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RECENT EXAMINATION OF ENERGY MARKETS VOLATILITY

JUDE Octavian
West University of Timisoara, Romania

TURGEMAN Avraham
West University of Timisoara, Romania

BOȚOC Claudiu
West University of Timisoara, Romania

Abstract:

The main aim of the paper is to examine if the energy market (crude oil, gas and electricity) realized volatility exhibits a symmetric or an asymmetric behaviour, for certain commodities over the period May 2012 – August 2022. We considered this time frame for data collection because it is ensuing after the extensively researched period of the financial crises that started in 2007. We took into consideration the STOXX Europe 600 index representing large, mid and small capitalization companies across 17 countries from the European Union. Subsidiary we want to examine if there are similarities in term of realized volatility between energy markets and equity markets. For energy markets the results are consistent with the leverage hypothesis of the asymmetric volatility, i.e. negative and positive returns with the same magnitude have different impact on volatility. Furthermore the volatility is more sensitive to its lagged values in the market place than it is to new information. In addition, for the entire period volatility is asymmetric for both energy and equity markets, but there are different sub-periods with different results. These results reinforce the diversification principle that must be considered in portfolio and risk management process.

Key words: *volatility, GARCH, energy markets, leverage effect*

1. Introduction

Volatility in all its forms creates opportunities as well as potentially dramatic situations. Michael Lewis once said that „real risk was not volatility; real risk was bad investment decisions". Financial markets are presented with a fundamental issue regarding volatility since its implications in risk management process, portfolio management, hedging and pricing operations or macroeconomic policy making. To better predict future outcomes in this financial markets, there is of great importance to understand volatility as a concept

and to model it properly. High volatility presents the markets with the prospect of higher instability, prompting investors to require a risk premium.

Broadly conceptualizing, volatility is an outcome of market activity which describe three dependent and interrelated concepts. These are fundamentals, information, and market expectations respectively. It is worth noting that this concepts are generating a chain reaction for stakeholders which will determine a post information price equilibrium (Botoc, 2014). Corporate transformations such as remodelling of policies (business strategy) and performance standards (profitability) will determine stock prices movements, thus increased volatility. Respectively alterations in corporate fundamentals and environmental information will generate fluctuating views in investment decision and market expectations, again causing price variations and implicitly market volatility. From a geopolitical perspective, factors such as tax as well as interest rate policies, may affect volatility. Policies that touch on tax and interest rates can bring significant changes in the market, thus affecting the volatility of that market and other interconnected markets.

Market volatility, explained as a simple risk measure estimated by standard deviation, is an applicable benchmark by stakeholder's adherent to financial markets principles. Particularly, it is relevant for investors concerned in taking rational decisions and generating high yielding investments. Also, is useful for market active participants seeking to determine the predictability of stock prices. Another aspect of its importance is the information provided by volatility measurements to all policy makers, in helping them better prepare for future crises.

The main aim of the paper is to examine the stock market volatility for certain commodities indexes and the STOXX 600 Europe index for the period June 2012-August 2022. The commodities indexes chosen we consider as of significant importance to the whole world. The indexes are the FTSE 350 Electricity Price Return Index, NYMEX Henry Hub Natural Gas Electronic Energy Future, ICE Europe Brent Crude Electronic Energy Future and the stock market index that is the STOXX Europe 600 EUR Price index. Mostly, it is of importance if the volatility exhibits a symmetric or an asymmetric response to past shocks, if it reacts different to negative and positive shocks, regardless of their nature of appearance. The motivation for the topic is the ongoing debate related to energy prices, amplified by the pandemic of COVID19 and the recently started armed confrontation that is unrevealing in the eastern part of the continent. In this respect, the contribution to existing literature that our paper brings is related to the recent period examined (up to August 2022), period that has not been examined in previous studies of commodities and stock markets indexes.

We employed both classical models (GARCH-M) and more flexible models (TARCH-M and EGACRH-M), and the results being engaging. Our findings show that there is an asymmetric response for all commodities examined and the STOXX600. The results are in accordance with the volatility fedd back theory (Pyndrick, 1984). Nevertheless, the NYMEX Henry Hub Gas Index displays high level of volatility when reacting to different macro economical inputs and different geopolitical risks than the other indexes. In other words, the gas index was more impacted by the ongoing confrontation in the eastern part of Europe that began in February 2022, while the other indexes examined are impacted mostly by the pandemic from 2020.

