Business Economics Series 05
Working Paper 94-29
July 1994

Departamento de Economía de la Empresa
Universidad Carlos III de Madrid
Calle Madrid, 126
28903 Getafe (Spain)
Fax (341) 624-9875

STOCK MARKET REGULATIONS AND INTERNATIONAL FINANCIAL INTEGRATION: THE CASE OF SPAIN

J. Ignacio Peña and Esther Ruiz*

Abstract

International financial integration effects on Spanish stock market are studied, both for the conditional mean and conditional variance. New institutional regulations in Spain are taken into account and its efficiency consequences are addressed. Results suggest an increasing international integration but nontrivial opportunities for financial diversification may still be relevant.

Key Words

EGARCH, GARCH, Stochastic Volatility, Financial integration.

* Peña, Departamento de Economía de la Empresa de la Universidad Carlos III de Madrid and Ruiz, Departamento de Estadística y Econometría de la Universidad Carlos III de Madrid.
The authors acknowledge financial support from the Applied Econometrics Program of the Argentaria Chair at the University Carlos III de Madrid, and are grateful to E. Morales and D. Manzano for providing some data. Earlier versions of this paper were presented in seminars at Universidad Complutense, Universidad del Pais Vasco, Universidad Carlos III and Chemical Bank-Imperial College Conference on Forecasting Financial Markets.

1. Introduction

This paper addresses the consequences of the Spanish Stock Exchange Reform on the market's degree of international financial integration. Time series properties of asset returns measured by the daily index of the Madrid stock exchange market are studied and its relationships with the main world stock markets addressed. The results suggest an increase in these relationships but possibilities for diversification might still be significant.

A sharp change in the regulated Spanish Stock Exchange (SSE) occurred in 1988 due to the Stock Market Reform Law (SMRL). The main points of this law were as follows. Firstly, Official Stock Market Agents, previously appointed by the Government, were replaced by private Brokers and Dealers. A new trading system was established, the Computer Assisted Trading System (CATS), which is opened from 11:00am to 5:00pm. This new system was the cause of the practical termination of the traditional open outcry trading process. That system become fully operational in the first quarter of 1990. However some floor trading remain for small stocks from 10:00am to 12:15pm.

Secondly, the previously regulated Brokerage Fees were liberalized, and the resulting commission price war among Spain's brokers has led to up to 0.12% commission for typical market transactions. Also, the Comisión Nacional del Mercado de Valores (CNMV) was created. This commission is the Spanish equivalent of the US's Securities and Exchange Commission.

Finally, a new settlement and clearing service was created and was operational at the same time that CATS; cash balances are cleared in 48 hours. Before SMRL, cash balances of operations from one given week (Monday to Friday) were cleared on next week's Friday. The new settlement period is T+10, and previously was T+30. In April 1993 the CNMV opened its new "Servicio de Compensación y Liquidación", the securities settlement and clearing service, aimed at expediting the settlement period. In 1994 the CNMV believes the settlement period will be reduced further to T+5.

Another important change took also place around those dates. The six main Spanish stocks (in terms of market value) become listed securities on the New York Stock Exchange in the period 6/87 to 5/89. Those firms' market value (in Spain) amounted to almost 50% of total value[1].

It is well known that U.S.A. and Japan account for approximately 80% of world's market value of exchange-listed securities being New York Stock Exchange (NYSE) and Tokyo Stock Exchange (TSE) the most representative stock markets. Other important European markets are London Stock Exchange (LSE) and Frankfurt Stock Exchange (FSE). However, although the total market value of equities listed on TSE was approximately 15 points larger than on the NYSE in late eighties and early nineties, some authors, for instance Eun and

[1] The firms, their market value in Spain and date of listing in NYSE are: Telefónica (11%) 6/87, Banco Santander (6%) 7/87, BCH (7%) 7/87 (formerly separate Banks Central and Hispano), ENDESA (10%) 5/88, BBV (7%) 10/88, Repsol (8%) 5/89. What is traded is not the stock itself but American Depository Receipts (ADR) which are financial assets issued by a U.S. bank and represent indirect ownership of a certain number of shares that are held on deposit in a bank in the company's home country. Telefónica, BBV and Banco Santander are also listed in the stock exchanges of Tokyo, London and Frankfurt.

Shim (1989), Hamao et al. (1990) and Becker et al. (1990), suggest that the U.S. market is the essential leader in price movements and the most influential market in the world. Similar results for the Spanish market are shown in Espitia and Santamaría (1991), Manzano and Mateos (1991) and Peña (1992a,b) using different models.

The institutional changes mentioned before might affect the time series properties of the security prices in SSE. In particular, such changes could have empirically testable implications for the variances, autocorrelations and cross-autocorrelations of returns of individual stocks and portfolios as well as of the Spanish Market Index (IGBM)[2].

We could expect that, after SMRL, the SSE should provide more efficiently valued securities and therefore autocorrelations, both in individual securities and in the Market Index, should decrease. Because of arbitrage reasons, the listing of major Spanish stocks in NYSE and other markets might increase the interdependence between domestic and international securities markets, both in mean returns and in volatility.

Thus, this work focuses on the influences of four main stock markets: New York Stock Exchange (represented by Dow-Jones Index, DJ), Tokyo Stock Exchange (Nikkei index, NIK), London Stock Exchange (FT100 index, FTD) and Frankfurt Stock Exchange (Commerzbank index, COM) over an small market (about 1% world's market value), the

---

[2] As the Spanish Market Index we use the Madrid Stock Exchange's General Index (IGBM). This index is made up each year of 72 companies and represents about 80-85% of the total capitalization of the market, excluding foreign stocks. It accounts for dividends and stock splits, and is a market value weighted index. Therefore it should reflect mainly the behavior of the big firms.

Spanish Stock Exchange, using daily data. The paper is organized as follows. In section 2 we present the econometric framework. Section 3 contains the empirical results and Section 4 some tentative conclusions.

