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Abstract

This paper adopts a VAR-GARCH approach to model the dynamic linkages between both the mean and the variance of macro news and commodity returns (Gold, Corn, Wheat, Soybeans, Silver, Platinum, Palladium, Copper, Aluminium and Crude Oil) over the period 01/01/2001-26/09/2014. The chosen specification also controls for the effect of the exchange rate. The results can be summarised as follows. Mean spillovers running from news to commodity returns are positive with the exception of Gold and Silver. Volatility spillovers are bigger in size and affect most commodity returns. Both firstand second moment linkages are stronger in the post-September 2008 period. Overall, our findings confirm that commodities, despite not being financial assets, are sensitive to macro news (especially their volatility), and also suggest that the global financial crisis has strengthened such linkages.

JEL-Code: C320, F360, G150.

Keywords: macro news, commodity prices, VAR-GARCH model.

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1 Introduction

The existing literature on the effects of macro news mainly focuses on the stock and bond markets, and typically considers two sources of news effects: scheduled macroeconomic announcements that do not correspond to agents' expectations (the announcement effect) and unscheduled announcements (the surprise effect). Most studies analyse the former, calculating the difference between news releases and their expected value, and then defining positive and negative news accordingly (see Kocenda and Hanousek, 2011, and Hanousek, et al., 2009). Stock prices have been shown to be affected by news about monetary variables such as money growth and interest rates (see, e.g., Chen, 1991; Cornell, 1983; Pearce and Roley, 1983, 1985), and in some cases also by real sector news (see, e.g., McQueen and Roley, 1993, and Boyd et al., 2005). Birz and Lott (2013) use newspaper headlines, and also find that news on GDP and unemployment affect stock returns. Caporale et al. (2014a) consider both mean and volatility spillovers in the case of the euro area.

Various studies have also been carried out for bond markets. For instance, Gurkaynak et al. (2005) show that long-term interest rates respond to the unexpected component of macro and monetary news releases, Balduzzi et al. (2001) and Andersen et al. (2005) find effects on US Treasury bond futures contracts, and Brenner et al. (2009) on bond return volatility. Beetsma et al. (2013) examine the impact of news on interest rate spreads vis-à-vis Germany in various countries in the euro area, and Caporale et al. (2014b) provide evidence of dynamic linkages in both the first and second moments.

Fewer studies have examined the effects of macro news on commodity prices. Despite not being financial assets, the latter have been shown to be affected by variables such as interest rates (Frankel, 2008) and the US dollar exchange rate, both of which are known to respond to news announcements. Frankel and Hardouvelis (1985) provide evidence of a statistically significant response to US money supply announcements; effects of macro news on various commodity prices are also found by Cai et al. (2001), Hess et al. (2008), Kilian and Vega (2008); commodities futures prices have been reported to be affected as well (Barnhart, 1989; Ghura, 1990). Roache and Rossi (2010) in particular show that they are influenced by the surprise element in macro news, with evidence of a pro-cyclical bias after controlling for the effects of the US dollar, the only exception being gold, which reacts counter-cyclically given its role as a safe heaven and store of value, and is more sensitive to bad news and higher uncertainty. Unlike most other authors, typically using OLS, they estimates a GARCH(1,1) model given the evidence of time variation and clustering of volatilities (Cai et al., 2001, is another of the few papers using a GARCH framework, specifically to examine the impact of news on gold futures prices).

Some recent literature focuses on investor psychology to explain the relationship between news and financial markets. For instance, De Long et al. (1990) distinguish between two categories of traders: rational arbitrageurs updating their Bayesian beliefs on the basis of economic fundamentals, and noise traders with random beliefs. In their model, because of risk aversion and other constraints for investors, low sentiment has a (temporary) negative effect on prices but increases volume, as noise traders react to negative belief shocks by selling shares to rational arbitrageurs (see also Campbell et al., 1993). Coval and Shumway (2001) and Antweiler and Frank (2004) instead relate investor sentiment to trading costs, with the perception of a more negative outlook resulting in lower trading volumes.