The rest of the paper Is structured as follows. In the next section there is a concise discussion about the literature on the energy and stock volatility, with an emphasis on asymmetric volatility theories. Section 3 explains the data and the empirical methodology. In Section 4 are discussed the main results and Section 5 presents the conclusions.

2. Literature review

The issue of modelling asymmetric volatility generated the development of two hypothesis. On the one hand, there is the leverage effect hypothesis which asserts that when stock prices decrease, debt ratio will increase and therefore volatility of stock return for shareholders is also increased (Black 1976; Christie, 1982). On the other hand, there is the volatility feedback hypothesis which conveys that an increase in volatility is correlated with both an increase in risk and an increase in the expected future risk (Pindyck, 1984; Campbell and Hentschel, 1992).

In more recent times, several other hypotheses were provided for asymmetric behavior. In their paper about asymmetric volatility and risk in equity markets, Bekaert and Wu (2000) display an asymmetric volatility hypothesis in aggregate market returns for instance, grounded on the connection between market return and company.

Volatility in energy markets is even higher than in financial markets and the usual techniques to deal with are the well-known GARCH type models. The autoregressive conditional heteroskedasticity (ARCH) models were developed to deal with this econometric issue, first by Engel (1982) and generalized by Bollerslev (1986) and Taylor (1986).

Inceptive employment of time-series models, such as ARCH and GARCH, integrated the supposition that volatility reacts in a symmetric manner to positive and negative shocks, based on the idea that volatile markets tend to follow the same path as other volatile markets. Because of the shortcomings of this models, multiple extensions followed, such as TARCH/EGARCH/PGARCH/IGARCH flexible models, which imply that stock volatility has an asymmetric impact on markets, positive shocks holding lower levels of impact than negative shocks (Poon and Granger, 2003).

A consistent body of literature containing empirical analysis focuses on the energy markets and stock markets. Analyzing the time-varying effects and spillovers effects in crude oil, heating oil and natural gas futures markets, Ramirez and Karali (2014) showcase in their results the presence of asymmetric effects. These effects can be found in both random disturbances and macroeconomic variables used as input. Likewise, asymmetric effects of geopolitical risks on energy returns (crude oil, heating gas and heating oil) are being investigated by Qin et al (2020), set out from daily data between 1990 and 2018. Their results verify that in the case of major events, geopolitical risks have asymmetric impacts on energy returns. Xu et al (2018) study the relationship between oil and stock markets, examining intra-day data from 2007 until 2016, and find strong evidence also of asymmetries in volatility shocks, due to bad volatility. A comparative evaluation, made by Jebabli et al (2022) between the global financial crises from 2008 and the Covid-19 pandemic regarding volatility spillovers between stock and energy unrevealed strong evidence of asymmetric volatility spillovers between the two markets. Furthermore, the asymmetric volatility was supported through leverage effect hypothesis (Bollerslev et al., 2006).

3. Data and methodology

The data consists of daily closing prices of several variables from the period 30.05.2012 to 31.08.2022. Based on a representatively criteria, in terms of the most used and most influential commodities nowadays, the variables analysed are FTSE 350 Electricity Price Return Index, NYMEX Henry Hub Natural Gas Electronic Energy Future, ICE Europe Brent Crude Electronic Energy Future. For comparison purpose with equity markets we used STOXX Europe 600 EUR Price Index as representative one. We considered this period for data collection because it is ensuing after the extensively researched period of the financial crises that started in 2007. The daily prices were obtained from Refinitiv and daily return is computed as continuous compounding return using the following formula:

$$\boldsymbol{R_t = \ln\left(\frac{P_t}{P_{t-1}}\right)} \qquad (1)$$

where R_t is the index return and P_t and P_{t-1} reflect closing price index at times t and t-1, respectively.

