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Recommended Citation

Morales, L.: International transmission effects of volatility spillovers between stock returns and exchange rates: evidence from Greece, Portugal and Spain since the introduction of the Euro. Proceedings of the IASK International Conference Global Management in the Algarve, Portugal, 2nd.-5th. May, 2007, pp.44-45.

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International Transmission Effects of Volatility Spillovers between Stock Returns and Exchange Rates: Evidence from Greece, Portugal and Spain since the introduction of the Euro

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Abstract

This paper investigates the nature of volatility spillovers between stock returns and exchange rate changes for Greece, Spain and Portugal for the 1999-2006 period after the introduction of the Euro as well as the 1999-2001 and 2002-2003/May and 2003/June-2006 periods since the Euro has been introduced. We use an EGARCH model which takes into account whether bad news has the same impact on volatility as good news. We also investigate whether volatility spillovers between exchange rates and equity markets is stronger for some currencies than others. We find that there were no significant volatility spillovers from stock returns to exchange rates for Greece prior the introduction of the Euro for the 1999-2001 time period while the coefficients are significant in the case of Portugal and Spain. However, since the introduction of the Euro, there were insignificant volatility spillovers from stock returns to exchange rates in all countries for all currencies, with the exception of Portugal in the more recent 2002-2006 period. The introduction of the Euro appears to have had little impact on the nature of volatility spillovers from exchange rates to stock returns which were generally insignificant prior to the introduction of the Euro as well as for the 1999-2006 period.

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1. Introduction

The international financial markets have experienced an increase in the degree of integration. The abolition of capital and exchange controls has produced an increase in the volume of cross-border transaction in securities and currencies, (Dark, Raghavan and Kamepalli, 2006). Economic theory suggests that these fund flows may create interdependence between stock and exchange rate returns. The empirical research examining volatility transmission and spillover effects provides mixed results, Bodart and Reding (1999) did not find any evidence of linkage between foreing exchange and stock markets, Kanas (2000) found evidence of uni-directional volatility spillover from the stock market to the foreign exchange market, Evans and Lyons (2001) found significant bidirectional volatility spillovers, Francis et al (2003) found evidence of volatility spillovers from the foreign exchange market to the stock market.

Our study intends to explore the presence of volatility spillover among three European markets named: Greece, Portugal and Spain in order to identify which currencies are generating the biggest impact in stock returns for each country.

To date the research has not examined the presence of volatility spillovers between the Euro exchange rates against US dollar, Japanese Yen, Swiss Franc and British pound for European financial markets. In this paper we employ EGARCH modelling to analyse this issue for Greece, Portugal and Spain. The layout of this paper is as follow: Section 2 brief literature review, section 3 describes the data and methodology, section 4 presents the empirical results and section 5 concludes the analysis.

2. Literature Review

Several theoretical models have analysed the link between stock markets and currency markets. The asset market approach to exchange rate determination (Branson, 1983; Frankel, 1983) posits that causality will run from stock prices to exchange rate changes as expectations of financial asset price movements affect the dynamics of exchange rates. Smith (1992) derives an estimable equation for the exchange rate where the stock price is included as an explanatory variable. The goods market approach suggests causality runs in the opposite direction, from exchange rates to stock prices (Mundell, 1963, 1964; Dornbusch and Fisher, 1980). In these models, movements in exchange rates affect the international competitiveness of firms which affects real income and output and eventually stock prices. Much of the available empirical evidence on the linkages between stock markets and exchange rates has concentrated on the first moments[1]. Yang and Doong (2004) note that there is a dearth of empirical evidence that concentrates on the linkages between the second moments of the distribution of the variables. A number of studies however have examined the extent to which volatility from one stock market spills over into other stock markets or between different assets[2]. Kanas (2000) was one of the first studies which analysed volatility spillovers from stock returns to exchange rate changes in the USA, the UK, Japan, Germany, France and Canada. He found evidence of spillovers from stock returns to exchange rate changes for all countries except Germany, suggesting that the asset approach to exchange rate determination is valid when formulated in terms of the second moments of the exchange rate distribution for the countries included in his analysis. Volatility spillovers from exchange rate changes to stock returns were

[1] See for example Nieh and Lee (2001), Yau and Nieh (2006) for recent evidence on this topic.
[2] See also for example, Nelson (1991), Koutmos and Booth (1995), Laopodis (1998).

