Advanced Studies in International Economic Policy Research
Kiel Institute for the World Economy
Düsternbrooker Weg 120
D-24105 Kiel/Germany

Working Paper No. 440

GARCH Modeling of Robust Market Returns

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May 2007

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May 27, 2007

Abstract

Daily financial market returns (as log difference in closing prices) may be quite sensitive to operations with low trading volumes and big changes in prices frequently traded at market closing times. This paper proposes a more robust estimation of market returns by providing a new indicator that accounts for the information content in prices and trading volumes: the volume weighted return. Then, we estimate a GARCH (1,1) model for the IBEX-35 futures market that includes shocks arising from countries linked to the Spanish economy. Our empirical findings suggest that the new measure of market evolution provide more moderate estimates of the impact of the relevant news coming from abroad and thus, it might be relevant to assess the linkages of one market to other economies.

Keywords: volume weighted return, trading volumes, international transmission of news, GARCH.

JEL codes: G14, G15, G10.

*This paper represents the personal views of the authors and should not be interpreted as reflecting the views of the Banco de España. The authors gratefully acknowledge the helpful comments by Vasyl Golosnoy and participants of the 2007 Term Paper Conference at the Advanced Studies Program in International Economic Policy Research at the Kiel Institute for World Economics. Contact data: Lucía Cuadro-Sáez. Department of International Economics and International Relations, Banco de España, c/ Alcalá 48, 28014 Madrid, Spain. e-mail: lucia.cuadro@bde.es. Manuel Moreno, Department of Economic Analysis and Finance, University of Castilla La Mancha, 45071 Toledo, Spain. e-mail: manuel.moreno@uclm.es.

1 Introduction

Arrival of new information at the market changes expectations of investors on the future evolution of financial variables and, from a practical point of view, it may be interesting to analyze the effect of this information on how investors build and diversify their portfolios. The assessment of market evolution has developed significantly thanks to the advances in the literature on the GARCH family models. However, daily financial market returns may be significantly biased due to operations with low trading volume and high change in prices frequently traded at market closing times. Therefore, the estimation of impact that other economies exert on a financial market calculated by the returns based on closing prices could be overestimated due to the bias caused by odd trading operations at closing times.

This paper proposes a set of new and more accurate measures for the representative market return, which are based on the movement strength weighted return presented by Cuadro-Sáez and Moreno (2007). Concretely, we develop four different specifications for the new indicator of volume weighed return that include the information content in prices and trading volumes. In this way, the new measures might be more robust to operations with low trading volumes and big changes in prices than the return based on closing prices. Next, we analyze the market evolution using the new set of volume weighted returns as the representative market returns. Namely, for each specification of the volume weighted return we estimate a standard GARCH(1, 1) model that includes shocks arising from developed and emerging market countries that are linked to the Spanish economy.

It should be emphasized that the goal of this paper is not identifying the relation between prices and volumes but analyzing what happens when assuming that both variables are important to assess the market evolution. Therefore, this paper should be distinguished from others that have analyzed such relationship as, for instance, Hiemstra and Jones (1994), which examined the dynamic relation between returns and trading volumes. These authors apply linear and nonlinear Granger causality tests to Dow Jones stock returns and the New York Stock Exchange trading volume and find evidence of significant bidirectional nonlinear causality between both variables. On a related topic, Avouyi-Dovi and Jondeau (2000) analyzes the role of trading volume on international financial markets studying the links between stock market return, volatility and trading volume of the G5 countries. Their findings suggest that the unexpected trading volume has a strong positive impact on all market returns and volatilities, although unexpected volume appears to have asymmetric effects on return as well as on volatility.

Our findings suggest that the new indicators of market evolution are more moderate than the return based on closing prices when assessing the impact of spillovers from developed and emerging markets countries to the Spanish stock market. These findings could be relevant from a monetary policy perspective provided that the use of the volume weighted return, as a more accurate measure of the market evolution, could shed some light on the understanding of the links between financial markets in one country and other countries. Besides, these findings on the linkages between different economies could also be helpful to design diversification strategies for investors especially interested in building multi-country portfolios.

The reminder of the paper is organized as follows: Section 2 reviews the literature, Section 3 presents the new measures and the methodology applied, while Section 4 details the data and the results of the empirical analysis. Finally, Section 5 summarizes the main concluding remarks.

2 Literature Review

The main objective of this paper is to analyze the performance of a new set of measures for the market return that accounts for the information content in volumes and prices rather than just relying on closing prices. These new set of measures is based on Cuadro-Sáez and Moreno (2007). These authors propose a new indicator of the Strength of the Market Movement based on prices and trading volumes and introduce the market strength weighted return as a measure to improve the information content of the data used for market analysis. The main qualitative conclusion in that paper is that the distribution of this new measure is a helpful instrument to identify the market opinion on the prices' evolution. Departing from this measure, we recognize the importance of the trading volume and we assess the impact of news stories on financial markets using also the trading volume. Concretely, we use some variations of this new volume weighted return to analyze the Spanish market using intra-day data from the Spanish Future on the IBEX-35 index during 2004.

Previous research (see, for example, Andersen (1996) and Brock and LeBaron (1996)) has already analyzed the information content in the trading volume and has tried to explain the trading volume in terms of the new information arrival as the relation between return volatility and trading volume. Similarly, Suominen (2001) also considers a market microstructure framework and explains why trading volume contains useful information for predicting volatility. Finally, on

the role of the information content in trading volumes, Tkac (1999) provides a theoretical benchmark for the trading volume that connects trading activity in individual stocks and market-wide volume.

