Msc in Finance and Financial Information Systems

Lead-Lag Relationship between Futures Market and Spot Market: Evidence from the Greek Stock and Derivatives Market.

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Christoforos Chatzivasileiou

ABSTRACT

This thesis examines the dynamic relationship between the FTSE/ASE-20 spot price index, the FTSE/ASE-20 futures price index and their respective volatilities. In other words, the main question under investigation is whether the daily changes of futures price index, convey information relevant regarding the trend that the stock market will follow, or whether the changes in the spot market constitute as a predicting tool of the trend of prices in the market of futures contracts traded in the Athens Exchange S.A. The sample used in this thesis consists of daily closing stock and futures prices for both the FTSE/ASE-20 index and the FTSE/ASE-20 futures index, respectively. The set period of study was from the period from January 2, 2000 to May 30, 2008. The empirical examination employs GARCH (Generalised Auto Regressive Conditional Heteroscedasticity) methodology for the quantification of the volatility of futures and stock price indices, as well as Granger causality tests in the framework of a structural equation model (SEM) which allows the examination for both simultaneity and causality among the variables. The results demonstrate simultaneous interactions and both unidirectional and bidirectional casual impacts running among the FTSE/ASE-20 index and the FTSE/ASE-20 futures index and their respective volatilities. It is worth mentioning that the findings of this dissertation have essential implications for both market participants and regulators.

Keywords: lead lag relationship, Greek stock and derivatives market, market returns, market volatilities, GARCH, SEM, Granger causality, simultaneity.

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1. INTRODUCTION

The emergence of derivatives market in April 1982 has brought about radical changes to the nature of financial transactions. The futures contracts have provided investors flexibility, in regard to their portfolio synthesis and rapidity in their transactions. Furthermore, their use has lead to the application of strategies that aim to the minimization of the systematic risk of portfolios, as well as to their more effective synthesis. As a result, a significant number of transactions have moved from spot markets to futures markets.

Opponents of derivatives markets are largely based on the argument, that futures destabilise the spot prices and increase price volatility. They support that this phenomenon is particularly clear at the maturity dates of futures' series. On the other hand, proponents of futures contracts argue that this phenomenon is temporary and non-systematic as well. They disagree that derivatives constitute means of forecasting and setting prices of the spot market index and they claim that futures just offer the possibility for an alternative placement of capital to investors.

The temporal relationship among stock and futures markets has been and continues to be of intense interest to researchers, regulators, financial analysts and practitioners. The root cause for examining this relationship is that in perfect efficient and ideally organized futures and stock markets, informed investors are indifferent among trading in either market, as the new information is disseminated in both markets in exactly the same time. This means that changes in the logarithm of futures and stock prices (futures and spot returns) would be estimated to be perfectly contemporaneous correlated and non cross-autocorrelated (Stoll and Whaley, 1990). In such environment the negotiation of future contracts taking into consideration the underlying spot market index would not provide any arbitrage opportunities**.**

However, the various market frictions, such as the institutional settings of the financial markets, the differences in transaction costs and the market microstructure effects may lead the returns of the stock market to lead or lag the futures market and vise versa. Therefore, arbitrage profits may be plausible. As indicated by Chan and Chung (1993), arbitrage is a strategy according to which, investors seek to earn from the distribution among prices in the futures and spot markets for stock indices. Sofianos (1993) states that the lead lag relationship among futures and spot market is significant for arbitrageurs who demand to "complete both legs of an index arbitrage transaction".

As supported by many researchers, another important reason for examining this particular relationship between the two markets is that derivatives markets play an important price discovery role. According to Booth et al. (1999), price discovery is the procedure by which markets incorporate the new information to arrive at equilibrium asset prices. Analytically, price discovery denotes the price changes in the derivatives market lead price changes in stock markets more frequently than the opposite. If the previous statement is true, then the lead lag relationship among the two markets exists and hence, the prices of derivatives enclose valuable information about subsequent stock prices.

Lastly, another motive for studying this specific relationship is whether volatility spillovers from one market to the other. More analytic, the existence of 'volatility spillover' (transmission of volatility) between the two markets indicates that the volatility of returns in one market has an important effect on the volatility of returns in the other market. Thus, as Kavussanos and Visvikis (2004) note, market agents can use the volatility transmitting market in order to cover the risk exposure that they challenge. It should be pointed out that spot price volatility has been studied more intense due to its financial consequences, mainly after the 1987 spot market crash (Harris, 1989).

In an efficient financial market, the equilibrium relation between the price of futures at time t (F_t) and the price of the spot market at time t (S_t) is articulated in the following cost of carry model (MacKinlay and Ramaswamy, 1988, sighted in Stoll and Whaley, 1990):

$$F_t = S_t e^{(r-d)(T-t)}$$

where (r) is the risk-free rate, (d) is the dividend yield of the underlying asset, (t) is the current date and (T) is the expiration date of futures contract. Therefore, (r-d) is the 'net cost of carrying the underlying stocks in the index' and (T-t) is the remaining time in the futures contract life. The cost of carry equation illustrates that contemporaneous futures and stock prices should move simultaneously through time.

However, previous studies indicate that futures prices "tend to lead or Granger-cause", and, thus, help forecast stock prices (Green and Joujon, 2000). A number of likely explanations for this lead lag relationship between the stock market returns and the index futures were provided by previous studies and their interpretations can be summarized as follows. First and foremost, a reason for the asymmetric relationship between futures and stock markets is the low- trading volume of the stocks that comprise the index (Kawaller et al., 1987; Shy et al, 1996). However, in their study Stoll and Whalley (1990) found that the stock price lags behind the futures price, even after eliminating the infrequent trading effect. Secondly, as Abhyankar (1995) stated, the dissimilarities in liquidity among the futures and stock market can also lead to an asymmetric relationship between them. In addition, the several market frictions, such as the differences in transaction costs and short selling restrictions provide an explanation as to why futures markets lead spot markets (Stoll and Whalley, 1990; Abhyankar, 1995; Fleming et al., 1996). Another reason sighted occasionally, is that informed traders that have some firm specific information, may prefer to trade in the stock market rather than in the derivatives market (Subrahmanyam, 1991; Chan, 1992). In alignment with the above, Green and Joujon (2000) mentioned that derivatives markets magnetise hedgers, while stock markets magnetise primary investors. Therefore, derivatives prices disclose dissimilar information when compared to stock prices. Also, the market architecture, as supported by Grunbichler et al. (1994), may be another root cause for this asymmetric relation between the two markets. Lastly, the market maturation, as reported by Kawaller et al., 1987; Stoll and Whalley, 1990; Chan, 1992; Fleming et al., 1996, may settle a lead lag relationship between the two markets. More specifically, the findings of the above studies indicated that in mature markets, like in the case of the US market, derivatives markets are more effective in incorporating information above the whole market, since the traders are well acquainted with derivatives contracts. However, as Chiang et al. (2001) noted, in emerging financial markets (i.e. Hong Kong), the derivatives markets may not be more effective, in terms of information content, than the stock index, since derivatives are unfamiliar to markets participants and therefore may meet low liquidity.

The purpose of the present dissertation is to examine the relationship between spot price index, futures price index and their respective volatilities. More specifically, the main question under examination is whether the daily changes of futures price index, convey information relevant with the trend that the stock market will follow, or whether the changes in the spot market constitute as a predicting tool of the trend of prices in the market of futures contracts traded in the Athens

Derivative Exchange (ADEX) and in the Athens Stock Exchange (ASE). The set period of study starts from January 2, 2000 and ends in May 30, 2008.

In other words, the lead lag relationship between futures market and spot market in Greece is going to be examined. The lead lag relationship will reveal whether the futures market leads the stock market, whether the stock market leads the futures market or whether a bi-directional feedback among the two markets exists. This relationship demonstrates how well the two markets are linked with each other and how one market reacts faster to the release of new information compared to the other. It is worth mentioning again, that when feedback exists between the two markets, then investors are in position to gain from arbitrage opportunities by using information of the past. Several relative studies have been undertaken to all the mature markets, unfortunately with mixed outcomes. However, the majority of previous findings indicate that futures returns lead stock returns. Hence, futures market causes a stronger lead effect. Based on the statements of opponents, that futures contract destabilise the spot prices and increase price volatility, especially on financial crisis periods (intense criticisms were also practiced in the Greek derivatives market - categories for speculation), the relationship between spot price index, futures price index and the respective volatilities in the Greek market during the period from January 2, 2000 to May 30, 2008 will be examined. The empirical examination employs GARCH (Generalised Auto Regressive Conditional Heteroscedasticity) methodology, first introduced by Engle in 1982, for the quantification of the volatility of futures and stock price indices and the Granger causality tests between the variables in question. Furthermore, Granger causality tests in the framework of a structural equation model (SEM) will be applied to examine for both simultaneity and causality features among the variables in examination. In general, the empirical results clearly and strongly indicate that the dynamic relationship among futures returns, stock returns, futures index volatility and stock index volatility can best be described by simultaneity and feedback.

The rest of the dissertation is structured as follows: In Section 2, the literature on the lead – lag relationship between futures and spot markets is reviewed. In Section 3, the Greek derivatives market is presented, the data set is illustrated. Moreover, the econometric methodology employed will be outlined. In section 4, the empirical results of the survey are presented and analysed. Lastly in the final section the main concluding remarks are presented.

2. LITERATURE REVIEW

Research on the relationship between stock and futures market was boosted after the 1987 stock market crash. A significant number of studies focused their analysis on the relationship between futures and stock market in regard to prices or returns. Furthermore, several surveys have concentrated their examination on return volatility, inter-market volatility and whether a connection between the volatility in stock market and the volatility in futures market exists. In addition, it should be emphasised that these studies are presented according to their differences which stem from the special characteristics and the geographical location of each markets under investigation, the frequency of the data used and the estimation methodology applied.

