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Hedging Effectiveness in Greek Stock Index Futures Market, 1999-2001

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Abstract

This paper examines hedging effectiveness in Greek stock index futures market. We focus on various techniques to estimate variance reduction from constant and time-varying hedge ratios. For both available stock index futures contracts of the Athens Derivatives Exchange (ADEX), we employ a variety of models to derive and estimate the effectiveness of hedging. We measure hedging effectiveness using three different methods: (i) the OLS method, (ii) the method of Ederington (1979), and (iii) the method suggested by Park and Switzer (1995). In both cases for Greek stock index futures, the hedge ratio from M-GARCH model provides greater variance reduction, in line with similar findings in the literature. These findings are helpful to risk managers dealing with Greek stock index futures.

Keywords: Hedging Effectiveness, Futures, ADEX, OLS, ECM, VECM, M-GARCH.
JEL Classification: G13, G15.

I. Introduction

The basic motivation for hedging is to eliminate/reduce the variability of profits and firm value that arises from market changes. Hedge effectiveness becomes relevant only when there is a significant change in the value of the hedged item. A hedge is effective if price movements of the hedged item and the hedging derivative roughly offset each other. According to Pennings and Meulenberg (1997), a determinant in explaining the success of financial futures contracts is the hedging effectiveness of futures contracts.

Ederington (1979) defines hedging effectiveness as the reduction in variance and states that the objective of a hedge is to minimise risk. Howard and D'Antonio (1984) define hedging effectiveness as the ratio of excess return per unit of risk of the optimal portfolio of the spot commodity and futures instrument to the excess return per unit of risk of the portfolio containing the spot position alone (see also, Pennings and Meulenberg, 1997). Hsin et al. (1994) measure hedging effectiveness by considering both risk and returns in hedging. However, all these measures assume that futures contracts do not introduce risks, an argument which is not correct.

Numerous studies, investigating measures of effectiveness, try to determine to what extent hedgers are able to reduce cash price risk by using futures contracts. First, Markowitz (1959) measures hedge effectiveness as the reduction in standard deviation of portfolio returns associated with a hedge. Then, Ederington[1] (1979), following Working (1953, 1962), Johnson (1960) and Stein (1961), measures hedging effectiveness as the percent reduction in variability. He explains that a hedge is effective if the R-squared of the OLS regression explaining the data is high, say 90%. But a high R-squared by itself is not always a reliable indicator of hedging effectiveness. Howard and D'Antonio (1984) define hedging effectiveness in terms of risk and return. However, the second order conditions derived by Howard and D'Antonio are incorrect (see, Chang and Shanker, 1987; Satyanarayan, 1998). In particular, Chang and Shanker (1987) show that the measure of Howard and D'Antonio (1984) produces inconsistent results. Lindahl (1991) discusses the measures used by Howard and D'Antonio (1984, 1987) and Chang and Shanker (1987), and states that both measures are not appropriate because they decrease as basis risk approaches zero. Furthermore, hedging effectiveness has also been measured by a simple variance or risk-minimisation criterion which indicates whether mean futures are zero. According to Lypny and Powalla (1998, p. 350), *'the appropriateness of this criterion depends on whether mean futures returns are zero; if they are not, hedging may be too expensive'*. Finally, most recent papers use other more advanced econometric methods (i.e. ECM, VECM or BGARCH models) with or without error correction terms to estimate the hedging performance. In this paper, we examine whether such methods (ECM, VECM or BGARCH (1,1)) provide better results over the conventional (OLS) regression in terms of hedging effectiveness. An additional purpose of this article is to investigate hedging effectiveness in an out-of-sample performance using Greek futures data. This is the first investigation of hedging effectiveness for Greece.

The paper is organised as follows: Section II provides a detailed literature review, while Section III shows an overview of methods employed for estimating hedging effectiveness. Section IV describes the data, and Section V presents empirical results from various methods. Finally, Section VI concludes the paper and summarises our findings.

II. Detailed Literature Review

Hedging effectiveness has been widely investigated. Most studies focus on the ex post hedging effectiveness of stock index futures contracts (Figlewski, 1984). Also, little attention has been given to ex ante[2] hedging effectiveness (Malliaris and Urrutia, 1991; Benet, 1990; Holmes, 1995). Next, we briefly review research papers on hedging effectiveness of financial futures contracts.