insignificant for all countries. Yang and Doong (2004) explored the nature of the mean and volatility transmission mechanism between stock and foreign exchange markets for the G-7 countries. The results point to significant volatility spillovers and an asymmetric effect from the stock market to the foreign exchange market for France, Italy, Japan and the US, suggesting integration between stock and foreign exchange markets in these countries. Wu (2005) who examines volatility spillovers between stock prices and exchange rates for Japan, South Korea, Indonesia, Philippines, Singapore, Thailand and Taiwan for the period 1997-2000, splitting the sample into crises and recovery periods. He found a bi-directional relationship between the volatility of stock returns and exchange rate changes during the recovery period in all countries except South Korea, as well as significant contemporaneous relationships between the two markets for most of the countries.

3. Data and Methodology

The analysis will be conducted with the purpose of investigating volatility spillovers between stock returns and exchange rate changes in three European countries named: Greece Portugal and Spain for the period 1 January 1999 to 31 December 2006. We decide to split up our data set in three sub samples that will cover an initial period from 1999-2000, when Portugal and Spain peg their currencies to the Euro, time period where Greece was still using the national currency (Drachma) as they did not fulfil the conditions to join the EMU at the initial stage. Greece was considered eligible to join the EMU during 2000, so at the beginning of 2001 the Drachma was peg to the Euro, so then our second sub sample will analyse what happen in the stock returns and exchange rate market during this year for the three countries. And finally in 2002 the Euro was physically introduced in the countries, so our final sample will cover from 2002-2006. The data set consists of daily closing values for the FTSE/ATHEX, PSI 20 and IBEX 35 stock market indices, and the Euro exchange rate against US dollar, Swiss Franc (CHF), Japanese Yen and British Pound, as the Drachma against the same exchange rates for Greece during 1999-2000. Our sample has a total of 2014 observations for each series. The original data set was subject to some modifications, all holidays and other closing days were removed from the sample in order to avoid inconsistencies with the data set and also to prevent problems in the modelling estimation. The exchange rates used for the analysis were obtained through the calculations of the cross exchange rates. Data was taken from DataStream and the Federal Reserve Statistic Release. Following Kanas (2000) we use continuously compounded stock returns and exchange rate changes calculated as the first differences of the natural log. That is, S= Stock Prices; $S_t = \ln\left(P_t^s\right) - \ln\left(P_{t-1}^s\right)$ and E= Exchange Rates; $E_t = \ln\left(P_t^e\right) - \ln\left(P_{t-1}^e\right)$.

As an initial step we provide descriptive statistics for stock returns and exchange rates, in order to summarise the statistical characteristics of our sample. We then proceed and perform a stationarity test on each of the relevant variables that are included in our analysis to ensure that the results from the analysis are not spurious. We apply the Dickey Fuller (DF) test or Augmented Dickey-Fuller test (ADF) procedure if serial correlation is present. We also apply the Lagrange Multiplier (LMF) test, to ensure that a sufficient number of lags have been added in the ADF test to ensure that there is no serial correlation present and the results of the ADF test are valid. The LMF test is applied given that it is valid in the presence of lagged dependent variables as well as having the advantage of testing for first and higher orders of serial correlation. If our variables are non-stationary in levels, we then proceed and perform a cointegration test on our variables using the Johansen

Cointegration test to investigate the long-run relationship between Stock Prices and Exchange Rates. As Enders (2004) notes given that the results of the test can be quite sensitive to the lag length, the most common procedure is to estimate a Vector Autoregression (VAR) model on the undifferenced data in order to determine the lag length for the Johansen test. We estimate the lag selection tests up 20 lags. In terms of choosing between the various lag length selection criteria we follow Johansen et al..(2000) who suggest that when different information criteria suggest different lag lengths, it is common practice to prefer Hannan-Quinn (HQ) criteria, we then proceed with our volatility analysis and apply a bivariate extension of the EGARCH (p,q) model in order to examine whether the volatility of stock returns affects and is affected by the volatility of exchange rate changes within each economy. The EGARCH specification (Nelson, 1991) is used in order to test whether the volatility spillover effects are asymmetric. The model is specified as follows:

$$S_t = a_{s,0} + \sum_{i=1}^{r} a_{s,i} S_{t-i} + \sum_{i=1}^{r} a_{e,i} E_{t-i} + \beta_s \lambda_{s,t-1} + e_{S,t} \quad \textbf{(6)}$$