We employed the Generalized Autoregressive Heteroskedasticity (GARCH) as an econometric procedure towards modelling volatility (Engle, 1982). The main approach is to deal with distributional characteristics of return (Brooks, 2008). We employed GARCH-M(1,1) model take into consideration previous findings (Guidi et al., 2011; Murinde and Poshakwale, 2002), with the following specification being estimated:

$$\boldsymbol{R_t = \mu + \delta \times \sigma_{t\text{-}1} + u_t,\ u_t \approx\ N\left(0, \sigma_t^2\right)} \qquad (2)$$

$$\boldsymbol{\sigma_t^2 = \alpha_0 + \alpha_1 \times u_{t-1}^2 + \beta \times \sigma_{t-1}^2} \qquad (3)$$

After specific post estimation tests (diagnostic and misspecification tests), we employed additional models witch deal with asymmetric volatility, particularly EGACRH-M(1,1) (equation 4) and TARCH-M(1,1) (equation 5):

$$\ln\left(\boldsymbol{\sigma_t^2}\right) = \boldsymbol{\omega + \beta \times \ln\left(u_{t-1}^2\right) + \gamma \times \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha \times \left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right]} \qquad (4)$$

$$\boldsymbol{\sigma_t^2 = \alpha_0 + \alpha_1 \times u_{t-1}^2 + \beta \times \sigma_{t-1}^2 + \gamma \times u_{t-1}^2 \times I_{t-1}}$$

$$\text{where } \boldsymbol{I_{t-1}} \begin{cases} = 1 \text{ if } u_{t\text{-}1} < \mathbf{0} \\ = 0 \text{ otherwise} \end{cases} \qquad (5)$$

First we analysed our data with the descriptive statistics tools, the results being reported in table no. 1. As preliminary interpretation one can state that the returns for all commodities and the STOXX600 have a leptokurtotic distribution, i.e. negative skewness and excess kurtosis. Secondly Jarque-Bera statistics do not reject the unconditional non-normal distribution. Thirdly, FTSE and NYMEX do not exhibit serial correlation according to the Breusch-Godfrey test (4 lags). Fourthly, ARCH LM test suggests the presence of ARCH effects in the residuals for all variables considered.

Table 1. Descriptive statistics

Specification	FTSE 350	NYMEX Gas	ICE Brent	STOXX600
Mean	7.39E-05	0.000501	-2.64E-05	0.000206
Median	0.000176	0.000000	0.000949	0.000591
Maximum	0.120248	0.381727	0.190774	0.080704
Minimum	-0.122175	-0.30048	-0.279761	-0.121915
Std. Dev.	0.014183	0.033487	0.024163	0.010329
Skewness	-0.717518	0.276184	-1.003868	-1.04103
Kurtosis	13.94890	14.74270	21.19084	15.63109
Jarque-Bera	13458.87***	15253.41***	36968.73***	18088.19***
BG Test(4)	3.988833***	6.022583***	0.609411	0.698993
Arch LM(4)	15.88962***	23.91796***	2.440005	2.798299
Observations	2649	2649	2649	2649

Notes: BG is Breusch-Godfrey test for serial correlation with 4 lags. ARCH is the Lagrange multiplier test for autoregressive conditional heteroskedasticity with 4 lags.

***,**,* The rejection of the null hypotheses of no autocorrelation, normality and homoscedasticity at the 1%, 5% and 10% respectively levels of significance for statistical tests.

Source: Author calculations using Eviews 12.

To better understand the behavior of the volatility, the daily return for each indexes is plotted in chart (Annex, figure No.1). When analyzing the charts, it can be noticed that all charts are subject to a certain level of seasonality, which means that there are areas in the charts that can be clustered into high price variation clusters and low-price variation clusters.

It means that for all indices, there seems to be a tendency for high price variations to follow high price variations, and low-price variations to follow low price variations.

As can be seen in the charts, the seasonality looks higher for STOXX600 index and lower for the FTSE350 electricity index.

4. Results

The results of the GARCH-M (1,1) specifications with the normal distribution function and conditional standard deviation term in the mean are reported in Panel A of table no. 2.