Figlewski (1984) studies hedging effectiveness of US stock index futures contracts and observes that basis risk increases as the duration of the hedging horizon decreases[3] . Marmer (1986) studies hedging effectiveness of Canadian dollar futures over the period July 1981 to September 1984. Marmer (1986) examines effectiveness of the minimum variance hedge ratio (MVHR) in an ex ante framework, and shows that usefulness of the MVHR is rather limited. Lasser (1987) considers hedging effectiveness of Treasury bill and Treasury bond futures contracts. He applies the MVHR on an ex ante basis, and finds that *'ex ante hedges generated on the basis of a longer estimation period proved to be more effective hedges'*. Furthermore, Benet (1990) investigates and analyses risk reduction potential on an ex ante basis with regard to foreign exchange futures contracts. He argues that there is a discrepancy between hedge ratios on an ex post and ex ante basis, and therefore, his results reveal a more indicative measure of hedging effectiveness. This is in line with Butterworth and Holmes (2000), who suggest that ex post hedge ratio leads to a discrepancy between ex post and ex ante effectiveness.

1 Ederington's (1979) measure has been applied and discussed by Pennings and Meulenberg (1997) and Herbst , Kare and Caples (1989).
2 According to Butterworth and Holmes (2000), hedging effectiveness is truly examined using an ex ante strategy.
3 According to early studies of Ederington (1979), Howard and D'Antonio (1984) and Malliaris and Urrutia (1991), the measures of hedging effectiveness change with the length of the hedging horizon.

Holmes (1995) examines ex ante hedging effectiveness of UK index futures contracts (FTSE 100) using data over the period 1984 to 1992. He assumes that the portfolio to be hedged is the one that underlies the FTSE 100. His results suggest that *'the introduction of the FTSE-100 futures contract has given portfolio managers a valuable instrument by which to avoid risk'* (Holmes, p. 59). In addition, Laws and Thompson (2002) discuss hedging effectiveness of stock index futures on LIFFE, while Butterworth and Holmes (2000) examine further the ex ante hedging effectiveness of the FTSE 100 and FTSE Mid 250 index futures contracts for a range of portfolios. According to their analysis, *'the FTSE 100 contract has been seen to provide the most effective hedge for portfolios dominated by large capitalisation stocks, and the Mid 250 contract provides the most effective hedge for stocks dominated by low capitalisation stocks'* (Butterworth and Holmes, 2000; p. 15).

Further, Chang and Shanker (1987) show a new definition of hedging effectiveness following the model proposed by Howard and D'Antonio (1984, 1987). According to their analysis, Howard and D'Antonio's second order conditions do not have to be greater than zero. Also, Jong *et al.* (1997) apply three models for hedging effectiveness of futures to measure the effectiveness of currency futures: (i) the minimum-variance model of Ederington (1979), (ii) the a-t model of Fishburn (1977), and (iii) the Sharpe ratio model of Howard and D'Antonio (1984, 1987). Their results indicate that hedges are only effective for the minimum-variance and the a-t models. Brailsford, Corrigan and Heaney (2000) discuss several techniques of measures of hedging effectiveness using the Australian All Ordinaries share price index futures contract. Their results show that there is an impact from selection of the measure of hedge effectiveness to the assessment of hedged portfolios.

In addition, Chou, Denis and Lee (1996) compare hedging performance using Japan's NSA and NSA index futures with different time intervals. They find that the conventional hedge outperforms the error-correction hedge over the in-sample period. However, the out-of-sample period evaluates better hedging strategies. Chou, Denis and Lee (1996) also find that the error-correction model outperforms the conventional model over the out-of-sample period.

Park and Switzer (1995) examine hedging effectiveness for three types of stock index futures: (i) S&P 500, (ii) MMI futures and (iii) Toronto 35 index futures. Their results show that the bivariate GARCH estimation improves hedging performance over the conventional constant (OLS) hedging strategy. Furthermore, Bera, Garcia and Roh (1997) use a bivariate GARCH model and a random coefficient autoregressive (RCAR) model to examine hedging performance of spot and futures prices of corn and soyabeans. They find that the diagonal vech presentation of BGARCH model provides the largest variance reduction of the return portfolio.