Reviewing the empirical literature, it is observable that the results can be characterised as mixed, although the majority of researchers, financial analysts and practitioners have suggested that futures markets lead the stock markets. In this chapter, the main literature findings are presented, from the year 1983 up to the present in a chronological order.

One of the first surveys examining the relation between stock and futures market was accomplished by Zeckhauser and Niederhoffer (1983). The results of this study indicated that futures prices seem to have some capability in anticipating movements in the stock index, especially in the short term.

Kawaller et al. (1987) employed in their study a time-series regression analysis and used minute to minute intraday data to investigate the lead lag relationship between the S&P 500 index future and the S&P 500 stock index. The authors examined and compared the stock and futures price relationship on the expiration days of the S&P 500 index future and on the days prior to the expiration day. The above comparison is quite interesting and provides useful and significant information to traders, since the market's activity on the expiration days is different from that on the days prior to expiration. The results of the analysis indicated that the S&P 500 index future leads the S&P 500 index by twenty to forty-five minutes, while movements in the index usually have an effect on futures within one minute. Furthermore, the lead from futures to spots extends for almost the same period of time, both on expiration and non expiration days. According to the researchers', this is due to two reasons. Firstly, future contracts have lower transaction costs than stocks. Secondly, a significant number of stocks do not trade continuously in the index, resulting in faster dissemination of the new market information to the futures market than the stock market.

. In the same year, Herbst et al., (1987) studied the relationship among stock and futures index in order to reveal if there is "evidence to support the hypothesised lead lag relationship between the two markets and to provide a measure of this timing relationship". More specifically, employing daily data from February 24, 1982 to September 18, 1982 (144 observations), they investigated the relationship between the Value Line stock index and the Kansas City Board of Trade's Value Line futures index. By using cross-correlation analysis, they concluded that futures lead stocks between zero and sixteen minutes. Also, employing ten second data (2200 observations per day) for a random week (May 3 - May 7, 1982,), they examined the relationship between the S&P 500 stock index and the S&P 500 futures index, concluding again that the futures market leads the stock market by eight minutes. It should be mentioned that although this lead lag relationship between the two markets seems to be more significant at longer time spans, the stock index responds at first in less than one minute.

An important research is that of Stoll and Whaley (1990) who examined the lead lag relationship between the spot prices of the S&P 500 and the Major Market (MM) stock Index and the futures prices of the S&P 500 and the MM futures Index respectively. They used intraday five-minute returns for the time period of five years and employed an ARMA process to carry out their study. The outcomes of the above investigation confirmed once again, that the futures market leads the stock market by five minutes on average and rarely by ten minutes or more. This is due in part, to the fact that not all stocks in the index trade frequently. Furthermore, it is important to be mentioned that the results showed a bidirectional relationship between spot and futures returns. More specifically, in some cases the lagged spot index returns have a mild positive prognostic impact on futures returns. However this effect gradually becomes less significant as the futures markets mature.

In contrast with many researchers, Chan et al. (1991) by applying bivariate GARCH methodology (Generalized Auto-Regressive Conditional Heteroscedasticity) investigated the intraday relationship between returns and returns volatility in the S&P 500 stock index and the stock index futures market for the period 1984 -1989. They came to the conclusion that, both the S&P 500 stock index and the stock index futures market cannot forecast any change of prices from one market to the other.

They also suggested that the above result stands true, when the volatility of price changes in the two markets, is examined. Strong bidirectional dependence exists both in returns and returns volatility between the stock and futures market. In particular, the dependence in volatility between the two markets is growing stronger as the dependence in price changes seem to weaken over the period under study. Thus, it is obvious that there is not a lead lag relationship between price changes and volatility in futures index and the underlying index. The new information regarding the market is disseminated in both stock and futures markets and both markets perform significant price discovery roles.

Additionally, Chan (1992) by using regression models investigated the intraday relationship between returns of the Major Market Index (MMI) and returns of the MMI futures and the S&P 500 futures index over two different time periods. More specific, the author observed if the lead lag relationship varies in accordance with i) good news against bad news; ii) the comparative intensity of trading activity in the two markets; iii) the size of market-wide movement. For the analysis, he tested data from August 1984 to June 1985 and during the period of January to September 1987. The results of the survey in each of the three above cases suggested that there is an asymmetric lead lag relation between the stock and futures market. Especially the futures market strongly leads the stock market, while the stock market weakly leads the futures market. According to the author, the most important finding of the survey is that the lead lag relationship between the two markets fluctuates, in consistent with the size of market-wide movement. When market -wide information exists, (the majority of stocks run together) then there is a strong lead of futures to stock market. Finally, Chan concluded that the asymmetric led-lag relationship between stock and futures market exists, because futures process information quicker and reflect market-wide information better than stocks.

Chan et al. (1993) continuing the research on the topic, by using a non linear multivariate regression model which firstly introduced by Gibbons in 1982 examined the lead-large relationship between stock and futures prices. The data used for the analysis, were produced from the Transaction File of the Institute for the Study of Security Markets (IISM) that contains all trades and bid-ask quotations on American and New York Stock Exchanges and the majority of regional exchanges. Moreover the data comprise five minutes stock and futures returns and bid-ask quotes for the first quarter of 1986. The authors based their survey on Stefan and Whaley's (1990) which supported, that stocks lead futures. Their results reconfirmed that stocks lead futures by fifteen minutes and this is due to the way stocks and futures are traded. In addition they supported, that the stocks lead disappears when the average of the bid and ask are used instead of transaction price. Thus, no arbitrage opportunities arise when the stock lead exists.

Moreover, Ghosh (1993), using error correction and cointegration processes, examined if the futures and stock price changes can be predicted and if any causal relation exists, among them. In order to carry out his survey, intraday observations from the S&P 500 stock index and the S&P 500 futures index (for the year 1988) were employed, as well as daily observations of the Commodity Research Bureau stock and futures index (from June 12, 1986 to December 31, 1989). It is worth to be mentioned, that the data from the S&P 500 stock index and the S&P 500 futures index were concurrent stock and future prices every fifteen minutes on each Wednesday of the year 1988. The reason for selecting the particular prices was the avoidance of the day-of-the-week effect. The empirical outcomes pointed out, that "both" systems are cointegrated, with a stable long-run equilibrium relationship" between them.

Furthermore, Puttonen (1993) studied the relationship between the Finnish stock index cash and derivatives market during the period from May 2, 1988 (beginning of the Finnish Options Markets) through the end of 1990. Employing a Vector Error Correction Model (VECM) to test causality on daily observations, he concluded that there is an essential information flow from futures returns to spot index returns. However, it should be pointed out, that this lead lag relationship among the Finnish futures and stock market fluctuates significantly depending on the period of examination. According to the survey, the dominant role of the Finnish derivatives market, in terms of the flow of information between the spot and derivatives market can be attributed to the great transaction costs, the immature arbitrage sector and the frictions of the Finnish spot market. Moreover, the author supported that all researchers with areas of study similar to the above, have to be very cautious when deciding the period of examination, before proceeding to additional assumptions concerning the behaviour of the examined markets. Lastly, he suggested that during the period of studying the flow of information among derivatives and spot markets, the cointegration of the markets must be taken into consideration.

In their study, Wahab and Lashgari (1993), by using various cointegration tests, claimed that a bidirectional relationship between futures and stock prices exists, although the domination of the stock prices seems to be stronger. More specifically by adopting daily prices for spots and futures, trading both in the Standard and Poor 500 index (S&P 500) and the Financial Times-Stock Exchange 100 share index of London (FT-SE 100) for the time period January 4, 1988 to May 30, 1992, investigated the daily price change relation between the above markets. The results of their study supported that the futures and the spot markets are cointegrated. Furthermore, the simultaneous relation between futures and stock prices is found to be "weak in magnitude" indicating market efficiency, as the predictive ability of one market to the other appears not to be economically important. In addition, even if feedback between futures and spot markets for both the indices exists, the lead from stocks to futures seems to be more obvious across days, compared to the lead from futures to stocks. Hence it is obvious that the results are consistent with previous findings, concerning the price discovery role that both markets serve. However, it should be noticed that the high degree of interdependence which detected between futures and spot market does not often appear in earlier analysis of similar surveys.

An interesting survey carried out by Grünbichler et al. (1994), who examined the lead lag relationship between floor traded stock returns and screen traded futures returns applying an ARMA process. The authors used floor traded data (five minutes return) from the German Stock index (DAX) of Frankfurt's Stock Exchange and screen traded data from (DAX) of the German Futures and Options Exchange (DTV) for the period of November 1990 to September 1991. The results of the study supported, that the DAX futures index leads the underlying stock index by fifteen to twenty minutes. Furthermore, the authors claimed that the lead lag relation between floor traded and screen traded returns seems to be more extensive and unidirectional than in cases where both the stock and future indices are floor traded.

An important analysis is that of Abhyankar (1995), where adopting EGARCH process and using hourly data investigated the relationship between the FTSE-100 index future of London's derivatives market (LIFFE) and the FTSE-100 index spot of London's spot market (LSE) for the period 1986-1990. He distinguished his survey into four sections. Firstly he investigated the lead-lad relationship between the FTSE 100 futures index and the underlying stock index. Secondly, he proceeded to the examination of the performance of the lead lag relationship under different market situations. Thirdly, the author examined the relationship between the forecasting power of the volatility of one market to the other employing a conditional estimate of the return variance. Lastly, he investigated the lead lag relationship in volatility between the stock and futures market under diverse market conditions. For the purpose of the study, Abhyankar separated the sample period of data into three sub-periods. The first period extends from April 1986 to October 1986, is the period before the beginning of the significant reforms in London's International Stock Exchange. The second period is from October 1986 to September 1987 where the crash happened. The last period starts on May 1988 and ends on March 1990. The results of the study showed that a contemporaneous relationship exist between the FTSE100 futures index and the underlying index. Furthermore, the futures market leads the stock market in the mean, even though in the second time period there is a weak lead of stock market. According to the author, traders with market wide information choose to use futures market because of lower transaction and entry costs. Therefore, any information is assimilated faster in futures market offering temporary speculation opportunities. More specific, during the periods of "moderate" news and high volatility, futures lead stock market. In addition during the periods of "good" and "bad" news, period of low volatility and high and low trading neither market lead the other. Finally, there is a bidirectional relationship in the volatility between futures and stock indices under any market circumstances.