2. Econometric framework

To model the dynamic relationships between the Spanish market's returns and the other international markets' returns considered in this paper, a single-equation econometric model is fitted. We define R_t, the daily return for the SSE index, as $R_t = \ln(x_t) - \ln(x_{t-1})$, where x_t is the spot price. The proposed model for SSE returns[3] is

$$R_t = \sum_i \sum_j \delta_{i,j} Z_{i,t-j} + \theta_1 e_{t-1} + e_t \qquad i = 1,\ldots,4 \quad j = 0,1 \tag{1}$$

where $Z_{i,t-j}$ are foreign stock markets returns for DJ, NIK, FTD and COM and e_t is a zero mean, uncorrelated noise process with constant unconditional variance. We estimate model (1) for the whole sample and for several subsamples by Maximum Likelihood, treating e_t as if it were Gaussian. To take into account the possible heteroscedasticity in the disturbances e_t, the covariance matrix of the estimates has been computed using White's (1980) heteroscedasticity-consistent covariance matrix. The reason to allow for serial correlation in

[3] We are assuming some kind of exogeneity for the variables Z (foreign stock market returns) in our model. The reasons for that are the small size of SSE, and the growing influence of foreign investment in it, specially after 1986. Foreign investors are the owners of more than 20% of total listed equity. On the other hand, holdings of foreign stocks in Spanish portfolios are negligible. Also, Granger's causality tests (available on request) do not show any influence of the SSE on any other of the markets considered in this study.

SSE index returns stems from the possible "Fisher effect" (nonsynchronous trading) and other frictions in the trading process, as discussed in Scholes and Williams (1977) and Lo and MacKinlay (1990).

Then, we consider several alternative univariate volatility models to represent the possibly time-varying conditional variances of the residuals e_t. First, following Engle (1982) and Bollerslev (1986), we fit a GARCH(1,1) model for the conditional variance which is given by

$$\sigma_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \tag{2}$$

where e_t is assumed to be conditionally normal, and σ_t is known as volatility. However, the GARCH specification for the conditional variance may not be the most appropriate when dealing with stock returns because of the possible asymmetry in the answer of volatility to positive and negative movements in prices; see Black (1986) and Nelson (1991). Therefore, we also consider the exponential GARCH (EGARCH) model proposed by Nelson (1991). Assuming conditional normality of e_t, the EGARCH(1,0) model is given by

$$\log(\sigma^2{}_t) = \omega + \beta \log(\sigma^2{}_{t-1}) + \delta \frac{e_{t-1}}{\sigma_{t-1}} + \alpha\left[\frac{|e_{t-1}|}{\sigma_{t-1}} - \left(\frac{2}{\pi}\right)^{1/2}\right] \tag{3}$$

In model (3), the volatility, σ_t, is observable at time t-1, and therefore, the model is conditionally Gaussian and $\sigma^2{}_t$ is the conditional variance.

Alternatively, we may treat σ_t as an unobservable variate at time t-1, allowing unexpected news at time t to have effects on the volatility at time t. In this vein, Taylor (1986) proposed the Stochastic Volatility (SV) models where the logarithm of the volatility is modelled as a linear process, for example an autoregression. In the simplest stationary SV model the volatility is given by

$$\log(\sigma^2_t) = \gamma + \phi \log(\sigma^2_{t-1}) + \eta_t \qquad (4)$$

where $\eta_t \sim$ Niid $(0,\sigma^2_\eta)$. Model (4) will be denoted by ARV(1).

To allow for asymmetric effects in volatility, we can extend model (4) by including past returns as follows

$$\log \sigma^2_t = \gamma + \phi \log \sigma^2_{t-1} + \sum \alpha_i \frac{e_{t-i}}{\sigma_{t-i}} + \eta_t \qquad (5)$$

Models (4) and (5) have the difficulty that, even assuming that e_t is Gaussian, they are not conditionally Gaussian. However, their estimation can be carried out by a Quasi-Maximum Likelihood (QML) method as proposed independently by Nelson (1988) and Harvey et al. (1994).

Finally, we also consider the possible relationships between the Spanish market volatility and volatilities in the other markets by means of analyzing the cross-correlations between the estimated volatilities in the different markets.

3. Empirical Results

3.1 The Data

The data consists of daily closing prices for all the indexes from January the 1st 1987 to October the 2nd 1992, and were obtained from the Studies Department of Madrid Stock Exchange (we also use the opening price data on New York). The sample size is 1353. All the series present a nonstationary behavior, with high values (near 0.99) in the first lags of the autocorrelation function. A formal extended Dickey-Fuller test does not reject the null hypothesis of one unit root, so it seems reasonable to work with the returns of this series as previously defined. The Hasza-Fuller test for a second unit root clearly rejects an additional unit root.

Table 1 shows some index features, as the index name, the market, number of stocks, adjustments for stocks splits, market value or new issues, if present. European indexes are market value weighted, in contrast with the American and Japanese indexes which are simple price indexes. All the indexes allow for stock splits and new issues, but only Madrid index takes into account dividends[4]. Also note that our data are not excess returns over one risk-free asset. The reason is the difficulty in comparing short-term rates across countries (for instance, short-term rates in Spain are monetary policy targets for the Central Bank and thus regulated).

---

[4] The procedure is as follows: on December 31 an estimation of the expected net dividends each stock will pay is computed. This amount, expressed as percent of par value is divided by 365. The resulting amount multiplied by the number of days elapsed since the beginning of the year is subtracted daily from the market price.

Table 2 shows opening and closing hours in Madrid time, as well as the relative market value of each stock exchange[5]. Note that there are time intervals when New York, Madrid and London overlap; however, European markets close before New York closing value is known. Also Tokyo's closing values are known before any market opens. Note also that in a given day, the agents in the Madrid market know all the closing values before Madrid itself closes, but only opening value for New York. Thus, in addition of the usual close-to-close return, we also computed the close-to-open (CTO) return for New York.

Data analysis and the changes in the institutional framework mentioned in the Introduction, suggest four different regimes in our sample. The first one goes from 1/1/87 to the big "correction" on 19th of October 1987 (190 data points). The second one goes from this day to the beginning of the Continuous Market (MC) (1/4/89) (334 data points)[6]. The third one is a transition period, lasting for one year approximately (242 data points) where new firms begin to quote their prices in the new system. During the last regime which consists of 567 observations, the MC is working normally and the main Spain's blue chips are listed in NYSE.