Lypny and Powalla (1998) examine hedging effectiveness of German stock index DAX futures using a bivariate GARCH (1,1) model and an error-correction of mean returns. Empirical results confirm that the dynamic model is superior to models with constant hedge with or without error-correction means. This is in accordance with Kroner and Sultan (1993). Kroner and Sultan (1993) argue that a bivariate error correction model with GARCH error structure leads to more effective hedges than the conventional (OLS) method. More recently, Kavussanos and Nomikos (2000) show that a GARCH-X model outperforms all other hedges, while constant hedge ratio provides greater variance reduction over the sample. However, out-of-sample results report that an ECM-GARCH-X model outperforms alternative hedging strategies. Also, Yang (2001) shows that M-GARCH dynamic hedge ratios provide the greatest degree of variance reduction.

III. Methodology

Different measures of hedging effectiveness include: the early measure of Markowitz (1959), the method of Ederington (1979), the measures by Howard and D'Antonio (1984, 1987), and Lindahl's (1991) measure.

An early measure of hedge effectiveness is introduced by Markowitz (1959). He measures hedging effectiveness in accordance to the reduction of the standard deviation of portfolio returns associated with a hedge. In this case, the greater the reduction in risk, the greater the hedging effectiveness.

Ederington (1979) states that hedging effectiveness is equal to R-squared of the OLS regression:

$$\Delta S_t = c + b\Delta F_t + u_t \tag{1}$$

where S_t and F_t are logged spot and futures prices at time period *t*, respectively, and u_t is the error term from OLS estimation. ΔS_t and ΔF_t represent spot and futures price changes.

Ederington (1979) shows that a hedge is effective if the R-squared of the regression line explaining the data is high. In other words, the higher the R-squared, the greater the effectiveness of the minimum-variance hedge.

However, effectiveness of the minimum-variance hedge can be determined by examining the percentage of risk reduced by the hedge (Ederington, 1979; Yang, 2001). Hence, the measure of hedging effectiveness is also defined as the ratio of the variance of the unhedged position minus the variance of the hedged position, over the variance of the unhedged position[4] :

$$E = \frac{Var(u) - Var(h)}{Var(u)} \tag{2}$$

where

$$Var(u) = \sigma_S^2$$
$$Var(h) = \sigma_S^2 + h^2\sigma_F^2 - 2h\sigma_{S,F}$$
$$R_u = S_{t+1} - S_t$$
$$R_h = (S_{t+1} - S_t) - h(F_{t+1} - F_t) \tag{3}$$

$Var(u)$ and $Var(h)$ represent variance of unhedged and hedged positions, respectively, while σ_S, σ_F are standard deviations of the spot and futures prices, respectively. The hedge ratio is defined as the value of *h* and $\sigma_{S,F}$ represents the covariability of the spot and futures price.

Further, Park and Switzer (1995) and Kavussanos and Nomikos (2000) measure the variance of the hedged returns to the portfolios by evaluating $Var(\Delta S_t - h_t\Delta F_t)$, where h_t is the computed hedge ratio. In this case, the variance reduction (i.e. HE) is calculated as:

$$\text{HE} = \frac{\sigma^2(Unhedged) - \sigma^2(Hedged)}{\sigma^2(Unhedged)} \tag{4}$$

IV. Data

The data employed in this paper 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).

Focusing on the above periods, (i) we test the hypotheses using data from the early stage of the ADEX (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[5] .

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

4 Similarly, Butterworth and Holmes (2000) examine the ex ante hedging effectiveness of the FTSE 100 and FTSE Mid 250 index futures contracts using the minimum variance strategy of Johnson (1960).

5 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.

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.

V. Empirical Results

In this section, we compare measures of hedging effectiveness using several types of hedging models. Since selection of the hedge effectiveness measure has a considerable impact on the assessment of hedged portfolios, we measure hedging effectiveness of Greek stock index futures markets using Model (1), Model (2) and Model (4)[6] . To do so, the hedge ratios obtained from the methods of OLS, ECM, VECM and BGARCH (1,1) [7] are considered (see Floros and Vougas, 2004). The main question in this section is whether hedge ratios calculated from several methods generate better results in terms of hedging effectiveness.