The econometric methodology to be employed in this paper is based on GARCH models. Several previous studies have evaluated the impact of trading volume on the volatility equation, aiming to incorporate the arrival of new information by using a GARCH specification. For instance, Lamoureux and Lastrapes (1990) analyzes empirically volume versus GARCH effects on daily data and finds that the variance of stock returns is explained at a high extend by the daily trading volume, used as a proxy for information arrival time. Furthermore, ARCH effects tend to disappear when the volume is included in the variance equation.[1] In a subsequent paper, Lamoureux and Lastrapes (1994) examines the ability of volume data to explain persistence in stock-return volatility and find that their procedure cannot accommodate serial dependence in squared returns. Then, Gallo and Pacini (2000) analyzes the effects of trading activity on market volatility reexamining the question of excessive implied persistence of volatility estimates when GARCH type models are used and corroborate that the estimated persistence decreases when the trading volume is inserted in the (E)-GARCH specification for returns.

To finish this section, it may be worth noting that some papers have analyzed directly the impact of news by using some type of (generalized) ARCH assumption. The seminal paper is Engle and Ng (1993) that defines the news impact curve to measure how new information is incorporated into volatility estimates with especial emphasis on the (potential) asymmetric response of the volatility to news. These authors compare several new and existing ARCH models and find that the Glosten et al. (1993) model is the best parametric one. Later, Andersen and Bollerslev (1998) characterizes in a large detail the volatility in the deutsche mark-dollar foreign exchange market using an annual sample of five-minute returns. Their approach illustrates that a substantial fraction of return variability (both at the intraday and daily level) can be explained in an explicit way by the intraday activity patterns, the macroeconomic announcements, and the volatility persistence.

Nofsinger and Prucyk (2003) examines the impact of 21 different types of scheduled macroeconomic news announcements on S&P 100 stock-index option volume and implied volatility. One of their findings is that there is a two hours

[1]The results of Lamoureux and Lastrapes (1990) are extended by Omran and Mckenzie (2000) to the UK stock market. The main conclusions of this paper are that GARCH modeling captures the serial dependence in the trading volume and the existence of a strong association in the timing of innovational outliers in returns and volume.

delay after the announcement before volume increases. However, there is an immediate increase in volatility, which slowly dissipates over several hours. Further analysis shows that most of the high volume and volatility after announcements come from the "bad" announcements whereas good news elicits lower volume and is not associated with higher volatility.

Hayo and Kutan (2005) consider six emerging markets and examine the reaction of stock market returns and volatilities to a set of IMF events. The focus of this paper is to analyze whether the IMF induces "investor panics" on the days of negative IMF events causing a significant drop in stock market returns. The main qualitative conclusion is that IMF news influence daily stock returns but do not have a significant impact on the volatility of stock markets. Thus, empirical evidence does not seem to support the hypothesis of IMF induced "investor panics".

Finally, Nikkinen et al. (2006) investigates how global stock markets react to the U.S. macroeconomic news announcements. To this end, they analyze the behavior of GARCH volatilities around ten important U.S. macroeconomic news announcements on six regions, for a total of 35 local stock markets. The main conclusion is that the G7 countries, the European countries other than G7 countries and Asian countries (developed and emerging) are closely integrated with respect to these news stories, while Latin America and Transition Economies are not affected. These results support that market integration is high among the major stock markets while some emerging markets are segmented.[2]

3 Methodology

To reconsider the importance of the information content in volumes and prices to assess market evolution, we base our analysis on the market strength weighted return (see equation 1) presented by Cuadro-Sáez and Moreno (2007) to calculate de volume weighted return, and we use this measure as a representative market return.

Departing from the above mentioned market strength weighted return, we present four different specifications of the volume weighted return depending on the reference price (previous day closing price versus same day opening price)

[2]Similar findings were obtained in previous papers as, for instance, Bekaert and Harvey (1995) and Rockinger and Urga (2001). Obviously, this result has important implications for international investors as they can obtain diversification benefits by investing in those segmented emerging regions.

and on the time frequency used to calculate the return (tick data versus 5-minutes interval data).[3]Concretely, we define:

$$WO\_tick_t = \sum_{n=1}^{N} \frac{v_n}{V_t} \cdot ln(F_{n,t}/F_{1,t}) \cdot 100, \tag{1}$$

$$WO\_5min_t = \sum_{i5=1}^{I} \frac{v_{i5}}{V_t} \cdot ln(F_{i5,t}/F_{1,t}) \cdot 100, \tag{2}$$

$$WC\_tick_t = \sum_{n=1}^{N} \frac{v_n}{V_t} \cdot ln(F_{n,t}/F_{N,t-1}) \cdot 100, \tag{3}$$

$$WC\_5min_t = \sum_{i5=1}^{I} \frac{v_{i5}}{V_t} \cdot ln(F_{i5,t}/F_{N,t-1}) \cdot 100. \tag{4}$$

Where,

- WO_tick_t stands for the volume weighted return based on the same day opening price using tick-data, WO_5min_t represents the volume weighted return based on the same day opening price using 5 minute interval data, WC_tick_t is the volume weighted return based on the previous day closing price using tick-data, and WC_5min_t is the volume weighted return based on the previous day closing price using 5 minute interval data.

- N is the total number of trading operations during the day,

- I is the total number of 5-minutes intervals during the day,

- V_t is the daily total trading volume,

- v_n denotes the trading volume on the nth intraday trading operation,

- v_{i5} denotes the cumulated trading volume within the ith 5-minutes interval,

- $F_{n,t}$ is the futures price of the n-th intraday trading operation,

[3]The authors gratefully acknowledge Vasyl Golosnoy for suggesting the use of 5-minutes interval data to avoid microstructure problems.

- $F_{i5,t}$ is the last futures price of the ith 5-minutes interval, and

- $F_{N,j}$ ($F_{1,j}$) is the closing (opening) price at day j ($j = t-1, t$).

- The return based on closing prices is calculated as the difference in log prices, $U_t = ln(F_{N,t}/F_{N,t-1}) \cdot 100$.

Using equations (1) to (4) we calculate the four different specifications of the volume weighted return and we compare them to the return based on closing prices using scatter plots for illustrative purposes. As can be seen in Figures 1 to 4, compared to the return based on closing prices, the volume weighted return shows a very similar evolution in calm market days while, at the same time, this new calculation for the representative return mitigates the impact of trading operations with extreme prices and small trading volumes. This type of operations could occur in days with high degree of uncertainty and could also correspond to potentially non-representative data.

