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Security transaction taxes and financial volatility: Athens stock exchange

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The study examines the effects of security transaction tax on volatility. It focuses on whether the tax has a greater effect on highly traded stocks since it penalizes entering and exiting the market and on whether it depends on the state of the stock market. The results highlight the differential effect of transaction tax on volatility during bear and bull periods casting doubts on the findings of previous studies, which did not allow for that. The effects are stronger for highly traded stocks and during bull periods but volatility increases instead of falling as intended by the proponents of transaction taxes.

I. Introduction

Financial markets are organised in such a way as to transform latent demands of investors into realized 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.[1] Opponents of STTs on the other hand, argue that markets have the ability to allocate resources efficiently without direct intervention 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.[2] Furthermore, investors can trade substitute securities, which are not affected by the tax and generate payoffs similar to 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. As Table 1 shows STTs have operated in major financial markets including Japan, UK, Germany, Italy and France, as well as in smaller OECD economies including Australia, Austria, Belgium, Denmark, Greece and Ireland and many emerging economies, such as Chile, China, India and Malaysia.[3]

The current study investigates the effects of transaction tax on the mean and volatility of stock market returns, in the Athens Stock Exchange (ASE) and makes the following contributions to the existing

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

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

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

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Table 1. Security transaction taxes in the world

Country	Stocks	Corporate bonds	Government bonds	Futures	Detail
Australia	0.3%	0.15%	–	–	Reduced twice in 1990s; 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
UK	0.5%	–	–	–	Present

Source: Pollin *et al*. (2001).
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.

literature on STTs.[4] First, it provides evidence on a capital market using both a market-wide index (i.e. All Share Index) and a large cap index (i.e. FTSE/ASE 20 Index).[5] Previous studies such as Umlauf (1993), Saporta and Kan (1997) and Hu (1998), have concentrated on capital markets by examining a market-wide 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 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.

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

The rest of the article is organized as follows. Section II reviews the literature on STTs. Section III provides background information related to the evolution of transaction taxes in Greece. Section IV discusses the Generalized Autoregressive Conditional Heteroskedasticity (GARCH)/Exponential GARCH (EGARCH) 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 V describes the data and presents the empirical results, while the final section concludes the article.

II. Literature Review

Researchers have attempted to resolve the debate on the effectiveness 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.[7]

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.[8] 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 UK 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 of their impact on transaction costs. For example, Jones and Seguin (1997) examined the effect on volatility of the introduction of negotiated commissions on US 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

[4] It should be noted that Greece was upgraded by the Morgan Stanley Capital International (MSCI) from the emerging market index to the developed market index on 31 May 2001.

[5] The FTSE/ASE 20 Index consists of 20 of the largest in market capitalization 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.

[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 in the US during bull, normal and bear periods.

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

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

Table 2. Volatility effects of transaction taxes

Author	Market	Sign of effect
Roll (1989)	23 Countries	Zero effect
Umlauf (1993)	Sweden	Positive
Jones and Seguin (1997)	US	Positive
Saporta and Kan (1997)	UK	Zero effect
Hu (1998)	Hong Kong, Japan, Korea and Taiwan	Zero effect
Green *et al.* (2000)	UK	Positive
Hau (2006)	France	Positive

securities 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'.[9]

Table 2 compares the results of a selection of articles 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.

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 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 market index was even greater in the case of UK. Saporta and Kan (1997) find that on the day stamp duty in UK 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 $t = -3.06$ and $p = 0.001$.

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

III. Securities Transaction Taxes in Greece

In Greece, the transaction tax was introduced on 19 February 1998, at the rate of 0.3% on the selling of shares transacted in the stock exchange. On 2 September 1999, the Government announced an increase in the rate from 0.3 to 0.6% with effect from 8 October 1999. On 4 December 2000, it was announced that the transaction tax would be reduced back to 0.3%, a move intended to support and boost liquidity in the ASE, which started 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 3 January 2001.[10]

IV. 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]

Conditional mean of returns

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

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

where $\mu_t \equiv E(r_t|i_{t-1})$ 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), T_{t-1} denotes the level of transaction tax at time $t-1$, r_{t-1} are past returns, ε_{t-j} are moving average terms and

[9] Hau (2006, p. 888).
[10] There was an additonal tax rate reduction on stock transaction from 0.3% to 0.15%, which was implemented in January 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 the latest tax rate change falls outside our sample period.
[11] For a detailed explanation of ARCH models see Bera and Higgins (1993).