First, Ederington (1979) argues that hedging effectiveness is equal to R-squared of the OLS regression (1). A hedge is effective if the R-squared of the OLS regression (1) is very high. Table 1 reports R-squared results for FTSE/ASE-20 and FTSE/ASE Mid 40. The R-sq. value for FTSE/ASE-20 is much higher than that of the FTSE/ASE Mid 40. Also, the fact that the R-sq. of FTSE/ASE-20 index is greater than 0.80 indicates that the hedge is effective. This is also in line with the main conclusion from previous studies that futures contracts perform well when R-sq. is between 0.80 to 0.99.

Table 1: In-Sample Hedging Effectiveness (R-Squared)

FTSE/ASE-20	**FTSE/ASE Mid 40**
R- sq. = 0.847163 (= 84.7163%)	R- sq. = 0.717509 (= 71.7509%)

Notes: Model: $\Delta S_t = c + b\Delta F_t + u_t$

Next, we measure hedging effectiveness of the FTSE/ASE-20 and FTSE/ASE Mid 40 using expressions (2) and (3). That is, we estimate the variance of the unhedged (i.e. *Var(u)*) and the hedged portfolios (i.e. *Var(h)*), and then calculate the hedging effectiveness, E. To do so, we take into consideration hedge ratios[8] estimated from the OLS regression, ECM, VECM and mean value of the selected BGARCH model. Table 2 reports (in-sample) results of hedging effectiveness from Model 2. It is clear that the FTSE/ASE-20 contract produces the most effective hedges. Also, for both contracts the OLS hedge ratio provides greater variance reduction. This is in contrast with recent papers (Yang, 2001), which show that the hedge ratio, calculated from the conventional regression model, does not perform well in terms of variance reduction (hedging effectiveness).

[6] We select to measure hedging effectiveness by using Models (1), (2) and (4) because both the Howard and D'Antonio (1984, 1987) and Lindahl (1991) measures require the risk-free rate of return series.

[7] We consider a restricted version of the Bivariate BEKK model by Engle and Kroner (1995), i.e. a Bivariate cointegration model with GARCH (1,1) error structure.

[8] The hedge ratios are estimated as follows: OLS 0.9160, ECM 0.9123, VECM 0.9129 and BGARCH (1,1) 0.9235 (FTSE/ASE-20), and OLS 0.7033, ECM 0.7150, VECM 0.7204 and BGARCH (1,1) 0.7542 (FTSE/ASE Mid 40).

Table 2: In-Sample Hedging Effectiveness (Model 2)

METHOD	FTSE/ASE-20	FTSE/ASE Mid 40
OLS hedge	0.850121 = *85.0121%*	0.71575 = *71.5751%*
ECM hedge	84.9866%	71.554%
VECM hedge	84.8711%	71.531%
BGARCH hedge	84.9875%	71.196%

Notes:

Model: $E = \frac{Var(u) - Var(h)}{Var(u)}$

Further, following Park and Switzer (1995) and Kavussanos and Nomikos (2000), we evaluate the variance of returns over the sample using Model (4). In other words, hedging effectiveness is now investigated by calculating $Var(\Delta S_t - h_t \Delta F_t)$, where h_t is the computed hedge ratio from the OLS, ECM, VECM and BGARCH models. In addition, we calculate percentage variance reductions of the unhedged position (i.e. $Var(S_t)$) over the other four hedges. Therefore, the variance of hedged positions is compared to the variance of unhedged position. The variance reduction (i.e. hedging effectiveness, HE) is now calculated as:

$$\text{HE} = \frac{\sigma^2(Unhedged) - \sigma^2(OLS, ECM, VECM, orBGARCH)}{\sigma^2(Unhedged)} \quad (5)$$

According to Park and Switzer (1995) and Kavussanos and Nomikos (2000), the larger the reduction in the unhedged variance, the higher the degree of hedging effectiveness. The variances are reported in Table 3, while the in-sample variance reductions are presented in Table 4.

