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Lead-Lag Relationship between Futures and Spot Markets in Greece: 1999 - 2001

Christos Floros
Department of Economics, University of Portsmouth
Portsmouth Business School, Portsmouth, PO1 3DE, UK
E-mail: Christos.Floros@port.ac.uk
Tel: +44 (0) 2392 844244

Dimitrios V. Vougas
Department of Economics, University of Wales Swansea
Singleton Park, Swansea, SA2 8PP, UK
E-mail: D.V.Vougas@swan.ac.uk
Tel: +44 (0) 1792 602102

Abstract

This paper examines the lead-lag relationship between futures and spot markets in Greece. For both available stock index futures contracts (FTSE/ASE-20 and FTSE/ASE Mid 40) of the Athens Derivatives Exchange (ADEX), we employ a Bivariate GARCH model to explain price discovery of futures market over the crisis period 1999 to 2001. Empirical results confirm that futures market plays a price discovery role, implying that futures prices contain useful information about spot prices (in line with similar findings in the literature). These findings are helpful to financial managers and traders dealing with Greek stock index futures.

Keywords: Futures, ADEX, BGARCH, Price Discovery.
JEL Classification: G13, G15. JEL Classification: G13, G15.

1. Introduction

From a financial point of view, there is a lead-lag relationship between the spot index and index futures contract. The lead-lag relationship investigates whether the spot market leads the futures market, whether the futures market leads the spot market or whether the bi-directional feedback between the two markets exists. The lead-lag relationship illustrates how well the two markets are linked, and how fast one market reflects new information from the other. If feedback between spot and futures exists, then it is possible that investors may use past information to predict prices (or returns) in the future. Feedback relationship exists if stock index futures price reacts to economy-wide information, see Antoniou and Garrett (1993). Most researchers show that futures returns lead spot returns, while futures market has a stronger lead effect. Also, when a bi-directional causality exists between the two series, then spot and futures have an important discovery role. Hence, an electronic market may enhance price discovery. The discovery of one price will definite provides valuable information about the other. According to Tse (1999), price discovery refers to the impounding of new information into the price.

Several studies report that futures markets lead spot (cash) markets from a few seconds to hours (Kawaller, Koch and Koch, 1987; Stoll and Whaley, 1990). According to Brooks *et al*. (2001) the lead–lag relationship between spot and futures markets do not last for more than half an hour. Reasons for why futures prices lead spot prices include the fact that futures markets are more informational efficient, and also by the fact that they have lower transaction costs and higher liquidity. Although empirical research generally suggests that the futures market leads the cash market (i.e. futures prices contain useful information about cash prices), other researchers show that cash market may lead futures market.

In this paper, we examine whether the price movements in futures markets lead the price movements in cash markets (i.e. whether futures discover spot prices) using data from Greece. The data employed in this study comprise daily (nearby) observations on the FTSE/ASE-20 stock index futures contract (August 1999 - August 2001) and daily (nearby) observations on the FTSE/ASE Mid 40 stock index futures contract (January 2000 - August 2001). Focusing on the above periods, (i) we test the hypotheses using data from the early stage of the Athens Derivatives Exchange (started its official operation on 27 August 1999), and (ii) we investigate whether the hypotheses exist after the dramatic rise of Athens Stock Exchange (ASE) stock prices[1].

2. Literature Review

The issue of price discovery on futures and spot markets and the lead-lag relationship are topics of interest to traders, financial economists and analysts. Although futures and spot markets react to the same information, the major question is which market reacts first. Several studies examine whether the returns of index futures lead the spot index. The early study by Gardbade and Silber (1983) suggests that futures markets lead the spot. Similarly, Herbst, McCormack and West (1987) examine the lead-lag relationship between the spot and futures markets for S&P 500 and VLCI indices. They find that for S&P 500 the lead is between zero and eight minutes, while for VLCI the lead is up to sixteen minutes. More sophisticated methods of causality (VAR-VECM) models show evidence that futures prices lead the spot prices. For example, Kawaller *et al*. (1987) use minute to minute data on the S&P 500 spot and futures contract and prove that futures lead the cash index by 20-45 minutes. Also, Stoll and Whaley (1990) find that S&P 500 and MM index futures returns lead the stock market returns by about 5 minutes. Similarly, Cheung and Ng (1990) analyse price changes over fifteen minute periods for the S&P 500 index using a GARCH model. Their results show that futures returns lead spot returns by at least fifteen minutes, while Chan, Chan, and Karolyi (1991) use a bivariate GARCH model and find that S&P 500 futures returns lead spot returns by about five minutes.