For the US market, Flemming et al. (1996) examined the relationship between the S&P 100 options, the S&P 500 futures and the underlying spot index. By using five minute returns during the period from January 1988 to March 1991 and by applying an ARMA process, they presented a "trading cost explanation" for the price discovery role that the three markets play. They supported that the form of trading costs allows the derivatives market to lead the stock market, as it absorbs first the new information. As far as the lead lag relationship, between the markets under investigation concerns, they concluded that the futures and the options markets lead the stock market. Summarising their survey, they pointed out that price discovery takes place in the derivatives market, as the trading costs are significantly less compared with those in the spot market.

In their study Shyy et al. (1996), supported that the Paris Bourse stock market leads the Matif futures market. For the purpose of the study, they applied Granger causality tests on minute by minute transaction prices and bid / ask quotes from the CAC futures index and the CAC 40 stock index for the time period of one month (September 1994). The authors decided to use both bid / ask quotes and transaction prices because they claimed that the first are more reliable than the second. Analytically, the bid / ask quotes are executable prices at the time of transaction, on the contrary transaction prices reflect the stale price of the final trade. Firstly transaction prices of the two markets tested, showing that the CAC futures index leads the underlying index. However, the authors repeated the test using bid / ask quotes and concluded that the outcomes are reverse, since the CAC40 stock index leads significantly the CAC futures index. Therefore, they suggested that the previous studies which support that futures lead stock markets are mainly based on trading systems employed in stock or futures market and to nonsynchronous trading in the two markets.

Moreover, Kutmos and Trucker (1996), using daily closing prices (2770 observations) and applying a bivariate EGARCH procedure, analysed dynamic interdependencies and volatility spillovers between the S&P 500 index and the S&P 500 futures index during the period from 1984 to 1993. The outcomes suggested that the short-term dynamics in the futures and in the stock market are almost the same. Also, they supported that innovations deriving from futures market rise volatility in the spot market in an asymmetric way, while innovations beginning from stock market do not affect futures market volatility.

In addition, Iihara et al. (1996) by employing minute-by-minute observations examined the relationship (in terms of returns and volatilities) between the Nikkei Stock Average (NSA) index and the NSA index futures trading in the Osaka Securities Exchange (OSE) in Japan. The period of examination covers three discrete time periods. The year 1989 which is characterised as a bull market, the year 1990 that is characterised as a bear market and covers the period until the introduction of stricter measures in OSE and the year 1991 which covers the period following the introduction of such measures and is considered a bear market too. Applying AR (1) process, they came to the conclusion that futures returns lead stock returns for all the three sub periods. Also, no bidirectional causality between the two markets was detected, indicating again that the futures market absorbs first the new information that is disseminated in the economy.

In their research Cheung and Fung (1997), using daily data investigated the relationship between the three-month Eurodollar stock rate and the Eurodollar futures rate during the years 1983 to 1997. By using an AR-GARCH model, cointegration analysis and Ganger causality tests they came to the conclusion that bidirectional feedback causality among the two markets exists with futures affecting spot rates and vice versa. However, it should be mentioned that futures have a larger impact on the stock market, in terms of interest rates and volatilities.

Furthermore, De Jong and Nijman (1997), utilising high frequency data examined the lead lag relationship among the S&P 500 stock index and its corresponding future contracts. More specifically, by employing one minute observations (the data are from the final quarter of 1993) into a process that prevents imputation and uses all obtainable transactions to estimate cross covariance, they concluded that bidirectional relationship between the two markets exists. Analytically, the futures index leads the stock index by ten minutes, while the stock index leads the futures index by two minutes.

Once more, Abhyankar (1998) continued his research on the lead lag relationship between the returns of the FTSE 500 futures index and the underlying index providing new evidences on the subject. For the purpose of the survey, he employed both linear and nonlinear Granger causality tests and used high frequency data. The results suggested that in the first case (linear Granger causality) the FTSE 500 futures index lead the underlying index by five to fifteen minutes. However, in the second case (non linear Granger causality) no unidirectional relationship exists between the two markets, since neither of them seems to lead the other.

Continuing, Nieto et al. (1998) employed Johansen cointegration technique to test Granger causality between the daily returns of the Spanish futures index (Ibex 35) and the underlying stock index. The sample period of the analysis is from March 1994 through September 1996. The authors examined causality for the short-term and for the long-term. The empirical results reported, that in the first case futures prices causes stock prices, while in the second case there is not a considerable indication of such a lead lag relationship. Therefore, the Spanish futures markets can be characterised as an efficient market for the period examined.

Moreover, De Jong and Donders (1998) examined the relationship between returns on the futures index, cash and options. The data employed in their survey were taken from the European Options Exchange (EOE) covering two sample periods, January 20 through July 17, 1992 and January 4 trough June 8, 1993. By using the underlying return generating model to estimate the lead lag relationships between the markets, they found that the three markets are contemporaneously correlated. Also, according to the results of their investigation an asymmetric relation among the markets exists. In particular, the results showed that the futures returns lead both the cash index and option returns by ten minutes. According to the authors, this is due to several reasons. Firstly, the transaction costs are smaller for futures market compared to those in the stock or option markets, leading informed investors to trade in this market. Other reasons are the infrequent trading of the stocks and the leverage effect which is higher for the futures. Another concluding remark of their research is the symmetrical lead lag relation between the stock index and the options, pointing out that neither market methodically leads the other. Lastly, from all the above it comes clear to the reader, that the futures market absorbs better and faster market-wide information

Pizzi et al. (1998) following the previous researchers, studied if price discovery takes place more considerably in the derivatives market compared to the stock market. Particularly, by exercising an error correction model and cointegration analysis and by employing minute by minute data investigated the relationship among the S&P 500 spot index and its corresponding futures contracts (three-month and six-month contracts) during the period from January 1987 to March 1987. The outcomes of this survey indicated, that the futures markets leads the spot market by at least twenty minutes, while the spot market leads the futures market by at least four (six-month contracts) and three minutes (three-month contracts). As the author noted, "while the futures market does tend to have a stronger lead effect, unidirectional causation of futures to spot is refuted". Lastly, the empirical results of the Engle-Granger analysis proved that the markets under examination are cointegrated, showing market efficiency.

Additionally, Turkington and Walsh (1999) investigated the high-frequency causality and the price discovery in the Australian Share Price Index futures market using five minute prices for the year 1995. By applying cointegration tests and an ARMA process, the researchers supported that there is bidirectional causality between future and spot prices with many significant lags. According to the authors' findings, neither market absorbs the new information faster than the other. Lastly, they pointed out that the main cause for a lead lag relationship from one market to the other is which market picks up the latest information first.

In their study, Silvapulle and Moosa (1999) examined the relationship between futures and stock prices for the WTI crude oil, using daily observations during the period from January 2, 1985 to July 11, 1996. Linear causality tests revealed that futures prices lead stock prices, while nonlinear causality tests showed that bidirectional causality between the two markets exists. In particular, they detected feedback from stock prices to futures prices and also that both the futures and the spot market react to new information at the same time. However, they indicated that this lead lag relationship varies significantly over different time periods. Summarising, it should be mentioned that even if the futures market holds the dominant role to the price discovery procedure, the stock market plays an essential role for its function as well.

Furthermore, Min and Najand (1999), used ten minute intraday data (2715 observations) from May 3, 1996 to October 16, 1996, from the KOSPI 200 index and its corresponding futures contracts to examine the lead lag relationship between the two markets, both in terms of volatility and return. In order to accomplish their study, a Vector Autoregression Model (VAR) and Dynamic Simultaneous Equation Models were employed. In the case of returns, the outcomes of their study indicated that the KOSPI 200 futures index leads the KOSPI 200 index by thirty minutes. This relationship between the two markets remains almost stable, "even after removing spurious positive autocorrelation in the stock returns". With regard to volatility relations between the two markets under examination, they concluded that bidirectional causality among the two markets exists. According to the authors, "this relationship is entirely sample-period-dependant". Lastly, summarising their survey, they attributed this lead lag relationship to stock market frictions (transactions costs and short sale limitations), which do not allow the stock market to react at the same time with futures market to new information that is disseminated in the market.

In the same year, Kyriacou and Sarno (1999) using daily data, examined the temporal relation among derivatives trading and stock market volatility in the United Kingdom. In particular, by employing GARCH methodology and a trivariate SEM (Simultaneous Equation Model), which permits for both causality and simultaneity they investigated the relation among put options, call options and futures trading activity on the FTSE-100 index and the volatility of the underlying spot index. The empirical results of the survey, confirmed by Monte Carlo evidence, indicated that important simultaneity and feedback causality exists between stock market volatility and options and futures trading. Lastly, according to their outcomes derivatives' trading seems to have an effect on stock market volatility in reverse directions in the model suggested.

