptotic distribution is changed. Phillips and Perron (1988) have weakened the i.i.d. assumption by using a non-parametric correction to allow for some serial correlation and heteroskedasticity:

$$y_t = \alpha_0 + a\, y_{t-1} + u_t \tag{2}$$

The PP test tends to be more robust to a wide range of serial correlations and time-dependent heteroskedasticity. In the PP test, the null hypothesis is that a series is non-stationary (i.e. difference stationary) if $\alpha = 1$, hence, rejection of the unit root hypothesis is necessary to support stationarity. The asymptotic distribution of the PP *t*-statistic is the same as the ADF *t*-statistic.

3.2 Cointegration

Evidence of price changes in one market generating price changes in the other market so as to bring about a long-run equilibrium relationship is given in eq. (3):

$$F_t - \delta_o - \delta_1 S_t = \varepsilon_t \tag{3}$$

where F_t and S_t are contemporaneous futures and cash prices at time t; δ_1 and δ_o are parameters; and ε_t is the deviation from parity. If F_t and/or S_t are nonstationary then the Ordinary Least Square (OLS) method is inappropriate because the standard errors are not consistent. This inconsistency does not allow hypothesis testing of the cointegrating parameter δ_1. If F_t and S_t are nonstationary but the deviations, ε_t, are stationary, F_t and S_t are cointegrated and an equilibrium relationship exists between them (Engle and Granger, 1987). For F_t and S_t to be cointegrated, they must be integrated of the same order. Performing unit root tests on each price series determines the order of integration. If each series is nonstationary in the levels, but the first differences and the deviations ε_t are stationary, then the prices are cointegrated of order (1,1), denoted CI (1,1), with the cointegrating coefficient δ_1.

In order to test for cointegration, two econometric procedures are implemented: the Engle-Granger two-step methodology (Engle and Granger, 1987) and the Johansen's Maximum Likelihood approach (Johansen, 1988 and 1991).

According to Engle and Granger, two basic steps are followed:

1. Testing the existence of unit roots (integration order) in each index, following Augmented Dickey-Fuller (ADF) test through equation 1.

2. Cointegration testing between stock index spot and futures market. Consider prices (in log) in spot market i and futures market j (S_t^i and F_t^j), and P_t is the vector that

consists of S_t^i and F_t^j. According to Engle and Granger (1987), S_t^i is said to be integrated of order d, denoted $S_t^i \sim$ I (d), if the dth difference of S_t^i is stationary. The vector P_t is said to be cointegrated of order d, b, denoted as $P_t \sim$ CI (d, b), if each component of P_t is integrated of order d, and there exists a non-zero vector δ such that δ′ P_t is integrated of order d-b, for b>0. If both S_t^i and F_t^j are I (1) and $P_t \sim$ CI (1,1) [i.e. δ′ $P_t \sim$ I (0)], then there are error-correction equations in the following form:

$$\Delta S_t^i = \alpha_1 [S_{t-1}^i - \delta_1 F_{t-1}^j] + \text{lagged}(\Delta S_t^i \text{ and } \Delta F_t^j) + e_t^i \qquad (4)$$

$$\Delta F_t^j = \alpha_2 [F_{t-1}^j - \delta_2 S_{t-1}^i] + \text{lagged}(\Delta S_t^i \text{ and } \Delta F_t^j) + e_t^j$$

where α_1 and α_2 are non-zero coefficients and e_t^i και e_t^j are stationary, possibly autocorrelated error terms. Engle and Granger proposed several cointegration tests; however, the most preferable is the ADF statistic test.

In order to test for cointegration between the two markets, the Johansen's Maximum Likelihood Procedure (Johansen, 1988) is also implemented. This is a preferred method of testing for cointegration as it allows restrictions on the cointegrating vectors to be tested directly, with the test statistic being x^2 distributed. This specific procedure provides a unified framework of estimating and testing the cointegration relationships in a VAR error correction mechanism, which incorporate different "short-run" and "long-run" dynamic relationships in a variable system.