Table 3. Descriptive statistics for Bull, Bear and normal periods

	$n=3$	$n=4$	$n=5$
Panel A. All share index (24 September 1997 to 31 December 2003)			
Number of observations in Bull periods	25 (32.9%)	22 (28.9%)	18 (23.7%)
Number of Bull periods	5	4	3
Number of observations in Bear periods	21 (27.6%)	9 (11.8%)	5 (6.6%)
Number of Bear periods	6	2	1
Number of observations 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 (24 September 1997 to 31 December 2003)			
Number of observations in Bull periods	22 (28.9%)	16 (21.1%)	16 (21.1%)
Number of Bull periods	5	3	3
Number of observations in Bear periods	18 (23.7%)	9 (11.8%)	5 (6.6%)
Number of Bear periods	5	2	1
Number of observations 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, 3–5 months. Numbers in brackets denote the proportion of observations in each category as a % of the sample.

$\sigma_t^2 \equiv \text{var}(r_t|i_{t-1})$ is the conditional variance of r_t based on i_{t-1}.

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 beyond its indirect influence through its possible association with volatility. In fact, if higher transaction taxes reduce uncertainty about future unwarranted 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:

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

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

Conditional variance of returns

The conditional variance of returns equation is modified 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 horizon 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 horizon n of our analysis takes three possible values, $n=3$–5 months.

Table 3 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 of 24 September 1997 to 31 December 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 same algebraic sign, are 30 $(=76-25-21)$, or 39.5% of the sample. It should be noted that as the horizon n increases the number of bull and bear periods (as well as the number of observations in them) decline. At the longest horizon we examine, the horizon of 5 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:

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

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.

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.[12] As mentioned earlier, the proponents of STTs argue that the purpose 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:

$$H2\colon \gamma_T < 0$$

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 ($n = 3$–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. This negative effect of transaction taxes on volatility during bull periods sets up the basis for the third testable hypothesis:

$$H3\colon \zeta_{\text{TBULL}} < 0$$

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. This symmetric effect of transaction taxes on volatility during bear periods sets up the fourth hypothesis to be tested as follows:

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

We have also tested for an asymmetric impact of good news (market advances) and bad news (market retreats) on volatility by estimating an EGARCH-M(p,q) model. 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.[13] In this case the conditional volatility based on Nelson (1991) is modified as follows:

$$\text{In}\left(\sigma_t^2\right) = \alpha_0 + \sum_{i=1}^{p} \alpha_i \left| \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right| + \sum_{i=1}^{p} \eta_i \left(\frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right) + \sum_{j=1}^{q} \beta_j \text{In}\left(\sigma_{t-j}^2\right) + \gamma_T T_{t-1} + \cdots + \delta_{\text{TBEAR}} \text{BEAR}_t T_{t-1} + \zeta_{\text{TBULL}} \text{BULL}_t T_{t-1} \qquad (3)$$

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 nonnegativity 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.

V. Empirical Analysis

Data

The data set comprises closing daily observations of the All Share Index and the FTSE/ASE 20 Index

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

[13] 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.

Table 4. Summary statistics of daily stock index returns

	All share index (24 September 1997 to 31 December 2003)	FTSE/ASE 20 index (24 September 1997 to 31 December 2003)
Mean	0.022	0.009
SD	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 $i = 1, \ldots, 10$ 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.

from 24 September 1997 to 31 December 2003 giving us in total 1564 observations.[14,15] The data is collected from the ASE records. The FTSE/ASE 20 Index is comprised of the 20 largest in market capitalization and most highly traded stocks of all the companies listed on the ASE. At the end of 2003, the market capitalization of FTSE/ASE 20 Index was 39.45% of the total market capitalization and the total number of companies listed on the ASE was 355.[16]

The daily stock returns r_t are calculated as the logarithmic first difference of the price index, using the formula $r_t = (\ln p_t - \ln p_{t-1}) \times 100$, where p_t is the stock index price in period t. Note that returns are expressed in a continuously compounded percentage form. The data on transaction tax, T_{t-1}, is expressed in decimals and, thus, can vary from zero to one.