Another research is that of Brooks et al. (1999), who investigated the lead lag relationship between the S&P 500 stock index and its future contacts and between the FTSE 100 and its corresponding contracts. They employed daily returns and used a method firstly introduced by Hinich in 1996, which allows both the examination "of cross-correlations and cross-bicorrelations" among spot index and spot index futures contracts. The sample period for the S&P 500 stock index and its future contacts span from January 1985 to December 1993, while for the FTSE 100 and its nearby contracts the period examined extents from January 1983 to December 1993. Their results showed a less obvious lead lag relationship between futures and spot market, compared to the results of previous studies which used traditional methodologies such as Granger and Sims causality tests. In general, as the authors suggested, the outcomes of their survey "are consistent with the prediction of the standard cost-of-carry model and market efficiency".

Frino et al. (2000) analysed the relationship between stocks and futures trading in the Australian Stock Exchange and in the Sidney Futures Exchange around information and macroeconomic releases during the period from 1 August 1995 to 31 December 1996. The Share Price Index (SPI) futures contract is based on the All Ordinaries Index, which is consisted of 280 stocks traded on the Australian Stock Exchange. Using an ARMA approach, Frino et al. concluded that around information and macroeconomic announcements the lead of the futures contracts strengthens. This means that investors with better market wide information choose to trade in the futures markets. Furthermore, according to the results, around stock specific information, the lead of the futures market weakens, while the lead of the stock market strengthens, which denotes that investors who choose to trade in stocks are those with stock-specific information. Therefore, it could be pointed out, that around spot specific information and macroeconomic releases " disintegration in the contemporaneous relationship between the future and the stock market, fact which is consistent with the effects of noise associated with price discovery" takes place.

Moreover, Gwilym and Buckle (2001), by using hourly data examined the relationship between the London's FTSE 100 stock market index and the options and futures contracts that are based upon it. They also investigated the inter-market relationship between the derivatives markets trading in the London International Financial Futures and Options Exchange (LIFFE). In order to accomplish their survey, the Black model and the GMM covariance matrix were used. The sample period is extended from January 1993 to December 1996. The results of their study showed, that both index options and index futures lead the stock index. However, it should be mentioned that although the option market leads the stock market, evidence of feedback causality exists among them. As far as, the interrelation between the derivatives market is concerned, they found that the call option market leads both the put option and index futures market. Summarising, they supported that transaction costs are the basic determinant of this lead lag relationship between the stock and the derivatives markets.

For the Greek market, Alexakis et al. (2002) investigated the lead lag relationship in daily returns and volatilities between cash and stock index futures. In particular, by using daily closing futures and stock prices from both the FTSE/ASE Mid-40 and the FTSE/ASE-20 markets of the Athens Stock Exchange (ASE), the researchers examined if information adjustment is quicker for futures than for stock index during the period from 1999 through 2001. Furthermore, by employing VECM-SURE and VECM-GARCH-X models they confirmed the results that appear in the majority of similar studies, that futures returns lead spot index returns. Alexakis et al. attributed this lead lag relationship to the fact that the new information is distributed quicker in the futures market than in the stock market. Hence, informed investors are concerned, trading among the stock and the futures market. Moreover, according to the empirical results of the study, it could be mentioned that futures prices can be utilised as "price discovery vehicles", as it is obvious that the last enclose valuable information about spot prices, information that can be applied in decision making. Lastly, the researchers proposed that the Greek derivatives market could make available futures contracts that accomplish their role as "price discovery vehicles", offering parallel an alternative investment solution.

In their survey Lin et al. (2002), using five-minute intraday data and employing an EGARCH and Vector Error Correction Model (VECM) investigated the relation of volatility and return among the Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX) and its related future contracts. The data covered the period from January 5, 1999 to March 31, 2000. The empirical outcomes of their study supported, that bidirectional Granger causality between the two markets exists, with spots activating a more significant role in the price discovery procedure. Also, the results of the EGARCH model indicated, that the information flow from futures to stocks is weaker compared to the flow from spot to futures. According to the authors, the TAIEX stock market absorbs faster the new information that is disseminated in the market and it is the dominant one in terms of volatility and return. The authors attributed this relationship to three factors: the recent introduction of TAIEX futures market, the high percentage of the individual investors (almost 90% of the total trading value of Taiwan stock market) and the very high turnover of trading value in Taiwan stock market.

Antoniou et al. (2003), moving one step forward from the other researchers, except from investigating the lead lag relationship between futures and spot market both in terms of return and volatility, examined the diffusion of volatility across international markets. They suggested that previous studies, which examined this relationship within one country, may have provided misleading outcomes, as they ignored market interdependencies among countries. By applying a multivariate VAR-EGARCH analysis and by using daily data, they investigated the lead lag relationship between the futures and stock markets of Germany (DAX 100), France (CAC-40) and the UK (FTSE-100) during the period from 1990 to 1998. The empirical results of their survey are of great interest. First of all, they confirmed that futures markets lead stock markets, not only within one country, but also across the examined countries. In addition, they proved that the internal spot-futures relation is affected by the behavior of foreign markets. Finally, they suggested that investors should take into consideration the relationship among foreign and domestic markets "when considering the price adjustment dynamics between markets".

Another research examining the lead lag relationship between stocks and futures trading in the Athens Stock Exchange and in the Athens Derivatives Exchange (ADEX) accomplished by Kenourgios D. F. in 2004. More specifically, by using daily data, he investigated the price discovery in the Greek index futures market and the information linkage among the FTSE/ASE-20 spot index and its three-month index future contracts. Employing both the Engle-Granger and Johansen methods he concluded that futures and spot market are cointegrated. The empirical results of the study indicated bidirectional causality between futures and spot market, meaning that information linkage among the two markets exists. Therefore, it becomes clear that futures prices include helpful information about spot prices and they can play their role as vehicles of price discovery. The existence of this relationship between the two markets can lead investors to take advantage of hedging and arbitrage opportunities (Kenourgios D. F., 2004).

Additionally, Athianos and Katrakilidis (2004) investigated the relation among stock index, futures index and the respective volatilities in Greece during the period from January 3, 2000 to April 5, 2002. More specifically, by using daily data and by employing GARCH methodology and Granger causality tests in the context of a SEM, they examined the relationship between the FTSE/ASE-20 futures index and the FTSE/ASE-20 stock index. The empirical results of their study indicated that simultaneous interactions among the involved variables (returns and volatilities) exist. Furthermore, they found bidirectional causal effects between the two markets, with futures returns affecting spot returns in a greater degree, indicating that futures market leads the stock market for the period examined. Lastly, they detected “a one way causal effect running from spot returns to the volatility of spot price index” and assumed that “the volatility of spot price index indirectly causes impacts on spot returns”.

Sinha (2006) studied the relationship between the S&P CNX Nifty and its related futures contracts during the period from April 2002 to March 2005. At the same time he aimed to investigate if this relationship remained stable or changed during the period examined. Thus, the main objective of his survey was to anticipate the information flow and its direction between the S&P CNX Nifty and its related futures contracts. After using linear regression and co-integration methods, Sihna found out that the futures market leads the cash market during all the period investigated. However, it should be mentioned that the relationship between the two markets examined, had been subject to significant changes throughout the years under study. From all the above it becomes clear, that information is disseminated from one market to the other. This outcome can help investors to foresee effects of shocks to the futures market on the stock market and as a result gain arbitrage opportunities.

Furthermore, Floros and Vougas (2007) examined the relationship between futures and spot market in Greece over the crisis period 1999 to 2001. More specifically, by employing a Bivariate GARCH model and by using daily observations, they examined the lead lag relation between stock index futures contracts and the spot index of FTSE/ASE-20 and FTSE/ASE Mid 40. The results of their investigation demonstrated that futures market plays a price discovery role, implying that futures prices enclose valuable information about stock prices. They attributed this to the fact, that futures market are more “informationally efficient” which means that Greek traders prefer to sell or buy stocks rather than futures, but when they want to take advantage of information about the economy they use futures market. According to the authors, this lead lag relationship between futures prices and spot prices exists, because futures contracts have higher liquidity and lower transaction costs than the underlying stock markets.

Another study is that of Chang and Lee (2008). They used five minute intraday prices as a sample and examined the relationship between stock and futures market in Taiwan. In particular, by analysing the threshold error-correction model (TECM) they studied the asymmetric causal relation between the TW index and the TX index futures contracts during the period from January 2001 to May 2005. Their results specified that the futures have greater volatility compared to the volatilities of the stock market. Also, "bidirectional feedback causality within an intraday" between the markets under examination was observed. Lastly, they concluded that futures prices react with the same intensity to positive and negative innovations.

Lastly, Pok (2008) investigated the lead lag relationship between futures and spot market in Malaysia. Particularly, by using daily closing futures and stock prices for the KLSE CI and employing the Johansen Cointegration, the VECM and Granger causality tests, he studied whether the futures and stock markets affect each other, both in the short-run and in the long-run. The sample period is divided into three sub-periods. The first period is pre-crisis (1995-1997), the second is throughout the crisis (1997-1998) and the third is after the imposition of capital controls (1998-2001). In the first two periods, foreign investors had an active participation in the market of Malaysia, while in the third, they removed their funds. The results of the study showed that the two markets are not cointegrated; indicating that there is not a long term relation and price linkage between the two markets. Conversely, as far as the short term concerns, unidirectional causality from the futures market to the stock market is found in all the three sub-periods. It should be emphasized, that futures' lead is shorter during the two first periods, indicating that the price discovery that futures activate, has significantly affected by the change in the composition of market participants in the Malaysian market.

