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The Response of European Energy Prices to ECB Monetary Policy[1]

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ABSTRACT

To our knowledge, this paper is the first to discuss the response of European energy commodity prices to unexpected monetary policy surprises from the European Central Bank (ECB). Using the Rigobon (2003) identification through heteroscedasticity method, we find a significant and positive response during the crisis period for Brent and coal. Similar results are obtained by other authors for European financial assets in this period. This result reinforces the idea that during this period, financial assets and some commodities positively responded to conventional and unconventional expansionary monetary policy measures, increasing confidence about the survival of the European monetary union. The remaining European energy commodities (electricity, EUAs, and natural gas prices) seem to be unaffected by monetary policy actions. We think these results are of interest to those economic agents and institutions involved in European energy markets and are especially important for the ECB in order to predict the consequences of its monetary policy on the inflation objective.

Keywords: Monetary Policy, European Central Bank, Energy Commodities
JEL Classifications: C26, E58, G13, Q41

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1. INTRODUCTION

In this paper, we estimate how European energy prices react to unexpected changes in European Central Bank (ECB henceforth) monetary policy. This topic has been extensively studied in the US, but this type of study is very scarce in Europe. "Since commodity prices help determine a wide range of consumer and producer prices, the response of commodity prices to monetary policy is an important aspect of monetary transmission mechanism," (Scrimgeour, 2015. p. 88). This is especially true for the ECB as its main objective is price stability. For monetary policymakers, this topic is important as they wish to anticipate the response of asset prices to their conventional or unconventional monetary policy actions. The main objective of the ECB is to control price inflation and one of the most important components of inflation is the price of energy.[1] Furthermore, oil price changes and market measures of inflation expectations are highly and positively correlated since the financial crisis and appear to be very high

1 In Choi et al. (2017) it is found that for the period 1970–2015, a 10% increase in global oil inflation increases, on average, domestic inflation by about a 0.4% point in a sample of 72 advanced and developing economies. This impact has decreased over the years. In Álvarez et al. (2011) and for the Euro zone, the impact of such an oil price increase on inflation is rated 0.17 for the period 1999–2008.

over the last few years (Confitti and Cristadoro, 2018). Financial market participants will follow with great attention central bank monetary policy decisions. The integration of commodity markets in the financial markets in the early 2000s make these assets more responsive to financial market surprises (Basak and Pavlova, 2016). Consequently, financial agents and institutions will also be interested in the responsiveness of their commodity portfolio to monetary policy actions before any investment or risk management decision is made.

Estimating the response of energy prices to monetary policy surprises is difficult because of the endogeneity of interest rates. Conventional monetary policy stance is steered by moving the policy rate. Obviously, short term interest rates will respond to unexpected changes in the policy rate, but also by movements in asset prices and this produces a difficult problem of endogeneity. Rigobon (2003) proposes a new methodology to solve the identification in simultaneous-equation models based on the heteroscedasticity in high-frequency data. This methodology was originally applied to measure the impact of monetary policy surprises on asset prices by Rigobon and Sack (2004). Scrimgeour (2015) applied this methodology to US commodity prices. The main assumption is that the variance of monetary policy shocks is higher on days the ECB governing council meets. On such meeting days, the shift in the variance of short term interest rates and its covariance with commodity prices is sufficient to measure the responsiveness of energy prices to monetary policy surprises. Using daily frequency, Scrimgeour (2015) found that a 100 basis-point increase in interest rates would cause commodity prices to fall 6% for the period 1994 until March 2008. The result is similar for oil but less precise. Furthermore, results are quite similar and consistent with the high frequency data of Basistha and Kurov (2015).

The most popular alternative to the Rigobon and Sack (2004) approach is the "event-study" method. In this method, the endogeneity problem of interest rates is reduced by using high frequency data embedded with the announcement timing. During this specific short period of time, any shock in asset prices can be assumed to be a response to the unexpected monetary policy actions and an ordinary least square regression can be a valid tool to measure the relationship between asset prices and monetary policy surprises. There are some insightful papers using the event-study approach with high-frequency data.[2] For example, in the period preceding the financial crisis, Conrad and Lamla (2010) find a significant effect on the EUR-USD exchange rate in the 30 min following the ECB press release. Unexpected tightening/easing of monetary policy leads to an immediate appreciation/depreciation of the euro against the US dollar. The authors argue that as price stability is the ECB's main objective, a communication on rising future inflation induces an appreciation of the euro because of the expected rise of future market rates.

