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Modeling the volatility of Mediterranean stock markets: a regime-switching approach

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Abstract

In this paper we use the Markov regime-switching model to investigate the volatility behavior of six Mediterranean stock markets (France, Spain, Greece, Egypt, Tunisia, and Turkey) over the turbulent period 1995-2010. Our results show strong evidence of regime shifts in each of these markets. We also find that the Mediterranean developed markets are less affected by international market events such as Asian and Russian financial crisis than emerging markets.

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1. Introduction

It is well documented that forecasting the volatility of stock returns plays an essential role in portfolio management and capital budgeting. Volatility is also an important element for the choice of risk hedging strategies and the pricing of derivatives securities. Over the two last decades, the Mediterranean stock markets constitute a new area for global investors following the suggestions of several papers that international diversification benefits can be achieved by investing regionally only (Lagoarde-Segot and Lucey, 2007; Driessen and Laeven, 2008; Chiou, 2008). There is thus need for a better understanding of their volatility behavior.

The Markov switching (MS) model has been widely applied to stock markets. Moore and Wang (2007) study regime shifts behavior in stock market returns for new EU member states, and find that the return generating process of all studied markets is characterized by two or three regimes. Wang and Theobald (2008) apply the MS Autoregressive model to explore the presence of regime shifts in six Asian emerging market returns. Their results show strong evidence of more than one regime in each of these stock markets. Ismail and Isa (2008) employ a univariate 2-regime MS Autoregressive model to detect regime shifts in Malaysian stock market. They conclude, on the one hand, that the MS model is suitable for capturing the timing of regime shifts, and on the other hand that regime shifts are generated by several economic and financial crises such as the 1973-1974 oil price shock, the 1987 stock market crash and the 1997 Asian financial crisis. Others papers have used the Hamilton and Susmel (1994)'s switching ARCH model (SWGARCH) which allows for regime switches in the conditional variance process. Canarella and Pollard (2007) apply the SWARCH model to some Latin American countries and find evidence to support the hypothesis of regime switching for all the markets considered. Further, each high volatility episode appears to be associated with either a local or an international financial crisis. In their study which focused on a group of Asian and Latin American emerging markets during the period from August 1989 to October 1999, Edwards and Susmel (2001) show that the conditional volatility of all the markets exhibits regime shifts behavior, and that high volatility regime is short lived and generally associated with common international crisis. Recently, Diamandis (2008) employ a SWARCH-L model to investigate the dynamic behavior of four Latin American stock markets (Argentina, Brazil, Chile and Mexico) over the period from January 1988 to July 2006. The author documents the existence of more than one volatility regime and a significant increase in volatility during the crisis periods including the 1994 Mexican crisis, the 1999 Brazilian crisis of 1999, and the 1997 Asian financial crisis.

The empirical literature on the application of MS models to Mediterranean stock markets is however very limited, with an exception of Kenourgios and Samitas (2009). These authors examine the potential of regime shifts in stock market returns of two Mediterranean countries, Turkey and Greece. In this paper we contribute to the related literature by investigating the regime-switching behavior in the volatility of six Mediterranean stock markets over the period 1995-2010. The use of Markov switching model, proposed by Hamilton (1989), allows us to not only detect regime shifts in volatility processes, but also to check whether the latter coincide with extreme market pressures and crisis events. In addition, our study also enables the comparison of the regime shift results for two kinds of markets, emerging and developed, composing our sample data.

The remainder of the paper is organized as follows. Section 2 presents the econometric method. Section 3 describes the data and basic statistics of stock market returns. Section 4 reports and discusses the obtained results. Section 5 concludes the paper.