Furthermore, Chan (1992) argues that this lead-lag relation is asymmetric. He suggests that under good news cash index prices lag futures prices, and more important, when stocks are moving together, cash and futures markets provide a support to the asymmetric lead-lag relation. In addition, Chang *et al*. (1995) suggest that futures market leads stock market with respect to the weekend effect. Also, Pizzi *et al*. (1998) suggest that both 3-month and 6-month S&P 500 futures contracts are the leaders of the spot market (by at least 20 minutes).

Antoniou and Garrett (1993) examine the pricing relationship between the FTSE 100 index and the FTSE 100 index futures contract on the 19th and 20th October 1987 (stock market crash period). They find that, in general, the futures price leads the stock index. Further, Abhyankar (1998) examines the relationship between futures and spot returns using 5-minute returns on the FTSE 100. He finds that the futures returns lead the spot returns by 15-20 minutes. Antoniou *et al*. (2001) use multivariate analysis (i.e. VAR-EGARCH methodology) to examine the lead-lag relationship between stock and futures markets of France, Germany and the UK, and confirm that futures markets lead spot markets.

[1] The Athens Stock Exchange (ASE), an important European emerging equity market, experienced a dramatic rise of stock prices between the years 1998-1999, followed then by an equally dramatic fall.

Brooks *et al*. (2001) investigate the lead-lag relationship between the spot index and futures contract for the FTSE 100 index. Their results from the Engle-Granger method show that there is a strong relationship between spot and futures prices. They also find that changes in spot index depend on the lagged changes in the spot index and futures price, while the lead–lag relationship between spot and futures markets do not last for more than half an hour.

This paper compares the results from the introduction of two stock index futures (FTSE/ASE-20 and FTSE/ASE Mid 40) in Greece. Our findings are very important since no previous work has examined the lead-lag relationship between the spot index and index futures contract traded in the Athens Derivatives Exchange (ADEX).

3. Methodology, Data & Results

If the markets are frictionless and functioning efficiently, changes in the log-spot prices and changes in the log-futures prices are expected to occur at same time, while the current change in the log-futures price is also expected not to be related to previous changes in the log-spot price (and vice-versa). In this paper we use a bivariate cointegration model with simple GARCH errors to examine lead-lag relationship between spot and futures. The multivariate GARCH model uses information from more than one market's history. It provides more precise estimates of the parameters because it utilises information in the entire variance-covariance matrix. The bivariate cointegration GARCH(1,1) distributions of log-spot (*s*) and log-futures (*f*) are given by:

$$\Delta s_t = a_0 + a_1(s_{t-1} - \gamma f_{t-1}) + \varepsilon_{st}$$
$$\Delta f_t = \beta_0 + \beta_1(s_{t-1} - \gamma f_{t-1}) + \varepsilon_{ft}$$
$$\varepsilon_t = \begin{bmatrix} \varepsilon_{st} \\ \varepsilon_{ft} \end{bmatrix} | \Psi_{t-1} \sim N(0, H_t)$$
$$h_{st}^2 = c_s + a_s \varepsilon_{s,t-1}^2 + b_s h_{s,t-1}^2$$
$$h_{ft}^2 = c_f + a_f \varepsilon_{f,t-1}^2 + b_f h_{f,t-1}^2 \tag{1}$$

where Ψ_{t-1} is the information at time *t-1*, and $s_{t-1} - \gamma f_{t-1}$ is the error term obtained from the equation $s_t = \delta + \gamma f_t + e_t$.

