MARKET MICROSTRUCTURE ISSUES RELATED TO THE GREEK CAPITAL MARKET

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ABSTRACT

Since the stock market crash of October 1987, academics and policy makers have been very concerned about the causes of the crash and whether the microstructure of the equity market should be redesigned to protect the market from drastic fluctuations. For their concerns, circuit breakers have been recommended as the mechanisms for the market stabilisation and for reducing the volatility of the stock market. Empirical and theoretical studies carried out so far have not been able to conclusively resolve the debate on the effects of circuit breakers on financial markets. As a result, this thesis aims to contribute to the market microstructure literature and to add empirical content to current academic and policy discussions, by conducting an investigation on the effects and implications of circuit breakers on financial markets, focusing on daily price limits, transaction taxes and margin requirements, with specific reference to the Greek capital market. Based on our empirical findings, we provide little evidence in support of the effectiveness of the above regulatory measures, in line with previous literature. Furthermore, our empirical findings suggest that both researchers and policy makers, should continue their efforts to conduct further tests on their suitability, as well as in exploring other mechanisms and channels, which might be more effective in stabilising the market and reducing volatility. Finally, the empirical findings in this thesis support what Roll (1989) stated over 17 years ago in his comprehensive review on the implications for regulatory policy, that there is little evidence in favour of the efficacy of margin requirements, price limits and transaction taxes.

ABBREVIATIONS

ADECH	Athens Derivatives Exchange Clearing House
ADEX	Athens Derivatives Exchange
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AR	Autoregressive
ARCH	Autoregressive Conditional Heteroskedasticity
ARMA	Autoregressive Moving Average
ASE	Athens Stock Exchange
ASIS	Automated Electronic Trading System
ATHEX	Athens Exchange
BoD	Board of Directors
CAPM	Capital Asset Pricing Model
CBOT	Chicago Board of Trade
CMC	Capital Market Commission
CSD	Central Securities Depository
DJIA	Dow Jones Industrial Average
EAGAK	Parallel Market for Emerging Markets
ECB	European Central Bank
EGARCH	Exponential GARCH
EGARCH-M	EGARCH-in-Mean
EMH	Efficient Market Hypothesis
EMU	European Economic and Monetary Union
EONIA	Euro Overnight Index Average
EU	European Union
EUR	Euro
FTSE	Financial Times Stock Exchange
GARCH	Generalised Autoregressive Conditional Heteroskedasticity
GARCH-M	GARCH-in-Mean
GDP	Gross Domestic Product
GNP	Gross Net Product
GRD	Greek Drachma
HKSE	Hong Kong Stock Exchange
IPO	Initial Public Offering
LIFFE	London International Financial Futures and Options Exchange
MA	Moving Average
MDH	Mixture of Distribution Hypothesis
MMI	Major Market Index
MSCI	Morgan Stanley Capital International
NEHA	New Market
NYSE	New York Stock Exchange
OASIS	Integrated Automatic Electronic Trading System
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares

OTC	Over-The-Counter
OTE	Hellenic Telecommunications Organisation
RATS	Regression Analysis of Time Series
SDRT	Stamp Duty Reserve Tax
SEC	Securities and Exchange Commission
SIAH	Sequential Information Arrival Hypothesis
SIC	Schwarz Information Criterion
S&P	Standard & Poor
STT	Security Transaction Tax
TSE	Taiwan Stock Exchange
TSE	Tokyo Stock Exchange
U.K.	United Kingdom
U.S.	United States
USD	U.S. Dollar
VAR	Vector Autoregression

CHAPTER 1

INTRODUCTION

1.1 Motivation

During its 130 years of operations the Greek capital market has managed to make significant progress in its development with the ultimate objective of matching the well-developed European markets. The efforts of the Greek Government and stock exchange officials, which especially intensified after the mid-1980's, were finally rewarded by the decision of the international investment houses to officially upgrade the Athens Stock Exchange (ASE) to the category of developed markets in 2001.

The purpose of this thesis is to empirically examine the effects of market-stabilisation mechanisms, such as daily price limits, transaction taxes and margin requirements on the price volatility, returns and trading activity of stocks in the ASE. These regulatory measures were introduced and revised on many occasions in the last 15 years, during the period when the Greek economy and Greek capital market were experiencing their most important developments, and undergoing major regulatory, technological and other structural changes.

There is no doubt that the globalisation and the upgrading of the ASE as a developed stock market since June 2001 provide evidence of the "maturity" and development of the Greek economy.[1] The transition to a developed market comes as a result on the one hand of developments in the economy, and on the other hand of the upgrading of the legal and regulatory framework and technological systems. With the participation of Greece in the "Euro Zone", the economic prospects have been the best in

[1] On July 31, 2000, Morgan Stanley Capital International (MSCI) announced that the MSCI Greece Index would be reclassified as a developed market index. Thus, it would fully join the MSCI Developed Markets Index series and would simultaneously be removed from the MSCI Emerging Markets Index series, effective as of June 1, 2001.

recent years.[2] In the new era, the Greek Exchange could contribute significantly to a new dynamism in the Greek economy.

The ASE had been classified as an emerging market – before its upgrade – with speculative characteristics of erratic and sometimes unjustifiable stock price movements. The latter gives an indication that market prices may not at all times rationally reflect all available information in the market, and it may be possible that other factors affect security prices.

A number of studies have been carried out on the price behaviour of the ASE and performed tests of the efficient market hypothesis (EMH).[3] For example, Koutmos *et al.* (1993) explore the stochastic behaviour of stock prices and find that both the first and the second moments of the distribution of returns are time-dependent. They employ Nelson's (1991) EGARCH-M model, which allows shocks to have an asymmetric impact on volatility. Niarchos and Alexakis (1998) use 'causality' models in order to test the price behaviour of two different types of shares (common and preferred) in the market. The evidence indicates that the price fluctuations of these two types of shares correlate, although there is a large discrepancy between their respective prices, which has increased after 1987. Chortareas *et al.* (2000) use the EGARCH-M model to analyse the autoregressive behaviour in the first and second moments, the asymmetric response of

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[2] During the period 1997 to 2000, the Greek economy was characterised by its attempt at readjusting its macroeconomic indicators and achieving the criteria to become the 12th member of the "Euro Zone", a feat that was realised on January 1, 2001.

[3] An extensive literature review includes Niarchos (1972); Papaioannou and Philippatos (1982); Papaioannou (1982, 1984); Niarchos and Georgakopoulos (1986); Panas (1990); Alexakis and Petrakis (1991); Alexakis (1992); Koutmos, Negakis and Theodossiou (1993); Theodossiou, Koutmos and Negakis (1993); Alexakis and Xanthakis (1995); Barkoulas and Travlos (1998); Niarchos and Alexakis (1998); Papachristou (1999); Chortareas, McDermott and Ritsatos (2000); Mills, Siriopoulos, Markellos and Harizanis (2000); Barkoulas, Baum and Travlos (2000); Coutts, Kaplanidis and Roberts (2000); Panas (2001); Kavussanos and Dockery (2001); Siourounis (2002); Niarchos and Alexakis (2003); Vougas (2004); Panagiotidis (2005); and Patra and Poshakwale (2006).

conditional variance to innovations of differing signs, and the risk premium associated with the index's own conditional variance. Contrasting the 1987-1991 and 1991-1997 periods they find significant changes in the time series properties of the ASE. Vougas (2004) examines long memory of returns in the ASE along with volatility, using an ARFIMA-GARCH model, estimated via conditional maximum likelihood, and finds weaker evidence in favour of long memory. His results differ to Barkoulas *et al.* (2000), who earlier examined long memory of returns in the ASE, and found evidence in favour of long memory. Panagiotidis (2005) tests the EMH in the case of the ASE after the introduction of the euro (EUR) for three different indices. That is, the FTSE/ASE 20 Index, which consists of 'high capitalisation' companies, the FTSE/ASE Mid-40 Index, which consists of medium sized companies, and the FTSE/ASE SmallCap-80 Index, which covers the next 80 companies. The underlying assumption is that stock prices would be more transparent; their performance easier to compare; the exchange rate risk eliminated and as a result the expectation is that the new currency would strengthen the argument in favour of the EMH. Five statistical tests are employed to test the residuals of the random walk model: the BDS, McLeod-Li, Engle LM, Tsay, and Bicovariance test. Bootstrap as well as asymptotic values of these tests are estimated. The random walk hypothesis is rejected in all three cases and alternative GARCH models are estimated.

The last two decades have seen the emergence of a substantial amount of literature in market microstructure, the area of finance that examines the process by which investors' latent demands are ultimately translated into transactions. However, interest in microstructure and trading is relatively new to the Greek literature, since a limited number of studies have been produced so far, which investigate issues relating to the procedure and outcomes of exchanging assets under a specific set of rules.

Phylaktis *et al.* (1999) use econometric techniques such as serial correlation and GARCH models to examine the effects of price limit mechanisms on the stock market volatility in the ASE. Based on a cross-section of stocks and the General Price Index, the imposition of price limits in the ASE did not have the desired effect on stock market volatility, which was to reduce it. Kavussanos and Phylaktis (2001) use GARCH models to examine the interaction of stock returns and trading activity in the ASE under different trading systems. They indicate the importance of the trading procedure for the informational content of trading activity and its effects on conditional volatility, and on the distribution of stock returns. They provide supportive evidence of the superiority of electronic trading as opposed to floor trading in the diffusion of information.

This thesis aims to contribute to the market microstructure literature and to add empirical content to current academic and policy discussions, by specifically studying the Greek capital market. An empirical investigation is conducted on the effects and implications of the imposition of: (1) daily price limits on the price volatility, stock returns and trading activity of individual stocks (Chapter 3); (2) transaction taxes on the conditional mean and volatility of stock index returns (Chapter 4); and (3) margin requirements on the conditional mean of trading volume of stock index futures (Chapter 5).

Each of these studies on the daily price limits, stock transaction taxes and futures margin requirements contribute to the existing literature in more than one ways. For example, the study on the price limits has a clear addition, as it uses a control sample of stocks, which consists of stocks that experienced a dramatic price change but did not hit their price limit. One can thus infer the effects of price limits by comparing the price behaviour of the control sample of stocks with those stocks that hit their price limit. In this way this study improves previous work done on the price limits within the Greek context. The study on the stock transaction taxes investigates the possibility of an asymmetry in the relation between transaction tax and volatility, which can originate from the different roles transaction taxes could play during bull, normal and bear periods. The study on the futures margin requirements conducts an investigation of the effects of margin changes on the trading volume of stock index futures, by taking into account, on the one hand, the effect of conditional volatility of stock returns on margin changes, and on the other hand, the relationship between conditional volatility of stock returns and trading volume. This study applies a new econometric methodology to allow for these inter-relationships, which were not considered in previous empirical research. The studies on the stock transaction taxes and the futures margin requirements are also the first empirical examinations to be carried out on the Greek capital market. The purpose, motivation and contribution of each of these studies to existing literature is summarised in sections 1.3 to 1.5 of this chapter, and discussed extensively in Chapters 3 to 5.

Specifically the remaining of this introductory chapter is organised as follows. Section 1.2 reviews some of the recent books and articles on market microstructure literature. Section 1.3 introduces the topic of daily price limits and explains why these mechanisms are of importance to both academics and market regulators. Section 1.4 discusses why exchange authorities impose transaction taxes on securities and presents the arguments for and against their adoption. Section 1.5 highlights the significant role that margin requirements play in futures markets and how their effectiveness is still under debate. Section 1.6 briefly reviews the data set used and econometric methodologies and models applied in the three main chapters. The final section concludes this chapter.

1.2 Market microstructure

The last two decades have seen the emergence of a significant amount of literature in market microstructure, the area of finance that examines the process by which investors' latent demands are ultimately translated into transactions. Interest in microstructure and trading is not new but the recent literature is distinguished by theoretical rigor and extensive empirical validation using new databases.

Some recent books and articles offer valuable summaries of important elements of the market microstructure literature. O'Hara's (1995) book provides a detailed survey of the theoretical literature in market microstructure. After an introduction to the general issues and problems in market microstructure, O'Hara (1995) examines the main theoretical models developed to address inventory-based issues. There is then an extensive examination and discussion of the information-based models with particular attention paid to the linkage with rational expectations model and learning models. The concluding chapters are concerned with price dynamics and with applications of the various models to specific microstructure problems including liquidity, multi-market trading, market structure, and market design. Harris (2002) provides a general conceptual overview of trading and the organisation of markets in his text, but his focus is not on the academic literature. Lyons (2001) examines the market microstructure of foreign exchange markets.

Survey articles emphasize depth over breadth, often focusing on a select set of issues. Biais *et al.* (2005) survey the theoretical literature within the framework of a simple synthetic model of the market for a risky asset with competing market makers. They also discuss which theoretical predictions have been tested, and to what level they have been rejected or found consistent with the data, and they rely on the theoretical analyses to offer an interpretation for empirical findings. They thus show how the market microstructure literature, building upon first economic principles, provides a tool to analyse traders' behaviour and market design, and offers a rationale for a large array of stylised facts and empirical findings. Their attempt to integrate the theoretical and empirical sides of the literature differs from O'Hara (1995), whose book surveys several theoretical models. Their focus also differs from Madhavan (2000), who offers an interesting survey of the microstructure literature, as they emphasize the microfoundations of the literature, and the scope for strategic behaviour. This approach enables them to offer an equilibrium-based analysis of policy and market design issues. They concentrate on the section of the literature that addresses price formation and market design, while not addressing other important issues such as the interactions between market microstructure and corporate finance or asset pricing.

Madhavan (2000) reviews the considerable theoretical, empirical and experimental literature on market microstructure with a special focus on informational issues relating to four major areas: price formation and price discovery, including both static issues such as the determinants of trading costs and dynamic issues such as the process by which prices come to impound information over time; market structure and design, including the effect of trading protocols on various dimensions of market quality;

market transparency, that is, the ability of market participants to observe information about the trading process; and interface of market microstructure with other areas of finance including asset pricing, international finance, and corporate finance. Keim and Madhavan (1998) survey the literature on execution costs, focusing on institutional traders. Coughenour and Shastri (1999) provide a detailed summary of recent empirical studies in four select areas: the estimation of the components of the bid-ask spread, order flow properties, the Nasdaq controversy, and linkages between option and stock markets. A survey of the early literature in the area is provided by Cohen *et al.* (1986).

Empirical market microstructure has emerged as an important research tool that can be used to develop an understanding of financial markets, enabling researchers to address issues that cannot be adequately explained with more aggregated methodologies. The objective of this thesis is to contribute to the market microstructure literature by focusing on a select set of market microstructure issues and examining empirically their effects on the price volatility, stock returns and trading activity of stocks. In particular, it examines the imposition of daily price limits (Chapter 3), transaction taxes (Chapter 4), and margin requirements (Chapter 5).

Since the stock market crash of October 1987, academics and policy makers have been very concerned about the causes of the crash and whether the microstructure of the equity market should be redesigned to protect the market from drastic fluctuations. For their concerns, circuit breakers have been recommended as the mechanisms for the market stabilisation and for reducing the volatility of the stock market. The most common types of circuit breakers are trading halts, price limits, transaction taxes, margin requirements and position limits, and collars. All these mechanisms limit trading activity in some way. Trading halts stop trading when prices have moved, or will imminently move, by some pre-specified amount. Trading resumes after some time interval. Price limits require all trade prices to be within a certain range. If traders are unwilling to negotiate prices within the limited range, trading will stop. Trading can resume any time traders are willing to negotiate prices within the price limits. Transaction taxes restrict trading by taxing it. Margin requirements and position limits restrict the size of positions that traders can accumulate. Collars restrict access to computerised order submission systems.[4,5]

Empirical and theoretical studies carried out so far have not been able to conclusively resolve the debate on the effects of circuit breakers on financial markets. As a result, this thesis intends to contribute to the current academic and policy discussions, by specifically examining the effects and implications of the imposition of these regulatory measures on Greek equities and futures.[6] In the remaining sections of this chapter the purpose, motivation, contribution and main literature review are briefly discussed for each of the circuit breakers examined in this thesis. The data set used and econometric methodologies and models applied are also described in subsequent sections before the completion of this introductory chapter.

1.3 Price limit performance of an emerging market: The case of the ASE

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[4] See Harris (1998) for an overview of the circuit breaker debate. Harris (1998) also provides an extensive literature review on circuit breakers.

[5] Harris (1998) defines trading halts, price limits, transaction taxes, margin requirements, position limits and collars as a type of a circuit breaker since the imposition of these mechanisms has the objective to limit trading activity in some way. In this thesis, we adopt Harris (1998) explanation and also define price limits, transaction taxes and margin requirements as a form of a circuit breaker.

[6] Roll (1989) provides a survey of the early literature on margin requirements, price limits and transaction taxes.

The use of daily price limits in financial asset markets has generated a great deal of discussion since the global market crash of 1987. A number of researchers have tried to examine the impact and effectiveness of price limits on financial asset markets, either empirically or theoretically. In essence, price limits are designed to reduce the total cost for market participants by serving as a price-stabilisation mechanism and in general to assure the proper operation of financial asset markets. Their impact and efficiency on the operation of markets, however, is still under debate.

Daily price limits are artificial boundaries, established by market regulators, on where security prices are allowed to fluctuate on any given trading day, within the pre-specified percentage level above or below the previous trading day's closing price. Trading (if any) continues at the ceiling or floor price until the demand and supply conditions are reversed, or until the closing of the trading day.

Price limits are currently in place in the United States (U.S.) futures markets and in several stock exchanges around the world including Austria, Belgium, France, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Spain, Switzerland, Taiwan, and Thailand [Roll (1989), Rhee and Chang (1993)]. Even though price limit mechanisms affect a significant part of the world's capital markets, little is known about how these price limits affect markets and market participants' behaviour, as Harris (1998) argues.

Empirical literature on price limits is limited and inconclusive, as Harris (1998) further notes. Price limit research on U.S. futures markets often uses a few contracts [Ma *et al.* (1989a,b)]. To examine price limit effects on stocks, researchers turn to non-U.S. markets, e.g., Chen (1993) studies the Taiwan Stock Exchange (TSE), Kim and Rhee

(1997) the Tokyo Stock Exchange (TSE), Phylaktis *et al.* (1999) and Diacogiannis *et al.* (2005) the ASE.

Empirical price limit research on U.S. futures and non-U.S. equities markets investigates two main questions. First, whether price limits reduce volatility, and second, whether they mitigate investor overreaction. Ma *et al.* (1989a,b) provide evidence in support of price limits and answer positively to both questions. However, Lehmann (1989) and Miller (1989) point out weaknesses with these studies that subsequent papers overcome. In later work, Chen (1993), Chen (1998), Kim and Rhee (1997), and Phylaktis *et al.* (1999) provide evidence against price limits and answer negatively to both questions. Diacogiannis *et al.* (2005) confirm the occurrence of short-term overreactions and also provide evidence against price limits.

Price limit proponents assert that price limits decrease stock price volatility, counter overreaction and do not interfere with trading activity. It is believed that such mechanisms would have prevented the price freefall during the 1987 global market crash. Price limit critics, on the other hand, argue that price limits cause higher volatility levels on subsequent days (volatility spillover), prevent prices from efficiently reaching their equilibrium level (delayed price discovery), and interfere with trading due to limitations imposed by price limits (trading interference).

The purpose of this study is to add empirical content to the debate on daily price limits by conducting an investigation on the impact and effectiveness of price limits on the volatility, return and trading activity of Greek equities. The study differs from Phylaktis *et al.* (1999) and Diacogiannis *et al.* (2005), which have also examined the effects of price limits on the Greek capital market, by taking into account supply and demand for liquidity. As Lehmann (1989) and Miller (1989) point out, effects associated with price limits can be either due to the price limits or to large price changes. As a result of Lehmann's (1989) and Miller's (1989) interpretations, the current study uses a control sample, which consists of stocks that experienced a dramatic price change taking in this way into account large price changes but did not hit their price limit. One can infer the effects of price limits by comparing the price behaviour of the control sample of stocks with those stocks that hit their price limit. In this way this study improves previous work done on the price limits within the Greek context.

1.4 Security transaction taxes and financial volatility: Evidence from the ASE

Financial markets are organised in such a way as to transform latent demands of investors into realised financial transactions. The imposition of securities transaction taxes (STTs) affects this transformation. Proponents of STTs argue that such taxes can reduce market volatility by reducing excessive trading for many financial transactions are highly speculative in nature.[7] Opponents of STTs, on the other hand, argue that markets have the ability to allocate resources efficiently without direct involvement from public policy. However, instead of providing evidence that the allocation of resources to the financial sector is justified on efficiency grounds, or that observed market volatility is optimal, the opponents of STTs have focused on issues relating to their implementation for if a STT is applied in one financial market but not in others, investors can circumvent the tax by trading in markets which are not taxed.[8] Furthermore, investors can trade substitute securities, which are not affected by the tax, and generate payoffs similar to

[7] See, for example, Tobin (1984), Summers and Summers (1989), Stiglitz (1989), and Eichengreen, Tobin, and Wyplosz (1995) for a discussion of the various arguments put forward in favour of STTs.

those whose transactions are taxed. In the whole debate concerning the desirability of STTs one should not forget the possible tax revenue implication for the Governments. By imposing a low tax rate on a broad range of transactions Governments can raise large amounts of funds.

STTs have been a common policy tool throughout the world. STTs have operated in major financial markets including Japan, the United Kingdom (U.K.), Germany, Italy, and France, as well as smaller Organisation for Economic Cooperation and Development (OECD) economies including Australia, Austria, Belgium, Denmark, Greece, and Ireland, and many emerging economies, such as Chile, China, India, and Malaysia.[9]

Researchers have attempted to resolve the debate on the efficacy of transaction taxes empirically, given the lack of a consensus on the theory. The studies reviewed below refer to the effects of STTs on security prices and price volatility.[10]

Roll (1989) was the first to study the effect of STT on stock return volatility. He examined 23 countries from 1987 to 1989 and found no evidence that volatility is reliably related to transaction taxes.[11] Umlauf (1993) studied the behaviour of equity returns in Sweden, before and during the imposition of transaction taxes on brokerage service providers over the period 1980-1987, and found significant increases in volatility; daily variances were highest during the period of greatest tax. On the other hand, Saporta and Kan (1997) examined the impact of the U.K. stamp duty on the volatility of securities' prices and found no significant effect. Evidence on Emerging Markets has also not been

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[8] See, for example, Campbell and Froot (1995), where they consider international experiences with STTs.

[9] For a description of STTs that have operated in developed economies, see Habermeier and Kirilenko (2001).

[10] A few studies have examined the effect on trading volume. See, for example, Campbell and Froot (1995) who examine the experiences of Sweden and the U.K. and find a fall in trading volume in the presence of STTs.

supportive of the tax. For example, Hu (1998) examined the effects on volatility of changes in transaction taxes that occurred in Hong Kong, Japan, Korea, and Taiwan from 1975 to 1994, and did not find significant effects.

The effects of STTs have also been examined by investigating the effects of types of other regulatory changes, which are equivalent to transaction taxes in terms on their impact on transaction costs. For example, Jones and Seguin (1997) examined the effect on volatility of the introduction of negotiated commissions on U.S. national stock exchanges in 1975, which resulted in a permanent decline in commissions. They argued that this event is equivalent to a one-time reduction of a tax on equity transactions since both are fixed in amount and levied on parties whenever a stock transaction takes place. They did not find that the lowering of commissions increased volatility; instead, they found that market volatility was reduced in the year following the deregulation.

More recently, Hau (2006) examined the effect on volatility of minimum price variation rules in the French stock market and argues that minimum price variation rules result in an increase of about 20% of transaction costs for stocks priced above a certain threshold (500 francs). He argues that this is equivalent to the application of a transaction tax on the stocks above the threshold and finds that the increase in transaction costs results in an increase in volatility, which is "significant both statistically and economically".[12]

Looking now at the empirical studies, which have examined whether transaction taxes have an impact on securities' prices the results support a negative impact. For example, Umlauf (1993) reporting on the Swedish experience finds that the All-Equity

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[11] Roll (1989) reviewed three proposals for dampening volatility: margin requirements, price limits, and transaction taxes, and claimed that transaction taxes are the least studied of the three.

Index fell by 2.2% on the day a 1% transaction tax was announced and again by 0.8% on the day it was increased to 2%. He finds these declines to be statistically significant compared to the mean daily return of the sample. The fall in stock market index was even greater in the case of the U.K. Saporta and Kan (1997) find that on the day stamp duty in the U.K. was increased from 1% to 2%, the stock market index declined by 3.3%. Hu (1998) reports similar results in the case of Korea and Taiwan. Over the nine changes in the two countries, the average return on the announcement date is –1% with a t value of –3.06 and a p value of 0.001.

Thus, overall the various empirical studies provide no clear conclusions regarding the relationship between STTs and volatility or trading volume, but offer more conclusive evidence with regard to STTs and securities' prices.

The purpose of this study is to contribute to the debate on STTs by examining the effects of transaction tax on the mean and volatility of stock market returns, in the ASE in Greece. The study makes the following contributions to the existing literature on STTs. First, it provides evidence on a capital market using both a marketwide index (i.e. All Share Index) and a large cap index (i.e. FTSE/ASE 20 Index).[13] By examining the effects of the transaction tax using the FTSE/ASE 20 Index, we will test whether the transaction tax has a greater impact on the volatility of actively traded stocks, as a result of investors entering (buying) and exiting (selling) the market (stocks) on a more frequent basis.

Second, the study investigates the possibility of an asymmetry in the relation between transaction tax and volatility, which can originate from the different roles

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[12] Hau (2006), page 888.

[13] The FTSE/ASE 20 Index consists of 20 of the largest in market capitalisation and most liquid stocks that trade on the ASE. It was developed in September 1997 out of a partnership between the ASE and FTSE International.

transaction taxes could play during bull and bear periods.[14] We expect transaction tax to have a greater impact on the volatility of stocks during bull periods compared to bear or normal periods, since trading activity is higher during those periods.

Finally, our study is the first empirical investigation of the effects of transaction tax on the mean and volatility of Greek stock returns.

1.5 Margin changes and futures trading activity: A new approach

Previous empirical research has generally failed to document a strong inverse association between margin requirements and trading volume as theory suggests. This study revisits the empirical examination of the effects of margin requirements on the trading volume of futures contracts, by applying a new econometric approach. Specifically, the tests are conducted on the stock index futures contracts of the Greek derivatives market, at a period when the Greek economy and financial markets were experiencing important developments, and undergoing significant regulatory and other structural changes.

Futures contracts typically are traded on organised exchanges in a wide variety of physical commodities (including grains, metals and petroleum products) and financial instruments (such as stocks, bonds and currencies). Futures traders are not required to put up the entire value of a contract. Rather, they are required to post a margin that is typically between 2% and 10% of the total value of the contract. Unlike stock margins, margins in the futures markets are not down payments, but are performance bonds that are designed to ensure that traders can meet their financial obligations.

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[14] Hardouvelis and Theodossiou (2002) also investigated the possible existence of an asymmetric relation between initial margin requirements, which is another form of transaction cost, and stock market volatility

A substantial amount of research on margin requirements has been on the relationship between margin requirements and trading volume. Studies have found little evidence of an inverse association between margins and volume although they have documented a small inverse relationship with respect to open interest. Fishe and Goldberg (1986) attempted to examine the effect of margin changes on both open interest and volume around a 3- to 5-day window of such changes. They found, on the one hand, that a 10% increase in margin requirements would reduce open interest by approximately one-third of 1%, and on the other hand it would increase volume traded by 14.62%. Other empirical studies have also failed to identify statistically significant inverse relationships between margins and volume.[15] For example, Hartzmark (1986) investigated 13 contract days calculating whether volume changed significantly from 15 days before to 15 days following the change. He found that in only 4 of 13 occurrences did volume move negatively and significantly in the opposite direction. As a result, the association between margins and volume is also weak over the longer period and does not support the assertion that increased margin requirements will reduce trading volume.

Dutt and Wein (2003) hypothesize that the reason for the empirical findings of previous research is that they have generally failed to consider that margins change when exchange margin committees believe that market risk has changed. In their analysis, they take into account this fundamental principle, by adjusting margins for underlying price risk, using variability estimates before and after each margin change. After controlling for risk, they find a statistically inverse relationship between margins and trading volume, for the 6 futures contracts examined.

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in the U.S. during bull, normal and bear periods.

[15] See Fishe and Goldberg (1986) for an early review.

Although the rationale for adjusting the margins by price variability has been discussed in the literature [e.g. Telser (1981), Fishe and Goldberg (1986)], previous researchers, with the exception of Dutt and Wein (2003), have generally neglected to consider this, when they empirically examined the relationship between margins and trading volume. According to Dutt and Wein (2003) this is the reason empirical findings on the effects of margin changes on trading volume have been unclear (either statistically significant positive or negative or insignificant), because changes in market risk can have an opposing effect on trading volume. For example, if price volatility increases, it is likely that volume of trading will increase as a result, and this is documented in the literature for the futures markets [see e.g. Jacobs and Onochie (1998)]. At the same time, if exchange margin committees can precisely predict when volatility is increasing, then they will cautiously raise margins [see e.g. Gay, Hunter and Kolb (1986), Fenn and Kupiec (1993), and Chatrath, Adrangi and Allender (2001)]. If increases in margins are a cost to the trader, then we expect that it will have the impact of reducing volume. As a result, because the two forces on volume contradict each other, the predicted impact on volume of a margin increase will be ambiguous.

The aim of this study is to contribute to the debate with regard to the effects of margin changes on trading volume of stock index futures. The main contribution of the paper to the existing literature is that the investigation takes into account, on the one hand, the effect of conditional volatility of stock returns on margin changes, and on the other hand, the relationship between conditional volatility of stock returns and trading volume. This study applies a new econometric methodology to allow for these inter-relationships, which were not considered in previous empirical research. The tests are also conducted on the stock index futures of the Greek derivatives market, a newly established market which was rapidly expanding to match that of its European counterparts, and at a period when the Greek economy and financial markets were experiencing important developments and changes.

Many studies have documented a positive contemporaneous correlation between trading volume and price volatility, which is relatively well established in the equities markets [see e.g. Schwert (1989), Lamoureux and Lastrapes (1991, 1994), Gallant, Rossi and Tauchen (1992), Phylaktis, Kavussanos and Manalis (1996), Kavussanos and Phylaktis (2001), Fleming, Kirby and Ostdiek (2006), and Henry and McKenzie (2006)]. The positive relationship between trading volume and price volatility is also documented in the futures markets [see e.g. Cornell (1981), Tauchen and Pitts (1983), Grammatikos and Saunders (1986), Najand and Yung (1991), Bessembinder and Seguin (1993), and Jacobs and Onochie (1998)].

As a result of the relationship between trading volume and price volatility documented in equities and futures markets, our study incorporates it, when it examines the effects of margin changes on the trading volume of stock index futures, and adjusting margins for underlying price risk, following Dutt and Wein's (2003) suggestion. This has not been studied before in the literature. In our study, we employ bivariate GARCH-M models on the stock prices and their trading volume. These models allow for autocorrelation in the first and second moments, and also have the advantages of avoiding simultaneity bias with regard to the effect of volume on price volatility, allowing for nonlinearities in the second moments, as well as providing a means for estimating a risk premium. Furthermore, the models employed allow us to examine the relationship between trading volume and stock returns, through the lagged volume and lagged return variables included in the conditional variance of returns and volume respectively, the contemporaneous correlation between returns and volume in the conditional covariance, and the lagged conditional variance of returns included in the conditional mean of volume.

As it has been mentioned earlier the study focuses on the Greek derivatives market, where the effectiveness of margins on trading volume has never been examined before.

1.6 Data and econometric methodologies

This section briefly reviews the data set used and econometric methodologies and models applied in the three main chapters, Chapters 3 to 5.

1.6.1 Data

To perform the empirical tests on the daily price limits study in Chapter 3, we use daily stock price data from January 2, 1997 to April 30, 2001, giving us in total 1,082 daily observations. The sample period begins on January 2, 1997, because some of the data used for the tests (e.g. daily opening prices of stocks) is available since this date. The sample period ends on April 30, 2001, just before the official upgrade of Greek capital markets by international investment houses to developed status. Thus, the examination is conducted at a period when the ASE was officially categorised as an emerging market. The daily adjusted opening, closing, high and low prices, for the 59 individual stocks comprising the ASE Composite Share Price Index as at the end of April 2001, were collected from the ASE records. The price data is adjusted to reflect capital distributions that include stock splits, reduction of capital, rights offerings, and stock dividends. The decisive criteria for the composition of the ASE Composite Share Price Index are the market capitalisation and the trading value of the listed stocks. Consequently, tests are performed on the 59 largest, most actively traded and liquid stocks in the ASE.

In Chapter 4, the stock transaction taxes study, the data set comprises closing daily observations of the All Share Index and the FTSE/ASE 20 Index from September 24, 1997 to December 31, 2003, giving us in total 1,564 observations. The data is collected from the ASE records. The sample period begins on September 24, 1997, because daily closing data for the FTSE/ASE 20 Index is available since the establishment of this large cap index on this date. The price indices are not adjusted for dividend payouts however Schwert (1990) and Gallant *et al.* (1992) demonstrate that volatility estimates are not influenced appreciably by dividends. The FTSE/ASE 20 Index comprises of the 20 largest in market capitalisation and most highly traded stocks of all the companies listed on the ASE, and it has a heavier weight on banking, telecommunication and energy stocks.[16] At the end of 2003, the market capitalisation of FTSE/ASE 20 Index was 39.45% of the total market capitalisation and the total number of companies listed on the ASE was 355.[17]

In Chapter 5, the futures margin requirements study, the data set comprises daily observations of settlement prices and trading volume, that is, the number of contracts traded, for the nearby futures contract of the FTSE/ASE 20 Index, from August 27, 1999 to December 31, 2005, giving us in total 1,584 observations. The data is collected from

[16] The FTSE/ASE 20 Index was developed in 1997 by the partnership of ASE with FTSE International and is already an established benchmark.

the ADEX records. The sample period begins on August 27, 1999, because daily data for the FTSE/ASE 20 Index futures contracts is available since the opening of trading on this date. The nearby futures contract of the FTSE/ASE 20 Index is the most highly traded and consequently the most liquid of all the futures contracts in ADEX.

1.6.2 Econometric methodologies

In Chapter 3, we base our empirical methodology to examine price limit performance in the ASE on Kim and Rhee (1997). As previously discussed, the main advantage of this event methodology is that it uses a control sample, which consists of stocks that experienced a dramatic price change but did not hit their price limit. One can thus infer the effects of price limits by comparing the price behaviour of the control sample of stocks with those stocks that hit their price limit.

In order to find occurrences of prices reaching their limits, we identify days where the high or low price matches its previous day's closing price plus or minus its price limit respectively. On days when price limits are reached, we classify stocks that did not reach the price limit into four subgroups: stocks that came within at least 0.90($LIMIT_t$) of reaching the daily limit; stocks that came within at least 0.80($LIMIT_t$), but less than 0.90($LIMIT_t$) of reaching the daily limit; stocks that came within at least 0.70($LIMIT_t$), but less than 0.80($LIMIT_t$) of reaching the daily limit; and stocks that came within at least 0.60($LIMIT_t$), but less than 0.70($LIMIT_t$) of reaching the daily limit.[18]

[17] The figure includes companies whose shares have been suspended from trading.

[18] In the rest of the subsection, our stock categories for those stocks that did not hit price limits are referred to as $stocks_{0\,90}$, $stocks_{0\,80}$, $stocks_{0\,70}$, and $stocks_{0\,60}$, where the subscripts denote the magnitude of a stock's price movement on Day 0, that is the limit-hit day. $Stocks_{hit}$ refer to those stocks that reach their daily price limit.

We initially employ a 21-day event window: Day –10 to +10. For $stocks_{hit}$, Day 0 represents the limit-hit day, for $stocks_{0.90}$, Day 0 represents the day the stocks experienced their $0.90(LIMIT_t)$ price movement and this similarly applies to $stocks_{0.80}$, $stocks_{0.70}$ and $stocks_{0.60}$. Day –1 represents the day before Day 0, and Day 1 is the day after Day 0, and so on.

Daily price volatility is measured by $V_{t,j} = (r_{t,j})^2$, where $r_{t,j}$ represents close-to-close returns using Day t – 1 closing price and Day t closing price for each stock j. We estimate this measure for each stock in all five stock categories and find averages for each Day t. If the $stocks_{hit}$ group experiences greater volatility during post-limit days than the other subgroups, then this finding supports the hypothesis that daily price limits cause volatility to increase on subsequent days.

To investigate price limits' effects on efficient price discovery, we consider the following two returns series for each of the five stock categories: $r(O_0C_0)$ and $r(C_0O_1)$. The first return series represents open-to-close returns on the limit day measured by $\ln(C_0/O_0)$ and the second return series represents close-to-open returns measured by $\ln(O_1/C_0)$. The ln indicates the natural logarithm operator; O and C indicate opening and closing prices, respectively; and subscripts indicate the day. Stock returns can be positive, negative, or zero and are denoted as (+), (-), and (0), respectively. As a result, nine returns series are possible: [+, +], [+, -], [+, 0], [0, +], [0, -], [0, 0], [-, +], [-, -], and [-, 0], where the first return symbol represents $r(O_0C_0)$ and the second return symbol represents $r(C_0O_1)$.

The reason we examine this particular return series is to observe the immediate stock price movement subsequent to price limit-hits on Day 0. By comparing the return series findings between all stock groups, we may be able to identify stock return behaviour which is unique to the $stocks_{hit}$ sample. Naturally, stocks always experience price continuations and reversals, therefore the price continuation behaviour of $stocks_{hit}$ would have to be greater than normal to conclude that limits are delaying the efficient price discovery process. Consequently, we use the price return behaviour of stocks that do not reach a price limit to represent normal behaviour. For upper limit hits, we classify the return series [+, +] and [0, +] as price continuations, [+, -], [0, -], [-, +], [-, 0], and [-, -] as price reversals, and [+, 0] and [0, 0] represent no change in prices. For lower limit hits, we classify the return sequences [-, -] and [0, -] as price continuations, [-, +], [0, +], [+, -], [+, 0], and [+, +] as price reversals, and [-, 0] and [0, 0] represent no change in prices.

To examine the trading activity behaviour around limit-days, we use the following turnover ratio as our measure for trading activity: $TA_{t,j} = TVOL_{t,j}/SOUT_{t,j}$, where $TVOL_{t,j}$ represents trading volume for each stock j on Day t and $SOUT_{t,j}$ represents the total number of shares outstanding for stock j on Day t. We calculate this ratio for each stock in all five stock categories and then find averages for each Day t. Because the liquidity interference hypothesis is interested in the day-to-day change in trading activity, we calculate a percentage change from the previous day as follows: $\ln(TA_{t,j}/TA_{j,t-1}) * 100$.

In this analysis, we present results for the 10-day period from Day –4 to Day +5. To support the trading interference hypothesis, we expect to find trading volume increases for the $stocks_{hit}$ group on the day after a limit-hit day indicating continued intense trading. With increased trading on following days, the implication is that price limits prevent rational trading on the event day, implying a harmful interference to liquidity. For other stock subgroups, we expect to see decreased or stabilised trading activity on subsequent days because price limits do not interfere with their trading on Day 0.

As previously discussed, empirical literature has documented a positive relation between price volatility and trading volume. The final part of the empirical analysis section in Chapter 3, examines the effect that trading interference may have on the volatility in order to further support or reject the trading interference hypothesis. To investigate this issue, we use the following cross-sectional regression:

$$V_j = a + b\,(\mathrm{TA})_j + c\,(\text{Hit-Dummy})_j + d_j, \qquad (1.1)$$

where V_j is our previously discussed volatility measure for each stock j, TA_j is the previously introduced turnover ratio for each stock j, and Hit-Dummy represents a dummy variable that equals 1 for stocks that reach an upper or lower price limit ($\text{stocks}_{\text{hit}}$) and 0 otherwise. The above regression is run for each day of our 21-day event period. We conduct two separate analyses for upper and lower price movements, where each sample includes two groups of stocks that experience nearly identical upward (downward) price movement on Day 0: $\text{stocks}_{\text{hit}}$ and $\text{stocks}_{0.90}$. The event methodology introduced in this section is also presented and analysed in more detail in Chapter 3.

In Chapter 4, we employ univariate GARCH-M(p,q)/EGARCH-M(p,q) models, which are used to investigate the relationship between transaction tax and the conditional moments – mean and variance – of daily stock market returns.[19] The conditional mean

[19] The GARCH model was developed by Bollerslev (1986), as a natural extension to the ARCH class of models introduced by Engle (1982), and has been used extensively to fit high frequency financial data. The EGARCH model was proposed by Nelson (1991) to allow for asymmetric shocks to volatility. Once we introduce the conditional variance into the mean equation, we then get the GARCH-M/EGARCH-M

equation describing the univariate GARCH-M(p,q) model of stock market returns is specified below as follows:

$$r_t = \mu_t + \varepsilon_t = a_0 + \sum_{i=1}^{p} c_i r_{t-i} + \sum_{j=1}^{q} d_j \varepsilon_{t-j} + e\sigma_t^2 + \varepsilon_t, \quad (1.2)$$

where $\mu_t \equiv E\,(r_t \mid i_{t-1})$ is the conditional mean of returns for period t based on information available up to time t-1, i_{t-1}, and ε_t is an error term used as proxy for market innovations (shocks). In addition, r_{t-i} are past returns, included to absorb serial correlation, ε_{t-j} are moving average (MA) terms, and $\sigma_t^2 \equiv \text{var}\,(r_t \mid i_{t-1})$ is the conditional variance of r_t based on i_{t-1}.

The conditional variance equation describing the univariate GARCH-M(p,q) model of stock market returns is specified below as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2, \quad (1.3)$$

where $\alpha_0 \geq 0$, and $\alpha_i, \beta_j \geq 0$ to ensure $\sigma_t^2 > 0$. The sum of the coefficients α_i and β_j, that is, the lags of the squared return and the conditional variance respectively, denote the degree of persistence in the conditional variance given a shock to the system. In particular, the above sum should be less than 1 in order to have a stationary variance. As the sum tends to 1 the higher is the instability in the variance and shocks tend to persist instead of dying out [see Engle and Bollerslev (1986)].

An interesting issue relating to the volatility of stock returns is the question of the asymmetric impact of good news (market advances) and bad news (market retreats) on

models. For a detailed explanation of ARCH models see Bera and Higgins (1993), and for a review of ARCH modelling in finance see Bollerslev *et al.* (1992).

volatility. That is, negative shocks (bad news) raise volatility more than positive shocks (good news) in the market. This phenomenon has been attributed to the "leverage effect" [see e.g. Black (1976), Nelson (1991), and Engle and Ng (1993)]. As explained by Black (1976) leverage can induce future stock volatility to vary inversely with the stock price; a fall in a firm's stock value relative to the market value of its debt causes a rise in its debt-equity ratio and increases its stock volatility.[20] The specification of short-term market volatility in terms of the natural logarithm of the conditional variance of returns, follows the work of Nelson (1991), and it is known as an EGARCH model. Thus, equation (1.3) of the GARCH-M(p,q) model is modified below as follows:

$$\ln(\sigma_t^2) = \alpha_0 + \sum_{i=1}^{p} \alpha_i |\varepsilon_{t-i}/\sigma_{t-i}| + \sum_{i=1}^{p} \eta_i (\varepsilon_{t-i}/\sigma_{t-i}) + \sum_{j=1}^{q} \beta_j \ln(\sigma_{t-j}^2). \quad (1.4)$$

Unlike the linear GARCH-M(p,q) model there are no restrictions on the parameters α_0, α_i, η_i and β_j to ensure non-negativity of the conditional variance. Persistence of volatility is measured by β_j. The asymmetric effect of negative and positive shocks is captured by η_i and α_i respectively; η_i measures the sign effect and α_i measures the size effect. If $\eta_i < 0$ a negative shock (bad news) tends to reinforce the size effect. The converse takes place when $\eta_i > 0$. Bad news will mitigate the size effect.

The conditional mean and variance equations describing the univariate GARCH-M(p,q)/EGARCH-M(p,q) models of stock market returns, are modified to include the transaction tax variable in the conditional mean and variance equations, and therefore capture the influence of the transaction tax during normal periods. In addition, the models

[20] Kavussanos and Phylaktis (2001) have also tested for the leverage effect using the EGARCH formulation of Nelson (1991). They examine the interaction of stock returns and trading activity in the ASE under different trading systems.

are modified to include the asymmetric relation between transaction tax and volatility during bull and bear periods in the conditional variance equations. The modified univariate GARCH-M(*p*,*q*)/EGARCH-M(*p*,*q*) models are presented and analysed in more detail in Chapter 4.

