INFORMATION SPILLOVERS FROM THE US TO THE SPANISH STOCK INDEX FUTURES MARKETS

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RESUMEN

Este trabajo desarrolla el modelo empleado por Kim (2005) para analizar la transmisión de información desde el índice bursátil del mercado de futuros de Estados Unidos al de España y el comportamiento de la persistencia de la volatilidad. El uso del índice bursátil de los futuros está basado en los resultados obtenidos por Boudoukh, Richardson y Whitelaw (1994), quienes sugieren que el uso de estos índices puede proporcionar una prueba más clara acerca de la transmisión de rentabilidades bursátiles y volatilidad. Utilizamos un modelo GJR-GARCH en vez de un modelo EGARCH y, además, incluimos diferentes medidas de volatilidad. El resultado sugiere la influencia del mercado estadounidense sobre el español especialmente en las rentabilidades *overnight*. Encontramos una transmisión de información positiva y significativa de las rentabilidades intradiarias del índice DOW sobre la rentabilidad *overnight* del IBEX en el siguiente período a la vez que la influencia del IBEX es negativa. Adicionalmente, encontramos evidencias de que la rentabilidad *overnight* del IBEX está influenciada de forma significativa y positiva por las diferentes medidas de volatilidad y el volumen del IBEX una vez eliminada la tendencia. Sin embargo, el volumen del DOW una vez eliminada la tendencia ejerce una influencia negativa. Finalmente, encontramos una significativa reducción de la persistencia de la volatilidad en contraste con la evidencia empírica previa.

PALABRAS CLAVE: Indices Bursátiles del Mercado de Futuros, GJR-GARCH, Volatilidad Extrema, Persistencia.

ABSTRACT

This paper develops the model used by Kim (2005) in order to analyze the information spillovers from the US to the Spanish stock index futures markets and the behavior of volatility persistence. The use of stock index futures prices is based on the findings of Boudoukh, Richardson and Whitelaw (1994), who suggest that the use of stock index futures can provide a cleaner test of international transmission of stock returns and volatility. We use a GJR-GARCH model instead of a EGARCH model and, additionally, we include different measures of volatility. The results suggest the influence of the US market upon the Spanish market especially on overnight returns. We find a significant and positive spillover effect from the previous intraday returns of the DOW index upon the IBEX overnight returns, while the influence from the IBEX is negative. Additionally, we find evidence that the IBEX overnight returns are positively and significantly influenced by the different volatility measures and the detrended volume of the IBEX. However, the detrended volume of the DOW exerts a negative influence.

Finally, we find a significant reduction of the volatility persistence in contrast to the previous empirical evidence.

KEYWORDS: Stock Index Futures Markets, GJR-GARCH, Extreme Volatility, Persistence.

1. INTRODUCTION

The existence and modeling of linkages among equity markets has been the subject of vast empirical and theoretical investigation in order to analyze its influence on market behavior. Studies have concentrated on analyzing how news from one stock market influences, the performance of other markets, see Hamao et al. (1990) or Koutmos and Booth (1995) and the integrating of emerging markets, see Masih and Masih (1999) or Bekaert and Harvey (2000). Other studies analyze the price and volatility spillovers between advanced markets, see Conolly and Wang (2000) or Bae et al. (2000), which find that the US market acts as a leader over other markets.

Related to this environment, the analysis of volatility has been an important issue in stock markets in recent years, specifically those following the publication of the ARCH model proposed by Engle (1982) and its generalization (GARCH model) proposed by Bollerslev (1986). Different studies have focused on evaluating other volatility measures that might improve the volatility results.

This paper improves the previous literature in various ways. Firstly, we use a GJR-GARCH model to analyze the nature of stock market linkages instead of the EGARCH model used by Kim (2005). We substitute some exogenous variables with others from the Spanish stock market. Additionally, we incorporate some other extreme value methods for measuring volatility, specifically those proposed by Parkinson (1980) and Rogers and Satchell (1991), which complement the Garman and Klass (1980) value originally used.

Secondly, this study analyzes whether the aggregation of different exogenous information affects the behavior of the markets and the volatility persistence, in accordance with the suggestions made by Aragó and Nieto (2005). Thirdly, there are no previous studies that analyze in this way information spillovers from the main US index, the Dow Jones Industrial Average, hereafter DOW to the main Spanish stock index, IBEX-35, hereafter IBEX,. Finally, we shed some light on the behavior of the Spanish stock market by providing some clues in order to better understand how volatility affects it.