Tetlock (2007) examines the links between media "pessimism" (generated by "bad news") and low investor sentiment in the US by estimating a VAR model. The former could be interpreted as a proxy for either investor sentiment or risk aversion, in which case pessimism should increase volume, or for trading costs, implying that pessimism should decrease volume. Also, pessimism could either forecast future or reflect past sentiment, and be due to negative information about asset prices not already incorporated in them or about dividends already reflected in them, with different implications for price behaviour. The empirical evidence suggests that models of noise and liquidity traders can account for the effects of low investor sentiment on financial markets (see also Tetlock et al., 2008, for further results). [1] Fang and Peress (2009) use a wider dataset including more US daily newspapers and a cross-section of countries and find that media coverage can increase the degree of recognition and therefore the corresponding returns on stocks only recognised by a few agents and consequently not sufficiently diversified; therefore it affects asset prices by disseminating information broadly, even if it does not represent news (see Merton, 1987).

The present paper adopts a VAR-GARCH approach to model the dynamic linkages between both the mean and the variance of macro news and commodity returns. This is in contrast to the vast majority of earlier contributions, which only examined level effects. Analysing simultaneously the interactions between the first and second moments sheds new light on the issues of interest. The layout of the paper is the following. Section 2 outlines the econometric modelling approach. Section 3 describes the data and presents the empirical findings. Section 4 summarises the main findings and offers some concluding remarks.

2 The model

We represent the first and second moments of commodity returns and news using a VAR-GARCH(1,1).[2] In its most general specification the model takes the following form:

$$\mathbf{x}_t = \boldsymbol{\alpha} + \boldsymbol{\beta}\mathbf{x}_{t-1} + \boldsymbol{\delta}\mathbf{f}_{t-1} + \mathbf{u}_t \tag{1}$$

where $\mathbf{x}_t = (Com\bmod ity\operatorname{Re}t_t, PositiveNews_t, NegativeNews_t)$ and $\mathbf{x}_{t-1}$ is a corresponding vector of lagged variables. We control for the exchange rate by including in the mean equation the Federal Reserve US dollar trade weighted index against major currencies, $\mathbf{f}_{t-1} = (US\ exrate_{t-1})$. The residual vector $\mathbf{u}_t = (e_{1,t}, e_{2,t}, e_{3,t})$ is trivariate and normally distributed $\mathbf{u}_t \mid I_{t-1} \sim (\mathbf{0}, H_t)$ with its corresponding conditional variance covariance matrix given by:

$$H_t = \begin{bmatrix} h_{11t} & h_{12t} & h_{13t} \\ h_{12t} & h_{22t} & h_{23t} \\ h_{13t} & h_{23t} & h_{33t} \end{bmatrix} \tag{2}$$

The parameter vectors of the mean return equation (1) correspond to the constant $\boldsymbol{\alpha} = (\alpha_1, \alpha_2, \alpha_3)$, and the autoregressive term, $\boldsymbol{\beta} = (\beta_{11}, \beta_{12} + \beta_{12}^*, \beta_{13} + \beta_{13}^* \mid 0, \beta_{22}, 0 \mid 0, 0, \beta_{33})$, which allows for commodity mean return effects from positive (β_{12}) and negative (β_{13}) news.

[1] Evidence on the direction of causality, running from media to stock market variables, is provided by both Engelberg and Parsons (2011) and Peress (2011).

[2] The model is based on the GARCH(1,1)-BEKK representation proposed by Engle and Kroner (1995).

Furthermore, δ measures the effect of the exchange rate and appears in the first equation only. The parameter matrices for the variance Equation (2) are defined as C_0, which is restricted to be upper triangular, and the two unrestricted matrices A_{11} and G_{11}. In order to account for the possible effects of the recent financial crisis, we include a dummy variable (denoted by *) with a switch on 15 September 2008, i.e. on the day of the collapse of Lehman Brothers. Therefore, the second moment will take the following form:[3]

$$H_t = C_0' C_0 + A_{11}' \begin{bmatrix} e^2_{1,t-1} & e_{2,t-1}e_{1,t-1} & e_{3,t-1}e_{1,t-1} \\ e_{1,t-1}e_{2,t-1} & e^2_{2,t-1} & e_{3,t-1}e_{2,t-1} \\ e_{1,t-1}e_{3,t-1} & e_{2,t-1}e_{3,t-1} & e^2_{3,t-1} \end{bmatrix} A_{11} + G_{11}' H_{t-1} G_{11} \quad (3)$$

where

$$A_{11} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} + a^*_{21} & a_{22} & 0 \\ a_{31} + a^*_{31} & 0 & a_{33} \end{bmatrix}; G_{11} = \begin{bmatrix} g_{11} & 0 & 0 \\ g_{21} + g^*_{21} & g_{22} & 0 \\ g_{31} + g^*_{31} & & g_{33} \end{bmatrix}$$