In Chapter 5, we employ bivariate GARCH-M(*p*,*q*) models, which are used to examine the effects of margin changes on trading volume, by taking into account, on the one hand, the effect of conditional volatility of stock returns on margin changes, and on the other hand, the relationship between conditional volatility of stock returns and trading volume. The best univariate GARCH-M(*p*,*q*) models are initially selected and these are subsequently used to construct the bivariate GARCH-M(*p*,*q*) model.[21]

The bivariate GARCH-M(*p*,*q*) models allow for autocorrelation in the first and second moments, and also have the advantages of avoiding simultaneity bias with regard to the effect of volume on price volatility, allowing for nonlinearities in the second moments, as well as providing a means for estimating a risk premium. Furthermore, the models employed allow us to examine the relationship between trading volume and stock returns, through the lagged volume and lagged return variables included in the conditional variance of returns and volume respectively, the contemporaneous correlation between returns and volume in the conditional covariance, and the lagged conditional variance of returns included in the conditional mean of volume.

[21] A recent survey on multivariate GARCH models is provided in Bauwens, Laurent and Rombouts (2006).

The conditional mean, the conditional variance and conditional covariance equations describing the bivariate GARCH-M(p,q) model are specified below as follows:[22]

$$\Delta f_t = a_0 + \sum_{i=1}^{p} b_i \Delta f_{t-i} + \sum_{j=1}^{q} c_j u^f_{t-j} + d_1 h^f_t + u^f_t, \tag{1.5}$$

$$v_t = e_0 + \sum_{i=1}^{p} g_i v_{t-i} + \sum_{j=1}^{q} k_j u^v_{t-j} + n_1 h^v_t + u^v_t, \tag{1.6}$$

$$(u^f_t, u^v_t)^T \sim N((0,0)^T, H_t), \tag{1.7}$$

$$(h^f_t, h^{fv}_t, h^v_t)^T = \text{vech}(H_t), \tag{1.8}$$

$$h^f_t = \alpha_0 + \sum_{i=1}^{p} \beta_i h^f_{t-i} + \sum_{j=1}^{q} \gamma_j u^f_{t-j}, \tag{1.9}$$

$$h^v_t = \varepsilon_0 + \sum_{i=1}^{p} \zeta_i h^v_{t-i} + \sum_{j=1}^{q} \eta_j u^v_{t-j}, \tag{1.10}$$

$$h^{fv}_t = \iota_0 + \sum_{i=1}^{p} \kappa_i h^{fv}_{t-i} + \sum_{j=1}^{q} \lambda_j u^{fv}_{t-j}, \tag{1.11}$$

$$L(\theta|Y,u) = -1/2 \sum_{t=0}^{T} (\ln (2\pi) + \ln|H_t| + u^T_t H_t^{-1} u_t). \tag{1.12}$$

In this specification, $f_t = \ln(F_t)$ is the natural logarithm of the contract's settlement futures price, F_t; $\Delta f_t = f_t - f_{t-1}$ is the price log-relative; $v_t = \ln(V_t)$ is the natural logarithm of

[22] The diagonal VECH formulation, of Bollerslev, Engle and Wooldridge (1988), is employed for the construction of the bivariate GARCH-M(p,q) model, to allow for greater flexibility and the inclusion of the various exogenous variables in the conditional mean, variance and covariance equations. The diagonal VECH formulation was preferred to the BEKK formulation of Engle and Kroner (1995), since the BEKK model is more complex and consequently more difficult to construct [see Brooks (2002)]. Jacobs and Onochie (1998) also use a diagonal VECH formulation for the creation of a bivariate EGARCH-M(p,q) model, to examine the relationship between return variability and trading volume in international futures markets.

the level of trading volume, V_t; and $u_t = (u^f_t, u^v_t)^T$ is the vector of random disturbance terms for log-relative price and log volume at time, t, respectively, with zero mean vector, 0, and conditional variance-covariance matrix, H_t, with elements, vech$(H_t) = (h^f_t, h^{fv}_t, h^v_t)^T$, as the respective conditional variances and covariance. Y,u are time series of observations and disturbances, respectively, and $L(.|.)$ is the log-likelihood of the parameter vector, θ, conditional on the observations.

Equations (1.5-1.6) describe a bivariate GARCH-M(p,q) structure for the first moments. In equation (1.5), Δf_{t-i} are past returns, included to absorb serial correlation, u^f_{t-j} are MA terms, h^f_t is the conditional variance of Δf_t, and u^f_t are random disturbance terms. Similarly in equation (1.6), v_{t-i} are past terms, u^v_{t-j} are MA terms, h^v_t is the conditional variance of v_t, and u^v_t are random disturbance terms.

Equations (1.9-1.10) describe a bivariate GARCH-M(p,q) structure for the second moments. In equations (1.9) and (1.10), the sum of the coefficients β_i and γ_j, and the sum of the coefficients ζ_i and η_j, respectively, that is, the lags of the conditional variance and squared return, denote the degree of persistence in the conditional variance given a shock to the system. In particular, the above sums should be less than 1 in order to have a stationary variance. As the sum tends to 1 the higher is the instability in the variance and shocks tend to persist instead of dying out. In addition, $\alpha_0, \beta_i, \gamma_j \geq 0$ to ensure $h^f_t > 0$, and $\varepsilon_0, \zeta_i, \eta_j \geq 0$ to ensure $h^v_t > 0$. Equation (1.11) describes the conditional covariance equation, which measures the contemporaneous correlation between price change and volume. The log-likelihood for this model is given by equation (1.12).

The conditional mean, variance and covariance equations describing the bivariate GARCH-M(p,q) model for stock index futures, are modified to examine the effects of margin changes on trading volume, by taking into account, on the one hand, the effect of conditional volatility of stock returns on margin changes, and on the other hand, the relationship between conditional volatility of stock returns and trading volume. The effect of conditional volatility of stock returns on margin changes is examined through the adjustment of margins by the lagged conditional volatility of stock returns included in the conditional mean of trading volume equation. The relationship between conditional volatility of stock returns and trading volume is examined through the lagged trading volume and lagged stock return variables included in the conditional variance of stock returns and trading volume equations respectively, the contemporaneous correlation between stock returns and trading volume in the conditional covariance equation, and the lagged conditional variance of stock returns included in the conditional mean of trading volume equation. The modified bivariate GARCH-M(p,q) models are presented and analysed in more detail in Chapter 5.

1.7 Conclusions

A number of studies have been carried out on the price behaviour of the ASE and performed tests of the EMH. However, interest in microstructure and trading is relatively new to the Greek literature, since a limited number of studies have been produced so far, which investigate issues relating to the procedure and outcomes of exchanging assets under a specific set of rules.

This thesis aims to contribute to the market microstructure literature and to add empirical content to current academic and policy discussions, by specifically studying the Greek capital market. An empirical investigation is conducted in examining the effects and implications of the imposition of: (1) daily price limits on the price volatility, stock returns and trading activity of individual stocks (Chapter 3); (2) transaction taxes on the conditional mean and volatility of stock index returns (Chapter 4); and (3) margin requirements on the conditional mean of trading volume of stock index futures (Chapter 5). It should be noted that the study in Chapter 4 is forthcoming in *Applied Financial Economics* in 2007.

Before examining each of the three topics in greater detail in Chapters 3 to 5, the next chapter, Chapter 2, presents the historical evolution of the ASE and the main regulatory changes that took place since its foundation. The final chapter of this thesis, Chapter 6, summarises the empirical findings and discusses implications on regulatory policy. It also suggests topics for further research.

CHAPTER 2

THE ATHENS STOCK EXCHANGE (1876-2006)

2.1 Historical evolution

The completion of 130 years of operations finds the Athens Stock Exchange (ASE) at its peak. Institutionally strong, functionally upgraded and financially robust, it is and will be for a long time to come, the epicentre of finance and economics of the country. The ASE is an organisation that reflects the "pulse" of the community and the resulting economic, social and political developments. In other words, the history of the development of the ASE is also the history of the development of the Greek State, the Greek society and the Greek economy.

Even though stock transactions have been carried out in Greece for approximately 130 years, the Institution of the Stock Market and the practice of holding shares in listed companies could not manage to infiltrate the general public, at least not until the end of the 1960's. Even when in the past – and especially up to 1970 – the markets lived through intense periods of excitement or disappointment, it only concerned a small section of society and a small proportion of the population, which mainly lived in Athens.

The depth of penetration of the "stock market idea" into a community always depends on the level of its economic development, its culture, its level of education, and its historical habits.

In following the evolution and growth of the Greek economy, we can differentiate the various stages through which the ASE passed.[1]

2.1.1 The period between 1876 and 1986

[1] The course of the evolution of the Greek Exchange and the Greek capital market is comprehensively presented in the special edition of the Athens Stock Exchange (2001). This edition, which refers to the 125 years of the ASE operation, presents all the basic economic, political and other factors, which contributed to its evolution. This chapter on the historical development of the ASE was particularly motivated by this

In the mid-19th Century, the newly established Greek State, tries to re-organise at the most basic of levels, whilst the economy, without infrastructure and destroyed from the freedom fighting, preserves to a large extent the characteristics of the Ottoman period. Around 1870, the first attempts at organised growth and development of infrastructure are made, whilst at the same time the high costs of maintaining the armed forces continued, which was necessary for defence and maintaining the freedom movement.

During this period, when industry was taking its first steps and tertiary sector remained in a state of underdevelopment, it is not realistic to talk of the Institution of the Stock Exchange or the "investment community". As the State's main objective at the time was to provide the basic necessities for its population, which often lived in a state of poverty, the concern with the stock market was a privilege – and often a hobby – for a select few of the upper socio-economic class of Athens. It constituted by wealthy merchants, landlords, expatriate capitalists, and higher level public servants.

At the beginning of the 20th Century, the Greek economy has still all the evidence of a "rural economy", with underdeveloped secondary and tertiary sectors. However, the potential for development was there. At this stage, the Stock Exchange becomes organised, evolves and increases in popularity, but continues to concern a small fraction of the population.

The Balkan Wars, the Asia-Minor Campaign and the arrival of the refugees, form a new set of circumstances for the Greek economy and society. Within this environment and circumstances of the time, the conditions for quick economic growth are created, whilst the definition of the borders that the Treaty of Lausanne (July 24, 1923) brings,

edition. Furthermore, this edition has assisted in the differentiation of the various stages and consequently sections included in this chapter.

changes the priorities of the Government. The main objectives now are the quick organisation and adjunction of the new territories and the steady integration of the newly arrived population with the Greek community. Per capita income and the level of education remain low and the main priority of the majority of the people is to satisfy its most basic of needs.

During that time, the stock markets of the western world were experiencing an intense level of growth and the idea of share market investment was quickly penetrating through the general public. This penetration could not be achieved in Greece, because the Greek economy and Greek society had completely different characteristics and abilities, and a completely different constituency. The stock market remains indifferent and in many cases unfamiliar to the majority of the general public, whilst developments on the Stock Exchange were reported only by a small section of the Press.

The Second World War and the Civil War delay once again the road to evolution and growth, and cause great disturbance to society. Following that, the successful attempt at reconstruction in the mid-1950's created the right conditions for development and the gradual convergence of the economy and society towards the standards of those of the western countries. It is during this period (1956-1965) that the first real issues arose as to the growth of the capital markets, the modernisation of the Stock Exchange and the greater penetration of the "stock market idea" into the now "urbanised" Greek population.

For many decades the Stock Exchange and the capital markets in general, could not fulfil their roles as the principal source for the raising of investment funds. For the whole period up to the beginning of the 1970's, the level of transactions was immaterial and the market's capitalisation as a proportion to Gross Net Product (GNP) extremely low. Up until the 1960's the stock market was a place where a small section of the populace could trade bonds, sovereigns and foreign currencies.

The first essential and important attempt at raising funds for the country's growth, through privatisation and Initial Public Offerings (IPO's) took place during the period 1970-1973. The second significant attempt occurred between the years 1990 and 1991, and following that, during the 1990's, where the stock market for the first time played its primary financial role, that is, in providing a source of funds to finance the development in venture and the economy.

Towards the end of the 1960's and the beginning of the 1970's, the "average" Greek becomes familiar with the stock market for the first time, having obtained a spectacular rate of income growth.

The international economic crisis and the Greek economy's entry into a period of stagflation have turned this first promising experience into a nightmare. The public distances itself from the stock market and remained so even during the impressive rally of 1987. In the 1990's, however, with the Greek society closely matching that of its western counterparts and the Greek economy gradually and steadily being incorporated into the group of developed European economies, the public once again embraces the stock market.[2]

2.1.2 The period between 1987 and 1996

From the beginning of the year and up to Friday October 16, 1987, the Index had risen from 103.86 points to 518.59 points, that is, an immense 399.32% in a period of only 10 months.[3] After October 19, 1987, and the sharp drop in stock prices on the New York Stock Exchange (NYSE) on "Black Monday", the Index ended the year at 272.47 points. That is, despite the 47.45% drop in just over two months, the General Index still managed to show gains of 162.34%.[4] However, this performance classifies 1987 as one of the best performing years in the history of the ASE.

The main stock market development of 1988 could be considered the passing of Law 1806, with which important and essential changes were made to Stock Exchange regulations. The main modifications of the new Law included the revision of the surveillance mechanism, the institution of Limited Liability Stockbrokerage Companies, the establishment of the "Parallel Market" and the Share Depository.[5] Moreover, in December 1988, the Greek financial market has been formally liberalised. This significant development has permitted the participation of foreign institutional and private investors in the Greek market and has considerably helped in enhancing the activity level and size of the market. Table 2.1 summarises the main changes in the regulatory framework of the ASE since its foundation and up to the end of year 2005.

The next couple of years, stock prices continued to rally strongly despite the political uncertainty and instability of the time. This was mainly attributed to the favourable international economic climate and also to the belief on the part of the public that an imminent change in Government would solve the country's serious economic problems of the time. The runaway bull market peaked in July 1990, when the General

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[2] Platanopoulos (1976) provides a comprehensive analysis on the initial 100 years of the ASE operation.
[3] This is the largest rise in such a small space of time ever recorded on the ASE.
[4] This is the largest fall in such a small space of time ever recorded on the ASE.
[5] The Parallel Market started operations in June 1990, as a means of allowing smaller companies unable to meet the strict listing requirements of the Main Market to offer shares to the public.

Index rose from 671.99 points on April 6, 1990 – following the elections of April 8, 1990 – to 1,684.31 points on July 5, 1990, recording a rise of over 150% in just three months.[6]

The loss of the opportunity to host the Golden Olympic Games of 1996, in September 1990, the worsening problems of the economy and the global recession of 1991-1992 which kept world stock markets bearish "brought down to earth" both investors and prices. By mid-November 1992, the General Index retreated to 550 points, a level not seen since before the 1990 elections. In the meantime, a series of qualitative changes have taken place, sending a clear message that the stock market had been upgraded and that it had played a more essential role in the economic developments of the country.

First, regardless of the fall in prices, interest on the part of the public remained intact. The number of stockbrokerage firms increased and their financial position remained satisfactory. Second, during the period 1991 and 1992, 19 IPO's were successfully launched. After many years the stock market finally played its role as a source of cheap capital for growing companies with strong potential. Third, the Parallel Market was successfully established. This new market was inaugurated in 1990 but took on its effective role in the years that followed. Fourth, the Automated Electronic Trading System (ASIS) was installed, ending 116 years of trading with the method of "outcry". Finally, the field of investment information and analysis developed to a significant level. The expansion was evident in the financial and specialised press as well as in the research departments of stockbrokerage firms.

[6] Figure 2.1 exhibits the performance of the ASE Composite Share Price Index from January 1989 to September 2006.

Daily price limits, a key institutional feature of the ASE, where stocks are allowed to trade within these specified limits, were initially introduced at ±8% for highly active stocks (±4% for less active stocks) in August 1992.

The Maastricht Treaty of December 1992 created the European Economic and Monetary Union (EMU) and also decided on the financial support of the weaker economies of the European Union (EU). The funds were to be directed towards the upgrading of infrastructure and to assist in the efforts of member countries with economic convergence. This decision on funding created the First Community Support Framework, which meant the influx of large amounts of capital into Greece. This development ignited a general enthusiasm in the stock market and in particular for construction companies, which gradually inundated the market.

Further to the rally in the construction sector, the outlook for the economy and corporate profits began to improve. During this period, speculation was common that the State-run Hellenic Telecommunications Organisation (OTE) was to be partially privatised. It was also widely believed that irrespective of which political party won the elections of October 1993, economic policy would have a similar goal, that of convergence with the economies of other member countries of the EU.

In the two years between 1993 and 1994, 56 new companies were listed on the Stock Exchange, raising the total to 196, the largest ever in the history of the ASE. Of course, over the course of the next few years, the number of companies listed on the Exchange was to be greatly surpassed.

The market remained relatively flat throughout the years 1995 and 1996, with alternating periods of volatility. The volatility was mainly caused by the greater correlation, which it was by now evident, between the Greek stock market and the foreign markets. The increasing use of information technology meant that the dissemination of information was quicker amongst investors and as a result reactions to news and events were now immediate. In addition, a series of domestic events added to the volatility of the market. The main features of the period were the rising value of transactions, the increase in the number and size of institutional investors and further renewal and strengthening of the capital market, through a series of legislation. The most important piece of legislation was the passage of Law 2324 in 1995, where it provided the basis for the transformation of the ASE into a joint stock company, further supplemented the listing regulations, permitted over-the-counter (OTC) transactions, defined the conditions for offering shares through private placement, broadened the scope of activities of brokerage firms, allowed for the possibility of remote brokerage, and amended several Capital Market Commission (CMC) regulations.[7]

2.1.3 The period between 1997 and 2001

During the period 1997 to 2000, the Greek economy was characterised by its attempt at readjusting its macroeconomic indicators and achieving the criteria to become the 12th member of the "Euro Zone", a success which was completed with the official entry of Greece into the EMU on January 1, 2001.

The main goals of this attempt were the reduction in the inflation rate to below 3%, the reduction in the fiscal deficit via fiscal disciplinary measures and the reversal in the upward trend of public debt.

[7] Mertzanis (1999) provides an analysis on the growth, developments and prospects of the capital market in Greece, during the 1990's, and summarises the main regulatory changes of the ASE since its establishment.

At the same time, within the framework of modernising and increasing production and improving the economy's competitiveness, significant attempts were made at deregulating the banking system, privatising state-owned organisations and deregulating the markets.

Between the period 1997 and 2000, GNP rose by an average rate of 3.5% and the inflation rate at the end of 2000 was 3.2%.

By the end of 2000, the Greek economy had transformed into a "modern" economy with an updated structure and strong dynamism, resembling that of a developed country. Moreover, with entry into EMU, the Greek economy had managed to solve one of its most long running, irritating and hindering problems, that of monetary and economic stability.

The same conditions prevailed in Greece during 2001, with economic growth, monetary stability, investment in infrastructure, growth in industry, growth in exports, and redirection of the business sector towards globalisation, as this is imposed by today's international economic environment.

At the same time, the stock market, having gone through a long period of stagnation and having overcome institutional and functional problems of the past, anticipated both successfully and in due time the positive changes taking place in the economy, resulting mostly from the preparation in joining EMU.

During this period, the most important piece of legislation was the passage of Law 2533 in 1997, where it provided the legal framework for the privatisation of the ASE. The same Law introduced the legal framework for the establishment of the Athens Derivatives Exchange (ADEX) and the Athens Derivatives Exchange Clearing House

(ADECH). The FTSE/ASE 20 Index futures were initially introduced with a 20% margin on August 27, 1999. Subsequently, FTSE/ASE Mid-40 Index futures were launched with an 18% margin on January 28, 2000, and at the same time the margin requirement for the FTSE/ASE 20 Index futures had already been modified by ADECH to 14%.[8] Both Index futures were gradually reduced to a 12% margin on October 12, 2001.[9]

The stock transaction tax was initially introduced at a 0.3% tax rate on February 19, 1998, as part of the annual tax package proposed by the Government and subsequently approved by the country's Parliament. The 0.3% tax rate applied on the selling of shares transacted in the stock exchange only. The stock transaction tax was increased from 0.3% to 0.6% on October 8, 1999, mainly to cover part of the cost of the tax package. This cost would have resulted from the reduction in other indirect taxes, tax reforms and income support for pensioners, farmers and the unemployed. These measures announced by the Government were specifically designed to provide tax relief to weaker income groups and to aid the Government's anti-inflation drive for entry into the Eurozone. The stock transaction tax was reduced from 0.6% to 0.3% on January 3, 2001, as part of a number of measures announced by the Government with the objective to support and boost liquidity in the ASE.

In the years between 1997 and 1999, the Greek stock market experienced its greatest period of growth, not so much in terms of prices since the largest rise in the General Index was recorded in the years from 1969 to 1972, but in other areas such as: First, the number of individual private investors, since by the end of 1999, the number of

[8] For futures on FTSE/ASE 20 that are traded in the derivatives market the underlying asset is the blue-chip index FTSE/ASE 20, which is based on the 20 largest ASE stocks. For futures on FTSE/ASE Mid-40 the underlying asset is the mid-cap index FTSE/ASE Mid-40, which is based on the 40 medium capitalisation stocks of the ASE.

active individuals reached 1,500,000. Second, the volume of turnover, since during 1999, the average daily turnover exceeded GRD 220 billion (EUR 646 million).[10] Third, market capitalisation as a percent of GNP, since by mid-September 1999, the capitalisation had reached 120% of GNP. Fourth, the participation of foreign institutional investors. Finally, the raising of capital from the primary market, since only in 1999, GRD 4.4 trillion (EUR 12.9 billion) were raised. In the four years between 1997 and 2000, GRD 10.8 trillion (EUR 31.7 billion) were raised from the capital markets.

Since the beginning of 1997, the value of turnover showed evidence of revitalisation and prices began trending upwards. The factors which mainly contributed towards this dynamism were the Government and the positive international environment. The former by quickly identifying the important role the capital markets had to play in the privatisation process and the latter because by 1997, international markets were already witnessing one of the greatest bull markets in history.

The rise in stock prices intensified and accelerated during 1998. The reasons that created this environment included the implementation of the 11-member EMU, the devaluation of the GRD, the increased activities of both foreign and domestic institutional investors, the spread of the share ownership idea among the masses and the attraction of thousands of individual investors to the stock market.

The international stock market crisis in autumn 1998 threatened to put an end to the bull market, however, the halt proved to be temporary, as the momentum of the market was so intense, that it was difficult to be stopped. The rally continued during the

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[9] ADECH has the right to increase or decrease the margin required for deposit, under extreme market conditions or at any time it deems as appropriate to act.

[10] Greek Drachma (GRD) amounts have been converted into Euro (EUR) amounts, for illustrative purposes, using the official "locked" exchange rate of EUR 1 = GRD 340.75.

first months of 1999 and it had further intensified by the second half of the year. Speculation was widespread and both the General Index and the value of turnover recorded new highs on a daily basis.

The intense bull market peaked in mid-September 1999, when the General Index reached its all time high of 6,484.38 points on September 17, 1999. The pressure that had built up in the over-valued stocks of 1999 was then released in a downward readjustment, which during 2000 and 2001 intensified due to the fact that the majority of the emerging markets and several of the developed markets also headed lower. The international fall in the capital markets, as well as the continuing negative course of the Greek stock market, peaked in mid-September 2001, when the General Index reached the year low of 1,997.82 points, on September 21, 2001, following the terrorist attacks in the United States (U.S.) on September 11, 2001.

Despite the downward trend of 2000 and 2001, the Greek stock market continued its course and having achieved all the necessary changes in its institutional and regulative framework and in its technological systems, and with the country's economic stability as its base, it entered a new era, with its promotion in June 2001 from an emerging market to the category of developed markets. [11,12]

Furthermore, in response to the fast growing and rapidly evolving Greek capital market as well as international intensifying competition, the ASE decided to implement a threefold strategy as follows:[13]

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[11] On July 31, 2000, Morgan Stanley Capital International (MSCI) announced the reclassification of Greece from the emerging market index to the developed market index. The MSCI index is one of the most widely used benchmarks for international equity investment. The change became effective on June 1, 2001.
[12] Malindretou (1998) and Stergiou (2000) provide a detailed description on the institutional characteristics, technological advances and regulatory framework of the ASE. In addition, they provide an analysis on the financial and economic factors, which contributed to its development.
[13] See ASE President's welcoming letter in ASE Fact Book 2002.

1. To educate retail investors and make all market participants aware of the consequences and implications deriving from the new standards that are being formulated at an EU level for market integration purposes and better investors protection.
2. To promote a strategic position in South East Europe and the South East Mediterranean as the gateway to the Eurozone.
3. To proceed with joint ventures or other strategic alliances/cooperation schemes with international exchanges and exchanges in the region within a mutually beneficial framework.

During the period 2000 to 2001, daily price limits imposed on all traded stocks, were increased in three different occasions, i.e., from ±8% to ±10% on February 7, 2000, from ±10% to ±12% on July 31, 2000, and from ±12% to ±18% on June 1, 2001.

2.1.4 The period between 2002 and 2006

The international economic environment in the period 2002 to 2003 was far from being the most favourable, as it was primarily marked by a slowdown and uncertainty. Non-economic and geopolitical issues were also important. A large number of financial markets recorded negative performance, as investors were not prepared to undertake risks while world economic recovery was delayed. However, during the same period, contrary to these conditions, the Greek economy sustained a fast pace of growth. The Greek stock market, being now a mature market, was mainly affected by international economic and financial developments, but it also operated within a macroeconomic environment that was on a stable path with strong Gross Domestic Product (GDP) growth, an accelerating privatisation program and the Athens Olympic Games 2004 preparations well under way.

The continuing process to improve investors' education level, to increase the level of transparency provided by all market participants, to enhance company disclosure requirements and provide sufficient dissemination of information, to upgrade the exchange's operating infrastructure and to improve regulatory framework, were among the highly ranked initiatives that were successfully carried out during this period.

At the same time, new targets were set, aimed to achieve synergies and improve profitability inside the Hellenic Exchanges group of companies. Such targets were the merger of the ASE with the ADEX into one exchange, the Athens Exchange (ATHEX), accommodating two markets, those of shares and derivatives, the upgrading of the corporate bond market, the introduction of the state bond market, and the expansion into new investment products in both the stock and derivative markets.[14] During this period, margin requirements on both the FTSE/ASE 20 Index futures and FTSE/ASE Mid-40 Index futures were gradually reduced from 15% on October 7, 2002, to 10% on February 5, 2004. The margins have remained unchanged ever since.

Despite the on-going efforts to upgrade the exchange's operating infrastructure and to improve regulatory framework, as well as to achieve synergies and improve profitability, the Greek stock market continued its downward trend, affected by the international economic and financial environment, predominantly resulting by non-economic and geopolitical developments. The General Index reached the year low of

[14] The General Meetings of the ASE S.A. and the ADEX S.A. approved on July 17, 2002, the Draft Merger Agreement of the two companies and the modifications in the Articles of Association of ASE. The corporate name of the new company is Athens Exchange S.A. (ATHEX). ADECH operates as a separate company.

1,462.19 points on March 31, 2003, the lowest level achieved since the all time high of 6,484.38 points on September 17, 1999, following the war outburst in Iraq in March 2003.

The war in Iraq in March 2003 created an unstable condition in the capital markets worldwide, as well as the Greek stock market that continued for several months. It was not earlier than 2004, that the international financial markets began to show the first signs of economic recovery and investors slowly but steadily began to restore their confidence in the markets. The improved international economic and financial conditions, the successful Athens Olympic Games that took place in August 2004, which resulted in the upgrade of the country's image, as well as all the efforts to improve the exchange's operating infrastructure and regulatory framework, that began well before and continued after the Olympic Games, were only the main reasons which persuaded the Greek and foreign institutional and private investors to reinstate their interest in the Greek stock market.

As a result, in the period between 2004 and 2005, the Greek stock market favoured by the international and domestic economic, financial and geopolitical developments, experienced a steady growth reaching highs in the General Index, not seen for a long period of time, at 2,801.71 points and 3,663.90 points at the end of December 2004 and at the end of December 2005 respectively. This increase continued in 2006 and as at the end of September 2006 the General Index stood at 3,931.05 points.

As of January 1, 2005, the ±18% daily price limit for the 20 stocks comprising the FTSE/ASE 20 Index was abolished. In addition, daily price limits were increased from ±18% to ±20% for the remaining stocks. The motive for this decision was that both ASE and CMC officials agreed that the Greek stock market was now matured enough to handle transactions without the presence of daily price limits. At the same time, the stock transaction tax was reduced from 0.3% to 0.15%, as part of the tax reforms included in the Government's annual budget. This move intended to further enhance the stock exchange's prospects. Both the daily price limits and stock transaction tax have remained unchanged ever since.

2.2 Circuit breakers

Circuit breakers like daily price limits, stock transaction taxes and futures margin requirements were introduced in the Greek financial markets in the 1990's, following the stock market crash of October 1987 and the plethora of debate that was created among academics and policy makers, who expressed their concerns about the causes of the crash and whether the microstructure of the equity market should be redesigned to protect the market and its participants from similar drastic price fluctuations.

As discussed in this chapter, in the case of the Greek capital markets, daily price limits were introduced in August 1992, stock transaction taxes in February 1998 and futures margin requirements in August 1999. Since their adoption, these mechanisms were amended in a number of occasions and in certain instances within short periods of time. The reasons for the implementation and changes in these regulatory measures included, among others, to increase the tax revenue raised by the Greek authorities, to assist in the Greek Government's efforts to successfully join the EMU, to enhance the stock exchange's prospects by supporting and boosting liquidity, and to protect the market and market participants by controlling volatility and excessive trading.

The historical perspective of circuit breakers in the Greek capital markets and the current academic and policy discussions have motivated this thesis to empirically investigate the impact and effectiveness of these specific regulatory measures more rigorously. The implementation and subsequent changes in circuit breakers might have plausibly affected investors' trading behaviour and portfolio strategies, which can be empirically quantified by performing various econometric tests on the price return, price volatility and trading volume of Greek equities. The purpose, motivation and contribution of each of these mechanisms to existing literature are discussed in further detail in Chapters 3 to 5 following this chapter.

Tables: **Table 2.1**

Main Regulatory Changes of the ASE

Year	Rule	Description
1876		Establishment of the ASE and issue of the first Stock Exchange Law based on the French Commercial Code.
1909		Modification of the existing stock exchange regulation.
1918	*Law 1308*	Sets up the ASE as a public law legal entity.
1920	*Law 2190*	Specifies the legal status, ownership, and control of private and public corporations.
1928	*Law 3632*	Clarifies the roles and responsibilities of brokers and other intermediaries.
1985	*Presidential Decree 350*	Sets forth the basic listing requirements for the Main Market.
	Presidential Decree 348	Sets forth the requirements for the drawing up, scrutiny and distribution of the prospectus to be published when transferable securities are offered to the investment public.
	Presidential Decree 360	Designates the financial data that the listed companies on the ASE must publish periodically.
1988	*Law 1806*	Introduces new concepts in stock exchange operation and regulation. Provides the legal framework for the establishment of the Parallel Market and the Central Securities Depository (CSD). Enlarges the Stock Exchange Board of Directors (BoD) and further modernises the exchange.
1989	*Ministerial Decision 6280/B508*	Defines the Books and Records to be kept by the ASE members and their relevant obligations.
	Ministerial Decision 6281/B	Defines the type of information that should appear on the ASE Daily Official List.
1990	*Law 1892*	Establishes the CSD as a joint stock company.
1991	*Law 1969*	Establishes the Capital Market Commission (CMC) as a supervisory authority.
1992	*Presidential Decree 50*	Specifies the type of information that should be included on a company's prospectus, as well as the procedure that should be followed for its acceptance.
	Presidential Decree 51	Stipulates the disclosure obligations of shareholders of listed companies in case of transfer of participations.
	Presidential Decree 53	Establishes the legal framework for the dissemination of confidential and/or inside information.

		Introduction of daily price limits at ±8% for highly active stocks (±4% for less active stocks)/03-08-1992.
1993	*Law 2166*	Reinforces the role of the CMC.
	Presidential Decree 14	Regulates the purchase of listed companies own shares.
1994	*Law 2198*	Introduces the dematerialisation of Treasury Fixed Income Securities.
1995	*Law 2324*	Transforms the ASE into a joint stock company, supplements the listing regulations, allows over-the-counter (OTC) transactions and short selling (under specific circumstances), defines the conditions for the disposal of shares through private placement, broadens the scope of activities of brokerage firms, allows remote broking, deregulates commissions and introduces amendments to the CMC regulations.
	Law 2328(Article 15)	Obliges all Greek joint stock companies engaged in public sector projects (including the provision of services) of a value greater than GRD 1 billion/EUR 2.93 million to ensure that all shares are registered with named ownership.
		Establishment of Thessaloniki Stock Exchange intending to organise stock market transactions in Northern Greece.
1996	*Law 2396*	Implements into the Greek Law the EU Directives on "The Provision of Investment Services" and on "The Capital Adequacy of Companies Providing Investment Services (CPIS)".
	Law 2414	Introduces an exception to Article 15 of Law 2328/95.
	Law 2372	Regulates issues regarding the non-compliance of the companies with the conversion of their shares into registered up to the individual shareholder upon the specified deadline.
	Law 2374	Provides the legal framework for launching of the first privatisation in the Greek capital market.
1997	*Law 2471*	Promulgates remedies and establishes the Supplementary Fund (Settlement Account).
	Law 2533	Provides the legal framework for the privatisation of the ASE. Introduces the legal framework for the establishment of the Athens Derivatives Exchange (ADEX) and the Athens Derivatives Exchange Clearing House (ADECH). Creates the Parallel Market for Emerging Markets (EAGAK) and the Market for Fixed Income Securities.
1998	*Law 2651*	Amends the listing requirements for the Main Market and provides legal authorisation to the ASE BoD to decide new listing requirements for admission to the ASE of special sectors of the economic activity.
		Introduction of stock transaction tax at 0.3% tax rate on the selling of shares transacted in the stock exchange/19-02-1998.
1999	*Ministerial Decision 2063/B69*	Sets up the basic listing requirements for the Parallel Market.

	Law 2733	Provides the regulatory framework for the New Market (NEHA), where small and medium sized companies that are fast growing or innovative can be admitted to listing.
		Introduction of margin requirements on FTSE/ASE 20 Index futures contracts at 20% margin/27-08-1999.
		Stock transaction tax increase from 0.3% to 0.6%/08-10-1999.
2000	*Law 3444/B/253*	Specifies required share capital of a company in order to be listed on the Main Market of the ASE.
	Law 2843	Defines the listing requirements for the admission of shares of ocean-going shipping investment companies.
		Margin requirements on FTSE/ASE 20 Index futures decrease from 20% to 14%/07-01-2000.
		Daily price limits increase from ±8% to ±10%/07-02-2000.
		Daily price limits increase from ±10% to ±12%/31-07-2000.
		Margin requirements on FTSE/ASE 20 Index futures decrease from 14% to 12%/24-10-2000.
2001	*Law 3445/B 253*	Re-adjustment of the net equity of the company in order to be listed on the Main Market of the ASE (GRD 4 billion/EUR 11.74 million).
	Law 3445/B 254	Re-adjustment of the net equity of the company in order to be listed on the Parallel Market of the ASE (GRD 1 billion/EUR 2.93 million).
	Ministerial Decision	Amendment of Regulation 8173 B444/11-03-1998 for the calculation of the closing price at the basic trading category A and NEHA.
	Ministerial Decision 30288/ B.1391	Replacement of the last paragraph 2A of chapter A of the Regulation 8173B/444/11-03-1998 of the Minister of National Economy.
	Law 2892	Amendment of the provisions 11, 13 and 16 of Law 291/20 concerning the reduction of the time period for the exercise of the preference right and the purchase of a company's own shares.
		Stock transaction tax decrease from 0.6% to 0.3%/03-01-2001.
		Daily price limits increase from ±12% to ±18%/01-06-2001.
		Margin requirements on FTSE/ASE 20 Index futures increase from 12% to 16%/12-09-2001.
		Margin requirements on FTSE/ASE 20 Index futures decrease from 16% to 12%/12-10-2001.
2002	*Law 3016*	Corporate Governance.

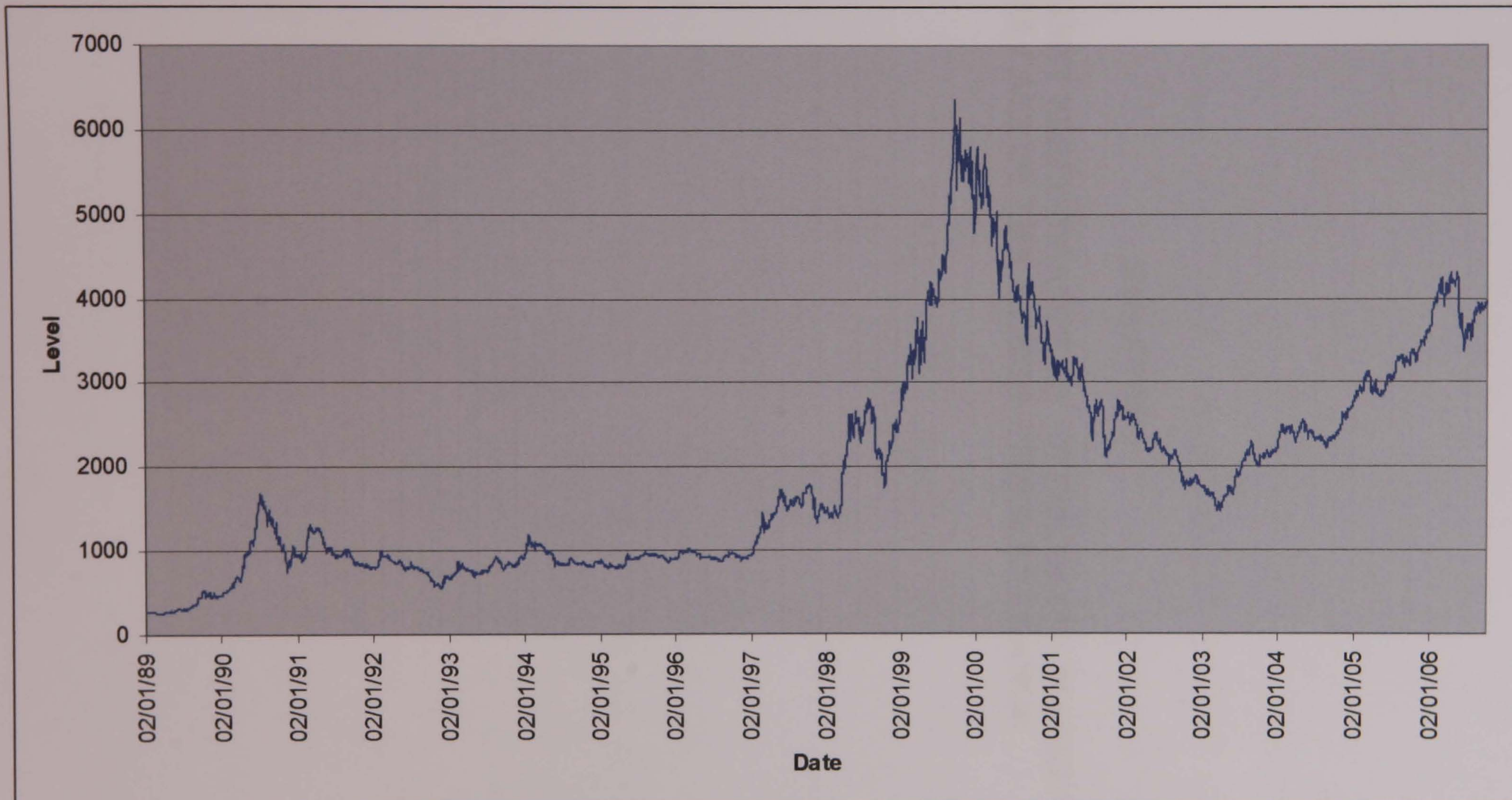
		Merger of ASE S.A. and ADEX S.A.: (Decision no. K2-10999/30-08-2002 of the General Secretariat of Commerce) – Approval of the merger of the joint stock companies ASE S.A. and ADEX S.A. As of August 31, 2002, the trade name of the new company is Athens Exchange S.A. (ATHEX). The objective of the new company is the organising, support and monitoring of the trading of securities, derivative products and other stock market products, the securing of the smooth operation of the market and the protection of the investing public, as well as the provision of all related activities.
		Margin requirements on FTSE/ASE 20 Index futures increase from 12% to 15%/07-10-2002.
		Margin requirements on FTSE/ASE 20 Index futures decrease from 15% to 14%/16-12-2002.
2003	*Law 3152*	Establishment and supervision of Stock Markets and organised markets, new tasks of the CMC and amendments of legislation concerning the capital market.
		Margin requirements on FTSE/ASE 20 Index futures decrease from 14% to 13%/14-01-2003.
		Margin requirements on FTSE/ASE 20 Index futures decrease from 13% to 12%/16-05-2003.
		Margin requirements on FTSE/ASE 20 Index futures decrease from 12% to 11%/20-06-2003.
2004		Regulation of ATHEX – During 2004, the project of the new ATHEX regulation was elaborated by a selection of working groups in order to be submitted for approval by the CMC. After all the new ATHEX Regulation, according to article no. 3 of the Law 3152/2003 and Decision no. 1/304/10-06-2004 of the CMC was published in the Government Gazette 900B/16-06-2004.
		Margin requirements on FTSE/ASE 20 Index futures decrease from 11% to 10%/05-02-2004.
2005		Regulation of ATHEX – During 2005, the revision of the new ATHEX regulation was elaborated by a selection of working groups in order to be submitted for approval by the CMC. After all the new ATHEX Regulation, according to article no. 3 of the Law 3152/2003 and Decision no. 4/358/08-11-2005 of the CMC was published in the Government Gazette 1635/25-11-2005.
		Daily price limits increase from ±18% to ±20%. Price limits abolished for the 20 stocks comprising the FTSE/ASE 20 Index/01-01-2005.
		Stock transaction tax decrease from 0.3% to 0.15%/02-01-2005.

Notes: Greek Drachma (GRD) amounts have been converted into Euro (EUR) amounts, for illustrative purposes, using the official "locked" exchange rate of EUR 1 = GRD 340.75.
Source: ASE Fact Book 2001-2006, Risk Management Department of ADECH.

Figures: **Figure 2.1**

The Athens Stock Exchange Composite Share Price Index

Daily – January 1989 to September 2006



Source: Datastream

CHAPTER 3

PRICE LIMIT PERFORMANCE OF AN EMERGING MARKET: THE CASE OF THE ATHENS STOCK EXCHANGE

3.1 Introduction

The use of daily price limits in financial asset markets has generated a great deal of discussion since the global market crash of 1987. A number of researchers have tried to examine the impact and effectiveness of price limits on financial asset markets, either empirically or theoretically. In essence, price limits are designed to reduce the total cost for market participants by serving as a price-stabilisation mechanism and in general to assure the proper operation of financial asset markets. Their impact and efficiency on the operation of markets, however, is still under debate.

Daily price limits are artificial boundaries, established by market regulators, on where security prices are allowed to fluctuate on any given trading day, within the pre-specified percentage level above or below the previous trading day's closing price. Trading (if any) continues at the ceiling or floor price until the demand and supply conditions are reversed, or until the closing of the trading day.

Price limits are currently in place in the United States (U.S.) futures markets and in several stock exchanges around the world including Austria, Belgium, France, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Spain, Switzerland, Taiwan, and Thailand [Roll (1989), Rhee and Chang (1993)]. Even though price limit mechanisms affect a significant part of the world's capital markets, little is known about how these price limits affect markets and market participants' behaviour, as Harris (1998) argues.

Empirical literature on price limits is limited and inconclusive, as Harris (1998) further notes. Price limit research on U.S. futures markets often uses a few contracts [Ma *et al.* (1989a,b)]. To examine price limit effects on stocks, researchers turn to non-U.S. markets, e.g., Chen (1993) studies the Taiwan Stock Exchange (TSE), Kim and Rhee

(1997) the Tokyo Stock Exchange (TSE), Phylaktis *et al.* (1999) and Diacogiannis *et al.* (2005) the Athens Stock Exchange (ASE).