Notice that estimation of all multivariate GARCH models above is carried out by using conditional quasi maximum likelihood estimation. The conditional log-likelihood function for a single observation can be written as

$$L_t(\theta) = -(n/2)\log(2\pi) - (1/2)\log(|H_t(\theta)|) - (1/2)\varepsilon_t(\theta)' H_t^{-1}(\theta)\varepsilon_t(\theta) \tag{2}$$

where θ represents a vector of parameters, *n* is the sample size, and *t* is the time index.

Recently, Brooks, Henry, and Persand (2002) use a bivariate VECM, which is given by

$$\Delta Y_t = \mu + \sum_{i=1}^{4} \Gamma_i \Delta Y_{t-i} + \Pi v_{t-1} + \varepsilon_t$$
$$Y_t = \begin{bmatrix} s_t \\ f_t \end{bmatrix}; \mu = \begin{bmatrix} \mu_F \\ \mu_S \end{bmatrix}; \Gamma_i = \begin{bmatrix} \Gamma_{i,f}^f \Gamma_{i,s}^f \\ \Gamma_{i,f}^s \Gamma_{i,s}^s \end{bmatrix}; \Pi = \begin{bmatrix} \pi_f \\ \pi_s \end{bmatrix}; \varepsilon_t = \begin{bmatrix} \varepsilon_{f,t} \\ \varepsilon_{s,t} \end{bmatrix} \tag{3}$$

However, a disadvantage of bivariate VECM is that it does not ensure the conditional variance-covariance matrix of spot and futures returns to be positive definite, see Lien, Tse, and Tsui (2002).

In this paper, we employ a restricted version of the bivariate BEKK of Engle and Kroner (1995). The Bivariate cointegration model, with GARCH error structure, (BGARCH), incorporates a time varying conditional correlation coefficient between spot and futures prices. We apply several BGARCH models to our data, so we can highlight the selected model. In particular, to account for cointegration, we model the mean equations (first moment) with a bivariate error correction model, see

Engle and Granger (1987). For estimation, a BHHH algorithm with the Marquardt correction is used. We use Akaike's information criterion (AIC) to select the best model (representation).

The data[2] employed in this study comprise 525 daily observations on the FTSE/ASE-20 stock index and stock index futures contract (August 1999 - August 2001) and 415 daily observations on the FTSE/ASE Mid 40 stock index and stock index futures contract (January 2000 - August 2001). Closing prices for spot indices were obtained from Datastream, and closing futures prices were obtained from the official web page of the Athens Derivatives Exchange (www.adex.ase.gr).

The FTSE/ASE-20 comprises 20 Greek companies, quoted on the Athens Stock Exchange (ASE), with the largest market capitalisation (blue chips), while the FTSE/ASE Mid 40 comprises 40 mid-capitalisation Greek companies. Futures contracts are quoted on the Athens Derivatives Exchange (ADEX). The price of a futures contract is measured in index points multiplied by the contract multiplier, which is 5 Euros for the FTSE/ASE-20 contract and 10 Euros for the FTSE/ASE Mid 40 contract. There are four delivery months: March, June, September and December. Trading takes place in the 3 nearest delivery months, although volume in the far contract is very small. Both futures contracts are cash-settled and marked to market on the last trading day, which is the third Friday in the delivery (expiration) month at 14:30 Athens time.

First, several BGARCH (1,1) models are employed with 1, 2, 3, 4, 5, and 6 lags in the mean equation. Although most empirical applications have restricted attention to BGARCH (1,1) model, with one lag for Δs and one lag for Δf, we find that, for our data, the BGARCH (1,1) model with two lags for Δs and two lags for Δf has the lowest AIC value[3]. Therefore, we select this model. The results are presented in Table 1 (FTSE/ASE-20) and Table 2 (FTSE/ASE Mid 40). The ARCH coefficients are all positive and significant thus implying volatility clustering both in the cash and futures returns. The ARCH coefficients are also less than unity in all cases. The sign and significance of the covariance parameters indicate significance interaction between the two prices. Furthermore, since the coefficient of the error correction term, a_1 , is always positive and significant, we conclude that futures market does indeed lead the spot market, in both cases. Also, the coefficient of the error correction term in the futures equation, β_1 , is positive and significant, indicating that the spot market leads the futures market (the hypothesis is stronger for FTSE/ASE-20).