The Johansen's procedure firstly specifies the following unrestricted N-variable VAR:

$$x_t = \mu + \sum_{i=1}^{k} \Pi_i x_{t-i} + \varepsilon_t \qquad (5)$$

where $x_t' = [\, f_t' \,,\, s_t' \,]$, μ is a vector of intercepts terms and ε_t is a vector of error terms. Johansen (1988) and Johansen and Juselius (1990) reparameterized eq. (5) in the form:

$$\Delta x_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \Pi x_{t-k} + \varepsilon_t \qquad (6)$$

Equation (6) is now a VAR reparameterized in error correction form, where $\Pi = -(\Pi - \Pi_1 - \ldots - \Pi_k)$ represents the long response matrix. Writing this matrix as $\Pi = \alpha\beta'$, then the linear combinations $\beta' \; x_{t-k}$ will be I(0) in the existing of cointegration, with α being the adjustment coefficients, and the matrix Π will be of reduced rank. The Johansen approach can be used to test for cointegration by assessing the rank (r) of the matrix Π. If r=0 then all the variables are I(1) and there are no cointegrating vectors. If r=N then all of the variables are I(0) and, given that any linear combinations of stationary variables will also be stationary, there are N cointegrating vectors. Last, if 0<r<N there will be r cointegrating vectors.

3.3 Error Correction Model and Causality

The cointegration between two series involves a continuous adjustment of innovations' prices, so that these would not become larger in the long run. Engle and Granger (1987) have shown that all the cointegrated series can include an error correction (the "Granger representation theorem") and, on the contrary, the existence of cointegration is a necessary condition in order to construct error correction models.

The acceptance that each pair of cash and futures prices composes a cointegrating system leads to the implementation of an error correction model for each series, which is characterized by the ability to overcome problems caused by spurious results.

If ΔS_t and ΔF_t denote the first differences of the futures and cash prices, the following cointegrating regressions are possible:

$$\Delta S_t = \alpha_1 + a_S z_{t-1} + \sum_{i=1}^{n} \alpha_{11}(i)\Delta S_{t-i} + \sum_{i=1}^{n} \alpha_{12}(i)\Delta F_{t-i} + \varepsilon_{St} \tag{7}$$

$$\Delta F_t = \alpha_2 + a_F z_{t-1} + \sum_{i=1}^{n} \alpha_{21}(i)\Delta S_{t-i} + \sum_{i=1}^{n} \alpha_{22}(i)\Delta F_{t-i} + \varepsilon_{Ft} \tag{8}$$

where $z_t = S_t - [b + a\ F_t]$ is the error correction term. Equations (7) and (8) represent a vector autoregression (VAR) in first differences; thus, all variables are held jointly endogenous and OLS is an appropriate method of estimation.

Each equation is interpreted as having two parts. The first part is the equilibrium error (from the cointegrating regressions). This measures how the left-hand-side variable adjusts to the previous period's deviation from long run equilibrium. The remaining portions of the equations are the lagged first differences, which represent short-run effects of the previous period's price changes on the current period's price changes. For example, in equation (7) the change in S_t is due to both "short-run" effects, possibly from both ΔFs and ΔSs, and to the last-period equilibrium error, z_{t-1}, which represents adjustment to long-run equilibrium.

The error correction term enters into the two equations with a one period lag and is estimated from the cointegrating regressions, with constant terms being included to make the mean of the error series zero. The coefficients α_S και α_F attached to the error correction term measures the single-period response of the left-hand-side variable to departures from equilibrium ("speed of adjustment coefficients"). At least one speed of adjustment coefficients must be nonzero for the model to be an error correction model.

If the value of α_S in eq. (7) is zero, the current period change in the index does not respond at all to the last period's deviation from long-run equilibrium.

The link between cointegration and causality stems from the fact that if spot and futures indices are cointegrated, then causality must exist in at least one direction (unidirectional causality) and possibly, in both directions (bi-directional causality) (Granger, 1986). Since cointegration implies that each series can be represented by an error correction model that includes last period's equilibrium error, as well as lagged values of the first differences of each variable, temporal causality can be assessed by examining the statistical significance and the relative magnitudes of the error correction coefficients and the coefficients on the lagged variables (Wahab and Lashgari, 1993).