2. The Markov Switching Autoregressive Model

Consider a time-series variable y_t, following the first-order Markov switching autoregressive (MS-AR) model can be written as (Hamilton, 1989)

$$y_t = \mu(S_t) + \left[\sum_{i=1}^{p} \phi_i (y_{t-i} - \mu(S_{t-i}))\right] + \varepsilon_t \quad (1)$$

$$\varepsilon_t \rightarrow iid(0, \sigma^2(S_t))$$

In Equation (1), ϕ_i are the model's coefficients. μ and σ are the mean and the standard deviation of the return distribution respectively. These distributional parameters depend on the regime at time *t*, represented by S_t. S_t is assumed to follow a two-state first order Markov process that takes the value 1 or 2 with the following fixed transition probability matrix *P*:

$$P = \begin{bmatrix} P_{11} & P_{21} \\ P_{12} & P_{22} \end{bmatrix} \quad (2)$$

where

$$\begin{cases} P(S_t = 1 | S_{t-1} = 1) = P_{11} \\ P(S_t = 1 | S_{t-1} = 2) = P_{12} = 1 - P_{11} \\ P(S_t = 2 | S_{t-1} = 1) = P_{21} = 1 - P_{22} \\ P(S_t = 2 | S_{t-1} = 2) = P_{22} \end{cases} \quad (3)$$

and $\sum_{j=1}^{2} P_{ij} = 1$ for all $i, j \in 1,2$

From Equation (3), the expected duration *D* of regime *j* is given by

$$E(D) = \frac{1}{1 - P_{jj}} \quad (4)$$

The MS-AR model as described above allows for regime shifts in both the mean and variance processes and can be estimated using the filtering algorithm proposed by Hamilton (1989). As a by-product of the maximum likelihood estimation, it is possible to make inferences about the state of the market at any date *t* through the filtered and smoothed probabilities. Indeed, the filtered probability $P(S_t, S_{t-1} | y_t, y_{t-1},...)$ denotes the conditional probability that the state of the market at time *t* being represented by S_t and at date *t*-1 by S_{t-1}, while the smoothed probability $P(S_t | y_T, y_{T-1},...)$ is the inference about the state of the market at date *t* based on data available through some future date *T*.

3. Data and Preliminary Analysis

We apply the MS-AR model to weekly closing price indices of six Mediterranean stock markets: Egypt, France, Greece, Spain, Tunisia, and Turkey. Data are dominated in local currencies and extracted from Datastream International. Depending on the availability of the data for each sample country, the starting date is March 7, 1995 for France and Spain, November 7, 1997 for Egypt and Turkey, January 1, 1998 for Tunisia, and January 5, 1998 for Greece. All series end on June 25, 2010. We compute the weekly returns by taking the difference in logarithm between two consecutive index prices, multiplied by 100.

Table 1. Summary statistics of stock market returns

	France	Spain	Greece	Tunisia	Egypt	Turkey
Mean (%)	0.071	0.135	-0.093	0.244	0.204	0.491
Std. dev.	3.153	3.142	4.105	1.416	3.178	6.021
Skewness	-0.817	-0.936	-0.263	0.976	-0.731	-0.192
Kurtosis	8.977	6.159	3.96	6.53	23.55	2.957
JB	1249.60^{++}	1348.80^{++}	417.85^{++}	1263.70^{++}	15680.00^{++}	250.50^{++}
Q(10)	23.05^{++}	19.27^{+}	17.52^{+}	38.11^{++}	41.08^{++}	17.44^{++}
$Q^2(10)$	125.16^{++}	161.20^{++}	95.08^{++}	42.67^{++}	109.72^{++}	64.61^{++}
ADF	-16.49^{++}	-14.98^{++}	-13.68^{++}	-10.92^{++}	-13.89^{++}	-13.25^{++}
Nbr. of obs.	781	781	627	652	676	676

Notes: JB, Q(10), $Q^2(10)$ and ADF refer to empirical statistics of the Jarque and Bera (1980)'s test for normality, the Ljung-Box test for autocorrelation of order 10 applied to raw and squared returns, and the Dickey and Fuller (1979)'s augmented test for unit root. $^{+}$ and $^{++}$ denote significance at the 5% and 1% levels, respectively.