[2] For statistical information about our data, see Floros and Vougas (2006a, 2006b).

[3] The AIC values obtained from BGARCH(1,1) models are available upon request.

Table 1: BGARCH(1,1) model for FTSE/ASE-20

Method: Maximum Likelihood (Marquardt)		
Variance Equation	**Coefficient**	**t-Statistic**
Cash Equation		
c_s	0.042260	2.007186*
Δs_{t-1}^{s}	-0.141378	-1.353795
Δs_{t-2}^{s}	-0.146921	-1.596316
Δf_{t-1}^{s}	0.332504	3.401907*
Δf_{t-2}^{s}	0.040960	0.416209
$s_{t-1} - \gamma f_{t-1}$	0.114168	2.394974*
a_0	.007956	9.716976*
GARCH(s)	0.804686	23.80546*
ARCH(s)	0.423974	10.56802*
γ	.050383	103.0508*
Futures Equation		
c_f	.092519	2.989234*
Δs_{t-1}^{f}	.131053	1.388659
Δs_{t-2}^{f}	0.019301	-0.204969
Δf_{t-1}^{f}	.003937	0.039961
Δf_{t-2}^{f}	0.083076	-0.812026
$s_{t-1} - \gamma f_{t-1}$	.245615	4.822821*
β_0	.006698	9.378375*
GARCH(f)	0.847669	34.70326*
ARCH(f)	0.381055	13.23386*
γ	0.002300	6.959035*

** Significant at 5% level. f: futures, s: spot*

Table 2: BGARCH(1,1) model for FTSE/ASE Mid 40

Method: Maximum Likelihood (Marquardt)		
Variance Equation	**Coefficient**	**t-Statistic**
Cash Equation		
c_s	.011458	1.168256
Δs_{t-1}^{s}	0.346692	-2.895789*
Δs_{t-2}^{s}	0.318809	-3.713140*
Δf_{t-1}^{s}	.441579	4.463374*
Δf_{t-2}^{s}	.179441	2.189103*
$s_{t-1} - \gamma f_{t-1}$	.107175	1.724858*
a_0	0.009551	-5.336643*
GARCH(s)	0.859352	17.51828*
ARCH(s)	0.273643	6.162817*
γ	.021911	130.2276*
Futures Equation		
c_f	.036394	2.078109*
Δs_{t-1}^{f}	0.099071	-0.676403
Δs_{t-2}^{f}	0.155119	-1.405703
Δf_{t-1}^{f}	.103691	0.831461
Δf_{t-2}^{f}	0.001695	-0.015657
$s_{t-1} - \gamma f_{t-1}$	.294419	3.861531*
β_0	0.003459	-4.525360*
γ	0.010365	-9.230157*
GARCH(f)	0.823916	26.19745*
ARCH(f)	0.418860	10.57977*

** Significant at 5% level. f: futures, s: spot*

4. Conclusion

The introduction of a futures market and, in particular, the impact of futures on stock market volatility is a long debate. This paper tests the empirical relationship between spot and futures traded in the Athens Derivatives Exchange (ADEX) for the period 1999-2001. In particular, we examine the lead-lag relationship between stock index and stock index futures contracts for FTSE/ASE-20 and FTSE/ASE Mid 40 over the crisis period 1999 to 2001 (the Athens Stock Exchange experienced a dramatic fall of stock prices after 1999). A lead-lag relation exists when one market reacts faster to information due to transaction costs or other capital market effects.

Using a Bivariate GARCH(1,1) model, we confirm cointegration (long-run relationship) and lead-lag relationship between spot (cash) and futures. For both FTSE/ASE-20 and FTSE/ASE Mid 40, we show that futures markets play a price discovery role, implying that futures prices contain useful information about spot prices. Futures markets are more informationally efficient than underlying stock markets in Greece during the period 1999 - 2001. Stock index futures reflect new information faster than spot markets because Greek traders buy or sell stocks rather than index futures, while they prefer to use futures market to exploit information about economy. Reasons for why futures prices lead spot prices include the fact that futures markets have lower transaction costs and higher liquidity. Our results are helpful to traders, speculators and financial managers dealing with Greek stock index futures.

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