Equation (3) models the dynamic process of H_t as a linear function of its own past values H_{t-1} and past values of the squared innovations $\left(e^2_{1,t-1}, e^2_{2,t-1}, e^2_{3,t-1}\right)$. The parameters of (3) are given by C_0, which is restricted to be upper triangular, and the two matrices A_{11} and G_{11}. Each of them has four zero restrictions since we are focusing on volatility spillovers (causality-in-variance) running from positive news before (a_{21}) and after the crisis ($a_{21} + a^*_{21}$), as well as from negative news before (a_{31}) and after the crisis ($a_{31} + a^*_{31}$), to stock returns. The BEKK representation guarantees by construction that the covariance matrix in the system is positive definite. Given a sample of T observations, a vector of unknown parameters θ and a 3×1 vector of variables $\mathbf{x}_t$, the conditional density function for model (1) is:

$$f\left(\mathbf{x}_t | I_{t-1}; \theta\right) = (2\pi)^{-1} \left|H_t\right|^{-1/2} \exp\left(-\frac{\mathbf{u}_t' \left(H_t^{-1}\right) \mathbf{u}_t}{2}\right) \quad (4)$$

The log-likelihood function is:

$$L = \sum_{t=1}^{T} \log f\left(\mathbf{x}_t | I_{t-1}; \theta\right) \quad (5)$$

where θ is the vector of unknown parameters. The standard errors are calculated using the quasi-maximum likelihood method of Bollerslev and Wooldridge (1992), which is robust to the distribution of the underlying residuals.

3 Empirical Analysis

3.1 Data

We use daily data (from Bloomberg) for ten commodities (Gold, Corn, Wheat, Soybeans, Silver, Platinum, Palladium, Copper, Aluminium and Crude Oil) over the period 01/01/2001

[3] The parameters (a_{21}) and (a_{31}) in Equation (3) measure the causality effect of positive and negative news volatility respectively, whereas ($a_{21} + a^*_{21}$) and ($a_{31} + a^*_{31}$) the possible effects of the 2008 financial crisis.

- 26/09/2014, for a total of 3582 observations. Furthermore, as already mentioned, we control for the exchange rate, which is defined as the Federal Reserve US dollar trade weighted index against major currencies, the data source being the St Louis Federal Reserve website. We construct daily returns as the logarithmic differences of commodity prices.

We consider news coverage of four macro economic data series, i.e. GDP, unemployment, retail sales and durable goods (Birz and Lott, 2013). The average number of stories about unemployment and GDP is very similar; these account for the majority of news articles, whereas there is less coverage of retail sales and durable goods releases. The index we use does not distinguish between different types of macro news; since the focus of this study is on the effects of positive and negative macro news respectively as reported and interpreted by the media, we use worldwide news.[4] The daily positive (negative) news index is defined as follows:

$$\text{positive (negative) } \mathbf{news\ index} = ln[\mathbf{e} + \mathbf{domestic\ positive\ (negative)\ news} + \mathbf{international\ positive\ (negative)\ news}] \quad (6)$$

Table 1 presents several descriptive statistics for the two sub-samples, before and after the 2008 crisis. The mean returns are positive for all commodities; in particular, copper, oil and platinum have higher returns than the other commodities. It is clear that returns for all commodities were severely hit by the 2008 crisis, and their returns fell in comparison to the pre- September 2008 period. In some cases (aluminium, copper, corn, oil, platinum and wheat) negative returns are observed. As for the second moment, all commodities are characterized by higher volatility in the post-September 2008 subsample. Visual inspection of commodity returns (see Figures 1 and 2) confirms the marked increase in volatility after September 2008. This evidence that the behaviout of the first and second moment for all commodities changed substantially from the first to the second subsample motivates the inclusion of a dummy variable to control for structural breaks in the causality dynamics.

The news index (for negative and positive news) also exhibits a clear structural break, with a higher number of news releases in the post-September 2008 crisis. This is not surprising, since the global financial crisis was covered extensively in the media. Please note that a news index equal to 2 means a total of 100 domestic and international news.