Table no. 2 Symmetric volatility models

Parameters	FTSE 350	NYMEX GAS	ICE BRENT	STOXX600
Panel A GARCH-M(1,1)				
μ	-0.000966	0.001636	-0.001236	-0.000863

	(0.001197)	(0.001533)	(0.000924)	(0.000498)
δ	0.09171	-0.043171	0.096152*	0.186692***
	(0.097922)	(0.059179)	(0.054024)	(0.062627)
α0	1.69E-05***	8.83E-06***	5.73E-06***	3.72E-06***
	(1.64E-06)	(1.99E-06)	(9.58E-07)	(4.50E-07)
α1	0.111656***	0.087704***	0.11305***	0.148233***
	(0.010273)	(0.006816)	(0.005386)	(0.011710)
β	0.797121***	0.909018***	0.887984***	0.818289***
	(0.016440)	(0.006519)	(0.005530)	(0.012946)
Panel B GARCH-M(1,1) QML				
μ	-0.000966	0.001636	-0.001236	-0.000863
	(0.001293)	(0.001470)	(0.00085)	(0.000570)
δ	0.09171	-0.043171	0.096152*	0.186692***
	(0.106218)	(0.058209)	(0.052213)	(0.071994)
α0	1.69E-05***	8.83E-06***	5.73E-06***	3.72E-06***
	(4.95E-06)	(3.50E-06)	(1.61e-06)	(8.86E-07)
α1	0.111656***	0.087704***	0.11305***	0.148233***
	(0.023354)	(0.013574)	(0.025225)	(0.020898)
β	0.797121***	0.909018***	0.887984***	0.818289***
	(0.038749)	(0.011673)	(0.020102)	(0.021979)
SSB	179.7886***	189.961***	16.23748***	73.10644***

Notes: Standard errors (Panel A) respectively robust standard errors (Panel B) in parentheses. SSB represent sign and size bias test for asymmetries in volatility. *** p<0.01, ** p<0.05, * p<0.1
Source: Author calculations using Eviews 12.

The δ parameter of the model represents the risk premium. The estimated δ is insignificant for FTSE 350 and for the NYMEX GAS which means that there is no dependency of the mean on the conditional variance. However, when estimated for ICE BRENT and STOXX 600, the estimated δ is indeed significant with p-val<10% for ICE BRENT and p-val<1% for STOXX600. This implies that in the case of ICE BRENT and STOXX600 there is significant feedback from the variance to the mean.

The α_0, α_1 and the β coefficients are all statistically significant for all the tested indices. Furthermore, since the sum of α_1 and β is close to 1, it implies that there is a persistent effect of the shocks on the conditional variance.

Another conclusion from the results is that the volatility is more affected by the lagged values of itself than by new information. This conclusion is derived from the ratio between β which is the coefficient of the lagged volatility value and α_1 which the coefficient of the new information.

It can also be observed that the sum of α_1 and β is smaller for the FTSE350 electricity market than all other indices which implies that electricity prices are less dependent on past prices and past volatility. This can also explain the lower seasonality in the FTSE350 daily return chart (see Annex, figure no. 1).

As often expected in financial products, the data sets are not normally distributed. The normal distribution assumption is examined by using misspecification test and as reported in table no.1, the normality assumption is rejected for all the tested indices. Due to the non-normality conclusion, the model was re-estimated by QML (Quasi Maximum Likelihood). However, as can be seen at table no. 2, the coefficients values are the same, with only a slight difference of the standard errors and p-values.

One of the key factors in evaluating the model, is evaluating the residuals. A valid model holds the assumption of independence of the residuals. The test that was performed, do not reject the null hypothesis of independence of the residuals.

GARCH models are limited in the sense of applying a symmetric response for both negative and positive shocks. This is directly derived from the equations of the model since the coefficients are not sensitive to the sign of the shock. However, in the financial world, it is often observed that the response of the volatility to negative shocks is stronger than the response to positive shocks. To test that issue, an SSB test is performed, which shows significantly that the assumption of symmetry is rejected and therefore the model must be extended.