Table 3: In-sample variances of Returns

METHOD	FTSE/ASE-20	FTSE/ASE Mid 40
OLS hedge	0.000059536	0.000157653
ECM hedge	0.000059552	0.0001577536
VECM hedge	0.000059552	0.0001578792
BGARCH hedge	0.0000581711	0.0001474767
Unhedged	0.000389	0.000556

Table 4: Percentage variance reductions (Model 5): In-sample

METHOD	FTSE/ASE-20	FTSE/ASE Mid 40
OLS hedge	84.695%	71.645%
ECM hedge	84.691%	71.627%
VECM hedge	84.691%	71.604%
BGARCH hedge	85.045%	73.475%

Notes:Model: $\text{HE} = \frac{\sigma^2(Unhedged) - \sigma^2(OLS, ECM, VECM, orBGARCH)}{\sigma^2(Unhedged)}$

Our results show that the BGARCH (1,1) hedge ratio provides greater variance reduction than the other models. Thus, the hedge ratio obtained from the Bivariate cointegration GARCH(1,1) model generates better results in terms of hedging effectiveness. In particular, for FTSE/ASE-20, the hedge ratio provides greater benefits from hedging as it significantly reduces the risk of price movements (i.e. the BGARCH (1,1) method reduces the variance by 85%). This is consistent with recent research papers (Park and Switzer, 1995; Kavussanos and Nomikos, 2000; Yang, 2001).

However, the more reliable measure of hedging effectiveness is the hedging performance of the post-sample periods. Since investors need to predict all about the future, we use an out-of-sample (post-sample) performance measure, which represents a way to evaluate effectiveness of hedge ratios. For this, we collect 100 observations of the sample (i.e. from April 2001 to end of August 2001). For

OLS, ECM and VECM hedging models, estimated hedge ratios are used for out-of-sample period. For BGARCH (1,1) model, we perform one-step ahead forecasts of covariance and the variance. Hence, the forecasted hedge ratio is the one-period forecast of the conditional covariance divided by the one-period forecast of the conditional variance. These out-of-sample estimated variances of returns are reported in Table 5, while the out-of-sample percentage variance reductions are reported in Table 6. Our results show that the hedge ratio[9] obtained from OLS and ECM generates better results in terms of hedging effectiveness. Both methods reduce variance by almost 90% and 85% for FTSE/ASE-20 and FTSE/ASE Mid 40, respectively. Also, we calculate Root Mean Squared Errors, Mean Absolute Errors and Mean Absolute Percent Errors for post-sample forecasts from the OLS method and Error Correction Model. Our results are presented in Figure 1 (FTSE/ASE-20) and Figure 2 (FTSE/ASE Mid 40). It can be observed that, Root Mean Squared Errors show that the error correction model (ECM) outperforms the OLS (conventional) model in both indices. Therefore, in this case the error correction model (ECM) is superior to the conventional model. This is consistent with Chou *et al.* (1996).

Table 5: Out-of-sample variances of Returns

METHOD	FTSE/ASE-20	FTSE/ASE Mid 40
OLS hedge	0.000034187409	0.000049773025
ECM hedge	0.000034187409	0.000049773025
VECM hedge	0.000034292736	0.000049787136
BGARCH hedge	0.000034621456	0.000049928356
Unhedged	0.000375274384	0.000327429025

Table 6: Percentage variance reductions (Model 5): Out-of-sample

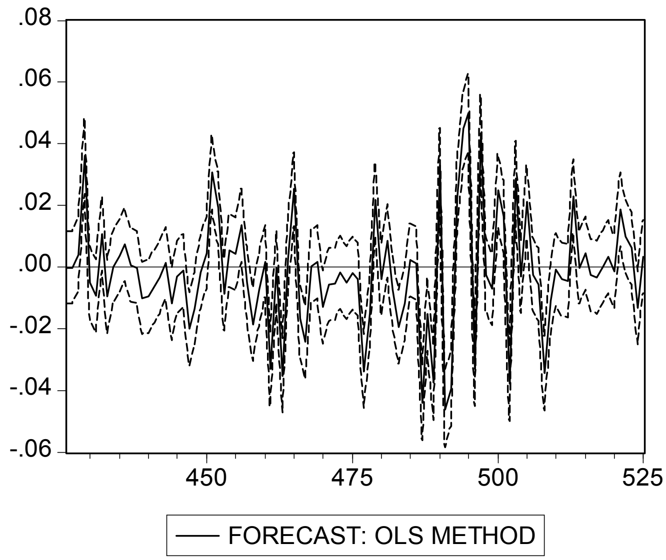
METHOD	FTSE/ASE-20	FTSE/ASE Mid 40
OLS hedge	90.890%	84.798%
ECM hedge	90.890%	84.798%
VECM hedge	90.861%	84.794%
BGARCH hedge	90.774%	84.751%