Phylaktis *et al.* (1999) use econometric techniques such as serial correlation and GARCH models to study the effects of price limits on the volatility of daily and monthly stock returns for the period 1990-1996. They perform the tests on ten stocks, which include heavily traded stocks as well as less active stocks, and cover a variety of industries, and on a market wide price index. Diacogiannis e*t al.* (2005), use an event study methodology in which the event is defined as an increase or decrease in the stock price that activates the price limit for one, two or three days, to investigate short-term overreaction and the existence of price limits. Their sample consists of 114 shares for the period 1995-1998.

Empirical price limit research on U.S. futures and non-U.S. equities markets investigates two main questions. First, whether price limits reduce volatility, and second, whether they mitigate investor overreaction. Ma *et al.* (1989a,b) provide evidence in support of price limits and answer positively to both questions. However, Lehmann (1989) and Miller (1989) point out weaknesses with these studies that subsequent papers overcome. In later work, Chen (1993), Chen (1998), Kim and Rhee (1997), and Phylaktis *et al.* (1999) provide evidence against price limits and answer negatively to both questions. Diacogiannis e*t al.* (2005) confirm the occurrence of short-term overreactions and also provide evidence against price limits.

On the one hand, price limit proponents assert that price limits decrease stock price volatility, counter overreaction and do not interfere with trading activity. Price limit critics, on the other hand, argue that price limits cause higher volatility levels on subsequent days (volatility spillover hypothesis), prevent prices from efficiently reaching their equilibrium level (delayed price discovery hypothesis), and interfere with trading due to limitations imposed by price limits (trading interference hypothesis).

The primary function of price limits is to reduce stock market volatility. The rationale is that by constraining prices, 'wild' or 'excessive' intra-day price swings are prevented from occurring, which, in turn, means that the markets will experience less volatility. Moreover, price limits provide time for rational reassessment during times of panic trading. It is believed by the advocates of price limits that such mechanisms would have prevented the price freefall during the 1987 global market crash.

Price limit opponents argue that there are at least three problems with price limits: volatility spillover, delayed price discovery, and trading interference. Fama (1989), and Kuhn *et al.* (1991) reason that if the price discovery process is interfered with, underlying volatility may increase as a result. Lehmann (1989) also suggests that supply and demand imbalances for trading actually induce prices to reach their limits, which implies a transfer of transactions to subsequent days. Consequently, rather than reducing volatility, price limits may cause volatility to spread out over a longer period of time because limits prevent large one-day price changes and also prevent immediate corrections in order imbalance. This spillover to following trading days is consistent with the volatility spillover hypothesis.

As price limits represent upper and lower bounds on stock prices, trading usually stops (when limit-hits occur) until the limits are revised creating an interference with the price discovery process, as previously discussed by Fama (1989), Lehmann (1989), and Lee *et al.* (1994). By putting restrictions on price movements, stocks may be prevented from reaching their equilibrium prices for that day. If limits block prices, then stocks have to wait until a subsequent trading session, usually the next day, to continue toward their true price. This concept is consistent with the delayed price discovery hypothesis.

Lauterbach and Ben-Zion (1993), and Fama (1989) claim that if price limits prevent trading, then stocks become less liquid, which as a result may cause intensified trading activity on subsequent days. A different interpretation presented by Lehmann (1989) is that order imbalances, and the consequent lack of trading, induce prices to reach their limits. The implication is that on following days, impatient investors will buy or sell at unfavourable prices or patient investors will wait for prices to reach their equilibrium levels so order imbalances can be corrected. In both scenarios, this implies that trading volume will be higher on the days following limit-hit days. These activities are consistent with the trading interference hypothesis.[1]

The purpose of this study is to add empirical content to the debate on daily price limits by conducting an investigation on the impact and effectiveness of price limits on the volatility, return and trading activity of Greek equities. Thus, we examine the ASE price limit system to empirically test the above three hypotheses stated. The sample period begins in January 1997 and ends in April 2001. For our study, we employ Kim and Rhee (1997) empirical methodology to examine price limit performance.

Our study provides empirical evidence against price limit effectiveness consistent with Kim and Rhee's (1997) findings. Conversely, we find significant evidence to support the position of price limit proponents. Unlike the upper limit-hit findings, the lower limit-hit findings do not provide robust evidence against price limit effectiveness.

[1] See Kim and Rhee (1997), for a complementary discussion on the three hypotheses presented above.

In other words, the results for the lower limit-hit cases are not qualitatively similar to the results for the upper limit-hit cases.

The remainder of this paper is organised as follows. The next section discusses the main institutional characteristics of the ASE. Section 3.3 formulates the three hypotheses to be tested. Section 3.4 describes the empirical approach. Section 3.5 presents the data and analyses the empirical results. The last section summarises the main findings and offers concluding remarks.

3.2 Institutional characteristics of the ASE

The ASE, founded in 1876, is the sole regulated Greek secondary capital market where shares of listed Greek companies, government and corporate bonds are traded. In 1988, stock exchange legislation brought radical changes to the rules and regulations. The passage of Law 1806/88 provided the legal framework for the establishment of the Parallel Market and the Central Securities Depository (CSD).[2] It enlarged the stock exchange Board of Directors (BoD) and modernised the exchange. The most important legislative action was the passage of Law 2324/95 in 1995; among others, Law 2324/95 transformed the ASE into a joint stock company, supplemented the listing regulations, broadened the scope of activities of brokerage firms, and amended several Capital Market Commission (CMC) regulations. In 1997, Law 2533/97 provided the legal framework for the privatisation of the ASE. The same Law introduced the legal framework for the establishment of the Athens Derivatives Exchange (ADEX) and the Athens Derivatives Exchange Clearing House (ADECH). Since November 1999, the Integrated Automatic

[2] The Parallel Market started operations in June 1990, as a means of allowing smaller companies unable to meet the strict listing requirements of the Main Market to offer shares to the public.

Electronic Trading System (OASIS), which replaced the old Automated Electronic Trading System (ASIS), has further facilitated the procedures and surveillance of the daily transactions.

Companies are listed on either the 'main' market or the 'parallel' market. At the end of 1997, a total of 227 companies were quoted on the ASE with a combined shares market capitalisation of EUR 28,793 million. These include 184 companies on the 'main' market and the remaining 43 companies on the 'parallel' market. By the end of 2000, the 327 listed companies were capitalised at EUR 117,956 million. These include 224 companies on the 'main' market and the remaining 103 companies on the 'parallel' market.[3] The total shares turnover increased from EUR 17,027 million in 1997 to EUR 101,394 million in 2000. Figures 3.1-3.6 illustrate the total number of companies listed, the total shares turnover and the total shares market capitalisation from 1993 to 2000.

In Figure 3.7 the ASE Composite Share Price Index is shown for the period January 1997 to April 2001. The ASE Index fluctuated between 1,000.00 and 1,800.00 points in year 1997 before experiencing an uninterrupted rise to reach its all time high of 6,484.38 points on September 17, 1999. Subsequently, the index has followed a downward trend and at the end of our sample period – April 30, 2001 – it stood at 3,286.67 points.

Trading on the ASE takes place five days a week (Monday-Friday), except on public holidays and other market holidays (when the Exchange is declared closed by the ASE Committee). Trading hours are set between 10:00 a.m. and 2:30 p.m. with a quarter of an hour pre-opening period. ASE members – namely brokerage firms and credit

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[3] Figures do not include companies whose shares have been suspended from trading (ASE Fact Book 2001).

institutions – which have obtained approval from the BoD of the ASE, are allowed to trade in the exchange.

Trades are conducted electronically through the OASIS. All orders introduced into the system at the pre-opening period can participate in the formation of the opening price. At the pre-opening period, the system accepts limit, market and at the opening orders. Limit orders determine the day's opening price, while market orders get time priority and are executed upon the opening of the market. If no limit orders exist, the opening price will be the same as the previous day's closing price. The criterion used for the determination of the opening price is the maximisation of transactions volume.

During the main trading session, orders are matched by price (the buy order at the highest price is matched with the sell order at the lowest price) and time. Members can change or reverse their orders during the main trading session if they feel that their orders cannot be executed at the given price.

Closing prices are formulated by the weighted average of the last 10 minutes of trading. If no transactions exist during this period, then the closing price is the weighted average of the last 20 minutes of trading. If no transactions exist during the last 20 minutes, then the closing price is the weighted average of the day's transactions. In case there are no transactions of a share during the day, the closing price is considered as the opening price of that day.

A daily price limit is a key institutional feature of the ASE. A price limit is currently imposed on traded stocks and stocks are traded within these specified limits. Price limits do not apply in the first three days of a company's listing. During the trading day, stocks that hit their price limit are still allowed to trade as long as the transaction price is within the limits. Thus, it is important to note that ASE price limits are boundaries, not trading-halt triggers.

Daily price limits were initially introduced at ±8% for highly active stocks (±4% for less active stocks) in August 1992, for the period up to 06/02/2000.[4] During the sample period (from 02/01/1997 to 30/04/2001), two changes in price limits took place. Specifically, on 07/02/2000 price limits were increased from ±8% to ±10%, and on 31/07/2000 price limits were increased from ±10% to ±12%, which lasted until 31/05/2001. Price limits were increased from ±12% to ±18% on 01/06/2001, for the period until the end of 2004. As of 01/01/2005, the ±18% price limit for the 20 stocks comprising the FTSE/ASE 20 Index was abolished. At the same time, price limits were increased from ±18% to ±20% for the remaining stocks.[5] A list summarising the dates and daily price limit changes in the ASE is provided in Table 3.1.

3.3 Hypotheses

This section formulates the three testable hypotheses: volatility spillover, delayed price discovery, and trading interference.

3.3.1 Volatility spillover hypothesis

Several researchers reason that if the price discovery process is interfered with, underlying volatility may increase as a result. Other researchers suggest that supply and demand imbalances for trading actually induce prices to reach their limits, which implies a transfer of transactions to subsequent days. Consequently rather than reducing

[4] The reasons for the introduction of price limits and the expected benefits are not clear.

volatility, price limits may cause volatility to spread out over a longer period of time because limits prevent large one-day price changes and also prevent immediate corrections in order imbalance. This spillover to following trading days is consistent with the volatility spillover hypothesis. The testable hypothesis for the volatility spillover scenario is:

H1: Daily price limits cause volatility to increase on subsequent days.

3.3.2 Delayed price discovery hypothesis

As price limits represent upper and lower bounds on stock prices, trading usually stops (when limit-hits occur) until the limits are revised creating an interference with the price discovery process. By putting restrictions on price movements, stocks may be prevented from reaching their equilibrium prices for that day. If limits block prices, then stocks have to wait until a subsequent trading session, usually the next day, to continue toward their true price. This concept is consistent with the delayed price discovery hypothesis. The testable hypothesis for the delayed price discovery scenario is:

H2: Daily price limits prevent stocks from reaching their equilibrium prices.

3.3.3 Trading interference hypothesis

If price limits prevent trading, then stocks become less liquid, which as a result may cause intensified trading activity on subsequent days. A different interpretation is that order imbalances, and the consequent lack of trading, induce prices to reach their limits. The implication is that on following days, impatient investors will buy or sell at

[5] The motive for this decision was that both ASE and CMC officials agreed that the Greek stock market was now matured enough to handle transactions without price limits.

unfavourable prices or patient investors will wait for prices to reach their equilibrium levels so order imbalances can be corrected. In both cases, this implies that trading volume will be higher on the days following limit-hit days. These activities are consistent with the trading interference hypothesis. The testable hypothesis for the trading interference scenario is:

H3: Daily price limits cause intensified trading activity on subsequent days.

3.4 Empirical approach

In order to find incidences of prices reaching their limits, we identify days where the high price matches its previous day's closing price plus its price limit. In other words, we assume upward limits are reached for a specific stock when $H_t \geq C_{t-1} + LIMIT_t$, where H_t represents Day t's high price, C_{t-1} represents the previous day's closing price, and $LIMIT_t$ is the maximum allowable upward price movement for each Day t. In the same way, we assume downward limits are reached when $L_t \leq C_{t-1} - LIMIT_t$, where L_t represents Day t's low price, and $LIMIT_t$ represents the maximum allowable downward price movement.

On days when price limits are reached, we classify stocks that did not reach the price limit into four subgroups: stocks that came within at least $0.90(LIMIT_t)$ of reaching the daily limit; stocks that came within at least $0.80(LIMIT_t)$, but less than $0.90(LIMIT_t)$ of reaching the daily limit; stocks that came within at least $0.70(LIMIT_t)$, but less than $0.80(LIMIT_t)$ of reaching the daily limit; and stocks that came within at least $0.60(LIMIT_t)$, but less than $0.70(LIMIT_t)$ of reaching the daily limit. In the rest of the paper, our stock categories for those stocks that did not hit price limits are referred to as

$stocks_{0.90}$, $stocks_{0.80}$, $stocks_{0.70}$, and $stocks_{0.60}$, where the subscripts denote the magnitude of a stock's price movement on Day 0, the limit-hit day. $Stocks_{hit}$ refer to those stocks that reach their daily price limit.

Table 3.2 reports the yearly breakdown of price limit-hit occurrences and shows the number of occurrences for each of the five stock categories for both upper and lower price movements. For our final samples, we identify 753 occurrences where upper daily price limits are reached and 495 occurrences where lower price limits are hit. This implies that limits prevent more stock price increases than decreases.

3.4.1 Volatility spillover hypothesis

To test H1, we employ a 21-day event window: Day −10 to +10. For $stocks_{hit}$, Day 0 represents the limit-hit day, for $stocks_{0.90}$, Day 0 represents the day the stocks experienced their 0.90($LIMIT_t$) price movement and this similarly applies to $stocks_{0.80}$, $stocks_{0.70}$ and $stocks_{0.60}$. Day −1 represents the day before Day 0, and Day 1 is the day after Day 0, and so on.

Daily price volatility is measured by $V_{t,j} = (r_{t,j})^2$, where $r_{t,j}$ represents close-to-close returns using Day $t - 1$ closing price and Day t closing price for each stock j.[6] We estimate this measure for each stock in all five stock categories and find averages for each Day t. If the $stocks_{hit}$ group experiences greater volatility during post-limit days than the other four subgroups, then this finding supports H1. Multiple limit day observations are excluded from the sample. Excluding observations when stocks hit their limit for the

[6] Kim and Rhee (1997) use a simple measure of volatility that does not incorporate extreme values. Lehmann (1989) points out that variance measures that use extreme values, such as Parkinson's (1980), are subject to measurement error, and that, "measurement errors are more probable on high volume days like limit price days."

second or third or even the tenth consecutive day, it eliminates the high pre-limit day volatility bias that occurs when we categorise these consecutive hits as independent events. We investigate the effects of both upper and lower price limit-hits in section 3.5.

3.4.2 Delayed price discovery hypothesis

To investigate price limits' effects on efficient price discovery, we consider the following two returns series for each of the five stock categories: $r(O_0C_0)$ and $r(C_0O_1)$. The first return series represents open-to-close returns on the limit day measured by $\ln(C_0/O_0)$ and the second return series represents close-to-open returns measured by $\ln(O_1/C_0)$. The ln indicates the natural logarithm operator; O and C indicate opening and closing prices, respectively; and subscripts indicate the day. Stock returns can be positive, negative, or zero and are denoted as (+), (-), and (0), respectively. As a result, nine returns series are possible: [+, +], [+, -], [+, 0], [0, +], [0, -], [0, 0], [-, +], [-, -], and [-, 0], where the first return symbol represents $r(O_0C_0)$ and the second return symbol represents $r(C_0O_1)$.

The reason we examine this particular return series is to observe the immediate stock price movement subsequent to price limit-hits on Day 0. By comparing the return series findings between all stock groups, we may be able to identify stock return behaviour which is unique to the stocks_{hit} sample. The delayed price discovery hypothesizes that we will observe positive (negative) overnight returns for stocks that reach their upper (lower) limit. Naturally, stocks always experience price continuations and reversals, therefore the price continuation behaviour of stocks_{hit} would have to be greater than normal to conclude that limits are delaying the efficient price discovery process. Consequently, we use the price return behaviour of stocks that do not reach a price limit to represent normal behaviour. These stocks also experience large price movements similar to $\text{stocks}_{\text{hit}}$, but without limit hits. If $\text{stocks}_{\text{hit}}$ experience greater price continuation than the other four subgroups, then the implication is that price limits prevent stock prices from reaching their equilibrium prices during event Day 0, thus delaying the efficient price discovery process. This price continuation behaviour implies that price limits prevent rational or informed trading [Roll (1989)]. Otherwise, we would observe price reversals in the context of overreactive behaviour [Ma *et al.* (1989a,b)]. It is worth noting that we do not exclude consecutive limit days from our sample since this would only underestimate the frequency of price continuation.

For upper limit hits, we classify [+, +] and [0, +] as price continuations. We include the latter as a price continuation since it represents stocks that open at the upper limit, remain unchanged on Day 0, and then experience price increases overnight. Also, for upper limit hits, we classify [+, -], [0, -], [-, +], [-, 0], and [-, -] as price reversals. The last three return series are considered reversals because the first negative sign indicates reversals before trading closes on the limit day. Return series [+, 0] and [0, 0] represent no change in prices. For lower limit hits, we classify the return sequences [-, -] and [0, -] as price continuations and the return sequences [-, +], [0, +], [+, -], [+, 0], and [+, +] as price reversals. Return series [-, 0] and [0, 0] represent no change in prices.

3.4.3 Trading interference hypothesis

To test H3, we only present results for the 10-day period from Day –4 to Day +5 because days outside this shorter event period offer no additional insight. To support H3, we expect to find trading volume increases for the $stocks_{hit}$ group on the day after a limit-hit day indicating continued intense trading. With increased trading on following days, the implication is that price limits prevent rational trading on the event day, implying a harmful interference to liquidity. For other stock subgroups, we expect to see decreased or stabilised trading activity on subsequent days because price limits do not interfere with their trading on Day 0.

To examine the trading activity behaviour around limit-days, we use the following turnover ratio as our measure for trading activity: $TA_{t,j} = TVOL_{t,j}/SOUT_{t,j}$, where $TVOL_{t,j}$ represents trading volume for each stock j on Day t and $SOUT_{t,j}$ represents the total number of shares outstanding for stock j on Day t. We calculate this ratio for each stock in all five stock categories and then find averages for each Day t. Because the liquidity interference hypothesis is interested in the day-to-day change in trading activity, we calculate a percentage change from the previous day as follows: $\ln(TA_{t,j}/TA_{j,t-1}) * 100$. In this analysis, we present results using samples that exclude consecutive limit-days to be consistent with our volatility analysis. Upper and lower limit hits are examined in the next section.[7]

3.5 Data description and empirical analysis

3.5.1 Data description

[7] The empirical approach in this section is also discussed in Kim and Rhee (1997).

We use daily stock price data from January 2, 1997 to April 30, 2001, giving us in total 1,082 daily observations.[8] The daily adjusted opening, closing, high and low prices, for the 59 individual stocks comprising the ASE Composite Share Price Index as at the end of April 2001, were collected from the ASE records.[9] The price data is adjusted to reflect capital distributions that include stock splits, reduction of capital, rights offerings, and stock dividends. Details on individual stocks are provided in Table 3.3.

Our analysis illustrates that stocks primarily with smaller market capitalisation and number of listed shares have reached their daily price limit – upper and lower – more frequently, to stocks with larger market capitalisation and number of listed shares. The stocks that reached their price limit more often, cover a variety of sectors, including non-metallic minerals and cement, holdings, food and beverages, textile industries, tobacco products, retail commerce, real estate, and wholesale commerce. Conversely, stocks that did not reach their price limits regularly include mainly banks, telecommunications and refinery. Table 3A in the Appendix reports the sector and the number of upper limit-hits for each stock. In addition, the 59 stocks comprising the ASE Composite Share Price Index, as at the end of April 2001, are ranked in terms of market capitalisation, trading volume and volatility. The average daily trading volume and volatility is calculated for December 1999, while market capitalisation corresponds to the last trading day of 1999.

3.5.2 Volatility spillover hypothesis

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[8] Some of the data used for the tests (e.g. daily opening prices of stocks) is available since 02/01/1997. The sample period ends on 30/04/2001, just before the official upgrade of Greek capital markets by international investment houses to developed status. Thus, the examination is conducted at a period when the ASE was officially categorised as an emerging market.

[9] Decisive criteria for the composition of the ASE Composite Share Price Index are the market capitalisation and the trading value of the listed stocks. Consequently, tests are performed on the 59 largest, most actively traded and liquid stocks in the ASE.

Tables 3.4A and 3.4B contain the V_t data of price increases for $stocks_{hit}$, $stocks_{0.90}$, $stocks_{0.80}$, $stocks_{0.70}$, and $stocks_{0.60}$ with multiple limit day observations excluded from the sample. As a result, this reduces the sample size for the $stocks_{hit}$ group from 753 to 381 for the upward price movements and from 495 to 293 for the downward price movements.

All stock categories (except $stocks_{0.60}$) experience their highest level of volatility on Day 0. This is the day when $stocks_{hit}$ reach their upper or lower daily price limits and when the other stock categories experience their extreme price movements. For each day, we compare volatility levels between stock categories by using the nonparametric Wilcoxon signed-rank test. The symbols "≥" and ">" denote that the left hand volatility measure is greater than the right hand measure at the 0.01 and 0.05 levels of significance, respectively.

A. Empirical results: Upper limits

On Day 1, we notice a large drop in volatility for $stocks_{hit}$ (from 6.039 on Day 0 to 2.767 on Day 1). Researchers may be tempted to conclude that price limits have effectively reduced volatility after upper price limits were reached. Ma *et al.* (1989a) in effect refer to this phenomenon as evidence that price limits reduce volatility. Nevertheless, this is considered as a very simplified explanation because volatility will naturally decline after extremely large volatility days. When we compare volatility for the other stock groups on Day 1, we again observe the same large drop in volatility despite the absence of limit reaches on Day 0. This finding further supports Lehmann's (1989) and Miller's (1989) interpretations and thus we interpret our results differently from Ma *et al.* (1989a). Specifically, we note that the volatility of $stocks_{hit}$ during the post-limit day period does not drop as much as the volatility of the other stock categories. On Day 1, the volatility of $stocks_{hit}$ is significantly higher to the volatility of $stocks_{0.90}$. Furthermore, we note that $stocks_{hit}$ continue to experience greater volatility than $stocks_{0.90}$ in the post-limit event period, however, volatility is not significantly higher in Days 2 to 4 and in Day 8.

We believe that $stocks_{hit}$ experience greater volatility on Day 1 because stocks that reach their daily price limit may be prevented from correcting their order imbalance. In fact, for $stocks_{hit}$, we see that volatility on Day 1 is greater than volatility on Day −1, further reflecting evidence of volatility spillovers, whereas for the other stock groups volatility is lower on Day 1 than on Day −1. Conversely, $stocks_{hit}$ does not experience significantly greater volatility in Days 2 to 4, providing evidence against volatility spillovers. This persistent volatility exists for $stocks_{0.90}$ and $stocks_{0.80}$ and there are post-limit day differences between $stocks_{0.90}$ and $stocks_{0.80}$.

We finally interpret our findings as evidence that price limits cause $stocks_{hit}$ to have volatility spillovers, as illustrated by the higher volatility on Day 1. Stocks that reach their limit are prevented from experiencing larger price changes on Day 0. In essence, price movement becomes contained on limit days, which leads to volatility spillovers in subsequent days (Day 1). On the other hand, we interpret our findings as evidence that price limits decrease volatility and that they do not spread volatility out over a longer period of time, as depicted in Days 2 to 4. This finding suggests that price limits might be useful in mitigating volatility.

B. Empirical results: Lower limits

On Day 1, we observe a large drop in volatility for $stocks_{hit}$ (from 5.639 on Day 0 to 2.786 on Day 1). When we compare volatility for the other stock groups on Day 1, we again see similar drops in volatility despite the absence of limit reaches on Day 0. Specifically, we note that the volatility of $stocks_{hit}$ during the post-limit day period does not drop as much as the volatility of the other stock categories. On Day 1, the volatility of $stocks_{hit}$ is significantly higher to the volatility of $stocks_{0.90}$. In fact, $stocks_{hit}$ continue to experience greater volatility than $stocks_{0.90}$ for up to four days after the limit-day with the exception on Day 2.

We believe that $stocks_{hit}$ experience greater volatility on Day 1 and Days 3 to 4 because stocks that reach their daily price limit may be prevented from correcting their order imbalance. In fact, for $stocks_{hit}$, we see that volatility on Day 1 is greater than volatility on Day −1, further reflecting evidence of volatility spillovers. Conversely, this persistent volatility exists for $stocks_{0.90}$ and $stocks_{0.80}$ and there are post-limit day differences between $stocks_{0.90}$ and $stocks_{0.80}$. Similarly, for the other stock groups volatility is greater on Day 1 than on Day −1. We interpret our findings as evidence that price limits cause $stocks_{hit}$ to have volatility spillovers, as illustrated by the higher volatility on Day 1 and Days 2 to 4.

3.5.3 Delayed price discovery hypothesis

Table 3.5, presents the frequency of price continuations, price reversals, and no changes.[10] For stocks that hit their upper limit, price continuations occur 79 percent of the

[10] To test for statistically significant differences, Kim and Rhee (1997) use a standard nonparametric binomial test. The following z-statistic is used: $z = (CON_{hit} - PrCON_{0.90}N_{hit})/(PrCON_{0.90}(1 - PrCON_{0.90})N_{hit})^{0.5}$. CON_{hit} denotes the number of price continuations that $stocks_{hit}$ experience; $PrCON_{0.90}$ represents the proportion of price continuations that occur for the $stocks_{0.90}$ sample and is calculated as

time and price reversals occur 17 percent of the time. In contrast, for stocks that almost hit the upper limit ($stocks_{0.90}$), price continuations occur 68 percent of the time and price reversals occur 27 percent of the time. For $stocks_{0.80}$, price continuations occur 60 percent of the time and price reversals occur 33 percent of the time. For lower limits, $stocks_{hit}$ experienced price continuations 43 percent of the time and price reversals 49 percent of the time. $Stocks_{0.90}$ and $stocks_{0.80}$ experienced nearly identical return patterns as $stocks_{hit}$.

In general, for upper limits, price continuations occur more often for $stocks_{hit}$ than for $stocks_{0.90}$, even though both stock categories experience nearly identical price changes on Day 0. This implies that price limits delay the price discovery process, thus supporting H2. In addition, limits do not seem to prevent overreactive behaviour since price reversal behaviour is not predominant for $stocks_{hit}$. Although reversals do occur after limit days (i.e. 17% for $stocks_{hit}$), they occur more frequently in the absence of limits (i.e. 27% for $stocks_{0.90}$ and 33% for $stocks_{0.80}$). From these results, we conclude that price limits seem to be preventing prices from continuing toward their equilibrium prices on Day 0, without curbing overreactive behaviour.

Conversely, for lower limits, price continuations do not occur more often for $stocks_{hit}$ than for $stocks_{0.90}$. Although price reversals do occur after limit days, they do not occur more frequently in the absence of limits. This implies that price limits do not delay the price discovery process, thus providing evidence against H2. From these results, we conclude that price limits do not seem to be preventing prices from continuing toward their equilibrium prices on Day 0.

$CON_{0.90}/N_{0.90}$, where $CON_{0.90}$ denotes the number of price continuations that $stocks_{0.90}$ experience and $N_{0.90}$ represents the $stocks_{0.90}$ sample size; and finally, N_{hit} represents the $stocks_{hit}$ sample size. The z-statistic is

3.5.4 Trading interference hypothesis

Tables 3.6A and 3.6B present the day-to-day trading activity changes for each of our five stock categories that show an overall pattern of trading increases as Day 0 approaches.

A. Empirical results: Upper limits

Our results reveal increases in trading activity on Day 0 that are much larger than the changes on previous days. However, the most unusual result is that $stocks_{hit}$ almost experienced an increase in trading activity on Day 1, the day after the limit day. For $stocks_{0.90}$ and $stocks_{0.80}$, trading decreases significantly on Day 1.

The general decline in trading for stocks with no limit hits shows that traders, for most of the time, obtain their desired positions on Day 0 in the absence of price limits. In comparison, since price limits interfere with trading for $stocks_{hit}$ on Day 0, traders have to wait for the following day to obtain their required positions. As hypothesized by Lehmann (1989), on the days after prices reach their limits, impatient investors will buy or sell at adverse prices or patient investors will wait for prices to reach their equilibrium levels so that order imbalances can be corrected. As a result, we observe higher trading activity on the days following limit-days, indicating order imbalances for liquidity. Our results also indicate that, for the $stocks_{hit}$ sample, investors are forced to wait until the next trading day to continue to transact.

B. Empirical results: Lower limits

Our results for the lower limit reaches differ considerably to the results of the upper limit reaches. For $stocks_{hit}$, trading activity decreases significantly on Day 1, the day after the limit day, which is even greater than the decrease for the other stock groups.

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distributed normally since sample sizes are all sufficiently large.

3.5.5 Relation between volatility and trading volume

French and Roll (1986), Harris (1986), Karpoff (1987), Schwert (1989), Stoll and Whaley (1990), Gallant, Rossi and Tauchen (1992), and Lamoureux and Lastrapes (1991, 1994), among others, document a positive relation between volatility and trading volume.[11] Until now, we have indicated that price limits interfere with trading activity, but only for the upward price movements. In this section, we examine the effect that trading interference may have on the volatility in order to further support or reject H3. To investigate this issue, we use the following cross-sectional regression:[12]

$$V_j = a + b\,(TA)_j + c\,(\text{Hit-Dummy})_j + d_j, \qquad (3.1)$$

where V_j is our previously discussed volatility measure for each stock j, TA_j is the previously introduced turnover ratio for each stock j, and Hit-Dummy represents a dummy variable that equals 1 for stocks that reach an upper or lower price limit ($\text{stocks}_{\text{hit}}$) and 0 otherwise. The above regression is run for each day of our 21-day event period. We conduct two separate analyses for upper and lower price movements, where each sample includes two groups of stocks that experience nearly identical upward (downward) price movement on Day 0: $\text{stocks}_{\text{hit}}$ and $\text{stocks}_{0.90}$. We use samples that exclude consecutive limit-hit days to be consistent with our previous analyses.

A. Empirical results: Upper limits

[11] Phylaktis, Kavussanos and Manalis (1996) investigate the relationship between volume and volatility in the ASE in Greece. They find a positive conditional volume-volatility relationship, when they apply a GARCH-type volatility specification and introduce 'lagged' volume in the variance equation. Kavussanos and Phylaktis (2001) also document a strong positive relation between trading activity and conditional volatility, when examining the effects of different trading systems in the ASE. Once again, they apply a GARCH model and introduce 'lagged' volume in the variance equation to avoid the problem of simultaneity.

[12] This econometric model is also employed by Kim and Rhee (1997).

During our 21-day event period, we expect the trading activity variable to be significantly positive on pre-limit days, consistent with previous literature. On the event Day 0, we question that the documented positive relation between volatility and trading activity can prevail because of the trading restrictions imposed by price limits. Thus, this would imply that on Day 0, the Hit-Dummy variable would become significantly positive. In addition, we expect the Hit-Dummy variable to remain significant on Day 1 because price limits, as we found earlier, cause volatility spillovers that last for one day.

Table 3.7A reports the regression results for our upper limit analyses. As discussed, Table 3.7A shows a positive significant relation between trading volume and volatility during the pre-limit day period, except Days –1, –2, and –6, and the positive relation disappears on the event Day 0 due to the trading interference that price limits cause. This result is further supported by the significantly positive Hit-Dummy variable on Day 0. The dummy variable also remains significant on Day 1, consistent with our volatility spillover findings and in line with our expectations.

B. Empirical results: Lower limits

During our 21-day event period, we expect the trading activity variable to be significantly positive on pre-limit days, consistent with previous literature. On the event Day 0, we question that the documented positive relation between volatility and trading activity can prevail because of the trading restrictions imposed by price limits. Thus, this would imply that on Day 0, the Hit-Dummy variable would become significantly positive. We also expect the Hit-Dummy variable to remain significant on Day 1 and Days 3 to 4 because price limits, as we found earlier, cause volatility spillovers on Day 1 and Days 3 to 4.

Table 3.7B reports the regression results for our lower limit analyses. As discussed, Table 3.7B shows a positive significant relation between trading volume and volatility during the pre-limit day period, except Day –4, and the positive relation disappears on the event Day 0 due to the trading interference that price limits cause. This result is further supported by the significantly positive Hit-Dummy variable on Day 0. Conversely, the dummy variable is not significant on Day 1 and Days 3 to 4, inconsistent with our volatility spillover findings and against our expectations.[13]

3.6 Conclusions

In this study we provide some evidence to support the position of price limit opponents who question the effectiveness of price limits in the stock markets. Our upper limit findings are more robust in providing evidence against price limit effectiveness, while our lower limit results are not qualitatively the same as the upper limit results. Using five categories of stocks based on the magnitude of a one-day price movement, we examine the ASE price limit system to compare volatility levels, price continuation and reversal activity, and trading activity patterns.

For stocks that experience upper limit-hits, we report the following results: volatility does not return to normal levels as quickly as for the stocks that did not reach price limits, although there is some evidence to support price limit effectiveness; price continuations occur more frequently than for stocks that did not reach limits; and trading activity almost increases on the day after the limit day, while all other stock subgroups experience noticeable trading activity declines. For lower limit-hits, we document the

[13] This inconsistency in the lower limits results can be potentially attributed to the lower trading activity and liquidity that exists when the market follows a downward trend and lower limit-hits are applied as a

following results: volatility does not return to normal levels as quickly as for the stocks that did not reach price limits, although there is again some evidence to support price limit effectiveness; price continuations do not occur more frequently than for stocks that did not reach limits; and trading activity drastically declines on the day after the limit day, while all other stock subgroups experience smaller trading activity declines.

Based on our upper limit findings, we question the effectiveness of price limits in countering overreaction and in reducing volatility. Moreover, price limits seem to cause delays in equilibrium price discovery and desired trading activity. On the other hand, our lower limit findings, support the effectiveness of price limits in countering overreaction and in reducing volatility, and do not seem to cause delays in equilibrium price discovery and desired trading activity. We believe, however, that our small sample sizes might be a weakness in our study.[14] The small sample and the inconsistent results suggest that all that can be learned is that the effects of the price limits, at least in the case of the ASE, are not overwhelmingly obvious. It is also worth noting, that the ASE price limits are set wide enough so that limit reaches are rare events.

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result.

[14] The small sample sizes issue arises mainly from the fact that the initial samples of 753 upper limit-hits and 495 lower limit-hits are subsequently reduced to 381 and 293 respectively, since consecutive limit-hit observations are excluded, for the volatility spillover and trading interference tests.

Tables: **Table 3.1**

Daily Price Limits in the ASE

Effective Date	Price Limits
03/08/1992	±8%
07/02/2000	±10%
31/07/2000	±12%
01/06/2001	±18%
01/01/2005[a]	±20%

Source: ASE Fact Book 2001-2006.

[a] Price limit for the 20 stocks comprising the FTSE/ASE 20 Index was abolished.

Table 3.2
Summary Statistics

Stocks are categorised into five groups based on the magnitude of their price movement on Day 0 (the event day). $Stocks_{hit}$ denote stocks that reach their daily price limit. $Stocks_{0.90}$ denote stocks that experience a price change of at least $0.90(LIMIT_t)$ from the previous day's close, but do not reach a price limit; where $LIMIT_t$ denotes the maximum allowable daily price movement on Day t. $Stocks_{0.80}$ denote stocks that experience a price change between $0.80(LIMIT_t)$ and $0.90(LIMIT_t)$. $Stocks_{0.70}$ denote stocks that experience a price change between $0.70(LIMIT_t)$ and $0.80(LIMIT_t)$. $Stocks_{0.60}$ denote stocks that experience a price change between $0.60(LIMIT_t)$ and $0.70(LIMIT_t)$. The sample size of each of these five categories, during the study period 1997 to 2001, is presented below, for both upward price movements and downward price movements.

Upward Price Movements		Downward Price Movements	
$Stocks_{hit}$	(n = 753)	$Stocks_{hit}$	(n = 495)
1997	n = 58	1997	n = 37
1998	n = 126	1998	n = 93
1999	n = 421	1999	n = 226
2000	n = 133	2000	n = 122
2001 (April)	n = 15	2001 (April)	n = 17
$Stocks_{0.90}$	(n = 957)	$Stocks_{0.90}$	(n = 863)
$Stocks_{0.80}$	(n = 819)	$Stocks_{0.80}$	(n = 705)
$Stocks_{0.70}$	(n = 862)	$Stocks_{0.70}$	(n = 763)
$Stocks_{0.60}$	(n = 1,010)	$Stocks_{0.60}$	(n = 916)

Table 3.3
Information on Individual Stocks

The 59 stocks comprising the ASE Composite Share Price Index (April 2001) are listed below. The second and third columns report the sector and the market capitalisation (in millions EUR) of each stock respectively.

Stock Name	Sector	Market Capitalisation[a] (millions EUR)
1. Aegek S.A. (CR)[b]	Constructions	346.66
2. Aktor S.A. Technical Company (CR)	Constructions	486.20
3. Alfa Alfa Holdings S.A. (CR)	Holdings	483.79
4. Alpha Bank A.E. (CR)	Banks	5,236.51
5. Alpha Invest. S.A. (CB)	Investment Companies	456.00
6. Altec C.A. Inform. & Commun. Syst. (CR)	I.T. Equipment-Solutions	438.88
7. Aluminium of Greece S.A. (CR)	Basic Metals	924.83
8. Aspis Pronia General Insurances S.A. (CR)	Insurances	232.46
9. Alpha Astika Akinita S.A. (CR)	Real Estate	167.72
10. Astir Palace Vouliagmeni S.A. (CR)	Hotels & Resorts	317.37
11. Athens Medical C.S.A. (CR)	Health Services	442.09
12. Eydap S.A. (CR)	Water Supplies	971.28
13. Attica Enterprises Holding S.A. (CB)	Holdings	891.73
14. Bank of Piraeus (CR)	Banks	2,420.44
15. Coca-Cola E.E.E. S.A. (CB)	Food & Beverages	4,023.37
16. Commercial Bank of Greece (CR)	Banks	4,756.25
17. Cosmote Mobile Communications S.A. (CR)	Telecommunications	3,227.40
18. Delta Informatics S.A. (CR)	Information Technology	446.60
19. Duty Free Shops S.A. (CR)	Retail Commerce	791.18
20. Efg Eurobank Ergasias Bank S.A. (CR)	Banks	5,121.77
21. Elmec Sport A.B.E.T.E. (CR)	Wholesale Commerce	124.10
22. Elval Alum. Process. Co. S.A. (CB)	Basic Metals	518.57
23. Ergo Invest. S.A. (CB)	Investment Companies	303.24
24. Esha S.A. (CB)	Non Metallic Minerals & Cement	189.13
25. Germanos Ind. & Com. Co. S.A. (CR)	Mobile Retail Services	654.91
26. Goodys S.A. (CB)	Restaurants	282.63
27. Halkor S.A. (Former Vector) (CB)	Basic Metals	409.26
28. Hellenic Petroleum S.A. (CR)	Refinery	2,585.57
29. Hellenic Sugar Industry S.A. (CB)	Food & Beverages	409.91
30. Hellenic Technodomiki S.A. (CR)	Constructions	798.00
31. Heracles General Cement Co. (CR)	Non Metallic Minerals & Cement	728.08
32. Hyatt Regency S.A. (CR)	Television & Entertainment	530.88
33. Interamerican Hellenic Life Ins. Co. S.A. (CR)	Insurances	1,473.40
34. Intracom S.A. (CR)	Electronic Equipment	2,410.60
35. Intrasoft S.A. (CR)	Information Technology	519.60
36. Klonatex Group of Companies S.A. (CB)	Holdings	211.03
37. Lambrakis Press S.A. (CR)	Publishing & Printing	1,066.25
38. Lavipharm S.A. (CR)	Wholesale Commerce	157.17
39. Inform P. Lykos S.A. (CR)	Publishing & Printing	337.29
40. M. J. Maillis S.A. (CR)	Basic Metals	688.12
41. Metka S.A. (CR)	Metallic Products	300.27
42. Minoan Lines (CR)	Passenger Shipping	344.70
43. Mytilineos Holdings S.A. (CR)	Wholesale Commerce	323.35
44. Naoussa Spinning Mills S.A. (CB)	Textile Industries	277.55
45. National Bank of Greece (CR)	Banks	10,258.85

46. N.B.G. Real Estate Development Co. (CR)	Transportation Related Fac. & Ser.	802.23
47. Hellenic Telecom. Org. (CR)	Telecommunications	8,468.11
48. Panafon S.A. (CR)	Telecommunications	3,608.00
49. Papastratos Cigarette Co. (CB)	Tobacco Products	408.52
50. Sanyo Hellas Holding S.A. (CB)	Holdings	278.64
51. Gr. Sarantis (CB)	Wholesale Commerce	67.08
52. Sidenor S.A. (Former Erlikon) (CB)	Basic Metals	351.46
53. Singular S.A. (CR)	Information Technology	331.86
54. Technical Olympic S.A. (CR)	Constructions	465.00
55. Tiletipos S.A. (CR)	Television & Entertainment	233.66
56. Themeliodomi S.A. (CR)	Constructions	213.21
57. Titan Cement Co. (CR)	Non Metallic Minerals & Cement	1,622.23
58. Viohalco (CB)	Holdings	2,260.51
59. X.K. Tegopoulos Publishing S.A. (CR)	Publishing & Printing	223.70

Source: The Athens Stock Exchange, Exchange Developments, Monthly Statistical Bulletin, April 2001.
[a] 30 April 2001, [b] *Abbreviations:* C = Common, R = Registered, B = Bearer.

Table 3.4A

Volatility Spillover: Upper Limit Reaches

For all five stock categories: $stocks_{hit}$, $stocks_{0.90}$, $stocks_{0.80}$, $stocks_{0.70}$, and $stocks_{0.60}$, we calculate volatility for each day for the 21-day period surrounding the event Day 0. The stock categories are based on the magnitude of their price movement on Day 0. $Stocks_{hit}$ denote stocks that reach their daily price limit. $Stocks_{0.90}$ denote stocks that experience a price change of at least 0.90($LIMIT_t$) from the previous day's close, but do not reach a price limit; where $LIMIT_t$ denotes the maximum allowable daily price movement on Day t. $Stocks_{0.80}$ denote stocks that experience a price change between 0.80($LIMIT_t$) and 0.90($LIMIT_t$). $Stocks_{0.70}$ denote stocks that experience a price change between 0.70($LIMIT_t$) and 0.80($LIMIT_t$). $Stocks_{0.60}$ denote stocks that experience a price change between 0.60($LIMIT_t$) and 0.70($LIMIT_t$). Day 0 denotes the day $stocks_{hit}$ reach their upper limit-hits. Day −1 represents the day before Day 0. We use daily returns-squared as our volatility measure, which is calculated as follows:

$$V_{t,j} = (r_{t,j})^2,$$

where $r_{t,j}$ denotes the daily return for each stock j on Day t. Here, $V_{t,j}$ is multiplied by 10^3. ≥ and > indicate that the left-hand figure is greater than the right-hand figure at the 0.01 and 0.05 levels of significance, respectively, using the Wilcoxon signed-rank test. n denotes the number of observations.