Table 1 reports summary statistics for weekly returns of sample markets over the study period. Turkey had the highest average return (0.491%) and Greece realized the lowest return (-0.093%). Unconditional volatility of Mediterranean stock markets, measured by standard deviation, is generally high, and ranges from 1.416 (Tunisia) to 6.021 (Turkey). Except for Tunisia, the sample skewness and excess kurtosis indicate that all the stock return distributions are negatively skewed and highly leptokurtic relative to the normal distribution. This result is confirmed by the Jarque-Bera (JB) test for normality. Results of Ljung-Box test for serial correlation of the 10th order applied to raw and squared returns reject the null hypothesis of no autocorrelation, suggesting the presence of autoregressive parameters in the return generating processes and heteroscedastic variance for all the markets. Finally, the Augmented Dickey-Fuller (ADF) test provides evidence to support the hypothesis of stationarity for all return series at the 1% level.

4. Estimation Results

4.1 Are there regime shifts in the return generating processes?

As a preliminary analysis, we use the likelihood ratio (LR) test, suggested by Garcia and Perron (1996), to determine whether regime shifts exist in Mediterranean stock market returns. The null hypothesis of no regime switching in volatility represented by a simple AR(1) model is indeed tested against the alternative hypothesis of a two-regime MS-AR(1) model. The LR test statistics is defined as $LR = 2|\ln L_{MS-AR} - \ln L_{AR}|$, where L_{AR} and L_{MS-AR} are the likelihood values of two respective models. The critical values for the two regime switching volatility model, based on Davies (1987)'s *p*-values, is presented in Garcia and Perron (1996). The results reported in Table 2 indicate that the null hypothesis of no regime switching is clearly rejected at the 1% level. Accordingly, stock market returns in the Mediterranean region are better described by a two-state switching MS-AR model than a simple AR specification. Moore and Wang (2007), and Wang and Theobald (2008) find similar results for new EU member states, and some Asian emerging markets respectively.

Table 2. Likelihood ratio test: AR(1) versus MS-AR(1) specifications

	$L_{AR(1)}$	$L_{MS-AR(1)}$	LR test statistic
France	-2000.80	-1927.58	146.44^{++}
Spain	-1999.80	-1912.78	174.04^{++}
Greece	-1770.35	1685.04	170.62^{++}
Tunisia	-1148.38	-1057.98	180.80^{++}
Egypt	-1734.83	-1502.28	46.51^{++}
Turkey	-2169.93	-2103.47	132.92^{++}

Note: $^{++}$ indicate the null hypothesis of no regime switching volatility is rejected at the 1% level.

4.2 Estimation results of MS-AR model

Following the rejection of the hypothesis of no regime switching, we now move to the estimation of the MS-AR model for six markets in the sample. We start by specifying the number of lags in the mean equation using the AIC and BIC information criteria. Both criteria choose one lag specification, AR(1), for all stock market. Table 3 reports the estimates obtained. At the first sight, we clearly observe the existence of two distinct regimes: the regime 1 corresponds to the high volatility state, and the regime 2 to the low volatility state. A close inspection of the estimates of σ_1^2 and σ_2^2 shows that market volatility is about twice (Greece, France, Spain, and Turkey), three (Tunisia), and four (Egypt) times higher in the high volatility regime than in low volatility regime. Furthermore, the probability that a week of high volatility will be followed by a week of high volatility (i.e., the probability of staying in regime 1) ranges from 0.785 for Tunisia to 0.981 for Greece. The probability of staying in low volatility regime is comprised between 0.930 (Tunisia) and 0.988 (Spain). The average duration for low volatility regime is slightly higher than that of the high volatility regime for all Mediterranean stock markets. On average, the high volatility regime lasts from 4.65 weeks for Tunisia to 52.63 weeks for Greece, while the low volatility regime holds out from 14.28 weeks for Tunisia to 83.33 weeks for Spain. Estimation results also indicate that the average return is positive and significant for five out of six Mediterranean markets during regime 2 (low volatility state) and ranges between 0.134% for Tunisia and 0.480% for Turkey. Inversely, the average return is significant for only two markets during the regime of high volatility (-0.718% for France and 0.589% for Tunisia). Our results, except those for Tunisia, are consistent with the findings of Maheu and McCurdy (2000) in the sense that they find a high return stable state and low return volatile state for the US stock markets.