Notes:

Model: HE = $$\frac{\sigma^2(Unhedged) - \sigma^2(OLS, ECM, VECM, orBGARCH)}{\sigma^2(Unhedged)}$$

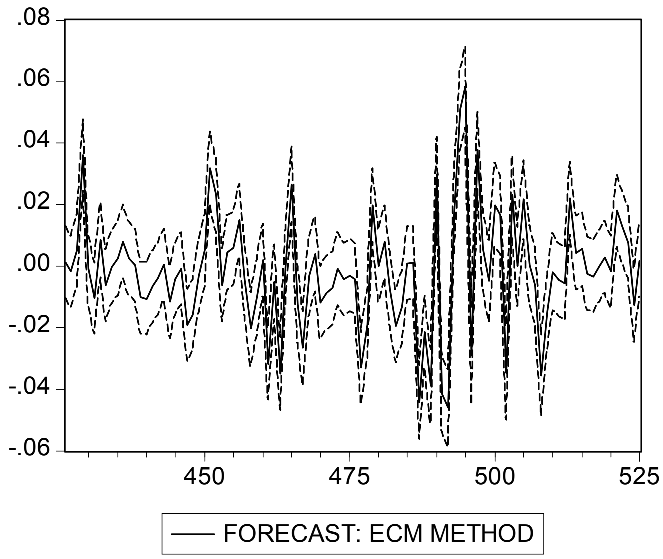
[9] The hedge ratio for the out-of-sample period is estimated as following: OLS 0.829832, ECM 0.831213, VECM 0.844990 and BGARCH (1,1) 0.872479 (FTSE/ASE-20), and OLS 0.787543, ECM 0.784684, VECM 0.794749 and BGARCH (1,1) 0.769032 (FTSE/ASE Mid 40).

Figure 1: FORECASTING (FTSE/ASE-20)



Forecast: OLS METHOD (FTSE/ASE-20)
Forecast sample: 426 525
Included observations: 100

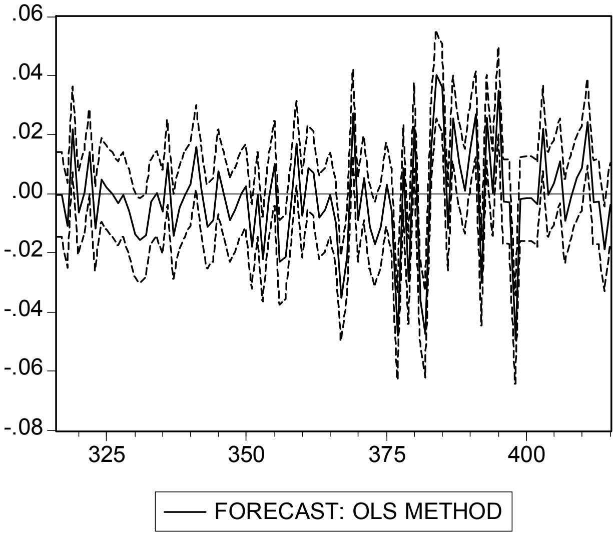
Root Mean Squared Error	0.005817
Mean Absolute Error	0.004570
Mean Abs. Percent Error	156.6240
Theil Inequality Coefficient	0.153856
Bias Proportion	0.000000
Variance Proportion	0.023872
Covariance Proportion	0.976128



Forecast: ECM METHOD (FTSE/ASE-20)
Forecast sample: 426 525
Included observations: 100