The presence of more extreme values when considering the return based on closing prices is clear compared to each specification of the volume weighted return (see Figures 1 to 4). The volume weighted return reduces the impact of the extreme prices if their associated volume is relatively small with respect to the total daily trading volume. In sum, the assessment of the impact of certain events on the market could be overestimated when using the return based on closing prices as the representative market return.

[INSERT FIGURES 1 TO 4 AROUND HERE]

The use of the volume weighted return as a daily representative return provides a better estimation of the market evolution considering the relative importance that must be given to trading operations with small volume and big changes in prices. In this way, an extreme closing price with a small trading volume would have little impact on the representative return of the day. Therefore, the volume weighted return is closer to that of the trading operations with a significant volume in relation to the total daily trading volume.

In the analysis of the market evolution we compare the performance of the four specifications of the volume weighted return to that of the return based on closing prices. Namely, we analyze the representative market return as a function of the shocks from developed markets, using the shocks from the US as a main global market driver, and also, as a function of shocks coming from

emerging markets countries where Spain has economic interests. Concretely, we estimate a GARCH (1,1) model of the form:

$$return_t = \beta_0 + \sum_{c=1}^{C} [\beta_{positive} \cdot D\_P_{i,t} + \beta_{negative} \cdot D\_N_{i,t}] + e_t \qquad (5)$$

Where:

$$\sigma^2_{e,t} = \alpha_0 + \alpha_1 \cdot \sigma^2_{e,t-1} + \alpha_2 \cdot e^2_{t-1},$$
$$e_t = \sigma_{e,t} \cdot u_t,\ u_t \sim white\ noise.$$
$$c = \{Developed,\ Latin\ America,\ Eastern\ Europe,\ Asia\}.$$

Regarding the definition of the shocks, we take into account those coming from the US as well as those coming from emerging markets where Spain has economic interests. To do this, we perform three steps on the calculation: first, and focusing on the emerging markets countries, we select the country sample including the main Spanish trading partners, as well as the main Spanish net recipients of Foreign Direct Investment (both in terms of flows and stocks). Then, for all the regions, we classify the shocks between positive and negative according to the sign of the local return where the domestic news were released. That is, if there is news from Argentina, we consider the positive or negative reaction of the Latin American return for the dummy of Latin America to classify the shock as positive or negative. Finally, we only consider those shocks that exceed certain threshold to avoid the inclusion of irrelevant shocks in the database. This is a delicate procedure since the various possible definitions of thresholds might distort the analysis. Thus, we proceed to define several thresholds to ensure the reliability of the results. Namely, we define the release of news (threshold=0%) and 6 different fixed thresholds to determine whether there is a shock or not. We do this by considering the cases in which the return exceeds (in absolute terms) 0.5%, 1%, 1.5%, 2%, 2.5% or 3%. The argument for these criteria is that they are easy to handle and they are somehow comparable to standard references as the normal distribution assumed for the asset returns. In the following section, we will describe in detail the dummies obtained by applying these criteria.

4 Empirical application

4.1 Data

We apply the methodology to estimate the evolution of the Spanish futures contract on the Ibex-35. The dependent variable, the volume weighted return, is built on the basis of intraday data on prices and trading volumes for the futures contract on the Ibex 35. We take the data on futures contract corresponding to the closest time to expiration provided its higher liquidity. Then, we compare the results of the four specifications for the volume weighted return to the daily return based on closing prices.[4] As for the control variables, we use daily returns on four aggregate regional market indices obtained from FTSE (developed markets, Latin America, Asia ex-Japan and Emerging Europe). We perform the empirical analysis over the period August 1st 2003 to July 31st 2004. Table 1 summarizes the main statistical properties of the data on returns.

[INSERT TABLE 1 AROUND HERE]

News stories were collected from Bekaert and Harvey (2000, 2004). For that news stories for which these authors do not indicate the exact date, we put a date on them using several newspapers' libraries and other Internet sources (BBC, El Mundo, Comisión Andina de Juristas, El País and Factiva among others).

To analyze the countries that might have a stronger impact on the Spanish stock market, we consider the relevant news from the US as main driver of global and developed stock markets. We also consider the emerging countries that are main trading partners of Spain and those that are net recipients of FDI (either in terms of flows or stocks) from Spain.[5]All main trading partners and main net FDI recipients are considered as potential sources of disturbances for the Spanish market.[6]

4.2 Empirical results

The volume weighted return is quite similar to the return based on closing prices on calm days. However, this new method to calculate the representative return

[4]The data are obtained from the Mercado Español de Futuros Financieros de Renta Variable (MEFF-RV).

[5]The data on trade and foreign direct investment has been obtained from the Spanish Ministry of Industry, Tourism and Trade.

[6]Namely, in Latin America we consider Argentina, Brazil, Colombia, Chile, Mexico, Peru, and Venezuela; in Eastern Europe: Czech Republic, Hungary, Poland, Russia and Turkey; finally, in Asia we include South Korea, China, India and Indonesia.

mitigates the impact of trading operations with extreme prices and small trading volumes that often occur at closing hours (see Figure 1). The idea is that some of these trading operations with small trading volume and large change in prices could correspond to potentially non-representative data and thus, provide a biased assessment of the evolution of the market.

We propose the volume weighted return as a daily representative market return. This indicator takes into account not just the impact of prices but also the relative size of the trading operations when assessing the market evolution. In this way, an extreme closing price with a small trading volume associated would have little impact on the representative return of the day. Hence, the assessment of the market evolution depends more on the trading operations with higher trading volume relative to the total daily trading volume.

Regarding the definition of the dummy variables, some countries seem to be overrepresented in the sample of news stories, as Mexico (see the first column in Table 2). We transform the news into shocks to ensure that the news stories included in the database are important for the domestic market where they were released, at least, to a certain extent. Therefore, we reject the news stories that do not have a significant impact in their local market. As explained before, we use seven different threshold criteria (0%, 0.5%, 1%, 1.5%, 2%, 2.5% and 3%). Table 2 shows the number of shocks that we obtain after applying these thresholds to filter news stories and delete those that are not relevant in the local market where they are released.