Table 3. Estimated MS-AR(1) model for Mediterranean countries

	France	Spain	Greece	Tunisia	Egypt	Turkey
μ_1	-0.718	-0.755	-0.276	0.589***	-0.202	0.515
	(0.478)	(0.754)	(0.355)	(0.230)	(0.398)	(0.582)
μ_2	0.249***	0.239***	0.091	0.134***	0.387***	0.480**
	(0.093)	(0.098)	(0.157)	(0.051)	(0.073)	(0.209)
α	-0.099***	0.023	0.084**	0.068*	0.025	0.018
	(0.037)	(0.036)	(0.042)	(0.046)	(0.037)	(0.038)
σ_1^2	5.348***	6.423***	5.459***	2.390***	5.352***	8.554***
	(0.465)	(0.629)	(0.266)	(0.223)	(0.330)	(0.515)
σ_2^2	2.393***	2.458***	2.268***	0.853***	1.345***	4.038***
	(0.092)	(0.079)	(0.123)	(0.056)	(0.072)	(0.166)
P_{11}	0.939	0.947	0.981	0.785	0.941	0.973
P_{22}	0.986	0.988	0.983	0.930	0.972	0.986
$E(D_1)$	16.39	18.87	52.63	4.65	16.95	37.04
$E(D_2)$	71.43	83.33	58.82	14.28	35.71	71.43
Log-likelihood	-1927.58	-1912.78	-1685.44	-1057.98	-1502.28	-2103.47

Note: standard deviations are reported in parentheses. *, ** and *** indicate that coefficients are significant at the 10%, 5% and 1% levels respectively.

We then employ some specification tests to check the goodness-of-fit of the two-state MS-AR(1) model as well as the robustness of the results. Table 4 reports the results from the ARCH test for conditional heteroscedasticity and the Ljung-Box test for autocorrelation in the standardized residuals. The null hypothesis of no ARCH effects cannot be rejected at conventional levels for four out of six cases (Greece, Spain, Tunisia, and Turkey). With regard to the Ljung-Box Q(10) statistics, standardized residuals appear to be not serially correlated. Taken together, these tests show that the two-state Markov switching model explains satisfactorily the time-variations in weekly stock returns of sample Mediterranean markets.

Table 4. Standardized residuals-based diagnostic tests

	France	Spain	Greece	Tunisia	Egypt	Turkey
Q(10)	9.94	10.76	13.48	27.38	31.11	13.57
	[0.445]	[0.377]	[0.142]	[0.08]	[0.56]	[0.193]
ARCH(4)	2.81	1.86	1.64	0.91	15.58	0.64
	[0.024]	[0.116]	[0.163]	[0.456]	[0.03]	[0.636]

Notes: Q(10) and ARCH(4) refer to empirical statistics of the Ljung-Box test for autocorrelation of order 10 applied to standardized residuals, and the ARCH test for conditional heteroscedasticity with four lags. Numbers in bracket are the associated *p*-values.

