Informational Efficiency and Spurious Spillover effects between Spot and Derivatives Markets

Abstract[1]

Research on the relationship between spot and derivatives markets has attracted the interest of many economists and financial analysts. According to many researchers there exists a puzzle regarding the lead-lag effect and the causality of possible spillover effects between these markets. Derivatives markets should produce the means for price discovery with a leading role in the transmission of new information. Thus, the standalone examination of the relationship of the volatility between spot and derivatives markets, does not account for possible disequilibria in the long term relationship and the informational efficiency between these markets and result in spurious spillover effects, diminishing, thus, the importance of derivatives markets as being well functioning and efficient ones.

This paper uses data from three European stock market indices and contributes to the literature on the spot-derivatives spillover effects by controlling for possible disturbances in the long run equilibrium relationship between them, through a regime shift econometric approach taking into account structural breaks which are statistically and economically important.

The empirical findings of the paper are in favour of the informational efficiency of these markets only partially for specific sub-periods, for which the spillover effects as well as the price discovery inherent in derivatives markets are significant.

Keywords: Spurious spillover effects, Derivatives markets, Regime shift

JEL Classification: C22, C52, C53, G15

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1. Introduction

During the past decades the derivatives markets have contributed substantially to the effectiveness of financial markets. Merton (1997, 1998) argued that, initially, the establishment of derivatives markets contributed to risk management through the hedging processes and enhanced the informational value of financial derivatives products, increasing, thus, the investment opportunity set in financial markets.

Research on the relationship between spot and derivatives markets is voluminous. As a rule, researchers focus either on the long or the short run relationship between derivatives and spot prices and yields, respectively. The long run relationship between spot and derivatives products is based on the hypothesis that derivatives contracts prices incorporate investor expectations of future spot yields, given all available information up to the date the contract is purchased. On the other hand, the transmission process of information governs the short run structure of the abovementioned relationship, since the lead-lag and the spillover effects imply an efficient functioning of derivatives markets. Nevertheless, previous papers investigate separately the unbiasedness hypothesis[2] (UH) and the lead-lag effects between these markets, deriving spurious spillover effects, which depend on the sample examined and the econometric methodology applied.

According to the normal backwardation theory the expected future spot prices are greater than derivatives prices and consequently greater than spot prices. The positive deviation between derivatives and spot prices represents the insurance premium that speculators require from hedgers in order to undertake the risk that arises from future spot price fluctuations.

The informational value of derivatives markets contributes to the efficiency and completeness of financial markets, mainly because derivatives yields represent unbiased predictors and/or expectations of future spot yields. The long run equilibrium relationship between spot and derivatives markets is very often disturbed by short run deviations, caused either by trading imbalances in the way demand and supply forces interact or by the different regulation framework of these markets. Hence, hedgers and speculators are active units in the

[2] The unbiasedness hypothesis states that the derivatives yields are efficient and unbiased predictors of future spot yields given all the available information.

derivatives markets and jointly contribute to the formation of fundamental values. The flow of information between these markets is jointly investigated with possible spillover effects that represent the mechanism according to which economic units react in the accumulation of new information, formulate efficient risk-return regimes and contribute to effective risk allocation.

The objective of this paper is to investigate the spillover effects between spot and derivatives financial products in a framework that takes into account the time properties of their long run equilibrium relationship. More specifically this paper fills the gap in the literature by examining the spillover and the lead-lag effects between spot and derivatives markets within a regime shift approach that considers separately the sub-periods for which there exist structural breaks on the cointegration relationship of spot and derivatives prices.

The rest of the paper is organized as follows. Section 2 provides a brief discussion of the literature, while section 3 describes the data and the applied econometric methodology. Section 4 presents the empirical findings and finally, Section 5 concludes the paper.

2. Literature Review

Grossman (1977) argued that financial information is traded in derivatives markets and as a result, derivatives yields should include the cost of the accumulated new information. However, he points out that in developed and efficient markets the transmission of information is publicly available and hence, is uniformly distributed to investors, eliminating any arbitrage opportunities. In the absence of noise, the information is costless and is transmitted from the informed to non-informed units.

Many analysts have investigated the long run equilibrium relationship between spot and derivatives yields and by considering the informational efficiency of financial products they have found that very often derivatives markets contribute substantially to the price discovery process. Fama and French (1987) investigated the relationship between spot and derivatives using data from 21 commodities. Based on both the theory of storage and the derivatives risk premium (decomposition of futures prices into an expected risk premium and a forecast of a future spot prices), their empirical results are in favour of the theory of the storage cost, according to which the contemporaneous spot and futures prices are expressed in terms of interest foregone in storing commodities, warehousing costs and a convenience yield on inventory.

Brenner and Kronner (1995) utilized the arbitrage free cost of carry asset pricing model in order to investigate the relationship of spot and derivatives markets. Using data from exchange rates as well as from commodities they applied a cointegration framework and concluded that the UH is valid in most cases. Norrbin and Reffett (1996) examined the UH using forward rates. They relied on a cointegration framework and found significant (1 -1) cointegrating vectors. Furthermore, by application of the VECM model they concluded that the forward rates adjust completely in possible short-run deviations of the common trend in contrast to spot rates.

Abhyankar (1998) used spot and futures prices from two main financial indices, the S&P500 and the FTSE100, and investigated the lead-lag and causality relationship between the two markets. Based on a nonlinear causality model he concluded that there exist significant bi-directional nonlinear causal relationships between the futures and spot markets. Pizzi, Economopoulos and O'Neil (1998) investigated the informational efficiency of spot and derivatives financial products of the S&P500 index. Using high frequency data and applying the Engle-Granger econometric methodology they concluded that the futures market contributes substantially to the price discovery, since futures contracts play the key role in the aforementioned relationship. Tse (1998) used data from the Euromark futures contracts which is traded on LIFFE and SIMEX, in order to investigate the informational efficiency and the price discovery process of these exchanges. By application of the Johansen cointegration framework he found a significant equilibrium state of the two exchanges.

Min and Najand (1999) used data from the Korean Stock exchange in order to investigate the lead-lag relationship between spot and futures markets. Utilizing high frequency data, they concluded that the futures market leads the common trend by approximately 30 minutes and that there exist significant bidirectional relationships in the volatility which is associated with the trading activity of the corresponding financial products. Illueca and Lafuente (2003) examined the Ibex-35 financial index and investigated the price discovery process of spot and futures contracts in a non-parametric framework. According to their empirical findings, the futures market contributes substantially in the formulation of the equilibrium prices of these markets. Villanueva (2007) investigated the UH in the currency market and the forward exchange (FOREX) of the US dollar, Deutsche Mark, British Pound and the Japanese Yen. He applied an econometric methodology that allows for possible endogenous structural breaks in the cointegrating relationship examined and concluded that the UH is valid over most periods either in the long or the short time horizon.

On the other hand, many analysts have investigated the spillover effects between spot and derivatives products. According to the empirical findings of previous research, derivatives markets, in most cases, play a key role in the transmission of new information. However, the extant literature is inconclusive regarding the direction of the spillover effects, since these are either sample or model specific. Kawalleer, Koch and Koch (1990) examined the volatility spillover between futures contracts and spot returns of the S&P500 stock index. They found that the futures' variance is higher than that of the underlying spot market, that there exist significant spillover effects from futures to spot returns and that there does not exist any significant lead-lag effect between the two markets. Koutmos and Tucker (1996) applied the VECM-GARCH model using the S&P500 futures contracts and spot index prices. They concluded that there exist a significant relationship between the two markets both in the short and the long run. They also found that there exist spillover effects from the futures to the spot market and that the leverage effect (volatility specification) is more significant in the futures market.

Sim and Zurbreugg (1999) investigated the spillover effects between the futures and spot markets of Australia and Japan simultaneously by the application of a multivariate GARCH model of dimension four. They found that there exist significant spillover effects within and between these markets. Silvapulle and Moosa (1999) used data from the WTI crude oil in order to investigate the relationship between futures and spot markets. Although conventional causality tests support the existence of significant relationships mainly from futures to spot markets, use of non-linear techniques sheds much light on the existence of bidirectional relationships. Tse (1999) examined the price discovery mechanism of the most tradable stock index, the DJIA, using high frequency data of the spot and the futures market. By application of the Hasbrouck cointegration and a bivariate EGARCH models he found that although the futures market contributes substantially to the price discovery process there exists significant bidirectional information flow in the second moment of the returns of these market.

Zhong, Darrat and Otero (2004) investigated the case of the Mexican stock market and found that the stock index futures contracts contribute to the price discovery process, while the introduction of stock index futures had a destabilization effect on the corresponding spot indices. Thus, they conclude that the supervision authorities could impose the necessary regulation framework in order to avoid high volatility spillovers from futures to spot prices.

Kenourgios (2004) used data from the FTSE/ATHEX-20 cash and futures markets and found that there exist significant bi-directional causal relationships between them. Kavussanos, Visvikis and Menachof (2004) used data from the Forward Freight Agreements (FFA) in order to investigate the informational efficiency of derivatives and spot markets. Applying the VECM-GARCH-X and the VECM-SURE econometric model, the authors concluded that there was a significant common trend and a bidirectional relationship between the two markets. However, this relationship depends on the type of the FFA and in most cases the forward market seems to play the leading role in the price discovery process. Holowczak, Simaan and Wu (2006) investigated the price discovery process within derivatives and spot markets. They applied a portfolio based approach on option prices which consists of a long call and a short put option, resulting on a payoff which depends only on the spot prices and not on the underlying volatilities or higher moments of spot returns. Using tick by tick data of the US stock options markets, they concluded that the spot prices contribute substantially on the price discovery process while their leading role is strengthened even more with the adoption of innovative automated quoting algorithms in derivatives markets, unless the trading activity in derivatives markets is increased. Moreover, Kavussanos, Visvikis and Alexakis (2008) investigated the lead-lag effect and the price discovery process between spot and futures markets using the FTSE/ATHEX-20 and the FTSE/ATHEX Mid-40 financial indices. By application of an augmented bivariate VECM-GARCH-X model they concluded that the futures markets contribute substantially to the price discovery process, the informational efficiency and the transmission mechanism of information. Moreover, there exist significant spillover effects from the futures markets to the corresponding spot, especially in the case of the FTSE/ATHEX-20 index.

3. Data and Research Methodology

Our dataset consists of the major financial indices of three European financial markets, the FTSE-100 from UK, the FTSE/ATHEX-20 from Greece and the Ibex-35 from Spain. The database is both of daily and monthly frequency for the spot and futures prices in order to account for the short and the long term properties of the time series examined, respectively. The futures contracts are near to maturity, in order to avoid the large disturbances between the examined spot-derivatives time series due to the fluctuation of the basis risk. The time period investigated covers a time span of twenty-four years for UK (03/05/1984-18/01/2008), sixteen years for Spain (20/04/1992-18/01/2008) and three years for Greece (02/01/2004-18/01/2007), as illustrated in Figure 1 of the appendix.

For the purposes of our analysis, we adopt both linear and non-linear econometric methodologies in order to account for possible regime shifts on either the long run equilibrium relationship or the short run re-adjustments around any common trend.