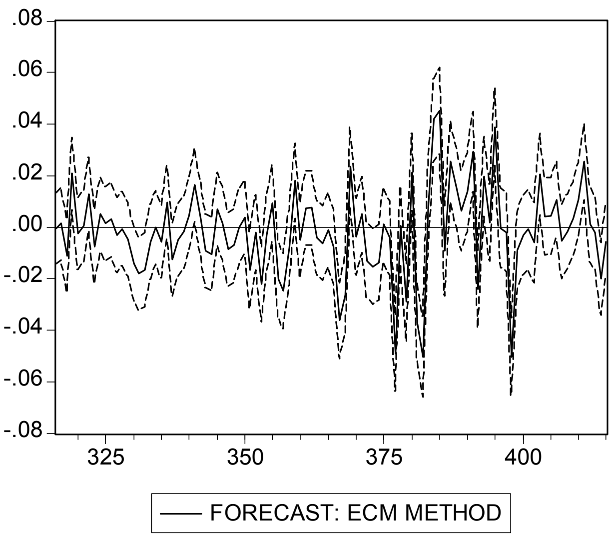
Root Mean Squared Error	0.005044
Mean Absolute Error	0.003981
Mean Abs. Percent Error	116.0238
Theil Inequality Coefficient	0.132665
Bias Proportion	0.000017
Variance Proportion	0.018627
Covariance Proportion	0.981355

Figure 2: FORECASTING (FTSE/ASE Mid 40)



Forecast: OLS METHOD (FTSE/ASE MID 40)
Forecast sample: 316 415
Included observations: 100

Root Mean Squared Error	0.007019
Mean Absolute Error	0.005134
Mean Abs. Percent Error	190.5715
Theil Inequality Coefficient	0.201896
Bias Proportion	0.000000
Variance Proportion	0.041195
Covariance Proportion	0.958805



Forecast: ECM METHOD (FTSE/ASE MID 40)
Forecast sample: 316 415
Included observations: 100

Root Mean Squared Error	0.006273
Mean Absolute Error	0.004741
Mean Abs. Percent Error	117.1410
Theil Inequality Coefficient	0.178873
Bias Proportion	0.000003
Variance Proportion	0.031915
Covariance Proportion	0.968082

VI. Conclusions

On theoretical grounds, a hedge is effective if price movements of the hedged item and the hedging derivative roughly offset each other. Ederington (1979) defines hedging effectiveness as the reduction in variance and states that the objective of a hedge is to minimise risk, while Howard and D'Antonio (1984) define hedging effectiveness as the ratio of excess return per unit of risk (of the optimal portfolio of the spot commodity) and the futures instrument to the excess return per unit of risk (of the portfolio containing the spot position alone). Furthermore, Hsin *et al*. (1994) measure hedging effectiveness by considering both risk and returns in hedging.

In this paper, we investigate hedging effectiveness of Greek stock index futures contracts (FTSE/ASE-20 and FTSE/ASE Mid 40). We compare several techniques of measuring hedging effectiveness. In particular, we measure hedging effectiveness of Greek stock index futures markets using three different methods: (i) the OLS model, (ii) the measure of hedging effectiveness which is defined as the ratio of the variance of the unhedged position minus the variance of the hedged position, over the variance of the unhedged position, and (iii) the method suggested, and applied, by Park and Switzer (1995) and Kavussanos and Nomikos (2000).

The primary objective of this paper is to examine whether specific hedge ratios (calculated from different methods) generate better results in terms of hedging effectiveness. Our hedge ratios obtained from the methods of OLS, ECM, VECM and BGARCH (1,1). First, results from OLS suggest that the R-sq. value of FTSE/ASE-20 is much higher than that of FTSE/ASE Mid 40. Therefore, the FTSE/ASE-20 index provides larger risk reduction. However, the ECM method indicates that the FTSE/ASE-20 contract produces most effective hedges. Following Park and Switzer (1995) and Kavussanos and Nomikos (2000), we show that the BGARCH (1,1) hedge ratio provides even greater variance reduction than the ones from other models. So, the hedge ratio obtained from the Bivariate cointegration GARCH(1,1) model generates better results in terms of hedging effectiveness. This is in accordance with Park and Switzer (1995), Kavussanos and Nomikos (2000) and Yang (2001).

Finally, we measure hedging effectiveness by considering hedging performance for post-sample periods. Using forecasting statistics for OLS and ECM, we find that the root mean squared error of ECM is lower than that of OLS for both indices. Hence, the ECM outperforms the OLS (conventional) model, and therefore, the error correction model (ECM) is superior to the conventional model. This is consistent with Chou *et al.* (1996).

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