The Spanish stock market has combined from the earlier nineties, when its main stock index IBEX-35 was created, sharp rises with periods of losses. Additionally, the improvement on the technical, operational and organizational systems supporting the market has enabled it to channel large volumes of investment and have made it more transparent, liquid and effective.

The Spanish stock market has also become a reference for the main European stock markets. In addition to the gains in trading volume, returns and market capitalization, the Spanish stock market has been a pioneer in market globalization. It incorporated into its trading system the shares of the main Latin American companies, where many large Spanish companies had invested heavily, which contributed positively to Spain’s equity performance.

The pooling of interests has enabled Spain to reach a significant size in the European context and a diversified structure that covers the whole chain of activities in the markets, from trading to settlement. That enables it to make better use of resources, reduced costs and streamline services.

The results indicate that the US stock market does indeed influence the Spanish stock market, especially the overnight returns. We find a significant and positive spillover effect from the previous intraday returns of the DOW index upon the IBEX overnight returns, while the influence from the IBEX is negative. Additionally, we find evidence that the IBEX overnight returns are positively and significantly influenced by the different volatility measures and the detrended volume of the IBEX. However, the detrended volume of the DOW exerts a negative influence. Finally, we find a significant reduction of the volatility persistence in contrast to the previous empirical evidence.

The remainder of the paper is organized as follows. Section 2 describes the data and the methodology. In Section 3 we show the principal results and in Section 4 we provide the main conclusions.

2. DATA AND METHODOLOGY

2.1. DATA

This paper analyzes the influence of the NYSE on the overnight and intraday returns of the Spanish stock market. Starting on January 2, 1998 we have compiled daily data of the opening, high, low and closing prices of the stock index futures of the IBEX and DOW, through April 28, 2006, which yields 2,082 daily observations. The use of stock index futures prices is based on the findings of Boudoukh et al. (1994) who suggest that the use of stock index futures can provide a cleaner test of international transmission of stock return and volatility. Furthermore, Chan (1992) provides evidence showing that stock index futures lead the underlying spot indexes. Thus, the use of stock index futures prices to investigate information transmission between national markets should better capture the characteristics of interactions.

We divide daily (close-to-close) returns into overnight (previous close-to-open) returns, NR, and daytime (open-to-close) returns, DR for both markets. Based on the common procedure, all returns are computed as logarithm differences of the stock price indexes and if one market is closed while the other market is open we set its returns equal to zero.

Once estimated the different returns we calculate the volatility values. In recent years several methods have been proposed to estimate the volatility parameter in different price models. The most common method is based on the use of the daily squared return in the volatility equation as in Lee et al. (2004) although there are other options as in Bessembinder and Seguin (1993) who model volume and use a forecast of volume adding it in the variance equation or the work of Laux and Ng (1993) who use the forecasted number of price changes instead of volume.

It is demonstrated that the daily squared return is an unbiased estimator of the realized daily volatility, however, Andersen and Bollerslev (1998) show that it is also extremely noisy. Additionally, it must be pointed out that by only looking at opening and closing prices we may wrongly conclude that volatility on a given day is small if both prices are near, despite large intraday price fluctuations. For that reasons other measures are needed to estimate the daily volatility.

Taylor and Xu (1997) use the standard deviation of the intraday returns and Martens (2001) use the sum of squared intraday returns providing both of them better results for the conditional variance. However, we consider more effective the extreme value methods.

Parkinson (1980) provides a simple way to measure the daily volatility given the daily range of the high/low prices suggesting the measurement of the daily volatility as follows:

$$VP_t = \frac{1}{4\ln 2}\left[\ln\left(\frac{H_t}{L_t}\right)\right]^2 = 0.361\left[\ln\left(\frac{H_t}{L_t}\right)\right]^2 \quad (1)$$

where H_t and L_t denote the highest and lowest prices respectively during the day trading on day t. It has been demonstrated that the efficiency of this estimator is very high, about 4.91 in comparison with the standard simple variance estimator and could be as much as 8.5 times more efficient than log-squared returns.

Since then, different methods have been proposed for estimating the volatility parameter. Garman and Klass (1980) incorporate the opening (O_t) and closing (C_t) prices and suggest the following measure (VGK_t) :

$$VGK_t = \frac{1}{2}\left[\ln\left(\frac{H_t}{L_t}\right)\right]^2 - (2\ln 2 - 1)\left[\ln\left(\frac{O_t}{C_t}\right)\right]^2 \quad (2)$$

Finally, Rogers and Satchell (1991) propose another alternative measure:

$$VRS_t = \left[\ln\left(\frac{H_t}{O_t}\right)\right]\left[\ln\left(\frac{H_t}{C_t}\right)\right] + \left[\ln\left(\frac{L_t}{O_t}\right)\right]\left[\ln\left(\frac{L_t}{C_t}\right)\right] \quad (3)$$

Second one of this measures of volatility was used by Kim (2005) to investigate, using an EGARCH framework, the nature of the stock market linkages in the advanced Asia-Pacific stock markets with the US.