The first step of our analysis consists of the examination of the stationary properties of the time series in a univariate framework, through conventional linear or non-linear methodologies. The Dickey & Fuller (1979) ADF test is implemented through the following equation:

$$\Delta x_t = a + \beta \cdot t + (\rho - 1) \cdot x_{t-1} + \sum_{i=1}^{q} \psi_i \cdot \Delta x_{t-i} + \varepsilon_t \tag{1}$$

where, x_t stands for the prices in the spot and futures markets for each financial index and the order of p and q is estimated through the AIC and BIC criteria. The pair of the null and the alternative hypothesis:

H_0: the x_t time series has a unit root on the characteristic polynomial or $|\rho| = 1$

H_1: the x_t time series is stationary or $|\rho| < 1$

is tested according to the t-statistic:

$$t - statistic = \left(1 - \hat{\rho}\right) / s.e.\left(\hat{\rho}\right) \tag{2}$$

The Kwiatkowski, Phillips, Schmidt & Shin (1992) KPSS test is based on a linear filter of the mean and trend of the time series. The pair of the null and the alternative hypothesis:

H_0: the x_t time series is stationary

H_1: the x_t time series is not stationary

is tested according to the maximum likelihood method according to the following equation:

$$LM = \frac{\sum_{t=1}^{T}\left(\sum_{r=1}^{t}\hat{\varepsilon}_{tr}^{2}\right)}{T^2 \cdot f_0} \qquad (3)$$

where f_0 is the frequency domain estimation of the residuals at zero.

We also apply the Lee and Strazicich (2002) test of stationarity which accounts for endogenous structural breaks in the time series being examined according to the following equations:

$$x_t = \delta' \cdot Z_t + \varepsilon_t \text{ and } \varepsilon_t = \beta \cdot \varepsilon_{t-1} + u_t \qquad (4)$$

where Z_t is a vector with exogenous variables or a linear filter of x_t and $u_t \sim$ iid $N(0,\sigma^2)$

$Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]$

$D_{jt} = 1$ for $t \geq TB_{j+1}$, and zero for $j \neq 1, 2$, where TB is the timing of the structural break. The pair of the null and the alternative hypothesis:

H_0: $x_t = \mu_0 + d_1 \cdot B_{1t} + d_2 \cdot B_{2t} + d_3 \cdot D_{1t} + d_4 \cdot D_{2t} + x_{t-1} + v_{1t}$

H_1: $x_t = \mu_1 + \gamma \cdot t + d_1 \cdot D_{1t} + d_2 \times D_{2t} + d_3 \cdot DT_{1t} + d_4 \cdot DT_{2t} + v_{2t}$

is tested through the maximum likelihood test statistic:

$$\Delta x_t = \delta' \cdot \Delta Z_t + \phi \cdot \tilde{S}_{t-1} + w_t \qquad (5)$$

$$\tilde{S}_t = x_t - \tilde{\Psi}_x - Z_t \cdot \tilde{\delta}, \text{ for } t = 2, \ldots, T, \ \tilde{\delta} \qquad (6)$$

H_0: $\varphi=0$, where $\varphi = T\tilde{\phi}$

H_1: otherwise

In this context we aim to determine possible endogenous structural breaks in the examined time series in a univariate framework, which is going to be re-evaluated while investigating the long-run properties of the cointegration analysis in the next steps of the analysis.

The second step of the analysis is the examination of the properties of the long run relationship between the examined indices; that is, the cointegration relationship between the spot-derivatives time series. A stable long run state between these series implies that the corresponding financial market is efficient in the weak sense and that the unbiasedness hypothesis (UH) holds.

The theoretical framework for the pricing of derivatives products is given below:

$$f_{t|t-k} = E_{t-k}\left(s_t \mid \Omega_{t-k}\right) \tag{7}$$

where:

$f_{t|t-k}$: the futures contract yield at *t-k* with delivery date *t*

$E_{t-k}\left(. \mid \Omega_{t-k}\right)$: the mathematical expectation of the random variable (.) given the information set at *t-k*

s_t: the yield of the underlying asset at *t*

Ω_{t-k}: the information set at *t-k* with respect to the financial random variables examined

According to Brenner and Kronner (1995) the most common way to examine the UH is the regression between lagged derivatives yields and future spot yields '*future Log Level regression*', as well as the regression between current spot and derivatives yields '*current LL regression*'. The coefficient 'β' of the '*future LL*' regression in the following equation plays a key role for the determination of a long run relationship of spot and derivatives prices:

$$s_{t+1} = \alpha + \beta f_t + d_{t+1} \tag{8}$$

The UH is valid if and only if the coefficient 'β' is unit and the disturbance term is a stationary process:

$$d_{t+1} = [(s_{t+1} - f_t) - \alpha] \sim I(0) \tag{9}$$

Thus, the UH implies that the difference between future spot yields and lagged futures yields should be a stationary process:

$$(s_{t+1} - f_t) = excess\ returns \sim I(0) \tag{10}$$

Alternatively, under the '*current LL regression*' the excess returns are decomposed into the spot returns and the derivatives premium:

$$(s_{t+1} - f_t) = (s_{t+1} - s_t) + (s_t - f_t) \tag{11}$$

and consequently the derivatives premium term should be a stationary process unless the excess return and the spot returns are not stationary:

$$(s_t - f_t) \sim I(0) \tag{12}$$

In this case, the UH could be examined through the current spot and derivatives yields. Indeed, in our analysis we implement the current spot-futures regression and we examine the the UH by testing if the cointegrated vector has a (1 -1) structure:

$$s_t = \alpha' + \beta' f_t + d_{t+1} \tag{13}$$

The investigation of the long run relationship is implemented under the Johansen's (1988, 1991) cointegration model. The statistical notion of cointegration of a set of non-stationary time series is derived by a linear combination of the time series vectors which is stationary. Thus, a set of cointegrated financial series implies the existence of a common trend. The existence of r cointegrating relations in a set of n variables means that there must also exist *n-r* common stochastic trends that are non-stationary and move the system in short run adjustments around their equilibrium state(s). In our case we are interested in one common long run relationship in each pair of spot-derivatives time series. Furthermore, the cointegration methodology was extended by Johansen and Juselius (1990, 1992 and 1994) and Gonzalo and Granger (1995) who considered the restrictions that should be imposed in the VAR cointegration analysis, as shown below:

$$x_t = \mu + \Pi_1 x_{t-1} + \Pi_2 x_{t-2} + \ldots + \Pi_k x_{t-k} + \varepsilon_t \qquad (14)$$

$$\text{or } \Delta x_t = \Pi \cdot x_{t-1} + \sum_{i=1}^{N} \sum_{j=1}^{k-1} \Gamma_{ij} \cdot \Delta x_{i,t-j} + \varepsilon_t \qquad (15)$$

where the residuals of these equations are assumed as independent identically random variables drawn from the zero mean Gaussian distribution with variance σ^2. The Π, Γ matrices consist of the cointegration coefficients of the system. More precisely, the Π matrix is partitioned into the 'β' coefficients that represent the long run equilibrium state of the system and into the 'α' coefficients that represent the short run adjustments around the common trend(s)[3]. Thus, the x_t time series are cointegrated of order r, with cointegration vector 'β'. In order to estimate the cointegration vector 'β' the Maximum Likelihood Estimation is applied[4]. Hence, the likelihood ratio statistic of H_0 (existence of at most r cointegration vectors) is the following:

$$-2 \cdot ln(Q) = -T \cdot \sum_{i=r+1}^{p} ln\left(1 - \hat{\lambda}_i\right) \qquad (16)$$

where $\hat{\lambda}_{r+1}, \ldots, \hat{\lambda}_p$ are the 'p-r' lowest squared normal equinvalues. The rank of the cointegration vector is based on the following two statistics:

$$\lambda_{trace} = -T \cdot \sum_{i=r+1}^{p} ln\left(1 - \hat{\lambda}_i\right) \text{ and } \quad \lambda_{\max} = -T \cdot ln\left(1 - \hat{\lambda}_{r+1}\right) \qquad (17)$$

Thus, based on these equations the likelihood ratio statistic turns to:

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[3] $A(z) = 1 - \Pi_1 z - \ldots - \Pi_k z^k$
$|A(z)| = 0$ for $z = 1$
$A(z)|_{z=1} = \Pi = 1 - \Pi_1 + \Pi_2 + \ldots + \Pi_k = \alpha\beta'$, $\alpha_{p,r}$, $\beta_{r,p}$
Rank $(r, m) = r < p$

[4]
i. estimate the r higher squared correlations of the residuals (ε_t) of x_{t-1} and Δx_{t-1} on $\Delta x_{t-1}, \ldots, \Delta x_{t-k}$ and calculate the S_{ij} term: $S_{ij} = \frac{1}{T} \cdot \sum_{t=1}^{T} \varepsilon_{it} \cdot \varepsilon'_{jt}$
ii. define the pair of the tested hypothesis
H_0: $rank(\Pi) \leq r$ or $\Pi = \alpha\beta'$
H_1: $rank(\Pi) = r+1$
iii. under the validity of the H_0 the MLE estimators of α, β coefficients are derived by the minimization of the following term with respect to the equinvalue 'β': $| S_{00} - S_{0k} \cdot \beta \cdot (\beta' \cdot S_{kk} \cdot \beta)^{-1} \cdot \beta' \cdot S_{k0} |$ where $\hat{\beta}$ is a vector with the highest r equinvalues that derive by the maximization of the term $S_{k0} \cdot \beta \cdot S_{0k}$ with respect to the S_{kk} standardized term $\hat{\beta}' \cdot S_{0k} \cdot \hat{\beta} = I$ and $\hat{a} = S_{0k} \cdot \hat{\beta}$

$$L = -T \cdot \sum_{i=r+1}^{p} ln\left[\left(1 - \hat{\lambda}^{*}_{i+(m-p)}\right) \Big/ \left(1 - \hat{\lambda}_i\right)\right] \sim X^2_{(n-r)(n-k)} \quad (18)$$

Our analysis is based on the current LL regression where the UH is tested through the following pair of hypothesis: H_0: $\beta=1$ & H_1: $\beta \neq 1$

However, the Johansen (1988, 1991) methodology does not capture any structural break that could possibly exist in the spot-derivatives relationship, due to exogenous factors that governs the financial system which are either unobserved or their identification and quantification is very difficult to be implemented.

For that reason, we apply the methodology proposed by Gregory and Hansen (1996), which allows the possible cointegration vector to readjust its parameters, according to a parameter ('τ') that represents the timing of structural breaks according to the following equations:

L/S $$futures_t = \mu_1 + \mu_2 \cdot \phi_{i\tau} + a_{\perp} \cdot spot_t + e_t \quad (19)$$

C/T $$futures_t = \mu_1 + \mu_2 \cdot \phi_{i\tau} + \beta \cdot t + a_{\perp} \cdot spot_t + e_t \quad (20)$$

C/S $$futures_t = \mu_1 + \mu_2 \cdot \phi_{i\tau} + a_{1\perp} \cdot spot_t + a_{2\perp} \cdot \phi_{i\tau} + e_t \quad (21)$$

where $$\phi_{i\tau} = \begin{cases} 0, t \leq [n\tau] \\ 1, t > [n\tau] \end{cases}, \tau \in (0,1) \quad (22)$$

According to this model, we aim to identify any disturbance of the possible equilibrium long run spot-derivatives relationship which will enable us to split our time series into sub-periods. Thus, in this framework we will investigate the spillover effects independently focusing mainly into those sub-periods for which the inherent of informational efficiency as examined through the UH, would provide a reasonable and justifiable interpretation of our results.