We find the required extension of the GARCH model in the TARCH-M (Threshold ARCH) and EGARCH-M (Exponential GARCH) which are known for better capturing asymmetric response for shocks. The results for TARCH-M(1,1) and EGARCH-M(1,1) are given in table no. 3.

Table no.3 Asymmetric volatility models

Parameters	FTSE 350	NYMEX GAS	ICE BRENT	STOXX600
Panel A TARCH-M(1,1)				
μ	-0.001057	0.001687	-0.000972	-0.000288
	(0.001287)	(0.001472)	(0.000829)	(0.000455)
δ	0.093971	-0.041421	0.055461	0.064369
	(0.105095)	(0.058061)	(0.051545)	(0.059304)
$\alpha 0$	1.73E-05***	8.83E-06***	5.43E-06***	3.58E-06***
	(4.87E-06)	(348E-06)	(1.51E-06)	(7.34E-07)
$\alpha 1$	0.087463***	0.092114***	0.055872*	-0.009709
	(0.032698)	(0.018524)	(0.028789)	(0.023009)
β	0.795548***	0.91033***	0.895233***	0.843375***
	(0.037261)	(0.011589)	(0.018379)	(0.016438)
ϕ	0.04423	-0.012031	0.087526***	0.25421***
	(0.041949)	(0.0027250)	(0.035077)	(0.030721)
AIC	- 5.891782	-4.245	-5.046133	-6.691476
BIC	-5.878459	-4.23213	-5.03281	-6.678154
LL	7809.665	5629.102	6689.603	8868.86
Panel B EGARCH-M(1,1) QML				
μ	-0.001155	0.00263	-0.001763	-0.000757

	(0.001276)	(0.001549)	(0.000904)	(0.000525)
δ	0.093987	-0.080427	0.098133*	0.105148
	(0.106918)	(0.060581)	(0.053037)	(0.068771)
ω	-0.66938***	-0.19756***	-0.273131***	-0.600272***
	(0.198155)	(0.048037)	(0.058707)	(0.103230)
ϕ	-0.039811*	0.013711	-0.068308***	-0.174493***
	(0.028252)	(0.0023101)	(0.026219)	(0.023694)
β	0.188746***	0.181011***	0.183443***	0.15857***
	(0.036783)	(0.029594)	(0.047483)	(0.031016)
α	0.938548***	0.991241***	0.982608***	0.949479***
	(0.021769)	(0.005352)	(0.004711)	(0.010949)
AIC	-5.898056	-4.538316	-5.053294	-6.695011
BIC	-5.884734	-4.224993	-5.039971	-6.681688
LL	7817.976	5619.649	6699.088	8873.542

Notes: Robust standard errors in parentheses. AIC, BIC and LL represent Akaike criterion, Schwarz criterion and Log likelihood ratio, respectively. *** p<0.01, ** p<0.05, * p<0.1
Source: Author calculations using Eviews 12.

The results show that in both TARCH-M(1,1) and EGARCH-M(1,1) models, the coefficient of the asymmetric part is significant, which supports the assumption of the asymmetric response of the volatility. According to the Akaike information criterion (AIC) and the Bayesian Information Criterion (BIC), there is no absolute preference to each of the models over the other.

Our results are in accordance with findings from Montero et al (2010), that investigate the presence of asymmetric patterns in the changing of spot prices of several energy related commodities. Employing TARCH and EGARCH models they conclude that both models detect asymmetric patterns for the commodities examined. Additionally, these results are reinforced by Montero et al (2011), obtained for the Spanish wholesale electricity spot market, indicating asymmetric response to volatility that is being detected by the EGARCH model utilised.

Similar findings can be extracted from the paper authored by Xu et al (2018), in which the empirical results display the presence of the asymmetric effect between the markets, bad volatility having a greater influence than good volatility for most of the time scale investigated. Qin et al (2020) investigate the asymmetric effects of geopolitical risks on energy returns and volatility between 1990 and 2018 and conclude that this macro events influence the energy markets in different ways, displaying strong asymmetric effects especially for crude oil.

There is strong evidence from the results mentioned above that human condition plays an important role in defining the responses regarding positive or negative information. Thus, affecting the market in different ways, resulting in asymmetric effects throughout both the energy and the stock market.