$$E_t = a_{E,0} + \sum_{i=1}^{r} a_{E,i} E_{t-i} + \sum_{i=1}^{r} a_{S,i} S_{t-i} + \beta_E \lambda_{E,t-1} + e_{E,t} \quad \textbf{(7)}$$

$$e_{S,t} / \Omega_{t-1} \approx N(0, \sigma^2_{S,t})$$

$$e_{E,t} / \Omega_{t-1} \approx N(0, \sigma^2_{E,t})$$

The conditional variances of stock returns and exchange rates changes are specified as follows:

$$\sigma^2_{S,t} = \exp\left\{ c_{S,0} + \sum_{j=1}^{ps} b_{S,j} \log(\sigma^2_{S,t-j}) + \delta_{S,S}\left[\left(|z_{S,t-1}| - E|z_{S,t-1}| + \theta_{S,Sz_{s,T-1}}\right) + \delta_{S,E}\left[\left(|z_{E,t-1}| - E|z_{E,t-1}| + \theta_{S,EzE,t-1}\right)\right]\right]\right.$$

(8)

$$\sigma^2_{E,t} = \exp\left\{ c_{E,0} + \sum_{j=1}^{ps} b_{E,j} \log(\sigma^2_{E,t-j}) + \delta_{E,E}\left[\left(|z_{E,t-1}| - E|z_{E,t-1}| + \theta_{E,Ez_{s,T-1}}\right) + \delta_{E,S}\left[\left(|z_{S,t-1}| - E|z_{S,t-1}| + \theta_{E,SzE,t-1}\right)\right]\right]\right.$$

(9)

$$\sigma_{S,E,T} = \rho_{S,E}\sigma_{S,t}\sigma_{E,t}$$

We summarise each of the relevant terms in equations (6-9) in Table 1.

4. Empirical Results

We begin our analysis by providing descriptive statistics for stock returns and exchange rates, in order to summarise the statistical characteristics of our sample which are set out from table 3 to table 6. For 1999-2000 the sample mean of stock returns is positive for Greece while they are negative for Portugal and Spain. During 2001 the means for stock returns becomes negative for the three countries while all of them are positive for 2002-2006. The SD is showing that the markets were quite volatile previous the physical introduction of the Euro, after the single currency consolidates in the financial markets the SD becomes lower. The descriptive statistics for the exchange rate returns show that during 1999-2000 the sample means are positive for the Drachma against the Euro, US dollar, UK Pound, Japanese Yen and Swiss Franc. In the case of Portugal and Spain the Euro exchange rates means are

negative in all the cases, the results for the 2001 show that the means for the Euro against the Japanese Yen are negative, while the means are positive with regard to the other cases. Finally during 2002-2006 Greece, Portugal and Spain are under the same currency the Euro; in this case the results are showing that the means for the exchange rates are all positive. The SD of exchange rate returns are higher during the 2001, indicating that the exchange rates were more volatility during the first years of the introduction on the Euro in the financial markets and when the single currency was not physically introduced in the EMU countries. Both the skewness and kurtosis coefficients indicate that stock returns and exchange rates are leptokurtic relative to the normal distribution, which Caporale et al. (2002) note is a common finding for stock returns. The Jarque-Bera test also rejects the hypothesis that stock returns and exchange rates are normally distributed in all time periods.

The results from the ADF tests are given in Table 7. The results indicate that we can reject the null hypothesis of the existence of unit root in levels for all variables in all periods indicating that all series are *I(0)*.[3] Given that all variables are integrated of the same order, and also given that they are an I(0) we will proceed to perform our volatility analysis using EGARCH (p,q) modelling.

The results from table 8 to 10 are showing the results in terms of the EGARCH model selection for each of the periods and equations included in the analysis.

The estimated parameters from the EGARCH estimation are set out in Tables 11-19, for the three periods of analysis 1999-2000, 2001 and 2002-2006 respectively. Firstly, we analyse the coefficients for the 1999-2000 time period, the results show significant persistence for 2001 the coefficients are significant for Portugal while for Greece and Spain the coefficients are insignificant. For 2002-2006 the results show significant persistence for all the Spanish cases and for €/£ for Portugal, in the rest of the cases the coefficients are insignificant. The volatility persistent coefficients in terms of the exchange rate equation show no significant coefficients in almost all the cases with the exceptions of DR/CHF for Greece, €/£ for Portugal and Spain during 1999-2000, during 2001 the coefficients are insignificant in all the cases. Finally for 2002-2006 we found significant coefficients for the €/£ for the three countries and €/CHF in the case of Spain, in the rest of the cases the coefficients are insignificant. Wu (2005) notes that a necessary condition for the volatility persistence terms to be stable is that the value of the estimated coefficients should be less than one; for our results, this applies in all cases for the three periods in the case that the coefficients are significant.