Furthermore, in order to investigate the informational efficiency (*price discovery*) of spot and derivatives yields, the vector error correction model (*VECM*) of Davidson, Hendry, Srba and Yeo (1978) is applied. The VECM model would enable us to decompose the contribution of each financial time series in the formulation of the equilibrium state for the whole time span and for each sub-period, according to the following equation:

$$\Delta x_t = \sum_{v=1}^{N-r} \alpha_v \cdot VECM_{v,t-1} + \sum_{i=1}^{N} \sum_{j=1}^{k-1} \Gamma_{ij} \cdot \Delta x_{i,t-j} + \varepsilon_t \,, \tag{23}$$

where the a_v vector of parameters represents the long run equilibrium of spot-derivatives yields and the elements of the Γ matrix, the short run re-adjustments around the common trend.

As mentioned previously, the investigation of the relationship of a set of financial time series depends on many unobserved factors that is not feasible to account for. For that reason the investigation of the price discovery process would be more efficient by consideration of more sophisticated econometric approaches that enable changes of the regime of the model. Regime shift models produce better results in terms of both statistical fit and predictive power, compared with conventional models. Furthermore, non-linear models allow for explosive shifts found in the mean process of the underlying returns. Even though the effect of a rare event, like a market crash, a new regulatory policy, the launch of new innovative financial products or the implementation of new trading systems, might be temporary, it is very likely that the magnitude of a rare event can have very serious effects on the estimation of time series models. In order to account for stochastic regimes in the adjustment process around equilibrium states we apply the 2-state Markov-switching model *MSI(M)(AH)-VECM* of Krozlig (1996, 1997):

$$\Delta x_t = \sum_{v=1}^{N-r} \alpha_v \left(s_t\right) \cdot VECM_{v,t-1} + \sum_{i=1}^{N} \sum_{j=1}^{k-1} \Gamma_{ij} \left(s_t\right) \cdot \Delta x_{i,t-j} + \varepsilon_t \tag{24}$$

where, S_t is a latent variable which corresponds to the 'regime' of the VECM model and follows an endogenous Markov-chain with two levels in the corresponding coefficient matrices for the long and short run dynamics of the cointegration relationship. The latent variable S_t corresponds to the 'State' or 'Regime' that the VECM process is at time *t* and is modeled through a Markov-chain of two levels, as follows:

$$P\left(S_t = j \mid S_{t-1} = i, ..., y_{t-1}, y_{t-2}, ...\right) = P\left(S_t = j \mid S_{t-1} = i\right) \tag{25}$$

$$P = \begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix}, \ \sum_{j=1}^{2} p_{ij} = 1 \tag{26}$$

where $P\ \{p_{ij}\}$ is the transition matrix of the above states. The MS-VECM model offers a better understanding of the cointegration process, since the parameter set is changing under a Markov-switching structure.

In order to investigate the lead-lag and the spillover effects between spot and derivatives financial products, we apply the multivariate GARCH models of Ledoit, Pedro and Wolf (2002) (Flexible Diagonal GARCH - FDG) and Engle and Shepaprd (2001) (Dynamic Conditional Correlation - DCC), using daily frequency of the data and controlling for the long run spot-derivatives relationship, as is determined economically by the unbiasedness hypothesis. Thus, we apply the MS-VECM-GARCH for the whole sample and for each sub-period, taking into account the long run properties of the time series. The FDG estimation procedure is simple and offers a flexible tool for researchers, especially for high dimension data sets. The DCC estimation procedure consists of two steps. Initially, we estimate the volatility in a univariate level and in the second step, we estimate the time varying covariance matrix H_t according to the following equations:

$$x_t = f(z_t) + \varepsilon_t \tag{27}$$

$$\varepsilon_t \mid \Psi_{t-1} \sim F\left[0, H_t\right] \tag{28}$$

$$H_t = \boldsymbol{\Sigma} + A \cdot \left(\varepsilon_{t-1}\varepsilon_{t-1}^{'}\right) + B \cdot H_{t-1} \tag{29}$$

where the 'f' function demeans the data, the Σ matrix denotes the unconditional covariance matrix, and the $H_{(.)}$ one represents the conditional covariance matrix. More specifically in the case of the DCC model the bivariate volatility specification becomes:

$$H_t = D_t \cdot R_t \cdot D_t \tag{30}$$

where the diagonal matrix D_t consists of the univariate conditional volatility $\sqrt{h_{it}}$, and the correlation matrix R_t which is derived by the unconditional variance-covariance matrix $\overline{Q}$:

$$Q_t = \left(1 - a - \beta\right) \cdot \overline{Q} + a \cdot \varepsilon_{t-1}^{*} \cdot \varepsilon_{t-1}^{*'} + \beta \cdot Q_{t-1} \tag{31}$$

$$R_t = Q_t^{*-1} \cdot Q_t \cdot Q_t^{*-1} \tag{32}$$

where ε^{*} are the standardized residuals of the first step analysis:

$$\left\{\varepsilon^*\right\}_{it} = \left\{\varepsilon_{it} / \sqrt{h_{it}}\right\} \tag{33}$$

$$Q_t^* = \left\{\sqrt{q_{ij}}\right\} \tag{34}$$

$$\rho_{ijt} = q_{ijt} / \sqrt{q_{ii} \cdot q_{jj}} \tag{35}$$

Finally, we apply causality tests on the diagonal elements of the estimated variance-covariance matrices using the results of the MS-VECM-GARCH model, in order to investigate the direction and the causality of the spillover effects between cash and derivatives markets. The causality tests are examined for various lag values, with a span of 1 to 40 trading days in order to examine the effect of the time period under investigation on the possible bi-directional causality of the spot-derivatives relationship.

5. Empirical Findings

The examination for the existence of unit roots over the whole time period for each stock index is implemented though the ADF and KPSS tests using monthly data, as shown in Table 1, panel A of the appendix. Both of these tests suggest that the indices are not stationary in levels unless the first differences are used. Hence, during the examined time period for each stock index, the time series process in levels has time varying first and/or second moment characteristics, which are flattened within the first differences process. The analysis of the stationarity through the non-linear methodology of Lee and Strazicich (2002), provides similar results with that of ADF and KPSS, but also suggests possible structural breaks of the time series under investigation. These structural breaks which are examined independently for each time series are not presented in the appendix, but their implications are considered in a later step of our analysis which refers to the structural breaks of the cointegration vectors. An interesting result however, regarding these structural breaks is that they occur at the same time for each pair of futures and spot prices.

Since our data are I(1) processes we turn to the investigation of the long run spot-derivatives relationship of the three indices, based on the Johansen cointegration methodology for each pair of the I(1) series. The examination of the unbiasednes Hypothesis (UH) is tested through the corresponding cointegration vector and the relative chi-square statistic for the existence of (1 -1) cointegrated relationships in the current spot-futures regressions.

As shown in Table 2 – panel A of the appendix, either the trace or the maximum likelihood statistic suggest that the spot-derivatives series are cointegrated significantly at 5%, for Greece (FTSE/ATHEX-20) and Spain (Ibex-35), while in the case of the FTSE-100 (UK) the results are against the cointegration of the pair of the series examined, since there exist two cointegrated vectors. However, this is not sufficient for the acceptance of the unbiasedness hypothesis. Thus, in the case of the cointegrated spot-derivatives series, i.e. for Greece and Spain, the chi-square statistics of the (1 -1) cointegrated vector and the corresponding p-values cast doubt on the validity of the UH (p-values<0.02). Thus, by consideration of the whole sample period, we have found that only for the cases of FTSE/ATHEX-20 and Ibex-35 the spot-derivatives series are cointegrated, while the unbiasedness hypothesis is not valid for any pair of spot-derivatives series.

In order to take into account the unobserved factors that interact with the financial system causing structural breaks and govern stock exchanges to reach different regimes very often, we apply the Gregory-Hansen (1996) methodology. Using monthly frequency of the data we derived two structural breaks for each cointegration relationship. More specifically, the structural breaks on the common trend for the FTSE/ATHEX-20 (Greece) occurred on January 2005 and on May 2006, for the FTSE-100 (UK) on January 1993 and on January 2000, and for the Ibex-35 (Spain) on November 1998 and on November 2001. It should be mentioned that in the case of the UK, in contrast to the results of the Johansen model, the results of the Gregory-Hansen (1996) model suggest that there exist sub-periods for which there exists a significant cointegration relationship between the spot-derivatives series.

Based on the above methodology, we have determined three non-overlapping sub periods for Greece, Spain and UK as follows with respect to the cointegration equation of spot-derivatives markets, as follows:

- Greece: 02/01/2004 – 18/01/2007
    - 1st sub-period: 02/01/04 – 31/01/05
    - 2nd sub-period: 01/02/05 – 02/05/06
    - 3rd sub-period: 01/06/06 – 18/01/07

- UK: 03/05/1984 – 18/01/2008
    - 1st sub-period:03/05/84 – 29/01/93
    - 2nd sub-period: 01/02/93 – 31/12/99
    - 3rd sub-period: 03/01/00 – 18/01/08

- Spain: 20/04/1992 – 18/01/2008
    - 1st sub-period: 20/04/92 – 30/10/98
    - 2nd sub-period: 02/11/98 – 31/10/01
    - 3rd sub-period: 01/11/01 – 18/01/08

The inherent advantage of regime shift models such as the Gregory-Hansen (1996) is at the same time also their weakness since these models let the data decide in what state the financial environment is at a specific time. Thus, we are going to enumerate a number of important changes that have taken place in the financial markets under investigation during the period of about two months around the dates of the structural breaks suggested by the Gregory-Hansen (1996) model. These changes concern legal practices, development of new strategies such as demutualization and cross-border mergers and/or collaboration between stock exchanges, introduction of new and innovative technology products and indices, and establishment of new trading platforms.

More specifically, in the case of the Athens Exchange[5] the Gregory Hansen (1996) model detects two structural breaks, on January 2005 and on May 2006. Regarding the first structural break the Athens Derivatives Exchange at the beginning of December 2004 has implemented a new regulation framework according to which investors could use Government bonds in order to provide the necessary guarantees for purchasing derivatives products, while the transaction and commission costs for purchasing derivatives products, such as futures contracts and options on the FTSE/ATHEX-20 have been decreased by 34% and 17%, respectively. Moreover, at the end of November 2004 the fixed volatility that is embedded in the RIVA model for the determination of the margin requirement on the FTSE-20 and Mid-40 futures contracts has been increased from 18% to 21%. In the same period, at the end of December 2004 the Athens Exchange has adopted a new version of the trading system according to which the price limits and the trading hours have been changed. Finally,

[5] Athens Exchange: www.ase.gr

at the end of January 2005 the Athens Exchange and the Cyprus Stock Exchange completed the final negotiations regarding their cooperation on many aspects while at the end of February 2005, the two exchanges determined the collaborative framework that would contribute to an efficient financial environment according to the standards imposed by developed European capital markets.