Table 4 reports descriptive statistics of the daily stock returns. 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 displays significant first order autocorrelation. Ljung and 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 24 September 1997 to 31 December 2003 are presented in the next section.

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 5 and 6, 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 24 September 1997 to 31 December 2003.

The appropriate GARCH-M(p,q)-ARMA(p,q) model is selected using 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 model is correctly specified the value of the coefficients of skewness and kurtosis of the standardized residuals should be smaller than the value of skewness and kurtosis of the stock index returns data, respectively.

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

[14] Daily closing data for the FTSE/ASE 20 Index is available since the establishment of this large cap index on 24 September 1997.

[15] 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.

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

Table 5. EGARCH-M(1,3)-ARMA(3,1) Estimation of daily stock index returns all share index (24 September 1997 to 31 December 2003)

Coefficients	Model 1		Model 2		Model 3		Model 4		Model 5	
Panel A. Conditional mean of returns										
a_0	−0.220*	(−2.047)	−0.024	(−0.085)	−0.135	(−0.733)	−0.144	(−0.790)	−0.136	(−0.761)
a_1	−0.080	(−0.573)	−0.071	(−0.515)	−0.106	(−0.769)	−0.119	(−0.896)	−0.097	(−0.704)
a_2	−0.099	(−0.860)	−0.055	(−0.465)	−0.097	(−0.845)	−0.084	(−0.733)	−0.093	(−0.817)
a_4	0.057	(0.557)	0.041	(0.394)	0.074	(0.707)	0.072	(0.686)	0.063	(0.603)
a_5	0.218**	(1.875)	0.184	(1.559)	0.203**	(1.723)	0.218**	(1.874)	0.226**	(1.916)
b_T			−0.647	(−0.788)	−0.450	(−0.883)	−0.437	(−0.852)	−0.408	(−0.825)
c_1	0.567*	(2.344)	1.092*	(28.829)	0.535*	(2.128)	0.484**	(1.771)	0.515**	(1.896)
c_2	−0.082**	(−1.729)	−0.157*	(−3.516)	−0.074	(−1.518)	−0.070	(−1.362)	−0.072	(−1.443)
c_3	0.080*	(2.557)	0.035	(1.154)	0.079*	(2.541)	0.079*	(2.586)	0.075*	(2.457)
d_1	−0.414**	(−1.682)	−0.937*	(−34.894)	−0.380	(−1.493)	−0.326	(−1.178)	−0.366	(−1.325)
e	0.064*	(2.695)	0.069*	(2.464)	0.084*	(3.425)	0.084*	(3.427)	0.076*	(3.123)
Panel B. Conditional variance of returns										
α_0	−0.107*	(−4.731)	−0.106*	(−4.075)	−0.101*	(−3.664)	−0.097*	(−3.351)	−0.096*	(−3.524)
α_1	0.189*	(5.335)	0.180*	(5.145)	0.179*	(5.241)	0.180*	(5.075)	0.186*	(5.280)
β_1	1.739*	(15.227)	1.753*	(14.530)	1.726*	(15.129)	1.698*	(13.261)	1.722*	(14.657)
β_2	−1.358*	(−6.885)	−1.374*	(−6.746)	−1.344*	(−6.930)	−1.291*	(−6.031)	−1.331*	(−6.616)
β_3	0.588*	(5.613)	0.592*	(5.659)	0.583*	(5.675)	0.550*	(4.969)	0.570*	(5.304)
γ_T			0.004	(0.091)	−0.036	(−0.739)	−0.012	(−0.232)	−0.026	(−0.535)
					$n=3$		$n=4$		$n=5$	
δ_{TBEAR}					0.049**	(1.727)	0.036	(1.086)	0.053	(1.451)
ζ_{TBULL}					0.096*	(2.685)	0.118*	(2.765)	0.075**	(1.891)
η_1	−0.042**	(−1.950)	−0.048*	(−2.232)	−0.053*	(−2.439)	−0.059*	(−2.668)	−0.049*	(−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 1 and 3 in text. The figures in parentheses are t-statistics based on estimated robust SEs. m_3 and m_4 are coefficients of skewness and kurtosis of the standardized 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 standardized and squared standardized residuals, respectively. (*) and (**) denotes significance at the 5 and 10% level, respectively.