The analysis of the coefficients for the volatility spillovers effects from stock returns to exchange rate changes, our results show that the coefficients are not significant in the case of Greece and Portugal, while for Spain the coefficients are significant in all the cases for the 1999-2000. During 2001 the results show that volatility spillovers effect is significant in the case of Portugal and Spain, while the coefficients are insignificant in all the cases with regard to Greece. Finally during 2002-2006 the volatility spillovers coefficients are insignificant in all the cases for Greece and Portugal, while they are significant in all the cases with regard to Spain.

In terms of volatility spillovers from exchange rates to stock markets, we found that for the 1999-2000 the coefficient is insignificant in all the cases. With regard to the sample period that cover 2001 we found that the coefficients for the €/CHF in the case of Greece and Spain are significant, being insignificant in the rest of the cases, situation that changes with regard to the analysis of the final sample that covers from 2002-2006 when the Euro is in circulation in the three countries, this period presents insignificant coefficients in all the cases. This result could be explained for the remaining effects in the exchange rates during the early years of introduction of the

[3] The LMF test results indicated that the ADF tests were free from serial correlation; for brevity we do not show the test results here.

single currency. The lack of significant spillovers from exchange rate changes to stock returns found here for some countries is consistent with results from Jorion (1990) as well as with Yang and Doong (2005). Jorion (1990) explained the lack of spillovers as possibly due to positive exchange rate volatility on stock returns for some firms offsetting negative exchange rate volatility on stock returns for other firms to give an insignificant or weak effect overall. In addition to this, the use of instruments to hedge exchange rate risk, may reduce the impact of exchange rate volatility on stock markets; Grant and Marshall, 1997, and Bodnar *et al.* (1995) both note that the use of hedging instruments to ameliorate exchange rate risk is pervasive amongst larger companies which are the main components of national stock market indices. The lack of significant spillovers from exchange rates to stock markets may thus be indicative of wider use of hedging by firms listed on the stock markets of these countries in order to hedge the exchange rate risk.

For the asymmetric spillover effects from stock returns to exchange rates, we find that the coefficients are significant in all the cases with the exception of €/$ for Greece during 2001 for the stock return equation. Analysing the exchange rate equation we found a mixture of results, during 1999-2000 the coefficients are insignificant for DR/$ and DR/£ in the case of Greece, for the €/$ and €/£ for Portugal and Spain, being the coefficients significant in the rest of the cases. For 2001 the coefficients are insignificant in the case of €/$ and €/¥ for the three countries. Finally during 2002-2006 the results show insignificant coefficients in all the cases for the three countries. The existence of insignificant coefficients indicate that the spillovers effects in these instances are symmetric, that is that positive and negative shocks have the same impact on volatility, or that a decrease in stock returns has the same impact on exchange rate volatility as an increase in stock returns. The positive sign on all significant coefficients indicates that unexpected good news has a greater impact on volatility than unexpected bad news.

The diagnostic tests results on the standardised residuals have been perform to check the validity of our model specification. The Jarque-Bera test indicates that in general terms we reject the hypothesis that the residuals are normally distributed. Hence, this is justifying the use of the Bollerslev-Woolridge robust *t*-statistics. The Ljung-Box statistics for all four periods in all the cases indicate that there are no residual linear or non linear dependencies.

Finally and to check the validity of the assumption of constant correlation adopted in the estimation of the bivariate models (Kanas, 2000), the LB and LB^2 statistics for the cross products of the standardised residuals from the stock returns equation and from the exchange rate equation are calculated for the eight equations, finding that the p-values are significant for all the models, therefore we found evidences that the assumptions of constant correlation over time may be accepted[4].

5. Conclusions

Relationships between equity returns and exchange rates are of particular interest for academics and practitioners due to the fact that these two variables play a crucial role in portfolio and risk management. Equity returns and exchange rate movements may be used to hedge portfolios against currency movements, where risk management will have to take into consideration the linkages between these to markets in order to design the appropriate strategies.