Please Insert Tables 1-2 and Figure 1

3.2 Hypotheses Tested

We test for mean and volatility spillovers by placing restrictions on the relevant parameters; specifically we consider the following two sets of null hypotheses[5] H_0:

1. Tests of no mean spillovers from news to commodity returns

H_{01}:Positive news to commodity returns before the 2008 crisis: $\beta_{12} = 0$

H_{02}:Positive news to commodity returns after the 2008 crisis: $\beta^*_{12} = 0$

H_{03}:Negative news to commodity returns before the 2008 crisis: $\beta_{13} = 0$

[4] Neutral and mixed news, which have been found not to be significant in previous studies, have not been considered given the aim of this paper.

[5] The joint restrictions $H_{05} - H_{08}$ are tested by means of a Wald test.

H_{04}:Negative news to commodity returns after the 2008 crisis: $\beta^*_{13} = 0$

2. Tests of no volatility spillovers from news to commodity returns
H_{05}:Positive news volatility to commodity volatility before the 2008 crisis: $a_{21} = g_{21} = 0$
H_{06}:Positive news volatility to commodity volatility after the 2008 crisis: $a^*_{21} = g^*_{21} = 0$
H_{07}:Negative news volatility to commodity volatility before the 2008 crisis: $a_{31} = g_{31} = 0$
H_{08}:Negative news volatility to commodity volatility after the 2008 crisis: $a^*_{31} = g^*_{31} = 0$

3.3 Discussion of the Results

In order to assess the adequacy of the estimated models, Ljung– Box portmanteau tests were performed on the standardized and squared residuals. Overall, the results indicate that the VAR-GARCH(1,1) specification captures satisfactorily the persistence in returns and squared returns of all the series considered. Causality effects in the conditional mean and variance vary in magnitude and sign across countries. Note that the signs on cross-market volatilities cannot be determined. The estimated VAR-GARCH(1,1) models with the associated robust p-values and likelihood function values are presented in Tables 2-6. We select the optimal lag length of the mean equation using the Schwarz information criterion.

The main findings can be summarised as follows. Concerning the effects of positive news on commodity returns (β_{12}), we find positive causality for most commodities (but not significant at the standard 5% significance level in the case of Aluminium, Copper, Palladium, Platinum and Soybeans), and negative causality for Gold and Silver. For the latter two the size of this negative effect increases (in absolute value) in the post-September 2008 period. As for the impact of negative news on commodities (β_{13}), there appears to be negative and significant causality at the standard 5% significance level for Aluminium, Corn and Wheat, whereas the effect on Gold and Silver is positive. All other commodities do not seem to be affected by news releases. The largest coefficient are those for Gold (0.133) and Wheat (-0.112). The post-September 2008 results indicate an increase in the effects of negative news on Aluminium, Corn, Gold, Palladium, Silver and Wheat with the corresponding coefficient (in absolute value) almost doubling (on average) in size in the second subsample. Instead neither negative nor positive news appear to affect Copper, Platinum and Soybeans. These patterns appear to have been reinforced by the recent financial crisis.

Please Insert Tables 2-6 about here

Concerning the conditional variance equations, the estimated "own-market" coefficients are statistically significant and the estimates of g_{11} suggest a high degree of persistence. The pattern is substantially different compared to the first moment for the commodities considered, with positive and negative news volatility having a significant impact on the volatility of commodity returns (remember that the sign cannot be established) in the case of Aluminium, Copper, Corn, Palladium, Silver and Wheat. The causality effect (in absolute value) for negative (measured by a_{21}) and for positive (measured by a_{31}) news volatility has the same size for all commodities examined except Gold, with negative news volatility having a larger effect than positive news volatility in this case. Furthermore, there is evidence of the 2008 crisis affecting the causality-in-variance dynamics. In particular, the post-crisis negative news volatility effect doubled at least for the non-agricultural commodities compared to the pre-September 2008 period, with the largest increase occurring for corn ($a^*_{31} = 0.143$). Finally, the exogenous variable included in the model is statistically significant for all commodities, its estimated coefficient indicating a negative exchange rate effect, as one would expect.