4.3 Volatility behavior of Mediterranean stock markets across regimes

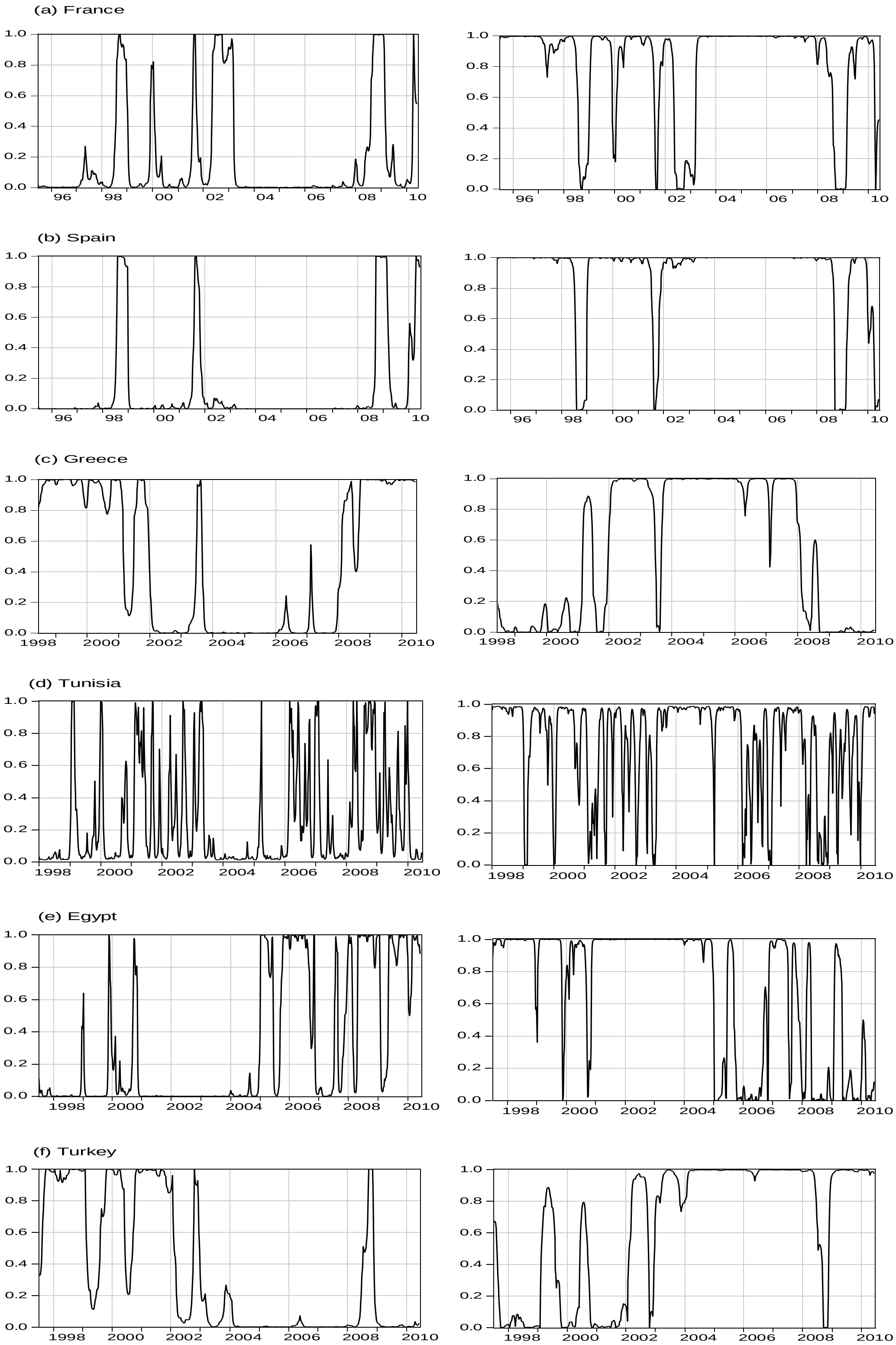
Figure 1 plots the time-varying smoothed probabilities of high volatility state (left panel) and low volatility state (right panel) for the six Mediterranean stock markets. Table 5 offers insights into the timing of each regime based on Hamilton (1989)'s method for dating regime switches according to which a stock market is in regime *i* if the associated smoothed probability $P(S_t = i)$ is higher than 0.5. A close look on these smoothed probabilities indicates that there is no common pattern in the regime shift dates among Mediterranean stock markets considered. The unique exception is around the year of 2008, when the smoothed probability of high volatility state increases for all markets, thus reflecting the advent of the US subprime crisis followed by a global financial crisis. Other regime shifts tend to be coincided with several economic and political events occurring over the study period. We now focus on these specific patterns by performing a country-by-country analysis.

We find a similar pattern in the regime shifts for France and Spain since the two markets experienced a high volatility regime during the Russian financial crisis starting in 1998. Besides, the smoothed probability plots of regime 1 also capture another period of high volatility in the late of 2001 as a result of the September 11 terrorist attack effects.