For the second structural break, which took place on May 2006, there have occurred many changes in the regulation of the Athens Derivatives Exchange and the Athens Exchange. More specifically, during May and June of 2006 the margin requirements of the options on the two main stock indices, FTSE-20 and Mid-40, have been changed from 20% to 24%, then to 32%, to 36%, to 30%, to 28% and finally to 26%. Moreover, during April of 2006 an assessment exercise has taken place on the Athens Exchange regarding the time required for the determination of the matching between bid and ask pairs, the mid bid-ask spread and the trading volume. Finally, during April and May of 2006 the ATHEX has published several reports which are publicly available and refer to statistical data and a fact book of the listed companies, contributing substantially to the transmission of new information to all investors.

Regarding the London stock exchange[6] the Gregory Hansen (1996) model detects two structural breaks, on January 1993 and on January 2000. With respect to the first structural change it is worth noting to mention that new stock indices (FTSE mid-250 and FTSE Actuaries 350) were introduced on November 1992, increasing the investment opportunity set of investors, and on December 1992, the code of dealing for the Gilt-Edged market has been updated to reflect changes in market practice since the code was last issued in 1989. This reflects changes to dealing and reporting rules and market practice over the past 18 months and provides guidance for dealers of stock exchange member firms who trade in UK equities.

During the period of two months around the second structural break several significant events have taken place. On October 1999 the London stock exchange announced that the techMARK will be launched in due time in order to bring together both listed and new innovative technology companies which was expected to offer benefits both to professional and private investors. In the same direction the London stock exchange announced on February 2000 the creation of the extraMARK for innovative products, such as exchange traded funds (ETFs). ETFs will offer investors access to the performance of an index by

[6] London stock Exchange: www.http://www.londonstockexchange.com/home/homepage.htm

buying shares in a single fund. Although tracking an index helps to spread risk and exposes investors to a wider variety of companies, it can be difficult and expensive for most private investors to do it on their own. Moreover, on October 1999, the London stock exchange announced plans to abandon mutual status and demutualize along the lines of the New York stock exchange. On February 2000 the London stock exchange set the date for an extraordinary general meeting at which its shareholders would vote on demutualization, which would give the exchange a competitive advantage through a simplified ownership structure. Thus, at the end of March of 2000, the 'B' shareholders of the London stock exchange voted in favour of demutualizing the exchange. However, the whole demutualization process which should be accompanied with necessary approvals would not be completed until April of 2000. Furthermore, on November of 1999, the Bank of England, the LSE and the CREST jointly announced proposals for the UK's equity and corporate debt markets to move from T+5 to T+3 settlement, which would be implemented in February 2001. On January 2000, a new arrangement was announced between the London stock exchange and the market data vendor Primark regarding a network provider that would allow domestic and foreign investors to access Europe's largest and most liquid equity market in an efficient and cost-effective manner. Finally, at the beginning of 2000 it was announced that the London stock exchange and the Deutsche Borse would merge to create a new company called iX-international exchanges plc. This merger which is said to represent one of the most significant regulatory and market changes for a generation is subject to regulatory consents in the UK and Germany and is not expected to take place until autumn 2000.

Unfortunately, very little information was found for Spain[7]. A possible important development which seems to be associated with the first structural break occurred on November 1998 and concerns the legal reform on significant issues (Law 37, November 1988) about the structure and functioning of the Spanish securities market. Regarding the second structural break, for the case of Spanish stock exchanges, which covers the period of November 2001, our knowledge is confined to a corruption case which shook the Spanish financial community for quite some time, causing sever negative consequences.

Given that there exist endogenous structural breaks in the cointegration relationship of the spot-derivatives series of Greece, UK and Spain, we continue by examining for each sub-period and for each stock market the stationarity, the cointegration and the unbiasedness

[7] Spanish Stock Exchanges: http://www.bolsamadrid.es/ing/portada.htm, http://www.borsabcn.es/, http://www.bolsavalencia.es/, http://www.bolsabilbao.es/bolsa/fr/html/home-fr.html

hypothesis. The results are shown in panels B, C and D of Tables 1 and 2 of the appendix, respectively.

Regarding the stationarity of the series examined (Table 1, panels B, C and D) we derive similar results with that of the whole time period analysis, with a small exemption for the third sub-period in the case of Greece. While the series in level are non-stationary and only the first differences are stationary, we have found that in Greece for the third sub-period according to the ADF test the spot and futures prices are stationary. In addition, in that case under the KPSS test we have found that the exemption refers only to the spot prices and not to the futures contracts prices. The third sub-period in Greece covers the time interval between 01/06/06 and 18/01/07. The ambiguous results of these tests (ADF and KPSS) as well as the clear positive trend which is obvious from Figure 1 of the appendix over this specific period, and the structural break which is found within this period using the univariate Lee and Strazicich (2002) model, cast doubts on this result. Thus, we will not attempt to answer whether or not the stationarity property hold during this period, since the research aim of our analysis is not affected significantly by this specific contradiction.

Regarding the spot-derivatives long run relationship for each sub-period we have found that the long run equilibrium relationship between spot and derivatives prices exists for UK and Spain for every sub-period, while for Greece the cointegration relationship exists only partially for the second sub-period. However, by consideration of the corresponding chi-square of the (1 -1) cointegration vector which refers to the unbiasedness hypothesis for the cases where we have found a unique cointegration equation, we conclude that for the case of Greece and UK only in the second sub-period the UH holds, while for Spain the UH is valid in each sub-period.

Thus, the application of the Gregory-Hansen (1996) enables us to detect sub-periods for which the UH is valid for Greece, UK and Spain, a result which was not found when the whole sample was used for the investigation of this hypothesis, especially in the case of Spain.

The next step of the analysis is the investigation of the price discovery process. The VECM representation of the spot-derivatives cointegration relationship enables us to make inferences of the contribution of the lagged spot and futures stock index yields to the common trend as well as to the current yields. In Table 3 of the appendix we represent the estimated coefficients for the whole sample analysis and the corresponding sub-periods of each stock index, panel A and panels B, C and D, respectively.

With respect to the FTSE/ATHEX-20 financial index (Greece), we observe that for the whole sample analysis the lagged spot yields contribute substantially to the formulation of the current spot and futures yields, while the price discovery takes effect mostly in the futures markets. In the subsequent non overlapping sub-periods, futures jointly with spot yields contribute to the price discovery process with an exemption of the second sub-period where the futures yields lead this relationship contributing substantially to the price discovery process.

In the case of the FTSE-100 stock index (UK), the results suggest that even for the whole sample analysis the lagged spot yields have a good explanatory power on the current spot and futures yields, an analysis of the price discovery process into the afore mentioned sub-periods suggests that in the first two sub-periods both markets contribute to the informational efficiency, while in the third sub-period spot yields play the leading role.

Finally, for the Ibex-35 stock index (Spain), we have found that either for the whole sample or for the three subsequent sub-periods, both spot and futures yields contribute substantially to the price discovery. However, the lagged futures yields are more informative than the corresponding spot yields for the whole sample analysis and the first sub-period, and vice versa for the first sub-period.

Thus, we conclude that in Greece for the second sub period, where the UH holds, the derivatives market jointly with the common trend between spot and derivatives products increase significantly the informational efficiency. Moreover, in the case of UK and specifically in the second sub-period where the UH holds, jointly spot and futures yields contribute to the price discovery process and finally in the case of Spain where the UH holds, in every sub-period, the price discovery takes place jointly in spot and futures markets.

A more careful analysis of the price discovery process between spot and derivatives markets is implemented through a regime shift analysis, allowing for two regimes for the whole parameter set, to switch through time. Table 4 of the appendix shows the estimated results of the Krozlig (1996, 1997) MS-VECM model, while Table 5 presents the transition probabilities of the two regimes of the model for each financial index, for the whole sample and for each of the aforementioned sub-periods.

In the case of the FTSE/ATHEX-20 stock index, in the whole sample analysis the second regime only, which is the high volatility regime, is significant and suggests that spot and derivatives markets jointly contribute to the price discovery process. While, similar results are found for the consequent sub-periods, with both regimes to be significant, in the second sub-period futures yields seem to play the key role in the informational efficiency of the spot-derivatives relationship.

Furthermore, for the FTSE-100 index it is found that both regimes are significant except for the third sub-period where the first regime dominates the system. More specifically, both spot and derivatives yields contribute to the price discovery process, in either the whole sample analysis or the first and third sub-periods where the UH does not hold. Only, in the second sub-period where the UH is valid, the futures yields seem to lead the common trend contributing thus to the informational efficiency between the two markets.

Finally, in the case of the Ibex-35 stock index, both markets contribute to the price discovery process, either for the whole sample period or for the subsequent sub-periods.

From the preceding discussion of the empirical results one can conclude that application of non-linear models, offers higher degrees of freedom in the investigation of lead-lag effects between spot and derivatives markets, in contrast to the conventional methodologies that the extant literature is based on.

The last part of the analysis consists of the investigation of the spillover effects between spot and derivatives yields (*MS-VECM-GARCH*), within the framework of the unbiasedness hypothesis. Thus we use the residuals of the VECM models in order to model the bivariate conditional covariance of the spot-derivatives time series. In this framework we investigate the causality relationship between the conditional variances of the two series, spot and derivatives either by application of the Flexible Diagonal GARCH model of Ledoit, Pedro and Wolf (2002) or the Dynamic Conditional Correlation model of Engle and Shepard (2001). For that reason, we apply the Granger causality test using 1, 10, 20 and 40 lags in order to account for the timing of possible lead-lag effects.

According to Table 6 of the appendix, we observe that in the case of the FTSE-ATHEX-20 there exist causal relationships between spot and derivatives yields for the whole sample and for every sub-period. More specifically, when this relationship considers one lag, futures yields Granger-cause spot yields in the whole sample and in the second sub-period only, while in the first sub-period there does not exist any causal relationship and finally in the third sub-period there exist significant bidirectional relationships. In the case of ten lags it is observed that futures yields Granger-cause spot yields in every sub-period except the first one. As we increase the order of lags, used in the analysis, to twenty and forty days we observe mainly bidirectional relationships with an exemption of the first sub-period for twenty lags and of the third sub-period for forty lags, where there is no causal relationship detected.

Regarding the FTSE-100 stock index by consideration of one to twenty lags in the whole sample and in the first sub-period there does not exist any causal relationship. However, in the cases of one and ten lags the futures market Granger-causes the corresponding spot market in the second sub-period and in the last sub-period, while in the second sub-period there exist bi-directional relationships when twenty lags are used. Finally, when we use forty lags we find that even for the whole sample the futures market Granger-causes the spot market, there exist significant bi-directional relationships in the second and third sub-periods.