4 Conclusions

This paper has adopted a multivariate GARCH approach to examine both mean and volatility spillovers between macro news and commodity returns (Gold, Corn, Wheat, Soybeans, Silver, Platinum, Palladium, Copper, Aluminium and Crude Oil) over the period 01/01/2001-26/09/2014. The chosen specification also controls for the effect of the exchange rate. The novel contribution of the analysis to the existing literature is twofold: it provides new evidence on volatility linkages, and also on the effects of the recent financial crisis. The results can be summarised as follows. Mean spillovers running from news to commodity returns are positive with the exception of Gold and Silver. This might reflect the fact that latter commodities are seen as a "safe heaven" (as well as a store of value). This asymmetric response is a common finding in the literature (see, e.g., Roache and Rossi, 2010). Volatility spillovers are bigger in size and affect most commodity returns. Both first- and second moment linkages are stronger in the post-September 2008 period. This is consistent with the evidence provided by previous studies that commodities such as gold are more sensitive to news releases during recessions, when there is greater uncertainty (see, e.g., Hess et al., 2008). Overall, our findings confirm that commodities, despite not being financial assets, respond to macro news (especially their volatility), and also suggest that the global financial crisis has strengthened such linkages.

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TABLE 1: Descriptive Statistics

	Pre-2008		Post-2008	
	Mean	Std. dev	Mean	Std. dev
		News		
Positive	1.601	0.891	2.034	0.674
Negative	1.548	0.857	2.045	0.696
		Commodities		
Alluminium	0.033	1.275	−0.043	1.541
Copper	0.093	1.681	−0.003	2.002
Corn	0.067	1.464	−0.018	1.944
Gold	0.069	1.074	0.022	1.265
Oil	0.097	2.099	−0.001	2.109
Palladium	0.061	2.128	0.053	2.127
Platinum	0.085	1.307	−0.019	1.585
Silver	0.066	1.713	0.021	2.392
Soybeans	0.056	1.487	0.023	1.638
Wheat	0.069	1.723	−0.011	2.064

Note: Commodity returns are the daily percentage changes in the market closing values. The number of positive (negative) newspaper headlines index is defined as follows: positive (negative) news index = ln[e+domestic positive (negative) news + international positive (negative) news]. Min and max values refer to the news index. The sample size covers the period 01/1/2001-26/9/2014, for a total of 3582 observations.

TABLE 2: Estimated VAR-GARCH(1,1) model

	Aluminium		Copper	
	Coefficient	p-values	Coefficient	p-values
		Conditional Mean Equation		
α_1	-0.002	(0.972)	0.015	(0.772)
α_2	1.723	(0.001)	1.724	(0.001)
α_3	1.715	(0.001)	1.714	(0.001)
β_{11}	0.001	(0.077)	-0.064	(0.001)
β_{12}	0.084	(0.248)	0.059	(0.327)
β_{12}^*	0.256	(0.049)	0.123	(0.294)
β_{13}	-0.121	(0.011)	-0.077	(0.215)
β_{13}^*	-0.307	(0.034)	-0.106	(0.361)
δ	-1.372	(0.048)	-2.805	(0.061)
		Conditional Variance Equation		
c_{11}	0.001	(0.001)	0.001	(0.004)
c_{22}	0.001	(0.003)	0.001	(0.002)
c_{33}	0.003	(0.002)	0.001	(0.001)
g_{11}	-0.981	(0.001)	-0.978	(0.001)
g_{21}	0.016	(0.001)	0.044	(0.001)
g_{21}^*	0.006	(0.597)	0.041	(0.001)
g_{22}	0.991	(0.001)	-0.990	(0.031)
g_{31}	0.986	(0.001)	-0.991	(0.001)
g_{31}^*	0.006	(0.001)	0.038	(0.044)
g_{33}	0.011	(0.001)	0.042	(0.001)
a_{11}	-0.176	(0.001)	0.201	(0.001)
a_{21}	-0.014	(0.035)	0.016	(0.003)
a_{21}^*	0.015	(0.041)	-0.012	(0.036)
a_{22}	0.128	(0.001)	-0.121	(0.001)
a_{31}	-0.015	(0.050)	0.011	(0.002)
a_{31}^*	-0.016	(0.049)	0.016	(0.001)
a_{33}	0.131	(0.001)	0.125	(0.001)
LogLik	-11491.22		-11131.19	
$LB_{Comm.,(10)}$	7.1261		8.4563	
$LB_{Comm.,(10)}$	9.2298		7.1351	