Thus, it is obvious from the above, that equivalent studies have been carried out to all mature markets all over the world. International evidence embraces for the US markets (Zeckhauser and Niederhoffer, 1983; Kawaller et al., 1987; Herbst et al., 1987; Stoll and Whaley, 1990; Chan et al., 1991; Chan, 1992; Ghosh, 1993; Chan et al., 1993; Kutmos and Trucker,1996; Flemming et al., 1996; De Jong and Nijman, 1997; Pizzi et al., 1998), for UK markets (Abhyankar, 1995 and 1998; Buckle and Gwilym, 2001), for Australian markets (Turkington and Walsh, 1999; Frino et al., 2000), for French markets (Shyy et al., 1996), for German markets (Grünbichler et al., 1994), for Spain markets (Nieto et al.,1998), for Korean markets (Min and Najand, 1999), for Indian markets (Sinha, 2006), for Holland markets (De Jong and Donders, 1998), for Malaysian markets (Pok, 2008), for Taiwan markets (Lin et al., 2002 ;Chang and Lee, 2008), for Japan markets (Iihara et al., 1996), for Finnish markets (Puttonen, 1993). In addition, there is a limited number of studies which involve the analysis of data from more than one country simultaneously, such as Antoniou et al. (2003) who investigated the lead lag relationship between futures and spot in UK, Germany and French markets and Brooks et al., (1999) and Wahab and Lashgari, (1993) who examined data from US and UK markets.

As far as the Greek stock and derivatives market is concerned, studies have been conducted by Alexakis et al. (2002), Athianos and Katrakilidis (2004), Kenourgios (2004) and Floros and Vougas (2007). According to their results, which are in line with similar findings in the international literature, the Greek futures market seems to lead the stock market. Furthermore, bidirectional causality between futures and the underlying stock market was observed, with futures prices mainly affecting stock prices in a greater extent.

Summarising it could be mentioned that futures market absorbs faster any information released than the spot market. The majority of the authors attribute this to the fact that futures contracts have low transaction costs and not all stocks trade in the index continuously. In futures market, even in the case where supply and demand is not present, the system supplies automatically prices every minute. On the contrary, in the spot market prices remain stable during the session.

3. METHODOLOGY

3. 1 THE GREEK DERIVATIVES MARKET

Before the formation of the framework for the foundation of the organised derivatives market in the Greek economy, the trading of derivatives was mostly performed by financial institutions. The creation of the Athens Derivatives Exchange (ADEX) and the Athens Derivatives Exchange Clearing House (ADECH) in 1997 by the law 2533/97 was a product of the growth of the Greek economy. The ADEX is a member of the European Committee of Futures and Options Exchanges (EOFEX) from June 5, 1999.

The focal point of ADEX is “the organisation and support of trading in the derivatives market, the organisation of the trading system, as well as any similar activity” (http://www. adex.ase.gr). Conversely, ADECH acting as counterparty in all trades concluded in ADEX, organises the clearing and the settlement of the transactions and generally supports similar processes. The control and the supervision on ADECH’s and ADEX’s operations are exercised by the Hellenic Capital Market Commission. In July 17, 2002, the merger of Athens Stock Exchange S.A. (ASE) and Athens Derivatives Exchange (ADEX) took place, creating a new company named Athens Exchange S.A. The aim of the new company is to organise, support and monitor all the transactions associated with stocks, derivatives and all the other financial products, to protect investors and to guarantee the effective operation of the financial markets. Athens Exchange S.A. is supervised by the minister of National Economy. Finally, it should be pointed out, that transactions are conducted electronically (screen trading) on the Integrated Electronic Trading System OASIS (Alexakis et al., 2002).

It is essential to be mentioned, that even though significant developments have been accomplished in the Greek derivatives market, still four features exist, leading to low marketability. First and foremost, the high charges for trading in the Greek derivatives markets lead investors to trade in other markets. Secondly, the low margin of futures contracts, which increases the already high prices of futures contracts, does not yield the prospective return. Third, the short-term maturity of futures contracts requires the continuous deposit of charges, leading thus to low marketability. Lastly but not least, the limited variety of futures products (futures and options contracts are based only on domestic cash underlying indices) reduces the alternative choices, in case the Greek derivatives market faces low volatility (Athianos, S., 2002).

3.2 DATA DESCRIPTION

ADEX 's main products are futures and options based on the FTSE/ASE-20 and FTSE/ASE Mid 40 indices and futures on the ten year Hellenic Republic Bond. The FTSE/ASE-20 futures contract, which released for trading on August 27, 1999, and was written on the FTSE/ASE-20 index, was the first traded product of ADEX. The FTSE/ASE- 20 index, which was created in September of 1997 by the ASE and the FTSE International, is based on twenty liquid and largely market capitalised companies (blue chips) listed on ASE. As Kenourgios (2004) states, the FTSE/ASE-20 index is the most appropriate sample due to its high liquidity, and turnover of its component shares.

The futures contracts based on the FTSE/ASE- 20 index are cash settled and quoted in index points. "At any point in time there are six stock index futures listed for trading and clearing corresponding to related expiration months. The expiration months are the three nearest consecutive months, and the three nearest months from the March, June, September, December quarter cycle, not included in the consecutive months" (http://www. adex.ase.gr- Specifications of the future in FTSE/ASE-20). Also, the FTSE/ASE-20 futures contracts are marked to market the third Friday (last trading day) of the delivery month at 14:30, Athens time (Floros and Vougas, 2007).

The sample used in this thesis consists of daily closing stock and futures prices for both the FTSE/ASE-20 index and the FTSE/ASE-20 futures index, respectively. The data for both the stock index futures and the stock index were obtained from the Dissemination Information Department of the Athens Stock Exchange. Data on futures price index are available from August 27, 1999, when the Athens Derivatives Exchange (ADEX) was established. However, the present sample does not include data concerning the trading of futures during the first five months of ADEX' s operation, because it is considered that it was too early, as market participants were completely unfamiliar and futures market liquidity was very low throughout this period. Therefore, the present time series will span from January 2, 2000 to May 30, 2008. The sample comprises 2100 trading days (4200 observations as a total for both variables). The spot index futures prices that are used in this study were those of the nearby contract. Lastly, it should be pointed out that the natural logarithms of the stock and futures prices were used ($R_i = \ln\left(\frac{P_t}{P_{t-1}}\right) \times 100$).

Many researches employ data of high frequency oscillated from bid/ask spread to hourly prices. Daily data is the best existing option if intraday data are not available, which is the case in this dissertation. In fact, the majority of similar studies was based on daily observations (Herbst et al., 1987; Ghosh, 1993; Puttonen, 1993; Wahab and Lashgari, 1993; Kutmos and Trucker, 1996; Cheung and Fung, 1997; Nieto et al., 1998; Silvapulle and Moosa, 1999; Brooks et al., 1999; Alexakis et al., 2002; Antoniou et al., 2003; Athianos and Katrakilidis, 2004; Kenourgios, 2004; Floros and Vougas, 2007 and Pok, 2008). Another reason for using daily closing prices was due to the low volume of transactions that characterises the Greek futures market. Lastly, it is significant to be addressed that the trading of spots ends fifteen minutes earlier to the trading hours of futures contracts, leading to a time lag. Closing prices are determined in a continuous trading system and thus are free of non-synchronicity which was present prior to 1990. Also, in the spot market, there is 'after closing trading', which lasts fifteen minutes. A non-synchronous trading technique will be employed to overcome this limitation (Papachristou, 1999).

3.3 SELECTION OF THE APPROPRIATE ECONOMETRIC MODEL

Following the researchers that adopted GARCH models, such as Chan et al. (1991); Abhyankar (1995); Koutmos and Tucker (1996); Cheung and Fung (1997); Kyriakou and Sarno (1999); Lin et al. (2002); Alexakis et al. (2002); Antoniou et al. (2003); Athianos and Katrakilidis (2004); Floros and Vougas (2007), a GARCH (p,q) model is going to be employed. This model aims to provide a volatility measure. Moreover, this specific model is the most frequently employed financial time series and has motivated to the creation of numerous other advanced models. GARCH are the initials for Generalized Autoregressive Conditional Heteroscedasticity. Analytically, the term autoregressive simply describes a feedback system which comprises past remarks into present. The term conditional implies a variance that depends upon immediate past information and heteroscedasticity could be specified as a time varying variance. Thus, GARCH is a process which is used to model and forecast the serial dependence of volatility or conditional variance.

The GARCH process was first introduced by Bollersev (1986) and is simply an extension of the ARCH process (Autoregressive Conditional Heteroscedasticity) developed earlier by Engle (1982). In contrast with a significant number of other relative econometric frameworks and time series which process assuming a constant variance, the ARCH model assumes that the conditional variance is not constant through time as a function of past errors, while the unconditional variance remains unchanged. Furthermore, most of the ARCH applications include a relative long memory lag in the conditional variance equation and a fixed lag structure to prevent difficulties associated with negative variance parameters estimates (Bollerslev, 1986). A generalized ARCH model is the ARCH (p) in which the conditional variance is based on past (p) squared disturbance terms. The GARCH model, as a more generalized approach of the ARCH process, is represented as "a linear function of the lagged squared residuals and the lagged residual conditional variance" (Antoniou and Holmes, 1993). Hence, the introduction of GARCH model provides a more flexible lag structure and allows a more parsimonious specification in a variety of cases. It offers a trustworthy method for estimating the volatility even in its simplest form. Furthermore, it has been detected to fit time varying volatility quite adequately (Pok and Poshakwale, 2004). Moreover, GARCH procedure is successful because it captures the tendency in asset returns for volatility clustering and equalises the potential negative correlation between future volatility and current returns which is identified as the leverage effect (Choudhry, 1995). Based on the above mentioned strengths, the GARCH model was selected as the most appropriate for the needs of the present dissertation since it enables to investigate the relationship between the returns on volatility of the stock and the futures indices.

The GARCH (p, q) model is best described through the following equation (Antoniou, and Holmes, 1995):

$$Y_t = a_0 + a_1 X_t + E_t \quad (1) \qquad E_t / \psi_{t-1} \succ N(0, h_t)$$

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-1}^2 + \sum_{j=1}^{p} \beta j h_{t-j} \quad (2)$$

Where (1) is the conditional mean equation and (2) is the conditional variance equation. (Yt) represents the stock return and (X t) is the mean (Yt) conditional in past information (Ψ t-1). Furthermore, the parameters (αo), (αi), (βj) should be greater than zero, so as the conditional variance (ht) to be positive. If p=0 then the model becomes an ARCH (p) model and when p=q=0 then it is considered to be only a white noise (Bologna and Cavallo, 2002).