From the investigation of possible causal spot-derivative relationships in the case of the Ibex-35 stock index we have concluded that there is a bi-directional relationship for each sub-period, using one to forty lags. However, by examining the whole sample we have concluded that there was no causal relationship in the cases of one to twenty lags. Unfortunately, several results on Table 6 regarding the cases of FTSE-100 and Ibex-35 are not presented since there exist estimation difficulties with the Markov-switching and the bivariate GARCH models.

Thus, by investigating the spillover effects between spot and derivatives markets our empirical results suggest that futures market's volatility Granger-causes the corresponding spot market's volatility especially in the second sub-period of the analysis for FTSE/ATHEX-20 and FTSE-100 while in the case of the Ibex-35 stock index this relationship is mostly bidirectional. A direct implication of this empirical finding is that the causality between the spot derivatives relationship especially when dealing with the corresponding volatility is associated with the informational efficiency of these markets. More specifically, it is found that in the specific sub-periods for which the unbiasedness hypothesis holds, the futures markets spillover in the corresponding spot market, while the opposite does not hold generally.

We should underline the importance of the lags used in the investigation of the causal relationships, since the higher lags used would enable the flow of information to be transmitted from spot to futures yields and vice versa causing bidirectional relationships.

Finally, we run several robustness and diagnostic statistics in the estimated models, in order to evaluate the usefulness of Markov-switching models compared to the linear and conventional models. As shown in Tables 7 and 8 the incorporation of regime shifts in the parameter set of the econometric methodology provides better results, offering higher degrees of freedom in the interpretation of the parameters estimated. Most of these diagnostic statistics, such as autocorrelation, normality, skewness and kurtosis are in favour of the MS-VECM model against the linear VECM model and hence the non-linear approach which was adopted by us is more reliable than the conventional one, in the estimation of the relevant parameters.

Regarding the case of the FTSE/ATHEX-20, Kenourgios (2004) and Kavussanos, Visvikis and Alexakis (2008) have found similar results with us. Using data for the period 2000-2003 and by application of an augmented bivariate VECM-GARCH-X model they concluded that the futures market contributes substantially to the price discovery process, the informational efficiency and the transmission mechanism of new information and that there exist significant spillover effects from futures to spot markets.

However, our approach considers structural breaks on the investigation of the long run spot-derivatives relationship and detects specific sub-periods for which the unbiasedness hypothesis holds with direct implications on the price discovery process and on the informational efficiency of stock exchanges. Furthermore, we have examined for causal relationships on the spillover effects, while extant literature considers the causal relationship only on the returns of the two markets. Thus, our major contribution on the literature is that we have adopted a methodology that accounts for the inherent of informational efficiency on the spot-derivatives spillover effects and offers an economic explanation of the relationship of the two markets.

6. Conclusions

The informational efficiency inherent in derivatives markets has been investigated in detail in the last decades and it is agreed that derivatives products produce the means for price discovery. Cox (1976), Ross (1976) and Merton (1995) argue that derivatives markets expand the investment opportunity set and increase the informational efficiency of stock exchanges. Furthermore, Karathanassis and Sogiakas (2010) investigated the puzzle regarding the stabilization or destabilization effects that the initiation of derivatives products causes on the corresponding cash market. They concluded that although derivatives onset produces a stabilization effect on the cash market, it is very possible to observe opposite results in the short run due to the presence of speculators and noise traders. Hence, the low transaction costs, the margin trading opportunities, the hedging strategies and the effective risk allocation that most institutional and individual investors are allowed to use through the derivatives markets, increase the depth of the stock exchange and allows the transmission of new information to take place rapidly.

However, the investigation of the spillover effects between the two markets has led to results which are either model or sample specific, making it difficult for researchers, investors and regulatory authorities to make important inferences and adopt new beneficial strategies. One possible explanation is that throughout the extant literature the investigation of the spot derivatives relationships are based on econometric models that do not account for the informational efficiency inherent in these markets and yield, thus, in most cases, spurious spillover effects.

The objective of the paper is the investigation of the spillover effects, the price discovery process and the lead-lag effects between spot and derivatives markets through an econometric approach that accounts for the informational efficiency concept between these two markets. It is worth mentioning that the investigation of spillover effects without the presence of control variables that are associated with the efficient market hypothesis in the weak sense, yield, more often than not, conflicting results and/or spurious spillover effects. For that reason, the inclusion of the first moment conditions in our analysis regarding an equilibrium state of spot-derivatives convergence, explains the way spot and derivatives markets react better in the transmission of new information. Thus, the investigation of the spillover effects, under the validity of the unbiasedness hypothesis is very important, since this provides the necessary economic framework for interpreting our empirical findings.

According to the results of our analysis, as shown in Table 9 of the appendix in a comprehensive way, there exist specific time periods where futures yields are efficient predictors of future spot yields although non-rational investor behaviour causes short run deviations from the long run equilibrium. As it is impossible to model these short run deviations through linear and conventional econometric methodologies we have adopted Markov-switching methodologies, according to which derivatives prices are unbiased estimators of future spot prices, only partially in specific sub-periods for which derivatives yields are the means for the price discovery process and consequently play a leading role in the transmission of information with significant spillover effects on the corresponding spot market. More specifically, we have found that in efficient capital markets, futures yields represent the unbiased expectations of future spot yields and there exist significant spillover effects from futures to spot markets.

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Appendix

Figure 1 Spot and Derivatives prices of FTSE/ATHEX-20, FTSE-100 and Ibex-35 indices

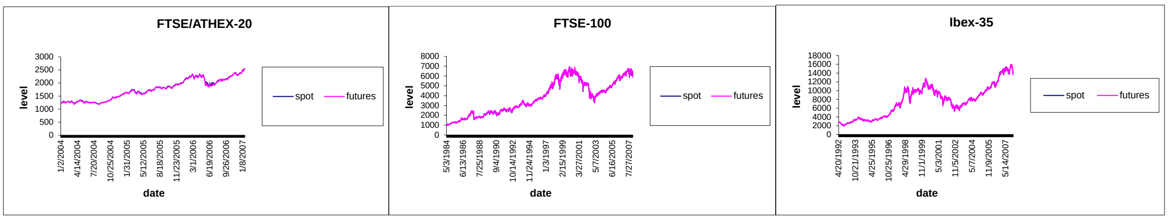

Table 1 Unit root and stationarity tests for the whole sample and for the sub-samples

Unit Root & Stationarity Tests for the whole sample & for the three subperiods												
	Greece				UK				Spain			
panel A: whole sample	(Gr: 02/01/04-18/01/07, UK: 03/05/84-18/01/08 & Spain: 20/04/92-18/01/08)											
	ADF*		KPSS**		ADF*		KPSS**		ADF*		KPSS**	
	level	1st d	level	1st d	level	1st d	level	1st d	level	1st d	level	1st d
spot	-2,158	-25,704	0,150	0,054	-1,933	-49,538	0,784	0,062	-1,632	-62,556	0,699	0,097
futures	-2,158	-27,720	0,137	0,032	-1,993	-49,918	0,783	0,059	-1,736	-64,984	0,701	0,092
* crit.values: -3,970 (1%), -3,416 (5%), -3,130 (10%)												
** crit.values: 0,216 (1%), 0,146 (5%), 0,119 (10%)												
panel B: first subperiod	(Gr: 02/01/04-31/01/05, UK: 03/05/84-29/01/93 & Spain: 20/04/92-30/10/98)											
spot	-0,770	-15,763	0,407	0,106	-2,875	-44,027	0,264	0,027	-2,377	-6,660	0,979	0,060
futures	-0,914	-17,536	0,411	0,087	-3,036	-46,071	0,269	0,025	-1,693	-40,129	0,979	0,056
* crit.values: -3,992 (1%), -3,426 (5%), -3,136 (10%)												
** crit.values: 0,216 (1%), 0,146 (5%), 0,119 (10%)												
panel C: second subperiod	(Gr: 01/02/05-02/05/06, UK: 01/02/93-31/12/99 & Spain: 02/11/98-31/10/01)											
spot	-2,484	-14,740	0,340	0,039	-2,730	-38,743	0,900	0,025	-2,005	-27,298	0,679	0,027
futures	-2,331	-15,663	0,322	0,040	-2,784	-41,914	0,903	0,027	-2,157	-28,960	0,676	0,026
* crit.values: -3,988 (1%), -3,424 (5%), -3,135 (10%)												
** crit.values: 0,216 (1%), 0,146 (5%), 0,119 (10%)												
panel D: third subperiod	(Gr: 01/06/06-18/01/07, UK: 03/01/00-18/01/08 & Spain: 01/11/01-18/01/08)											
spot	-3,955	-9,936	1,479	0,196	-2,193	-48,182	1,384	0,084	-2,349	-41,004	0,895	0,113
futures	-4,085	-9,565	0,048	0,080	-2,194	-30,012	1,385	0,084	-2,398	-41,032	0,897	0,112
* crit.values: -4,018 (1%), -3,439 (5%), -3,144 (10%)												
** crit.values: 0,216 (1%), 0,146 (5%), 0,119 (10%)												

Table 2 Cointegration tests and the unbiasedness hypothesis for the whole sample and for the sub-samples