Note: Standard errors (S.E.) are calculated using the quasi-maximum likelihood method of Bollerslev and Wooldridge (1992), which is robust to the distribution of the underlying residuals. Parameters not statistically significant at 10% level are not reported. $\mathrm{LB}_{Comm.(10)}$ and $\mathrm{LB}^2_{Comm.(10)}$ are the Ljung-Box test (1978) of significance of autocorrelations of ten lags in the standardized and standardized squared residuals respectively. The parameters β_{12} and β_{13} measure the causality effect of positive and negative news on commodity returns respectively, .a_{21} and a_{31} measure the causality in variance effect of positive and negative news respectively whereas θ_{12} and θ_{13} capture the effect of positive and negative news volatility on commodity returns. The effect of the 2008 financial crises on commodities is measured by $(\beta_{12}+\beta_{12}^*)$ and $(\beta_{13}+\beta_{13}^*)$ whereas

$(a_{21}+a^*_{21})$ and $(a_{31}+a^*_{31})$ capture the effect on commodity return volatilities. The covariance stationarity condition is satisfied by all the estimated models, all the eigenvalues of $A_{11}\otimes A_{11}+G_{11}\otimes G_{11}$ being less than one in modulus. Note that in the conditional variance equation the sign of the parameters cannot be determined.

TABLE 3: Estimated VAR-GARCH(1,1) model

	Corn		Gold	
	Coefficient	p-values	Coefficient	p-values
		Conditional Mean Equation		
α_1	-0.044	(0.408)	0.103	(0.002)
α_2	1.726	(0.001)	1.725	(0.001)
α_3	1.716	(0.001)	1.715	(0.001)
β_{11}	0.058	(0.001)	-0.069	(0.001)
β_{12}	0.045	(0.046)	-0.162	(0.001)
β^*_{12}	0.037	(0.623)	-0.233	(0.009)
β_{13}	-0.021	(0.045)	0.133	(0.001)
β^*_{13}	-0.086	(0.034)	0.240	(0.008)
δ	-1.591	(0.001)	-6.749	(0.001)
		Conditional Variance Equation		
c_{11}	0.033	(0.071)	0.014	(0.101)
c_{22}	-0.006	(0.094)	-0.001	(0.078)
c_{33}	0.006	(0.085)	0.004	(0.062)
g_{11}	0.967	(0.001)	-0.964	(0.001)
g_{21}	-0.003	(0.001)	-0.079	(0.094)
g^*_{21}	0.002	(0.001)	0.072	(0.092)
g_{22}	0.978	(0.001)	0.980	(0.001)
g_{31}	-0.003	(0.001)	-0.082	(0.003)
g^*_{31}	-0.004	(0.001)	0.062	(0.229)
g_{33}	0.991	(0.001)	0.993	(0.001)
a_{11}	-0.231	(0.002)	-0.223	(0.001)
a_{21}	-0.023	(0.023)	-0.005	(0.012)
a^*_{21}	-0.024	(0.048)	0.003	(0.035)
a_{22}	0.024	(0.001)	0.126	(0.001)
a_{31}	0.027	(0.037)	-0.065	(0.045)
a^*_{31}	0.143	(0.003)	-0.046	(0.036)
a_{33}	0.139	(0.001)	0.129	(0.001)
LogLik	-11059.37		-9333.98	
$LB_{Comm.,(10)}$	4.3456		10.564	
$LB_{Comm.,(10)}$	7.1291		10.452	

Note: See the notes to Table 2.