It should be emphasised that GARCH (1,1) has been found as the most reliable and most useful GARCH representation that fits suitably in a significant number of financial time series. The sufficient condition in a GARCH (1,1) model that needs to be met in order for (εt) to be covariance stationary is the following (Bollersev, 1986):

$$\sum_{i=1}^{p} a_i + \sum_{j=1}^{q} \beta_{\xi} \langle 1 \quad (3)$$

The above sum describes the change in the corresponding function of stocks to volatility. If equation (3) is greater than unity then the responding function rises with time and if (3) is less that unity then stocks reduce over time (Chou,1988).

However, the GARCH (1,1) model according to the existing literature is considered to be appropriate only for short term forecasts, thus the GARCH (p,q) model was selected as the most suitable for the needs of the present study, since a sample of long span data is used.

For the estimation of the GARCH (p, q) model, log likelihood ratio tests are applied to identify the most parsimonious GARCH (p, q) representation of the conditional variance equation. The log likelihood function, which stands on the assumption, that the condition of joint distribution of ($R_{s,t}$) and ($R_{f,t}$) is normal, is provided by the following equation:

$$L(\theta) = \sum_{t=1}^{T} \left(-\frac{1}{2}\ln(2\pi) - \frac{1}{2}\ln h_t - \frac{1}{2}\frac{y_t^2}{h_t} \right) \quad (4)$$

Where (T) is the number of observations and the parameter vector (θ) is the likelihood estimator that maximises the maximum likelihood equation.

In addition, a Granger causality test is going to be applied to the selected sample of data in the context of a SEM (Structural equation model) with the aim to investigate the dynamic relationship between stock returns, futures returns, stock index volatility and futures index volatility. The SEM model which is also referred as Simultaneous Equation Model is a multiple equation regression model. Specifically, it is a significant multivariate analysis technique that represents causal, simultaneous relationships and interdependence among the observed and unobserved variables of the structural equations. In contrast with a conventional multivariate linear model, in a SEM model the response variable in one regression equation may look as an explanatory in another equation. Furthermore, when applying the SEM, variables can influence each other reciprocally, either directly or through other variables as intermediaries.

The structural form of the SEM model that is gong to be used in the present study, provided by Athianos and Katrakilidis (2004), is the following:

$$R_{s,i} = \alpha_1 + \sum_{j=0}^{k1} \beta_{1,j} h_{s,i-j} + \sum_{j=0}^{k2} \gamma_{1,j} h_{f,i-j} + \sum_{j=1}^{k3} \delta_{1,j} R_{s.i-j} + \sum_{j=0}^{k4} \lambda_{1,j} R_{f,i-j} + e_{1i} \quad (5)$$

$$R_{f,i} = \alpha_2 + \sum_{j=0}^{k1} \beta_{2,j} h_{s,i-j} + \sum_{j=0}^{k2} \gamma_{2,j} h_{f,i-j} + \sum_{j=0}^{k3} \delta_{2,j} R_{s.i-j} + \sum_{j=1}^{k4} \lambda_{2,j} R_{f,i-j} + e_{2i} \quad (6)$$

$$h_{s,i} = \alpha_3 + \sum_{j=1}^{k1} \beta_{3,j} h_{s,i-j} + \sum_{j=0}^{k2} \gamma_{3,j} h_{f,i-j} + \sum_{j=0}^{k3} \delta_{3,j} R_{s.i-j} + \sum_{j=0}^{k4} \lambda_{3,j} R_{f,i-j} + e_{3i} \quad (7)$$

$$h_{f,i} = \alpha_4 + \sum_{j=0}^{k1} \beta_{4,j} h_{s,i-j} + \sum_{j=1}^{k2} \gamma_{4,j} h_{f,i-j} + \sum_{j=0}^{k3} \delta_{4,j} R_{s.i-j} + \sum_{j=0}^{k4} \lambda_{4,j} R_{f,i-j} + e_{4i} \quad (8)$$

where ($R_{s,i}$) are the stock returns, ($R_{f,i}$) represents the futures returns and ($h_{s,i}$), ($h_{f,i}$), are the stock and futures index volatilities respectively. The terms (β_{tj}), (γ_{tj}), (δ_{tj}) and (λ_{tj}) are parameters, (k_t) is selected on standard statistical grounds, and (e_{hi}) stands for the white noise error term (t = 1, 2, 3, 4).

To estimate the SEM model of equations, the SUR (Seemingly, Unrelated Regression) model, which first introduced by Zellner (1962), was chosen. The SUR model is a method that analyses a set of multivariate equations that employ the same sample of data and permits correlated error terms among the equations resulting in more efficient parameter estimates. More specifically, it applies the estimates of the covariance of the residuals across equation to raise the effectiveness of the parameter estimates (Chan and Chung, 1993).

According to previous literature findings, most earlier studies (such as Koch 1993, Chatrath et al., 1995,1996) performed Granger causality tests in a context of a VAR model to examine whether a lead lag relationship exist between different variables rather than performing a SEM model. Koch (1993) supported that the VAR model that includes only lagged values, can easily be estimated by OLS (Ordinary Least Squares). However, according to the same author, the VAR Model does not take into account contemporaneous relations among variables. On the contrary, it simply indicates that each variable under examination is based on its past information and on the past information of the rest of the variables but it does not incorporate any simultaneous relations among them. Hence, it cannot identify the dynamic structural interactions. Therefore, the selection of the VAR model, over the selection of the SUR model, in order to estimate the parameters will allow simultaneity among variables, thus lead to biased outcomes. According to Kawaller et al. (1987) and Chan and Chung, (1993), when a number of series are contemporaneously correlated, then employing OLS estimation would result in inefficient and unreliable estimators. In addition Koch (1993) states that the reading of the concurrent equations model is simple, as the simultaneous coefficients reflect the concurrent relations between the variables examined, while the lagged coefficients are a sign of the lagged responses between variables after accounting for their simultaneous interaction. Thus, adopting a SEM model framework, where concurrently correlations exist among the error terms of its equations, will permit to investigate for both causality and contemporaneously evidences between the variables in question.

The Granger causality tests are applied in the context of the SEM model to examine the causality between stock returns, futures returns, stock and future index volatilities and also to provide evidence regarding as to if a feedback is taking place or not. For this reason, the equations (5), (6), (7), (8) of the SEM model can be written again in a form of a matrix, assuming that $k_1 = k_2 = k_3 = k_4 = n$:

$$\begin{bmatrix} R_{s,i} \\ R_{f,i} \\ h_{s,i} \\ h_{f,i} \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix} + \begin{bmatrix} \beta_1\gamma_1\delta_1\lambda_1 \\ \beta_2\gamma_2\delta_2\lambda_2 \\ \beta_3\gamma_3\delta_3\lambda_3 \\ \beta_4\gamma_4\delta_4\lambda_4 \end{bmatrix} \begin{bmatrix} R_{s,i} \\ R_{f,i} \\ h_{s,i} \\ h_{f,i} \end{bmatrix} + \begin{bmatrix} e_{1i} \\ e_{2i} \\ e_{3i} \\ e_{4i} \end{bmatrix} \quad (9)$$

Where (β_t) is [β_{t0}….β_{tn}], (γ_t) is [γ_{t0}…γ_{tn}], (δ_t) is [δ_{t0}…δ_{tn}], and [λ_{t0}……λ_{tn}] for t = 0,1,2,3,4…. Also, it is assumed that p = $R_{s,i}$, $R_{f,i}$, $h_{s,i}$, $h_{f,i}$ where (p) = [p_i, p_{i-1}, …..p_{i-n}]. According to Granger (1969), a time series (X_t) can Granger cause an additional time series (Y_t) when current (Y) can be forecasted more effectively by making use of past information concerning the values of (X) than by not acting in this way. Executing a Granger causality test in the case of the present study, one of the twelve hypothesis that could be assumed is that ($R_{s,i}$) (stock returns) do not Granger cause ($R_{f,i,}$) when the distribution of ($R_{f,i}$) conditional on the past information of ($R_{f,i}$), ($R_{s,i}$), ($h_{s,i}$) and ($h_{f,i}$) is similar as that conditional on the past history of ($R_{f,i}$), ($h_{s,i}$) and ($h_{f,i}$). The above assumption can be represented as follows:

Ho: $\beta_{11} R_{i-1} = \beta_{12} R_{i-1} = \ldots = \beta_{1n} R_{i-1} = 0$ (10)

This means, that historical values of stock returns do not provide any explanatory power on futures return, stock volatility and futures volatility.

Taking into consideration, all the above analysis, the individual characteristics of the sample of the present study, as well as the needs of the present study, the use of the SEM model seems as the most appropriate. This technique was selected since it is expected to provide more consistent Granger causality outcomes that will provide better insight to the matter under question. This is enabled since the Granger causality has been found to provide more descriptive powering in each equation in the case of stock returns, futures returns, futures and stock index volatilities.

4. EMPIRICAL RESULTS

Having clearly discussed the data for the present dissertation, as well as the methodology that was applied in order to test the lead- lag relationship between spot prices and futures prices and their volatilities, the major statistical findings are presented in the present chapter. The main aim of this section is simply to clarify, through the analysis of the statistical outputs whether and to what extend the prices of the futures market convey information regarding the trend that the stock market prices will follow or oppositely, whether the prices of the stock market provide predictive information for the future fluctuation of futures prices.