Johansen's Cointegration Test and the Unbiasedness Hypothesis for the whole sample and for the three subperiods										
panel A: whole sample	(Gr: 02/01/04-18/01/07, UK: 03/05/84-18/01/08 & Spain: 20/04/92-18/01/08)									
			λTrace					**λMax**		
			Greece	**UK**	**Spain**			**Greece**	**UK**	**Spain**
	crit.val.* 5%	crit.val.* 1%				crit.val. 5%	crit.val. 1%			
$\lambda<1$	25,32	30,45	43,498	2803,015	219,056	18,98	23,65	39,404	1612,300	216,416
$\lambda<2$	12,25	26,26	4,093	1190,715	2,639	12,25	16,26	4,093	1190,715	2,639
* Osterwald Lennum 1992 crit. Values										
			Chi-square Tests on the Restrictions of the Cointegration Relation							
			Greece			**UK**			**Spain**	
H0: $\beta f = 0$	**x2** (p-value)		47,127	<0,000		1.004,412	<0,001		353,452	<0,001
H0: (βf βs) = (1 -1)	**x2** (p-value)		5,508	0,019		49,922	<0.001		6,900	0,009
panel B: first subperiod	(Gr: 02/01/04-31/01/05, UK: 03/05/84-29/01/93 & Spain: 20/04/92-30/10/98)									
			Greece	**UK**	**Spain**			**Greece**	**UK**	**Spain**
	crit.val.* 5%	crit.val.* 1%				crit.val. 5%	crit.val. 1%			
$\lambda<1$	25,32	30,45	17,437	85,241	109,256	18,98	23,65	14,087	75,308	104,930
$\lambda<2$	12,25	26,26	3,350	9,933	4,325	12,25	16,26	3,349	9,933	4,325
* Osterwald Lennum 1992 crit. Values										
			Chi-square Tests on the Restrictions of the Cointegration Relation							
			Greece			**UK**			**Spain**	
H0: $\beta f = 0$	**x2** (p-value)		13,668	<0,001		80,765	<0,001		199,181	<0,001
H0: (βf βs) = (1 -1)	**x2** (p-value)		0,575	0,447		6,280	0,012		0,423	0,515
panel C: second subperiod	(Gr: 01/02/05-02/05/06, UK: 01/02/93-31/12/99 & Spain: 02/11/98-31/10/01)									
			Greece	**UK**	**Spain**			**Greece**	**UK**	**Spain**
	crit.val.* 5%	crit.val.* 1%				crit.val. 5%	crit.val. 1%			
$\lambda<1$	25,32	30,45	36,067	59,942	81,298	18,98	23,65	29,716	50,055	75,780
$\lambda<2$	12,25	26,26	6,351	6,887	5,519	12,25	16,26	6,351	6,887	5,519
* Osterwald Lennum 1992 crit. Values										
			Chi-square Tests on the Restrictions of the Cointegration Relation							
			Greece			**UK**			**Spain**	
H0: $\beta f = 0$	**x2** (p-value)		31,083	<0,001		73,049	<0.001		107,981	<0,001
H0: (βf βs) = (1 -1)	**x2** (p-value)		1,383	0,239		3,125	0.077		0,490	0,484
panel D: third subperiod	(Gr: 01/06/06-18/01/07, UK: 03/01/00-18/01/08 & Spain: 01/11/01-18/01/08)									
			Greece	**UK**	**Spain**			**Greece**	**UK**	**Spain**
	crit.val.* 5%	crit.val.* 1%				crit.val. 5%	crit.val. 1%			
$\lambda<1$	25,32	30,45	18,782	54,210	62,171	18,98	23,65	11,181	49,286	54,702
$\lambda<2$	12,25	26,26	7,601	4,924	7,469	12,25	16,26	7,601	4,924	7,469
* Osterwald Lennum 1992 crit. Values										
			Chi-square Tests on the Restrictions of the Cointegration Relation							
			Greece			**UK**			**Spain**	
H0: $\beta f = 0$	**x2** (p-value)		0,375	0,54		70,596	<0,001		54,563	<0,001
H0: (βf βs) = (1 -1)	**x2** (p-value)		3,486	0,061		23,537	<0,001		0,401	0,526661

Table 3 VECM model for the whole sample and the sub-samples

Vector Error Correction Model for the whole sample & for the three subperiods												
	Greece				UK				Spain			
panel A: whole sample	02/01/04-18/01/07				03/05/84-18/01/08				20/04/92-18/01/08			
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,171245	0,215230	0,284649	0,329040	-0,005617	-0,008740	-0,003238	-0,004750	-0,037690	-0,020190	-0,021495	-0,010780
ECM	-0,210282	-0,894470	1,304560	5,127600	-0,621751	-4,395770	1,234340	8,219520	-0,718025	-4,082130	1,456756	7,756060
ΔS(-1)	-0,583750	-3,247340	-0,848455	-4,361290	-0,433780	-4,059430	0,831277	-7,327140	-0,392590	-3,010610	-0,988255	-7,097270
ΔF(-1)	-0,021871	-0,125880	0,182083	0,968380	-0,184718	-1,782960	0,177369	1,161251	-0,244997	-1,891610	0,339160	2,452350
panel B: first subperiod	02/01/04-31/01/05				03/05/84-29/01/93				20/04/92-30/10/98			
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	-0,094757	-0,105280	-0,849060	-0,084180	0,000527	0,001140	0,000769	0,001380	0,129968	0,063560	0,134492	0,058020
ECM	-2,618446	-6,721380	-1,848033	-4,233090	-0,528445	-4,197840	1,143498	7,575660	-0,910872	-4,007140	1,276738	4,954880
ΔS(-1)	1,483342	4,735500	1,864828	5,312480	-0,604249	-6,267290	-0,981839	-8,493020	-0,643158	-3,899540	-1,276117	-6,825610
ΔF(-1)	-1,662200	-6,389120	-2,199049	-7,542690	-0,015644	-0,178930	0,229768	2,191730	0,004010	0,613383	0,613383	3,227350
panel C: second subperiod	01/02/05-02/05/06				01/02/93-31/12/99				02/11/98-31/10/01			
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,026300	0,022220	0,008767	0,006970	0,031372	0,025730	0,033951	0,024960	-0,059313	-0,009800	-0,041598	-0,006340
ECM	0,483837	1,320660	2,094962	5,387330	0,556999	2,365960	2,447322	9,318770	-1,017211	-2,901640	1,320113	3,476040
ΔS(-1)	-1,058600	-3,616110	-1,341178	-4,316200	-1,109990	-6,340650	-1,510778	-7,736240	0,054258	0,209620	-0,624775	-2,228070
ΔF(-1)	0,535230	1,846420	0,815281	2,649740	0,549468	3,166570	0,952163	4,918950	-0,670275	-2,637380	-0,007887	-0,028650
panel D: third subperiod	01/06/06-18/01/07				03/01/00-18/01/08				01/11/01-18/01/08			
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,381099	0,210330	0,271283	0,125520	0,090528	0,061130	0,095230	0,063420	-0,233121	-0,077950	-0,192470	-0,063440
ECM	-2,195203	-9,768090	-1,898389	-7,081910	-1,658916	-5,095610	0,348422	1,055510	1,877328	4,350110	3,346457	7,643720
ΔS(-1)	0,737818	3,683910	1,488799	6,231990	0,342766	1,399350	-0,118873	-0,478630	-2,226993	-6,625900	-2,408067	-7,062420
ΔF(-1)	-0,493525	-3,740560	-1,335091	-8,483360	-0,958319	-4,037080	-0,536411	-2,228640	1,568026	4,651190	1,764050	5,157990

Table 4 MS-VECM model for the whole sample and the sub-samples

Markov Switching Vector Error Correction Model for the whole sample & for the three subperiods

Greece

	regime 1				regime 2			
panel A: whole sample	02/01/04-18/01/07							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	0,01	0,00	0,01	0,00	0,01	0,00	0,01
ECM	-2,01	-0,04	-0,45	-0,01	234,47	4,65	236,08	4,68
ΔS(-1)	-17,42	-0,47	-17,92	-0,47	-188,96	-4,82	-188,90	-4,82
ΔF(-1)	17,11	0,45	17,28	0,45	188,03	4,80	188,24	4,80
panel B: first subperiod	02/01/04-31/01/05							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	-0,03	0,00	-0,03	0,00	-0,02	0,00	-0,02
ECM	-152,42	-3,80	-151,43	-3,77	-130,82	-2,73	-129,79	-2,71
ΔS(-1)	109,81	3,45	110,07	3,46	95,67	2,56	95,87	2,56
ΔF(-1)	-110,25	-3,47	-110,51	-3,48	-96,14	-2,58	-96,34	-2,58
panel C: second subperiod	01/02/05-02/05/06							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	0,01	0,00	0,01	0,00	-0,02	0,00	-0,02
ECM	110,84	3,32	112,42	3,37	211,05	6,58	212,58	6,62
ΔS(-1)	-87,33	-3,33	-87,61	-3,34	-163,13	-6,30	-163,40	-6,30
ΔF(-1)	17,74	0,49	17,02	0,44	162,55	6,27	162,82	6,28
panel D: third subperiod	01/06/06-18/01/07							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	0,06	0,00	0,06	0,01	0,10	0,01	0,10
ECM	-55,86	-9,93	-55,76	-9,93	-118,89	-8,88	-118,76	-8,85
ΔS(-1)	37,18	3,50	38,06	3,59	85,34	6,23	86,22	6,28
ΔF(-1)	-36,87	-3,48	-37,75	-3,57	-85,09	-6,25	-85,97	-6,30

UK

	regime 1				regime 2			
panel A: whole sample	03/05/84-18/01/08							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	0,01	0,00	0,01	0,00	0,01	0,00	0,01
ECM	-36,13	-3,68	-34,46	-3,51	90,05	8,62	91,81	8,77
ΔS(-1)	21,91	2,94	21,59	2,90	-70,20	-8,87	-70,58	-8,91
ΔF(-1)	-22,55	-3,03	-22,23	-2,98	69,52	8,79	69,90	8,83
panel B: first subperiod	03/05/84-29/01/93							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	0,02	0,00	0,02	0,00	0,02	0,00	0,02
ECM	-31,70	-2,86	-30,12	-2,72	89,52	7,29	91,22	7,43
ΔS(-1)	19,94	2,36	19,65	2,33	-69,01	-7,36	-69,40	-7,39
ΔF(-1)	-20,58	-2,44	-20,30	-2,41	68,29	7,30	68,68	7,32
panel C: second subperiod	01/02/93-31/12/99							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	0,01	0,00	0,02	0,00	0,01	0,00	0,01
ECM	31,58	1,70	33,41	1,79	62,12	2,97	63,98	3,06
ΔS(-1)	-18,89	-2,29	-18,28	-2,27	-34,73	-2,13	-35,14	-2,15
ΔF(-1)	12,65	0,89	13,03	0,91	34,49	2,11	34,89	2,13
panel D: third subperiod	03/01/00-18/01/08							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	-0,01	0,00	-0,01	0,00	0,00	0,00	0,00
ECM	-115,82	-3,74	-113,82	-3,67	22,93	0,72	24,99	0,78
ΔS(-1)	77,90	3,35	77,44	3,33	-22,12	-0,92	-22,62	-0,94
ΔF(-1)	-78,50	-3,38	-78,04	-3,36	21,49	0,90	21,99	0,92

Spain

	regime 1				regime 2			
panel A: whole sample	20/04/92-18/01/08							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	-0,01	0,00	-0,01	0,00	-0,01	0,00	-0,01
ECM	-33,46	2,99	-31,39	-2,74	88,57	7,38	90,70	7,54
ΔS(-1)	20,83	2,43	20,30	2,36	-69,09	-7,72	-69,66	-7,78
ΔF(-1)	-21,48	-2,51	-20,95	-2,44	68,42	7,65	68,99	7,71
panel B: first subperiod	20/04/92-30/10/98							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	0,05	0,00	0,05	0,00	0,04	0,00	0,04
ECM	-27,51	-2,04	-25,49	-1,88	88,21	5,92	90,31	6,05
ΔS(-1)	13,64	1,35	13,14	1,30	-71,76	-6,51	-72,35	-6,54
ΔF(-1)	-14,32	-1,41	-13,81	-1,36	71,07	6,45	71,66	6,48
panel C: second subperiod	02/11/98-31/10/01							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	-0,02	0,00	-0,02	0,00	-0,03	0,00	-0,03
ECM	-55,64	-2,27	-53,33	-2,18	64,72	2,57	67,10	2,66
ΔS(-1)	41,27	2,28	40,60	2,24	-46,44	-2,50	-47,15	-2,53
ΔF(-1)	-41,91	-2,32	-41,23	-2,28	45,80	2,46	46,52	2,50
panel D: third subperiod	01/11/01-18/01/08							
	ΔS	(t-statistic)	ΔF	(t-statistic)	ΔS	(t-statistic)	ΔF	(t-statistic)
C	0,00	-0,08	0,00	-0,08	0,00	-0,07	0,00	-0,07
ECM	187,07	4,55	188,59	4,58	272,78	6,66	274,30	6,69
ΔS(-1)	-137,79	-4,33	-137,99	-4,33	-199,85	-6,29	-200,05	-6,29
ΔF(-1)	137,16	4,31	137,36	4,31	199,23	6,27	199,43	6,27