[INSERT TABLE 2 AROUND HERE]

The empirical results confirm our intuition that the volume weighted return produces a more moderate assessment of how other economies affect the Spanish market. In general, we find that the use of the volume weighted return produces more moderate estimates of the impact of the shocks on the Spanish market and improves the significance of the parameters of the dummies. The regional analysis shows the following features when we consider the volume weighted return as representative market return (see Tables 3 to 6):

[INSERT TABLES 3 to 6 AROUND HERE]

Moreover, we find that there are no significant differences when using tick data or 5-minutes interval data so that the results based on tick data seem to be robust to the possible microstructure problems. Besides, we also find a stronger impact when considering the previous day closing price as reference price for the

calculation of the volume weighted return. This makes sense provided that the volume weighted return measures based on the opening price are not accounting for the information released overnight, and thus, may provide a smaller impact than that obtained when using also the overnight information. Therefore, and for simplicity on the discussion of the results, we will compare the results based on the use of the tick data.

4.3 Discussion

This subsection deals with the linkages between the Spanish market and other economies that are found on the empirical results, according to the different measures of the volume weighted returns based on tick data (see Tables 3 to 6). As expected, relevant news stories from the US affect the Spanish market. However, the size and the impact of positive an negative news differ in the following aspects:

(i) Positive news stories from the US are always relevant. The size of the impact increases as the impact on the US market also increases. These results also suggest that using the volume weighted return as the representative market return, the average impact is about 58% of the average impact calculated using the return based on closing prices as the representative return. That is, the use of the return based on closing prices overestimates the effect of positive news form the US on the Spanish market.

(ii) It seems that negative news affect the Spanish market if the impact on the US market is at least -1.0%. Unfortunately, the model does not contain enough information to derive a consistent conclusion when comparing to the return based on closing prices.

News stories coming from Latin America always affect the Spanish market. However, the impact of the negative news is larger than the impact of positive news, particularly in the case of shocks that largely affect the Latin American market. The results point to the following facts:

(i) On the one hand, positive shocks do affect the Spanish market. Concretely, if relevant news stories are released in a Latin American country, they have an average impact on the Spanish volume weighted return of 0.16% (using WO_tick) or 0.18% (using WC_tick). However, these coefficients vary according to the strength of the impact on the Latin American local market. Contrary to the usual pattern, it is not always the case that the stronger the impact on the local Latin American market, the stronger the impact on the

Spanish market. Among the possible explanations, one of the reasons could be that the stronger the impact on the Latin American market, the more likely is that "odd" operations will take place at closing times. The asynchrony of trading between the Latin American and the Spanish markets may play an important role. Further research on this issue is needed. Namely, the next step would be to calculate the volume weighted return considering only the time period where the Latin American market and Spanish market are opened simultaneously. In addition, the volume weighted return produces, on average, an impact that is 59% of that calculated using the return based on closing prices.

(ii) On the other hand, in the case of the negative shocks, the impact on the Spanish market raises as the impact on the Latin American local market increases. If a Latin American country releases a negative and relevant news story, it has an average impact of -0.26% (for WO_tick) and -0.45% (for WC_tick) on the Spanish market, but this impact increases (up to -0.87% -WO_tick-, and -1.02% -WC_tick-) as the effect of the news on the Latin American market also increases (up to 3%). Besides, the size of the impact of negative shocks is smaller (around 63% on average) compared to the results of the return based on closing prices.

Shocks from Eastern European countries seem to affect the Spanish market only in the case of positive news and only if the impact of the shock on the Eastern European local market is quite high (at least 2.5%). This result could be explained by the fact this period witnessed part of the process of integration of many of these countries on the European Union. In the case of the Eastern European countries, the impact of positive shocks calculated using the volume weighted return is approximately 67% of the impact calculated using the return based on closing prices.

As regards shocks from Asia, they present a similar pattern to that of Latin America and US in the following aspects:

(i) First, positive shocks from Asia do impact more on the Spanish market the stronger the impact on the Asian market is. However, compared to the return based on closing prices, the volume weighted return provide a slightly more moderate estimation of the impact of the Asian shocks (87% of the impact calculated using the return based on closing prices).

(ii) Second, there is not much information to assess the influence of

negative shocks and we find some statistically significant negative impact on the Spanish stock market for moderate shocks. However, the lack of observations causes some counter-intuitive results for stronger shocks that are not considered in the conclusions.[7] They matter even if the shock has a weak impact on the Asian market, but we think that the scarcity of observations made the coefficients statistically insignificant when assessing the effect of shocks with a larger impact on Asia.

Concerning the asymmetry between positive and negative shocks from the regions analyzed, we find that according to the new indicators, the news stories from the US have the strongest and most symmetric effect on the Spanish market if we use the opening price as reference (around 45bp for positive and -0.45bp for negative shocks on average), although the impact becomes asymmetric if we account for the overnight information (103bp for positive and -16bp for negative news). Then, Latin America is the emerging region with the strongest impact on the Spanish market, which also presents asymmetries between positive and negative news (27bp and -51bp when using the same day opening price as reference price and 31bp and -78bp when using the previous day closing price as reference). The impact of shocks arising in Eastern Europe is more moderate than in US and Latin America (14bp and -8bp, opening price; and 15bp and -17bp, closing price). Also, Asia presents a similar moderate impact of shocks on the Spanish market (10bp and -12bp, opening price; and 23bp and -16bp, closing price) present, on average, much more moderate impacts on the Spanish market for both positive and negative shocks.