In Table 3, which shows several sample moments for all the indexes analyzed during the last period of the sample, it is possible to observe that all indexes have significant excess kurtosis and autocorrelations of the squares. These stylized facts are present in many financial time

[5] There are some arguments about the real significance of Tokyo Stock Exchange figures. Some studies allowing for the effect of cross-participation between firms, reduce its market value about 40% ;see French and Poterba (1990).

[6] To minimize data problems related to the big crash, two weeks of data before and after the crash were deleted

series, which may be caused by the presence of conditional heteroscedasticity. We may also observe that only the SSE and DJ indexes present some minor first order autocorrelation.

3.2 Estimation of the conditional mean.

First, we estimate by Maximum Likelihood the dynamic regression model (1). The estimation results are summarized in Table 4, where we may observe that:

i) In the first regime, before 10/89 and before MC, no relevant foreign stock market effects are detected, as can be deduced from the non significant parameters and low R^2 (multiple correlation coefficient) value. Note also the high value of the MA(1) parameter[7].

ii) In the second regime, influences from New York, Tokyo and London begin to become apparent. These effects are instantaneous or with one day lag. The reason for lagged effects might be that the old trading system was only open from 10 to 13 hours. R^2 increases its value. Note the low value of the MA(1) parameter in comparison with the previous period.

iii) In the transition period, the foreign effects are again detected, albeit somewhat different in magnitude.

iv) The last period shows a significant effect from New York (close-to-open return CTO) and

[7] This result could be seen as evidence against the weak form of the efficient market hypothesis in Madrid market. However, results in Peña (1993) suggests a high degree of nonsynchronous trading in Madrid due to the thinness of the market.

a mild effect from previous day close-to-close return. Also, less important but still significant effects are found from Tokyo, London and Frankfurt. The MA(1) parameter is the lowest of all periods suggesting an increase in efficiency after MC. The fit is reasonably good, taking into account the simple model we are using[8].

High values of McLeod-Li Q_2 statistic in all periods suggest that some form of time-varying variance is present in the residuals, which we will consider in the next sub section.

The empirical results summarized above suggests an increase in SSE operational efficiency after the Reform as reflected by the decrease in SSE return's inertia. Also, the joint effects of the Reform and the listing of Spain's blue chips in foreign markets seems to increase the international integration of SSE.

To check the performance of the estimated model, we carried out a simple forecasting exercise, whose results appear in Table 5. The procedure was as follows: we reestimated the model without the last 150, 100, 50 and 25 days and then we forecast one step ahead those days. The same procedure is applied to a MA(1) model and a Random Walk models and the Root Mean Squared forecast errors are computed. Results in table 5 suggest a consistent improvement of about 20% over simple extrapolative models. However much more work is needed before we can conclude that any significant economic profit could be extracted from

[8] All series showed abnormally low values from the 19th to the 22nd of August of 1991. This could be related with the events surrounding the kidnapping suffered by Mr. Gorbachov. We performed the analysis both with original data and with optimally interpolated data. The results were not very different, but we choose to use the data free of these abnormal values.

this model. For instance, some trading rules should be explored and risk, transaction costs and simple rules like "buy and hold" should be taken into account.

3.3 Estimation of volatility

The objective of this subsection is to analyze the dynamics of the volatility in the SSE market index first using univariate GARCH, EGARCH and SV models and then analyzing the multivariate relationships with the volatilities of the other foreign markets considered.

We study only the last period, when the influence of foreign stock markets on the SSE are stronger. Table 6 shows sample moments of residuals from the regression model (1) fitted to IGBM. Comparing tables 3 and 6 we may observe that skewness and kurtosis of the residuals are smaller than in the original index, but still significant. Also, as we pointed out before, the McLeod-Li statistic is highly significant. We may also observe that the Q_3 statistics are not significant[9].

Consequently, we fit the univariate GARCH(1,1), EGARCH(1,0) and ARV(1) models to the residuals from model (1). The estimation results appear in Table 7, where it is possible to observe that all these models imply high persistence of volatility. The EGARCH estimate of the asymmetric effects is not significant. Also, the estimates of the asymmetric effects with two lags in the ARV(1) model, i.e. α_i in model (5), are not significant. This is not surprising given the previous results for Q_3 in Table 6.

[9] The Q_3 statistic is the sample correlation between y_t and y^2_{t-h}. For $h>0$ is a test for asymmetric effects. For $h<0$ is a test for ARCH-M effects.

Comparing the GARCH, EGARCH and ARV models, we may observe that the standardized residuals are closer to normality in the ARV model. In Figure 1 we represent the estimated density of the residuals standardized using the volatility estimated by the GARCH and ARV models together with the normal density. The density estimated using the EGARCH estimates of volatility is very similar to the GARCH density and therefore is not plotted. Comparing the GARCH and ARV densities we may also observe that the ARV density is closer to the normal. All models seem to be successful in taking account of the autocorrelation present in the squared residuals form model (1), but when looking at the diagnostics proposed by Pagan and Schwert (1990) we may observe that the ARV model has the best fit between squared residuals and the estimated conditional variances. However, the Box-Ljung statistic for 10 lags, of the residuals of these regressions are significant for the three models. It seems that this could be due to the presence of some seasonal effects, related with the day of the week, present in the volatility process.

Consequently, we adopt the ARV(1) model in (4) for the volatility of the residuals of the SSE. We fit the same model for all market's volatilities. The estimation results appear in Table 8, where we may observe that the autorregresive parameter of the log-volatility process is very close to unity for all indexes considered, implying high persistence in variance. In this table we also report the results of the extended Dickey-Fuller tests for $\log(y^2_t)$ for each of the indexes. In all cases there seems to be signals that one unit root might be present in the volatility. We fitted model (4) imposing the unit root and results were pretty similar to the model without that restriction.

Figure 2 represents the one-step ahead and smoothed estimates of volatility for each index.

Looking at the smoothed estimates in the different markets, we may observe that it seems that there are common movements in volatility, specially when the markets have high volatility, with common sources. This fact has been also observed by other authors as Aderhold et al. (1988) and Furstenberg and Jeon (1989).