Finally, because the trading volume in DOW contains significant linear and non-linear trends we use the residuals from the detrending equation $Volume_t = a + bT + cT^2 + e_t$ as detrended volume, denoted as $VM_{ID,t}$.

2.2. METHODOLOGY

There are different options to analyze the information transmission between two or more markets. Wang et al. (2002), Wang and Firth (2004) and Lee et al. (2004), among others, use a standard two-stage procedure. In the first stage, they use alternative GARCH models to estimate the unexpected returns for each index and each market that cannot be predicted based on public information. In the second stage, they use those unexpected returns to analyze the interdependence of returns and volatilities between the markets.

Blasco et al. (2005) perform the two stage adjustment process proposed by Gallant et al. (1992) by using a set of dummy and time-trend variables to capture some systematic effects and then analyze the influence of basic news on returns, volatility and volume.

However, we adapt the methodology used by Kim (2005) to analyze the contemporaneous and dynamic spillover effects from DOW to IBEX by employing the following EGARCH model:

$$R_t = \delta_0 + \delta_1 R^{DOW}_{ID,t-1} + \delta_2 VM^{DOW}_{ID,t-1} + \varepsilon_t$$

(4)

$$\log\sigma_t^2 = \omega + \alpha\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \sqrt{\frac{2}{\pi}}\right| + \gamma\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \beta\log\sigma^2_{t-1} + \varphi_1 VT^{DOW}_{t-1} + \varphi_2 VM^{DOW}_{ID,t-1}$$

where:

R_t: Overnight and intraday returns in the IBEX on day t.

$\log\sigma_t^2$: Conditional variance of overnight or intraday returns in the IBEX on day t.

$R^{DOW}_{ID,t-1}$: Intraday returns of the DOW index on day t-1.

$VM^{DOW}_{ID,t-1}$: Detrended trading volume in the DOW on day t-1.

VT^{DOW}_{t-1} : Garman-Klass (GK), Parkinson (P) or Rogers-Satchell (RS) volatility in the DOW on day t-1

This is one of the most popular methods used in the empirical literature to capture the asymmetric effects in the data. Asymmetry is indicated by a statistically significant negative value for γ while the degree of volatility persistence is measured by β.

However, Engle and Ng (1993) argued that the GJR-GARCH model, another popular way to model the asymmetry of positive and negative innovations, is better than the EGARCH model because the conditional variance implied by the latter is too high due to its exponential functional form.

For that reason we propose the following GJR-GARCH model to analyze the information spillover:

$$R_t = \delta_0 + \delta_1 R^{DOW}_{ID,t-1} + \delta_2 VM^{DOW}_{ID,t-1} + \varepsilon_t$$

(5)

$$\sigma_t^2 = \omega + \alpha\varepsilon^2_{t-1} + \gamma\varepsilon^2_{t-1}I_{t-1} + \beta\sigma^2_{t-1} + \varphi_1 VT^{DOW}_{t-1} + \varphi_2 VM^{DOW}_{ID,t-1}$$

where I_{t-1} =1 if $\varepsilon_t < 0$ and 0 otherwise. In this model, good news $\varepsilon_{t-1} > 0$, and bad news $\varepsilon_{t-1} < 0$, have differential effects on the conditional variance; good news has an impact of α, while bad news has an impact of $\alpha+\gamma$. If $\gamma>0$ bad news increases volatility and we say that there is a leverage effect. Finally, the degree of volatility persistence is measured by $\alpha+\beta$.

3. EMPIRICAL RESULTS

Table 1 reports basic statistics for daily, overnight and intraday returns for the IBEX and DOW indexes covering the sample period from January 2, 1998 to April 28, 2006. The first notable findings are the differences between intraday and overnight returns and volatilities. In both indexes overnight returns are higher than intraday returns (0.047045 versus –0.023442 for the IBEX and 0.012249 versus 0.004901 for the DOW). In contrast, volatilities are higher during the trading day. The intraday volatility for the IBEX and DOW indexes are 1.330155 and 1.084471 respectively, while the overnight volatilities are 0.748151 and 0.561742 respectively. These values reveal an important finding: daytime trading entails more risk and is less profitable in both markets while overnight trading is more intense due to the higher values on its returns and lower values of volatility. This is due to the arrival of information and noise from the DOW which takes place overnight. Furthermore, these four series have significant skewness and kurtosis, which indicates that their empirical distributions have heavy tails relative to the normal distribution.