In sum, our findings support the fact that the volume weighted returns, as representative measures of market evolution, provide more moderate estimates of the impact of the relevant news coming from abroad. In this sense, the difference on the impact of news from abroad estimated using the return based on closing prices instead of the volume weighted returns -depending on the specification of the volume weighted return- may range between 1.2 to 1.5 for news from Eastern Europe and positive news from Asia, and it may range between 1.6 to 1.9 for news from US and Latin America. The impact of negative news from Asia may be about 3 times larger if we use the return based on closing prices rather than the volume weighted return.

[7] The results for shocks with an impact on the local Asian market larger than -2% are represented by only one piece of news. Therefore, we do not consider this as a relevant result.

5 Conclusions

Non-representative operations with low trading volumes and big changes in prices at market closing times frequently distort the return based on closing prices as the representative market return. This paper analyzes the effect of adjusting daily returns by volume information to minimize this distortion. For this purpose, and extending the approach of Cuadro-Sáez and Moreno (2007), we use the four different specifications of the volume weighted return as the representative market returns to analyze the Spanish IBEX-35 futures market, using a standard GARCH(1,1) model over the period between August 2003 and July 2004. In our approach, we control for shocks coming from developed and emerging markets countries that are linked to the Spanish economy, which allows us to explore the linkages between the Spanish market and other economies using a better estimation of market returns.

The results support the fact that the volume weighted returns, as the representative measures of market evolution, provide more moderate estimates than the return based on closing prices when analyzing spillovers from other countries. In this sense, our main finding point out that the use of the return based on closing prices could provide misleading conclusions about the sensitivity of financial markets, and that this problem could be mitigated using the volume weighted returns as the representative market returns. Using these new and more robust indicators of market evolution, we analyze the Spanish stock market and find that the most influential regions for the Ibex-35 futures market are the US and Latin America, followed by Eastern Europe and Asia, in line with the results obtained using the return based on closing prices. However, we also find that the size of the impact is overestimated when using the return based on closing prices instead of a more robust measure of market evolution, as the volume weighted returns.

These findings could be interesting, from a monetary policy perspective, to get a deeper knowledge of the linkages between financial markets in one country and other countries. It could be especially relevant in the case of countries where Spain has economic interests and therefore, has a higher exposition to their domestic shocks as is the case of many Latin American countries. Besides, on the linkages between countries, it could also be helpful to design diversification strategies for investors especially interested in building multi-country portfolios.

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Tables and Figures

Table 1
Summary statistics for market returns

The table contains the main summary statistics for the return indexes used on the empirical analysis over the period between August 2003 and July 2004. The first row contains the summary statistics for the volume weighted return based on the same day Opening price using tick-data (WO_tick), the second row contains volume weighted return based on the same day Opening price using 5 minute interval data (WO_5min); row 3 shows the results for the volume weighted return based on the previous day Closing price using tick-data (WC_tick), row 4 row contains volume weighted return based on the previous day Closing price using 5 minute interval data (WC_5min); and row 5 contains the return based on closing prices (U). Rows 6 to 9 contain the summary statistics for the regions and aggregates used in the analysis.

	Obs.	Mean	Median	Std. Dev.	Min	Max.	Skew.	Kurt.
Volume Weighted Returns								
WO_ tick	261	0.014	0.052	0.491	-1.449	1.691	0.062	3.242
WO_ 5min	261	0.005	0.016	0.438	-1.132	1.223	-0.053	3.049
WC_ tick	261	0.051	0.104	0.717	-3.063	1.880	-0.632	4.520
WC_ 5min	261	0.051	0.105	0.721	-3.057	1.883	-0.628	4.492
Return based on closing prices								
U	261	0.057	0.160	0.916	-4.432	2.333	-0.630	5.030
Regions and aggregates								
Developed markets	261	0.056	0.107	0.624	-2.360	2.044	-0.344	3.865
Latin America	261	0.114	0.192	1.268	-5.194	4.471	-0.676	5.637
Eastern Europe	261	0.116	0.209	1.483	-6.442	5.807	-0.419	5.225
Asia	261	0.077	0.150	0.826	-3.911	3.085	-0.783	6.162

Table 2
Number of news / shocks per region and impact on the local market

The table contains the number of news / shocks recorded over the period August 2003 to July 2004. The conditions for the dummy Shock=1 are: (a) news are released in that day, and (b) the daily return on the region where the domestic news is released is bigger (in absolute terms) than {0.5%, 1%, 1.5%, 2%, 2.5%, 3%}.

	News	Shocks					
	$\geqslant 0.0\%$	$\geqslant 0.5\%$	$\geqslant 1.0\%$	$\geqslant 1.5\%$	$\geqslant 2.0\%$	$\geqslant 2.5\%$	$\geqslant 3.0\%$
Positive shocks							
Developed markets	10	2	1	0	0	0	0
Latin America	49	30	16	7	2	2	0
Eastern Europe	36	27	22	11	4	1	1
Asia	25	7	3	1	0	0	0
Negative shocks							
Developed markets	6	3	1	1	0	0	0
Latin America	34	21	14	9	4	2	2
Eastern Europe	32	24	14	8	6	4	3
Asia	21	13	7	3	1	0	0

Table 3
Impact of news/shocks on Volume Weighted Returns

The table contains the regression results for robust standard GARCH(1,1) model in equation (5) for the cases where the impact of the news stories on the local market of origin is (in absolute terms) greater than 0.0% and 0.5%. The first column contains the result for the volume weighted return based on the same day Opening price using tick-data (WO_tick), the second column contains volume weighted return based on the same day Opening price using 5 minute interval data (WO_5min); column 3 shows the results for the volume weighted return based on the previous day Closing price using tick-data (WC_tick), column 4 column contains volume weighted return based on the previous day Closing price using 5 minute interval data (WC_5min); finally, the regression results for column 5 contains the return based on closing prices (U). $***$, $**$, $*$ indicate significantly different from zero at the 1, 5, and 10 percent level, respectively.