For the Greece, the Asian financial crisis that started in July 1997 marked the beginning of its first high volatility episode. Another high volatility regime is identified during the Russian and Brazilian financial crisis of 1998-1999. This finding indicates that the Greek stock market is more likely to be affected by financial contagion and volatility transmission from the countries in crisis. It should be noted that the high volatility states observed after the Brazilian crisis is due to country specific factors rather than external events or contagion effects (e.g., Greece's adherence to Eurozone in 2001; Greek market's full privatization in 2003). The final episode of high volatility happened between 2008 and 2010, and can be explained not only by the effects of the US subprime crisis, but also by the Greece's public dept crisis.

For the two African Mediterranean countries (Tunisia and Egypt), the estimated smoothed probabilities do not clearly show the separation between the two regimes as found in France and Spain. For Tunisia, the regime is very unstable given that returns shift frequently between low and high volatility states during the period 1998-2001. This period coincided with the last stage of the financial liberalization programme in Tunisia. We can also observe another period of frequent shifts between the two regimes starting in 2006 as a result of the full liberalization of the Tunisian economy. As for Egypt, the stock market returns entered into the high volatility regime between 1999 and 2000 following the Brazilian crisis. The period of high volatility observed between 2005 and 2006 is due to the country-specific factors particularly related to the removal of the peg exchange rate system and to the implementation of an inflation targeting policy.

Figure 1. The smoothed probability of being in regime 1 (left) and regime 2 (right)



For Turkey, four main high volatility episodes were identified and each of them appears to be connected with a financial crisis and its contagion effects. In addition to the recent global financial crisis, the Asian and Russian financial crisis of 1997-1998, the Turkish economic crisis of 2001, the Argentinean debt crisis of 2002 are found to coincide with the high volatility regimes of Turkish stock market.

Table 5. Duration of regime 1 and regime 2

	Regime 1 (high volatility)	Regime 2 (low volatility)
France	1998:34-1999:04	1995:29-1998:33
	1999:51-2000:07	1999:05-1999:50
	2001:12-2001:42	2000:08-2001:11
	2002:21-2003:13	2001:43-2002:20
	2008:36-2009:12	2003:14-2008:35
	2010:17-2010:25	2009:13-2010:16
Spain	1998:33-1999:02	1995:29-1998:32
	2001:34-2001:46	1999:03-2001:33
	2008:41-2009:14	2001:47-2008:40
	2010:05-2010:25	2009:15-2010:04
Greece	1998:20-2001:04	2001:05-2001:21
	2001:22-2001:46	2001:47-2003:20
	2003:21-2003:37	2003:38-2007:08
	2007:09-2007:10	2007:11-2008:08
	2008:09-2008:28	2008:29-2008:35
	2008:36-2010:25	
Egypt	1999:04-1999:05	1997:25-1999:03
	1999:48-1999:52	1999:06-1999:47
	2000:40-2000:47	2000:01-2000:39
	2005:04-2005:26	2000:48-2005:03
	2005:39-2006:39	2005:27-2005:38
	2006:45-2006:47	2006:40-2006:44
	2007:31-2007:36	2006:31-2007:48
	2007:49-2008:10	2007:37-2007:48
	2008:20-2009:07	2008:11-2008:19
	2009:22-2010:25	2009:08-2009:21
Turkey	1997:25-1997:26	1997:27-1997:33
	1997:34-1999:18	1999:19-1999:33
	1999:34-2000:25	2000:26-2000:39
	2000:40-2002:09	2002:10-2002:43
	2002:44-2003:01	2003:02-2008:30
	2008:31-2008:32	2008:33-2008:35
	2008:36-2008:50	2008:51-2010:25

Overall, our results suggest that changes in the volatility level and regime duration vary across countries and types of event. Economic, political and social events thus cause each market's volatility to change differently, a finding that is consistent with that of Aggarwal et al. (1999).

5. Conclusion

This paper uses the Markov switching autoregressive (MS-AR) model to study the volatility of six stock markets in the Mediterranean region over the period 1995-2010. The results show very strong evidence of regime shifts in all markets, which appear to be associated with international economic and political events as well as country-specific factors. In addition, developed stock markets under consideration are found to be less affected by emerging financial crises (e.g., Asian and Brazilian crises) than emerging stock markets of the Mediterranean region.

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