To analyze the possible relationship between the volatility in SSE and the international volatilities we computed the correlation matrix between the smoothed estimates of volatility, which is given by Table 9. Looking at the matrix, it seems that after discounting the international effects on the conditional mean, the conditional variance of SSE is mainly related to DJ (New York) volatility, although it has also relationships with the other markets. A principal component analysis of the correlation matrix reveals that with two components we may explain 76% of the variability in the volatilities. The weights of each volatility on these two components are given in Table 10. The first components may be interpreted as a "world" underlying volatility while the second component is mostly "european", with Frankfurt and London as the dominant factors.

4. Conclusions

From the previous analysis, it seems to be a growing influence of the main world stock markets on SSE. Although the main relevant markets are New York, London and Frankfurt, it is worth noting that New York seems to be the most influential market both in mean and in variance. This influence was first realized about October 1987 meltdown and is getting stronger since, specially when the Continuous Market system is working. Thus, the reforms seems to improve operational efficiency and also act as a catalyst of international financial integration. The joint effect of those markets could perhaps be interpreted as one equation in the single factor world capital asset pricing model by Harvey and Zhou (1993). However in spite of the increased integration with other markets, the idiosyncratic component of SSE mean return is still higher than 50% of the total. This suggests that valuable diversification gains for investing in SSE may still be relevant.

Also, there are some suggestions that econometric models that take into account those relationships outperform simple extrapolative models like Random Walks or ARIMA, in one-step-ahead forecasting. However much more research is needed to clarify the real economic ,and not only statistical, relevance of the results.

The implications for future research include to expand the model in the line of multivariate-SV models. In fact, the principal components analysis in the previous section suggest that it could be worth to try to estimate a multivariate model for the volatility as in Harvey et al. (1994) and this is left for future research. Other lines of research include trading simulations to check if the (risk-adjusted) excess profits, the model could generate, vanish when transaction costs and taxes are included. Measures for risk-free rates could be in the line of Solnik (1993) who uses one-month Euro-currency interest rates or alternatively, we could use daily interbank offer rates. Additionally we could use the models for the volatility to price derivatives on the SSE index, specially options.

Table 1. Some Stock Markets Features

MARKET	INDEX	STOCKS	WEIGHTS	CORRECTNS
New York	Dow Jones	30	-	AC,S
London	FT100	100	Market value	AC
Madrid	IGBM	72	Market value	AC,D
Frankfurt	CommerzBank	60	Market value	AC
Tokyo	Nikkei	225	-	AC,S

Note

AC = New equity issues (not first time issues)

S = Stock splits

D = Dividends

Table 2. Markets' Open and Close times

MARKET	OPEN	CLOSE	% World M.V.
New York	14:30	21:00	29.4
London	9:00	15:30	8.9
Madrid	11:00	17:00	1.1
Frankfurt	11:30	13:30	2.8
Tokyo	1:00	7:00	46.3

(Hours of Open and Close are in Madrid Time)

Table 3. Sample Moments of Stock Indexes

	SSE	DJO	COM	NIK	FTD
Mean	-0.0005	0.0003	-0.0006	-0.0008	0.0002
Variance	0.0002	0.0001	0.0002	0.0004	0.0001
Skewness	-0.4751	-0.0984	-0.6051	0.5847	0.4043
Kurtosis	10.1791	6.3984	12.6182	7.2365	6.0823
r(1)	0.1080	-0.1198	-0.0246	0.0080	-0.0007
Q(10)	13.70	19.68	10.09	21.14	20.87
$Q_2(10)$	37.29	15.30	14.48	52.53	29.32

Table 4. Estimation results Model (1) White's Covariance Matrix

	(1)	(2)	(3)	(4)
DJD (CTO)	0.01(.01)	0.06(2.2)	0.01(0.0)	0.63(7.3)
DJD(-1)	0.18(1.8)	0.24(6.6)	0.21(5.3)	0.08(1.8)
NIK	-0.09(1.0)	0.07(2.1)	0.20(7.2)	0.06(2.6)
FTD	0.04(0.35)	-0.06(1.3)	0.05(1.4)	0.24(5.2)
FTD(-1)	0.01(0.12)	0.12(3.0)	0.03(0.8)	-.08(1.6)
COM	-0.15(2.0)	0.04(1.3)	0.13(5.4)	0.28(6.7)
MA(1)	0.41(5.4)	0.22(3.5)	0.27(4.1)	0.12(2.4)
Adjusted R^2	0.16	0.39	0.59	0.49
S.D. RESID	1.27%	0.62%	0.42%	0.84%
Skewness	0.6	0.3	0.4	-0.27
Kurtosis	6.1	5.1	7.3	5.4
Q(10)	7.12	24.2	22.1	7.91
$Q_2(10)$	79.6	44.9	32.6	69.63

t-statistics computed using White's (1980) heteroscedasticity-consistent covariance matrix

(1) Sample 1 (1/1/87-8/10/87) T=190
(2) Sample 2 (28/10/87-1/4/89) T=334
(3) Sample 3 (2/4/89-30/3/90) T=242
(4) Sample 4 (1/4/90-2/10/92) T=567

DJD(-1) = Dow Jones returns in time t-1
DJD (CTO) = Dow Jones returns (close-open)
NIK = Nikkei returns
FTD = FT100 returns
COM = Commerzbank returns
MA(1) = Moving average parameter order 1
S.D. RESID = Residual standard error
Q = Ljung-Box Test
Q_2 = Mcleod-Li Test

Table 5. Forecasting exercise

(*)	(1)	(2)	(3)	(4)
150 Days	1.10	1.08	0.87	19.4
100 Days	1.28	1.27	1.00	21.2
50 Days	1.54	1.52	1.18	22.3
25 Days	1.75	1.74	1.45	16.3

(*) Per cent values

(1) Root Mean Square Forecast Error (RMSE) Random Walk
(2) RMSE MA(1)
(3) RMSE Econometric model
(4) Gain in forecast accuracy of (3) over (2)

Table 6. Sample Moments of Residuals Regression Model (1)

	Model(1)
y_t	
Mean	-0.0284
Variance	0.6911
Skewness	-0.2735
Kurtosis	5.4332*
r(1)	0.0337
r(5)	0.0494
Q(10)	7.91
y^2_t	
$r_2(1)$	0.1618*
$r_2(5)$	0.2432*
$Q_2(10)$	69.63*
$y_t\ y^2_{t-\tau}$	
$Q_3(-5)$	-0.0637
$Q_3(-2)$	-0.0714
$Q_3(-1)$	0.0702
$Q_3(1)$	0.0354
$Q_3(2)$	0.0070
$Q_3(5)$	-0.0614

* significant at the 5% level

Table 7. Volatility Models for Residuals of Madrid Index from 1st March 1990 to 2nd October 1992.