	|local return| $\geqslant$ 0.0%					|local return| $\geqslant$ 0.5%				
Dependent variable	WO_tick	WO_5min	WC_tick	WC_5min	U	WO_tick	WO_5min	WC_tick	WC_5min	U
Mean equation										
DP US	0.232**	0.239**	0.484***	0.486***	0.582***	0.493***	0.393***	1.055***	1.061***	1.284***
DN US	-0.017	-0.041	0.277	0.284	0.001	-0.235	-0.183	0.493	0.496	0.233
DP Latin America	0.163**	0.084	0.183**	0.186**	0.208*	0.337***	0.265***	0.317***	0.323***	0.428**
DN Latin America	-0.261***	-0.220***	-0.453***	-0.456***	-0.674***	-0.383***	-0.332***	-0.584***	-0.587***	-0.915***
DP Eastern Europe	-0.050	0.014	0.045	0.046	0.102	-0.064	-0.003	0.010	0.010	0.154
DN Eastern Europe	-0.002	0.025	-0.116	-0.118	-0.056	-0.058	-0.012	-0.155	-0.156	-0.047
DP Asia	0.112	0.114	0.193*	0.194*	0.037	0.130	0.191	0.067	0.070	-0.050
DN Asia	-0.104	-0.067	-0.191	-0.190	-0.170	-0.157	-0.135	-0.289*	-0.289*	-0.277
Constant	0.025	0.007	0.073	0.072	0.124	0.035	0.013	0.102**	0.101**	0.120*
Variance equation										
L.arch	0.096*	0.063*	0.133*	0.132*	0.164*	0.144*	0.076*	0.173*	0.173*	0.223*
L.garch	0.765***	0.794***	0.726***	0.729***	0.682***	0.630***	0.765***	0.582***	0.583***	0.547***
Constant	0.031	0.026	0.063	0.062	0.118*	0.048**	0.027*	0.107**	0.108*	0.172**
Regression statistics										
Observations	261.0	261.0	261.0	261.0	261.0	261.0	261.0	261.0	261.0	261.0
Akaike IC	362.9	310.1	535.2	537.9	670.3	344.9	294.0	531.3	534.0	660.4
Schwarz C	405.7	352.9	578.0	580.7	713.1	387.6	336.8	574.0	576.8	703.2
Wald-test(chi2)	27.31	18.22	62.14	62.89	50.33	135.63	56.76	76.89	77.48	68.89
p-value	0.001	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log-likelihood	-169.4	-143.0	-255.6	-256.9	-323.1	-160.4	-135.0	-253.6	-255.0	-318.2

Table 4
Impact of news/shocks on Volume Weighted Returns (*Cont.*)

This table contains the regression results for robust standard GARCH(1,1) model in equation (5) for the cases where the impact of the news stories on the local market of origin is (in absolute terms) greater than 1.0% and 1.5%. The first column contains the result for the volume weighted return based on the same day Opening price using tick-data (WO_tick), the second column contains volume weighted return based on the same day Opening price using 5 minute interval data (WO_5min); column 3 shows the results for the volume weighted return based on the previous day Closing price using tick-data (WC_tick), column 4 column contains volume weighted return based on the previous day Closing price using 5 minute interval data (WC_5min); finally, the regression results for column 5 contains the return based on closing prices (U). $***$, $**$, $*$ indicate significantly different from zero at the 1, 5, and 10 percent level, respectively.

	|local return| $\geqslant$ 1.0%					|local return| $\geqslant$ 1.5%				
Dependent variable	WO_tick	WO_5min	WC_tick	WC_ 5min	U	WO_tick	WO_5min	WC_tick	WC_5min	U
Mean equation										
DP US	0.632***	0.534***	1.537***	1.546***	1.986***					
DN US	-0.768***	-0.827***	0.542	0.569	-0.217	-0.771***	-0.833***	-1.947*	0.553	-2.346
DP Latin America	0.342***	0.326***	0.382***	0.388***	0.462***	0.326**	0.179	0.459**	0.476***	0.504*
DN Latin America	-0.482***	-0.413***	-0.705***	-0.711***	-1.045***	-0.550***	-0.483***	-0.583***	-0.588***	-0.878***
DP Eastern Europe	-0.060	-0.009	0.042	0.042	0.125	0.028	0.092	0.184	0.179	0.241
DN Eastern Europe	-0.157	-0.147	-0.346*	-0.349*	-0.344	-0.303*	-0.288	-0.482	-0.484	-0.384
DP Asia	0.130**	0.165***	0.444**	0.445**	0.515**	0.045	0.126***	0.214***	0.217***	0.298***
DN Asia	-0.112	-0.034	-0.013	-0.011	-0.029	0.046	0.094	0.353	0.359	0.394
Constant	0.045	0.023	0.091**	0.090**	0.109*	0.048	0.030	0.085**	0.084**	0.103*
Variance equation										
L.arch	0.118	0.061	0.178	0.180	0.135	0.146	0.062	0.195	0.196	0.140
L.garch	0.694***	0.789***	0.471	0.464	0.619**	0.617***	0.746***	0.575**	0.575**	0.694***
Constant	0.041*	0.025	0.155	0.158	0.178	0.054*	0.034	0.112	0.113	0.136
Regression statistics										
Observations	261.0	261.0	261.0	261.0	261.0	261.0	261.0	261.0	261.0	261.0
Akaike IC	351.2	291.9	534.8	537.6	666.2	357.1	300.2	553.1	553.8	686.0
Schwarz C	386.9	327.6	574.0	576.8	705.4	389.2	332.3	592.3	589.5	721.6
Wald - test (chi2)	825.12	900.99	1714.27	1713.94	1848.92	719.95	1139.50	54.84	52.39	60.04
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log-likelihood	-165.6	-136.0	-256.4	-257.8	-322.1	-169.5	-141.1	-265.5	-266.9	-333.0

Table 5
Impact of news/shocks on Volume Weighted Returns (*Cont.*)