As far as the volatilities of the spot and futures indexes are concerned, the GARCH model was considered as the most appropriate measure given the current context. In particular, the GARCH outcomes are presented in Table 1. From the examination of the below table it becomes clear, that the GARCH model is present in the residuals from the SEM model unless, however, the volatility measure used unambiguously accounts for GARCH. Furthermore, log likelihood ratio tests were applied in order to identify which is the most parsimonious GARCH illustration of the conditional variance of returns. GARCH (0,2) and GARCH (1,2) models have been selected as the most appropriate volatility measures of the spot index and for the futures price index, respectively. In addition, the estimates of the parameters in the GARCH models for spot and futures indices are also found in Table 1.

Table 1. The Estimated GARCH models for spot and future price indices

$$h^2_{s,i} = \underset{(0.000041)^{888}}{0.000022} + \underset{(0.041052)^{88}}{0.075310} * \varepsilon^2_{i-1} + \underset{(0.074364)^{8}}{0.15471} * \varepsilon^2_{i-2}$$

$$h^2_{f,i} = \underset{(0.000056)^{888}}{0.000063} + \underset{(0.050105)^{8}}{0.098100} * \varepsilon^2_{i-1} + \underset{(0.059199)^{8}}{0.14442} * \varepsilon^2_{i-2} + \underset{(0.040019)^{888}}{0.58221} * h^2_{i-1}$$

∗ Numbers in parentheses denote the coefficients standard errors.

Note; * indicates a significant difference from zero at the 10% level, ** indicates a significant difference from zero at the 5% level and *** indicates a significant difference from zero at the 1% level.

Table 2 reports the SUR (Seemingly Unrelated Regressions) estimates of the SEM model equations. It should be noted that results are outcomes of a 3SLS (three-stage-least squares) procedure. More specific, the initial two stages of the 3SLS procedure are provided by the two stage least squares (2SLS) when applied independently to every equation of the system (i.e. equations 5,6,7,8,9). Moreover, the final stage is basically similar to the last stage of the possible generalised least squares evaluation applied in Seemingly Unrelated Regressions methods (Zellner and Theil, 1962 sighted in Kyriacou and Sarno, 1999). Identification of the SEM model was accomplished without assuming the variance-covariance matrix that was calculated directly from the equation using the equation of the 2SLS residuals.

The statistical outcomes were calculated and evaluated with the help of the application of the SEM (5-9) model using GARCH (0,2) and GARCH (1,2) processes in order to proxy spot market and futures market volatility respectively. As presented in Table 2, the highly important estimated simultaneous coefficients in every equation of the model could be considered as a strong indication that the two variables in examination are concurrently determined.

Table 2. SUR Estimates of the SEM equations

Equation 5

$R_{f,i} = -\ 0.0090113 + 0.251274 * R_{s,i} + 0.42013 * R_{s,i-1} + 0.39625 * R_{s,i-2} + 0.071226 * R_{s,i-3}$
(0.0090)* (0.1505) (0.1492) (0.1483) (0.0454)

$-\ 0.038948 * R_{s,i-4} + 0.022893 * R_{s,i-5} - 0.099387 * R_{f,i-1} - 0.41962 * R_{f,i-2} - 0.33762 * R_{f,i-3}$
(0.0429) (0.0478) (0.1427) (0.1469) (0.1440)

$-\ 1.1281 * h_{s,i} + 2.3275 * h_{s,i-1} - 0.31012 * h_{s,i-2} - 1.2197 * h_{f,i} + 2.4031 * h_{f,i-1} - 2.4061 * h_{f,i-2}$
(1.415) (1.442) (1.439) (0.3600) (0.5592) (0.5966)

Equation 6

$R_{s,i} = -\ 0.00139 - 0.30425 * R_{s,i-1} - 0.20231 * R_{s,i-2} - 0.0069252 * R_{s,i-3} + 0.0100726 * R_{s,i-4}$
(0.0029) (0.0439) (0.0402) (0.0171) (0.01290)

$-\ 0.032900 * R_{s,i-5} + 0.020913 * R_{f,i} + 0.90928 * R_{f,i-1} + 0.33269 * R_{f,i-2} + 0.17844 * R_{f,i-3}$
(0.01315) (0.01215) (0.0128) (0.0403) (0.04100)

$+\ 0{,}30112 * h_{s,i} - 0.054112 * h_{s,i-1} + 0.096080 * h_{s,i-2} + 0.085109 * h_{f,i} - 0.20018 * h_{f,i-1}$
(0.4188) (0.4501) (0.4049) (0.1079) (0.1627)

$+\ 0.074148 * h_{f,i-2}$
(0.1073)

Equation 7

$h_{s,i} = 0.0031927 + 0.0032092 * R_{s,i} + 0.0075629 * R_{s,i-1} + 0.010664 * R_{s,i-2} + 0.0014378 * R_{s,i-3}$
(0.2291) (0.0041) (0.0047) (0.0044) (0.0012)

$-\ 0.0246172 * R_{s,i-4} - 0.0026912 * R_{s,i-5} - 0.0010996 * R_{f,I} - 0.0045412 * R_{f,i-1} - 0.0048996 * R_{f,i-2}$
(0.0013) (0.0013) (0.0013) (0.0042) (0.0044)

$-\ 0.0093911 * R_{f,i-3} + 0.41801 * h_{s,i-1} - 0.12209 * h_{s,i-2} + 0.0016094 * h_{f,i} + 0.036996 * h_{f,i-1}$
(0.0043) (0.0430) (0.0423) (0.0107) (0.0170)

$-\ 0.0079790 * h_{f,i-2}$
(0.0109)

Equation 8

$h_{f,i} = 0.00202914 + 0.015122 * R_{s,i} + 0.0081554 * R_{s,i-1} + 0.020992 * R_{s,i-2} - 0.0052495 * R_{s,i-3}$
(0.0011) (0.0179) (0.0187) (0.0176) (0.0054)

$-\ 0.0014228 * R_{s,i-4} + 0.7914673 * R_{s,i-5} - 0.017922 * R_{f,I} - 0.011019 * R_{f,i-1} + 0.0014261 * R_{f,i-2}$
(0.0054) (0.0054) (0.0052) (0.0169) (0.0182)

$-\ 0.028081 * R_{f,i-3} + 0.026021 * h_{s,i} + 0.080262 * h_{s,i-1} - 0.10652 * h_{s,i-2} + 1.2901 * h_{f,i-1}$
(0.0171) (0.1764) (0.1878) (0.1702) (0.0409)

$-\ 0.39981 * h_{f,i-2}$
(0.0494)

Furthermore, the simultaneous coefficients are usually quite large in magnitude. This is considered to be of great importance since it implies that the market forces functions to adjust rapidly in order to cause the two examined variables to interact considerably during the same day

The findings of the dissertation generally indicate that significant causality evidence between the variables under examination exists. More specifically, simultaneous interactions take place among the futures market and the stock market. Futures returns have a significant effect on both spot returns and futures volatility at a 5% significance level for both variables (i.e. hfi=0.040 and Rsi=0.045). Furthermore, stock returns influence to a significant extent both the futures returns and the spot index volatility, at a significant level of 5% and 1% respectively. Moreover, the futures returns are significant at a 1% significance level (i.e.Rfi=0.012), while the spot index volatility is significant at 1% significance level (i.e. hsi=0.004). Finally, futures volatility greatly affects futures returns at a significant level of 1% (i.e. 0.005). The above results are best illustrated in the following figures presented hereunder.

Figure (1): Interaction of Returns and Volatilities in the Futures and Spot Markets separately

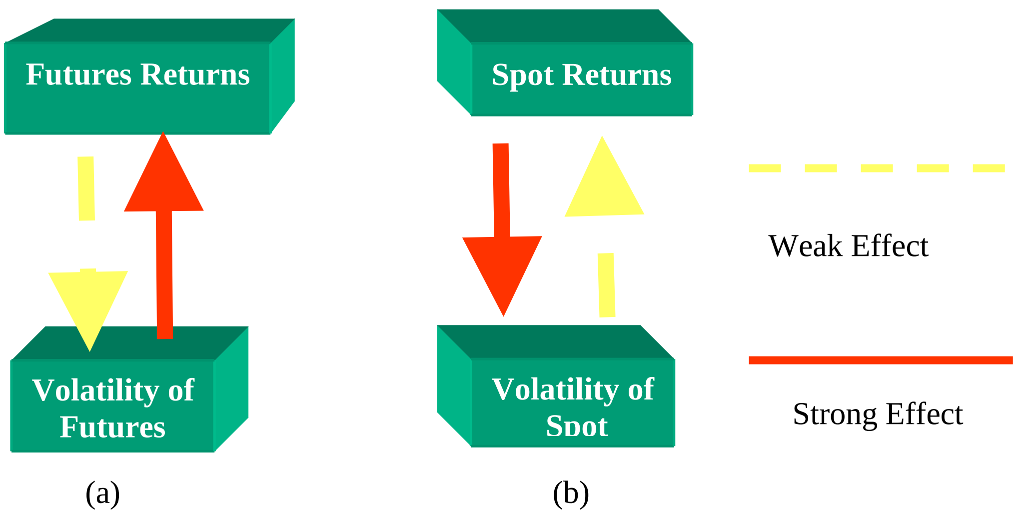
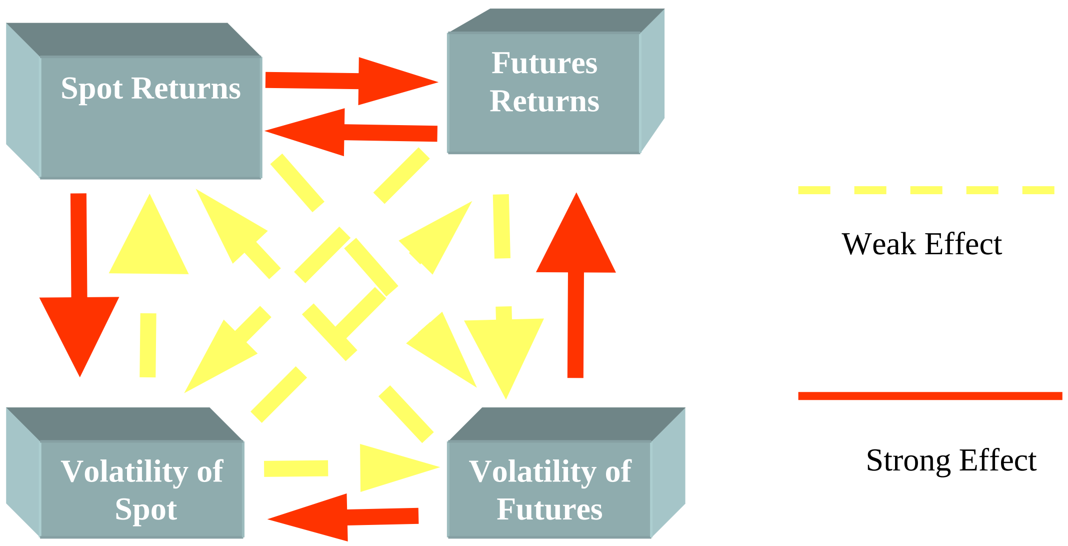