[4] For brevity we do not include the diagnostic test tables in the document.

We examine volatility spillovers between these two financial markets since the introduction of the Euro for Greece, Portugal and Spain during 1999-2006. Our findings show evidences of unidirectional volatility spillovers, the coefficients for spillovers effects from stock returns to exchange rates appear to be significant in almost all the cases for the three sample periods.

. Overall our results found a unidirectional volatility spillovers from stock returns to exchange rates, results that are consistent with the finding of Kanas (2000), and Doong (2004) where they found evidence of volatility spillovers from stock returns to exchange rates but no evidences of vice versa relationship.

Thus further research along these lines is required in order to establish more comprehensively the true nature of spillovers from exchange rates to equity markets which should provide valuable information on the possibilities for diversifying holdings of stocks and currencies in investment portfolios, as well as the potential for hedging amongst these assets.

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Table 1 *Description of Parameters Equations (6)-(9)*

	Stock Returns	Exchange Rate Returns
Error correction terms (lagged residuals from the cointegrating regression of S_t, E_t)	$\lambda_{S,t-1}$	$\lambda_{E,t-1}$
Stochastic error terms	$e_{S,t}$	$e_{E,t}$
Information set at time *t-1*	Ω_{t-1}	Ω_{t-1}
Conditional (time varying) variances	$\sigma^2_{S,t}$	$\sigma^2_{E,t}$
Standardised residuals assumed to be normally distributed with 0 mean and variances of $\sigma^2_{S,t}, \sigma^2_{E,t}$	$z_{S,t} = e_{S,t} / \sigma_{S,t}$ $e_{S,t} / \Omega_{t-1} \sim N(0, \sigma^2_{S,t})$	$z_{E,t} = e_{E,t} / \sigma_{E,t}$ $e_{E,t} / \Omega_{t-1} \sim N(0, \sigma^2_{E,t})$
Persistence of Volatility	$\sum_{j=1}^{ps} b_{S,j}$	$\sum_{j=1}^{pE} b_{E,j}$
ARCH effect where the parameters $\theta_{S,S}, \theta_{E,E}$ allow this effect to be asymmetric	$\left[\lvert z_{S,t}\rvert - E\lvert z_{S,t}\rvert + \theta_{S,S z_{S,t}}\right]$	$\left[\lvert z_{E,t}\rvert - E\lvert z_{E,t}\rvert + \theta_{E,E z_{E,t}}\right]$
Volatility Spillover	$\delta_{S,E}\left[\lvert z_{E,t-1}\rvert - E\lvert z_{E,t-1}\rvert + \theta_{S,E z_{E,t-1}}\right]$	$\delta_{E,S}\left[\lvert z_{S,t-1}\rvert - E\lvert z_{S,t-1}\rvert + \theta_{E,S z_{SSt-1}}\right]$
Measures of spillovers	$\delta_{S,E}$	$\delta_{E,S}$
Asymmetry of Spillovers	[5] $\theta_{S,E}$	$\theta_{E,S}$
Correlation Coefficient for Standardised Residuals	$\rho_{S,E}$	$\rho_{E,S}$

Table 3 *Descriptive Statistics Stock Returns*

	Mean	SD	Skewness	Kurtosis	JB
1999-2000					
FTSE/ATHEX 20	1.58E-05	0.0224	0.2032	5.1180	95
PSI 20	-0.00019	0.0122	-0.0271	4.4748	46
IBEX 35	-0.00027	0.0139	-0.2719	4.4345	49
2001					
FTSE/ATHEX 20	-0.00125	0.0184	-0.0397	5.1736	49
PSI 20	-0.001141	0.0117	-0.2889	4.4638	26
IBEX 35	-0.00033	0.0173	-0.0699	3.8082	7
2002-2006					
FTSE/ATHEX 20	0.000405	0.0116	0.0822	4.7207	156
PSI 20	0.000285	0.0076	-0.2812	5.9981	486
IBEX 35	0.000415	0.0120	0.0787	6.1747	529

*FTSE/ATHEX 20: Greek stock returns series, PSI 20: Portuguese stock returns series, IBEX 35: Spanish stock returns series.