This table contains the regression results for robust standard GARCH(1,1) model in equation (5) for the cases where the impact of the news stories on the local market of origin is (in absolute terms) greater than 2.0% and 2.5%. The first column contains the result for the volume weighted return based on the same day Opening price using tick-data (WO_tick), the second column contains volume weighted return based on the same day Opening price using 5 minute interval data (WO_5min); column 3 shows the results for the volume weighted return based on the previous day Closing price using tick-data (WC_tick), column 4 column contains volume weighted return based on the previous day Closing price using 5 minute interval data (WC_5min); finally, the regression results for column 5 contains the return based on closing prices (U). $***$, $**$, $*$ indicate significantly different from zero at the 1, 5, and 10 percent level, respectively.

	|local return| $\geqslant$ 2.0%					|local return| $\geqslant$ 2.5%				
Dependent variable	WO_tick	WO_5min	WC_tick	WC_ 5min	U	WO_tick	WO_5min	WC_tick	WC_5min	U
Mean equation										
DP US										
DN US										
DP Latin America	0.231***	0.111***	0.392***	0.397***	0.777***	0.239***	0.118***	0.403***	0.409***	0.795***
DN Latin America	-0.921***	-0.783***	-1.089***	-1.101***	-1.458***	-0.810***	-0.634***	-1.002***	-1.007***	-1.353***
DP Eastern Europe	0.200	0.276	0.060	0.058	-0.025	0.448***	0.413***	0.339***	0.350***	0.432***
DN Eastern Europe	-0.185	-0.212	-0.174	-0.172	-0.176	0.017	-0.004	0.026	0.026	-0.064
DP Asia										
DN Asia	0.456*	0.507**	0.307	0.317	0.507					
Constant	0.038	0.020	0.086**	0.086**	0.097*	0.030	0.014	0.077**	0.076*	0.087*
Variance equation										
L.arch	0.122*	0.060	0.123	0.121	0.114	0.118*	0.078*	0.128*	0.127*	0.126
L.garch	0.638***	0.712***	0.698***	0.703***	0.749***	0.694***	0.753***	0.725***	0.728***	0.746***
Constant	0.055**	0.041	0.087	0.086	0.113*	0.045	0.032	0.073	0.073	0.107*
Regression statistics										
Observations	261.0	261.0	261.0	261.0	261.0	261.0	261.0	261.0	261.0	261.0
Akaike IC	364.0	306.4	554.7	559.6	688.1	370.7	311.8	558.6	559.5	688.4
Schwarz C	392.5	334.9	583.2	591.7	716.6	399.2	336.7	587.1	584.5	713.3
Wald - test (chi2)	532.69	2723.16	1033.07	1005.29	604.67	388.88	799.17	3829.87	3037.68	158.07
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log-likelihood	-174.0	-145.2	-269.4	-270.8	-336.1	-177.4	-148.9	-271.3	-272.8	-337.2

Table 6
Impact of news/shocks on Volume Weighted Returns (*Cont.*)

Notes: this table contains the regression results for robust standard GARCH(1,1) model in equation (5) for the case where the impact of the news stories on the local market of origin is (in absolute terms) greater than 3.0% . The first column contains the result for the volume weighted return based on the same day Opening price using tick-data (WO_tick), the second column contains volume weighted return based on the same day Opening price using 5 minute interval data (WO_5min); column 3 shows the results for the volume weighted return based on the previous day Closing price using tick-data (WC_tick), column 4 column contains volume weighted return based on the previous day Closing price using 5 minute interval data (WC_5min); finally, the regression results for column 5 contains the return based on closing prices (U). $***$, $**$, $*$ indicate significantly different from zero at the 1, 5, and 10 percent level, respectively.

	$\|$local return$\| \geqslant 3.0\%$				
Dependent variable	WO_tick	WO_5min	WC_tick	WC_ 5min	U
Mean equation					
DP US					
DN US					
DP Latin America					
DN Latin America	-0.870***	-0.724***	-1.012***	-1.019***	-1.398***
DP Eastern Europe	0.448***	0.414***	0.336***	0.348***	0.430***
DN Eastern Europe	0.142	0.189	0.042	0.045	0.025
DP Asia					
DN Asia					
Constant	0.030	0.013	0.079**	0.079**	0.089*
Variance equation					
L.arch	0.118*	0.080*	0.131*	0.130*	0.130
L.garch	0.694***	0.759***	0.719***	0.723***	0.741***
Constant	0.045	0.030	0.075	0.075	0.109*
Regression statistics					
Observations	261.0	261.0	261.0	261.0	261.0
Akaike IC	368.8	309.4	557.2	560.2	689.6
Schwarz C	393.7	330.8	582.1	585.1	714.6
Wald - test (chi2)	718.96	877.62	7285.55	5850.68	175.73
p-value	0.000	0.000	0.000	0.000	0.000
Log-likelihood	-177.4	-148.7	-271.6	-273.1	-337.8

Figure 1
Volume weighted return (WO_tick) vs. return based on closing prices

This figure represents the volume weighted return against the return based on closing prices during the period August 2003−July 2004. The specification for the volume weighted return is WO_tick, based on tick data and using the same day opening price as reference price.