All share index. Table 5 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 24 September 1997 to 31 December 2003.[17] 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 3–5 include the bear and bull coefficients in the variance equation, for the periods three, four or five consecutive ($n=3$–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 earlier studies, which also examine the effect of transaction taxes on volatility during normal periods.

In Panel A of Table 5, daily stock market returns are modelled using an ARMA(3,1) process to capture the serial correlation due to individual stocks in the index which are not all trading exactly at the close [see Lo and Mackinlay (1988)].[18]

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

[17] 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.

[18] Lo and Mackinlay (1988) discuss the effects of nonsynchronous trading on autocorrelations. Their view is that since small capitalization stocks trade less frequently than larger stocks, new information is absorbed first into large capitalization stock prices and then into smaller stocks with a lag. This lag induces a positive serial correlation.

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.[19]

The coefficient e for the conditional variance is statistically significant in all models, indicating that there is very strong positive linkage 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.

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.

Panel B of Table 5 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 $|-1+\eta_1|/(1+\eta_1)$.[20] 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 5, 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 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)].

Panel C of Table 5 presents the model diagnostics. The Ljung–Box statistics Q(20) and $Q^2(20)$ of the standardized and squared standardized 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 standardized residuals have a smaller value, than the kurtosis of the stock index returns data, while the coefficients of skewness of the

[19] See Kohers and Kohers (1995) and Mills *et al.* (2000) for the case of the Greek capital markets.
[20] See Booth *et al.* (1997).

Table 6. GARCH-M(1,3)-ARMA(3,1) Estimation of daily stock index returns FTSE/ASE 20 index (24 September 1997 to 31 December 2003)

Coefficients	Model 1		Model 2		Model 3		Model 4		Model 5	
Panel A. Conditional mean of returns										
a_0	−0.215**	(−1.949)	−0.139	(−0.845)	−0.349**	(−1.923)	−0.287**	(−1.702)	−0.272	(−1.580)
a_1	−0.077	(−0.529)	−0.082	(−0.562)	−0.041	(−0.287)	−0.051	(−0.372)	−0.053	(−0.375)
a_2	−0.062	(−0.526)	−0.065	(−0.556)	−0.025	(−0.218)	−0.071	(−0.618)	−0.080	(−0.678)
a_4	−0.001	(−0.006)	0.000	(0.002)	0.004	(0.036)	−0.007	(−0.064)	−0.020	(−0.175)
a_5	0.179	(1.491)	0.174	(1.431)	0.258*	(2.094)	0.245*	(2.065)	0.236*	(1.973)
b_T			−0.221	(−0.556)	−0.090	(−0.238)	−0.153	(−0.417)	−0.149	(−0.396)
c_1	0.358	(0.531)	0.345	(0.482)	0.370	(0.592)	0.417	(0.619)	0.409	(0.629)
c_2	−0.046	(−0.423)	−0.043	(−0.380)	−0.064	(−0.653)	−0.070	(−0.630)	−0.068	(−0.642)
c_3	0.024	(0.801)	0.023	(0.775)	0.027	(0.834)	0.024	(0.738)	0.028	(0.870)
d_1	−0.202	(−0.299)	−0.1909	(−0.264)	−0.216	(−0.345)	−0.255	(−0.377)	−0.249	(−0.381)
e	0.067*	(2.708)	0.068*	(2.729)	0.111*	(3.861)	0.103*	(3.849)	0.100*	(3.638)
Panel B. Conditional variance of returns										
α_0	0.145*	(3.319)	0.126*	(2.085)	0.435*	(3.129)	0.554*	(3.091)	0.481*	(2.977)
α_1	0.125*	(3.499)	0.121*	(3.498)	0.168*	(4.050)	0.163*	(4.009)	0.167*	(4.024)
β_1	1.241*	(4.725)	1.268*	(4.945)	0.954*	(3.163)	0.938*	(2.977)	0.955*	(3.120)
β_2	−0.747*	(−2.054)	−0.790*	(−2.234)	−0.262	(−0.634)	−0.220	(−0.506)	−0.273	(−0.650)
β_3	0.347*	(2.005)	0.369*	(2.199)	0.007	(0.040)	−0.019	(−0.103)	0.021	(0.116)
γ_T			0.030	(0.176)	0.118	(0.395)	−0.164	(−0.537)	−0.097	(−0.320)
					$n = 3$		$n = 4$		$n = 5$	
δ_{TBEAR}					−0.454*	(−2.050)	−1.005*	(−3.003)	−0.909*	(−2.657)
ζ_{TBULL}					0.932**	(1.941)	1.134*	(2.067)	1.174*	(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 1 and 2 in text. The figures in parentheses are *t*-statistics based on estimated robust SE. m_3 and m_4 are coefficients of skewness and kurtosis of the standardized 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 standardized and squared standardized residuals, respectively. (*) and (**) denotes significance at the 5 and 10% level, respectively.

standardized residuals exhibit an insignificantly larger value.