TABLE 4: Estimated VAR-GARCH(1,1) model

	Oil		Palladium	
	Coefficient	p-values	Coefficient	p-values
		Conditional Mean Equation		
α_1	−0.071	(0.347)	0.041	(0.605)
α_2	1.723	(0.001)	1.721	(0.001)
α_3	1.714	(0.001)	1.711	(0.001)
β_{11}	−0.041	(0.005)	0.081	(0.001)
β_{12}	0.155	(0.049)	0.035	(0.121)
β^*_{12}	0.208	(0.046)	0.118	(0.021)
β_{13}	−0.045	(0.712)	−0.015	(0.502)
β^*_{13}	−0.151	(0.341)	−0.162	(0.001)
δ	−5.361	(0.004)	−3.034	(0.114)
		Conditional Variance Equation		
c_{11}	0.001	(0.001)	0.178	(0.002)
c_{22}	−0.002	(0.001)	−0.002	(0.009)
c_{33}	0.003	(0.001)	0.003	(0.007)
g_{11}	−0.975	(0.001)	−0.958	(0.001)
g_{21}	0.027	(0.166)	0.005	(0.231)
g^*_{21}	−0.031	(0.234)	0.004	(0.563)
g_{22}	0.990	(0.001)	0.885	(0.001)
g_{31}	0.023	(0.446)	0.007	(0.333)
g^*_{31}	−0.020	(0.786)	0.011	(0.438)
g_{33}	0.890	(0.001)	0.991	(0.001)
a_{11}	−0.208	(0.001)	0.259	(0.001)
a_{21}	−0.006	(0.254)	0.012	(0.005)
a^*_{21}	0.002	(0.697)	0.017	(0.001)
a_{22}	0.127	(0.001)	0.128	(0.001)
a_{31}	−0.005	(0.398)	0.013	(0.009)
a^*_{31}	0.020	(0.687)	0.014	(0.006)
a_{33}	0.129	(0.001)	0.131	(0.001)
LogLik	−10687.85		−11855.65	
$LB_{Comm.,(10)}$	12.453		11.329	
$LB_{Comm.,(10)}$	9.775		10.764	

Note: See the notes to Table 2.

TABLE 5: Estimated VAR-GARCH(1,1) model

	Platinum		Silver	
	Coefficient	p-values	Coefficient	p-values
		Conditional Mean Equation		
α_1	0.043	(0.413)	0.017	(0.788)
α_2	1.721	(0.001)	1.718	(0.001)
α_3	1.711	(0.001)	1.709	(0.001)
β_{11}	0.033	(0.088)	−0.024	(0.161)
β_{12}	0.002	(0.549)	−0.006	(0.012)
β^*_{12}	0.182	(0.176)	−0.274	(0.026)
β_{13}	−0.011	(0.712)	0.002	(0.027)
β^*_{13}	−0.159	(0.341)	0.289	(0.048)
δ	−2.126	(0.009)	−4.076	(0.043)
		Conditional Variance Equation		
c_{11}	−0.001	(0.001)	−0.003	(0.067)
c_{22}	0.005	(0.001)	0.004	(0.564)
c_{33}	0.003	(0.001)	0.001	(0.331)
g_{11}	−0.966	(0.001)	−0.972	(0.001)
g_{21}	0.026	(0.166)	−0.015	(0.443)
g^*_{21}	0.003	(0.234)	0.017	(0.776)
g_{22}	0.991	(0.001)	0.991	(0.001)
g_{31}	0.009	(0.446)	−0.011	(0.123)
g^*_{31}	0.019	(0.786)	0.014	(0.353)
g_{33}	0.990	(0.001)	0.990	(0.001)
a_{11}	0.227	(0.001)	0.226	(0.001)
a_{21}	−0.023	(0.254)	−0.015	(0.001)
a^*_{21}	−0.057	(0.697)	−0.016	(0.001)
a_{22}	0.125	(0.001)	0.126	(0.001)
a_{31}	−0.021	(0.398)	0.016	(0.001)
a^*_{31}	−0.012	(0.047)	0.015	(0.001)
a_{33}	0.129	(0.001)	0.131	(0.001)
LogLik	−10397.71		−11536.39	
$LB_{Comm.,(10)}$	6.8961		8.1413	
$LB_{Comm.,(10)}$	9.7875		10.1267	

Note: See the notes to Table 2.