[5] $\theta_{S,E} < 0$, $\theta_{S,E} < 0$, implies that negative exchange rate shocks increase the volatility of stock returns more than positive shocks

Table 4 *Descriptive Statistics Exchange Rates 1999-2000*

	Mean	SD	Skewness	Kurtosis	JB
GREECE					
DR/€	0.001051	0.0096	-0.3263	4.0442	31
DR/$	0.000562	0.0065	-0.4520	4.3198	52
DR/£	7.71E-04	0.0101	-0.6432	4.3596	71
DR/¥	0.000503	0.0093	-0.1308	4.0871	25
DR/CHF	8.53E-05	0.0091	0.2906	3.9480	25
PORTUGAL & SPAIN					
€/$	-0.00049	0.0065	0.5675	4.4896	73
€/£	-0.00027	0.0054	0.1448	4.1784	31
€/¥	-0.00044	0.0093	0.1847	4.1595	31
€/CHF	-0.00012	0.0022	-0.7083	7.0095	378

Table 5 *Descriptive Statistics Exchange Rates 2001*

	Mean	SD	Skewness	Kurtosis	JB
GREECE, PORTUGAL & SPAIN					
€/$	-0.00025	0.0068	-0.3226	3.2439	5
€/£	-1.19E-04	0.0049	-0.0814	3.5728	4
€/¥	0.000305	0.0082	-0.2417	3.8493	10
€/CHF	-1.07E-04	0.0028	-0.4996	16.1621	1808

Table 6 *Descriptive Statistics Exchange Rates 2002-2006*

	Mean	SD	Skewness	Kurtosis	JB
GREECE, PORTUGAL & SPAIN					
€/$	0.000311	0.0058	-0.1351	3.4397	14
€/£	7.28E-05	0.0038	0.1982	4.5268	130
€/¥	0.000234	0.0055	-0.2774	4.5475	141
€/CHF	6.66E-05	0.0021	-0.2991	4.2208	97

Table 7 *Augmented Dickey-Fuller Test*

	1999-2000	2001	2002-2006
Stock Returns			
FTSE/ATHEX 20	-19.31*	-13.79*	-32.88*
PSI 20	-16.70*	-6.49*	-9.05*
IBEX 35	-22.13*	-15.56*	-8.52*
Exchange Rates			
GREECE			
DR/€	-7.74*	n/a	n/a
DR/$	-20.24*	n/a	n/a
DR/£	-20.41*	n/a	n/a
DR/¥	-20.78*	n/a	n/a
DR/CHF	-20.47*	n/a	n/a
GREECE			
€/$	n/a	-16.06*	-6.72*
€/£	n/a	-12.08*	-17.73*
€/¥	n/a	-17.17*	-14.21*
€/CHF	n/a	-16.70*	-35.74*
GREECE, PORTUGAL & SPAIN			
€/$	-20.93*	-16.06*	-6.72*
€/£	-8.74*	-12.08*	-17.73*
€/¥	-20.78*	-17.17*	-14.21*
€/CHF	-20.90*	-16.70*	-35.74*

*1% significance level

Table 8 *Likelihood Ratio Test (Greece)*

1999-2000	**DR/€**	**DR/$**	**DR/£**	**DR/¥**	**DR/CHF**
Stock Returns	0.808	0.820	0.738	1.434	0.632
Exchange Rates	0.992	0.656	0.046	0.356	34.782*
2001	**€/$**	**€/£**	**€/¥**	**€/CHF**	
Stock Returns	9.624*	0.618	0.579	0.644	
Exchange Rates	0.582	3.230	15.868*	6.76*	
2002-2006	**€/$**	**€/£**	**€/¥**	**€/CHF**	
Stock Returns	10.49*	11.22*	11.55*	10.37*	
Exchange Rates	34.92*	0.18	1.67	0.036	

Table 9 *Likelihood Ratio Test (Portugal)*

1999-2000	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0	0	0.042	0.012
Exchange Rates	0.296	0.266	7.97*	3.356
2001	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.467	0.354	0.427	0.12
Exchange Rates	0.605	2.99	12.77*	7.07*
2002-2006	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.058	0.184	0.168	0.436
Exchange Rates	0.2	0.15	1.838	35.138*

Table 10 *Likelihood Ratio Test (Spain)*

1999-2000	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	1.834	2.34	1.01	2.22
Exchange Rates	0.29	0.29	8.35*	3.57
2001	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	1.75	0.28	2.57	2.08
Exchange Rates	0.50	2.88	13.44*	6.44*
2002-2006	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	4.720	5.47	5.63	5.92
Exchange Rates	36.29*	0.112	1.45	0.084

*Note: H_0: EGARCH (1,1), H_1: EGARCH(2,1) The 5% critical value for the LR test distributed as χ^2 with 2 degrees of freedom is 5.99.