FTSE/ASE 20 index. Table 6 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 24 September 1997 to 31 December 2003. We have selected GARCH-M(p,q) modelling to examine the relationship between transaction tax and the conditional mean and variance, because the leverage effect coefficient has been found to be statistically insignificant.

In Panel A of Table 6, 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 nonsynchronous 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 3–5, 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 5, 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 linkage between conditional stock market volatility and conditional mean returns, consistent with the CAPM theory. The coefficient b_T,

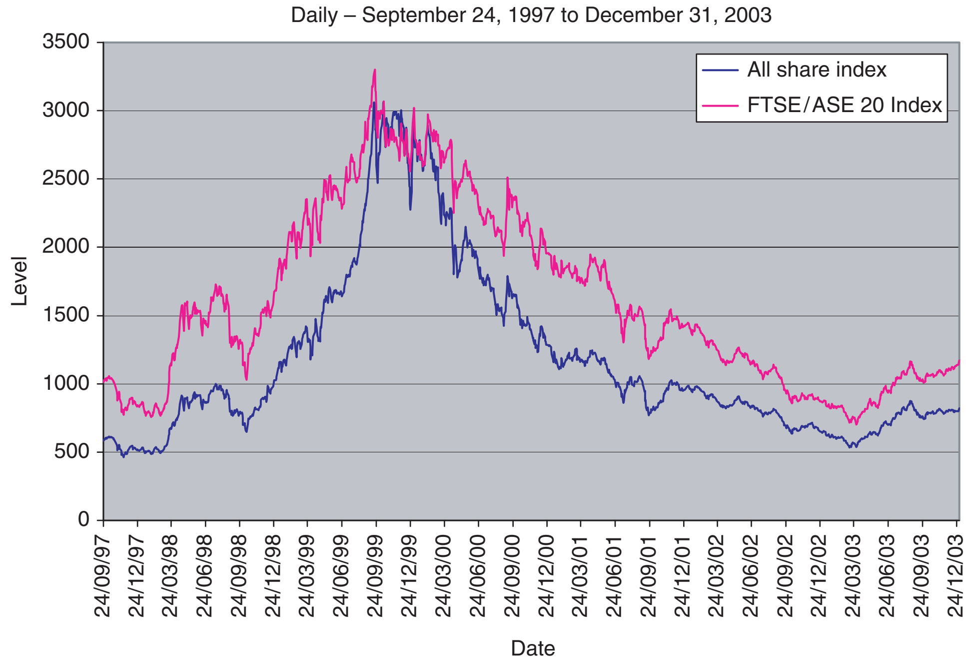

Fig. 1. The Athens stock exchange all share index and FTSE/ASE 20 index
Source: ASE.

which captures the effect of the transaction tax on the conditional mean of returns, is also negative and statistically insignificant, therefore rejecting *H*1.

Panel B of Table 6 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 6, 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 *H*2.

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 *H*4. 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 *H*3.

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. Indeed, 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.

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 8 October 1999, in order to prevent the excesses of an ongoing bull market and lowered the transaction tax from 0.6 to 0.3% on 3 January 2001, with the intention of simply counteracting the earlier increase once it believed that the excesses of the earlier bull market were over.[21]

Panel C of Table 6 contains the model diagnostics, which confirm that the conditional mean and variance equation of returns are well specified.

VI. Summary and Main Policy Conclusions

The effects of stock transaction taxes on financial markets are not only of interest to academics, but it is 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.

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 market-wide index like the All Share Index and a large cap index like the FTSE/ASE 20 Index, for the sample period 24 September 1997 to 31 December 2003.

The empirical results can be summarized 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 is 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.

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[21] See Fig. 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 3067.04 points and 3301.69 points (closing prices) on 13 October 1999 and 20 September 1999, respectively. The stock market followed a downward trend thereafter.

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