As this paper deals with the relationship between monetary policy actions and energy commodity prices, it is important to describe how unexpected interest rate movements can influence energy prices. An unexpected increase (decrease) in interest rates will increase (reduce) the carry costs and increase (reduce) the incentive for extraction sooner rather than later – and so lead to higher (lower) supply of commodities and lower (higher) commodity prices. Furthermore, considering energy commodities as financial assets, an unexpected reduction in interest rates will increase the levels of quality fly trading by investors and speculators in commodities: Moving from the fixed income market to commodity markets in search of higher returns. Therefore, after a policy monetary surprise that increases interest rates, a decrease in commodity prices should be expected if commodities are seen as assets like bonds or stocks. Likewise, after an expansive non-conventional monetary policy announcement, oil prices are expected to increase.[3]

There is a controversy about the permanent or transitory nature of the response of asset prices to monetary policy actions. Chan and Gray (2017) agree and extend the work of Kilian and Vega (2011) in studying future energy price jumps in response to macroeconomic announcements. They found little evidence of an increase in jump arrival rates coinciding with scheduled releases of economic data. This result is evidence in favour of taking the crude oil price as predetermined (and so it cannot be regarded as an asset). In contrast, Basistha and Kurow (2015) and Rosa (2014) found a significant intraday response of energy prices to monetary policy surprises. This controversial finding seems to agree with the idea that the response disappears at the end of the day and is transitory rather than permanent Kilian and Vega (2011), Rosa (2014), and Basistha and Kurow (2015). But for other financial assets, Basistha and Kurow (2015) find that the effect remains significant at the end of the day. Using several VAR specifications, Basistha and Kurov (2015) conclude that the accumulated response for 5 and 20 days are small and imprecise. Only a significant response on energy returns on the same day is found for unscheduled target surprises computed with intraday data. With monthly data, their results provide support for the assumption of predetermined oil prices as no response is found.

The analysis of the asset price reaction to central bank monetary policy measures has become more difficult after the 2007 crisis because of the rapid depletion of conventional monetary policies based on interest rate cuts that turned negative at various maturities and the successive implementation of unconventional expansionary monetary policies known as quantitative easing. The unconventional ECB monetary policy actions did have the opposite effect on financial assets than in other monetary areas during the crisis period. Rogers et al. (2014) found that expansionary monetary surprises led the euro to appreciate and the German bond and Eurozone corporate bonds to rise – and a contrarian response was observed in peripheral bonds (Italian and Spanish). These authors argue that these sometimes audacious actions lessened safe-haven flows into bunds and promoted financial stability and confidence in the survival of the European monetary union. ECB actions during this period were aimed at reducing intra-Eurozone sovereign spreads. Therefore, these spreads can be considered an important part of the transmission

2 Insightful recent references for this approach are Conrad and Lamla (2012), Rogers et al. (2014), Basistha and Kurov (2015), Rosa (2014) and Haitsma et al. (2016).

3 Chan and Gray (2017) and Basistha and Kuron (2015).

mechanism for monetary policy during the financial crisis. These results are very important for explaining energy commodity responses to ECB surprises during the crisis period, and this is especially true in the Brent oil case.

Our results show that Brent oil returns are positively related with unexpected shocks in interest rates on the governing council meeting days during the crisis period. That is, expansive non-conventional monetary policy announcements led Brent oil to rise, probably as a result of an increase in confidence in an earlier economic recovery, and also because financialisation of the commodity markets makes Brent respond in the same way as stocks and high quality bonds. Eser and Schwaab (2016) have found that weekly Security Marque Programme (SMP) purchase amounts have no effect on the Overnight Interest Swaps (OIS) rates and government bond yields for non-stressed euro area countries, and therefore, these authors accept that the SMP does not signal information about future low monetary policy rates. The largest purchase occurred after the introduction of the SMP on 10 May and after its reactivation on 8 August 2011. On these dates, the OIS rates and sovereign bond yields of countries not included in the SMP were almost unaffected. Therefore, following this evidence, we decided not to extend our analysis to consider the SMP purchase amounts.

2. ESTIMATION FRAMEWORK

When the effects of monetary policy surprises on energy prices are estimated using interest rates, two important problems appear. Firstly, many omitted variables probably influence both asset prices and short-term interest rates (such as variables that provide information about the macroeconomic outlook or changes in risk preferences).[4] Secondly, the existence of endogeneity in the relationship between both variables, that is, asset prices are influenced by short-term interest rates, but the short-term interest rate is simultaneously affected by asset prices (primarily through their influence on monetary policy expectations).[5] The conventional monetary transmission mechanism works correctly when the yield curve closely reflects market expectations about the future path of the central bank monetary policy stance. Energy prices are influenced by short-term interest rates, but interest rates are also influenced by energy prices – one of the most important determinants of inflation rates – and the main aim of the ECB is price stability.