TABLE 6: Estimated VAR-GARCH(1,1) model

	Soybeans		Wheat	
	Coefficient	p-values	Coefficient	p-values
		Conditional Mean Equation		
α_1	0.037	(0.401)	0.021	(0.707)
α_2	1.722	(0.001)	1.721	(0.001)
α_3	1.711	(0.001)	1.715	(0.001)
β_{11}	−0.019	(0.195)	0.001	(0.675)
β_{12}	0.033	(0.432)	0.082	(0.043)
β^*_{12}	0.116	(0.312)	0.249	(0.002)
β_{13}	−0.046	(0.223)	−0.112	(0.016)
β^*_{13}	−0.129	(0.111)	−0.302	(0.001)
δ	−2.401	(0.045)	−1.414	(0.076)
		Conditional Variance Equation		
c_{11}	0.001	(0.001)	−0.002	(0.046)
c_{22}	0.001	(0.002)	0.006	(0.007)
c_{33}	−0.005	(0.034)	0.002	(0.034)
g_{11}	−0.965	(0.003)	−0.981	(0.001)
g_{21}	−0.051	(0.028)	0.001	(0.978)
g^*_{21}	−0.048	(0.001)	0.006	(0.001)
g_{22}	0.990	(0.001)	0.088	(0.001)
g_{31}	0.048	(0.001)	−0.005	(0.049)
g^*_{31}	0.043	(0.038)	−0.011	(0.086)
g_{33}	0.992	(0.001)	0.993	(0.001)
a_{11}	0.214	(0.001)	0.174	(0.001)
a_{21}	−0.008	(0.078)	0.011	(0.041)
a^*_{21}	−0.002	(0.112)	0.010	(0.038)
a_{22}	0.126	(0.001)	0.132	(0.001)
a_{31}	0.012	(0.021)	0.012	(0.042)
a^*_{31}	0.007	(0.041)	0.010	(0.011)
a_{33}	0.129	(0.001)	0.131	(0.001)
LogLik	−10791.41		−11491.26	
$LB_{Comm.,(10)}$	4.2231		5.1514	
$LB_{Comm.,(10)}$	5.6114		9.3715	

Note: See the notes to Table 2.

Figure 1: Commodity Returns

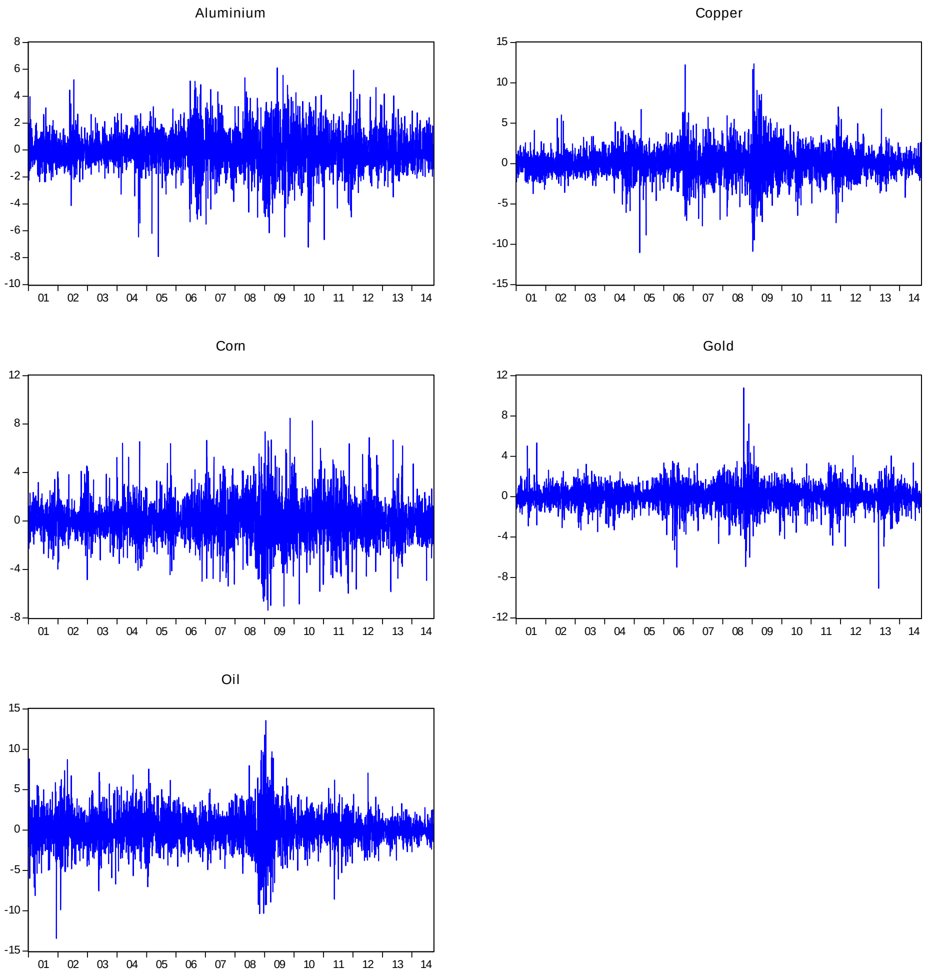

Figure 2: Commodity Returns