5. Conclusions

The leading objective of the paper is to analyse the stock market volatility for certain commodities indexes and the STOXX 600 Europe index for the period June 2012-August 2022. Mostly, it is of great relevance if the volatility displays a symmetric or an asymmetric response to past shocks, if it behaves differently when receiving negative and positive shocks, regardless of their nature of appearance.

We used in our study classical models (GARCH-M) and flexible models (TARCH-M and EGACRH-M) and our findings are inciting. From one perspective, we noticed that the estimated GARCH coefficients in the conditional variance equation are considerably larger than ARCH coefficients. The inference is that volatility displays higher sensitivity to its lagged values in the financial markets, rather than to new information.

Our results could have implications for several stakeholders. On the one hand, the process of liberalization and deregulation of the electricity market has resulted in higher volatility. On the other hand, it should be considered the effect that variation in oil prices has on the net present value (NPV) of an oil field as well as the estimations for economic limit analysis. Furthermore, energy is an essential factor of production, witch indirectly impact all other markets. For instance, risk-adverse investors would be interested in investing in commodities or stock market indexes with symmetric and low volatility whereas risk lover investors would be interested in investing in commodities or stock market indexes with asymmetric and higher volatility. Finally, the diversification principle is strengthened by the results, an issue which must be considered in portfolio and risk management process.

From a geopolitical perspective, we can also observe and could be a case for future studies that gas, the only commodity not impacted by the pandemic, a major black swan event with no historical feedback, is pressured by a relatively small and low impacting event, such as the confrontation in Eastern Europe.

When taking into consideration future studies, one can examine structural breaks in order to accurately assess how new information from the energy market feeds into estimates of price volatility.

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ANNEXES

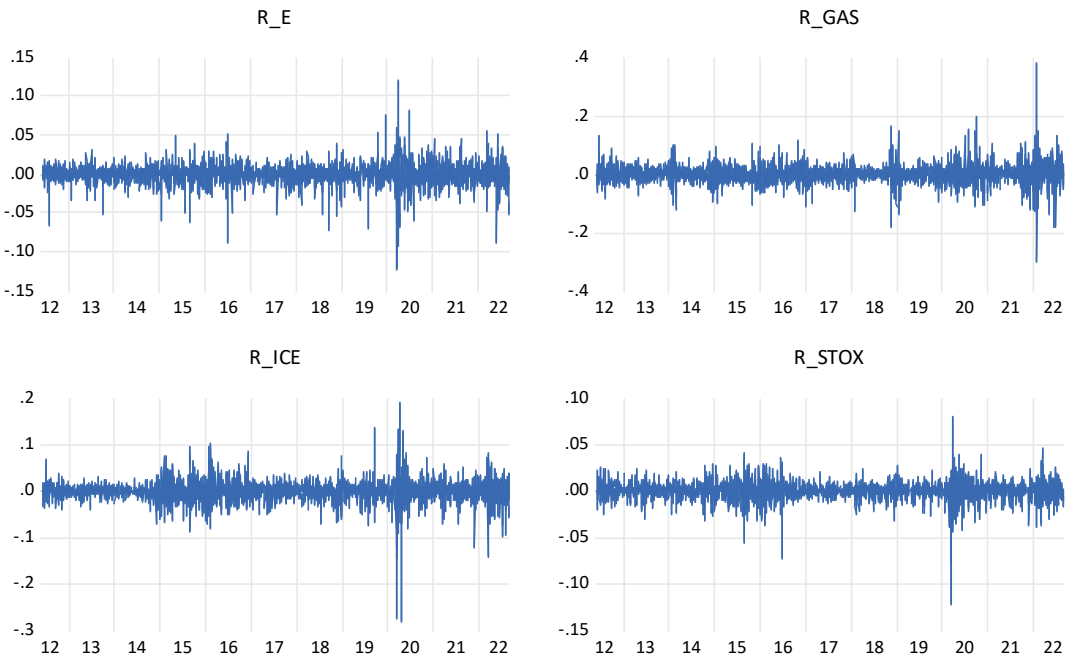


Figure no. 1 Daily plot return