	GARCH(1,1)	EGARCH(1,0)	ARV(1)
ω	0.0744	-0.0305	-
α	0.1745	0.2840	-
β	0.7274	0.9164	0.9982
δ	-	0.0176	-
σ^2_η	-	-	0.0099
σ^2_ξ	-	-	4.6745
log L	0.2608	0.2608	1.2949
e_t			
σ^2_e	0.9961	1.0004	1.
κ_e	3.8422	3.7703	3.5933
$Q_2(10)$	3.68	4.72	13.67
Regression			
a_0	0.1449 (0.1715)	-0.0132 (0.2912)	-0.6059 (0.5431)
a_1	0.7803 (0.3308)	1.0296 (0.5343)	2.0501 (0.9875)
R^2	0.0568	0.0616	0.1152
Q(10)	23.08	22.45	23.41

Notes:

The regression was proposed by Pagan and Schwert (1990) and is given by:

$$y_t^2 = a_0 + a_1\hat{\sigma}_t^2 + u_t$$

Under the null, $a_0=0$, $a_1=1$.

Table 8. Estimation of Volatility Models

	SSE	DJ	COM	FTD	NIK
β	0.9982	0.9994	0.9954	0.9996	0.9896
σ^2_η	0.0099	0.0303	0.0234	0.0015	0.0201
σ^2_ξ	4.6746	7.9818	5.5606	4.9869	6.4266
log L	734.20	891.32	787.74	744.96	824.48
σ^2_*	3.7575	15.6726	4.5484	4.0711	5.5947
e_t					
mean	-0.0378	-0.0015	-0.0376	0.0281	-0.0305
variance	1	1	1	1	1
skewness	-0.0859	-3.8087*	-0.0290	0.3158*	0.5268*
kurtosis	3.5933*	66.3102*	8.5227*	5.5732*	5.0128*
r(1)	0.0511	0.0166	-0.0524	-0.0068	0.0064
r(5)	0.0419	0.0569	0.0438	-0.0958*	0.1062*
Q(10)	8.32	12.52	9.34	20.84*	16.46
$r_2(1)$	0.0938	-0.0085	0.3202*	0.1754*	0.0010
$r_2(5)$	0.0991	-0.0065	-0.0165	0.0607	-0.0552
$Q_2(10)$	13.67	0.22	65.44*	25.66*	13.75
Regression					
a_0	-0.6059 (0.5431)	-0.0685 (0.2883)	0.1323 (0.2066)	-0.7643 (2.7314)	-0.4696 (41.03)
a_1	2.0501 (0.9874)	0.8034 (0.7928)	0.8424 (0.0900)	1.7973 (2.9725)	1.1961 (18.034)
R^2	0.1152	0.0485	0.1339	0.0284	0.0841
Q(10)	23.41*	10.83	3.83	25.19*	21.89*
EDF(23)	-3.6897	-1.5189	-2.6019	-4.7932	-3.4833

* Significant at the 5% level

EDF Extended Dickey-Fuller Test

Regression is Pagan & Schwert's

Table 9 Correlation Matrix of smoothed estimates of volatility

	SSE	DJ	COM	FTD	NIK
SSE	1.0	0.5817	0.1360	0.4140	0.4093
DJ		1.0	0.3860	0.2524	0.6282
COM			1.0	-0.3125	0.2199
FTD				1.0	0.4230
NIK					1.0

Table 10 Principal component analysis

	First component	Second component
SSE	0.2064	-0.0680
DJ	0.2286	0.1586
COM	0.0830	0.5527
FTD	0.1468	-0.4595
NIK	0.2167	-0.0029

REFERENCES

Aderhold, R., C. Cumming and A. Harwood (1988), International linkages among equities markets and the October 1987 market break. Federal Reserve Bank of New York Quarterly Review, 13, 33-46.

Becker, K.G., J.E. Finnerty and M. Gupta (1990), The Intertemporal Relation Between the U.S. and Japanese Stock Markets. Journal of Finance, 45, 1297-1306.

Black, F. (1976), "Studies in Stock Price Volatility Changes", Proceedings of the 1976 Business Meeting of the Business and Economic Statistics Section, ASA, 177-81.

Bollerslev T. (1986), Generalized Autoregressive Conditional Heteroscedasticity.Journal of Econometrics 31,309-328.

Engle R.F. (1982), Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of U.K. Inflation. Econometrica 50,987-1008.

Espitia, M. y R. Santamaría (1991), Interaccion Internacional entre Mercados de Valores. Informacion Comercial Española, 689.

Eun, C.S. and S. Shim (1989), International Transmission of Stock Market Movements. Journal of Financial and Quantitative Analysis, 24, 2, 241-256.

French, K. and I. Poterba (1990), Are Japanese Stock Prices Too High?. N.B.E.R. Summer Institute.

Furstenberg, G. and B. Jeon (1989), International stock price movements: links and messages. Brookings Papers on Economic Activity, 1, 125-179.

Hamao, Y., R.W. Masulis and V. Ng (1990), Correlations in Price Changes and Volatility Across International Stock Markets. Review of Financial Studies, 3, No. 2, 281-307.

Harvey, C.R. and G. Zhou (1993), International Asset pricing with Alternative Distributional Specifications. Journal of Empirical Finance, 1, 107-131.

Harvey, A.C., E. Ruiz and N.G. Shephard (1994), "Multivariate Stochastic Variance Models". Review of Economic Studies. (forthcoming)

Lo, A.W. and A.C. MacKinlay (1990), An Econometric Analysis of Nonsynchronous Trading. Journal of Econometrics, 45, 181-211.

Manzano, D. y B. Mateos (1991), Los Principales Mercados Bursatiles tras el Crash de 1987: Comportamiento e interrelación. Papeles de la Economia Española, 34.

Nelson, D.B. (1988), "The Time Series Behavior of Stock Market Volatility and Returns", unpublished Ph.D. dissertation, Massachusetts Institute of Technology.