Day	$Stocks_{hit}$ $n = 381$		$Stocks_{0.90}$ $n = 509$		$Stocks_{0.80}$ $n = 493$		$Stocks_{0.70}$ $n = 584$		$Stocks_{0.60}$ $n = 693$
-10	1.513		1.551		1.414	>	1.276		1.249
-9	1.774	≥	1.564		1.545	≥	1.255		1.275
-8	1.702	≥	1.519		1.281		1.364		1.349
-7	1.771	>	1.687		1.399		1.296		1.307
-6	1.868	≥	1.419		1.361		1.438	≥	1.128
-5	1.665	≥	1.460		1.296		1.308	≥	1.160
-4	1.698	≥	1.508		1.506	≥	1.300		1.251
-3	1.696		1.842		1.710	≥	1.455	>	1.404
-2	2.122		2.212		1.815	≥	1.523	≥	1.274
-1	2.167		2.511		2.093	>	1.885		1.703
0	6.039	≥	5.046	≥	2.994	≥	2.289	≥	1.471
1	2.767	≥	2.306	≥	1.650	≥	1.437		1.396
2	1.993		1.914		1.696	≥	1.262		1.355
3	2.057		1.960	≥	1.447		1.331		1.339
4	2.011		2.004	≥	1.447		1.375	≥	1.201
5	2.072	≥	1.638	>	1.388		1.348	≥	1.198
6	1.920	>	1.775		1.545		1.414	≥	1.229
7	2.092	≥	1.820		1.532	≥	1.315		1.321
8	1.815		1.779		1.455	≥	1.250	≥	1.135
9	2.199	≥	1.702		1.362	>	1.182	>	1.157
10	1.800	≥	1.507		1.342		1.250		1.175

Table 3.4B

Volatility Spillover: Lower Limit Reaches

For all five stock categories: $stocks_{hit}$, $stocks_{0.90}$, $stocks_{0.80}$, $stocks_{0.70}$, and $stocks_{0.60}$, we calculate volatility for each day for the 21-day period surrounding the event Day 0. The stock categories are based on the magnitude of their price movement on Day 0. $Stocks_{hit}$ denote stocks that reach their daily price limit. $Stocks_{0.90}$ denote stocks that experience a price change of at least 0.90($LIMIT_t$) from the previous day's close, but do not reach a price limit; where $LIMIT_t$ denotes the maximum allowable daily price movement on Day *t*. $Stocks_{0.80}$ denote stocks that experience a price change between 0.80($LIMIT_t$) and 0.90($LIMIT_t$). $Stocks_{0.70}$ denote stocks that experience a price change between 0.70($LIMIT_t$) and 0.80($LIMIT_t$). $Stocks_{0.60}$ denote stocks that experience a price change between 0.60($LIMIT_t$) and 0.70($LIMIT_t$). Day 0 denotes the day $stocks_{hit}$ reach their lower limit-hits. Day −1 represents the day before Day 0. We use daily returns-squared as our volatility measure, which is calculated as follows:

$$V_{t,j} = (r_{t,j})^2,$$

where $r_{t,j}$ denotes the daily return for each stock *j* on Day *t*. Here, $V_{t,j}$ is multiplied by 10^3. ≥ and > indicate that the left-hand figure is greater than the right-hand figure at the 0.01 and 0.05 levels of significance, respectively, using the Wilcoxon signed-rank test. *n* denotes the number of observations.

Day	$Stocks_{hit}$ $n = 293$		$Stocks_{0.90}$ $n = 454$		$Stocks_{0.80}$ $n = 437$		$Stocks_{0.70}$ $n = 517$		$Stocks_{0.60}$ $n = 643$
-10	1.720	≥	1.426		1.481	≥	1.294	≥	1.104
-9	1.318	>	1.373	<	1.570	≥	1.196		1.317
-8	1.572		1.677		1.519	≥	1.273		1.572
-7	1.721		1.679		1.633		1.427	>	1.411
-6	1.857	>	1.801		1.743		1.552		1.477
-5	2.017	>	1.844		1.923	≥	1.512		1.550
-4	2.150	≥	1.941		1.588		1.564	≥	1.379
-3	2.035	>	1.762		1.698	≥	1.287		1.346
-2	1.996		1.996		1.797	≥	1.595		1.587
-1	2.286		2.199	>	1.807	>	1.482	≥	1.336
0	5.639	≥	4.136	≥	2.526	≥	1.890	≥	1.392
1	2.786	>	2.517	>	2.082	≥	1.697	≥	1.251
2	2.832		2.500	≥	1.844	≥	1.580	≥	1.284
3	2.285	>	2.126		1.840	>	1.563	≥	1.278
4	2.180	≥	1.826		1.740	≥	1.240		1.333
5	1.979		1.892		1.663	≥	1.307	>	1.242
6	1.832		1.918		1.695	≥	1.227		1.195
7	1.800		1.763	>	1.415	≥	1.225		1.187
8	1.635		1.679	>	1.384		1.269	≥	1.115
9	2.145	≥	1.772		1.467	≥	1.245	>	1.149
10	1.912	>	1.778		1.466		1.287	≥	1.158

Table 3.5

Delayed Price Discovery: Price Continuations and Reversals

To identify price continuations and reversals, we look at the following two returns series: $r(O_tC_t)$ and $r(C_tO_{t+1})$. The first measure represents open-to-close returns measured by $\ln(C_t/O_t)$ and the latter represents close-to-open returns measured by $\ln(O_{t+1}/C_t)$, where O and C denote opening and closing prices respectively and t represents the day. Specifically, we examine $r(O_0C_0)$ and $r(C_0O_1)$ for all stocks subgroups, where the first measure looks at the open-to-close returns for Day 0 and the latter measure looks at the immediate following overnight returns. Stock return can either be positive, negative, or zero, and is denoted as (+), (-), and (0), respectively. Consequently, nine returns series are possible: [+, +], [+, 0], [+, -], [0, +], [0, 0], [0, -], [-, +], [-, 0], and [-, -], where the first return represents $r(O_0C_0)$ and the second return represents $r(C_0O_1)$. For upper limit-hits, we classify [+, +] and [0, +] as price continuations, we classify [+, -], [0, -], [-, +], [-, 0], and [-, -] as price reversals, and we classify [+, 0] and [0, 0] as no change. For lower limit-hits, we classify [-, -] and [0, -] as price continuations, we classify [-, +], [0, +], [+, -], [+, 0], and [+, +] as price reversals, and we classify [-, 0] and [0, 0] as no change. We present the total proportions of continuations, reversals, and no change for each stock subgroup. Stocks are categorised into five categories based on the magnitude of their price movement on Day 0 (the event day). $Stocks_{hit}$ denote stocks that reached their daily price limit. $Stocks_{0.90}$ denote stocks that experience a price change of at least $0.90(LIMIT_t)$ from the previous day's close, but do not reach a price limit; where $LIMIT_t$ denotes the maximum allowable daily price movement on Day t. $Stocks_{0.80}$ denote stocks that experience a price change between $0.80(LIMIT_t)$ and $0.90(LIMIT_t)$. $Stocks_{0.70}$ denote stocks that experience a price change between $0.70(LIMIT_t)$ and $0.80(LIMIT_t)$. $Stocks_{0.60}$ denote stocks that experience a price change between $0.60(LIMIT_t)$ and $0.70(LIMIT_t)$. Day 0 denotes the day $stocks_{hit}$ experience their limit-hits. We use the abbreviation "S" for each stock group. For each stock group, the proportions may not add to 1.00 due to rounding. The last column reports the difference between S_{hit} and $S_{0.90}$. Z-values based on a binomial test statistic are given in parenthesis. We do not report z-values for other pairwise comparisons. n denotes the number of observations.

Price Behaviour	S_{hit}	$S_{0.90}$	$S_{0.80}$	$S_{0.70}$	$S_{0.60}$	$S_{hit} - S_{0.90}$ (z-value)
Upward Price Movements	n=753	n=957	n=819	n=862	n=1,010	
Continuation	0.79	0.68	0.60	0.60	0.56	0.11 (6.64)
Reversal	0.17	0.27	0.33	0.34	0.37	-0.10 (-6.35)
No change	0.04	0.06	0.07	0.07	0.07	-0.02 (-2.33)
Downward Price Movements	n=495	n=863	n=705	n=763	n=916	
Continuation	0.43	0.39	0.40	0.38	0.35	0.04 (1.84)
Reversal	0.49	0.51	0.52	0.51	0.54	-0.02 (-0.94)
No change	0.08	0.11	0.08	0.11	0.11	-0.03 (-2.08)

Table 3.6A

Trading Interference: Upper Limit Reaches

For all five stock categories: $stocks_{hit}$, $stocks_{0.90}$, $stocks_{0.80}$, $stocks_{0.70}$, and $stocks_{0.60}$, we calculate trading activity for each day for the 11-day period surrounding the event Day 0. The stock categories are based on the magnitude of their price movement on Day 0. $Stocks_{hit}$ denote stocks that reach their daily price limit. $Stocks_{0.90}$ denote stocks that experience a price change of at least 0.90($LIMIT_t$) from the previous day's close, but do not reach a price limit; where $LIMIT_t$ denotes the maximum allowable daily price movement on Day t. $Stocks_{0.80}$ denote stocks that experience a price change between 0.80($LIMIT_t$) and 0.90($LIMIT_t$). $Stocks_{0.70}$ denote stocks that experience a price change between 0.70($LIMIT_t$) and 0.80($LIMIT_t$). $Stocks_{0.60}$ denote stocks that experience a price change between 0.60($LIMIT_t$) and 0.70($LIMIT_t$). Day 0 denotes the day $stocks_{hit}$ experience their upper limit-hits. Day −1 represents the day before Day 0. Trading activity (TA) is measured by a turnover ratio where for each company j on Day t, we divide daily trading volume by daily total shares outstanding. For each day, we report the percentage change in trading activity from the previous day: $\ln(TA_{j,t}/TA_{j,t-1}) * 100$, where ln represents the natural log operator. We calculate this percentage change for each stock j and report the daily means. ≥ and > indicate that the left-hand figure is greater than the right-hand figure at the 0.01 and 0.05 levels of significance, respectively, using the Wilcoxon signed-rank test. n denotes the number of observations.

Day	$Stocks_{hit}$ $n = 381$		$Stocks_{0.90}$ $n = 509$		$Stocks_{0.80}$ $n = 493$		$Stocks_{0.70}$ $n = 584$	$Stocks_{0.60}$ $n = 693$
-4	-7.53%	≤	6.99%	>	-1.23%		1.73%	-1.48%
-3	6.29%		0.73%		7.90%	>	2.08%	7.97%
-2	2.54%		4.16%		-2.01%		6.30%	0.78%
-1	8.94%		13.41%		10.03%		8.06%	6.02%
0	37.75%		35.36%	>	27.31%		28.06%	22.50%
1	-2.53%	>	-12.62%		-13.76%		-22.00%	-17.18%
2	-25.01%		-22.88%	<	-13.92%		-6.85%	-4.61%
3	-7.77%		-8.61%		-3.46%		-6.55%	-3.80%
4	-5.51%		0.55%		-3.41%		0.36%	-3.12%
5	1.84%		-1.32%		-1.59%		-3.58%	2.27%

Table 3.6B

Trading Interference: Lower Limit Reaches

For all five stock categories: $stocks_{hit}$, $stocks_{0.90}$, $stocks_{0.80}$, $stocks_{0.70}$, and $stocks_{0.60}$, we calculate trading activity for each day for the 11-day period surrounding the event Day 0. The stock categories are based on the magnitude of their price movement on Day 0. $Stocks_{hit}$ denote stocks that reach their daily price limit. $Stocks_{0.90}$ denote stocks that experience a price change of at least 0.90($LIMIT_t$) from the previous day's close, but do not reach a price limit; where $LIMIT_t$ denotes the maximum allowable daily price movement on Day t. $Stocks_{0.80}$ denote stocks that experience a price change between 0.80($LIMIT_t$) and 0.90($LIMIT_t$). $Stocks_{0.70}$ denote stocks that experience a price change between 0.70($LIMIT_t$) and 0.80($LIMIT_t$). $Stocks_{0.60}$ denote stocks that experience a price change between 0.60($LIMIT_t$) and 0.70($LIMIT_t$). Day 0 denotes the day $stocks_{hit}$ experience their lower limit-hits. Day –1 represents the day before Day 0. Trading activity (TA) is measured by a turnover ratio where for each company j on Day t, we divide daily trading volume by daily total shares outstanding. For each day, we report the percentage change in trading activity from the previous day: $\ln(TA_{j,t}/TA_{j,t-1})$ * 100, where ln represents the natural log operator. We calculate this percentage change for each stock j and report the daily means. ≥ and > indicate that the left-hand figure is greater than the right-hand figure at the 0.01 and 0.05 levels of significance, respectively, using the Wilcoxon signed-rank test. n denotes the number of observations.

Day	$Stocks_{hit}$ $n = 293$		$Stocks_{0.90}$ $n = 454$	$Stocks_{0.80}$ $n = 437$	$Stocks_{0.70}$ $n = 517$		$Stocks_{0.60}$ $n = 643$
-4	1.14%		2.19%	-1.19%	0.16%		0.67%
-3	11.27%	>	0.76%	2.38%	0.30%		-1.16%
-2	-5.10%		2.08%	-0.85%	-1.32%		2.78%
-1	-2.53%		2.59%	-3.14%	-1.61%		-5.64%
0	12.60%		4.83%	2.19%	5.97%	≥	-4.35%
1	-20.09%	≤	-6.86%	-4.88%	-9.95%		-9.30%
2	4.88%	≥	-10.48%	-6.49%	0.10%		4.55%
3	-9.02%		-2.34%	1.67%	-1.59%		-1.65%
4	-7.57%		-6.47%	-4.70%	-8.76%		-9.38%
5	-3.35%		-4.76%	-9.02%	-3.77%	≤	6.36%

Table 3.7A

Trading Interference: Regression Results for Upper Limit Reaches

The following cross-sectional ordinary least squares regressions are run to examine the relation between trading activity (TA) as measured by trading volume/shares outstanding and volatility (V):

$$V_j = a + b\,(TA)_j + c\,(\text{Hit-Dummy})_j + d_j,$$

where Hit-Dummy equals 1 for stocks that reached an upper price limit ($stocks_{hit}$) and 0 otherwise. V_j is measured by the daily returns-squared for each stock j and TA_j is measured by a turnover ratio where for each company j, we divide daily trading volume by daily total shares outstanding. For each day, the percentage change in trading activity from the previous day is calculated as follows: $\ln(TA_{j,t}/TA_{j,t-1}) * 100$, where ln represents the natural log operator. The above regression is run for each day for our 21-day event period. Our sample includes two groups of stocks that experience nearly identical upward price movement on Day 0: $Stocks_{hit}$ and $stocks_{0.90}$. $Stocks_{hit}$ denote stocks that reach their daily price limit. $Stocks_{0.90}$ denote stocks that experience a price change of at least $0.90(LIMIT_t)$ from the previous day's close, but do not reach a price limit; where $LIMIT_t$ denotes the maximum allowable daily price movement on Day t. Day 0 denotes the day $stocks_{hit}$ experience their upper limit-hits. Consistent with previous volatility data, we multiply V_j by 10^3. The number of observations is 890.

Day	Intercept	Trading Activity	Hit-Dummy	Adj. R^2	F-Value
-10	1.559**	0.002*	-0.032	0.003	2.46
-9	1.551**	0.003**	0.224	0.007	4.24*
-8	1.522**	0.003**	0.164	0.008	4.55*
-7	1.685**	0.004**	0.095	0.018	9.15**
-6	1.423**	0.002	0.444**	0.010	5.53**
-5	1.467**	0.003**	0.195	0.008	4.56*
-4	1.493**	0.002*	0.221	0.005	3.05*
-3	1.841**	0.002*	-0.159	0.004	2.65
-2	2.211**	0.000	-0.090	-0.002	0.12
-1	2.526**	-0.001	-0.349	0.003	2.16
0	5.045**	0.000	0.994**	0.026	12.92**
1	2.397**	0.007**	0.388*	0.054	26.19**
2	1.980**	0.003**	0.085	0.008	4.48*
3	1.980**	0.002*	0.095	0.004	2.83
4	2.001**	0.006**	0.044	0.030	14.74**
5	1.644**	0.004**	0.421**	0.022	10.94**
6	1.795**	0.003**	0.139	0.007	3.94*
7	1.826**	0.004**	0.267	0.010	5.41**
8	1.769**	0.003*	0.049	0.003	2.47
9	1.728**	0.004**	0.494**	0.023	11.32**
10	1.509**	0.004**	0.282	0.021	10.53**

Notes: ** and * denote statistical significance at the 0.01 and 0.05 levels, respectively.

Table 3.7B

Trading Interference: Regression Results for Lower Limit Reaches

The following cross-sectional ordinary least squares regressions are run to examine the relation between trading activity (TA) as measured by trading volume/shares outstanding and volatility (V):

$$V_j = a + b\,(TA)_j + c\,(\text{Hit-Dummy})_j + d_j,$$

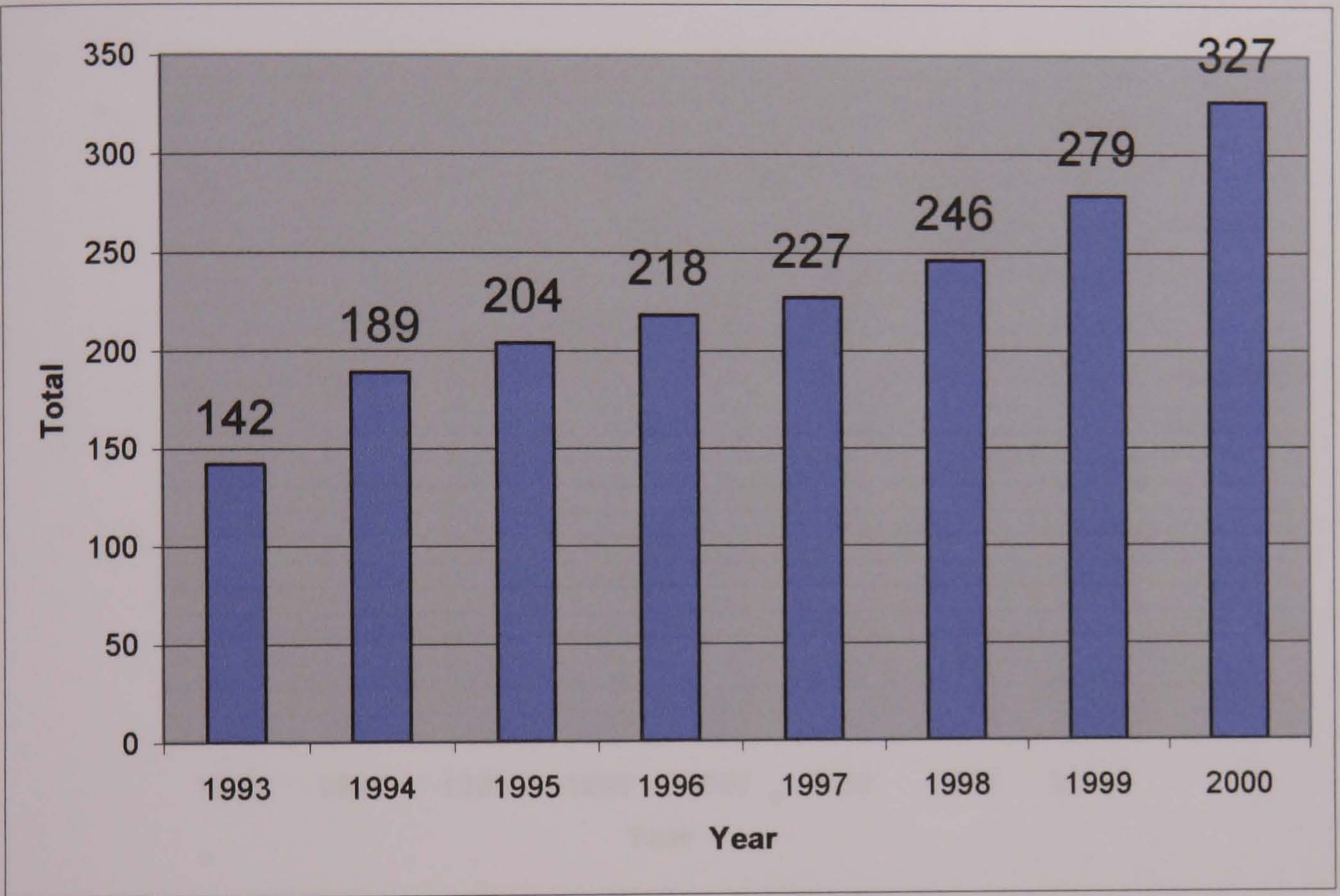
where Hit-Dummy equals 1 for stocks that reached a lower price limit ($stocks_{hit}$) and 0 otherwise. V_j is measured by the daily returns-squared for each stock j and TA_j is measured by a turnover ratio where for each company j, we divide daily trading volume by daily total shares outstanding. For each day, the percentage change in trading activity from the previous day is calculated as follows: $\ln(TA_{j,t}/TA_{j,t-1}) * 100$, where ln represents the natural log operator. The above regression is run for each day for our 21-day event period. Our sample includes two groups of stocks that experience nearly identical downward price movement on Day 0: $Stocks_{hit}$ and $stocks_{0.90}$. $Stocks_{hit}$ denote stocks that reach their daily price limit. $Stocks_{0.90}$ denote stocks that experience a price change of at least $0.90(LIMIT_t)$ from the previous day's close, but do not reach a price limit; where $LIMIT_t$ denotes the maximum allowable daily price movement on Day t. Day 0 denotes the day $stocks_{hit}$ experience their lower limit-hits. Consistent with previous volatility data, we multiply V_j by 10^3. The number of observations is 747.

Day	Intercept	Trading Activity	Hit-Dummy	Adj. R^2	F-Value
-10	1.434**	0.003*	0.293	0.010	4.80**
-9	1.369**	0.003**	-0.054	0.011	4.99**
-8	1.682**	0.003**	-0.115	0.010	4.82**
-7	1.662**	0.002*	0.062	0.003	2.25
-6	1.797**	0.003**	0.053	0.007	3.79*
-5	1.855**	0.004**	0.136	0.022	9.58**
-4	1.941**	0.000	0.209	-0.001	0.61
-3	1.758**	0.006**	0.214	0.031	13.04**
-2	1.991**	0.002*	0.018	0.003	2.21
-1	2.188**	0.004**	0.107	0.012	5.46**
0	4.142**	-0.001	1.511**	0.039	16.12**
1	2.526**	0.001	0.285	0.000	0.94
2	2.555**	0.005**	0.251	0.013	6.03**
3	2.131**	0.002	0.172	0.001	1.46
4	1.856**	0.005**	0.359	0.016	7.25**
5	1.908**	0.003**	0.082	0.008	3.85*
6	1.921**	0.002	-0.089	0.001	1.41
7	1.750**	0.003**	0.071	0.008	4.19*
8	1.689**	0.002*	-0.065	0.006	3.08*
9	1.775**	0.003**	0.386*	0.018	7.87**
10	1.770**	0.002	0.132	0.001	1.53

Notes: ** and * denote statistical significance at the 0.01 and 0.05 levels, respectively.

Figures: **Figure 3.1**
Total Number of Companies Listed*

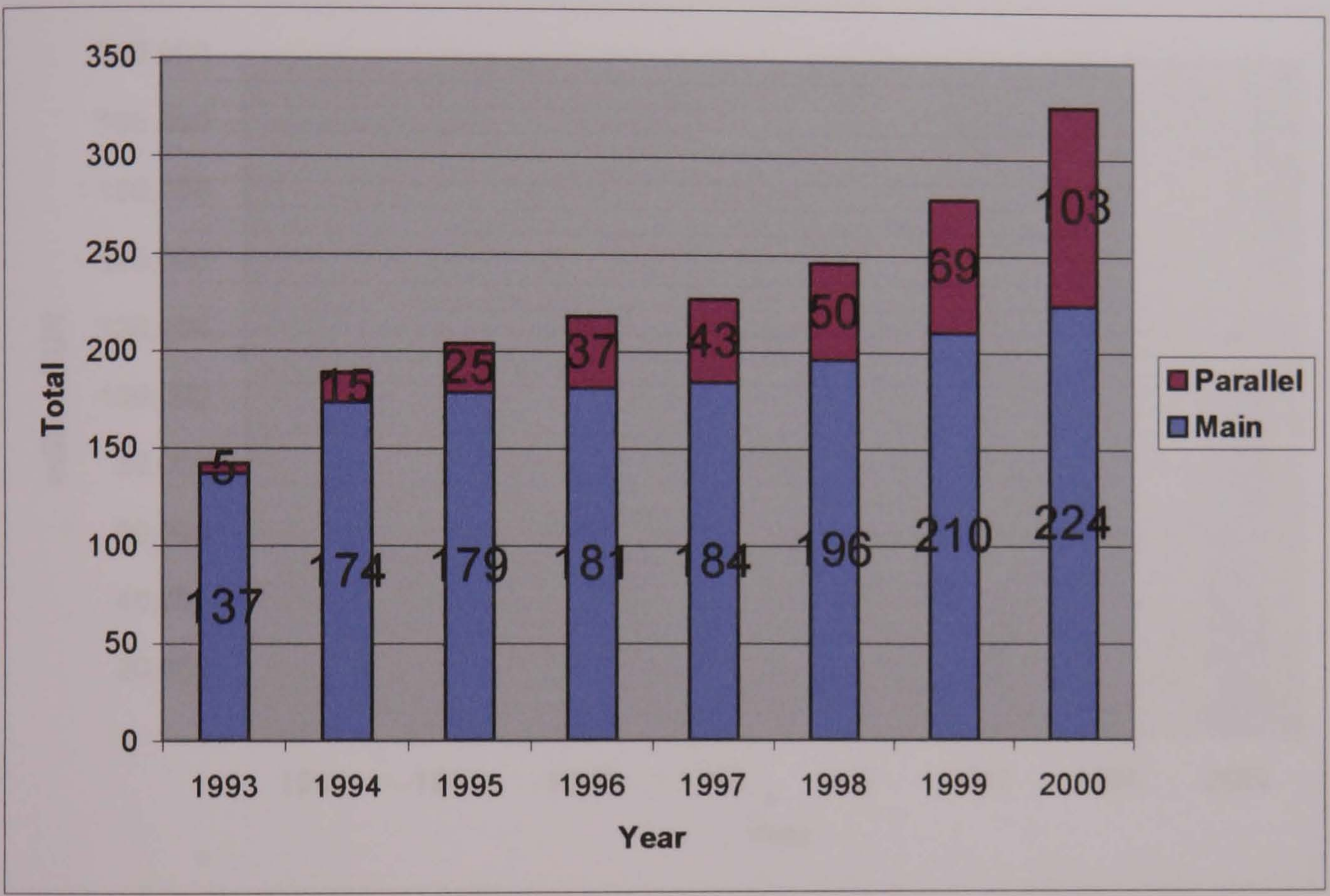
Yearly – 1993 to 2000



Source: ASE Fact Book 2001.
* Figures do not include companies whose shares have been suspended from trading.

Figure 3.2
Number of Companies Listed for Main and Parallel Markets*

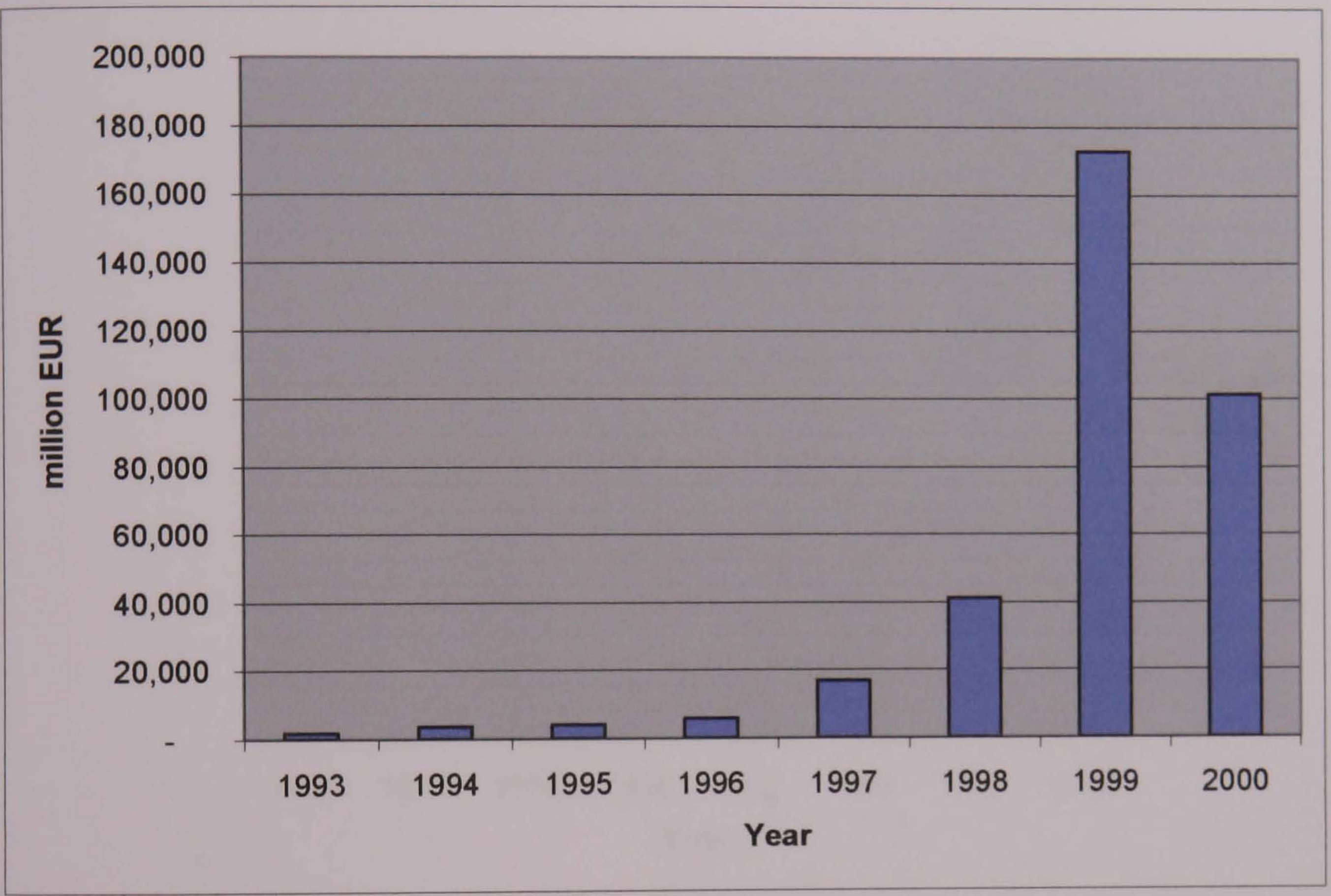
Yearly – 1993 to 2000



Source: ASE Fact Book 2001.
* Figures do not include companies whose shares have been suspended from trading.

Figure 3.3
Total Shares Turnover (million EUR)

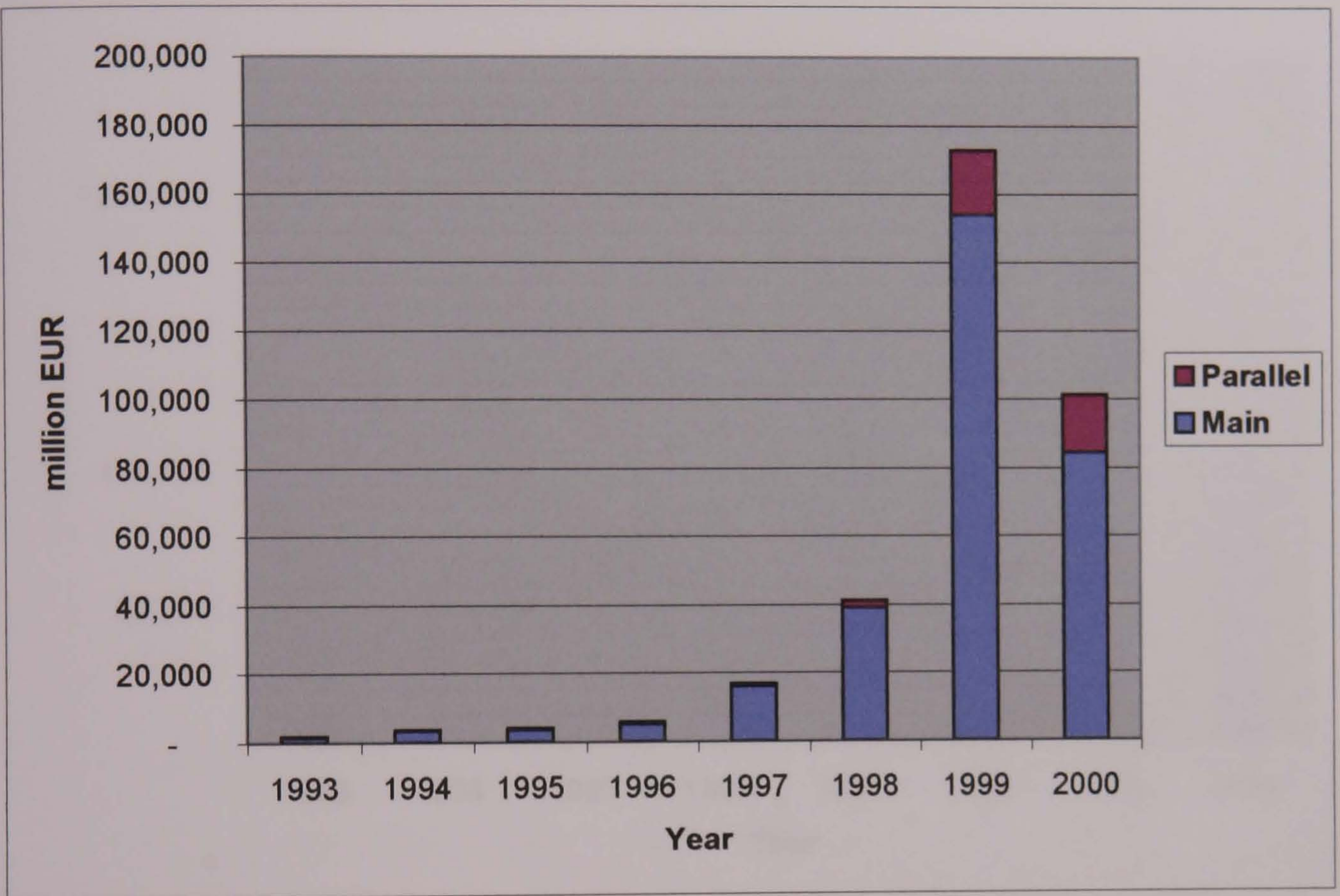
Yearly – 1993 to 2000



Source: ASE Fact Book 2001.

Figure 3.4
Shares Turnover for Main and Parallel Markets (million EUR)

Yearly – 1993 to 2000

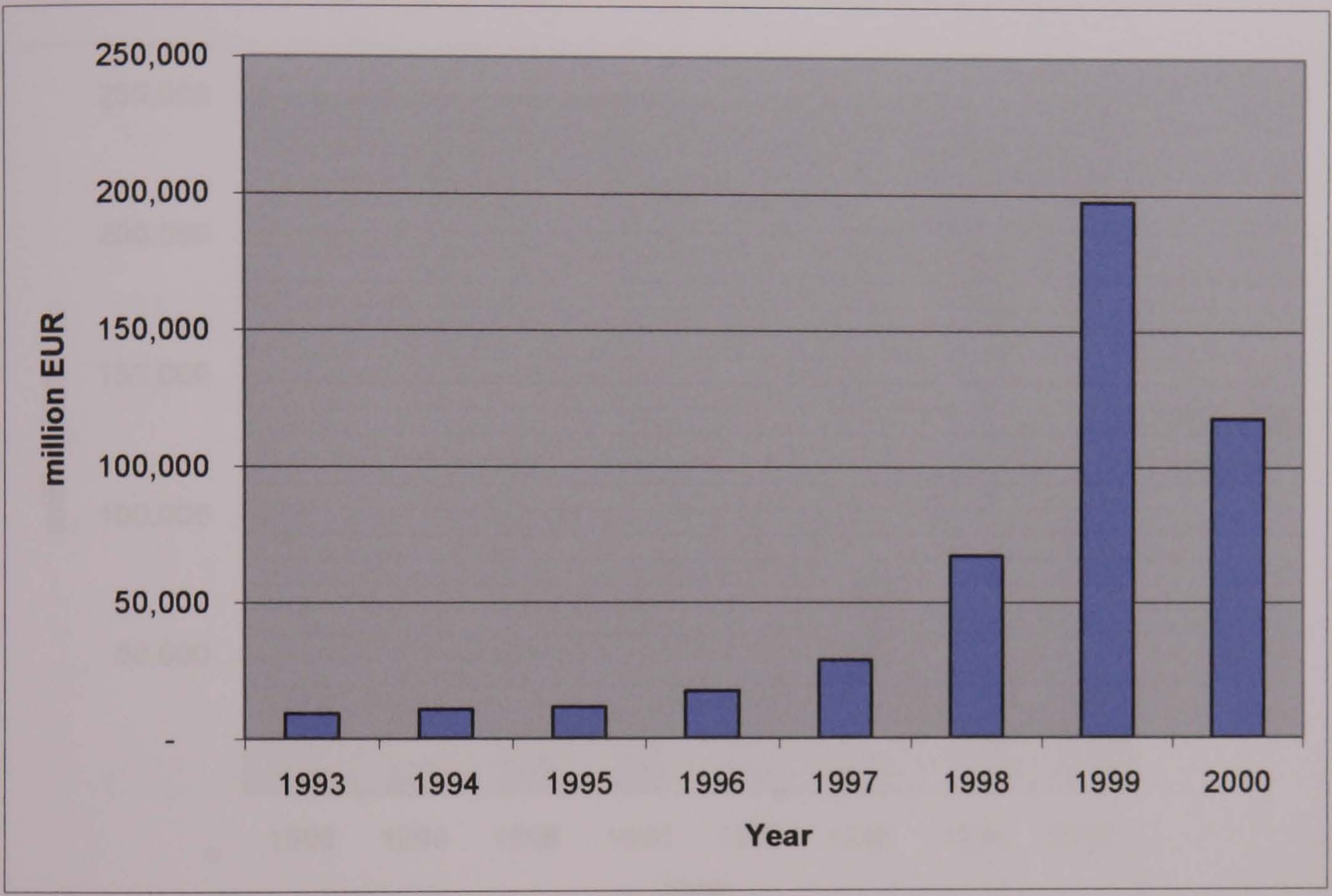


Source: ASE Fact Book 2001.

Figure 3.5

Total Shares Market Capitalisation (closing prices, million EUR)

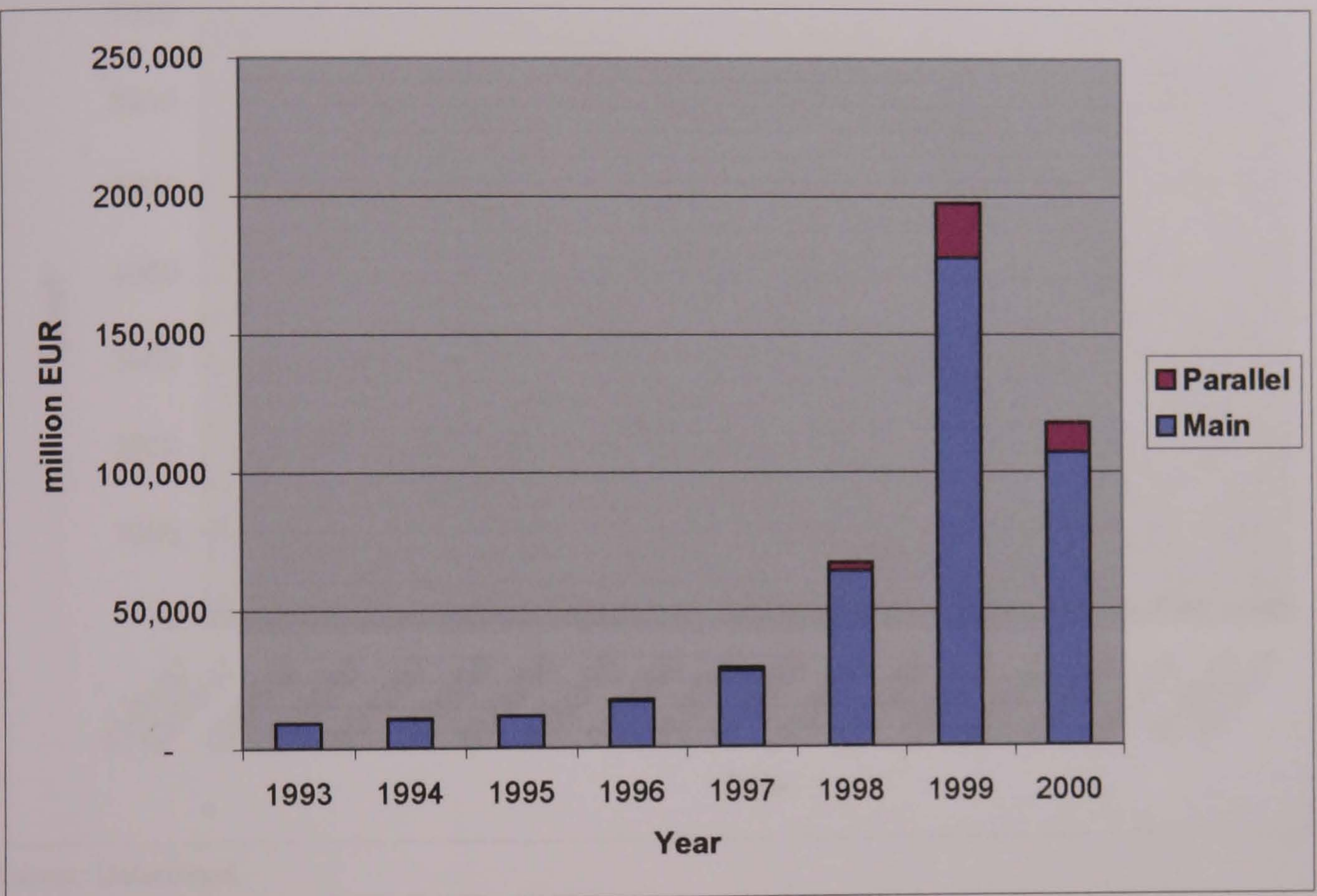
Yearly – 1993 to 2000



Source: ASE Fact Book 2001.

Figure 3.6
Shares Market Capitalisation for Main and Parallel Markets (closing prices, million EUR)

Yearly – 1993 to 2000

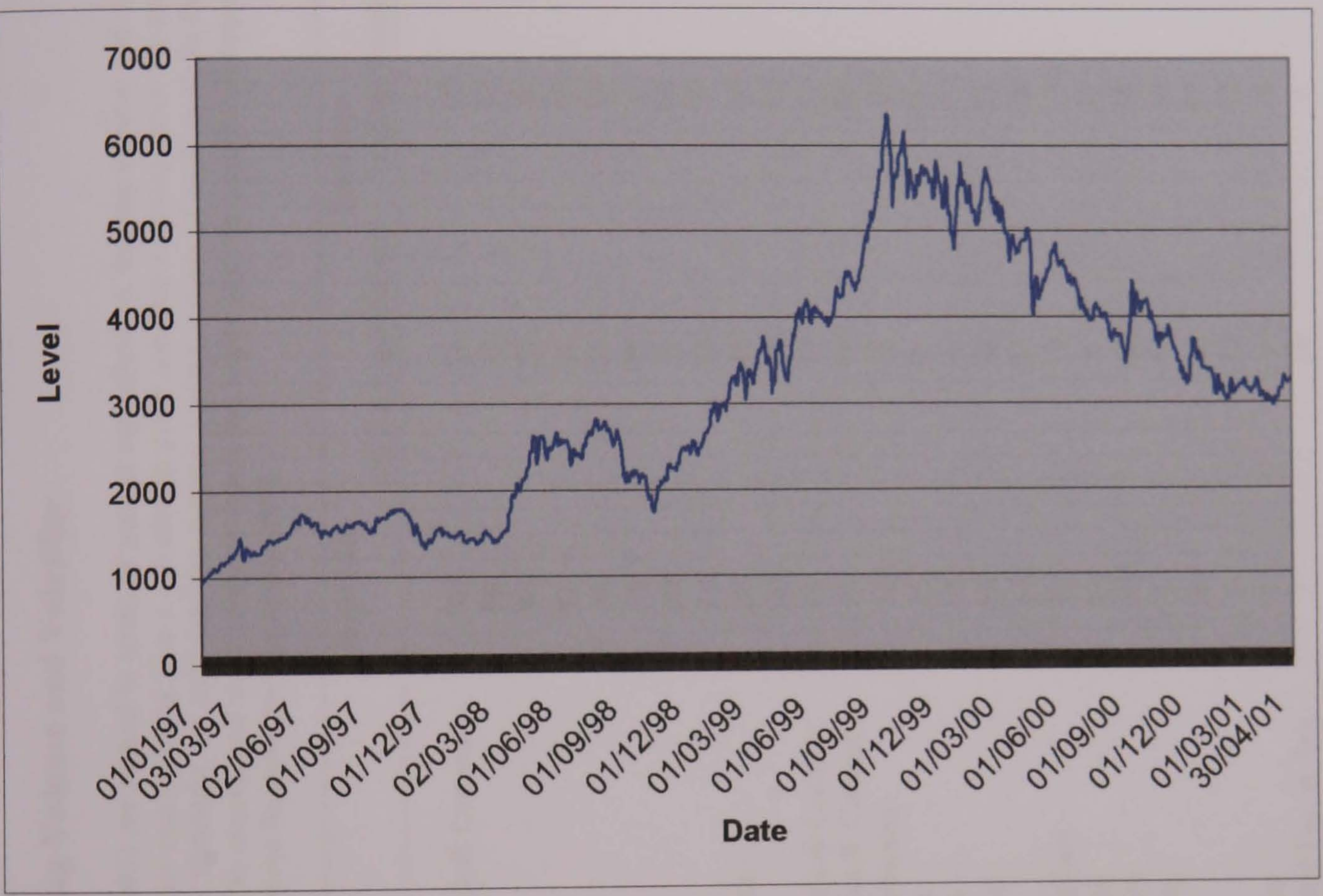


Source: ASE Fact Book 2001.