Table 1: Descriptive Statistics

	$R^{IBEX}_{D,t}$	$R^{IBEX}_{ON,t}$	$R^{IBEX}_{ID,t}$	$R^{DOW}_{D,t}$	$R^{DOW}_{ON,t}$	$R^{DOW}_{ID,t}$
Mean	0.023603	0.047045	-0.023442	0.017150	0.012249	0.004901
Median	0.089042	0.050277	0.010963	0.019434	0.029840	0.009450
Maximum	7.163004	6.392365	5.869614	6.378317	3.936956	7.989037
Minimum	-8.019481	-5.947660	-6.918422	-8.111243	-10.51881	-8.388916
Std. Dev.	1.516175	0.748151	1.330155	1.181941	0.561742	1.084471
Skewness	-0.178968	0.148266	-0.167413	-0.173392	-3.300402	-0.137119
Kurtosis	5.621789	11.03252	5.447040	7.224227	68.01004	7.881363
Jarque-Bera	607.4147	5604.857	529.1848	1558.408	370411.7	2073.578
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Note: $R^{IBEX}_{D,t}, R^{DOW}_{D,t}$ are daily (close to close) returns for Ibex and Dow, $R^{IBEX}_{ID,t}, R^{DOW}_{ID,t}$ are overnight (close to open) returns for Ibex and Dow and $R^{IBEX}_{ID,t}, R^{DOW}_{ID,t}$ are intraday (open to close) returns for Ibex and Dow.

Table 2 reports the regression results for the first hypothesis, which analyzes the impact of DOW's intraday return, detrended volume and volatility (all of them from the previous day) on the overnight and intraday returns of the Spanish stock index.

Table 2: Results of the initial EGARCH Model

Dependent Variable		$R^{IBEX}_{ON,t}$			$R^{IBEX}_{ID,t}$	
Volatility Measure	GK	P	RS	GK	P	RS
δ_0	0.037	0.038	0.036	0.003	0.003	0.003
	(3.467)	(3.497)	(3.360)	(0.161)	(0.168)	(0.159)
δ_1	0.301	0.295	0.304	-0.046	-0.045	-0.046
	(25.880)	(24.867)	(24.478)	(-1.844)	(-1.801)	(-1.864)
δ_2	0.047	0.043	0.047	-0.072	-0.071	-0.072
	(2.473)	(2.185)	(2.581)	(-2.335)	(-2.305)	(-2.350)
ω	-0.322	-0.378	-0.274	-0.137	-0.138	-0.136
	(-13.174)	(-13.621)	(-13.151)	(-8.714)	(-8.762)	(-8.727)
α	0.217	0.229	0.204	0.166	0.166	0.166
	(12.211)	(11.645)	(12.633)	(8.644)	(8.629)	(8.654)
γ	0.003	-0.004	0.010	-0.072	-0.071	-0.071
	(0.321)	(-0.367)	(1.018)	(-6.787)	(-6.771)	(6.789)
β	0.919	0.897	0.937	0.981	0.980	0.982

	(92.642)	(79.532)	(112.436)	(215.679)	(216.108)	(219.652)
φ_1	623.404	786.827	468.118	57.301	66.592	49.780
	(8.465)	(10.522)	(7.094)	(1.398)	(1.701)	(1.266)
φ_2	-0.038	-0.043	-0.031	-0.003	-0.003	-0.003
	(-5.722)	(-5.916)	(-5.219)	(-0.501)	(-0.562)	(-0.464)
Log-Likelihood	-1728.633	-1722.409	-1734.229	-3161.221	-3160.803	-3161.404
Adjusted R^2	0.2253	0.2245	0.2256	0.0015	0.0015	0.0015
Skewness	-0.611	-0.503	-0.672	-0.151	-0.149	-0.152
Kurtosis	9.804	8.654	10.629	3.237	3.231	3.239
Q(20)	19.780	21.082	18.825	23.746	23.863	23.674
$Q^2(20)$	19.277	24.318	16.874	30.344*	31.017*	30.021*
ARCH-LM	0.573	0.743	0.446	0.385	0.392	0.383

Note: *, **, *** Significance at the 10%, 5% and 1% level respectively.