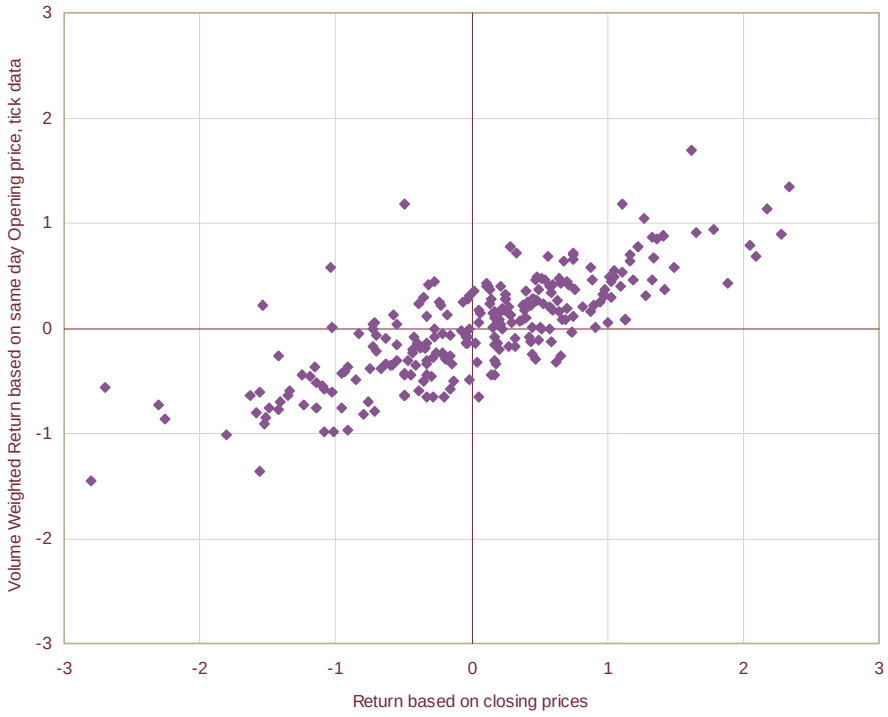

Figure 2
Volume weighted return (WO_5min) vs. return based on closing prices

This figure represents the volume weighted return against the return based on closing prices during the period August 2003−July 2004. The specification for the volume weighted return is WO_5min, based on 5-minutes interval data and using the same day opening price as reference price.

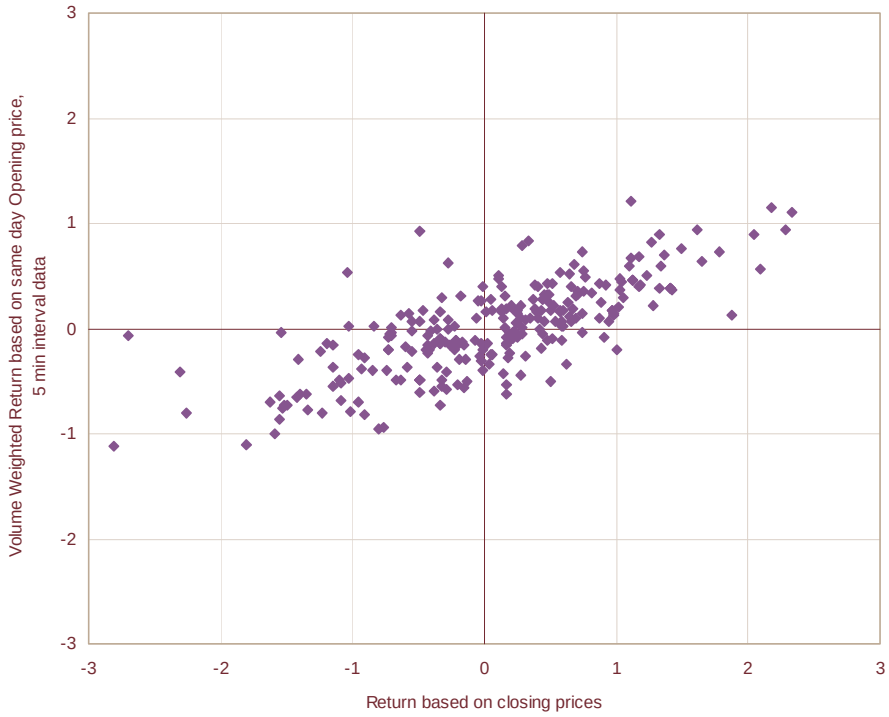

Figure 3
Volume weighted return (WC_tick) vs. return based on closing prices

This figure represents the volume weighted return against the return based on closing prices during the period August 2003−July 2004. The specification for the volume weighted return is WC_tick, based on tick data and using the previous day closing price as reference price.

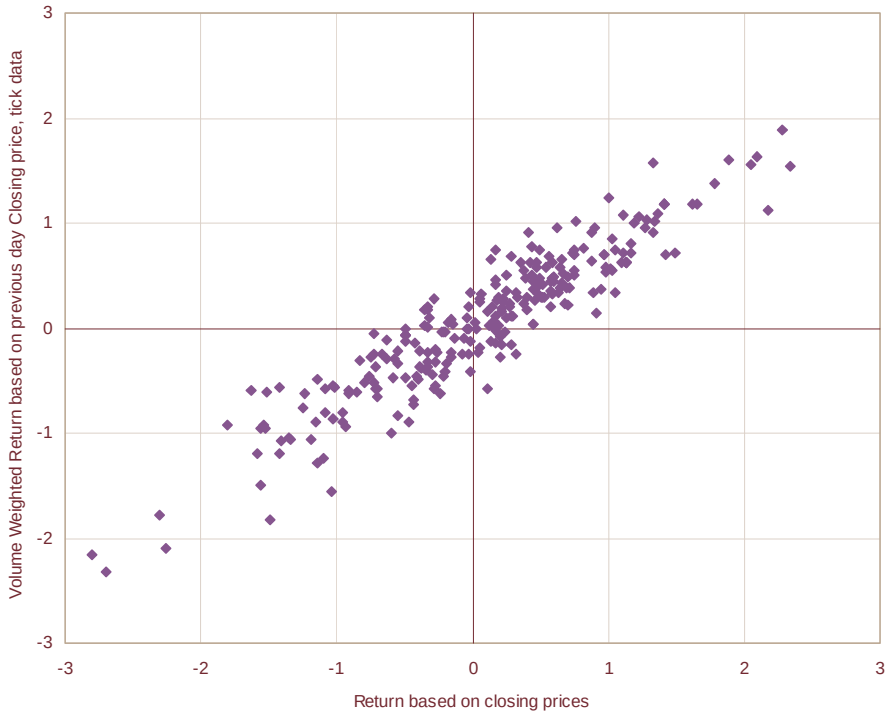

Figure 4
Volume weighted return (WC_5min) vs. return based on closing prices

This figure represents the volume weighted return against the return based on closing prices during the period August 2003−July 2004. The specification for the volume weighted return is WC_5min, based on 5-minutes interval data and using the previous day closing price as reference price.