Table 11 *EGARCH Results Volatility Persistence1999-2000*

Greece	**DR/€**	**DR/$**	**DR/£**	**DR/¥**	**DR/CHF**
Stock Returns	0.4214	0.4144	0.4106	0.4178	0.4186
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	0.0771	0.1728	0.0975	0.1245	0.4542
	(0.397)	(0.108)	(0.337)	(0.153)	(0.000)
Portugal	**€/$**	**€/£**	**€/¥**	**€/CHF**	
Stock Returns	0.2381	0.2409	0.2372	0.2365	
	(0.000)	(0.000)	(0.000)	(0.000)	
Exchange Rates	-0.0506	0.2937	0.2037	0.0832	
	(0.672)	(0.006)	(0.060)	(0.048)	
Spain	**€/$**	**€/£**	**€/¥**	**€/CHF**	
Stock Returns	0.0960	0.0979	0.0952	0.0970	
	(0.038)	(0.034)	(0.039)	(0.035)	
Exchange Rates	-0.0476	0.2999	0.1991	0.0841	
	(0.693)	(0.005)	(0.069)	(0.058)	

Table 12 *EGARCH Results Volatility Persistence2001*

Greece	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.3333	0.2904	0.2922	0.2918
	(0.089)	(0.016)	(0.016)	(0.016)
Exchange Rates	-0.2374	-0.0122	0.2346	-0.1184
	(0.058)	(0.843)	(0.070)	(0.529)
Portugal	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.1441	0.1404	0.1526	0.1438
	(0.002)	(0.002)	(0.002)	(0.002)
Exchange Rates	-0.2492	0.0135	0.2235	-0.1194
	(0.052)	(0.818)	(0.084)	(0.546)
Spain	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	-0.0121	0.0174	0.0267	0.0128
	(0.815)	(0.551)	(0.390)	(0.706)
Exchange Rates	-0.2505	0.0070	0.2230	-0.0871
	(0.046)	(0.906)	(0.087)	(0.641)

Table 13 *EGARCH Results Volatility Persistence2002-2006*

Greece	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	-0.0884	-0.0933	-0.0979	-0.0809
	(0.213)	(0.189)	(0.173)	(0.255)
Exchange Rates	-0.1077	0.0977	0.0629	0.1120
	(0.196)	(0.000)	(0.015)	(0.019)
Portugal	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.1215	0.1204	0.1208	0.1190
	(0.010)	(0.009)	(0.010)	(0.013)
Exchange Rates	-0.1018	0.0980	0.0639	0.1107
	(0.226)	(0.000)	(0.015)	(0.001)
Spain	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.1250	0.1238	0.1213	0.1209
	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	-0.1046	0.0994	0.0628	0.1131
	(0.206)	(0.000)	(0.015)	(0.001)

Table 14 *EGARCH Results Volatility Spillovers 1999-2000*

Greece	**DR/€**	**DR/$**	**DR/£**	**DR/¥**	**DR/CHF**
Stock Returns	-0.1055	-0.1038	-0.1086	-0.1069	-0.1052
	(0.105)	(0.114)	(0.093)	(0.100)	(0.108)
Exchange Rates	-0.0808	0.0109	-0.0529	0.1064	-0.0658
	(0.118)	(0.903)	(0.516)	(0.022)	(0.011)
Portugal	**€/$**	**€/£**	**€/¥**	**€/CHF**	
Stock Returns	-0.0838	-0.0870	-0.0829	-0.0813	
	(0.050)	(0.043)	(0.048)	(0.057)	
Exchange Rates	0.1006	-0.0178	0.0136	-0.0846	
	(0.178)	(0.826)	(0.808)	(0.034)	
Spain	**€/$**	**€/£**	**€/¥**	**€/CHF**	
Stock Returns	-0.0892	-0.0894	-0.0910	-0.0896	
	(0.003)	(0.003)	(0.003)	(0.003)	
Exchange Rates	0.0998	-0.0173	0.0143	-0.0849	
	(0.187)	(0.829)	(0.798)	(0.031)	