The estimated EGARCH regressions show that there are significant transmissions of information between the DOW and the IBEX. All the coefficients in the mean equations are significant, which means that both the overnight and intraday returns of the IBEX are influenced by the intraday return and the detrended volume of the DOW. These results are consistent with the previous empirical evidence that shows the existence of contemporaneous and dynamic spillover effects between the US markets and different developed and emerging markets (a few examples are Becker et al. 1990; Peiró et al. 1998; and Lee et al. 2004).

The most important findings with respect to the volatility equation are the existence of significant spillover effects from DOW volatility (with a higher influence on the IBEX when the Parkinson measure is used) and detrended volume into the Spanish overnight returns. However, when intraday return of the IBEX is used as a dependent variable there is no longer influence from the detrended volume and two of the volatility measures (only when the Parkinson measure is used the coefficient is positive and significant at the 10% level).

It is also interesting to point out that when we use intraday returns as the dependent variable persistence values are higher[1] and we find evidence of asymmetry effects (γ is negative and statistically significant). However, when we use overnight returns as the dependent variable those asymmetric effects disappear. Finally, all the regressions show no additional ARCH effects in the standardized residuals as shown in the ARCH LM test.

Table 3: Results of the initial GJR-GARCH Model

Dependent Variable	$R^{IBEX}_{ON,t}$			$R^{IBEX}_{ID,t}$		
Volatility Measure	GK	P	RS	GK	P	RS
δ_0	0.0035	0.035	0.035	0.009	0.010	0.008
	(3.426)	(3.463)	(3.473)	(0.470)	(0.542)	(0.399)
δ_1	0.295	0.293	0.298	-0.033	-0.033	-0.033
	(23.088)	(21.297)	(24.554)	(-1.304)	(-1.282)	(-1.326)
δ_2	0.016	0.014	0.018	-0.081	-0.081	-0.080
	(0.858)	(0.756)	(0.989)	(-2.608)	(-2.621)	(-2.594)

1 According with the higher values of the standard deviations referred before.

ω	-0.006	-0.004	-0.005	0.002	0.001	0.005
	(-5.207)	(-3.250)	(-4.998)	(0.663)	(0.415)	(1.395)
α	0.033	0.034	0.035	0.038	0.038	0.038
	(3.088)	(2.788)	(3.211)	(2.990)	(2.962)	(3.035)
γ	0.046	0.055	0.041	0.102	0.102	0.103
	(2.957)	(3.045)	(2.715)	(5.319)	(5.259)	(5.495)
β	0.779	0.752	0.793	0.875	0.871	0.880
	(59.919)	(44.848)	(61.468)	(54.481)	(54.549)	(57.535)
φ_1	711.001	758.91	662.65	523.493	582.543	408.999
	(15.089)	(14.821)	(14.159)	(2.650)	(3.037)	(2.311)
φ_2	-0.005	-0.003	-0.007	-0.004	-0.004	-0.004
	(-3.446)	(-2.118)	(-4.145)	(-0.809)	(-0.712)	(-0.773)
Log-Likelihood	-1664.718	-1657.357	-1671.062	-3157.907	-3156.404	-3159.557
Adjusted R^2	0.2239	0.2265	0.2273	0.0018	0.0017	0.0018
Skewness	-0.451	-0.379	-0.494	-0.122	-0.115	-0.131
Kurtosis	7.345	6.718	7.811	3.225	3.203	3.239
Q(20)	17.877	19.047	17.742	23.343	23.724	23.186
$Q^2(20)$	29.202*	36.900***	24.619	28.641	29.274*	28.326
ARCH-LM	0.6013	0.813	0.528	0.899	0.998	0.846

Note: *, **, *** Significance at the 10%, 5% and 1% level respectively.

These results are different when the GJR-GARCH methodology is used. Columns 2 to 4 of Table 3 show the results of the regressions for each volatility measure when the overnight return is the dependent variable. In this case, the influence of the detrended volume on the mean equation disappears (none of the coefficients are significant) while, the conditional variance continues to be influenced by both exogenous variables.

With respect to the volatility equation we find lower values for volatility persistence and higher values for the Log-Likelihood coefficients, which indicates that the GJR-GARCH model is better suited than the EGARCH model to illustrate the relationship between the IBEX and the DOW indexes. Additionally, the values of the adjusted R^2 are higher in the three regressions compared with those obtained using the EGARCH methodology.

The last three columns of Table 3 show the results of the dynamic spillover analysis. There are various differences with respect to the results obtained in Table 2. Firstly, the DOW intraday return from the previous day have no influence on the IBEX intraday returns from the following day. However, the significant values of the coefficients referred to the detrended volume reveal that there is information transmission between the two markets. Secondly, the volatility measures appear to be significant in these regressions in contrast to the lower significance that we obtained using the EGARCH model. Finally, the results of the Log-Likelihood coefficient, as well as the higher values of the adjusted coefficient of the regression, reveal that this model better defines the relationship between the two indexes.