Figure 1 clearly presents the interaction that exists between the returns and the volatilities for both the futures market (a) and the spot market (b). Figure (1a) illustrates that the volatility of futures strongly affects the prices of the futures index. However, there are instantaneous bidirectional effects, with future returns weakly affecting the volatility of the futures. On the other hand, figure (1b) shows significant relations between spot index prices and the volatility of the underlying spot index.

Figure (2): Simultaneous Interactions of Returns and Volatilities in the Futures and in the Spot Markets



Lastly, figure 2 presents the overall interactions between the variables in question for both markets. More precisely, it demonstrates that both simultaneity and feedback best describe the dynamic relationship among futures returns, stock returns; futures index volatility and stock index volatility. As it comes obvious from the figures above, there are simultaneous interactions running among the stock index and the spot futures index and their respective volatilities.

As far as the results of the Granger causality tests are concerned, bi-directional casual effects between spot and futures returns was observed, however, it should be pointed out that the effect running from stock returns seems to be weaker. In particular, according to the results obtained from the application of the Wald Test, stock returns weakly affect futures returns at a significant level of 6.5%. Regarding the lead lag relationship among the two market indices, the results, presented in Table 3, strongly indicate that the stock index futures market leads the underlying stock market significantly at a 1% (0.000) level of significance. In addition, one-way causal effect running from spot returns to the volatility of spot price index was detected to be significant at a 5% (0.01) level of significance. Lastly, causality evidence was found running from the volatility of futures price index to the volatility of the underlying spot price index at a 5% (0.023) level of significance, as well as to the futures price index at a 1% (0.000) level of significance. Therefore, it is clear that the volatility of the stock price index indirectly causes effects on stock returns.

Table 3. Causality test

Depended Variable	Hypothesis Tested	Wald Test
$R_{f.i}$	h_s does not Granger cause R_f	$x^2(3)$=3.0012 [.419]
$R_{f.i}$	h_f does not Granger cause R_f	$x^2(3)$=20.1931 [.000]888
$R_{f.i}$	R_s does not Granger cause R_f	$x^2(5)$=10.2899 [.064]8
$R_{s,i}$	h_f does not Granger cause R_s	$x^2(3)$=2.0012 [.582]
$R_{s,i}$	h_s does not Granger cause R_s	$x^2(3)$=0.51699 [.882]
$R_{s,i}$	R_f does not Granger cause R_s	$x^2(3)$=5225.1 [.000]888
$h_{s,i}$	R_f does not Granger cause h_s	$x^2(3)$=5.2310 [.161]
$h_{s,i}$	h_f does not Granger cause h_s	$x^2(2)$=7.6001 [.023]88
$h_{s,i}$	R_s does not Granger cause h_s	$x^2(5)$=13.0899 [.018]88
$h_{f,i}$	R_f does not Granger cause h_f	$x^2(3)$=3.209 [.352]
$h_{f,i}$	h_s does not Granger cause h_f	$x^2(2)$=0.3989 [.811]
$h_{f,i}$	R_s does not Granger cause h_f	$x^2(5)$=2.4021 [.794]

Note; * indicates a significant difference from zero at the 10% level, ** indicates a significant difference from zero at the 5% level and *** indicates a significant difference from zero at the 1% level.

In general, the empirical outcomes clearly and strongly indicate that the dynamic relationship among futures returns, stock returns, futures index volatility and stock index volatility can best be described by simultaneity and feedback. It is worth to be mentioned that the above findings and in particular the evidence of strongly significant simultaneity has essential implications for hedgers, arbitrageurs, speculators and regulators. Furthermore, the bidirectional causality between futures and stock returns imply that both stocks and futures have a significant price discovery role.

However, the presentation of the present findings would not be complete without a comparison to the findings of other previous relative researches that were conducted using Greek data from the Greek stock and futures market. First of all, Alexakis et al. (2002), in contrast to the findings of the present thesis, reported that there is no bidirectional relationship among the examined variables in the FTSE/ASE-20 Index. Analytically, they detected that futures lead stock index returns and that there is a weak spillover from stock index volatility to the futures index volatility. Additionally, Floros and Vougas (2007), supported that futures market in the

FTSE/ASE-20 index plays a discovery role indicating that it reflects new information quicker that the stock market. Thus the futures market leads the stock market, while there are no evidences of bidirectional causality among them. An alternative research carried out by Kenourgios (2004), suggesting the existence of bidirectional causal effects between the futures index and the underlying stock index markets. Finally, Athianos and Katrakilidis (2004), provided evidences of causality (unidirectional and bidirectional) between futures and stock returns as well as their stock and futures volatility.

The present chapter tried to present the major statistical outputs in an attempt to shed some light to the matter under question. From all the above analysis, it becomes clear, in contradiction to some other relative researches that used Greek data, that, simultaneous interactions and both unidirectional and bidirectional casual impacts run among the FTSE/ASE-20 Index and the FTSE/ASE-20 Futures Index and their respective volatilities. The findings are consistent with the findings of previous researches that applied the same methodology like the one used in the present thesis. The main implication from the present findings (that interactions between the two Indexes (Spot and Future) exist) is of great importance to market participants and regulators and even theoreticians.

5. SUMMARY AND CONCLUSIONS

In this dissertation the dynamic relationship among the FTSE/ASE-20 spot index, the FTSE/ASE-20 cash futures index and their respective volatilities was investigated. The empirical analysis was applied on the total of 4200 daily observations for both of the variables, arising from 2100 trading days. More particularly, the sample used consists of daily closing stock and futures prices for both the FTSE/ASE-20 Index and the FTSE/ASE-20 Futures Index during the period from January 2, 2000 to May 30, 2008.

It should be pointed out that both stock and futures market volatilities are time varying and best described by the GARCH procedure. In addition, the variables under examination were defined in a model of contemporaneous equations (SEM) that permits simultaneous feedback and causality, as one could anticipate if hedging, speculation and cross-market arbitrage function effectively. Furthermore, Granger causality tests were employed in the framework of the applied SEM, aiming to offer more reliable results due to the explanatory power of the related variables in every equation.

With regard to the SUR estimates of the SEM model, simultaneous interactions among the examined variables were observed. Specifically, futures returns affect both stock returns and the volatility of the futures index to a significant degree. Another major outcome of the present analysis was that stock returns influence significantly both futures returns and stock index volatility. Moreover, futures volatility significantly affects futures returns. Additionally, concerning the results of the Granger causality tests, bidirectional causal effects between futures returns and spot returns were detected. However, it should be noted that the effect running from futures returns to spot returns appears to be stronger compared to the effect running from stock returns to futures returns. A unidirectional causal effect from spot returns to the volatility of the underlying spot index was also observed. In addition, the outputs of the Granger causality tests showed that futures volatility influences futures returns but also stock index volatility. Finally, as far as the lead lag relationship between the two markets is concerned, the empirical results of the present thesis indicate that the spot index futures market leads the underlying spot market.

In overall, the outcomes of the models employed in the present dissertation show simultaneous interactions and both unidirectional and bidirectional casual impacts running among the FTSE/ASE-20 Index and the FTSE/ASE-20 Futures Index and their respective volatilities, indicating information linkage among the two markets. The existence of such an informational linkage among spot and futures markets means that investors are able to discover significant hedging opportunities and arbitrage profits (Kenourgios, 2004). It is worth mentioning that the above findings have essential implications for traders, speculators, financial managers and regulators.

Reviewing the literature concerning the relationship between futures and spot market, it becomes quite clear that the results are mixed. However, the majority of previous studies, that were conducted using data from the Greek markets, as well as from markets all over the world, reported that the futures market index strongly leads the stock market index (unidirectional relationship), since it reflects information more rapidly. Therefore, it is obvious that the results of each survey, over this topic, differentiate from the special characteristics and the geographical location of each market under investigation, the frequency of the data used and the estimation methodology applied.

Summarising, the findings of the present dissertation strongly indicate that bidirectional and unidirectional causal effects between the Greek futures and spot market exists. The lead or lag relationship is assumed to be more strong (in terms of significance) when intraday day observations are included in the sample. However, the present study applied the necessary tests using daily data. A possible issue that requires further examination is to apply intraday observations in order to add a significant viewpoint to the subject of whether the spot index futures markets destabilises the stock markets. Hence, a motivating issue for further investigation would be to examine the informational role of FTSE/ASE-20 futures contracts and underlying FTSE/ASE-20 spot index of the Athens Exchange S.A., employing intraday observations.

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