Table 5 Transition probabilities for the whole sample and the sub-samples

Transition Probablitites of the Markov Switching Vector Error Correction Model for the whole sample & for the three subperiods						
	Greece		**UK**		**Spain**	
panel A: whole sample	**02/01/04-18/01/07**		**03/05/84-18/01/08**		**20/04/92-18/01/08**	
	Regime 1	**Regime 2**	**Regime 1**	**Regime 2**	**Regime 1**	**Regime 2**
Regime 1	0,824947	0,020852	0,790214	0,058412	0,926711	0,088624
Regime 2	0,175053	0,979148	0,209786	0,941588	0,073289	0,911376
panel B: first subperiod	**02/01/04-31/01/05**		**03/05/84-29/01/93**		**20/04/92-30/10/98**	
	Regime 1	**Regime 2**	**Regime 1**	**Regime 2**	**Regime 1**	**Regime 2**
Regime 1	0,522061	0,999000	0,616019	0,044993	0,877162	0,046428
Regime 2	0,477939	0,001000	0,383981	0,955007	0,122838	0,953572
panel C: second subperiod	**01/02/05-02/05/06**		**01/02/93-31/12/99**		**02/11/98-31/10/01**	
	Regime 1	**Regime 2**	**Regime 1**	**Regime 2**	**Regime 1**	**Regime 2**
Regime 1	0,210585	0,195998	0,914611	0,035544	0,971131	0,245693
Regime 2	0,789415	0,804002	0,085359	0,964456	0,028869	0,754307
panel D: third subperiod (	**01/06/06-18/01/07**		**03/01/00-18/01/08**		**01/11/01-18/01/08**	
	Regime 1	**Regime 2**	**Regime 1**	**Regime 2**	**Regime 1**	**Regime 2**
Regime 1	0,745736	0,061579	0,962759	0,021655	0,790950	0,106747
Regime 2	0,254264	0,938421	0,037241	0,978345	0,209050	0,893253

Table 6 Granger causality tests for the whole sample and the sub-samples

Granger Causality Test for the DCC and Flexible Multivariate GARCH - MS-VECM models for 1, 10, 20 & 40 lagges for the whole sample & for the three subperiods

		Greece						**UK**						**Spain**					
panel A: whole sample		**02/01/04-18/01/07**		**MSVECM**				**03/05/84-18/01/08**		**MSVECM**				**20/04/92-18/01/08**		**MSVECM**			
		VECM		*regime 1*		*regime 2*		**VECM**		*regime 1*		*regime 2*		**VECM**		*regime 1*		*regime 2*	
	lags	**DCC**	**FLM**	**DCC**	**FLM**	**DCC**	**FLM**	**DCC**	**FLM**	**DCC**	**FLM**	**DCC**	**FLM**	**DCC**	**FLM**	**DCC**	**FLM**	**DCC**	**FLM**
Ho, spot yields do not Granger cause	**1**	0.090	0.068	0.190	0.559	0.190	0.325	0.087	-	-	0.101	-	0.144	0.183	-	0.283	0.106	0.182	0.144
Ho, futures yields do not Granger cause		**0.044**	**0.038**	0.269	0.399	0.269	0.434	0.089	-	-	0.121	-	0.148	0.138	-	0.138	0.121	0.139	0.154
Ho, spot yields do not Granger cause	**10**	0.068	0.051	0.088	0.074	0.888	0.081	0.083	-	-	0.121	-	0.195	0.187	-	0.187	0.322	0.187	0.231
Ho, futures yields do not Granger cause		**0.016**	**<0,001**	**0.045**	**0.047**	**0.006**	**<0,001**	0.098	-	-	0.261	-	0.200	0.143	-	0.143	0.241	0.943	0.244
Ho, spot yields do not Granger cause	**20**	0.087	**0.008**	0.198	0.245	0.098	**0.007**	0.092	-	-	0.122	-	0.101	-	-	-	0.144	-	0.171
Ho, futures yields do not Granger cause		**0.007**	**<0,001**	0.070	**0.029**	**0.017**	**<0,001**	0.085	-	-	0.163	-	0.189	-	-	-	0.181	-	0.111
Ho, spot yields do not Granger cause	**40**	0.054	**0.009**	0.477	0.770	0.057	0.051	0.094	-	-	0.083	-	0.051	0.098	-	0.098	**0.031**	0.090	**<0,001**
Ho, futures yields do not Granger cause		**0.048**	**<0,001**	0.488	0.415	**0.041**	**<0,001**	**0.048**	-	-	0.122	-	**0.049**	0.099	-	0.099	**0.021**	0.090	**<0,001**
panel B: first subperiod		**02/01/04-31/01/05**						**03/05/84-29/01/93**						**20/04/92-30/10/98**					
Ho, spot yields do not Granger cause	**1**	0.071	0.085	0.186	0.749	0.826	0.317	-	-	-	0.125	-	0.184	0.182	-	0.091	**0.026**	0.051	0.078
Ho, futures yields do not Granger cause		0.400	0.096	0.390	0.747	0.390	0.219	-	-	-	0.177	-	0.091	0.160	-	0.059	**0.006**	0.160	**0.020**
Ho, spot yields do not Granger cause	**10**	0.538	0.292	0.546	0.133	0.546	0.677	-	-	-	0.310	-	0.091	0.199	-	**0.019**	**<0,001**	**0.009**	**0.001**
Ho, futures yields do not Granger cause		0.712	0.195	0.715	0.132	0.715	0.676	-	-	-	0.092	-	0.077	0.199	-	**0.019**	**<0,001**	**0.009**	**0.001**
Ho, spot yields do not Granger cause	**20**	0.178	0.266	0.175	0.286	0.175	0.569	-	-	-	0.717	-	0.172	-	-	-	0.071	-	0.289
Ho, futures yields do not Granger cause		0.448	0.152	0.336	0.284	0.336	0.568	-	-	-	0.100	-	0.647	-	-	-	**<0,001**	-	0.354
Ho, spot yields do not Granger cause	**40**	0.558	0.129	0.532	0.312	0.532	0.357	-	-	-	0.423	-	0.389	0.099	-	0.099	**0.009**	0.094	**<0,001**
Ho, futures yields do not Granger cause		**0.045**	**0.019**	**0.033**	0.310	**0.033**	**0.030**	-	-	-	-	-	0.287	0.099	-	0.099	**0.007**	0.090	**<0,001**
panel C: second subperiod		**01/02/05-02/05/06**						**01/02/93-31/12/99**						**02/11/98-31/10/01**					
Ho, spot yields do not Granger cause	**1**	0.071	0.370	0.175	0.188	0.115	0.316	-	-	-	0.053	-	0.085	0.083	0.095	0.178	0.115	0.178	0.157
Ho, futures yields do not Granger cause		0.402	0.733	**0.041**	**0.050**	0.411	0.319	-	-	-	**0.043**	-	**0.039**	**0.046**	**0.018**	0.192	0.121	0.192	0.154
Ho, spot yields do not Granger cause	**10**	0.497	0.229	0.501	0.426	0.501	0.57	-	-	-	0.092	-	0.077	0.090	0.069	0.085	0.072	**0.025**	**<0,001**
Ho, futures yields do not Granger cause		0.910	0.601	0.913	0.422	0.913	0.572	-	-	-	0.186	-	**0.049**	**0.027**	**0.007**	**0.018**	**0.015**	**0.044**	**<0,001**
Ho, spot yields do not Granger cause	**20**	0.266	0.371	0.269	0.408	0.269	0.192	-	-	-	0.056	-	0.407	0.090	0.079	0.098	0.110	0.098	**0.002**
Ho, futures yields do not Granger cause		0.069	0.097	0.709	0.406	0.072	**0.015**	-	-	-	**0.041**	-	**<0,001**	**0.027**	**0.001**	**0.024**	**0.010**	**0.021**	**0.002**
Ho, spot yields do not Granger cause	**40**	0.749	**0.033**	0.759	0.564	0.759	0.207	-	-	-	0.109	-	**0.044**	0.070	0.064	0.067	**0.048**	0.177	0.108
Ho, futures yields do not Granger cause		**0.049**	0.059	**0.049**	**0.050**	0.051	**0.021**	-	-	-	**0.039**	-	0.280	**<0,001**	**0.036**	**<0,001**	**0.047**	**<0,001**	0.109
panel D: third subperiod		**01/06/06-18/01/07**						**03/01/00-18/01/08**						**01/11/01-18/01/08**					
Ho, spot yields do not Granger cause	**1**	0.091	0.092	**0.038**	**0.025**	0.085	**<0,001**	-	0.229	-	-	-	0.074	0.059	**0.014**	0.188	0.152	**0.048**	0.06
Ho, futures yields do not Granger cause		0.390	0.552	**0.039**	**0.025**	**0.039**	**<0,001**	-	0.056	-	-	-	0.057	**0.049**	**0.048**	0.187	0.355	**0.019**	**0.022**
Ho, spot yields do not Granger cause	**10**	0.647	0.996	0.067	0.079	0.657	0.173	-	0.201	-	-	-	0.079	0.090	**0.048**	0.069	0.070	0.069	0.077
Ho, futures yields do not Granger cause		0.832	0.985	**0.008**	**0.047**	0.085	**0.015**	-	0.601	-	-	-	**<0,001**	0.094	**0.023**	0.094	0.010	**0.049**	**0.027**
Ho, spot yields do not Granger cause	**20**	0.509	0.871	0.520	**0.029**	0.520	0.854	-	0.080	-	-	-	0.178	-	**<0,001**	-	**<0,001**	-	**<0,001**
Ho, futures yields do not Granger cause		0.608	0.759	0.061	**0.030**	0.621	0.854	-	0.092	-	-	-	0.904	-	**<0,001**	-	**<0,001**	-	**<0,001**
Ho, spot yields do not Granger cause	**40**	0.897	0.978	0.879	0.268	0.879	0.832	-	**0.007**	-	-	-	0.078	-	**<0,001**	-	**0.008**	-	**<0,001**
Ho, futures yields do not Granger cause		0.443	0.714	0.350	0.265	0.350	0.830	-	**0.002**	-	-	-	0.098	-	**<0,001**	-	**0.012**	-	**<0,001**