In order to analyze the effect of the flow of new information into the market the intraday return and the detrended volume of the previous day of the IBEX are included in the mean equation of the previous models. The three different measures of volatility, as well as the detrended volume, of the previous day are also included in the variance equation.

Equations 6 and 7 show the new formulations of the EGARCH and the GJR-GARCH models respectively:

$$R_t = \delta_0 + \delta_1 R^{DOW}_{ID,t-1} + \delta_2 VM^{DOW}_{ID,t-1} + \delta_3 R^{IBEX}_{ID,t-1} + \delta_4 VM^{IBEX}_{ID,t-1} + \varepsilon_t$$

$$\log\sigma^2_t = \omega + \alpha\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \sqrt{\frac{2}{\pi}}\right| + \gamma\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \beta\log\sigma^2_{t-1} + \varphi_1 VT^{DOW}_{t-1} + \varphi_2 VM^{DOW}_{ID,t-1} + \varphi_3 VT^{IBEX}_{t-1} + \varphi_4 VM^{IBEX}_{ID,t-1} \quad (6)$$

$$R_t = \delta_0 + \delta_1 R^{DOW}_{ID,t-1} + \delta_2 VM^{DOW}_{ID,t-1} + \delta_3 R^{IBEX}_{ID,t-1} + \delta_4 VM^{IBEX}_{ID,t-1} + \varepsilon_t$$

$$\sigma^2_t = \omega + \alpha\varepsilon^2_{t-1} + \gamma\varepsilon^2_{t-1}I_{t-1} + \beta\sigma^2_{t-1} + \varphi_1 VT^{DOW}_{t-1} + \varphi_2 VM^{DOW}_{ID,t-1} + \varphi_3 VT^{IBEX}_{t-1} + \varphi_4 VM^{IBEX}_{ID,t-1} \quad (7)$$

where:

$R^{IBEX}_{ID,t-1}$: Intraday returns of the IBEX index on day t-1.

$VM^{IBEX}_{ID,t-1}$: Detrended trading volume of the IBEX on day t-1.

VT^{IBEX}_{t-1}: Garman-Klass (GK), Parkinson (P) or Rogers-Satchell (RS) volatility of the IBEX on day t-1

The results for the EGARCH model are shown in Table 4. Focusing on the results in columns 2 to 4, we find that neither the detrended volume of the DOW nor that of the IBEX are significant when the Spanish data is added. In contrast, the coefficients relative to the DOW and IBEX intraday returns of the previous day and the estimated values of the different volatility measures are statistically significant in both equations of the contemporaneous analysis.

Table 4: Contemporaneous and Dynamic Spillover Effects including Spanish Market Information (EGARCH Model)

Dependent Variable	$R^{IBEX}_{ON,t}$			$R^{IBEX}_{ID,t}$		
Volatility Measure	GK	P	RS	GK	P	RS
δ_0	0.034	0.035	0.034	0.005	0.005	0.005
	(3.333)	(3.387)	(3.277)	(0.276)	(0.290)	(0.296)
δ_1	0.328	0.330	0.328	-0.041	-0.041	-0.042
	(28.837)	(28.740)	(29.333)	(-1.617)	(-1.595)	(-1.643)
δ_2	0.005	0.009	0.003	-0.088	-0.088	-0.088
	(0.287)	(0.501)	(0.194)	(-2.848)	(-2.812)	(-2.870)
δ_3	-0.099	-0.098	-0.099	-0.016	-0.017	-0.016
	(-11.199)	(-10.583)	(-11.539)	(-0.715)	(-0.762)	(-0.704)
δ_4	-0.027	-0.027	-0.028	0.061	0.060	0.063
	(-1.165)	(-1.186)	(-1.172)	(1.593)	(1.568)	(1.645)