The Standard Granger causality tests do not take into account the significance of error correction coefficients. Engle and Granger (1987) focused on the fact that the estimates of a VAR are misspecified in the case of cointegrated variables, because the error correction terms that are attached to error correction models are not accounted. The argument is that the models implemented for testing the causality relationship are misspecified if the variables, which are tested for the direction of causality, are cointegrated.

The existence of a unidirectional causality from S_t to F_t requires: (i) that some of the a_{21} *'s* in eq. (8) must be non-zero while all the a_{12} 's in eq. (4) must be equal to zero and/or (ii) the error correction coefficient α_F in eq. (8) is statistically significant at conventional levels.

If the coefficients a_{21} and a_{12} are individually and jointly non-zero, then a feedback relationship or a bi-directional causality between the two price series is existed. On the other hand, if the above coefficients are equal to zero, then there is not a causality relationship between the two variables, as each variable is determined by its prices and the relevant innovations.

4. DATA AND EMPIRICAL RESULTS

Price data on the FTSE/ASE-20 stock index and the three-month FTSE/ASE-20 index futures contract are from the Athens Stock Exchange (ASE) and the Athens Derivatives Exchange (ADEX) respectively. Daily data are used during the period from August 1999 until June 2002. The logs of the spot and futures prices are used. The futures prices are always those of the nearby contract. To avoid thin markets and expiration effects, we rollover to the next nearby contract one week before the nearby expires. Moreover, in order to eliminate the stale price effects, prices before and after the specified trading hours of ASE and ADEX are not used.

After the establishment of ADEX and from August 1999 until March 2000, average monthly trading volume in FTSE/ASE-20 futures contracts has risen 76.6% (30.978 contracts in March 2000), while daily average number of contracts in March 2000 has increased 131% relative to August 1999 (2.816 and 1.219 contracts in March 2000 and August 1999 respectively). The selection of the estimation period's length is due to the significant increase of a number of statistics concerning the FTSE/ASE-20 futures contract in 2001 compared to the previous year. Table 2 reports total volume, daily average volume and daily open interest on FTSE/ASE-20 index futures during the period 2000-2001. Average daily traded volume for 2001 was up to 173% compared to 2000, open interest averaged over 11.500 contracts, while daily average trading value for 2001 was 41,76 mil. euros. These statistics indicate the strong growth of so far the star product of ADEX[2].

TABLE 2: Main Indicators: FTSE/ASE-20 Index Futures

Year	2001	2000	% change from 2000
Trading days	252	250	
Total volume	1.320,625	484.243	
Daily average volume	5.259	1.927	173%
Daily average open interest	11.638	4.154	180%
Traded value (in mln euros)	41.76	26.20	60%

Source: ADEX

To determine the order of each price series, the Augmented Dickey-Fuller τ-test and the Phillips-Perron test are computed on the levels of each price series. Performing the tests on the levels of each series shows that the null hypothesis of a unit root is not rejected; thus, each series is I(0). On the contrary, the results of the tests on the first differences indicate that each series is I(1). Table 3 reports the results of the Unit roots tests.

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[2] According to Federation of European Securities Exchanges, ADEX ranked 7th in stock index futures by trading value during 2000-2001 among European derivatives markets, leaving behind the markets in Portugal, Denmark, Finland, Austria, Norway, Poland, and Hungary.

TABLE 3: Unit Root Tests

Statistic tests	Spot index	Futures index
ADF levels	-2.6308	-2.8782
ADF first differences	-21.1479*	-24.0264*
PP levels	-2.6826	-2.7256
PP first differences	-30.4291*	-31.9872*
The null hypothesis is that series has a unit root. *Denotes that the test statistics are significantly different from zero at the 5% level. The critical value for ADF and PP tests is -3.44 at the 5% level.		