Table 7 Diagnostic statistics for the whole sample and the sub-samples

Diagnostic Statistics on the Residuals of the MS-VECM DCC BEKK Bivariate GARCH model for the whole sample & for the three subperiods																		
	Greece						UK						Spain					
panel A: whole sample	02/01/04-18/01/07		MSVECM				03/05/84-18/01/08		MSVECM				20/04/92-18/01/08		MSVECM			
	VECM		*regime 1*		*regime 2*		VECM		*regime 1*		*regime 2*		VECM		*regime 1*		*regime 2*	
	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures
skewness	0,099	-0,721	0,119	-0,561	0,206	-0,588	-0,261	0,054	-0,268	-0,192	-0,116	0,046	0,074	-0,156	-0,045	-0,311	0,096	-0,134
kurtosis	4,363	6,076	4,297	6,091	3,611	6,572	4,648	11,929	5,087	14,719	4,352	15,137	5,744	7,015	5,843	7,334	4,775	8,027
J-B	0,004	0,021	0,011	0,084	0,041	0,049	<0,001	<0,001	0,022	<0,001	0,034	<0,001	<0,001	0,008	0,011	0,018	0,089	0,011
Q(6)	0,015	0,019	0,015	0,076	0,016	0,071	0,015	0,015	0,015	0,015	0,015	0,014	0,015	0,015	0,014	0,014	0,055	0,013
Q(12)	<0,001	<0,001	0,062	0,060	0,025	0,041	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
AIC	-21,362			-32,108			10,878			9,861			10,648			9,447		
LRS			0,007						0,056						0,059			
panel B: first subperiod			02/01/04-31/01/05						03/05/84-29/01/93						20/04/92-30/10/98			
skewness	0,061	-0,197	0,152	-0,152	0,104	-0,241	-0,185	-0,014	-0,074	-0,048	-0,001	0,084	-0,053	-0,291	0,180	-0,133	0,142	-0,153
kurtosis	3,997	3,215	4,645	3,299	3,572	3,608	4,621	12,741	6,478	15,459	3,489	10,528	5,984	5,784	5,712	4,488	5,525	4,898
J-B	0,004	0,343	0,071	0,390	0,148	0,040	<0,001	0,041	0,035	0,008	0,051	0,017	<0,001	<0,001	0,045	0,071	0,026	0,021
Q(6)	0,014	0,018	0,014	0,017	0,014	0,017	0,011	0,008	0,009	0,018	0,083	0,048	0,017	0,016	0,016	0,045	0,016	0,035
Q(12)	<0,001	<0,001	0,010	0,011	0,041	0,084	<0,001	<0,001	0,008	0,070	0,009	0,018	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
AIC	-22,470			-33,306			9,586			7,379			9,715			8,393		
LRS			0,057						0,048						0,047			
panel C: second subperiod			01/02/05-02/05/06						01/02/93-31/12/99						02/11/98-31/10/01			
skewness	-0,134	-0,697	0,151	-0,389	0,105	-0,687	-0,012	-0,001	-0,863	0,001	0,067	-0,075	0,388	-0,236	0,400	-0,004	0,270	-0,152
kurtosis	3,455	5,312	3,536	4,290	2,919	5,630	4,548	6,524	3,697	4,357	5,217	7,157	5,237	12,011	5,803	8,530	3,732	10,811
J-B	0,192	<0,001	0,105	0,074	0,070	0,240	0,008	0,001	0,054	0,086	0,015	0,001	<0,001	<0,001	0,027	0,014	0,040	<0,001
Q(6)	0,016	0,015	0,066	0,045	0,026	0,015	0,011	0,001	0,064	0,018	0,041	0,057	0,016	0,016	0,015	0,016	0,026	0,037
Q(12)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	0,001	<0,001	<0,001	0,094	0,014	0,008	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
AIC	-22,235			21,361			7,987			6,984			9,108			7,636		
LRS			0,001						0,001						0,009			
panel D: third subperiod			01/06/06-18/01/07						03/01/00-18/01/08						01/11/01-18/01/08			
skewness	-0,257	-0,051	-0,048	-0,068	-0,033	-0,436	0,001	-0,008	-0,025	-0,010	-0,005	0,001	0,007	-0,029	0,238	0,009	0,185	0,033
kurtosis	4,915	2,958	4,250	3,142	3,602	4,823	6,852	9,218	5,364	12,548	4,964	8,154	6,150	5,383	5,747	5,335	5,043	5,620
J-B	<0,001	0,048	0,071	0,095	0,377	0,037	0,009	0,001	0,011	<0,001	0,018	0,002	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Q(6)	0,014	0,018	0,015	0,096	0,074	0,038	0,001	<0,001	0,002	0,001	0,009	0,012	0,016	0,014	0,016	0,014	0,016	0,014
Q(12)	<0,001	<0,001	<0,001	0,084	0,001	0,012	0,001	<0,001	0,001	0,001	0,001	0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
AIC	-23,639			-33,469			8,963			7,486			9,104			8,697		
LRS			0,036						0,049						0,008			

Table 8 Diagnostic statistics for the whole sample and the sub-samples

Diagnostic Statistics on the Residuals of the MS-VECM Flexible Bivariate GARCH model for the whole sample & for the three subperiods																		
	Greece						UK						Spain					
panel A: whole sample	**02/01/04-18/01/07**		**MSVECM**				**03/05/84-18/01/08**		**MSVECM**				**20/04/92-18/01/08**		**MSVECM**			
	VECM		*regime 1*		*regime 2*		**VECM**		*regime 1*		*regime 2*		**VECM**		*regime 1*		*regime 2*	
	Spot	**Futures**	**Spot**	**Futures**	**Spot**	**Futures**	**Spot**	**Futures**	**Spot**	**Futures**	**Spot**	**Futures**	**Spot**	**Futures**	**Spot**	**Futures**	**Spot**	**Futures**
skewness	0,035	-0,183	0,124	0,123	-0,076	-0,077	-	-	-0,107	-0,110	-0,402	-0,405	-	-	-0,254	-0,255	0,091	0,089
kurtosis	3,062	3,622	2,922	2,922	3,450	3,454	-	-	5,846	5,893	10,669	10,729	-	-	4,829	4,834	4,442	4,445
J-B	0,886	<0,001	0,339	0,343	0,032	0,030	-	-	<0,001	<0,001	<0,001	<0,001	-	-	0,010	0,011	0,012	0,014
Q(6)	0,018	0,018	0,073	0,084	0,058	0,028	-	-	0,017	0,017	0,017	0,017	-	-	0,014	0,014	0,017	0,017
Q(12)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	-	-	<0,001	<0,001	<0,001	<0,001	-	-	<0,001	<0,001	<0,001	<0,001
AIC	5,671		8,302				-		10,368				-		9,901			
LRS	0,048						-						-					
panel B: first subperiod	**02/01/04-31/01/05**						**03/05/84-29/01/93**						**20/04/92-30/10/98**					
skewness	-0,110	-0,159	0,105	0,105	0,018	0,017	-	-	-0,458	-0,466	-1,239	-1,245	-	-	0,160	0,159	0,033	0,031
kurtosis	2,788	2,836	2,924	2,924	3,030	3,032	-	-	9,308	9,416	20,612	20,715	-	-	4,907	4,905	4,653	4,649
J-B	0,563	0,471	0,740	0,741	0,992	0,992	-	-	<0,001	<0,001	<0,001	<0,001	-	-	0,014	0,009	0,011	0,007
Q(6)	0,035	0,027	0,053	0,034	0,076	0,045	-	-	0,018	0,018	0,017	0,017	-	-	0,017	0,017	0,017	0,017
Q(12)	0,007	0,006	0,013	0,012	0,014	0,013	-	-	<0,001	<0,001	<0,001	<0,001	-	-	<0,001	<0,001	<0,001	<0,001
AIC	4,660		7,173				-		7,003				-		8,987			
LRS	0,039						-						-					
panel C: second subperiod	**01/02/05-02/05/06**						**01/02/93-31/12/99**						**02/11/98-31/10/01**					
skewness	0,002	-0,144	0,065	0,065	0,058	0,056	-	-	0,249	0,249	0,265	0,265	0,284	0,251	0,322	0,322	0,297	0,296
kurtosis	2,639	3,048	2,529	2,530	2,816	2,822	-	-	3,112	3,114	3,256	3,258	3,583	3,817	3,641	3,644	3,865	3,870
J-B	0,403	0,586	0,200	0,200	0,709	0,723	-	-	0,015	0,014	0,012	0,010	<0,001	<0,001	0,021	0,014	0,018	0,017
Q(6)	0,017	0,017	0,017	0,017	0,017	0,017	-	-	0,020	0,020	0,020	0,020	0,018	0,018	0,018	0,018	0,018	0,018
Q(12)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	-	-	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
AIC	4,178		7,252				-		9,104				6,158		8,226			
LRS	0,007						-						0,048					
panel D: third subperiod	**01/06/06-18/01/07**						**03/01/00-18/01/08**						**01/11/01-18/01/08**					
skewness	-0,344	-0,279	-0,073	-0,076	-0,141	-0,141	0,013	0,081	-	-	0,118	0,119	-0,010	-0,080	0,162	0,162	0,149	0,149
kurtosis	3,800	2,912	4,148	4,109	2,522	2,515	3,320	3,422	-	-	3,463	3,467	3,837	3,882	3,701	3,701	3,783	3,784
J-B	0,039	0,362	0,022	0,028	0,345	0,337	0,011	<0,001	-	-	0,011	0,009	0,012	0,013	0,016	0,017	0,013	0,014
Q(6)	0,014	0,015	0,044	0,044	0,072	0,074	0,017	0,018	-	-	0,018	0,018	0,017	0,017	0,017	0,017	0,017	0,017
Q(12)	<0,001	<0,001	0,014	0,013	0,043	0,042	<0,001	<0,001	-	-	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
AIC	3,751		6,216				6,879		9,352				7,644		9,096			
LRS	0,018						0,069						0,034					

Table 9 Comprehensive results for the price discovery process and the spillover effects for the whole sample and the sub-samples

Comprehencive Table of the Unbiasedness Hypothesis, the Price Discovery & the Spillover Effects for the whole sample and for the three subperiods			
	Greece	**UK**	**Spain**
panel A: whole sample (Gr: 02/01/04-18/01/07, UK: 03/05/84-18/01/08 & Spain: 20/04/92-18/01/08)			
Unbiasedness Hypothesis	not significant	not significant	not significant
Price Discovery Process	futures, spot (2nd regime)	futures, spot (2nd regime)	futures, spot
Spillover Effects	from futures to spot	not significant	not significant
panel B: first subperiod (Gr: 02/01/04-31/01/05, UK: 03/05/84-29/01/93 & Spain: 20/04/92-30/10/98)			
Unbiasedness Hypothesis	not significant	not significant	significant
Price Discovery Process	futures, spot	futures, spot	futures, spot (2nd regime)
Spillover Effects	not significant	not significant	from futures to spot
panel C: second subperiod (Gr: 01/02/05-02/05/06, UK: 01/02/93-31/12/99 & Spain: 02/11/98-31/10/01)			
Unbiasedness Hypothesis	significant	significant	significant
Price Discovery Process	futures, spot	futures (2nd regime)	futures, spot
Spillover Effects	from futures to spot	from futures to spot	from futures to spot
panel D: third subperiod (Gr: 01/06/06-18/01/07, UK: 03/01/00-18/01/08 & Spain: 01/11/01-18/01/08)			
Unbiasedness Hypothesis	not significant	not significant	significant
Price Discovery Process	futures, spot	futures, spot (1st regime)	futures, spot
Spillover Effects	bi-directional effects	not significant	from futures to spot