Nelson, D.B. (1991), "Conditional Heteroscedasticity in Asset Returns: A New Approach", Econometrica, 59, 347-70.

Pagan, A. and G. Schwert (1990), Alternative Models for Conditional Stock Volatility. Journal of Econometrics, 45, 267-290.

Peña, J.I. (1992a), Sobre la Relacion entre los Mercados Bursatiles Internacionales y la Bolsa de Madrid. Informacion Comercial Española, 704, 16-24.

Peña, J.I. (1992b), On Meteor Showers in Stock Markets. Investigaciones Economicas, 16, 225-234.

Peña, J.I. (1993), Stock Market Microstructure in Spain: A note. Mimeo. Universidad Carlos III de Madrid.

Scholes, M. and J. Williams (1977), Estimating Betas from Nonsynchronous Data. Journal of Financial Economics, 5, 309-327.

Solnik, B. (1993), International Asset Allocation Strategies. Journal of Empirical Finance, 1, 33-56.

Taylor, S.J. (1986), Modelling Financial Time Series. John Wiley, Chichester.

White, H. (1980), A Heteroskedastic-consistent Covariance Matrix Estimates and a Direct Test for Heteroscedasticity. Econometrica, 48, 817-838.

Figure 1

Estimated Densities of standardized residuals

a) GARCH estimates of volatility

b) ARV estimates of volatility

Figure 2

One-step-ahead and smoothed estimates of ARV volatility

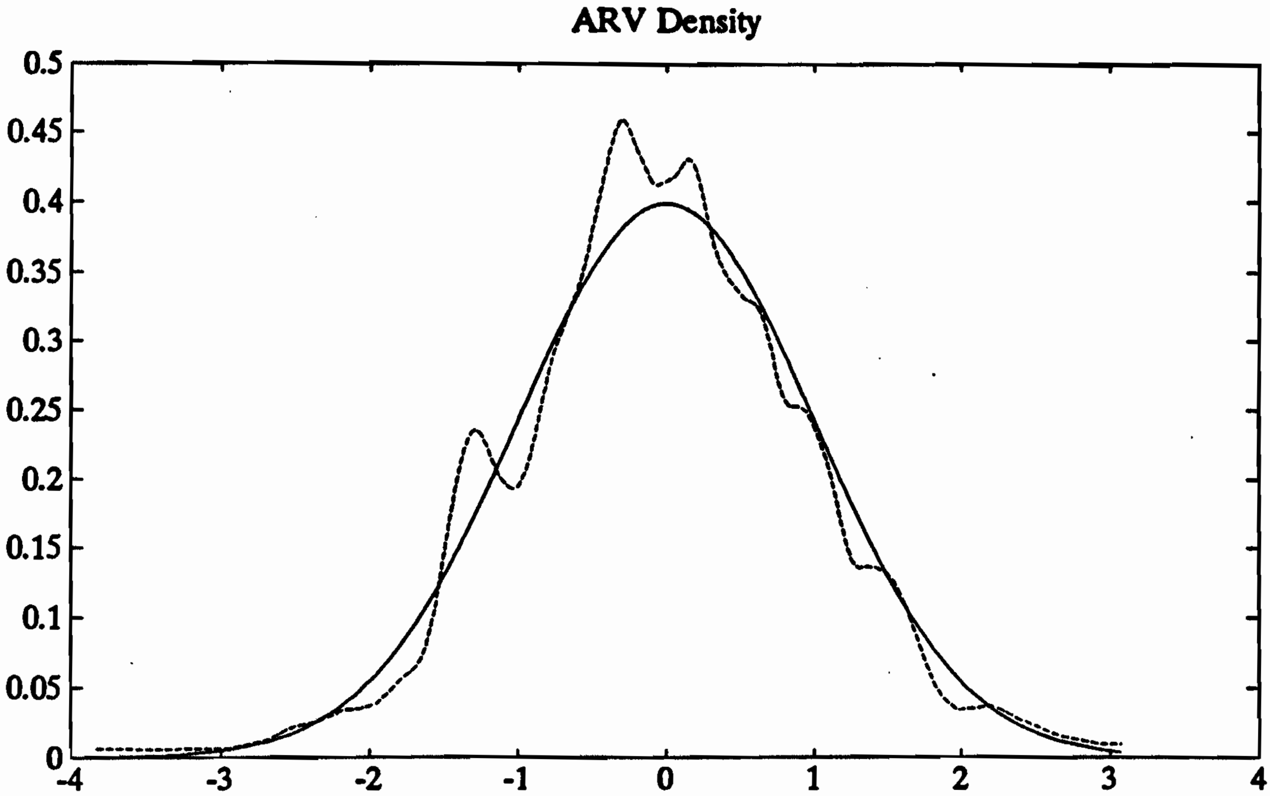
a) Volatility estimates SEE

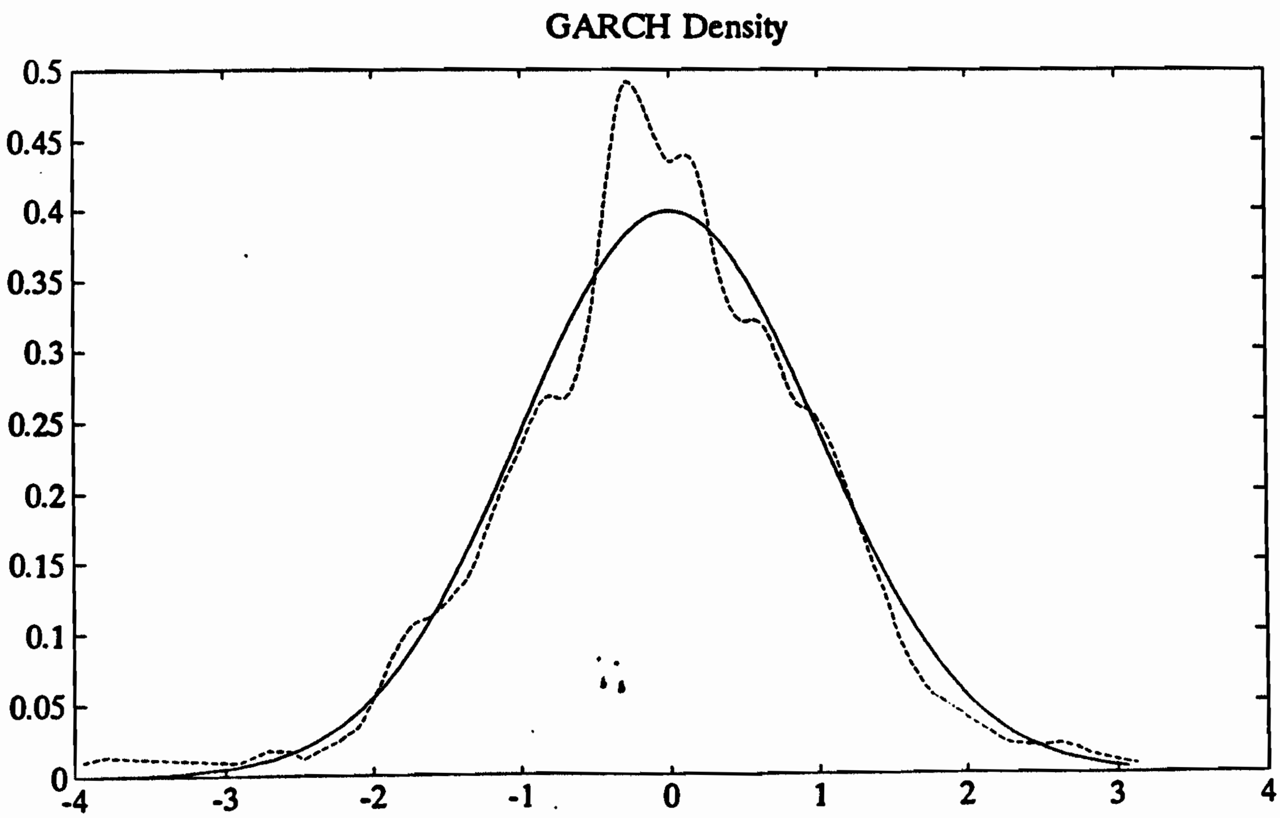