Figure 3.7

The Athens Stock Exchange Composite Share Price Index

Daily – January 1997 to April 2001



Source: Datastream.

Appendix: **Table 3A**

Upper Limit-Hits, Market Capitalisation, Trading Volume and Volatility

The 59 stocks comprising the ASE Composite Share Price Index (April 2001) are ranked in terms of market capitalisation, trading volume and volatility. Daily price volatility is measured by $V_{t,j} = (r_{t,j})^2$, where $r_{t,j}$ represents close-to-close returns using Day $t - 1$ closing price and Day t closing price for each stock j. We calculate this measure and find averages for each stock in December 1999. Similarly, we calculate the average trading volume of each stock in December 1999, while market capitalisation corresponds to the last trading day of 1999. The second and third columns report the sector and the number of upper limit-hits for each stock respectively. Data is non-applicable (N/A) for those stocks that were floated after December 1999.

Stock Name	Sector	Upper Hits	Rankings		
			Market Capitalisation	Trading Volume	Volatility
1. Esha S.A. (CB)	Non Metallic Minerals & Cement	105	54	19	1
2. Klonatex Group of Companies S.A. (CB)	Holdings	99	35	17	2
3. Hellenic Sugar Industry S.A. (CB)	Food & Beverages	74	29	6	15
4. Naoussa Spinning Mills S.A. (CB)	Textile Industries	41	22	11	4
5. Papastratos Cigarette Co. (CB)	Tobacco Products	38	31	54	18
6. Duty Free Shops S.A. (CR)	Retail Commerce	30	25	2	19
7. Alpha Astika Akinita S.A. (CR)	Real Estate	30	37	50	7
8. Aluminium of Greece S.A. (CR)	Basic Metals	29	24	55	39
9. Elmec Sport A.B.E.T.E. (CR)	Wholesale Commerce	28	43	14	3
10. Coca-Cola E.E.E. S.A. (CB)	Food & Beverages	20	11	41	52
11. Heracles General Cement Co. (CR)	Non Metallic Minerals & Cement	19	17	52	46
12. Titan Cement Co. (CR)	Non Metallic Minerals & Cement	19	14	48	50
13. Hyatt Regency S.A. (CR)	Television & Entertainment	16	18	16	9
14. Panafon S.A. (CR)	Telecommunications	15	3	4	43
15. Hellenic Telecom. Org. (CR)	Telecommunications	15	1	5	47
16. Inform P. Lykos S.A. (CR)	Publishing & Printing	14	38	53	23
17. Minoan Lines (CR)	Passenger Shipping	14	23	28	26
18. Altec C.A. Inform. & Commun. Syst. (CR)	I.T. Equipment-Solutions	12	19	25	11
19. Lambrakis Press S.A. (CR)	Publishing & Printing	11	6	22	8
20. Lavipharm S.A. (CR)	Wholesale Commerce	10	45	46	6
21. X.K. Tegopoulos Publishing S.A. (CR)	Publishing & Printing	9	55	30	10
22. Themeliodomi S.A. (CR)	Constructions	8	48	49	5
23. Interamerican Hellenic Life Ins. Co. S.A. (CR)	Insurances	8	13	42	41
24. Intracom S.A. (CR)	Electronic Equipment	8	7	26	24
25. N.B.G. Real Estate Development Co. (CR)	Transportation Related Fac. & Ser.	7	36	9	20

26. Goodys S.A. (CB)	Restaurants	6	46	51	30
27. Tiletipos S.A. (CR)	Television & Entertainment	6	33	21	32
28. Sanyo Hellas Holding S.A. (CB)	Holdings	6	51	10	12
29. Ergo Invest. S.A. (CB)	Investment Companies	6	47	13	45
30. Alfa Alfa Holdings S.A. (CR)	Holdings	5	49	29	22
31. Attica Enterprises Holding S.A. (CB)	Holdings	4	15	36	27
32. Eydap S.A. (CR)	Water Supplies	4	N/A	N/A	N/A
33. National Bank of Greece (CR)	Banks	4	2	7	51
34. Intrasoft S.A. (CR)	Information Technology	4	32	27	25
35. Metka S.A. (CR)	Metallic Products	3	27	33	38
36. Technical Olympic S.A. (CR)	Constructions	3	42	8	28
37. Aspis Pronia General Insurances S.A. (CR)	Insurances	3	44	37	21
38. Commercial Bank of Greece (CR)	Banks	3	4	31	48
39. Mytilineos Holdings S.A. (CR)	Wholesale Commerce	2	10	44	34
40. Halkor S.A. (Former Vector) (CB)	Basic Metals	2	26	34	33
41. M. J. Maillis S.A. (CR)	Basic Metals	2	34	43	44
42. Alpha Invest. S.A. (CB)	Investment Companies	2	21	45	37
43. Hellenic Technodomiki S.A. (CR)	Constructions	2	39	23	17
44. Viohalco (CB)	Holdings	1	16	24	35
45. Aktor S.A. Technical Company (CR)	Constructions	1	50	3	29
46. Delta Informatics S.A. (CR)	Information Technology	1	20	47	14
47. Sidenor S.A. (Former Erlikon) (CB)	Basic Metals	1	30	38	36
48. Elval Alum. Process. Co. S.A. (CB)	Basic Metals	1	28	35	40
49. Alpha Bank A.E. (CR)	Banks	1	5	15	53
50. Efg Eurobank Ergasias Bank S.A. (CR)	Banks	1	8	20	55
51. Hellenic Petroleum S.A. (CR)	Refinery	0	9	1	49
52. Athens Medical C.S.A. (CR)	Health Services	0	40	32	42
53. Gr. Sarantis (CB)	Wholesale Commerce	0	52	40	31
54. Aegek S.A. (CR)	Constructions	0	53	18	16
55. Astir Palace Vouliagmeni S.A. (CR)	Hotels & Resorts	0	N/A	N/A	N/A
56. Singular S.A. (CR)	Information Technology	0	41	39	13
57. Germanos Ind. & Com. Co. S.A. (CR)	Mobile Retail Services	0	N/A	N/A	N/A
58. Bank of Piraeus (CR)	Banks	0	12	12	54
59. Cosmote Mobile Communications S.A. (CR)	Telecommunications	0	N/A	N/A	N/A

CHAPTER 4

SECURITY TRANSACTION TAXES AND FINANCIAL VOLATILITY: EVIDENCE FROM THE ATHENS STOCK EXCHANGE

4.1 Introduction

Financial markets are structured in such a way as to transform latent demands of investors into realised financial transactions. The imposition of securities transaction taxes (STTs) affects this transformation. Advocates of STTs argue that such taxes can reduce market volatility by reducing excessive trading for many financial transactions are highly speculative in nature and help to prevent financial crises, while the opponents of STTs believe that such taxes are difficult to implement and enforce and instead can do great damage to financial markets.

Some of the arguments put forward in favour of STTs include the following:[1] First, the contribution of financial markets to economic welfare does not substantiate the resources they command. During a given time period, the value of the resources that change hands in financial markets is far greater than the value of the underlying or "real" transactions. Second, several financial transactions which are highly speculative in nature may contribute to financial or economic instability. Third, market volatility, including crashes, enhances the positions of insiders and speculators, while the costs are borne by the general public. Fourth, financial market activity increases inequalities in the distribution of income and wealth. Finally, the large volume of financial transactions in developed markets allows large amounts of tax revenue to be raised by the Governments by imposing very low tax rates on a broad range of transactions.

Opponents of STTs, on the other hand, argue that markets have the ability to allocate resources efficiently without direct involvement from public policy. However, they also need a convincing argument in order to justify the volume of resources flowing

[1] See, for example, Tobin (1984), Summers and Summers (1989), Stiglitz (1989), and Eichengreen, Tobin, and Wyplosz (1995).

through financial markets. A number of documented irregularities, as well as a history of market crashes, do not easily provide support to the notion that financial markets are fully efficient. In addition, market participants do not devote considerable resources in analysing previous transaction prices and volumes. Thus, instead of providing evidence that the allocation of resources to the financial sector is justified on efficiency grounds, or that observed market volatility is optimal, the opponents of STTs have focused on the difficulties of implementing them.[2]

There are two dimensions to consider regarding these difficulties. First, if a STT is applied in one financial market but not in others, then the volume of transactions tends to move from the market that is taxed to markets that are not. Second, since similar payoffs can be generated by portfolios consisting of different types of assets, the imposition of a STT can create a greater distortion than the one which is trying to mitigate. Investors instead of trading less because of the tax, they may transact more in assets that are taxed less or not at all. Consequently, real resources engaged to financial transactions may in fact increase rather than diminish following the imposition of a STT.

STTs have been a common policy tool throughout the world. Table 4.1 presents the levels of STTs that have operated in major financial markets including Japan, the United Kingdom (U.K.), Germany, Italy, and France. The table also shows that the smaller Organisation for Economic Cooperation and Development (OECD) economies, such as Australia, Austria, Belgium, Denmark, Greece, and Ireland, and many emerging economies, such as Chile, China, India, and Malaysia have also operated with STTs.

The trend in developed countries has been toward reducing or eliminating the STTs. For example, Sweden and Finland experimented with STTs and decided to

[2] See, for example, Campbell and Froot (1995), where they consider international experiences with STTs.

eliminate them in the early 1990's. Germany abolished the stock exchange turnover tax and the tax on bills and notes in 1991. Canada and Netherlands no longer have STTs. A description of STTs that have operated in developed economies is reported in the Appendix 4A.[3]

In Greece, the stock transaction tax was introduced on February 19, 1998, at a 0.3% tax rate on the selling of shares transacted in the stock exchange, as part of the annual tax reforms proposed by the Government. The transaction tax was increased from 0.3% to 0.6% on October 8, 1999, mainly to cover part of the cost of the annual tax changes proposed by the Government, resulting from cuts in indirect taxes, other tax reductions and income support for pensioners, farmers and the unemployed. The transaction tax was reduced from 0.6% to 0.3% on January 3, 2001, as part of a number of measures announced by the Government, a move intended to support and boost liquidity in the stock exchange. The transaction tax was finally reduced from 0.3% to 0.15% on January 2, 2005, as part of the tax reforms included in the Government's annual budget, a measure intended to further enhance the stock exchange's prospects.[4]

The purpose of this study is to add empirical content to the debate on STTs by conducting an investigation of the effects of transaction tax on the mean and volatility of stock market returns, in the Athens Stock Exchange (ASE) in Greece. The study makes the following contributions to the existing literature on STTs. First, it provides evidence on a capital market using both a marketwide index (i.e. All Share Index) and a large cap

[3] For a description of STTs that have operated in developed economies, see Habermeier and Kirilenko (2001).

[4] More information regarding the history of stock transaction taxes in the Greek stock exchange is provided in Section 4.3.

index (i.e. FTSE/ASE 20 Index).[5] Previous studies like Umlauf (1993), Saporta and Kan (1997), and Hu (1998), have concentrated on capital markets by examining a marketwide price index, such as an All Share Index. By examining the effects of the transaction tax using the FTSE/ASE 20 Index, we will test whether the transaction tax has a greater impact on the volatility of actively traded stocks, as a result of investors entering (buying) and exiting (selling) the market (stocks) on a more frequent basis.

Second, the study investigates the possibility of an asymmetry in the relation between transaction tax and volatility, which can originate from the different roles transaction taxes could play during bull and bear periods.[6] We expect transaction tax to have a greater impact on the volatility of stocks during bull periods compared to bear or normal periods, since trading activity is higher during bull periods. In addition, we expect transaction tax to have a greater impact on the volatility of the 20 largest and most highly traded stocks compared to all traded stocks.

Finally, our study is the first empirical investigation of the effects of transaction tax on the mean and volatility of Greek stock returns.

In summary, our investigation has the following objectives: (i) to examine whether the introduction and changes of transaction tax in the ASE has significantly affected the conditional mean of daily stock market returns; (ii) to test whether transaction tax has significantly affected the conditional volatility of daily stock market returns; (iii) to investigate the possibility of an asymmetry in the relation between transaction tax and volatility during bull and bear periods; and (iv) to examine whether

[5] The FTSE/ASE 20 Index consists of 20 of the largest in market capitalisation and most liquid stocks that trade on the ASE. It was developed in September 1997 out of a partnership between the ASE and FTSE International.

the results relating to the above tests differ for the FTSE/ASE 20 Index compared to the All Share Index.

The rest of the paper is organised as follows. Section 4.2 reviews the literature on STTs. Section 4.3 provides background information related to the evolution of transaction taxes in Greece. Section 4.4 discusses the GARCH (Generalised Autoregressive Conditional Heteroskedasticity)/EGARCH (Exponential GARCH) models, which are used to investigate the relationship between transaction tax and the conditional moments – mean and variance – of daily stock market returns and sets up the hypotheses. Section 4.5 describes the data and presents the empirical results. The final section summarises the empirical findings and presents the main policy conclusions.

4.2 Literature review

Due to the lack of a consensus on the theory, researchers have attempted to resolve the debate on the efficacy of transaction taxes empirically. However, empirical studies carried out so far have not been able to conclusively resolve the debate on the effects of transaction taxes on financial markets. In general, empirical research encountered three major problems. First, the effects of taxes on prices and volume are difficult to separate from other structural and policy changes taking place at the same time. As a result, estimates based on the assumption that everything else in the economy is held constant are potentially biased. Second, it is hard to differentiate transaction volume into stable (or "fundamental") and destabilising (or "noise") components. Therefore, it is not clear to say which part of the volume is more affected by the tax.

[6] Hardouvelis and Theodossiou (2002) also investigated the possible existence of an asymmetric relation between initial margin requirements, which is another form of transaction cost, and stock market volatility

Third, it is difficult to distinguish among multiple ways in which transaction taxes can affect asset prices. These ways include changes in expectations about the impact of the taxes, the cost of creating portfolios and trading in close substitutes not covered by the tax, and changes in market liquidity.

Empirical studies have attempted to find answers to three main questions. The first question is whether transaction taxes have an effect on price volatility. Roll (1989) examined stock return volatility in 23 countries from 1987 to 1989 and found no evidence that volatility is reliably related to transaction taxes.[7] Umlauf (1993) studied the behaviour of equity returns in Sweden, before and during the imposition of transaction taxes on brokerage service providers over the period 1980-1987, and found significant increases in volatility; daily variances were highest during the period of greatest tax. On the other hand, Saporta and Kan (1997) examined the impact of the U.K. stamp duty on the volatility of securities' prices and found no significant effect. Evidence on Emerging Markets has also not been supportive of the tax. For example, Hu (1998) examined the effects on volatility of changes in transaction taxes that occurred in Hong Kong, Japan, Korea, and Taiwan from 1975 to 1994, and did not find significant effects.

The effects of STTs have also been examined by investigating the effects of types of other regulatory changes, which are equivalent to transaction taxes in terms on their impact on transaction costs. For example, Jones and Seguin (1997) examined the effect on volatility of the introduction of negotiated commissions on U.S. national stock exchanges in 1975, which resulted in a permanent decline in commissions. They argued that this event is equivalent to a one-time reduction of a tax on equity transactions since

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in the United States (U.S.) during bull, normal and bear periods.

both are fixed in amount and levied on parties whenever a stock transaction takes place. They did not find that the lowering of commissions increased volatility; instead, they found that market volatility was reduced in the year following the deregulation.

More recently, Hau (2006) examined the effect on volatility of minimum price variation rules in the French stock market and argues that minimum price variation rules result in an increase of about 20% of transaction costs for stocks priced above a certain threshold (500 francs). He argues that this is equivalent to the application of a transaction tax on the stocks above the threshold and finds that the increase in transaction costs results in an increase in volatility, which is "significant both statistically and economically".[8]

Table 4.2 compares the results of a selection of papers that have considered the effects of transaction taxes on volatility. In all of these cases, the authors have either found a statistically insignificant or a positive effect of transaction taxes on volatility, i.e., an increase in STT increases volatility.

The second question is whether transaction taxes affect trading volume. Umlauf (1993) reports that after Sweden increased its transaction tax from 1% to 2% in 1986, 60% of the volume of the 11 most actively traded Swedish stocks migrated to London, which represented over 30% of all trading volume in Swedish equities. By 1990, that share increased to around 50%. Campbell and Froot (1995) also report that only 27% of the trading volume in Ericsson, the most actively traded Swedish stock, took place in Stockholm in 1988. Hu (1998) examined 14 tax changes in four Asian markets and found

[7] Roll (1989) reviewed three proposals for dampening volatility: margin requirements, price limits, and transaction taxes, and claimed that transaction taxes are the least studied of the three.
[8] Hau (2006), page 888.

that differences in turnover before and after changes in the tax level are not statistically significant.

Thirdly, empirical studies try to find out whether transaction taxes have an impact on securities' prices and empirical findings support a negative impact. For example, Umlauf (1993) reporting on the Swedish experience finds that the All-Equity Index fell by 2.2% on the day a 1% transaction tax was announced and again by 0.8% on the day it was increased to 2%. He finds these declines to be statistically significant compared to the mean daily return of the sample. The fall in stock market index was even greater in the case of the U.K. Saporta and Kan (1997) find that on the day stamp duty in the U.K. was increased from 1% to 2%, the stock market index declined by 3.3%. Hu (1998) reports similar results in the case of Korea and Taiwan. Over the nine changes in the two countries, the average return on the announcement date is –1% with a t value of –3.06 and a p value of 0.001.

Thus, overall the various empirical studies provide no clear conclusions regarding the relationship between STTs and volatility or trading volume, but offer more conclusive evidence with regard to STTs and securities' prices.

4.3 Securities transaction taxes in Greece

The ASE was established in 1876 and is the only official market for shares and rights trading in Greece, both for the public and institutional investors. During the period 1997 to 2000, the Greek economy was characterised by its attempt at readjusting its macroeconomic indicators and achieving the criteria to become the 12th member of the

"Euro Zone", a success which was completed with the official entry of Greece into the European Economic and Monetary Union (EMU) on January 1, 2001.

The Greek stock market having achieved all the necessary changes in its institutional and regulative framework and in its technological systems, and with the country's economic stability as its base, it entered a new era, with its promotion in June 2001 to the category of developed markets. In specific, the upgrading of Greece by the Morgan Stanley Capital International (MSCI) from the emerging market index to the developed market index became effective on May 31, 2001.[9]

In Greece, the transaction tax was introduced on February 19, 1998, as part of the annual tax package proposed by the Government. The tax package recommended the imposition of new taxes and the increase in existing taxes (18 tax changes in total), including the establishment of a 0.3% tax rate on the selling of shares transacted in the stock exchange. The new tax package was presented to the country's Parliament on January 7, 1998, and although a significant portion of public opinion opposed the proposed new tax changes, the Government having the majority of seats in the Parliament approved the new tax package on January 22, 1998.

On September 2, 1999, the Government announced a number of measures designed to provide tax relief to weaker income groups and to aid the Government's anti-inflation drive for entry into the Eurozone. The package included cuts in indirect taxes, tax reforms and income support for pensioners, farmers and the unemployed. Part of the cost of the package was expected to be covered by an increase in the existing stock transaction tax from 0.3% to 0.6%. The tax rate increase was implemented on October 8, 1999.

On December 4, 2000, the Government announced a number of measures including the reduction in the stock transaction tax from 0.6% to 0.3%, a move intended to support and boost liquidity in the ASE. It should be noted that the ASE followed a downward trend since September 1999, when the stock market had reached its all time highs. The tax rate reduction from 0.6% to 0.3% was implemented on January 3, 2001.[10] A list summarising the dates and stock transaction tax changes in the ASE is provided in Table 4.3.

4.4 Methodological issues

This section discusses the GARCH-M(p,q)/EGARCH-M(p,q) models, which are used to investigate the relationship between transaction tax and the conditional moments – mean and variance – of daily stock market returns.[11]

4.4.1 Conditional mean of returns

The specification of the conditional mean of returns equation is modified as follows:

$$r_t = \mu_t + \varepsilon_t = a_0 + b_T T_{t-1} + \sum_{i=1}^{p} c_i r_{t-i} + \sum_{j=1}^{q} d_j \varepsilon_{t-j} + e\sigma_t^2 + \varepsilon_t, \tag{4.1}$$

[9] The MSCI index is one of the most widely used benchmarks for international equity investment.

[10] There was an additional tax rate reduction on stock transactions from 0.3% to 0.15%, which was implemented on January 2, 2005. The tax reduction was announced as part of the tax reforms included in the Government's annual budget, and the move intended to further enhance the stock exchange's prospects. It is worth noting, that this latest tax rate change, falls outside our sample period.

[11] The GARCH model was developed by Bollerslev (1986), as a natural extension to the ARCH class of models introduced by Engle (1982), and has been used extensively to fit high frequency financial data. The EGARCH model was proposed by Nelson (1991) to allow for asymmetric shocks to volatility. Once we introduce the conditional variance into the mean equation, we then get the GARCH-in-Mean (GARCH-M)/EGARCH-in-Mean (EGARCH-M) models.

where $\mu_t \equiv E(r_t \mid i_{t-1})$ is the conditional mean of returns for period t based on information available up to time t-1, i_{t-1}, and ε_t is an error term used as proxy for market innovations (shocks). In addition, T_{t-1} denotes the level of transaction tax at time t-1, r_{t-i} are past returns, ε_{t-j} are moving average (MA) terms, and $\sigma_t^2 \equiv \text{var}(r_t \mid i_{t-1})$ is the conditional variance of r_t based on i_{t-1}.[12]

Lagged returns are included to absorb serial correlation. Day of the week effects on the level of returns are removed by including dummy variables a_1, a_2, a_4, a_5, which equal one if the trading day is a Monday, Tuesday, Thursday, and Friday, respectively, and equal zero otherwise. The σ_t^2 term is intended to capture a possible association between the first and second conditional moments of the distribution of returns. This specification is consistent with the static capital asset pricing model (CAPM) that assumes a positive linear relationship between μ and σ^2.

Finally, the variable, T_{t-1}, is included in order to capture a possible direct influence of transaction tax on the risk premium further than its indirect influence through its possible association with volatility. In fact, if higher transaction taxes reduce uncertainty about future unjustifiable stock price movements, that is, uncertainty originating from bubbles, fads, the pyramiding-depyramiding process, etc., that is not entirely captured by our measures of volatility, they may well reduce the return investors require in order to invest in the stock market. Based on this explanation, the presence of transaction taxes in the ASE should have a significantly adverse effect on the conditional mean of returns and therefore the first hypothesis to be tested is set up as follows:

$$\text{H1}: b_T < 0$$

[12] We use lagged tax as an instrument for contemporaneous tax to avoid the problem of simultaneity since lagged values of endogenous variables are classified as predetermined [see e.g. Harvey (1989)]. The lagged

The following section specifies the conditional variance of returns equation and sets up the remaining hypotheses.

4.4.2 Conditional variance of returns

In this section we modify the conditional variance of returns equation to include an asymmetric relation between transaction tax and stock market volatility by separating out periods of rising stock prices, the so-called "bull" markets, and periods of declining stock prices, i.e., "bear" periods. A bull or a bear market is a period of consecutive monthly increases or decreases in stock prices whose time period is perceived to last more than one month. That is, a period during which there are at least *n* consecutive monthly stock returns with the same algebraic sign. Because there is no widely accepted definition of a bull or a bear period, the time period *n* of our analysis takes three possible values, $n = 3$, 4, and 5 months. In this way, we allow the readers to concentrate on the findings that best suit their intuition of a bull or a bear market.[13]

Table 4.4 presents some descriptive statistics for these periods for both the All Share Index and the FTSE/ASE 20 Index. In the case of $n = 3$, for the All Share Index (for the period September 24, 1997 to December 31, 2003), there are 5 disjoint "bull" periods, i.e., periods containing at least three consecutive positive monthly returns. These periods contain 25 monthly observations, or 32.9% of the sample. The "bear" periods are 6 and the number of observations falling into these periods is 21, or 27.6% of the sample. The "normal" periods, i.e., periods with at most two consecutive monthly returns with the

tax is also applied in the conditional variance of returns equations.

[13] Hardouvelis and Theodossiou (2002) apply the same definition of a bull or a bear period when examining the possible existence of an asymmetric relation between initial margin requirements and stock market volatility in the U.S.

same algebraic sign, are 30 (= 76-25-21), or 39.5% of the sample. It should be noted that as the time period n increases the number of bull and bear periods (as well as the number of observations in them) decline. At the longest time period, we examine the time period of five months, the bull periods are 3 and the bear periods 1, and jointly they cover only 30.3% of the sample.

The conditional variance of returns equation, including the asymmetric relation between transaction tax and volatility during bull and bear periods, is specified as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \gamma_T T_{t-1} + \delta_{TBEAR} \text{BEAR}_t T_{t-1} + \zeta_{TBULL} \text{BULL}_t T_{t-1}, \quad (4.2)$$

where $\alpha_0 \geq 0$, and α_i, $\beta_j \geq 0$ to ensure $\sigma_t^2 > 0$.

The sum of the coefficients α_i and β_j, that is, the lags of the squared return and the conditional variance respectively, denote the degree of persistence in the conditional variance given a shock to the system. In particular, the above sum should be less than 1 in order to have a stationary variance. As the sum tends to 1 the higher is the instability in the variance and shocks tend to persist instead of dying out [see Engle and Bollerslev (1986)].[14]

The coefficient, γ_T, captures the influence of transaction tax on volatility during normal periods and therefore this will enable us to compare our results to those of previous studies.[15] As mentioned earlier, the proponents of STTs argue that the purpose

[14] For a detailed explanation of ARCH models see Bera and Higgins (1993), and for a review of ARCH modelling in finance see Bollerslev *et al.* (1992).

[15] In essence, normal periods in this case refer to the full sample.

of these taxes is to reduce market volatility and excessive trading [see e.g. Roll (1989)]. Based on this, the second hypothesis to be tested is set up as follows:

$$H2: \gamma_T < 0$$

The coefficients δ_{TBEAR} and ζ_{TBULL}, allow for a different relationship between transaction tax and volatility during bear and bull periods respectively. To check for a possible asymmetry effect across bear and bull periods, we define two dummy variables, $BEAR_t$ and $BULL_t$, which take the value of unity during bear and bull periods respectively and the value zero otherwise. As previously defined, bear and bull periods represent periods of at least three, four or five consecutive (n = 3, 4 or 5) total monthly returns of the same algebraic sign.

It is important to note, that by differentiating the bull periods, we are effectively trying to capture the transaction tax effect on volatility at a time when it should have its greatest impact, as a result of the higher trading activity. Indeed, if the proponents of STTs argue that these taxes should reduce market volatility and excessive trading during normal periods, then the effect on volatility should be even greater during bull periods. Based on this explanation, the presence of transaction taxes is expected to have a significantly negative effect on volatility during bull periods and therefore this sets up the third testable hypothesis as follows:

$$H3: \zeta_{TBULL} < 0$$

Further to the above, if the purpose of STTs is to reduce market volatility and excessive trading during normal and bull periods, then the complementary objective of these taxes should be to support and boost liquidity, which may result in higher volatility, during bear periods. In other words, the presence of transaction taxes should have a significantly positive effect on volatility during bear periods. This symmetric effect of transaction taxes on volatility during bear periods sets up the fourth hypothesis to be tested as follows:

$$\text{H4: } \delta_{TBEAR} > 0$$

An interesting issue relating to the volatility of stock returns is the question of the asymmetric impact of good news (market advances) and bad news (market retreats) on volatility. That is, negative shocks (bad news) raise volatility more than positive shocks (good news) in the market. This phenomenon has been attributed to the "leverage effect" [see e.g. Black (1976), Nelson (1991), and Engle and Ng (1993)]. As explained by Black (1976) leverage can induce future stock volatility to vary inversely with the stock price; a fall in a firm's stock value relative to the market value of its debt causes a rise in its debt-equity ratio and increases its stock volatility.[16]

The specification of short-term market volatility in terms of the natural logarithm of the conditional variance of returns, follows the work of Nelson (1991) with some modifications, which allow for a possible nonlinear and asymmetric association between transaction tax and conditional volatility. It is known as Nelson's (1991) EGARCH model. Thus, equation (4.2) of the GARCH-M(p,q) model is modified as follows:

$$\ln(\sigma_t^2) = \alpha_0 + \sum_{i=1}^{p} \alpha_i |\varepsilon_{t-i}/\sigma_{t-i}| + \sum_{i=1}^{p} \eta_i (\varepsilon_{t-i}/\sigma_{t-i}) + \sum_{j=1}^{q} \beta_j \ln(\sigma_{t-j}^2) + \gamma_T T_{t-1} + \ldots$$

$$\ldots + \delta_{TBEAR} \mathrm{BEAR}_t T_{t-1} + \zeta_{TBULL} \mathrm{BULL}_t T_{t-1}. \qquad (4.3)$$

[16] Kavussanos and Phylaktis (2001) have also tested for the leverage effect using the EGARCH formulation of Nelson (1991). They examine the interaction of stock returns and trading activity in the ASE under different trading systems.

Unlike the linear GARCH-M(p,q) model there are no restrictions on the parameters α_0, α_i, η_i and β_j to ensure non-negativity of the conditional variance. Persistence of volatility is measured by β_j. The asymmetric effect of negative and positive shocks is captured by η_i and α_i respectively; η_i measures the sign effect and α_i measures the size effect. If $\eta_i < 0$ a negative shock (bad news) tends to reinforce the size effect. The converse takes place when $\eta_i > 0$. Bad news will mitigate the size effect.

4.5 Empirical analysis

4.5.1 Data

The data set comprises closing daily observations of the All Share Index and the FTSE/ASE 20 Index from September 24, 1997 to December 31, 2003, giving us in total 1,564 observations.[17,18] The data is collected from the ASE records. The FTSE/ASE 20 Index comprises of the 20 largest in market capitalisation and most highly traded stocks of all the companies listed on the ASE. At the end of 2003, the market capitalisation of FTSE/ASE 20 Index was 39.45% of the total market capitalisation and the total number of companies listed on the ASE was 355.[19]

The daily stock returns r_t are calculated as the logarithmic first difference of the price index, using the formula $r_t = (\ln p_t - \ln p_{t-1}) * 100$, where p_t is the stock index price in period t. Note that returns are expressed in a continuously compounded percentage

[17] Daily closing data for the FTSE/ASE 20 Index is available since the establishment of this large cap index on September 24, 1997.
[18] The price indices are not adjusted for dividend payouts. Schwert (1990) and Gallant *et al.* (1992) show that volatility estimates are not influenced appreciably by dividends.
[19] The figure includes companies whose shares have been suspended from trading.

form. The data on transaction tax, T_{t-1}, is expressed in decimals and, thus, can vary from zero to one.

To assess the distributional properties of the daily stock returns various descriptive statistics are reported in Table 4.5. As can be seen the return series is negatively skewed for the All Share Index and positively skewed for the FTSE/ASE 20 Index and highly leptokurtic for both indices compared to the normal distribution. The returns series display significant first order autocorrelation. The Ljung-Box (1978) Q(20) statistic for 20th order autocorrelations is statistically significant, while the Ljung-Box test statistic $Q^2(20)$ (for the squared data) indicates the presence of conditional heteroskedasticity.

The empirical results for the All Share Index and FTSE/ASE 20 Index from September 24, 1997 to December 31, 2003, are presented in the next section.

4.5.2 Estimates of the conditional mean and variance equations of stock returns

The following subsections present the maximum likelihood estimates of the various GARCH-M(*p,q*)/EGARCH-M(*p,q*) models for daily stock index returns. In Tables 4.6 and 4.7, different versions of the model are presented, with and without the presence of transaction taxes. Each table has three panels. Panel A presents the estimates of the conditional mean equation, Panel B presents the estimates of the conditional volatility equation, and Panel C presents the model diagnostics. The tables present the estimation results for the All Share Index and FTSE/ASE 20 Index from September 24, 1997 to December 31, 2003.

The appropriate GARCH-M(p,q)-ARMA(p,q) model is selected using mainly the Akaike (AIC) and Schwarz (SIC) information criteria, but also taking into account the significance of the coefficients, the Ljung-Box test statistics Q(20) and $Q^2(20)$, and the sum of the coefficients α_i and β_j [β_j for EGARCH-M(p,q)-ARMA(p,q) model]. Moreover, if our modelling is correctly specified, the value of the coefficients of skewness and kurtosis of the standardised residuals should be smaller than the value of skewness and kurtosis of the stock index returns series respectively.

An iterative procedure is used based upon the method of Marquardt to maximise the log-likelihood function. The quasi-maximum likelihood procedure of Bollerslev and Wooldridge (1992) is also applied, in order to estimate robust standard errors and covariance.

4.5.2.1 All Share Index

Table 4.6 reports the estimated results of different versions of the selected EGARCH-M(1,3)-ARMA(3,1) model for daily stock returns for the period September 24, 1997 to December 31, 2003.[20] Model 1 includes the conditional variance in the mean equation, model 2 adds the transaction tax coefficient in the mean and variance equations, while models 3, 4 and 5 include the bear and bull coefficients in the variance equation, for the periods three, four or five consecutive (n = 3, 4 or 5) total monthly returns respectively, as previously defined. Model 2, which includes the transaction tax coefficient in the variance equation, will enable us to compare our results to those of

[20] We use EGARCH-M(p,q) modelling to examine the relationship between transaction tax and the conditional moments – mean and variance – of daily stock market returns, since the leverage effect coefficient has been found to be statistically significant at the 5% level.

earlier studies, which also examine the effect of transaction taxes on volatility during normal periods.

In Panel A of Table 4.6, daily stock market returns are modelled using an ARMA(3,1) process. The presence of serial correlation in daily stock returns is evident, since the ARMA(3,1) process modelled, presents statistically significant terms. This is not surprising since a reason for serial correlation is thin trading, with individual stocks in the index not all trading exactly at the close. Lo and Mackinlay (1988) discuss the effects of non-synchronous trading on autocorrelations. Their view is that since small capitalisation stocks trade less frequently than larger stocks, new information is absorbed first into large capitalisation stock prices and then into smaller stocks with a lag. This lag induces a positive serial correlation.

For the day of the week effects on the level of returns, dummy variable, a_5, which equals one if the trading day is a Friday, is positive and statistically significant at the 10% level apart from model 2. This could be due to higher trading activity on the last day of the week, as a result of investors' reluctance to leave any trading positions open during the weekend. This is in agreement with earlier studies on developed markets, although they find in addition a negative day of the week effect on Mondays, and in the case of the Greek capital market on Wednesdays.[21]

The coefficient, e, for the conditional variance is statistically significant in all models, indicating that there is very strong positive association between conditional stock market volatility and conditional mean returns, consistent with the CAPM theory, which assumes a positive linear relationship between μ and σ^2.

[21] See Kohers and Kohers (1995), and Mills *et al.* (2000), for the case of the Greek capital markets.

The coefficient, b_T, which captures the effect of the transaction tax on the conditional mean of returns is negative, however it is statistically insignificant and therefore H1 is rejected. Hardouvelis and Theodossiou (2002) also report a negative and statistically insignificant association between margin requirements and conditional mean of returns.

Panel B of Table 4.6 presents the results for the conditional variance of returns. The leverage effect coefficient, η_1, is found to be negative and statistically significant at the 5% level, indicating the existence of an asymmetric effect in daily stock index returns during the sample period. In addition, α_1 is positive and statistically significant at the 5% level, indicating that it is both the direction of news measured by η_1 and the size of the news measured by α_1, which exerts an asymmetric impact on volatility. The relative importance of the asymmetry is measured by the ratio $|-1+\eta_1|/(1+\eta_1)$.[22] This statistic is greater than one, equal to one, and less than one for negative asymmetry, symmetry, and positive asymmetry respectively. In our case the ratio varies from 1.09 to 1.13, i.e., there is a negative asymmetry. Negative innovations increase volatility approximately between 1.09 to 1.13 times more than positive innovations. This result is in line with those expected by the leverage effect and found by other studies [e.g. Booth *et al.* (1997)].

It should be noted that the coefficients, β_j, for the logarithm of past conditional variances are similar across the five models of Table 4.6, regardless of model specification. The sum of the coefficients for the logarithm of past conditional variances is close to unity, indicating high persistence of volatility over time.

The coefficient, γ_T, which captures the association between the level of transaction tax and volatility, is close to zero and statistically insignificant in all versions of the model, hence H2 is rejected. The results are consistent with the findings of previous studies, like Roll (1989), Saporta and Kan (1997), and Hu (1998), who also find a statistically insignificant effect of transaction taxes on volatility.

The association of transaction tax with volatility is also weak during bear periods. The coefficient, δ_{TBEAR}, is positive but statistically insignificant for $n = 4$ and 5 and only statistically significant at the 10% level for $n = 3$, hence rejecting H4. The coefficient, ζ_{TBULL}, is positive and statistically significant indicating a stronger (more positive) relation between transaction tax and volatility during bull periods relative to normal periods, therefore also rejecting H3.

Thus, our results show that transaction tax increases volatility during bull periods. Conversely, transaction tax does not have a significant effect on volatility during bear periods. Indeed, the empirical results signify the importance of considering the differential effect of transaction tax on volatility during bear and bull periods. That is, in model 2 when coefficients δ_{TBEAR} and ζ_{TBULL} are not included, we find transaction tax not to have a significant effect on the volatility of stock returns during normal periods. Consequently, the findings of previous studies, which did not take into account this differential effect of transaction tax on volatility, should be treated with some caution.

As mentioned above, we find transaction tax to have a positive effect on volatility when there is a bull market. That is, we find transaction tax to increase volatility when there is higher trading activity, which consequently might be increasing the tax revenue raised by the Government. On the other hand, the increase in volatility during bull periods, defeats the main argument put forward by the proponents of STTs, which is to reduce market volatility and excessive trading [i.e. Roll (1989)].

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[22] See Booth *et al.* (1997).

Panel C of Table 4.6 contains the model diagnostics, that is, m_3 and m_4 are the coefficients of skewness and kurtosis of the standardised residuals respectively, while Q(20) and $Q^2(20)$ are 20th order Ljung-Box statistics of the standardised and squared standardised residuals respectively. The Ljung-Box statistics are used to test the null hypothesis of no serial correlation in the standardised residual and squared standardised residual series, Q(20) and $Q^2(20)$. Serial correlation in the Q(20) series may imply that the conditional mean equation of returns is misspecified. Similarly, serial correlation in the $Q^2(20)$ series may imply that the conditional variance equation of returns is misspecified. The Ljung-Box statistics are calculated using 20 lags.

The Ljung-Box statistics Q(20) and $Q^2(20)$ of the standardised and squared standardised residuals respectively exhibit no serial correlation, in all five models, implying that the conditional mean equation of returns and the conditional variance equation of returns are well specified. Moreover, the coefficients of kurtosis of the standardised residuals have a smaller value, than the kurtosis of the stock index returns series, while the coefficients of skewness of the standardised residuals exhibit an insignificantly larger value.

4.5.2.2 FTSE/ASE 20 Index

Table 4.7 reports the estimated results of different versions of the selected GARCH-M(1,3)-ARMA(3,1) model for daily stock returns for the period September 24, 1997 to December 31, 2003. We have selected GARCH-M(p,q) modelling to examine the relationship between transaction tax and the conditional mean and variance, since the leverage effect coefficient has been found to be statistically insignificant.

In Panel A of Table 4.7, the presence of serial correlation in daily stock returns is less evident than in the All Share Index, since the ARMA(3,1) process presents statistically insignificant terms. This is not surprising as non-synchronous trading is less evident in the FTSE/ASE 20 Index.

As in the All Share Index, we find some evidence for a day of the week effect on the level of returns. Dummy variable, a_5, which equals one if the trading day is a Friday, is positive and statistically significant at the 5% level in models 3 to 5, indicating higher trading activity on the last day of the week, as a result of investors' willingness to close any trading positions before the weekend.

As in Table 4.6, for the All Share Index, we find the coefficient, e, for the conditional variance to be statistically significant in all models, indicating that there is very strong positive association between conditional stock market volatility and conditional mean returns, consistent with the CAPM theory. The coefficient, b_T, which captures the effect of the transaction tax on the conditional mean of returns, is also negative and statistically insignificant, therefore rejecting H1.

Panel B of Table 4.7 presents the results for the conditional variance of returns. It should be noted that the coefficients α_i and β_j, for past squared return and past conditional variances respectively, are similar across the five models of Table 4.7, regardless of model specification. The sum of the coefficients of past squared return and past conditional variances is close to unity, indicating high persistence of volatility over time.

The coefficient, γ_T, which captures the association between the level of transaction tax and volatility, is close to zero and statistically insignificant in all versions of the model, similar to the results for the All Share Index, hence rejecting H2.

Although the transaction tax does not have an effect on volatility during normal periods, it has a substantial effect on volatility during bear and bull periods. In all three frequencies, the coefficient, δ_{TBEAR}, is negative and statistically significant at the 5% level, hence rejecting H4. In addition to the negative and significant coefficient δ_{TBEAR}, the coefficient, ζ_{TBULL}, is positive and statistically significant as well, indicating a stronger (more positive) relation between transaction tax and volatility during bull periods relative to normal periods, therefore also rejecting H3.

The results show that the transaction tax increases volatility during bull periods and the effect is even stronger when comparing it to the All Share Index, i.e., ζ_{TBULL} is greater for FTSE/ASE 20 Index. This could be the result of the higher trading activity that takes place for the 20 largest and most liquid stocks. It could that, in a rising market investors are less affected by the presence of transaction taxes, and instead buy stocks in anticipation that the market will continue to rise and subsequently close their trading positions with profits.

Furthermore, the results show that the transaction tax reduces volatility during bear periods, as indicated by the negative and statistically significant δ_{TBEAR} coefficient. This could be because in a falling market investors are not only reluctant to buy any stocks, but they also become more price sensitive and consider the additional cost of the transaction tax.

The imposition of the transaction tax has been successful in reducing market volatility during bear periods, apparently supporting the arguments put forward by the proponents of STTs. However, the transaction tax should act as a mechanism to decrease volatility and excessive trading during bull periods, and support and boost liquidity, which may result in higher volatility during bear periods.[23]

These results do not support the historical decisions with regard to changes of the level of the transaction tax, which supported the use of the tax as a mechanism to control volatility other than the obvious reason of raising revenue. The ASE raised the transaction tax from 0.3% to 0.6% on October 8, 1999, in order to prevent the excesses of an ongoing bull market, and lowered the transaction tax from 0.6% to 0.3% on January 3, 2001, with the intention of simply counteracting the earlier increase once it believed that the excesses of the earlier bull market were over.[24]

Panel C of Table 4.7 contains the model diagnostics, which confirm that the conditional mean and variance equation of returns are well specified.

4.6 Summary and main policy conclusions

The effects of stock transaction taxes on financial markets are not only of interest to academics, but these are of practical concern to policy makers. Empirical studies carried out so far have not been able to conclusively resolve the debate on the effects of transaction taxes on financial markets.

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[23] It is important to note that when interpreting the results of the effects of transaction taxes on volatility during bull and bear periods, one should consider the unique market conditions that prevailed at the time. The sample period captures the important measures and efforts of the Greek Government to successfully join the EMU, as well as the significant regulatory, structural and technological changes in the Greek financial markets, which resulted in the upgrade by international investment houses to developed status. Furthermore, any decisions by the Government regarding the changes in transaction taxes were announced either as part of the annual tax reforms or other measures, which intended to assist in the attempts for entry into the Eurozone, but also to support and boost the stock exchange's prospects. In the whole discussion concerning the effects on volatility, one should not forget the trading behaviour of the different types of investors as a result of changes in transaction taxes, an assertion which is not considered in our estimations.