ω	-0.674	-0.608	-0.692	-0.147	-0.148	-0.148
	(-15.621)	(-15.765)	(-15.339)	(-8.338)	(-8.235)	(-8.434)
α	0.256	0.233	0.268	0.176	0.179	0.177
	(9.849)	(9.365)	(10.216)	(8.072)	(7.714)	(8.249)
γ	-0.044	-0.047	-0.038	-0.070	-0.070	-0.071
	(-2.620)	(-2.959)	(-2.292)	(-6.493)	(-6.469)	(-6.494)
β	0.769	0.798	0.760	0.980	0.981	0.979
	(43.142)	(52.305)	(40.116)	(182.467)	(182.442)	(180.752)
φ_1	446.595	317.856	491.972	57.308	87.969	39.971
	(3.730)	(3.090)	(4.183)	(0.844)	(1.444)	(0.610)
φ_2	-0.019	-0.017	-0.027	-0.007	-0.001	$-1.66\cdot10^{-4}$
	(-1.298)	(-1.189)	(-1.801)	(-0.101)	(-0.245)	(-0.022)
φ_3	891.686	845.007	884.357	16.053	-11.670	28.960
	(17.056)	(16.332)	(16.293)	(0.307)	(-0.226)	(0.546)
φ_4	0.023	-0.001	0.047	-0.026	-0.023	-0.028
	(0.886)	(-0.064)	(1.727)	(-1.518)	(-1.355)	(-1.607)
Log-Likelihood	-1625.033	-1609.192	-1640.857	-3159.029	-3158.579	-3159.205
Adjusted R^2	0.2298	0.2305	0.2297	0.0026	0.0026	0.0026
Skewness	-0.222	-0.188	-0.277	-0.153	-0.151	-0.154
Kurtosis	5.434	5.174	5.849	3.250	3.245	3.252
Q(20)	29.701*	29.179*	29.628*	23.779	23.713	23.870
$Q^2(20)$	34.596***	30.981*	34.969***	31.357***	32.118***	31.133*
ARCH-LM	0.8153	0.6389	0.8953	0.4203	0.4345	0.4217

Note: *, **, *** Significance at the 10%, 5% and 1% level respectively.

Furthermore, the contemporaneous return spillover from the Spanish index has a negative influence upon the overnight returns while the DOW influence is positive. Additionally, both positive volatility coefficients indicate that a higher intraday volatility in both markets has a significant market exciting effect upon the overnight returns of the Spanish market.

The results relative to the significance of the coefficients are worse in the dynamic spillover analysis, the results of which are shown in Columns 5 to 7 of Table 4. We find no information spillover from the Spanish intraday returns, volatility and volume variables of the previous day into the intraday returns of the following day. Spillovers from the DOW are not much better because only the detrended volume in the mean equation has some influence upon the IBEX intraday return. Finally, the log-likelihood and the adjusted R^2 reveal that this model better estimates the relation between the two indexes. However, the Ljung-Box tests indicate that ARCH effects persists in the variance equation which means that is not properly specified.

The information spillovers are more intense when the GJR-GARCH model is used. The mean equations relative to the contemporaneous spillover analysis reported in Table 5 once again show that only the previous intraday returns of both indexes have some influence upon the overnight returns of the IBEX. Furthermore, the volatility equations, shown in columns 2 to 4, reveal that the IBEX overnight returns are positively and significantly influenced by the different volatility measures and the detrended volume of the IBEX while the detrended volume of the DOW exerts a negative influence.

Relative to the dynamic spillover analysis, it is worth pointing out that the best results are obtained when the Parkinson volatility measure is used. In this case, the intraday returns of the IBEX are positively influenced by the previous day volatilities of both indexes, but negatively influenced by the detrended volume of the Spanish market.

Finally, both models (EGARCH and GJR-GARCH) find significant asymmetric effects as expected. However, we consider that the GJR-GARCH model better adjust the information spillovers between the Spanish and the US markets. This opinion is based on the values of the Log-Likelihood coefficients, the adjusted R^2 and the results of the tests which analyze the existence of serial correlation in the mean equation or ARCH effects in the variance ones. Another interesting note is the high value of the R^2 coefficients in the contemporaneous spillover analysis of both models which we attribute to a clear transmission spillover effect between the two markets and to a correct specification of the model.

We also analyze whether the aggregation effect of variables has any influence on the volatility persistence of the models following the method of Aragó and Nieto (2005). The flow of information into the market provided by the inclusion of exogenous variables would produce a reduction in the persistence of conditional volatility reflected in an important reduction in the coefficients α and β of the GJR-GARCH model and the loss of their significance. In contrast to the results obtained by Aragó and Nieto (2005), who included in their different models the total, expected and unexpected volume, we find a significant reduction in the volatility persistence when the detrended volume and the different volatility measures of the Spanish market are included in the model.