Since the two series are I(1), both the Engle-Granger's tests and the Johansen's procedure tests for cointegration are used. Engle-Granger's cointegration tests are implemented to the residuals of the bivariate regressions. Table 4 reports the results of DF and ADF tests[3]. The results indicate the existence of a statistically significant cointegration relationship between the two markets.

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[3] Analysis of the data indicated the presence of non-normality. The problem of non-normality in the data is overcome by including a dummy variable relating to a specific observation in each index. The results in Table 4 and 5 relate to tests including stationary dummy variables. Exclusion of the dummies does not alter the pattern of results.

TABLE 4: Engle- Granger Cointegration Tests

System	DF	ADF
Spot ; Futures	-2.4321	-5.3658* (5)
Futures ; Spot	-2.8399	-4.8199* (5)

On each system, the first market is the dependent variable (on the left of the sign ;), while the other market is the independent variable (on the right of the sign ;).

* Denotes that the null hypothesis of no cointegration is rejected at the 5% level. The critical value is -3.18 at the 5% level. The number in parentheses shows the least required lag order to have white noise innovations.

Departing from the bivariate cointegration regressions in the Engle-Granger framework, a VAR error cointegration model such as in Equation (6) is estimated in order to consider the two series jointly and cross check the existence of cointegration between them, according to the procedure advanced by Johansen. Hall (1991) has demonstrated that in using this procedure to test for cointegration it is necessary to carry out tests to establish the appropriate order of the VAR. The choice of optimal lags is given by consideration of minimizing the Akaike information criterion (Akaike, 1973) and absence of autocorrelation in the VAR residuals; five lags for the levels of the variables are included.

Table 5 reports the Likelihood ratio (LR) test for cointegration based on Maximal eigenvalue and Trace test statistics for the number of cointegrating vectors. The test statistics for the alternative hypothesis $r \leq 1$ are greater than the critical values at the 5% level. These results indicate that the null hypothesis of zero cointegrating vectors is rejected at 5% level, whilst the hypothesis of one cointegrating vector cannot be rejected. Thus, the spot price level and the futures price level are I(1), with linear combinations being I(0), confirming that the two price series are CI(1,1)[4].

TABLE 5: Johansen Tests for Cointegration of Spot and Futures Prices

Variables	Null Hypothesis	Alternative Hypothesis	LR Test for cointegrating vectors based on		
			Maximal eigenvalue	Trace	Eigenvalues
LS, LF	r=0	r≤1	18.8756[*]	19.0229[*]	0.0259
	r≤1	r=2	1.2368	1.2368	0.0015

LS and LF denote the log of spot and futures prices respectively.

[*] Denotes that the null hypothesis of no cointegration is rejected, while the alternative hypothesis of one cointegrating vector is accepted at the 5% level. The critical value for Maximal eigenvalue and Trace statistics is -13.88 and 15.89 at the 5% level respectively.

Since both price series are CI(1,1), an error correction model (ECM) with lag length 5 on ΔS_t and ΔF_t is estimated using OLS regression[5]:

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[4] The robustness of the results using the Johansen procedure in relation to violations of non-normality and heteroskedasticity was examined using error-based test for cointegration proposed by Phillips and Perron (1988). The results here were confirmed.

[5] The full output from the estimation of the error correction model is available from the author upon request.

$$\Delta LS_t = a_1 + a_S z_{t-1} + \sum_{i=1}^{5} \alpha_{11}(i) \Delta LS_{t-i} + \sum_{i=1}^{5} \alpha_{12}(i) \Delta LF_{t-i} + \varepsilon_{St} \quad (9)$$

$$\Delta LF_t = a_1' + a_F \ z_{t-1} + \sum_{i=1}^{5} \alpha_{21}(i) \Delta LS_{t-i} + \sum_{i=1}^{5} \alpha_{22}(i) \Delta LF_{t-i} + \varepsilon_{Ft} \quad (10)$$

In estimating the ECM, we faced with the problem of serial correlation and heteroskedasticity. So, the OLS estimation is carried out using Cochrane-Orcutt two step method auto-regressive processes (AR) and White (1980) correction for heteroskedasticity to account for those problems.