[24] See Figure 4.1 for developments in the stock market over this period. As it can be seen, the All Share Index and the FTSE/ASE 20 Index reached their all time highs of 3,067.04 points and 3,301.69 points (closing prices) on October 13, 1999 and September 20, 1999, respectively. The stock market followed a downward trend thereafter.

The current study has added two different dimensions to the examination of STTs, which should make one treat the results of previous studies with caution. We have investigated, on the one hand, the possibly different effect of the transaction tax on the most highly traded stocks, and on the other hand, the potentially different effect of the transaction tax depending on the state of the stock market.

In our analysis, we use different versions of the selected GARCH-M(p,q)/EGARCH-M(p,q) models to investigate the relationship between transaction tax and the conditional mean and variance, during bull, normal and bear periods of daily stock returns, using both a marketwide index like the All Share Index and a large cap index like the FTSE/ASE 20 Index, for the sample period September 24, 1997 to December 31, 2003.

The empirical results can be summarised as follows: First, the transaction tax does not have a significant effect on the mean of daily stock returns for both indices. Second, the transaction tax does not have an effect on the volatility of daily stock returns during normal periods for both indices, and being consistent with the findings of previous studies. Third, the transaction tax increases volatility during bull periods, but does not have a significant effect on volatility during bear periods for the All Share Index. Fourth, the transaction tax increases volatility during bull periods for the FTSE/ASE 20 Index, and the effect is even stronger when comparing it to the All Share Index. This might be the result of the higher trading activity that takes place for the 20 largest and most liquid stocks. Finally, the transaction tax reduces volatility during bear periods for the FTSE/ASE 20 Index, as indicated by the negative and statistically significant δ_{TBEAR} coefficient.

The empirical findings signify the importance of considering the differential effect of transaction tax on volatility during bear and bull periods. Consequently, the findings of previous studies, which did not take into account this differential effect of transaction tax on volatility, should be treated with caution.

Nevertheless, our empirical results have highlighted that the transaction tax increases volatility during bull periods, when the objective is to reduce volatility and excessive trading, and decreases volatility during bear periods, when the objective should be to support and boost liquidity and volatility. Thus, the use of transaction taxes, at least in the ASE, has not had the desired effect on volatility, since decisions concerning the changes in the transaction tax seem to have been taken with the intention of controlling volatility.

Appendix 4A: Transaction taxes in developed economies

STTs have been a common policy tool throughout the world. STTs have operated in major financial markets including Japan, the U.K., Germany, Italy, and France. Smaller OECD economies, such as Australia, Austria, Belgium, Denmark, Greece, and Ireland, and many emerging economies, such as Chile, China, India, and Malaysia have also operated with STTs. The following section provides a description of STTs that have operated in developed economies.

The U.S. has a 0.003% transaction tax levied on the majority of stock transactions. The tax, which is known as a Section 31 fee, was introduced in the Securities Exchange Act of 1934 to cover the annual operating costs of the Securities and Exchange Commission (SEC). The federal government collected $1.8 billion in revenue from these fees in 1998, which was approximately five times the annual operating costs of the SEC.

The U.K. charges a 0.5% stamp duty and stamp duty reserve tax (SDRT) on equity and other financial transactions. The stamp duty is levied on a document specifying a financial transaction. The SDRT is levied on a verbal, electronic, or other agreement to transact (dematerialised) financial assets. Trades in U.K. registered shares outside the U.K. are liable to stamp duty only after the document enters the U.K. The SDRT has no territorial restrictions. The stamp duty and SDRT are payable by the purchasing party.[25] According to the Stamp Office, 2.1 billion pounds was collected from securities transactions during the 1998-1999 fiscal year.[26]

[25] The rationale for the imposition of the stamp duty and SDRT on the purchasing and not the selling party is that only the purchasing party has the need to prove the legal title to an asset in the event of a dispute.
[26] The stamp duty is also levied on property-related transfer of legal ownership. The amount collected from property-related transactions, during the 1998-1999 fiscal year, was approximately 2.5 billion pounds.

Belgium has a 0.17% transaction tax on stocks and a 0.07% tax on bonds. Transactions in other financial instruments are also subject to taxes of varying rates. Both buyers and sellers are subject to the tax, but the tax base is calculated differently. For the buyers, the tax base includes brokers' commissions, while for the sellers it does not. There is a ceiling of 10,000 Belgian francs on the joint amount payable. Financial intermediaries trading on their own behalf, some institutional investors, and non-residents are exempt from the tax. In addition, transactions done without a professional intermediary are also exempt from the tax.

France has a 0.15% transaction tax on equity trades exceeding 1 million francs. For transactions below 1 million francs the rate is 0.3%. The tax is payable by both parties. An allowance of 150 francs is applied to the tax due on each trade. This means that transactions valued below approximately 50 thousands francs are effectively exempt from the tax. There is also a ceiling of 5,000 francs on the total amount of tax payable. Shares of companies listed on the Nouveau Marché and former regional exchanges are exempt from the tax. Non-residents are also exempt from the tax when trading on the Paris Bourse.

Italy has a 0.14% stamp duty on domestic off-exchange transactions. The tax is collected by the brokers and then remitted to the government. Domestic transactions instituted abroad are exempt from the tax.

Switzerland has a stamp duty on transactions in which one of the parties is a certified domestic securities broker. The tax rate is 0.15% for transactions in Swiss securities and 0.3% for those in foreign securities. However, members and remote members of the Swiss exchange pay a 0.15% tax on trades in foreign securities. The tax is split evenly between the buyer and the seller. The broker is liable to the tax. The exchange calculates the tax and the settlement system collects it. Transactions in Swiss shares outside the country and trading in Eurobonds are exempt from stamp duty. In addition, starting January 2001, foreign institutional investors such as state and central banks, investment funds, social security organisations, pension funds, life insurance companies, as well as domestic investment funds and domestic participants of a foreign exchange are exempt from stamp duty. In addition to stamp duty, the Swiss exchange levies a share turnover fee of 0.0001%. The fee is also split evenly between the parties. A portion of collected fees covers operational costs of the Federal Banking Commission. Authorised official dealers are exempt from the fee.

Japan eliminated STTs in April 1999. Previously, individuals and corporations were liable to differentiated STTs. The tax was levied on the seller only. The tax rates varied according to the type of security and the type of seller. Lower tax rates applied to licensed securities companies. Transactions in stocks were subject to a tax of 0.3% of the sale price for sellers that are not licensed securities companies and 0.12% for those with a license. Trades in debentures were taxed at 0.16% and 0.06%, respectively. Transactions in bonds were subject to a tax of 0.03% and 0.01%, for the non-licensed and licensed sellers. Taxes were either collected by the securities companies and remitted to the government or were paid directly by the seller.

The trend in developed countries has been toward lowering or eliminating the STTs. For example, Sweden and Finland experimented with STTs and decided to eliminate them in the early 1990's. Germany abolished the stock exchange turnover tax and the tax on bills and notes in 1991. Canada and Netherlands no longer have STTs.[27]

[27] The description of STTs that have operated in developed economies, contained in the Appendix 4A, is drawn from Habermeier and Kirilenko (2001).

Tables: **Table 4.1**

Security Transaction Taxes in the World

Country	Stocks	Corporate Bonds	Government Bonds	Futures	Detail
Australia	0.3%	0.15%	-	-	Reduced twice in 1990's; currently 0.15% each on buyer and seller
Austria	0.15%	0.15%	-	-	Present
Belgium	0.17%	0.07%	0.07%	-	Present
Chile	18% VAT on trade costs	18% VAT on trade costs	-	-	Present
China	0.5% or 0.8%	[0.1%]	-	-	Tax on bonds eliminated 2001; higher rate on stock transactions applies to Shanghai exchange
Denmark	[0.5%]	[0.5%]	-	-	Reduced in 1995, 1998; abolished effective Oct. 1999
Finland	1.6%	-	-	-	Introduced January 1997; applies only to trades off HEX (main electronic exchange)
France	0.15%	See note	See note	-	Present
Germany	[0.5%]	0.4%	0.2%	-	Removed 1991
Greece	0.3%	-	-	-	Imposed 1998; doubled in 1999; halved in 2001
Hong Kong	0.3%+$5 stamp fee	[0.1%]	[0.1%]	-	Tax on stock transactions reduced from 0.6% 1993; tax on bonds eliminated Feb. 1999
India	0.5%	0.5%	-	-	Present
Ireland	1%	-	-	-	Present
Italy	[1.12%]	-	-	-	Stamp duties eliminated 1998
Japan	[0.1%], [0.3%]	[0.16%]	-	-	Removed April 1999
Korea	0.3%	-	-	-	Present
Malaysia	0.5%	0.5%	0.015%, [0.03%]	0.0005%	Present

Netherlands	[0.12%]	[0.12%]	-	-	1970 – 1990
Portugal	[0.08%]	[0.04%]	[0.008%]	-	Removed 1996
Sweden	[1%]	-	-	-	Removed 1991
Switzerland	0.15%	0.15%	0.15%	-	Present; 0.3% on foreign securities; 1% on new issues
Taiwan	0.3%, [0.6%]	0.1%	-	0.05%	Reduced 1993
U.K.	0.5%	-	-	-	Present

Notes: [...] indicates former tax rate. Sources ambiguous as to whether tax applies to bonds in France. Austria, Belgium, Finland, Germany, Italy, Japan, and Portugal also impose VAT type taxes on commodity future trades.
Source: Pollin, Baker and Schaberg (2001).

Table 4.2
Volatility Effects of Transaction Taxes

Author	Market	Sign of Effect
Roll (1989)	23 countries	Zero
Umlauf (1993)	Sweden	Positive
Jones and Seguin (1997)	U.S.	Positive
Saporta and Kan (1997)	U.K.	Zero
Hu (1998)	Hong Kong, Japan, Korea, Taiwan	Zero
Green, Maggioni and Murinde (2000)	U.K.	Positive
Hau (2006)	France	Positive

Table 4.3
Stock Transaction Taxes in the ASE

Effective Date	Transaction Taxes
19/02/1998	0.3%
08/10/1999	0.6%
03/01/2001	0.3%
02/01/2005	0.15%

Notes: The tax rate applies on the selling of shares transacted in the stock exchange.

Table 4.4

Descriptive Statistics for Bull, Bear and Normal Periods

	$n = 3$	$n = 4$	$n = 5$
Panel A. All Share Index (September 24, 1997 – December 31, 2003)			
Number of obs. in bull periods	25 (32.9%)	22 (28.9%)	18 (23.7%)
Number of bull periods	5	4	3
Number of obs. in bear periods	21 (27.6%)	9 (11.8%)	5 (6.6%)
Number of bear periods	6	2	1
Number of obs. in normal periods	30 (39.5%)	45 (59.2%)	53 (69.7%)
Number of normal periods	25	30	32
Panel B. FTSE/ASE 20 Index (September 24, 1997 – December 31, 2003)			
Number of obs. in bull periods	22 (28.9%)	16 (21.1%)	16 (21.1%)
Number of bull periods	5	3	3
Number of obs. in bear periods	18 (23.7%)	9 (11.8%)	5 (6.6%)
Number of bear periods	5	2	1
Number of obs. in normal periods	36 (47.4%)	51 (67.1%)	55 (72.4%)
Number of normal periods	27	32	33

Notes: n is the number of consecutive monthly stock returns with the same algebraic sign. n takes three possible values, 3, 4 and 5 months. Numbers in brackets denote the proportion of observations in each category as a percent of the sample.

Table 4.5
Summary Statistics of Daily Stock Index Returns

	All Share Index (24/09/1997-31/12/2003)	FTSE/ASE 20 Index (24/09/1997-31/12/2003)
Mean	0.022	0.009
Std. Deviation	1.962	1.975
Minimum	-9.674	-9.605
Maximum	10.727	8.681
Skewness	-0.017	0.114
Kurtosis	5.500	5.464
ρ_1	0.163*	0.163*
ρ_2	0.014	0.029
ρ_3	0.032	0.018
ρ_4	0.002	0.005
ρ_5	-0.018	-0.022
ρ_6	-0.011	-0.017
ρ_7	-0.003	-0.009
ρ_8	0.006	0.017
ρ_9	0.043	0.018
ρ_{10}	0.042	-0.001
Q(20)	62.78*	59.03*
$Q^2(20)$	289.26*	302.07*

Notes: Stock index return is calculated as $r_t = (\ln p_t - \ln p_{t-1}) * 100$, where p_t is the stock index price in period t. ρ_i, where i = 1,...,10 are sample autocorrelations. * denotes significance of diagnostic statistics at the 5% level. Q(20) and $Q^2(20)$ for the squared data, are Ljung-Box statistics of 20^{th} order.

Table 4.6

EGARCH-M(1,3)-ARMA(3,1) Estimation of Daily Stock Index Returns All Share Index (24/09/1997-31/12/2003)

Coefficients	Model 1	Model 2	Model 3	Model 4	Model 5
Panel A. Conditional mean of returns					
a_0	-0.220*	-0.024	-0.135	-0.144	-0.136
	(-2.047)	(-0.085)	(-0.733)	(-0.790)	(-0.761)
a_1	-0.080	-0.071	-0.106	-0.119	-0.097
	(-0.573)	(-0.515)	(-0.769)	(-0.896)	(-0.704)
a_2	-0.099	-0.055	-0.097	-0.084	-0.093
	(-0.860)	(-0.465)	(-0.845)	(-0.733)	(-0.817)
a_4	0.057	0.041	0.074	0.072	0.063
	(0.557)	(0.394)	(0.707)	(0.686)	(0.603)
a_5	0.218**	0.184	0.203**	0.218**	0.226**
	(1.875)	(1.559)	(1.723)	(1.874)	(1.916)
b_T		-0.647	-0.450	-0.437	-0.408
		(-0.788)	(-0.883)	(-0.852)	(-0.825)
c_1	0.567*	1.092*	0.535*	0.484**	0.515**
	(2.344)	(28.829)	(2.128)	(1.771)	(1.896)
c_2	-0.082**	-0.157*	-0.074	-0.070	-0.072
	(-1.729)	(-3.516)	(-1.518)	(-1.362)	(-1.443)
c_3	0.080*	0.035	0.079*	0.079*	0.075*
	(2.557)	(1.154)	(2.541)	(2.586)	(2.457)
d_1	-0.414**	-0.937*	-0.380	-0.326	-0.366
	(-1.682)	(-34.894)	(-1.493)	(-1.178)	(-1.325)
e	0.064*	0.069*	0.084*	0.084*	0.076*
	(2.695)	(2.464)	(3.425)	(3.427)	(3.123)
Panel B. Conditional variance of returns					
α_0	-0.107*	-0.106*	-0.101*	-0.097*	-0.096*
	(-4.731)	(-4.075)	(-3.664)	(-3.351)	(-3.524)
α_1	0.189*	0.180*	0.179*	0.180*	0.186*
	(5.335)	(5.145)	(5.241)	(5.075)	(5.280)
β_1	1.739*	1.753*	1.726*	1.698*	1.722*
	(15.277)	(14.530)	(15.129)	(13.261)	(14.657)
β_2	-1.358*	-1.374*	-1.344*	-1.291*	-1.331*
	(-6.885)	(-6.746)	(-6.930)	(-6.031)	(-6.616)
β_3	0.588*	0.592*	0.583*	0.550*	0.570*
	(5.613)	(5.659)	(5.675)	(4.969)	(5.304)
γ_T		0.004	-0.036	-0.012	-0.026
		(0.091)	(-0.739)	(-0.232)	(-0.535)
			$n = 3$	$n = 4$	$n = 5$
δ_{TBEAR}			0.049**	0.036	0.053
			(1.727)	(1.086)	(1.451)
ζ_{TBULL}			0.096*	0.118*	0.075**
			(2.685)	(2.765)	(1.891)
η_1	-0.042**	-0.048*	-0.053*	-0.059*	-0.049*
	(-1.950)	(-2.232)	(-2.439)	(-2.668)	(-2.099)

Panel C. Model diagnostics

m_3	0.084	0.052	0.033	0.004	0.073
m_4	4.738	4.771	4.585	4.587	4.753
$X^2(2)$	198.36*	204.79*	163.72*	163.90*	201.15*
Q(20)	18.865	16.151	15.777	14.878	16.333
$Q^2(20)$	18.628	23.015	19.501	18.944	18.544

Notes: For the specification of the EGARCH-M(1,3)-ARMA(3,1) model refer to equations (4.1) and (4.3) in text. The figures in parentheses are *t*-statistics based on estimated robust standard errors. m_3 and m_4 are coefficients of skewness and kurtosis of the standardised residuals respectively. $X^2(2)$ is the Jarque-Bera-normality test. Q(20) and $Q^2(20)$ are 20th order Ljung-Box statistics of the standardised and squared standardised residuals respectively. * and ** denotes significance at the 5% and 10% level respectively.

Table 4.7

GARCH-M(1,3)-ARMA(3,1) Estimation of Daily Stock Index Returns FTSE/ASE 20 Index (24/09/1997-31/12/2003)

Coefficients	Model 1	Model 2	Model 3	Model 4	Model 5
Panel A. Conditional mean of returns					
a_0	-0.215**	-0.139	-0.349**	-0.287**	-0.272
	(-1.949)	(-0.845)	(-1.923)	(-1.702)	(-1.580)
a_1	-0.077	-0.082	-0.041	-0.051	-0.053
	(-0.529)	(-0.562)	(-0.287)	(-0.372)	(-0.375)
a_2	-0.062	-0.065	-0.025	-0.071	-0.080
	(-0.526)	(-0.556)	(-0.218)	(-0.618)	(-0.678)
a_4	-0.001	0.000	0.004	-0.007	-0.020
	(-0.006)	(0.002)	(0.036)	(-0.064)	(-0.175)
a_5	0.179	0.174	0.258*	0.245*	0.236*
	(1.491)	(1.431)	(2.094)	(2.065)	(1.973)
b_T		-0.221	-0.090	-0.153	-0.149
		(-0.556)	(-0.238)	(-0.417)	(-0.396)
c_1	0.358	0.345	0.370	0.417	0.409
	(0.531)	(0.482)	(0.592)	(0.619)	(0.629)
c_2	-0.046	-0.043	-0.064	-0.070	-0.068
	(-0.423)	(-0.380)	(-0.653)	(-0.630)	(-0.642)
c_3	0.024	0.023	0.027	0.024	0.028
	(0.801)	(0.775)	(0.834)	(0.738)	(0.870)
d_1	-0.202	-0.190	-0.216	-0.255	-0.249
	(-0.299)	(-0.264)	(-0.345)	(-0.377)	(-0.381)
e	0.067*	0.068*	0.111*	0.103*	0.100*
	(2.708)	(2.729)	(3.861)	(3.849)	(3.638)
Panel B. Conditional variance of returns					
α_0	0.145*	0.126*	0.435*	0.554*	0.481*
	(3.319)	(2.085)	(3.129)	(3.091)	(2.977)
α_1	0.125*	0.121*	0.168*	0.163*	0.167*
	(3.499)	(3.498)	(4.050)	(4.009)	(4.024)
β_1	1.241*	1.268*	0.954*	0.938*	0.955*
	(4.725)	(4.945)	(3.163)	(2.977)	(3.120)
β_2	-0.747*	-0.790*	-0.262	-0.220	-0.273
	(-2.054)	(-2.234)	(-0.634)	(-0.506)	(-0.650)
β_3	0.347*	0.369*	0.007	-0.019	0.021
	(2.005)	(2.199)	(0.040)	(-0.103)	(0.116)
γ_T		0.030	0.118	-0.164	-0.097
		(0.176)	(0.395)	(-0.537)	(-0.320)
			$n = 3$	$n = 4$	$n = 5$
δ_{TBEAR}			-0.454*	-1.005*	-0.909*
			(-2.050)	(-3.003)	(-2.657)
ζ_{TBULL}			0.932**	1.134*	1.174*
			(1.941)	(2.067)	(2.163)
Panel C. Model diagnostics					
m_3	0.135	0.134	0.058	0.054	0.076
m_4	4.896	4.887	4.719	4.695	4.847

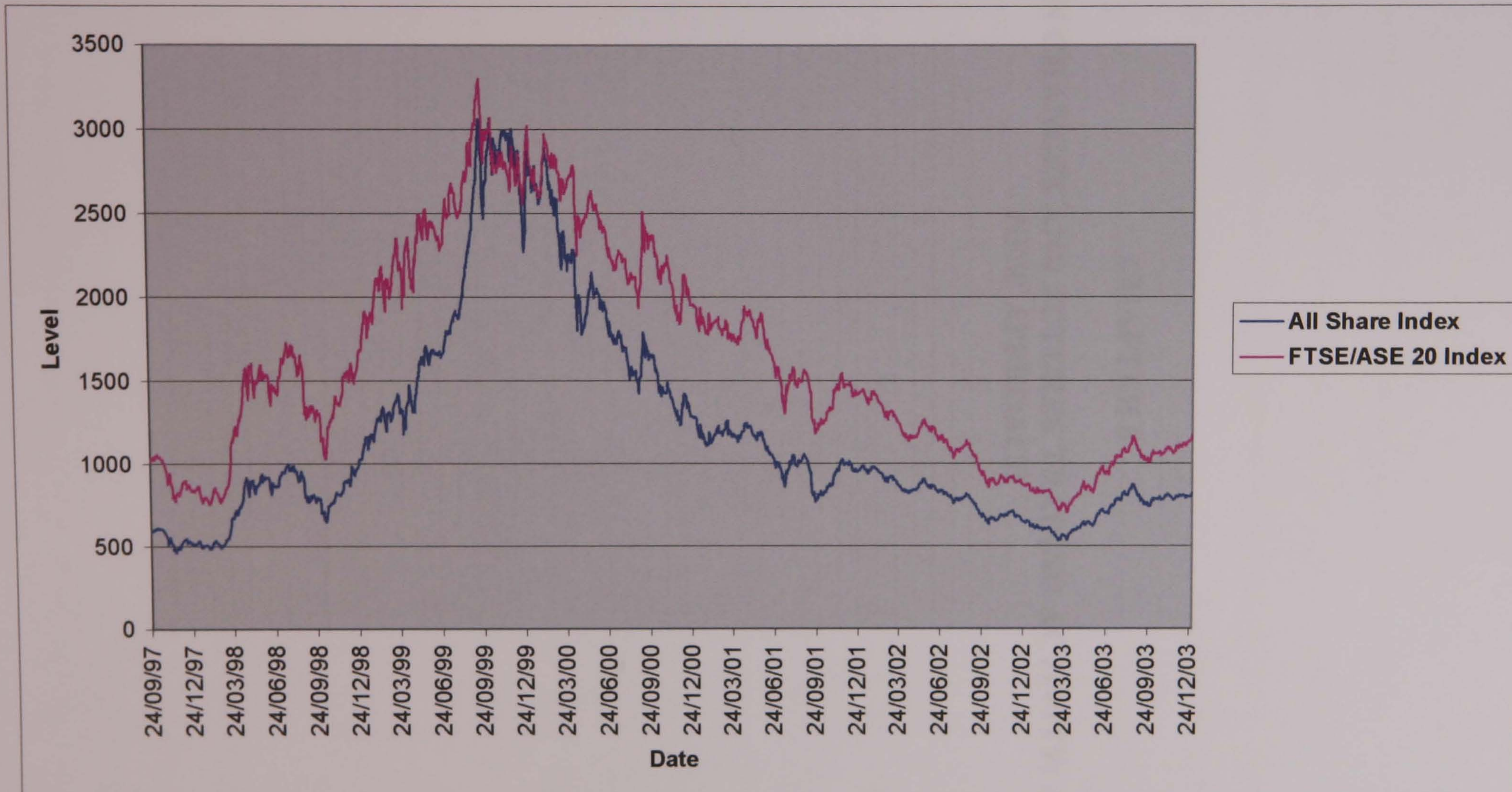
$X^2(2)$	238.70*	236.23*	193.01*	187.57*	223.36*
Q(20)	18.280	18.147	23.514	20.645	21.616
$Q^2(20)$	16.280	16.888	10.289	8.703	9.776

Notes: For the specification of the GARCH-M(1,3)-ARMA(3,1) model refer to equations (4.1) and (4.2) in text. The figures in parentheses are *t*-statistics based on estimated robust standard errors. m_3 and m_4 are coefficients of skewness and kurtosis of the standardised residuals respectively. $X^2(2)$ is the Jarque-Bera-normality test. Q(20) and $Q^2(20)$ are 20th order Ljung-Box statistics of the standardised and squared standardised residuals respectively. * and ** denotes significance at the 5% and 10% level respectively.

<u>Figures:</u> **Figure 4.1**

The Athens Stock Exchange All Share Index and FTSE/ASE 20 Index

Daily – September 24, 1997 to December 31, 2003



Source: ASE

CHAPTER 5

MARGIN CHANGES AND FUTURES TRADING ACTIVITY: A NEW APPROACH

5.1 Introduction

Previous empirical research has generally failed to document a strong inverse association between margin requirements and trading volume as theory suggests. This study revisits the empirical examination of the effects of margin requirements on the trading volume of futures contracts, by applying a new econometric approach. Specifically, the tests are conducted on the stock index futures contracts of the Greek derivatives market, at a period when the Greek economy and financial markets were experiencing important developments, and undergoing significant regulatory and other structural changes.[1]

Futures contracts typically are traded on organised exchanges in a wide variety of physical commodities (including grains, metals and petroleum products) and financial instruments (such as stocks, bonds and currencies). Before 1970, most futures trading was in agricultural commodities, such as corn and wheat. Today, there are successful futures markets in a variety of non-agricultural commodities, including metals such as gold, silver, platinum and copper, and fossil fuels such as crude oil and natural gas. The most widely traded futures contracts are however in financial instruments, such as interest rates, foreign currencies and stock indices. Single-stock futures were banned in the United States (U.S.) for many years but began trading in November 2002.

Traditionally, futures contracts have been traded in an open outcry environment where traders and brokers in brightly coloured jackets shout bids and offers in a trading pit or ring. As of 2006, open outcry is still the primary method of trading agricultural and

[1] These important developments and changes include, among others, the official entry of Greece into the European Economic and Monetary Union (EMU) on January 1, 2001, and the official upgrade of Greek financial markets by Morgan Stanley Capital International (MSCI) from an emerging to developed status on June 1, 2001.

other physical commodity futures in the U.S., but trading in many financial futures in the U.S. has been migrating to electronic trading platforms (where market participants post their bids and offers on a computerised trading system). Almost all futures trading outside the U.S. is now conducted on electronic platforms.

Futures traders are not required to put up the entire value of a contract. Rather, they are required to post a margin that is typically between 2% and 10% of the total value of the contract. Unlike stock margins, margins in the futures markets are not down payments, but are performance bonds that are designed to ensure that traders can meet their financial obligations. When a futures trader enters into a futures position, he or she is required to post initial margin of an amount specified by the exchange or clearing organisation. Thereafter, the position is "marked to the market" daily. If the futures position loses value (i.e. if the market moves against it – e.g. you are buying and the market goes down), the amount of money in the margin account will decline accordingly. If the amount of money in the margin account falls below the specified maintenance margin (which is set at a level less than or equal to the initial margin), the futures trader will be required to post additional variation margin to bring the account up the initial margin level. On the other hand, if the futures position is profitable, the profits will be added to the margin account. It should be noted that brokerage firms often require their customers to maintain funds in their margin accounts that exceed the exchange-specified levels.

A substantial amount of research on margin requirements has been on the relationship between margin requirements and trading volume. Studies have found little evidence of an inverse association between margins and volume although they have documented a small inverse relationship with respect to open interest. Fishe and Goldberg (1986) attempted to examine the effect of margin changes on both open interest and volume around a 3- to 5-day window of such changes. They found, on the one hand, that a 10% increase in margin requirements would reduce open interest by approximately one-third of 1%, and on the other hand it would increase volume traded by 14.62%. Other empirical studies have also failed to identify statistically significant inverse relationships between margins and volume.[2] For example, Hartzmark (1986) investigated 13 contract days calculating whether volume changed significantly from 15 days before to 15 days following the change. He found that in only 4 of 13 occurrences did volume move negatively and significantly in the opposite direction. As a result, the association between margins and volume is also weak over the longer period and does not support the assertion that increased margin requirements will reduce trading volume.

Dutt and Wein (2003) hypothesize that the reason for the empirical findings of previous research is that they have generally failed to consider that margins change when exchange margin committees believe that market risk has changed. In their analysis, they take into account this fundamental principle, by adjusting margins for underlying price risk, using variability estimates before and after each margin change. After controlling for risk, they find a statistically inverse relationship between margins and trading volume, for the 6 futures contracts examined.

The rationale for adjusting the margins by price variability is consistent with both Telser's (1981), and Fishe and Goldberg's (1986) interpretations. Specifically, Telser (1981) argued that it was changes in margins at given levels of risk that would inversely affect volume. Furthermore, Fishe and Goldberg (1986) argued that margin changes that

[2] See Fishe and Goldberg (1986) for an early review.

affect the value of a trader's option to default on the contract will impact trading activity, which is reflected in changes of the ratio of margin levels to price variability.

Although the rationale for adjusting the margins by price variability has been discussed in the literature, previous researchers, with the exception of Dutt and Wein (2003), have generally neglected to consider that margin requirements change in response to changes in volatility, when they empirically examine the relationship between margins and trading volume. According to Dutt and Wein (2003) this is the reason empirical findings on the effects of margin changes on trading volume have been unclear (either statistically significant positive or negative or insignificant), because changes in market risk can have an opposing effect on trading volume. For example, if price volatility increases, it is likely that volume of trading will increase as a result, and this is documented in the literature for the futures markets [see e.g. Jacobs and Onochie (1998)]. At the same time, if exchange margin committees can precisely predict when volatility is increasing, then they will cautiously raise margins [see e.g. Gay, Hunter and Kolb (1986), Fenn and Kupiec (1993), and Chatrath, Adrangi and Allender (2001)]. If increases in margins are a cost to the trader, then we expect that it will have the impact of reducing volume. As a result, because the two forces on volume contradict each other, the predicted impact on volume of a margin increase will be ambiguous.

The concept that margin increases are a cost to the trader is highlighted on the above analysis. Even though some researchers have argued that margins do not impose opportunity costs [Anderson (1981); Black (1976)], the majority of academics believe that margins possibly impose significant opportunity costs [Figlewski (1984); Fishe, Goldberg, Gosnell and Sinha (1990); Gay, Hunter and Kolb (1986); Hartzmark (1986);

and Telser (1981)]. More recently, however, Chatrath, Adrangi and Allender's (2001) empirical findings support that margins do not impose significant opportunity costs.

The relationship between margins and trading volume has important implications for financial regulation. First, the effect of margin changes on volume will relate to the revenue stream generated by trading for the exchanges. For this reason, it is important to correctly assess the costs resulted by such a policy decision on private entities such as exchanges and the financial industry participants. Second, if volume is significantly reduced, liquidity may be impeded, and as a result this may lead to price volatility and ultimately systemic risk to the financial market system.

The aim of this study is to provide further empirical evidence to the debate with regard to the effects of margin changes on trading volume. The main contribution of the paper to the existing literature is that it conducts the investigation of the effects of margin changes on the trading volume of stock index futures, by taking into account, on the one hand, the effect of conditional volatility of stock returns on margin changes, and on the other hand, the relationship between conditional volatility of stock returns and trading volume. This study applies a new econometric methodology to allow for these inter-relationships, which were not considered in previous empirical research. The tests are also conducted on the stock index futures of the Greek derivatives market, a newly established market which was rapidly expanding to match that of its European counterparts, and at a period when the Greek economy and financial markets were experiencing important developments and changes.

Many studies have documented a positive contemporaneous correlation between trading volume and price volatility. Karpoff (1987) provides a review of the early literature and cites 18 separate studies that document this relation in a variety of financial markets including equities, currencies and Treasury bills. This finding of an unconditional volatility-volume relation extends to conditional volatility also. This positive relationship between trading volume and price volatility is relatively well established in the equities markets. For example, Schwert (1989) using monthly aggregates of daily data on Standard & Poor (S&P) composite index in New York Stock Exchange (NYSE) finds a positive relationship between estimated volatility and current and lagged volume growth rates in linear distributed lag and vector autoregression (VAR) models. Lamoureux and Lastrapes (1991) using individual stocks from the S&P index find also a positive conditional volatility-volume relationship in models with Gaussian errors and Generalised Autoregressive Conditional Heteroskedasticity (GARCH)-type volatility specifications.[3] Gallant, Rossi and Tauchen (1992), using nonparametric methods, confirm the positive correlation between conditional volatility and volume, when examining daily S&P data from 1928 to 1987.[4]

In a more recent study, Darrat, Rahman and Zhong (2003) examine the contemporaneous correlations, as well as the lead-lag relations, between trading volumes and return volatility in all 30 stocks comprising the Dow Jones Industrial Average (DJIA). They use intraday return volatility and trading volume, and use an exponential

[3] Their results, however, should be treated with caution as they may be seriously biased due to simultaneity between stock returns and volume. In subsequent work, Lamoureux and Lastrapes (1994) relax the assumption that volume is weakly exogenous by using a mixture model in which a latent common factor restricts the joint density of volume and returns. They use a point-in-time signal extraction procedure to identify this latent process and calibrated simulation to conduct analysis of the viability of the model to explain important properties of the data.

[4] Phylaktis, Kavussanos and Manalis (1996) investigate the relationship between volume and volatility in the Athens Stock Exchange (ASE) in Greece. They find a positive conditional volume-volatility relationship, when they apply a GARCH-type volatility specification and introduce 'lagged' volume in the variance equation. Kavussanos and Phylaktis (2001) also document a strong positive relation between trading activity and conditional volatility, when examining the effects of different trading systems in the

GARCH-in-Mean (EGARCH-M) process to incorporate persistence in return volatility. They adjust their tests for the large-sample problem using posterior odds ratios, and examine the lead-lag relations between volume and volatility using individual and pooled Granger-causality tests. Their results suggest that contemporaneous correlations are positive and statistically significant in only 3 of the 30 DJIA stocks. However, all remaining stocks of the DJIA (27) exhibit no significant positive correlation between trading volumes and return volatility. Such weak evidence of contemporaneous correlations contradicts the prediction of the mixture of distribution hypothesis (MDH) in intraday data. The results support instead the sequential information arrival hypothesis (SIAH) since trading volume and return volatility are found to follow a clear lead-lag pattern in a large number of the DJIA stocks.[5]

The positive relationship between trading volume and price volatility is also documented in the futures markets however it is not as well established as in the equities markets, mainly due to the inconclusive nature of the results reported so far in the literature. For example, Karpoff (1987) in a review of the early literature finds insignificant correlations between price changes and the level of trading activity when using futures market data.

On the other hand, a number of studies have documented a positive relationship between trading volume and price volatility in the futures markets. For example, Cornell

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ASE. Once again, they apply a GARCH model and introduce 'lagged' volume in the variance equation to avoid the problem of simultaneity.

[5] Fleming, Kirby and Ostdiek (2006), using state-space methods to investigate the relation between volume, volatility, and ARCH effects within a MDH framework, find evidence of a large nonpersistent component of volatility that is closely related to the contemporaneous nonpersistent component of volume. Their analysis covers the 20 stocks in the major market index (MMI) in the U.S. Henry and McKenzie (2006) consider the relationship between traded volume and volatility allowing for the impact of short sales. The evidence supports a non-linear, bidirectional relationship between volume and volatility. Their analysis covers the 21 most actively traded and liquid stocks on the Hong Kong Stock Exchange (HKSE).

(1981) studied 17 commodity futures markets and found a positive correlation between changes in both the average trading volume and the standard deviation of log-relatives at two-month intervals. Tauchen and Pitts (1983) found a similar relationship when examining futures on Treasury bills. Grammatikos and Saunders (1986) studied 5 foreign currency contracts at daily intervals with Granger-causality tests and documented significantly positive results that reveal no maturity effect on price variability. Najand and Yung (1991) applied univariate GARCH methodology, with volume as an explanatory variable in the conditional variance, examining futures on U.S. Treasury bonds. They found both significant GARCH and volume effects in the second moments of futures returns. In addition, they documented a positive volume-variability relationship, using only lagged volume in the conditional variance due to the problem of simultaneity bias. Bessembinder and Seguin (1993) examined 8 U.S. futures contracts using ordinary least squares (OLS), and found that unexpected volume shocks have a significant positive effect on volatility. Jacobs and Onochie (1998) applied bivariate EGARCH-M modelling and looked at a cross-section of financial futures trading on the London International Financial Futures and Options Exchange (LIFFE). They found that there is a positive relationship between trading volume and price volatility, as measured by the conditional heteroscedasticity of price change. Moreover, they documented statistically significant findings of positive contemporaneous and time varying correlation between price changes and volume, negative time varying risk premia in futures return, and a monotonically declining and asymmetric effect of innovations on price volatility.

As a result of the relationship between trading volume and price volatility documented in equities and futures markets, our study incorporates it, when it examines the effects of margin changes on the trading volume of stock index futures, and adjusting margins for underlying price risk, following Dutt and Wein's (2003) suggestion. This has not been studied before in the literature. In our study, we employ bivariate GARCH-M models.[6,7] These models allow for autocorrelation in the first and second moments, and also have the advantages of avoiding simultaneity bias with regard to the effect of volume on price volatility, allowing for nonlinearities in the second moments, as well as providing a means for estimating a risk premium.[8] Furthermore, the models employed allow us to examine the relationship between trading volume and stock returns, through the lagged volume and lagged return variables included in the conditional variance of returns and volume respectively, the contemporaneous correlation between returns and volume in the conditional covariance, and the lagged conditional variance of returns included in the conditional mean of volume.

Our study also examines the effects of margin changes on the trading volume of stock index futures, by specifically looking at the Greek derivatives market, where the effectiveness of margins on trading volume has never been examined before. Specifically, it conducts the tests on a large-capitalisation index futures contract (i.e. FTSE/ASE 20 Index) comprising of the 20 largest stocks in terms of market capitalisation and liquidity. Previous studies like Adrangi and Chatrath (1999), Chatrath,

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[6] The GARCH model was developed by Bollerslev (1986), as a natural extension to the ARCH class of models introduced by Engle (1982), and has been used extensively to fit high frequency financial data. Once we introduce the conditional variance into the mean equation, we then get the GARCH-M model.

[7] A recent survey on multivariate GARCH models is provided in Bauwens, Laurent and Rombouts (2006). They assert that these models are important for the study of the relations between the volatilities and co-volatilities of several assets and markets, since it is now widely accepted that financial volatilities move together over time across assets and markets. These models are also useful in the computation of time-varying hedge ratios.

[8] Jacobs and Onochie (1998) use a bivariate EGARCH-M model to test the relationship between return variability and trading volume in international futures markets.

Adrangi and Allender (2001), and Dutt and Wein (2003) have primarily focused on individual financial and/or commodity futures contracts.

In summary, our investigation has the following main objectives: (i) to examine whether changes in margin requirements have significantly affected trading volume; (ii) to investigate the effects of margin changes on trading volume, after adjusting margins for underlying price risk, following Dutt and Wein's (2003) work; and (iii) to incorporate in the analysis of the effects of margin changes on trading volume the empirical regularity of a positive contemporaneous correlation between trading volume and price volatility.

The remaining of the paper is organised as follows. Section 5.2 reviews the literature of the effects of margin requirements on trading volume and volatility in the futures markets. Section 5.3 provides a discussion on the establishment and development of the Greek derivatives market. Section 5.4 describes the univariate and bivariate GARCH-M models, which are employed to examine the effects of margin changes on trading volume. This section also sets up the hypotheses to be tested. Section 5.5 describes the data and presents the empirical results. The final section summarises the empirical findings and presents the main policy conclusions.

5.2 Literature review

Economic theory suggests that futures margins add assurances that both parties to a futures contract will abide by their contractual obligations. Margin requirements, daily mark-to-market, and daily price limits are mechanisms especially designed to minimise the funds necessary in relation to a futures position and limit risk to the counterparty and the exchange-tiered risk-bearing clearing structure.[9] The level of the margin requirement is based on the underlying historical price volatility as well as other factors, and it is generally determined by the tiered risk-bearing clearing system.[10]

Policy proposals often arise that involve an outside entity, for instance the government, in order to establish minimum margin requirements that would generally be greater of those established by exchanges. These proposals attempt to establish margins other than those imposed by the tiered risk-bearing clearing system. The fundamental concept is that increases in margin requirements in futures markets intend to lower "overspeculation", and because speculative activities are thought to cause price volatility, decrease price volatility and consequently systematic risk.

Exchange margin setting in futures markets has generated research interest within the academic community. A number of academics examined issues involving the efficacy of margin setting and as well as issues related to government regulation [e.g. Figlewski (1984); Fishe and Goldberg (1986); Fishe, Goldberg, Gosnell and Sinha (1990); Fenn and Kupiec (1993); Gay, Hunter and Kolb (1986); and Kupiec (1993)]. These studies generally agreed that exchanges are setting margins appropriately and government intervention in setting margin levels would be unnecessary and risky. This result arises from a number of factors.

First, there is the need of convincing evidence that "overspeculation" causes excess price volatility, and, in fact, the opposite may be true. For example, Gray (1967) found that it is lack of speculation that leads to increased price volatility. In a later work, Gray (1979) did not find evidence that short speculation results to depressed prices.

[9] Hardouvelis and Theodossiou (2002) investigated the asymmetric relation between initial margin requirements and volatility in the U.S. stock market during bull and bear periods.

further supporting the existing literature that long speculation does not result to inflated prices. Rutledge (1979) examined the temporal relationship between price volatility and speculation, and found that price volatility does not temporally follow increases in speculative trading. Nathan (1967) illustrated that high levels of speculation were associated with relative price stability, while low levels of speculation were associated with relatively volatile price behaviour [see e.g. Kuhn (1980)].

Second, margin level changes will not likely affect all trader groups uniformly, irrespective of whether speculation causes price volatility. It is therefore possible that informed traders would be disproportionately affected by margin changes, unintentionally causing greater price volatility [Chatrath, Adrangi and Allender (2001); Hartzmark (1986)].

Third, several researchers have also discussed that higher minimum margin requirements imposed outside the tiered risk-bearing clearing structure would potentially reduce volume traded in the futures contract. However, the literature has found little evidence of an inverse association between margins and volume although it has documented a small inverse relationship with respect to open interest. Fishe and Goldberg (1986) attempted to examine the effect of margin changes on both open interest and volume around a 3- to 5-day window of such changes. Specifically, they examined futures contracts trading on the Chicago Board of Trade (CBOT), like corn, iced broilers, wheat, gold, silver, oats, plywood, soybean meal, soybean oil, and soybean, for the period 1972 to 1978. They found, on the one hand, that a 10% increase in margin requirements would reduce open interest by approximately one-third of 1%, and on the other hand, they found that a 10% increase in margins would increase volume traded by 14.62%. This

[10] The futures settlement system is discussed in Gay, Hunter and Kolb (1986), and Fenn and Kupiec (1993).

finding was explained by the fact that as margin requirements increased, volume increases as well, as traders move to unwind their futures positions to avoid the higher costs imposed, eventually causing a net reduction in open interest. Other empirical studies have also failed to identify statistically significant inverse relationships between margins and volume. For example, Hartzmark (1986) investigated 13 contract days calculating whether volume changed significantly from 15 days before to 15 days following the change. He found that in only 4 of 13 occurrences did volume move negatively and significantly in the opposite direction. Therefore, as a result, the association between margins and volume is also weak over the longer period and does not support the assertion that increased margin requirements will reduce trading volume.

Further to Fishe and Goldberg's (1986) and Hartzmark's (1986) findings, Dutt and Wein (2003) initially found statistically positive and/or insignificant relationships between volume and margin changes, as it was done in previous research. They examined 3 financial futures contracts (gold, Dow Jones and 10-year Treasury Notes) and 3 agricultural futures contracts (wheat, corn and oats) over a 17-year time period. However, after adjusting margins for underlying price risk, using variability estimates calculated as the variance of the daily settlement price changes for 20 days before and 20 days after each margin change, in all 6 of the futures contracts under examination, margins exhibit a statistically significant inverse relationship with trading volume. Further, the effect is more evident in financials than in the more traditional agricultural futures contracts.