b) Volatility estimates New York

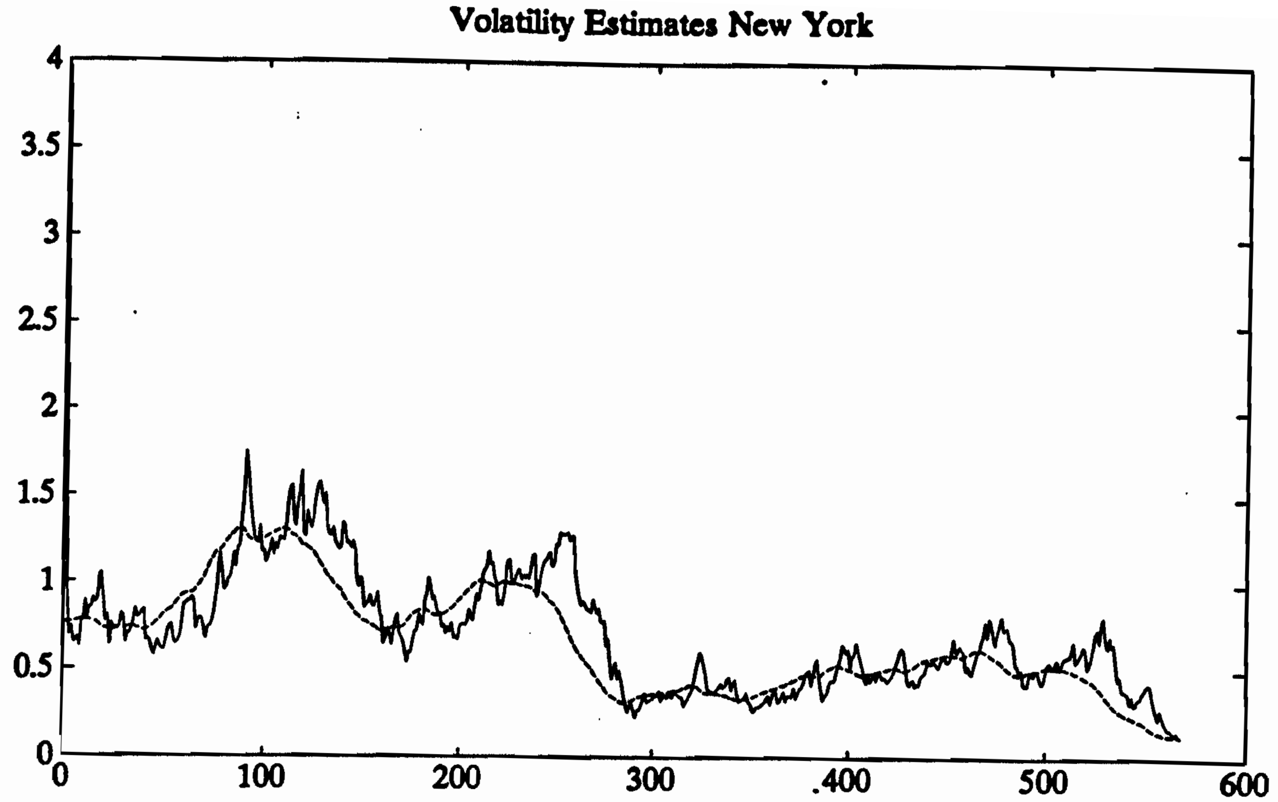
c) Volatility estimates Frankfurt

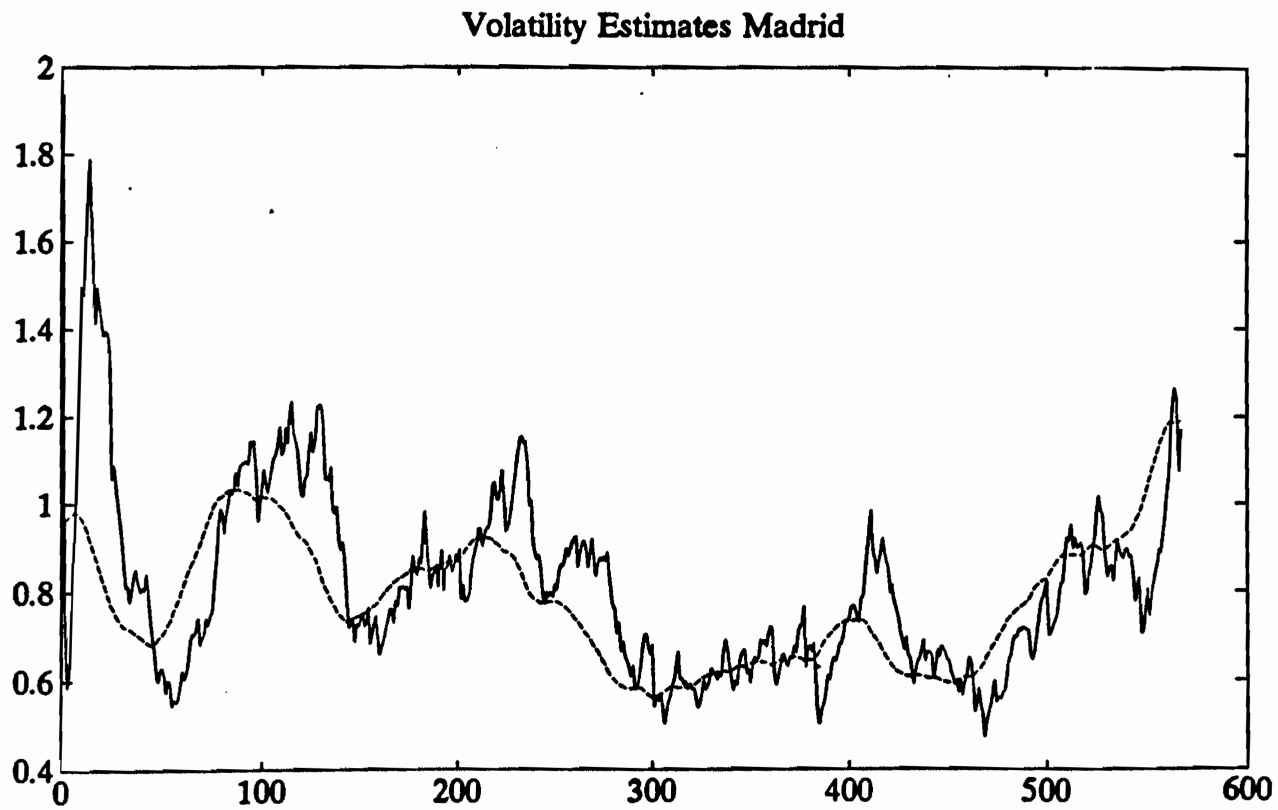
b) Volatility estimates London

b) Volatility estimates Tokyo

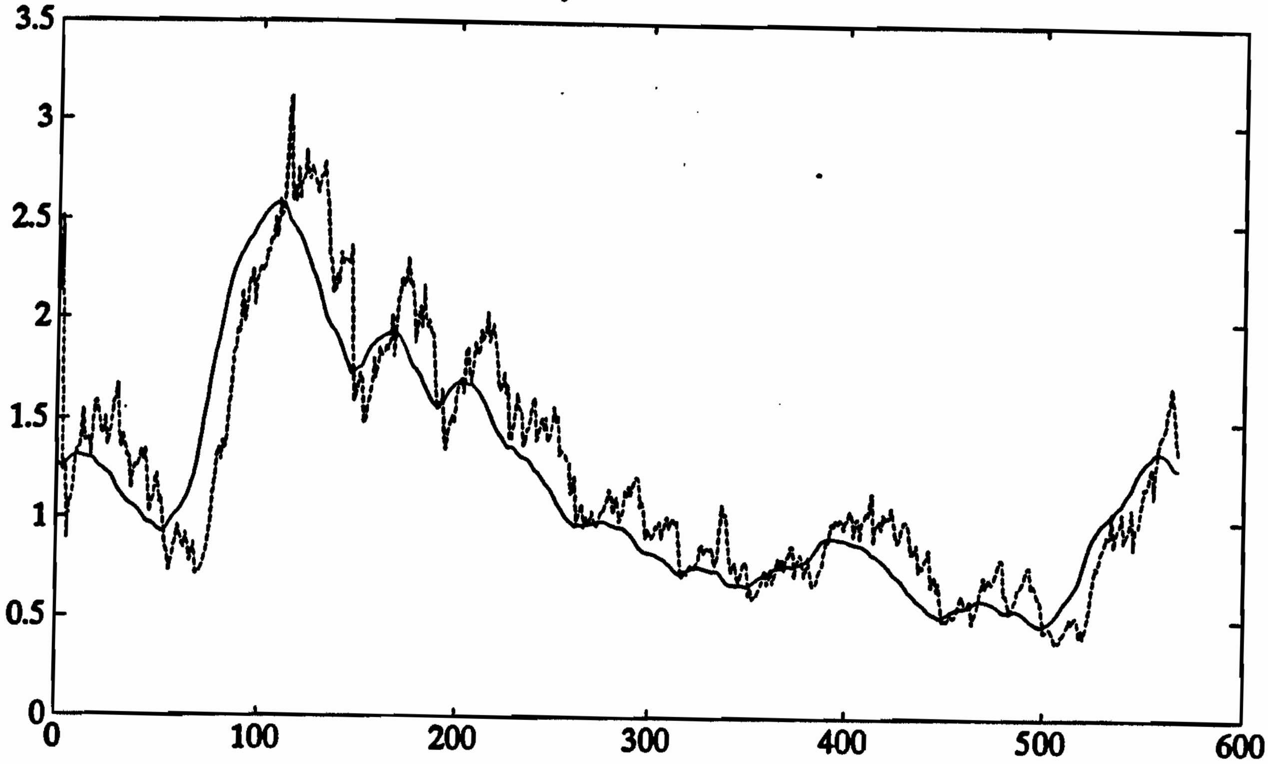

ARV Density
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-4
-3
-2
-1
0
1
2
3
4


GARCH Density
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-4
-3
-2
-1
0
1
2
3
4


Volatility Estimates New York
4
3.5
3
2.5
2
1.5
1
0.5
0
100
200
300
400
500
600


Volatility Estimates Madrid
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0
100
200
300
400
500
600

Volatility Estimates Frankfurt



Volatility Estimates Tokio