Table 15 *EGARCH Results Volatility Spillovers 2001*

Greece	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	-0.0175	-0.1032	-0.1081	-0.1027
	(0.887)	(0.209)	(0.191)	(0.216)
Exchange Rates	-0.0931	-0.1032	-0.0100	-0.2338
	(0.150)	(0.103)	(0.902)	(0.006)
Portugal	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	-0.1410	-0.1398	-0.1437	-0.1422
	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	-0.0937	-0.1067	-0.0052	-0.2286
	(0.166)	(0.098)	(0.949)	(0.010)
Spain	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	-0.1278	-0.1542	-0.1488	-0.1605
	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	-0.1026	-0.1041	-0.0084	-0.2310
	(0.121)	(0.100)	(0.918)	(0.008)

Table 16 *EGARCH Results Volatility Spillovers 2002-2006*

Greece	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	-0.0455	-0.0450	-0.0447	-0.0471
	(0.031)	(0.034)	(0.035)	(0.029)
Exchange Rates	0.0055	-0.0039	-0.0050	0.0023
	(0687)	(0.840)	(0.810)	(0.929)
Portugal	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	-0.0261	-0.0273	-0.0273	-0.0272
	(0.201)	(0.175)	(0.180)	(0.171)
Exchange Rates	0.0054	-0.0045	-0.0063	0.0046
	(0.702)	(0.814)	(0.765)	(0.862)
Spain	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	-0.0813	-0.0797	-0.0791	-0.0801
	(0.001)	(0.001)	(0.001)	(0.001)
Exchange Rates	0.0049	-0.0055	-0.0073	0.0021
	(0.730)	(0.777)	(0.727)	(0.937)

Table 17 *EGARCH Asymmetric Spillovers 1999-2000*

Greece	**DR/€**	**DR/$**	**DR/£**	**DR/¥**	**DR/CHF**
Stock Returns	0.8302	0.8293	0.8268	0.8321	0.8298
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	0.7084	-0.5128	-0.6883	0.7790	0.9979
	(0.005)	(0208)	(0.014)	(0.000)	(0.000)
Portugal	**€/$**	**€/£**	**€/¥**	**€/CHF**	
Stock Returns	0.9066	0.9026	0.9096	0.9101	
	(0.000)	(0.000)	(0.000)	(0.000)	
Exchange Rates	0.4702	-0.3519	-0.7093	0.9829	
	(0.400)	(0.286)	(0.000)	(0.000)	
Spain	**€/$**	**€/£**	**€/¥**	**€/CHF**	
Stock Returns	0.9499	0.9497	0.9485	0.9498	
	(0.000)	(0.000)	(0.000)	(0.000)	
Exchange Rates	0.4793	-0.3482	-0.7113	0.9831	
	(0.403)	(0.275)	(0.000)	(0.000)	

Table 18 *EGARCH Asymmetric Spillovers 2001*

Greece	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	-0.4513	0.8608	0.8647	0.8571
	(0.156)	(0.000)	(0.000)	(0.000)
Exchange Rates	0.5357	0.8976	-0.1675	0.9084
	(0.127)	(0.000)	(0.772)	(0.000)
Portugal	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.9836	0.9822	0.9815	0.9835
	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	0.4446	0.8995	-0.1868	0.9075
	(0.246)	(0.000)	(0.747)	(0.000)
Spain	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	1.0138	1.0008	1.0012	1.0042
	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	0.4581	0.8982	-0.1594	0.9071
	(0.206)	(0.000)	(0.782)	(0.000)

Table 19 *EGARCH Asymmetric Spillovers 2002-2006*

Greece	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.9552	0.9548	0.9550	0.9527
	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	0.9785	0.9728	0.9854	0.9611
	(0.000)	(0.000)	(0.000)	(0.000)
Portugal	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.9756	0.9754	0.9751	0.9763
	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	0.9781	0.9726	0.9850	0.9627
	(0.000)	(0.000)	(0.000)	(0.000)
Spain	**€/$**	**€/£**	**€/¥**	**€/CHF**
Stock Returns	0.9784	0.9783	0.9789	0.9784
	(0.000)	(0.000)	(0.000)	(0.000)
Exchange Rates	0.9778	0.9725	0.9853	0.9612
	(0.000)	(0.000)	(0.000)	(0.000)