Chatrath, Adrangi and Allender (2001) examined the impact of margin requirements on the positions of four groups of traders and tested for the nature of liquidity costs in the gold and silver markets. On the one hand, they argued that if margins impose significant opportunity costs, trading activity will be more influenced by margin changes relatively far from maturity. On the other hand, if margins impose no opportunity costs, and only transaction costs, then trading activity will be more sensitive to margin changes relatively close to maturity. They found open interest and trading volume to be relatively insensitive to margin changes further away from maturity. In addition to the evidence that margins impose significant transaction costs, they found that speculators and small traders are relatively more sensitive to margin changes. Finally, the results from a VAR estimation indicated that margins are likely to be increased following periods of extreme volatility, and reduced following periods of relative stability.

The current study conducts an empirical investigation of the effects of margin changes on the trading volume of Greek stock index futures. Consequently, the study attempts to add empirical content to the debate with regard to the effectiveness of margins on financial markets. Among others, Dutt and Wein (2003) also investigated the effects of margin changes on futures trading volume, but they adjusted margins by price variability, based on the rationale that any changes in margins are set in response to expected changes in underlying volatility [i.e. Chatrath, Adrangi and Allender (2001)]. Our study applies Dutt and Wein's (2003) suggestion and adjusts margins by the variance of stock returns. However, our study uses the effect of conditional volatility of stock returns on margin changes, and at the same time, takes into account the relationship between conditional volatility of stock returns and trading volume. Our study employs bivariate GARCH-M models in both stock returns and trading volume.

5.3 The Greek derivatives market

Law 2533/97 provided the necessary legal framework for the establishment of the formal and organised derivatives market in Greece. The Athens Derivatives Exchange S.A. (ADEX) and the Athens Derivatives Exchange Clearing House S.A. (ADECH) have been established for the organisation, operation and development of the market. The main purpose of ADEX was the organisation and support of trading in the derivatives market, the organisation of the trading system as well as any similar activity. At the same time, ADECH is to organise the clearing and settlement of transactions concluded on derivative products, and support such procedures in general. The Capital Market Commission (CMC), exercises control and supervision on ADEX's and ADECH's operations, in respect to the adherence to the rules and regulations of the capital market. Trading operations in the Greek derivatives market were officially inaugurated on August 27, 1999.

Interest to acquire membership to ADEX and ADECH remained strong among companies from the financial sector throughout 2005. As a result, the number of ADEX and ADECH members remained significant. At the end of 2005, ADEX numbered 55 member-companies with the capacities of agents, proprietary traders and market makers, while 3 further applications for ADEX membership had been submitted for approval. With respect to ADECH membership, the number of ADECH members is 36 (12 General Clearing Members and 24 Direct Clearing Members) at the end of 2005. At the time, 2 further ADECH membership applications were pending. The number of ADEX investor accounts has been growing rapidly since the start, totalling 27,399 accounts at the end of 2005. The average rate of increase in 2005 was 250 new accounts on a monthly basis. From the total number of accounts, close to 12% trade at least once per month. The investor base of ADEX includes Greek and foreign institutional investors, while the largest share belongs to individual investors. The dynamic course of growth of the Greek derivatives market since the beginning of its operations on August 27, 1999, is depicted in Table 5.1.

The range of derivative products traded in ADEX continued to expand during 2005. At present ADEX investors are able to choose from a range of liquid, euro (EUR)-denominated products, including futures and options on the blue-chip FTSE/ASE 20 and mid-cap FTSE/ASE Mid-40 indices of the ASE; stock futures and stock options on major Greek stocks with physical delivery on exercise/expiration; stock repo and stock reverse repo contracts, an innovative traded approach to stock lending – borrowing for all market participants; repurchase agreements, developed specifically for the needs of market makers in the underlying market; and currency futures on the EUR/USD exchange rate. According to the law, there is no stamp duty or tax on products traded in ADEX. Trading hours for ADEX products are Monday to Friday between 11:15 a.m. and 5:00 p.m. local time, while for EUR/USD currency futures trading hours are 11:00 a.m. to 5:00 p.m.

For futures on FTSE/ASE 20 that are traded in the derivatives market the underlying asset is the blue-chip index FTSE/ASE 20. The FTSE/ASE 20 Index is based on the 20 largest ASE stocks. It was developed in 1997 by the partnership of ASE with FTSE International and is already an established benchmark. It represents over 50% of ASE's total capitalisation and currently has a heavier weight on banking, telecommunication and energy stocks.

For futures on FTSE/ASE Mid-40 that are traded in the derivatives market the underlying asset is the mid-cap index FTSE/ASE Mid-40. The index is a diversified and well-balanced basket of 40 medium capitalisation stocks of the ASE, from a large number of sectors. It tracks a popular segment of the stock market that has demonstrated high historic volatility levels. Its constituent stocks account for over 15% of ASE's total capitalisation. The index was developed in 1999 by the partnership of ASE with FTSE International.[11]

The year 2005 was another year of growth for the Greek derivatives market. Market indicators and trading statistics marked an increase on 2004 figures. The annual total of futures and options contracts traded reached 5,390,828 contracts, an increase of 10.07% against 2004. The most heavily traded contracts were the index futures and options on the FTSE/ASE 20, the blue-chip stock index. Average daily traded volume in FTSE/ASE 20 Index futures amounted at 9,520 contracts, while average daily traded volume in FTSE/ASE Mid-40 Index futures amounted at 530 contracts, for the year 2005. The total traded value in FTSE/ASE 20 Index futures increased from EUR 13,374.84 million in 2003 to EUR 19,189 million in 2005. Similarly, the total traded value in FTSE/ASE Mid-40 Index futures increased from EUR 306.59 million in 2003 to EUR 1,733 million in 2005. On the basis of trading value, ADEX ranked sixth in Europe in index futures and options in 2003. Summary trading statistics for ADEX index futures products are provided in Table 5.2.[12]

All futures market participants – buyers and sellers – must deposit money with their brokers in futures margin accounts to guarantee contract obligations. As far as

[11] The General Assemblies of the ASE S.A. and the ADEX S.A. that were held on July 17, 2002, approved the Draft Merger Agreement of the two companies and the modifications in the Articles of Association of ASE. The corporate name of the new company is Athens Exchange S.A. (ATHEX). ADECH operates as a separate company.

[12] It is worth noting that we did not perform the tests on the FTSE/ASE Mid-40 Index futures contracts, due to the low trading volume, when compared to the trading volume of the FTSE/ASE 20 Index futures contracts.

ADECH's daily operation is concerned, there are no notions such as initial margins and maintenance margins. The mark-to-market of the futures position, which is known as daily settlement, is done separately from the margining. Specifically, every day, for each clearing account, two numbers are issued by ADECH. One number is the daily settlement amount that can be either positive or negative, depending on the outcome of the mark-to-market of the futures position, whether it results in profit or loss. The other number is the minimum required balance of the margin account, for example a 10% margin of the nominal value of the futures position. It is the responsibility of each futures trader, every day, through the clearing member, to both pay for the daily settlement amount, if this is negative resulting from a loss-making position, and also maintain the minimum balance of a 10% margin of the futures position, on his or her margin account that ADECH requires.

As far as a clearing member's daily operation is concerned, it is possible and logical, that a member requests from a futures trader, an amount of money, before he or she is allowed to open a futures position, which is higher than ADECH's minimum margin requirement. In this case this additional amount requested would qualify as an initial margin. Any daily settlement payments, if and when required, are made using the initial margin, and once the balance gets close to ADECH's minimum margin requirement, then the clearing member makes a margin call to the futures trader, requesting for additional funds. Consequently, ADECH's minimum margin requirement would correspond to what we refer to as the maintenance margin.

The FTSE/ASE 20 Index futures were initially introduced with a 20% margin on August 27, 1999. Subsequently, FTSE/ASE Mid-40 Index futures were launched with an

18% margin on January 28, 2000, and at that time the margin requirement for the FTSE/ASE 20 Index futures had already been modified by ADECH to 14%. ADECH has the right to increase or decrease the margin required for deposit, under extreme market conditions or at any time it deems as appropriate to act. For example, ADECH had increased the margins for both index futures contracts from 12% to 16% on September 12, 2001, as a result of the terrorist attacks that occurred in the U.S. the day before. Many such changes in the margin requirements have been performed in the past, since the launch of these products. However, since October 7, 2002, when margins had increased from 12% to 15%, there has been a gradual reduction to the margins, with the last decrease taking place on February 5, 2004, from 11% to10%. The margins have remained unchanged ever since. A list comprising all the margin changes that occurred since the introduction of the stock index futures contracts in the Greek derivatives market is shown in Table 5.3. The historical information was provided by the Risk Management Department of ADECH.[13]

5.4 Methodological issues

This section discusses the univariate and bivariate GARCH-M(p,q) models, which are used to examine the effects of margin changes on trading volume, by taking into account, on the one hand, the effect of conditional volatility of stock returns on margin changes, and on the other hand, the relationship between conditional volatility of stock returns and trading volume. The best univariate GARCH-M(p,q) models are initially

[13] The information on the establishment and development of the Greek derivatives market included in this section was extracted from the *ASE Fact Book 2006*. Moreover, the description on the functioning of margin requirements in the Greek derivatives market was based on the information provided by the Risk Management Department of ADECH.

selected and these are subsequently used to construct the bivariate GARCH-M(p,q) model. This section also sets up the hypotheses to be tested.

5.4.1 Univariate GARCH-M(p,q) models

The conditional mean and conditional variance equations describing the univariate GARCH-M(p,q) models of stock index returns and the level of trading volume are specified in the following two subsections.

5.4.1.1 Conditional mean and variance of stock returns

The conditional mean of stock returns equation is specified below as follows:

$$\Delta f_t = a_{0\text{uni}} + \sum_{i=1}^{p} b_{iuni}\Delta f_{t-i} + \sum_{j=1}^{q} c_{juni}u^f_{t-j} + d_{1\text{uni}}h^f_t + u^f_t, \qquad (5.1)$$

where $f_t = \ln(F_t)$ is the natural logarithm of the contract's settlement futures price, F_t; $\Delta f_t = f_t - f_{t-1}$ is the price log-relative, Δf_{t-i} are past returns, u^f_{t-j} are moving average (MA) terms, h^f_t is the conditional variance of Δf_t, and u^f_t are random disturbance terms.

Equation (5.1) models the futures return as having a deterministic constituent, $a_{0\text{uni}} + d_{1\text{uni}}h^f_t$, the expected rate of price change given the information set at time, t, and a stochastic constituent, u^f_t, which is conditionally heteroscedastic and correlated with volume. The normal futures return constituent is also modelled as an ARMA(p,q) process. $a_{0\text{uni}}$ is the unconditional expected rate of price change, and following Domowitz and Hakkio (1985), and Engle, Lilien and Robbins (1987) interpretations, the risk premium constituent, $d_{1\text{uni}}h^f_t$, is modelled as being proportional to the conditional heteroscedasticity of the futures return process. This is a representation for the systematic risk associated with unanticipated movements in interest rates. Greater systematic risk related with unanticipated shifts in the yield curve is reflected in innovations to the futures price change process, which, as a result, directly influences conditional variance in the GARCH equation. One can thus say that the conditional heteroscedasticity proxies for systematic risk and it is expected that the estimated coefficient, $d_{1\text{uni}}$, would be negative.[14]

The conditional variance of stock returns equation is specified below as follows:

$$h^f_t = \alpha_{0\text{uni}} + \sum_{i=1}^{p} \beta_{iuni} h^f_{t-i} + \sum_{j=1}^{q} \gamma_{juni} u^f_{t-j} + \delta_{1\text{uni}} v_{t-1}, \qquad (5.2)$$

where $\alpha_{0\text{uni}} \geq 0$, and β_{iuni}, $\gamma_{juni} \geq 0$ to ensure $h^f_t > 0$.

The sum of the coefficients β_{iuni} and γ_{juni}, that is, the lags of the conditional variance and squared return respectively, denote the degree of persistence in the conditional variance given a shock to the system. In particular, the above sum should be less than 1 in order to have a stationary variance. As the sum tends to 1 the higher is the instability in the variance and shocks tend to persist instead of dying out [see Engle and Bollerslev (1986)].[15]

The coefficient, $\delta_{1\text{uni}}$, the lagged volume in the conditional variance of the futures return models the effect of information flow upon price change through the volatility of return, which is in traders' information sets and, as such, is separate from the contemporaneous correlation of the innovations. Consistent with the MDH and many models of sequential information transmission and noisy rational expectations

[14] A theoretical rationale for this specification can be found in Engle, Lilien and Robbins (1987).
[15] For a detailed explanation of ARCH models see Bera and Higgins (1993), and for a review of ARCH modelling in finance see Bollerslev, Chou and Kroner (1992).

equilibrium, the coefficient, δ_{1uni}, is expected to have a positive sign.[16] Therefore, the first hypothesis to be tested is set up as follows:

$$H1: \delta_{1uni} > 0$$

We use lagged volume as an instrument for contemporaneous volume to avoid the problem of simultaneity since lagged values of endogenous variables are classified as predetermined [see e.g. Harvey (1989)].

5.4.1.2 Conditional mean and variance of trading volume

The conditional mean of trading volume equations are specified below as follows:

$$v_t = e_{0uni} + \sum_{i=1}^{p} g_{iuni} v_{t-i} + \sum_{j=1}^{q} k_{juni} u^v_{t-j} + l_{1uni} t + n_{1uni} h^v_t + w_{1uni} m_t + \ldots$$
$$\ldots + y_{1uni} r_t + z_{1uni} x_t + u^v_t, \qquad (5.3a)$$

$$v_t = e_{0uni} + \sum_{i=1}^{p} g_{iuni} v_{t-i} + \sum_{j=1}^{q} k_{juni} u^v_{t-j} + l_{1uni} t + n_{1uni} h^v_t + w_{2uni}(m_t / h^f_{t-1}) + \ldots$$
$$\ldots + y_{1uni} r_t + z_{1uni} x_t + u^v_t, \qquad (5.3b)$$

where $v_t = \ln(V_t)$ is the natural logarithm of the level of trading volume, V_t; v_{t-i} are past terms, u^v_{t-j} are MA terms, h^v_t is the conditional variance of v_t, and u^v_t are random disturbance terms.

The law of motion for the logarithm of volume has deterministic and stochastic constituents as well. The normal volume constituent is modelled as an ARMA(p,q) process with the margin level, m_t, either unadjusted or adjusted for underlying price risk,

[16] For an elaboration of the MDH, see Clark (1973), Harris (1987), and Andersen (1996); for several sequential equilibrium models of speculative markets, see Copeland (1976), Jennings, Starks and Fellingham (1981), and Smirlock and Starks (1985); and for certain newer classes of noisy rational expectations equilibria, see Blume, Easley and O'Hara (1994), and Easley, Keifer and O'Hara (1997).

denoted as h^f_{t-1}, a short-term interest rate, r_t, time to contract maturity, x_t, and a time-trend variable, t.[17]

The innovation, u^v_t, is interpreted as abnormal volume. In several asymmetric information models of trading volume, it is expected that there is some persistence in abnormal volume following an information event [Karpoff (1986)]. The use of the conditional volatility in volume allows one to separate increases in volume due to informed market participants from the uninformed traders as well as from surprises. To the extent that new information arrival associated with increased asymmetry of information among traders results in an increase in trading volume [Karpoff (1987)], and may be proxied for by h^v_t, the estimated coefficient, n_{1uni}, is expected to be positive.

The margin level, m_t, on day t, is included to examine the effects of margin requirements on trading volume. As mentioned before, previous researchers, apart from Dutt and Wein (2003), have generally neglected to consider that margins change in response to changes in volatility, when examining the relationship between margins and trading volume. For this reason empirical findings on the effects of margin changes on trading volume have been unclear [see e.g. Fishe and Goldberg (1986), Hartzmark (1986), and Dutt and Wein (2003)], because changes in volatility can have an opposing effect on trading volume. For example, if price volatility increases, it is likely that volume traded will increase as a result, as it is empirically documented in the literature for the futures markets [see e.g. Jacobs and Onochie (1998)]. At the same time, however, increases in volatility, will cause an increase in margins, and consequently a reduction in volume, as increases in margins act as a cost to the trader [see e.g. Chatrath, Adrangi and Allender (2001)]. Based on this rationale, as the two forces on volume contradict each

[17] See Weiss (1984) for combining the Box-Jenkins style ARMA and GARCH time series model.

other, the predicted effect on volume of a margin increase will be ambiguous, that is, the coefficient, w_{1uni}, in equation (5.3a), can be either positive, negative, or zero.

Dutt and Wein (2003), incorporated in their analysis, the fundamental principle that margins change in response to expected changes in market risk, when examining the effects of margins on trading volume. Thus, they adjusted margins for underlying price risk, using the variance of the daily settlement price changes for 20 days before and 20 days after, for each margin change. Our study also includes Dutt and Wein's (2003) suggestion, and margins are adjusted for market risk, using the lagged conditional variance of the change in daily settlement prices, denoted as h^f_{t-1}. According to Dutt and Wein's (2003), Fishe end Goldberg's (1986), and Telser's (1981) interpretations, it is changes in margins at given levels of risk that would inversely affect volume. Based on this rationale, the coefficient, w_{2uni}, in equation (5.3b), which examines the effects of margins, when adjusted, on trading volume, is predicted to be negative and statistically significant. Dutt and Wein (2003) also document a statistically significant inverse relationship between margins and trading volume for all 6 futures contracts examined. Following this, the presence of margin requirements in ADEX is expected to have a significantly adverse effect on the conditional mean of trading volume and therefore the second hypothesis to be tested is set up as follows:

$$H2: w_{2uni} < 0$$

A short-term interest rate, the Euro Overnight Index Average (EONIA) rate, r_t, is included to represent the short-term changes in storage and holding costs and may therefore affect volume.[18] The coefficient, y_{1uni}, is expected to have a negative sign, since

[18] EONIA is the effective overnight reference rate for the euro. It is computed as a weighted average of all overnight unsecured lending transactions undertaken in the interbank market, initiated within the euro area

an increase (decrease) in the cost of holding inventories would lead to a reduction (increase) in futures market activity. Dutt and Wein (2003) find negative and statistically significant coefficients in both the unadjusted model and margins adjusted model, while Fishe and Goldberg (1986) find positive but insignificant values.

Time to contract maturity, x_t, that is, the number of days until expiration of the contract on day t, affects contract volume and it is therefore included in the model. The coefficient, $z_{1\text{uni}}$, is expected to have a positive sign, meaning that trading volume increases as the contract approaches its expiry. The reason for the increase in volume as the contract approaches its delivery is that futures traders begin to close out their positions to avoid receiving the physical commodity and at the same time they open new positions in other contracts with longer expiry dates. Dutt and Wein's (2003) findings are mixed, in both the unadjusted and adjusted models, while Fishe and Goldberg (1986) find positive and significant values only for the distant futures contract.

Finally, a time-trend variable, t, is included to control for long-term changes in contract interest. Dutt and Wein (2003) find negative time-trend coefficients, while Jacobs and Onochie (1998) find positive coefficients given the growth of the markets during the period under study.

The conditional variance of trading volume equation is specified below as follows:

$$h^v_t = \varepsilon_{0\text{uni}} + \sum_{i=1}^{p} \zeta_{iuni} h^v_{t-i} + \sum_{j=1}^{q} \eta_{juni} u^v_{t-j} + \theta_{1\text{uni}} \Delta f_{t-1}, \tag{5.4}$$

where $\varepsilon_{0\text{uni}} \geq 0$, and ζ_{iuni}, $\eta_{juni} \geq 0$ to ensure $h^v_t > 0$.

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by the contributing banks. EONIA is computed with the help of the European Central Bank (ECB). The

As in the conditional variance of stock returns equation, the sum of the coefficients ζ_{iuni} and η_{juni}, that is, the lags of the conditional variance and squared return respectively, denote the degree of persistence given a shock to the system, and should be less than 1 in order to have a stationary variance. As the sum tends to 1 the higher is the instability in the variance and shocks tend to persist instead of dying out.

The coefficient, θ_{1uni}, the lagged return in the conditional variance of volume models the informational impact of price on volume. To the extent that price increases signal lower systematic risk, so that there is less hedging and/or speculative activity relative to informationally motivated trade, the expectation is that the coefficient estimate of θ_{1uni} will be positive. The third testable hypothesis is therefore set up as follows:

$$H3: \theta_{1uni} > 0$$

The following subsection presents the bivariate GARCH-M(p,q) model, which is created using the selected univariate GARCH-M(p,q) models.

5.4.2 Bivariate GARCH-M(p,q) model

This section discusses the bivariate GARCH-M(p,q) model, which is constructed using the best selected univariate GARCH-M(p,q) models. The conditional mean, the conditional variance and conditional covariance equations describing the bivariate GARCH-M(p,q) model are specified below as follows:[19]

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historical data of EONIA was provided by Reuters Support Services.

[19] The diagonal VECH formulation, of Bollerslev, Engle and Wooldridge (1988), is employed for the construction of the bivariate GARCH-M(p,q) model, to allow for greater flexibility and the inclusion of the various exogenous variables in the conditional mean, variance and covariance equations. The diagonal VECH formulation was preferred to the BEKK formulation of Engle and Kroner (1995), since the BEKK model is more complex and consequently more difficult to construct [see Brooks (2002)]. Jacobs and Onochie (1998) also use a diagonal VECH formulation for the creation of a bivariate EGARCH-M(p,q) model, to examine the relationship between return variability and trading volume in international futures markets.

$$\Delta f_t = a_{0\text{biv}} + \sum_{i=1}^{p} b_{ibiv}\Delta f_{t-i} + \sum_{j=1}^{q} c_{jbiv}u^f_{t-j} + d_{1\text{biv}}h^f_t + u^f_t, \tag{5.5}$$

$$v_t = e_{0\text{biv}} + \sum_{i=1}^{p} g_{ibiv}v_{t-i} + \sum_{j=1}^{q} k_{jbiv}u^v_{t-j} + l_{1\text{biv}}t + n_{1\text{biv}}h^v_t + w_{1\text{biv}}m_t + \ldots$$
$$\ldots + y_{1\text{biv}}r_t + z_{1\text{biv}}x_t + u^v_t, \tag{5.6a}$$

$$v_t = e_{0\text{biv}} + \sum_{i=1}^{p} g_{ibiv}v_{t-i} + \sum_{j=1}^{q} k_{jbiv}u^v_{t-j} + l_{1\text{biv}}t + n_{1\text{biv}}h^v_t + w_{2\text{biv}}(m_t/h^f_{t-1}) + \ldots$$
$$\ldots + y_{1\text{biv}}r_t + z_{1\text{biv}}x_t + u^v_t, \tag{5.6b}$$

$$(u^f_t, u^v_t)^T \sim N((0,0)^T, H_t), \tag{5.7}$$

$$(h^f_t, h^{fv}_t, h^v_t)^T = \text{vech}(H_t), \tag{5.8}$$

$$h^f_t = \alpha_{0\text{biv}} + \sum_{i=1}^{p} \beta_{ibiv}h^f_{t-i} + \sum_{j=1}^{q} \gamma_{jbiv}u^f_{t-j} + \delta_{1\text{biv}}v_{t-1}, \tag{5.9a}$$

$$h^v_t = \varepsilon_{0\text{biv}} + \sum_{i=1}^{p} \zeta_{ibiv}h^v_{t-i} + \sum_{j=1}^{q} \eta_{jbiv}u^v_{t-j} + \theta_{1\text{biv}}\Delta f_{t-1}, \tag{5.9b}$$

$$h^{fv}_t = \iota_{0\text{biv}} + \sum_{i=1}^{p} \kappa_{ibiv}h^{fv}_{t-i} + \sum_{j=1}^{q} \lambda_{jbiv}u^{fv}_{t-j} + \mu_{1\text{biv}}\sqrt{|\Delta f_{t-1}v_{t-1}|}, \tag{5.9c}$$

$$L(\theta|Y,u) = -1/2 \sum_{t=0}^{T} (\ln(2\pi) + \ln|H_t| + u^T_t H_t^{-1} u_t). \tag{5.10}$$

As previously stated, $f_t = \ln(F_t)$ is the natural logarithm of the contract's settlement futures price, F_t; $\Delta f_t = f_t - f_{t-1}$ is the price log-relative; $v_t = \ln(V_t)$ is the natural logarithm of the level of trading volume, V_t; and $u_t = (u^f_t, u^v_t)^T$ is the vector of random disturbance terms for log-relative price and log volume at time, t, respectively, with zero mean vector, 0, and conditional variance-covariance matrix, H_t, with elements, vech(H_t) = $(h^f_t, h^{fv}_t, h^v_t)^T$, as the respective conditional variances and covariance. Y,u are time series of observations and disturbances, respectively, and $L(.|.)$ is the log-likelihood of the parameter vector, θ, conditional on the observations.

Equations (5.5-5.6b) describe a bivariate GARCH-M(p,q) structure for the first moments, similar to the univariate GARCH-M(p,q) models presented in the previous subsections. Equations (5.9a-c) describe a bivariate GARCH-M(p,q) structure for the second moments. The cross-equation structure restricts the conditional moments to depend only upon their past levels, mean equation innovations, and lagged levels of the other variable.[20] Equations (5.9a-b) are similar to the univariate GARCH-M(p,q) models as previously presented.

The contemporaneous correlation between price change and volume is measured by the coefficient, $\iota_{0\text{biv}}$, in the conditional covariance equation, that is, equation (5.9c). The MDH, several sequential information, and noisy rational expectations models suggest that this coefficient should be positive. The majority of both the empirical and theoretical literature documents a non-negative correlation. Based on this, the fourth testable hypothesis is set up as follows:

$$H4: \iota_{0\text{biv}} > 0$$

The asymptotically efficient estimators of these parameters are obtained by the exact maximum likelihood method, which needs only the specification of some arbitrary initial conditions to perform the maximisation. If, in addition to the distributional assumption, the standard regularity conditions hold, then these estimators are also asymptotically normal, and the classical inference procedures are valid [Hamilton

[20] Including contemporaneous variables results in difficulty of interpretation, more complex asymptotics and less tractable estimation [Hamilton (1994)].

(1994)].[21] The log-likelihood for this model is given by equation (5.10). The convergence algorithm employed is the method of Broyden, Fletcher, Goldfarb and Shanno (BFGS), described in detail in Press, Flannery, Teukolsky and Vetterling (1992), which relies on the gradient vector to compute the asymptotic variance-covariance matrix.

5.5 Empirical analysis

5.5.1 Data

The data set comprises daily observations of settlement prices and trading volume, that is, the number of contracts traded, for the nearby futures contract of the FTSE/ASE 20 Index, from August 27, 1999 to December 31, 2005, giving us in total 1,584 observations. The data is collected from the ADEX records.[22] The FTSE/ASE 20 Index comprises of the 20 largest in market capitalisation and most highly traded stocks of all the companies listed on the ASE. It represents over 50% of ASE's total capitalisation and currently has a heavier weight on banking, telecommunication and energy stocks.[23] The nearby futures contract of the FTSE/ASE 20 Index is the most highly traded and consequently the most liquid of all the futures contracts in ADEX.

To assess the distributional properties of the daily stock index returns and trading volume, various descriptive statistics are reported in Table 5.4. As can be seen the returns

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[21] If conditional normality fails to hold, but the first two conditional moments are correctly specified, it can be shown that the quasi-maximum likelihood estimators that obtain will still be consistent and asymptotically normal, under suitable technical conditions and an adjustment of the standard errors [Bollerslev and Wooldridge (1992)]. The ROBUSTERRORS option in the Regression Analysis of Time Series (RATS) econometrics software programme is employed to account for the latter.

[22] Daily data for the FTSE/ASE 20 Index futures contracts is available since the opening trading date on August 27, 1999.

[23] The FTSE/ASE 20 Index was developed in 1997 by the partnership of ASE with FTSE International and is already an established benchmark.

series is positively skewed – figure is statistically insignificant – and highly leptokurtic compared to the normal distribution. The returns series also display significant first order autocorrelation. The Ljung-Box (1978) Q(20) statistic for 20th order autocorrelations is statistically significant, while the Ljung-Box test statistic $Q^2(20)$ (for the squared data) indicates the presence of conditional heteroskedasticity.

Moreover, the volume series is negatively skewed and leptokurtic compared to the normal distribution. The volume series display significant autocorrelations, which remain large for the ten lags reported. Significant autocorrelations in trading activity series have also been found in many earlier studies [see e.g. Gallant, Rossi and Tauchen (1992), and Campbell, Grossman and Wang (1993)].[24] The Ljung-Box (1978) Q(20) statistic for 20th order autocorrelations is statistically significant, while the Ljung-Box test statistic $Q^2(20)$ (for the squared data) indicates the presence of conditional heteroskedasticity. The Augmented Dickey-Fuller (ADF) test statistic for unit roots indicates that the trading volume series is I(0), that is trading volume series has a unit root, since a constant and trend component was found to be statistically insignificant. The lag length was chosen using the Schwarz information criterion (SIC).

The empirical results of the univariate and bivariate GARCH-M(p,q) models for the FTSE/ASE 20 Index nearby futures contract from August 27, 1999 to December 31, 2005, are presented in the next subsections. The best univariate GARCH-M(p,q) models are initially selected and these are subsequently used to construct the bivariate GARCH-M(p,q) model.

[24] Kavussanos and Phylaktis (2001) also document significant autocorrelations in the value of trading transactions series. They investigate the effects of different trading systems on the dynamics of price changes and information flow to the market, as proxied by trading activity, by drawing on the experience of the ASE.

5.5.2 Estimates of univariate GARCH-M(p,q) models

The following two subsections present the maximum likelihood estimates of the univariate GARCH-M(p,q) models for stock index returns and trading volume. In Table 5.5, estimates of different univariate GARCH-M(p,q) models of stock index returns are reported. In Tables 5.6 and 5.7, estimates of different univariate GARCH-M(p,q) models of trading volume are reported. In Table 5.6, the results on the effects of margin requirements on trading volume are summarised, with the margin levels initially not adjusted for underlying price risk. Margin requirements are subsequently adjusted for underlying price risk, using the lagged conditional variance of the change in daily settlement prices, denoted as h^f_{t-1}, and the results are summarised in Table 5.7. Each table has three panels. Panel A presents the estimates of the conditional mean equation, Panel B presents the estimates of the conditional variance equation, and Panel C presents the model diagnostics. The tables present the estimation results for the FTSE/ASE 20 Index nearby futures contract from August 27, 1999 to December 31, 2005.

The appropriate univariate GARCH-M(p,q)-ARMA(p,q) models are selected using mainly the Akaike (AIC) and Schwarz (SIC) information criteria, but also taking into account the significance of the coefficients, the Ljung-Box test statistics Q(20) and $Q^2(20)$, and the sum of the coefficients of lagged squared returns and lagged conditional variances. Moreover, if our modelling is correctly specified, the value of the coefficients of skewness and kurtosis of the standardised residuals should be smaller than the value of skewness and kurtosis of the returns series and volume series respectively.

As mentioned before, an iterative procedure is used based upon the method of BFGS to maximise the log-likelihood function. The quasi-maximum likelihood procedure of Bollerslev and Wooldridge (1992) is also applied, in order to estimate robust standard errors and covariance. The empirical findings presented in the next subsections were established using the RATS econometrics software programme.

5.5.2.1 Results of conditional mean and variance of stock returns

Table 5.5 reports the estimated results of different univariate GARCH-M(p,q) models of stock index returns for the period August 27, 1999 to December 31, 2005.

In Panel A of Table 5.5, the results for the conditional mean of stock index returns are presented, modelled with various ARMA processes.

The coefficient estimate of d_{1uni}, which measures the sensitivity of price change to time variation in the risk premium, is negative but statistically insignificant in all four models. Jacobs and Onochie (1998) find negative and significant coefficients in 5 of 6 futures contracts examined. These results can be interpreted as a relationship between unanticipated changes in interest rates (a measure of systematic risk) and expected futures prices changes as specified in equation (5.1).

Panel B of Table 5.5 presents the results for the conditional variance of returns. The sum of coefficients β_{iuni} and γ_{juni}, the past conditional variances and past squared returns respectively, is close to unity, indicating high persistence of volatility over time.

The coefficient, δ_{1uni}, the lagged volume in the conditional variance of returns, is negative and statistically significant at the 5% level (models 1 and 4) and significant at the 10% level in models 2 and 3.[25] This is contrary to our predictions of a positive coefficient, and inconsistent with the MDH and several models of sequential information transmission and noisy rational expectations equilibrium. Therefore, the first hypothesis tested, H1, is rejected. Jacobs and Onochie (1998) find positive and significant coefficients in all 6 futures contracts examined.

Panel C of Table 5.5 contains the model diagnostics, that is, m_3 and m_4 are the coefficients of skewness and kurtosis of the standardised residuals respectively, while Q(20) and $Q^2(20)$ are 20th order Ljung-Box statistics of the standardised and squared standardised residuals respectively. The Ljung-Box statistics are used to test the null hypothesis of no serial correlation in the standardised residual and squared standardised residual series, Q(20) and $Q^2(20)$. Serial correlation in the Q(20) series may imply that the conditional mean equation of returns is misspecified. Similarly, serial correlation in the $Q^2(20)$ series may imply that the conditional variance equation of returns is misspecified. The Ljung-Box statistics are calculated using 20 lags. The AIC and SIC information criteria are finally included to act as a guidance for the selection of the most appropriate model.

The Ljung-Box statistics Q(20) and $Q^2(20)$ of the standardised and squared standardised residuals respectively exhibit no serial correlation, in all four models, implying that the conditional mean equation and the conditional variance equation of returns are well specified. Moreover, the coefficients of skewness and kurtosis of the standardised residuals exhibit a smaller value, than the skewness and kurtosis of the returns series respectively, further implying that the models are correctly specified.

[25] It is worth noting that the coefficient, δ_{1biv}, although it remains negative, it is statistically insignificant in the bivariate GARCH-M(p,q) model.

Based primarily on the AIC and SIC information criteria, but also taking into account all the other conditions described above, model 1, the GARCH-M(1,1)-ARMA(1,0) model was determined as the most appropriate model.[26] This univariate model is subsequently used to construct the bivariate GARCH-M(p,q) model.

Before we proceed to the results of the conditional mean and variance of trading volume, it is worth noting, that we also attempted an EGARCH-M specification, for the conditional mean and variance equations of stock index returns.[27] The estimated results of different univariate EGARCH-M(p,q) models of stock index returns for the period August 27, 1999 to December 31, 2005, are reported in Table 5A in the Appendix.

The first three models in Table 5A (models 1-3) demonstrate that the conditional variance equation is not well specified, as the Ljung-Box statistic $Q^2(20)$ of the squared standardised residuals exhibits serial correlation. By adding an extra GARCH term in the conditional variance equation, it rectifies this misspecification. Consequently, as it is shown in model 4, the EGARCH-M(2,1)-ARMA(1,0) model, the conditional variance equation becomes well specified, as the Ljung-Box statistic $Q^2(20)$ exhibits no serial correlation.

Although the leverage effect coefficient, ξ_{1uni}, is found to be negative and statistically significant at the 5% level, indicating the existence of an asymmetric effect in returns, model 4, the EGARCH-M(2,1)-ARMA(1,0) model, is not superior to GARCH-M(1,1)-ARMA(1,0) model, using the AIC and SIC information criteria. In addition, the estimation of trading volume using the univariate EGARCH-M specification failed to

[26] The GARCH-M(1,1)-ARMA(1,0) model, is considered superior to model 4, the GARCH-M(2,1)-ARMA(1,0) model, as depicted by the smaller AIC and SIC information criteria.
[27] The EGARCH model was proposed by Nelson (1991) to allow for asymmetric shocks to volatility.

converge, and as a result we could not employ an EGARCH-M specification for the bivariate model.

5.5.2.2 Results of conditional mean and variance of trading volume

Table 5.6 reports the estimated results of different univariate GARCH-M(*p*,*q*) models of trading volume for the period August 27, 1999 to December 31, 2005.

The first three models in Table 5.6 (models 1-3) demonstrate that the conditional mean equation is not well specified, as the Ljung-Box statistic Q(20) of the standardised residuals exhibits serial correlation. By adding more ARMA terms in the conditional mean equation, which are found to be statistically significant, it rectifies this misspecification. Consequently, as it is shown in model 4, the GARCH-M(1,1)-ARMA(3,2) model, the conditional mean equation becomes well specified, as the Ljung-Box statistic Q(20) exhibits no serial correlation.

We were able to further improve on model 4 by adding an extra MA term and including only one AR term in the conditional mean equation, as it is depicted by the smaller AIC and SIC information criteria. Therefore model 5, the GARCH-M(1,1)-ARMA(1,3) model was determined as the most appropriate model. This univariate model is subsequently used to construct the bivariate GARCH-M(*p*,*q*) model.

In Panel A of Table 5.6, the results for the conditional mean of trading volume are presented. In model 5, the selected model, trading volume is modelled as an ARMA(1,3) process. The presence of serial correlation is evident, since the ARMA terms included are statistically significant.

The coefficient, n_{1uni}, the conditional variance, h^v_t, is found to be positive and statistically significant at the 10% level. Jacobs and Onochie (1998) find positive and significant coefficients in all 6 futures contracts examined. This finding is also consistent with the simulation result of Karpoff (1986).

The coefficient, w_{1uni}, which examines the effects of margin requirements on trading volume, is negative and statistically significant at the 5% level. As discussed in the methodological issues section, the coefficient, w_{1uni}, can be either positive, negative, or zero. Fishe and Goldberg (1986) find that a 10% increase in margins would increase volume traded by 14.62%, using a 3- to 5-day window around margin changes. Hartzmark (1986) find that in only 4 of 13 contract days did volume move negatively and significantly in the opposite direction, using a 15-day window around margin changes. Dutt and Wein (2003) find statistically positive and/or insignificant relationships between volume and margins, using a 20-day window around margin changes.

The coefficient, y_{1uni}, the EONIA rate, r_t, is found to be negative but statistically insignificant, failing to support the view that an increase (decrease) in the cost of holding inventories would lead to a reduction (increase) in futures market activity. This result might reflect the relatively low interest rates that prevailed in the Eurozone during the sample period. Dutt and Wein (2003) find negative and statistically significant coefficients in 5 of 6 futures contracts, while Fishe and Goldberg (1986) find positive but insignificant values.

The coefficient, z_{1uni}, time to contract maturity, x_t, is found to be positive and statistically significant. This finding supports the view that as the contract approaches its delivery futures traders begin to close out their positions to avoid receiving the physical commodity and at the same time they open new positions in other contracts with longer expiry dates, consequently causing an increase in trading volume. Dutt and Wein (2003) find mixed results, while Fishe and Goldberg (1986) find positive and significant values only for the distant futures contract.

Finally, a time-trend variable, *t*, included to control for long-term changes in contract interest is found to have a negative but statistically insignificant coefficient. Dutt and Wein (2003) find negative time-trend coefficients, while Jacobs and Onochie (1998) find positive coefficients given the growth of the markets during the period under study.

Panel B of Table 5.6 presents the results for the conditional variance of volume. The sum of coefficients ζ_{iuni} and η_{juni}, the past conditional variances and past squared returns respectively, is less than 1, and therefore has a stationary variance.

The coefficient, $\theta_{1\text{uni}}$, the lagged return in the conditional variance of volume, is negative, contrary to our expectations of a positive coefficient. However, it is statistically insignificant. The lagged return models the informational impact of price on volume, and to the extent that price increases signal lower systematic risk, there is less hedging and/or speculative activity relative to informationally motivated trade. Therefore, the third hypothesis tested, H3, is rejected. Jacobs and Onochie (1998) find positive and significant coefficients in all 6 futures contracts examined.

Panel C of Table 5.6 contains the model diagnostics, which confirm that the conditional mean and variance equations of volume are well specified.

The same procedure was followed as above, for the selection of the most appropriate model, when margin requirements are adjusted for underlying price risk, using the lagged conditional variance of the change in daily settlement prices, denoted as

h^f_{t-1}, in the conditional mean equation of trading volume. Table 5.7 reports the estimated results of different univariate GARCH-M(p,q) models of trading volume for the period August 27, 1999 to December 31, 2005.

The first two models in Table 5.7 (models 1 and 2) demonstrate that the conditional mean equation is not well specified, as the Ljung-Box statistic Q(20) of the standardised residuals exhibits serial correlation. By adding more ARMA terms in the conditional mean equation, which are found to be statistically significant, it rectifies this misspecification. Consequently, as it is shown in models 3 and 4, the conditional mean equation becomes well specified, as the Ljung-Box statistic Q(20) exhibits no serial correlation.

We were able to further improve on models 3 and 4, and as previously proven, model 5, the GARCH-M(1,1)-ARMA(1,3) model was determined as the most appropriate model, based mainly on the values of the AIC and SIC information criteria, but also taking into consideration all the other conditions. This univariate model is subsequently used to construct the bivariate GARCH-M(p,q) model.

In Panel A of Table 5.7, the results for the conditional mean of trading volume are presented. The most appropriate model, model 5, is modelled as an ARMA(1,3) process.

The coefficient, n_{1uni}, the conditional variance, h^v_t, is positive but statistically insignificant, unlike the significant coefficient found in the unadjusted model. Jacobs and Onochie (1998) also find positive and significant coefficients in the 6 futures contracts examined.

The coefficient, w_{2uni}, which examines the effects of margin requirements on trading volume, but margins are adjusted for underlying price risk, using the lagged conditional variance of the change in daily settlement prices, denoted as h^f_{t-1}, is found to be positive and statistically insignificant, against the expectations of a negative coefficient. Thus, the second hypothesis tested, H2, is rejected. Dutt and Wein (2003) were the first researchers to account for this rationale in their empirical examinations, and contrary to our findings, they document a statistically significant inverse relationship between margin changes and trading volume for all 6 futures contracts examined.

The findings on the EONIA rate variable, r_t, time to contract maturity variable, x_t, and time-trend variable, t, are similar to the results for the unadjusted model, and therefore we will not repeat the comments.

Panel B of Table 5.7 presents the results for the conditional variance of volume. The sum of coefficients ζ_{iuni} and η_{juni}, the past conditional variances and past squared returns respectively, is less than 1, and therefore has a stationary variance.

The coefficient, θ_{1uni}, the lagged return in the conditional variance of volume, is negative but statistically insignificant, against the expectation of a positive coefficient, and similar to the result for the unadjusted model. Therefore, the third hypothesis tested, H3, is rejected. Jacobs and Onochie (1998) find positive and significant coefficients in the 6 futures contracts under examination.

Panel C of Table 5.7 contains the model diagnostics, which confirm that the conditional mean and variance equations of volume are well specified.

5.5.3 Estimates of bivariate GARCH-M(p,q) model

Table 5.8 reports the estimated results of different versions of the bivariate GARCH-M(1,1) model of stock index returns and trading volume for the period August

27, 1999 to December 31, 2005. The bivariate GARCH-M(1,1) model is constructed using the selected univariate models, that is, the GARCH-M(1,1)-ARMA(1,0) model and the GARCH-M(1,1)-ARMA(1,3) model, for the stock index returns and trading volume respectively.

Model 1 in Table 5.8 examines the effects of margin requirements on trading volume and compares the results to the findings of previous research. Model 2 examines the effects of margin requirements on trading volume, but margins are adjusted for underlying price risk, using the lagged conditional variance of the change in daily settlement prices, denoted as h^f_{t-1}. The results are compared to Dutt and Wein's (2003) findings. Model 3 also examines the effects of margin requirements on trading volume, but margins are adjusted by the conditional variance of the change in daily settlement prices lagged twice, denoted as h^f_{t-2}. This is done to check the robustness of our results. Finally, model 4 examines the effects of margin requirements on trading volume, and margins are adjusted by the lagged conditional variance of returns, denoted as h^f_{t-1}, however the lagged conditional variance of returns is separately included in the conditional mean of volume, in order to capture the direct effect of volatility on trading volume, which might have been wrongly accounted for when adjusting margin requirements for risk. The results in models 3 and 4, are similar to the results of the initial model 2, further providing evidence on the robustness of the bivariate GARCH-M(1,1) model.[28]

In Panel A of model 1, the results for the conditional mean of stock index returns and trading volume are presented. The conditional mean of returns is modelled as an

[28] The results are also similar for both models 1 and 2, when using contemporaneous trading volume, instead of lagged trading volume, in the conditional variance of stock index returns.

ARMA(1,0) process, and the conditional mean of volume is modelled as an ARMA(1,3) process. The presence of serial correlation is evident, since the ARMA processes modelled, present statistically significant terms.

The coefficient estimate of d_{1biv}, which measures the sensitivity of price change to time variation in the risk premium, is negative but statistically insignificant, as in the univariate model. The coefficient, n_{1biv}, the conditional variance, h^{v}_{t}, is found to be positive and statistically significant at the 5% level, while for the univariate model it is significant at the 10% level.