Table 5: Contemporaneous and Dynamic Spillover Effects including Spanish Market Information (GJR-GARCH Model)

Dependent Variable	$R_{ON,t}^{IBEX}$			$R_{ID,t}^{IBEX}$		
Volatility Measure	GK	P	RS	GK	P	RS
δ_1	0.326	0.327	0.326	-0.030	-0.030	-0.031
	(25.897)	(25.167)	(27.067)	(-1.150)	(-1.119)	(-1.186)
δ_2	0.003	0.002	0.005	-0.083	-0.084	-0.082
	(0.188)	(0.151)	(0.279)	(-2.627)	(-2.661)	(-2.630)
δ_3	-0.089	-0.088	-0.090	-0.005	-0.003	-0.005
	(-8.880)	(-8.080)	(-9.594)	(-0.211)	(-0.159)	(-0.249)
δ_4	-0.026	-0.026	-0.029	0.049	0.050	0.049
	(-1.243)	(-1.253)	(-1.354)	(1.288)	(1.285)	(1.288)
ω	0.002	0.001	0.002	0.005	0.004	0.007
	(1.003)	(0.825)	(1.073)	(1.061)	(0.798)	(1.561)
α	0.027	0.014	0.034	0.020	$4.27 \cdot 10^{-4}$	0.028
	(1.538)	(0.919)	(1.909)	(1.373)	(0.020)	(2.078)
γ	0.096	0.091	0.113	0.108	0.107	0.108
	(3.365)	(3.596)	(3.959)	(5.001)	(4.973)	(5.143)
β	0.543	0.618	0.534	0.846	0.844	0.853

	(18.413)	(23.574)	(18.355)	(34.339)	(34.355)	(36.825)
φ_1	448.103	350.981	510.487	334.322	418.999	223.733
	(5.759)	(5.203)	(6.753)	(1.536)	(2.005)	(1.137)
φ_2	-0.008	-0.005	-0.010	-0.001	$-8.94 \cdot 10^{-4}$	-0.001
	(-2.321)	(-1.882)	(-2.653)	(-0.278)	(-0.136)	(-0.218)
φ_3	638.835	524.965	612.062	622.247	784.349	522.782
	(13.039)	(12.598)	(13.542)	(2.277)	(2.100)	(2.323)
φ_4	0.007	0.005	0.008	-0.023	-0.024	-0.023
	(1.732)	(1.432)	(1.961)	(-2.290)	(-2.268)	(-2.376)
Log-Likelihood	-1565.175	-1557.944	-1577.866	-3150.872	-3150.104	-3152.382
Adjusted R^2	0.2315	0.2320	0.2313	0.0023	0.0023	0.0024
Skewness	-0.246	-0.195	-0.305	-0.114	-0.109	-0.119
Kurtosis	4.964	4.782	5.294	3.166	3.159	3.180
Q(20)	24.458	24.987	23.660	24.154	16.815	24.092
$Q^2(20)$	27.930	27.630	24.552	29.031	29.535	28.766
ARCH-LM	0.6652	0.5897	0.7780	0.8542	0.8007	0.9062

Note: *, **, *** Significance at the 10%, 5% and 1% level respectively.

Volatility persistence, measured by the sum of α and β coefficients, is significantly reduced in the contemporaneous spillover estimations: from 0.812 to 0.57, when using the Garman-Klass volatility measure; from 0.786 to 0.632 with the Parkinson volatility; from 0.828 to 0.568 with the Rogers-Satchell one. The α coefficient lose its significance, as expected, when the Garman-Klass and the Parkinson volatility measures are used. On the other hand, volatility persistence reduction is not so significant in the dynamic spillover analysis because it is only reduced from 0.913 to 0.866 in the first regression, from 0.909 to 0.844 in the second one, and from 0.918 to 0.881 in the third. Once again the α coefficient is not significant in the first two regressions.

4. CONCLUSIONS

This study has improved the methodology proposed by Kim (2005) who analyzes different stock market linkages. We adapted it to the Spanish stock market in order to analyze the contemporaneous and dynamic spillover transmissions from the US market. We have added different extreme value methods for measuring volatility and we have analyzed whether the aggregation of different exogenous information affects the behavior of persistence in volatility.

The main results show that the information spillovers are more intense when the GJR-GARCH model is used. We find a significant and positive spillover effect from the previous intraday returns of the DOW index upon the IBEX overnight returns, while the influence from the IBEX is negative. Additionally, we find evidence that the IBEX overnight returns are positively and significantly influenced by the different volatility measures and the detrended volume of the IBEX. However, the detrended volume of the DOW exerts a negative influence.

Furthermore, we have analyzed the volatility persistence of the models and, in contrast with the results obtained by Aragó and Nieto (2005), we find a significant reduction in the volatility persistence when the detrended volume and the different volatility measures of the Spanish market are included in the model.

To sum up, our findings strongly support the conclusion that the proposed GJR-GARCH model reduces the volatility persistence effects and improves other information spillover analysis.

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