Table 6 displays the test results of the restrictions imposed on the speed of adjustment coefficients (α_S and α_F) and the lagged variables coefficients (α_{12} and α_{21}) to eq. (9) and (10), using the Wald test statistic, which being x^2 distributed.

TABLE 6: Wald Test Results

Null Hypothesis (H_0)	Wald statistic	P – value
$\alpha_S = 0$	0.5221	0.632
$\alpha_F = 0$	9.0253	0.009
$\alpha_{12} = 0$	39.4622	0.001
$\alpha_{21} = 0$	21.9413	0.005
$\alpha_{12} = 0$, $\alpha_{21} = 0$	41.0257	0.002

The results of the Wald test on the speed of adjustment coefficients (α_S and α_F) indicate that the spot and futures contract behave somewhat differently. The lack of significance of α_S means the spot market does not respond to the previous period's deviation from equilibrium. The significance of α_F means the current period futures innovation responds to the previous period's deviation from equilibrium. The finding that one of the speeds of adjustment coefficients is nonzero ($\alpha_F \neq 0$) confirms that the model is an error correction model.

The significant speed of adjustment in eq. (10) does not mean that the spot market leads or causes the futures market. Respectively, the insignificant speed of adjustment in eq. (9) does not mean that the futures market is not leading the spot market. In order to conclude about the direction of causality or the lead-lag relationship between the two markets, we have to test the significance of the lagged variables coefficients. The results of the Wald test on coefficients α_{12} and α_{21} show that the null hypothesis (the coefficients are individually and jointly equal to zero) cannot be accepted. Thus, the significance of α_{12} and α_{21} indicates the existence of a bi-directional causality or a feedback relationship between the two markets, since the last period's price changes in S_t (F_t) "short run" affect the current period's price changes in F_t (S_t).

This finding indicates that the FTSE/ASE- 20 futures contract serves as a focal point of information assimilation and fulfills its price discovery function. So, futures prices contain useful information about subsequent spot prices, beyond that already embedded in the current spot price. This has an important implication for market participants in the Greek capital market, indicating that there are opportunities for significant arbitrage profits and hedging strategies.

Finally, our finding that a newly established (emerging) derivatives market provides the function of price discovery deserves further discussion. There are many reasons which might explain why futures prices lead cash index prices. The first explanation is that the futures market is less costly for traders to utilize than the cash market. Other reasons could be the lower transactions costs in the futures market, the ease in shorting futures contracts and the investors' preference to hold futures contracts because they are not interested in the underlying asset per se.

5. SUMMARY AND CONCLUSIONS

This paper examines the relationship between the FTSE/ASE- 20 stock index and its three-month futures contract during the period from August 1999 until June 2002. The aim is to investigate the price discovery in the Greek FTSE-20 index futures market and to determine the informational linkage between the spot and the futures market.

The unit root tests conclude that each series is non-stationary in the levels but stationary after first differencing. Both the spot index and the futures markets are tested for cointegration using both the Engle-Granger and Johansen methods. Both testing procedures indicate that the two markets are cointegrated. Thus, an error correction model is developed in order to investigate the causality or the lead-lag relationship between the two markets.

The results of this model indicate the presence of a bi-directional causality between the spot index and the futures index markets, and thus an informational linkage between them. That means the index prices in futures market (cash market) may contain useful information regarding consequent price movements of the stock index market (futures market). This empirical finding suggests that the newly established ADEX market provide futures contracts that can be used as vehicles of price discovery and indicates the important role that this futures market plays in the Greek capital market towards its ultimate maturity, transparency and secure functioning. The existence of such an informational linkage between stock index spot and futures markets implies that investors using these markets can explore significant arbitrage profits and hedging opportunities.

Finally, this paper provides two directions for future research regarding the price discovery in the ADEX. First, the relationship between price discovery and volume of futures trading in each month of the FTSE/ASE-20 contract constitutes an interesting topic for research. Second, attention has to be given to the relationship in volatilities between the two markets. If volatility spillovers exist from one market to the other, then the volatility transmitting market may be used as a vehicle of price discovery, since such information may contribute to the decision-making process.

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