The results on the remaining coefficients, that is, the margin level variable, m_t, the EONIA rate variable, r_t, time to contract maturity variable, x_t, and time-trend variable, t, are similar to the results reported for the univariate model, and therefore we will not repeat the comments. In effect, m_t, the variable of most interest to our examination, is found to be negative and statistically significant at the 5% level, when margins are not adjusted for underlying price risk.

Panel B of model 1 presents the results for the conditional variances of returns and volume and the conditional covariance between returns and volume. The sum of the coefficients of the past conditional variances and past squared returns, for both the conditional variances of returns and volume, is less than 1.

The coefficient, δ_{1biv}, the lagged volume in the conditional variance of returns, is negative and statistically insignificant, unlike the negative and significant coefficient found in the univariate model, but still inconsistent to our expectations of a positive coefficient. The coefficient, θ_{1biv}, the lagged return in the conditional variance of volume, is also negative and statistically insignificant, as in the univariate model, but still inconsistent to our predictions of a positive coefficient. Therefore, the two hypotheses tested, H1 and H3, are both rejected.

The coefficient, i_{0biv}, in the conditional covariance, which measures the contemporaneous correlation between price change and volume, is negative and statistically significant at the 5% level, inconsistent with the MDH, several sequential information, and noisy rational expectations models, which suggest that this coefficient should be positive. Therefore, the fourth hypothesis tested, H4, is rejected. Jacobs and Onochie (1998) find positive and statistically significant coefficients in all 6 futures contracts examined. Their result is at odds, however, with the typically insignificant correlations that have been found in futures market data between price changes and the level of trading activity [i.e. Karpoff (1987)]. Similar results have also been found in the equities markets. For example, Darrat, Rahman and Zhong (2003), when examining the contemporaneous correlations between volumes and return volatility in all 30 stocks comprising the DJIA, they find only 3 stocks to be positive and statistically significant. Furthermore, from the remaining 27 stocks, 8 stocks exhibit a negative correlation between volumes and return volatility, with 2 stocks having statistically significant coefficients.

Panel C of model 1 contains the model diagnostics, which confirm that the conditional mean and variance equations of returns and volume and the conditional covariance equation between returns and volume are well specified.

In Panel A of model 2, the results for the conditional mean of returns and volume are presented. Panel B presents the results for the conditional variances of returns and volume and the conditional covariance between returns and volume. Panel C contains the model diagnostics, which confirm that all the conditional mean, variance and covariance equations are well specified.

The results of model 2 are similar to the results of model 1 and therefore we will not repeat the comments. As in the univariate model, coefficient, w_{2biv}, which examines the effects of margin requirements on trading volume, after margins are adjusted for underlying price risk, using the lagged conditional variance of returns, denoted as h^f_{t-1}, is found to be positive and statistically insignificant, failing to find an inverse association between margins and volume traded. This is also contrary to Dutt and Wein's (2003) findings who document a statistically significant inverse relationship between margin changes and trading volume. Thus, the second hypothesis tested, H2, is rejected.

As mentioned in the beginning of this subsection, the results in model 3, when margins are adjusted by the conditional variance of returns lagged twice, denoted as h^f_{t-2}, are similar to the results of the initial model 2. In model 4, the lagged conditional variance of returns, denoted as h^f_{t-1}, is separately included in the conditional mean of volume, in order to capture the differential effect of margin changes on volume. Although the lagged conditional variance of returns coefficient, s_{1biv}, is found to be negative and statistically significant, contrary to the expectations of a positive coefficient [see e.g. Rutledge (1979), Cornell (1981)], the coefficient, w_{2biv}, is found to be negative but still statistically insignificant. The remaining of the results is similar to the results of the initial model 2.

5.6 Summary and main policy conclusions

The effects of margin requirements on financial markets are not only of interest to academics, but these are of practical concern to policy makers. Empirical studies undertaken so far have not been able to conclusively resolve the debate on the effects of margin requirements on financial markets.

The aim of this study is to provide further empirical evidence to the debate with regard to the effects of margin changes on trading volume. The main contribution of the paper to the existing literature is that it conducts the investigation of the effects of margin changes on the trading volume of stock index futures, by taking into account, on the one hand, the effect of conditional volatility of stock returns on margin changes, and on the other hand, the relationship between conditional volatility of stock returns and trading volume. The effect of conditional volatility of stock returns on margin changes is examined through the adjustment of margins by the lagged conditional volatility of stock returns. The relationship between conditional volatility of stock returns and trading volume is examined through the lagged trading volume and lagged stock return variables included in the conditional variance of stock returns and trading volume respectively, the contemporaneous correlation between stock returns and trading volume in the conditional covariance, and the lagged conditional variance of stock returns included in the conditional mean of trading volume.

The current study has added two different dimensions to the examination of margin requirements on trading volume, which should make one treat the results of previous studies with caution. On the one hand, previous research, has generally neglected to consider the rationale that margin requirements change in response to changes in price volatility, and on the other hand, they did not take into account the relationship between price volatility and trading volume.

In our analysis, we employ a bivariate GARCH-M(p,q) model, which is constructed using the best selected univariate GARCH-M(p,q) models. The bivariate GARCH-M(p,q) model allows for autocorrelation in the first and second moments, and also has the advantages of avoiding simultaneity bias with regard to the effect of trading volume on price volatility, allowing for nonlinearities in the second moments, as well as providing a means for estimating a risk premium. Furthermore, the model employed allows us to examine the relationship between trading volume and stock returns, through the lagged trading volume and lagged stock return variables included in the conditional variance of stock returns and trading volume respectively, the contemporaneous correlation between stock returns and trading volume in the conditional covariance, and the lagged conditional variance of stock returns included in the conditional mean of trading volume. We examine the effects of margin changes on trading volume, using the most liquid futures contract traded in the Greek derivatives market, the FTSE/ASE 20 Index nearby futures contract, for the period August 27, 1999 to December 31, 2005.

The empirical results can be summarised as follows: An association between margin changes and trading volume is not found, when margins are adjusted for underlying price risk, using the lagged conditional variance of stock returns, and against the expectations of a negative relationship. This association remains also statistically insignificant, when margins are adjusted by the conditional variance of stock returns lagged twice, and when separately incorporating the lagged conditional variance of stock returns in the conditional mean of trading volume. This highlights the importance of adjusting margin requirements for risk and casts doubts on the results of previous studies which did not allow for these inter-relationships. Regarding the relationship between volatility of stock returns and trading volume, we find a contemporaneous correlation which is negative and statistically significant. This is in contrast to our expectations. However, other studies, e.g., Darrat, Rahman and Zhong (2003), find also a negative relationship.

Finally, it seems that margin requirements are used only as a mechanism to prevent trader default, at least in the case of the Greek derivatives market, and any decisions associated with the changes in margins, did not have a significant effect on trading volume. The findings further support what Roll (1989) stated in his comprehensive review on the implications for regulatory policy, that there is little evidence in favour of the efficacy of margin requirements, price limits and transaction taxes.

Tables: **Table 5.1**

The Growth of the Greek Derivatives Market

Year End	2000	2001	2002	2003	2004	2005
Trading Members (ADEX)	40	65	70	67	60	55
Clearing Members (ADECH)	36	42	47	47	41	36
- Direct Clearing Members	29	33	35	35	29	24
- General Clearing Members	7	9	12	12	12	12
Terminals	171	333	419	429	405	310
API Service Member Subscribers	21	28	34	35	33	30
Investor Accounts	3,181	9,133	15,482	21,256	24,373	27,399
Products	5	7	8	10	11	11

Source: ASE Fact Book 2006.

Table 5.2
Summary Trading Statistics for Stock Index Futures

Year	1999	2000	2001	2002	2003	2004	2005
FTSE/ASE 20 Index Futures							
Total Traded Volume	48,190	484,246	1,326,089	2,085,056	2,809,211	2,792,168	2,380,010
Daily Average Trading Vol.	554	1,922	5,283	8,442	11,373	11,036	9,520
Traded Value (Mil. EUR)	815.88	6,514.23	10,464.48	11,181.61	13,374.84	18,146.57	19,189.00
FTSE/ASE Mid-40 Index Futures							
Total Traded Volume	N/A	428,985	527,726	344,476	76,939	130,751	132,453
Daily Average Trading Vol.	N/A	1,702	2,099	1,395	311	517	530
Traded Value (Mil. EUR)	N/A	2,792.44	1,758.49	819.99	306.59	1,442.02	1,733.00

Source: ASE Fact Book 2006. N/A refers to non-applicable.

Table 5.3
Margin Requirements on Stock Index Futures

Effective Date	FTSE/ASE 20 Index	FTSE/ASE Mid-40 Index
27/08/1999	20%	-
07/01/2000	14%	-
28/01/2000	-	18%
24/10/2000	12%	16%
12/02/2001	-	12%
12/09/2001	16%	16%
12/10/2001	12%	12%
07/10/2002	15%	15%
16/12/2002	14%	14%
14/01/2003	13%	13%
16/05/2003	12%	12%
20/06/2003	11%	11%
05/02/2004	10%	10%

Notes: The above list including the margin changes of the stock index futures was provided by the Risk Management Department of ADECH.

Table 5.4
Summary Statistics of FTSE/ASE 20 Index Nearby Futures Contract (27/08/1999-31/12/2005)

	Stock Index Returns	Trading Volume
Mean	-0.000	8.090
Std. Deviation	0.016	1.171
Minimum	-0.106	3.045
Maximum	0.097	10.164
Skewness	0.098	-1.143*
Kurtosis (excess)	4.080*	0.608*
ρ_1	0.080*	0.932*
ρ_2	-0.013	0.905*
ρ_3	-0.016	0.894*
ρ_4	0.041	0.888*
ρ_5	-0.002	0.885*
ρ_6	0.007	0.877*
ρ_7	0.011	0.875*
ρ_8	-0.005	0.877*
ρ_9	-0.014	0.875*
ρ_{10}	-0.022	0.869*
Q(20)	35.41*	24529.93*
$Q^2(20)$	275.78*	23890.28*
ADF(7)		-3.813

Notes: Stock index return is calculated as $\Delta f_t = (f_t - f_{t-1})$ the price log-relative, where $f_t = \ln(F_t)$ is the natural logarithm of the contract's settlement futures price, F_t. Trading volume is calculated as $v_t = \ln(V_t)$, the natural logarithm of trading volume, V_t. ρ_i, where i = 1,...,10 are sample autocorrelations. * denotes significance of diagnostic statistics at the 5% level. Q(20) and $Q^2(20)$ for the squared data, are Ljung-Box statistics of 20th order. ADF(7) is the Augmented Dickey-Fuller test statistic with lag length 7 chosen using SIC; the critical value is -3.413.

Table 5.5

Univariate GARCH-M(*p*,*q*) Estimation of Stock Index Returns FTSE/ASE 20 Index Nearby Futures Contract (27/08/1999-31/12/2005)

Coefficients	Model 1	Model 2	Model 3	Model 4
Panel A. Conditional mean				
a_{0uni}	0.000	0.000	0.000	0.000
	(0.604)	(0.592)	(0.636)	(0.490)
b_{1uni}	0.079*	0.080*	-0.001	0.080*
	(2.861)	(2.660)	(-0.006)	(2.672)
b_{2uni}		-0.009		
		(-0.328)		
c_{1uni}			0.081	
			(0.429)	
d_{1uni}	-0.751	-0.733	-0.910	-0.465
	(-0.334)	(-0.322)	(-0.379)	(-0.203)
Panel B. Conditional variance				
α_{0uni}	0.000*	0.000*	0.000**	0.000*
	(2.084)	(2.032)	(1.801)	(2.165)
β_{1uni}	0.856*	0.855*	0.856*	1.111*
	(18.368)	(19.135)	(16.626)	(5.604)
β_{2uni}				-0.235
				(-1.227)
γ_{1uni}	0.111*	0.111*	0.111*	0.094*
	(3.357)	(3.469)	(3.209)	(3.442)
δ_{1uni}	0.000*	0.000**	0.000**	0.000*
	(-2.010)	(-1.952)	(-1.751)	(-2.090)
Panel C. Model diagnostics				
m_3	-0.088	-0.093	-0.090	-0.098
m_4	1.519*	1.524*	1.524*	1.536*
$X^2(2)$	154.13*	155.31*	155.41*	158.14*
Q(20)	19.100	19.686	19.481	18.997
$Q^2(20)$	22.633	22.712	22.651	19.963
AIC	-8.2580	-8.2564	-8.2569	-8.2568
SIC	-8.2343	-8.2292	-8.2298	-8.2297

Notes: For the specification of the univariate GARCH-M(*p*,*q*) model refer to equations (5.1) and (5.2) in text. The subscript *uni* refers to univariate. The figures in parentheses are *t*-statistics. m_3 and m_4 are coefficients of skewness and kurtosis of the standardised residuals respectively. $X^2(2)$ is the Jarque-Bera-normality test. Q(20) and $Q^2(20)$ are 20th order Ljung-Box statistics of the standardised and squared standardised residuals respectively. AIC and SIC are the Akaike and Schwarz information criteria respectively. * and ** denotes significance at the 5% and 10% level respectively.

Table 5.6

Univariate GARCH-M(1,1) Estimation of Trading Volume-Margins Unadjusted FTSE/ASE 20 Index Nearby Futures Contract (27/08/1999-31/12/2005)

Coefficients	Model 1	Model 2	Model 3	Model 4	Model 5
Panel A. Conditional mean					
e_{0uni}	1.100*	0.783*	0.009	-0.139*	-0.107
	(3.790)	(3.302)	(0.065)	(-2.584)	(-1.035)
g_{1uni}	0.819*	0.611*	0.975*	0.620*	0.996*
	(50.527)	(22.636)	(83.754)	(45.610)	(458.733)
g_{2uni}		0.252*		0.628*	
		(10.678)		(40.892)	
g_{3uni}				-0.253*	
				(-59.668)	
k_{1uni}			-0.602*	-0.136*	-0.529*
			(-10.046)	(-5.743)	(-20.294)
k_{2uni}				-0.649*	-0.188*
				(-33.227)	(-6.016)
k_{3uni}					-0.085*
					(-3.098)
l_{1uni}	0.000*	0.000*	0.000	0.000	0.000
	(4.660)	(3.261)	(0.621)	(-0.461)	(-0.558)
n_{1uni}	1.812	1.805	1.577*	1.501*	1.217**
	(1.285)	(1.301)	(6.017)	(8.440)	(1.681)
w_{1uni}	-2.271*	-1.890*	-0.683	-0.320*	-0.262*
	(-2.661)	(-3.428)	(-1.494)	(-2.219)	(-2.958)
y_{1uni}	2.387	1.771	0.035	-0.131	-0.194
	(1.167)	(1.045)	(0.037)	(-0.360)	(-0.574)
z_{1uni}	0.003*	0.004*	0.002*	0.001*	0.001*
	(2.460)	(3.625)	(2.696)	(2.322)	(2.209)
Panel B. Conditional variance					
ε_{0uni}	0.146*	0.124*	0.142*	0.137*	0.112*
	(4.560)	(4.394)	(11.921)	(13.911)	(6.086)
ζ_{1uni}	0.009	0.102	-0.077	-0.082	0.092
	(0.063)	(0.701)	(-1.105)	(-1.157)	(0.787)
η_{1uni}	0.112	0.102	0.105*	0.096*	0.102*
	(1.180)	(1.144)	(10.634)	(16.066)	(3.155)
θ_{1uni}	-0.524	-0.324	-0.459**	-0.343	-0.338
	(-0.995)	(-0.384)	(-1.702)	(-1.213)	(-1.188)
Panel C. Model diagnostics					
m_3	-0.094	-0.115**	-0.155*	-0.213*	-0.225*
m_4	0.853*	0.944*	0.954*	0.923*	0.929*
$X^2(2)$	50.33*	62.18*	66.42*	68.08*	70.33*
Q(20)	189.678*	114.195*	73.968*	20.744	25.061
$Q^2(20)$	15.569	14.448	18.703	22.544	21.725
AIC	-1.7818	-1.8409	-1.8975	-1.9469	-1.9494
SIC	-1.7445	-1.8002	-1.8568	-1.8960	-1.9018

Notes: For the specification of the univariate GARCH-M(1,1) model refer to equations (5.3a) and (5.4) in text. The subscript *uni* refers to univariate. The figures in parentheses are *t*-statistics. m_3 and m_4 are coefficients of skewness and kurtosis of the standardised residuals respectively. $X^2(2)$ is the Jarque-Bera-normality test. Q(20) and $Q^2(20)$ are 20th order Ljung-Box statistics of the standardised and squared standardised residuals respectively. AIC and SIC are the Akaike and Schwarz information criteria respectively. * and ** denotes significance at the 5% and 10% level respectively.

Table 5.7
Univariate GARCH-M(1,1) Estimation of Trading Volume-Margins Adjusted FTSE/ASE 20 Index Nearby Futures Contract (27/08/1999-31/12/2005)

Coefficients	Model 1	Model 2	Model 3	Model 4	Model 5
Panel A. Conditional mean					
e_{0uni}	0.672*	0.378**	-0.206*	-0.239*	-0.159
	(2.372)	(1.723)	(-4.244)	(-4.020)	(-1.108)
g_{1uni}	0.812*	0.615*	0.630*	0.601*	0.999*
	(38.531)	(24.334)	(30.018)	(5.114)	(297.860)
g_{2uni}		0.249*	0.634*	0.159	
		(9.913)	(20.248)	(1.454)	
g_{3uni}			-0.249*	0.426*	
			(-65.188)	(9.530)	
g_{4uni}			-0.016	-0.188*	
			(-0.803)	(-4.735)	
k_{1uni}			-0.155*	-0.129	-0.531*
			(-5.055)	(-1.125)	(-18.728)
k_{2uni}			-0.654*	-0.142*	-0.190*
			(-20.785)	(-2.419)	(-5.672)
k_{3uni}				-0.464*	-0.086*
				(-9.393)	(-2.966)
l_{1uni}	0.001*	0.000*	0.000	0.000	0.000
	(7.243)	(5.816)	(-0.173)	(-0.087)	(-0.065)
n_{1uni}	2.104	1.922	1.357*	1.463*	1.061
	(1.258)	(1.501)	(4.867)	(5.918)	(1.027)
w_{2uni}	0.000*	0.000	0.000	0.000	0.000
	(-2.240)	(-0.867)	(1.442)	(1.074)	(0.918)
y_{1uni}	5.427*	4.183*	0.113	0.243	0.089
	(2.661)	(2.263)	(0.438)	(0.571)	(0.290)
z_{1uni}	0.003*	0.004*	0.001*	0.002*	0.001*
	(2.076)	(3.282)	(2.560)	(2.460)	(2.297)
Panel B. Conditional variance					
ε_{0uni}	0.159*	0.129*	0.132*	0.130*	0.106*
	(3.139)	(4.228)	(8.078)	(8.067)	(2.681)
ζ_{1uni}	-0.070	0.076	-0.050	-0.039	0.134
	(-0.280)	(0.463)	(-0.447)	(-0.348)	(0.506)
η_{1uni}	0.107	0.101**	0.098*	0.105*	0.104*
	(1.229)	(1.867)	(10.814)	(11.446)	(2.127)
θ_{1uni}	-0.567	-0.355	-0.287	-0.276	-0.279
	(-1.518)	(-0.924)	(-1.092)	(-1.055)	(-0.628)
Panel C. Model diagnostics					
m_3	-0.073	-0.099	-0.216*	-0.212*	-0.224*
m_4	0.758*	0.907*	0.952*	0.980*	0.949*
$X^2(2)$	39.32*	56.80*	72.02*	75.03*	72.71*
Q(20)	183.660*	113.111*	20.506	20.661	25.798
$Q^2(20)$	15.387	13.767	20.731	18.134	19.601
AIC	-1.7790	-1.8370	-1.9476	-1.9443	-1.9471

SIC	-1.7417	-1.7962	-1.8933	-1.8866	-1.8995

Notes: For the specification of the univariate GARCH-M(1,1) model refer to equations (5.3b) and (5.4) in text. The subscript *uni* refers to univariate. The figures in parentheses are *t*-statistics. m_3 and m_4 are coefficients of skewness and kurtosis of the standardised residuals respectively. $X^2(2)$ is the Jarque-Bera-normality test. Q(20) and $Q^2(20)$ are 20th order Ljung-Box statistics of the standardised and squared standardised residuals respectively. AIC and SIC are the Akaike and Schwarz information criteria respectively. * and ** denotes significance at the 5% and 10% level respectively.

Table 5.8

Bivariate GARCH-M(1,1) Estimation of Stock Index Returns and Trading Volume FTSE/ASE 20 Index Nearby Futures Contract (27/08/1999-31/12/2005)

Coefficients	Model 1	Model 2	Model 3	Model 4
Panel A. Conditional mean				
a_{0biv}	0.000	0.000	0.000	0.001
	(0.706)	(0.744)	(0.732)	(1.215)
b_{1biv}	0.081*	0.083*	0.083*	0.078*
	(3.834)	(2.422)	(2.666)	(3.383)
d_{1biv}	-1.238	-1.135	-1.133	-1.771
	(-0.512)	(-0.510)	(-0.491)	(-1.026)
e_{0biv}	-0.111*	-0.155*	-0.161*	-0.119
	(-35.757)	(-9.168)	(-9.319)	(-1.444)
g_{1biv}	0.996*	0.998*	0.998*	0.996*
	(397.327)	(271.928)	(407.049)	(243.650)
k_{1biv}	-0.527*	-0.528*	-0.528*	-0.533*
	(-29.229)	(-23.219)	(-21.741)	(-20.247)
k_{2biv}	-0.188*	-0.190*	-0.190*	-0.189*
	(-6.631)	(-7.005)	(-6.637)	(-6.715)
k_{3biv}	-0.092*	-0.093*	-0.093*	-0.093*
	(-3.680)	(-3.377)	(-3.674)	(-4.177)
l_{1biv}	0.000	0.000	0.000	0.000
	(-0.499)	(-0.029)	(0.002)	(0.101)
n_{1biv}	1.215*	1.040*	1.081*	1.123*
	(61.982)	(12.509)	(6.492)	(2.049)
s_{1biv}				-44.164*
				(-2.005)
w_{1biv}	-0.242*			
	(-2.692)			
w_{2biv}		0.000	0.000	0.000
		(0.689)	(1.017)	(-0.866)
y_{1biv}	-0.176	0.087	0.092	0.041
	(-0.579)	(0.279)	(0.326)	(0.144)
z_{1biv}	0.001*	0.001*	0.001*	0.001*
	(2.623)	(2.281)	(2.589)	(2.288)
Panel B. Conditional variance and covariance				
α_{0biv}	0.000**	0.000**	0.000**	0.000**
	(1.728)	(1.692)	(1.747)	(1.665)
β_{1biv}	0.854*	0.855*	0.855*	0.867*
	(17.512)	(18.832)	(17.887)	(18.972)
γ_{1biv}	0.110*	0.109*	0.109*	0.102*
	(3.646)	(3.671)	(3.535)	(3.523)
δ_{1biv}	0.000	0.000	0.000	0.000
	(-1.631)	(-1.576)	(-1.636)	(-1.599)
ε_{0biv}	0.108*	0.103*	0.104*	0.103*
	(20.731)	(6.224)	(6.601)	(4.136)
ζ_{1biv}	0.124*	0.163	0.152	0.154
	(7.226)	(1.306)	(1.283)	(0.952)
η_{1biv}	0.094*	0.098*	0.096*	0.101*
	(5.376)	(4.785)	(4.333)	(3.840)

θ_{1biv}	-0.363	-0.316	-0.321	-0.316
	(-1.521)	(-1.332)	(-1.210)	(-1.327)
ι_{0biv}	0.000*	0.000*	0.000*	0.000*
	(-2.277)	(-2.321)	(-2.797)	(-2.186)
κ_{1biv}	0.849*	0.852*	0.852*	0.847*
	(10.289)	(11.005)	(11.613)	(11.606)
λ_{1biv}	0.041**	0.040	0.040	0.041**
	(1.762)	(1.469)	(1.572)	(1.817)
μ_{1biv}	0.001*	0.001*	0.001*	0.001*
	(2.333)	(2.363)	(2.833)	(2.275)
Panel C. Model diagnostics				
m_{3sr}	-0.080	-0.079	-0.079	-0.078
m_{3tv}	-0.224*	-0.223*	-0.224*	-0.227*
m_{4sr}	1.543*	1.552*	1.552*	1.545*
m_{4tv}	0.924*	0.943*	0.941*	0.889*
$X^2_{sr}(2)$	158.52*	160.45*	160.44*	159.04*
$X^2_{tv}(2)$	69.47*	71.78*	71.52*	65.59*
$Q_{sr}(20)$	18.861	18.780	18.782	18.876
$Q_{tv}(20)$	25.154	25.814	25.845	26.107
$Q^2_{sr}(20)$	22.484	22.863	22.860	23.458
$Q^2_{tv}(20)$	20.481	18.541	18.571	18.961
AIC_{sr}	-8.2552	-8.2552	-8.2552	-8.2516
AIC_{tv}	-1.9508	-1.9484	-1.9487	-1.9521
SIC_{sr}	-8.2314	-8.2315	-8.2315	-8.2277
SIC_{tv}	-1.9033	-1.9009	-1.9012	-1.9013

Notes: For the specification of the bivariate GARCH-M(1,1) model refer to equations (5.5) to (5.10) in text. The coefficient, s_{1biv}, is the 'lagged' conditional variance of stock index returns included in the conditional mean of trading volume. The subscript *biv* refers to bivariate. The figures in parentheses are *t*-statistics. m_3 and m_4 are coefficients of skewness and kurtosis of the standardised residuals respectively. $X^2(2)$ is the Jarque-Bera-normality test. Q(20) and $Q^2(20)$ are 20th order Ljung-Box statistics of the standardised and squared standardised residuals respectively. AIC and SIC are the Akaike and Schwarz information criteria respectively. The subscripts *sr* and *tv* refer to the stock index returns and trading volume equations respectively. * and ** denotes significance at the 5% and 10% level respectively.

Appendix: **Table 5A**

Univariate EGARCH-M(p,q) Estimation of Stock Index Returns FTSE/ASE 20 Index Nearby Futures Contract (27/08/1999-31/12/2005)

Coefficients	Model 1	Model 2	Model 3	Model 4
Panel A. Conditional mean				
a_{0uni}	-0.007	-0.006	-0.008	-0.007
	(-1.333)	(-1.157)	(-0.983)	(-1.336)
b_{1uni}	0.065*	0.068*	-0.037	0.065*
	(2.960)	(3.147)	(-0.119)	(2.982)
b_{2uni}		-0.008		
		(-0.315)		
c_{1uni}			0.103	
			(0.339)	
d_{1uni}	-0.001	-0.001	-0.001	-0.001
	(-1.327)	(-1.162)	(-0.995)	(-1.324)
Panel B. Conditional variance				
α_{0uni}	-0.353*	-0.356*	-0.354**	-0.343**
	(-17.109)	(-2.470)	(-1.677)	(-1.772)
β_{1uni}	0.966*	0.967*	0.966*	1.102*
	(138.890)	(56.030)	(38.307)	(7.503)
β_{2uni}				-0.136
				(-0.878)
γ_{1uni}	0.209*	0.210*	0.210*	0.193*
	(6.132)	(3.868)	(2.931)	(2.953)
δ_{1uni}	-0.011	-0.011	-0.011	-0.011
	(-1.526)	(-1.428)	(-1.335)	(-0.976)
ζ_{1uni}	-0.053*	-0.053*	-0.053*	-0.048*
	(-2.238)	(-2.523)	(-2.344)	(-2.086)
Panel C. Model diagnostics				
m_3	0.019	0.015	0.017	0.012
m_4	1.635*	1.639*	1.640*	1.640*
$X^2(2)$	176.35*	177.24*	177.57*	177.33*
Q(20)	21.698	22.067	22.077	21.759
$Q^2(20)$	28.937**	29.236**	28.956**	27.028
AIC	-8.2565	-8.2549	-8.2555	-8.2551
SIC	-8.2294	-8.2244	-8.2250	-8.2246

Notes: For the specification of the univariate EGARCH-M(p,q) model refer to equations (5A) and (5B) below. The subscript *uni* refers to univariate. The figures in parentheses are t-statistics. m_3 and m_4 are coefficients of skewness and kurtosis of the standardised residuals respectively. $X^2(2)$ is the Jarque-Bera-normality test. Q(20) and $Q^2(20)$ are 20th order Ljung-Box statistics of the standardised and squared standardised residuals respectively. AIC and SIC are the Akaike and Schwarz information criteria respectively. * and ** denotes significance at the 5% and 10% level respectively.

Model: The conditional mean and variance equations of the univariate EGARCH-M(p,q) specification are:

$$\Delta f_t = a_{0uni} + \sum_{i=1}^{p} b_{iuni}\Delta f_{t-i} + \sum_{j=1}^{q} c_{juni}u^f_{t-j} + d_{1uni}h^f_t + u^f_t, \qquad (5A)$$

$$\ln(h^f_t) = \alpha_{0uni} + \sum_{i=1}^{p} \beta_{iuni} \ln(h^f_{t-i}) + \sum_{j=1}^{q} \gamma_{juni} |u^f_{t-j}/\sqrt{h^f_{t-j}}| + \sum_{j=1}^{q} \xi_{juni}(u^f_{t-j}/\sqrt{h^f_{t-j}}) + \delta_{1uni} v_{t-1}, \qquad (5B)$$

where $f_t = \ln(F_t)$ is the natural logarithm of the contract's settlement futures price, F_t; $\Delta f_t = f_t - f_{t-1}$ is the price log-relative, Δf_{t-i} are past returns, u^f_{t-j} are moving average terms, h^f_t is the conditional variance of Δf_t, and u^f_t are random disturbance terms. Unlike the linear GARCH-M(p,q) model there are no restrictions on the parameters α_{0uni}, β_{iuni}, γ_{juni}, and ξ_{juni} to ensure non-negativity of the conditional variance. Persistence of volatility is measured by β_{iuni}. The asymmetric effect of negative and positive shocks is captured by ξ_{juni} and γ_{juni} respectively; ξ_{juni} measures the sign effect and γ_{juni} measures the size effect. If $\xi_{juni} < 0$ a negative shock (bad news) tends to reinforce the size effect. The converse takes place when $\xi_{juni} > 0$. Bad news will mitigate the size effect. Finally, the lagged volume variable, v_{t-1}, is intended to capture the effect of trading volume on the conditional variance of returns.

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Introduction

The last two decades have seen the emergence of a substantial amount of literature in market microstructure, the area of finance that examines the process by which investors' latent demands are ultimately translated into transactions. However, interest in microstructure and trading is relatively new to the Greek literature, since a limited number of studies have been produced so far, which investigate issues relating to the procedure and outcomes of exchanging assets under a specific set of rules.

This thesis aims to contribute to the market microstructure literature and to add empirical content to current academic and policy discussions, by specifically studying the Greek capital market. An empirical investigation is conducted on the effects and implications of the imposition of: (1) daily price limits on the price volatility, stock returns and trading activity of individual stocks (Chapter 3); (2) transaction taxes on the conditional mean and volatility of stock index returns (Chapter 4); and (3) margin requirements on the conditional mean of trading volume of stock index futures (Chapter 5).

The objective of the study in Chapter 3 is to conduct an investigation on the impact and effectiveness of price limits on the volatility, return and trading activity of Greek equities. The study differs from Phylaktis *et al.* (1999) and Diacogiannis *et al.* (2005), which have also examined the effects of price limits on the Greek capital market, by taking into account supply and demand for liquidity. As Lehmann (1989) and Miller (1989) point out, effects associated with price limits can be either due to the price limits or to large price changes. As a result of Lehmann's (1989) and Miller's (1989) interpretations, the current study uses a control sample, which consists of stocks that experienced a dramatic price change but did not hit their price limit. One can thus infer the effects of price limits by comparing the price behaviour of the control sample of stocks with those stocks that hit their price limit. We base our empirical methodology to examine price limit performance in the Athens Stock Exchange (ASE) on Kim and Rhee (1997).

The purpose of the study in Chapter 4 is to conduct an investigation of the effects of transaction tax on the mean and volatility of stock market returns, in the ASE in Greece. The study makes the following contributions to the existing literature on securities transaction taxes (STTs). First, it provides evidence on a capital market using both a marketwide index (i.e. All Share Index) and a large cap index (i.e. FTSE/ASE 20 Index). By examining the effects of the transaction tax using the FTSE/ASE 20 Index, we test whether the transaction tax has a greater impact on the volatility of actively traded stocks, as a result of investors entering (buying) and exiting (selling) the market (stocks) on a more frequent basis. Second, the study investigates the possibility of an asymmetry in the relation between transaction tax and volatility, which can originate from the different roles transaction taxes could play during bull and bear periods. We expect transaction tax to have a greater impact on the volatility of stocks during bull periods compared to bear or normal periods, since trading activity is higher during bull periods. In addition, we expect transaction tax to have a greater impact on the volatility of the 20 largest and most highly traded stocks compared to all traded stocks. Finally, this study is the first empirical investigation of the effects of transaction tax on the mean and volatility of Greek stock returns. In our study, we employ univariate GARCH-M/EGARCH-M models, which are used to investigate the relationship between transaction tax and the conditional moments – mean and variance – of daily stock market returns.

The aim of the study in Chapter 5 is to provide further empirical evidence on the debate with regard to the effects of margin changes on trading volume. The main contribution of the paper to the existing literature is that it conducts the investigation of the effects of margin changes on the trading volume of stock index futures, by taking into account, on the one hand, the effect of conditional volatility of stock returns on margin changes, and on the other hand, the relationship between conditional volatility of stock returns and trading volume. As a result of the relationship between trading volume and price volatility documented in equities and futures markets, our study incorporates it, when it examines the effects of margin changes on the trading volume of stock index futures, and adjusting margins for underlying price risk, following Dutt and Wein's (2003) suggestion. This has not been studied before in the literature. In this study, we employ bivariate GARCH-M models. These models allow for autocorrelation in the first and second moments, and also have the advantages of avoiding simultaneity bias with regard to the effect of volume on price volatility, allowing for nonlinearities in the second moments, as well as providing a means for estimating a risk premium. Furthermore, the models employed allow us to examine the relationship between trading volume and stock returns, through the lagged volume and lagged return variables included in the conditional variance of returns and volume respectively, the contemporaneous correlation between returns and volume in the conditional covariance, and the lagged conditional variance of returns included in the conditional mean of volume. Our study also examines the effects of margin changes on the trading volume of stock index futures, by specifically looking at the Greek derivatives market, where the effectiveness of margins on trading volume has never been examined before. Specifically, it conducts the tests on a large-capitalisation index futures contract (i.e. FTSE/ASE 20 Index) comprising of the 20 largest stocks in terms of market capitalisation and liquidity.

The remainder of this conclusive chapter is organised as follows. Section 6.2 summarises the main empirical findings of Chapters 3, 4 and 5. Section 6.3 discusses the main implications of the findings on regulatory policy. The last section suggests topics for further research.

6.2 Empirical findings

In Chapter 3, using five categories of stocks based on the magnitude of a one-day price movement, we examine the ASE price limit system to compare volatility levels, price continuation and reversal activity, and trading activity patterns. We find some evidence to support the position of price limit critics who question the effectiveness of price limits in the stock markets. Our upper limit findings are more robust in providing evidence against price limit effectiveness, while our lower limit results are not qualitatively the same as the upper limit results.

For stocks that experience upper limit-hits, we document the following results: volatility does not return to normal levels as quickly as for the stocks that did not reach price limits (volatility spillover hypothesis), although there is some evidence to support price limit effectiveness; price continuations occur more frequently than for stocks that did not reach limits (delayed price discovery hypothesis); and trading activity almost increases on the day after the limit day, while all other stock subgroups experience noticeable trading activity declines (trading interference hypothesis).

For lower limit-hits, we document the following results: volatility does not return to normal levels as quickly as for the stocks that did not reach price limits (volatility spillover hypothesis), although there is again some evidence to support price limit effectiveness; price continuations do not occur more frequently than for stocks that did not reach limits, hence rejecting the delayed price discovery hypothesis; and trading activity drastically declines on the day after the limit day, while all other stock subgroups experience smaller trading activity declines, therefore rejecting the trading interference hypothesis.

Based on our upper limit results, we question the effectiveness of price limits in countering overreaction and in reducing volatility. Moreover, price limits seem to cause delays in equilibrium price discovery and desired trading activity. On the other hand, our lower limit results, support the effectiveness of price limits in countering overreaction and in reducing volatility, and do not seem to cause delays in equilibrium price discovery and desired trading activity.

In Chapter 4, we have added two different dimensions to the examination of STTs, which should make one treat the results of previous studies with caution. We have investigated, on the one hand, the possibly different effect of the transaction tax on the most highly traded stocks, and on the other hand, the potentially different effect of the transaction tax depending on the state of the stock market.

The empirical results can be summarised as follows: First, the transaction tax does not have a significant effect on the mean of daily stock returns for both indices. Second, the transaction tax does not have an effect on the volatility of daily stock returns during normal periods for both indices, and being consistent with the findings of previous studies.[1] Third, the transaction tax increases volatility during bull periods, but does not have a significant effect on volatility during bear periods for the All Share Index. Fourth, the transaction tax increases volatility during bull periods for the FTSE/ASE 20 Index, and the effect is even stronger when comparing it to the All Share Index. This might be the result of the higher trading activity that takes place for the 20 largest and most liquid stocks. Finally, the transaction tax reduces volatility during bear periods for the FTSE/ASE 20 Index.

The empirical findings signify the importance of considering the differential effect of transaction tax on volatility during bear and bull periods. Consequently, the findings of previous studies, which did not take into account this differential effect of transaction tax on volatility, should be treated with caution.

In Chapter 5, we have added two different dimensions to the examination of margin requirements on trading volume, which should make one treat the results of previous studies with caution. On the one hand, previous research, has generally neglected to consider the rationale that margin requirements change in response to changes in price volatility, and on the other hand, they did not take into account the relationship between price volatility and trading volume.

The empirical results can be summarised as follows: An association between margin changes and trading volume is not found, when margins are adjusted for underlying price risk, using the lagged conditional variance of stock returns, and against the expectations of a negative relationship. This association remains also statistically

[1] Please note, normal periods refer to the full sample.

insignificant, when margins are adjusted by the conditional variance of stock returns lagged twice, and when separately incorporating the lagged conditional variance of stock returns in the conditional mean of trading volume. This highlights the importance of adjusting margin requirements for risk and casts doubts on the results of previous studies which did not allow for these inter-relationships. Regarding the relationship between volatility of stock returns and trading volume, we find a contemporaneous correlation which is negative and statistically significant. This is in contrast to our expectations. However, other studies, e.g., Darrat, Rahman and Zhong (2003), find also a negative relationship.

6.3 Policy implications

Since the stock market crash of October 1987, academics and policy makers have been very concerned about the causes of the crash and whether the microstructure of the equity market should be redesigned to protect the market from drastic fluctuations. For their concerns, circuit breakers have been recommended as the mechanisms for the market stabilisation and for reducing the volatility of the stock market. The most common types of circuit breakers are trading halts, price limits, transaction taxes, margin requirements and position limits, and collars. All these mechanisms limit trading activity in some way.

Empirical and theoretical studies undertaken so far have not been able to conclusively resolve the debate on the effects of circuit breakers on financial markets. As a result, this thesis intends to contribute to the current academic and policy discussions, by conducting an investigation on the effects and implications of circuit breakers on financial markets focusing on daily price limits, transaction taxes, and margin requirements, by specifically studying the Greek capital market.

As previously discussed, in the case of daily price limits, the impact and effectiveness of price limits differ for the upper limit and lower limit findings. On the one hand, we find evidence to support the position of price limit critics who question the effectiveness of price limits in the stock markets, and our upper limit results are more robust in providing evidence against price limit effectiveness. On the other hand, our lower limit results are not qualitatively the same as the upper limit results, as they provide some evidence in favour of price limit effectiveness. Consequently, this inconsistency in the results suggests that all that can be learned is that the effects of the price limits, at least in the case of the ASE, are not overwhelmingly obvious. Further research with a bigger number of stocks and an extended sample period might be the catalytic factor in deciding the effectiveness of price limits in the ASE.

In the case of transaction taxes, the empirical results have highlighted that the transaction tax increases volatility during bull periods, when the objective is to reduce volatility and excessive trading, and decreases volatility during bear periods, when the objective should be to support and boost liquidity and volatility. Thus, the use of transaction taxes, at least in the ASE, has not had the desired effect on volatility, since decisions concerning the changes in the transaction tax seem to have been taken with the intention of controlling volatility.

In the case of margin requirements, the empirical results have emphasized that margin changes do not have an effect on the trading volume of the most highly traded and liquid futures contract in the Greek derivatives market. It seems that margin requirements are used only as a mechanism to prevent trader default, and any decisions associated with the changes in margins, which occurred throughout the operation of the Greek derivatives market, did not have a significant effect on trading volume.

Based on our empirical findings, we conclude that daily price limits, transaction taxes and margin requirements, provide little evidence in support of their effectiveness, at least when applied to the Greek capital market. The empirical findings in this thesis suggest that academics and policy makers, who have been supportive of the circuit breakers as the appropriate mechanisms for market stabilisation and for reducing volatility, should continue their efforts to conduct further tests on their suitability, as well as in exploring other mechanisms and channels, which might be more effective in stabilising the market and reducing volatility.

The empirical findings in this thesis also support what Roll (1989) stated over 17 years ago in his comprehensive review on the implications for regulatory policy, that there is little evidence in favour of the efficacy of margin requirements, price limits and transaction taxes.

Before we proceed to the last section of this conclusive chapter, it will be interesting to summarise and highlight the main changes and trends that occurred during the last years with regard to price limits, transaction taxes and margin requirements. This might help us understand the motives behind the decisions of stock exchange officials and provide any additional support on the empirical findings of this thesis. Specifically, in the last few years we observe the following:

- Gradual increase of daily price limits from the initial price limit of ±8% for highly active stocks in August 1992 to the elimination of the ±18% price limit for the 20 stocks comprising the FTSE/ASE 20 Index as well as the increase to ±20% for the remaining stocks since 01/01/2005.

- Gradual reduction of transaction taxes from 0.6% on 08/10/1999 to the current 0.15% since 02/01/2005.
- Gradual decrease of margin requirements from the initial 20% margin on 27/08/1999 to the current 10% margin since 05/02/2004.

The decisions concerning the above changes and trends in price limits, transaction taxes and margin requirements might be the result of mainly two factors. First, the belief by both ASE and Capital Market Commission (CMC) officials that the Greek capital market is now matured enough to handle transactions without the presence of these mechanisms. Second, their belief that these mechanisms do not have the desired effect on the financial markets and consequently market participants, which it is to achieve market stabilisation, the reduction of excessive volatility and the boosting of liquidity and trading volume. Finally, the decisions of stock exchange officials regarding the changes of these mechanisms provide additional support on the empirical findings of this thesis, which finds little evidence to justify their effectiveness and thus their continued adoption.

6.4 Further research

The empirical findings in this thesis have emphasized the need that academics and policy makers should continue their research and investigation on the effectiveness and suitability of circuit breakers like daily price limits, transaction taxes and margin requirements on financial markets.

Using the Greek capital market, the impact and effectiveness of price limits can be examined from 2001 until the present date, capturing in this way the differential effects that these mechanisms might have on the financial markets, following Greece's entry into the European Economic and Monetary Union (EMU) and the official upgrade by Morgan Stanley Capital International (MSCI) from an emerging to a developed market. These results can be compared to the results of previous research, like our study, which have examined price limit performance of the ASE price limits when Greece was undergoing significant socio-economic, regulatory and technological changes to become the 12th member of the "Euro Zone" and at the same time upgrading the status of its financial markets. In addition, the sample size can be extended to incorporate medium sized and small cap stocks, and in this way the differential effects of medium sized and small cap stocks compared to large cap stocks will be unfolded.

Similarly to the daily price limits, the effects of STTs on financial markets can also be extended on the medium and small cap indices like the FTSE/ASE Mid-40 Index and FTSE/ASE SmallCap-80 Index. In the case of margin requirements, the effects of margin changes on individual stock futures, which are continuously becoming popular among futures traders, might be of research interest once there is satisfactory historical data, as these products were relatively launched and developed in recent years. This is specifically interesting since the margin requirements for individual stock futures are normally larger than stock index futures ranging from 15%-30% of the net position value and varies by stock.

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