The intuition of the identification through heteroscedasticity method proposed by Rigobon (2003) is based on splitting the sample in two subsamples (pre-event and event days) of the same size and assuming that the covariance between interest rates and commodities is higher on the days of policy shock increases. As other forces may move interest rates and commodity prices on event days, Rigobon and Sack (2004) use instrumental variables built on non-event days to provide information about the typical relationship between interest rates and commodity prices.[6] They interpret any deviation from this normal relationship on event days as being due to monetary policy surprises.

Consider estimating β in

$$\Delta p_t=\beta\Delta i_t+\epsilon_t \quad (1)$$

$$\Delta i_t=mp_t+v_t \quad (2)$$

Where mp is the monetary policy surprise which is zero in non-event days and may be non-zero on event days. Δp_t and Δi_t represent unexpected variations in asset prices and interest rates. Endogeneity problems arise because interest rates move for many reasons, even on event days, and these reasons may be related to other factors that affect commodity prices (ϵ_t). The shock v_t may be correlated with ϵ_t causing Δi_t to be endogenous, even on event days. On event days, the variance covariance matrix of $[\Delta i_t, \Delta p_t]$' changes in a way that enables us to identify β.

The instrumental variable proposed in Rigobon and Sack (2004) to identify β is defined as

$$z_t=\begin{cases}\Delta i_t & on\,event\,days\\ -\Delta i_t & on\,pre-event\,days\end{cases} \quad (3)$$

The equation (1) is then estimated using all the event days and the days immediately prior to an event day (so the event days are half of the sample). Rigobon and Sacks (2004) show that the instrumental variable estimator is consistent.[7] Rogers et al. (2014) and Haitsma et al. (2016) analyse the effects on financial asset prices of ECB unconventional monetary policy surprises during the crisis period. With unconventional monetary policy, there is no clear indicator of monetary authority policy stance, and therefore, it is not easy to determine policy expectations and unexpected shocks. Under normal circumstances monetary easing will increase asset prices, but in times of crisis it may be understood that future economic conditions are worse than expected, and consequently, asset prices may decrease. ECB actions during the crisis period were clearly aimed at intra-Eurozone sovereign spreads. These polices are effective in reducing sovereign risk premiums as interest rate are stuck at the zero lower bound. Because of this evidence, we will repeat all the analysis for the crisis period, but using the 10-year Italian risk premium on the German Bund as instrumental variable. Similar to Rogers et al. (2014) the policy surprise for the European case will be measured as the change in this risk premium.

The most popular alternative to our approach is the "event-study" method as we have said in the introduction. This method uses high frequency data to reduce the endogeneity problem, encrusting the unexpected interest rate and asset prices responses in the time schedule of the central bank press release. During this specific short period of time, any shock in asset prices can be

4 Chan and Gray (2016).

5 Rigobon and Sack (2004).

6 Other papers using this methodology are: Rogers et al. (2014), Gilchrist and Zakrajsek (2013), Arai (2013), Haitsma et al. (2016) and Wright (2012).

7 Ordinary least squares estimator in the event-study approach is biased and underestimates the asset price response to unexpected monetary policy shocks. This bias asymptotically disappears when the Rigobon and Sack (2004) identification through heteroscedasticity technique is used.

assumed to be a response to unexpected monetary policy actions and an ordinary least square regression can be a valid tool for measuring the relationship between asset prices and monetary policy surprises. Rigobon and Sack (2004) show that the event-study approach is an extreme case of the heteroscedasticity-based estimator they propose. Consequently, given that the event-study approach requires stronger assumptions, the heteroskedastic-based estimator can be used to check if any bias remains in the event-study approach estimates. Theoretically, this method requires the variance of the policy shocks on interest rates to become infinitely large relative to the variance of the other shocks, otherwise some bias will remain. In contrast, identification based on heteroscedasticity relies on the change in the covariance of interest rates and energy prices when the variance of the policy shocks increases. Furthermore, the assumption that monetary policy surprise can be directly measured from jumps in interest rates, or bond yields, in an intraday window around the announcement time may be questionable. This is especially true when announcements are complicated and take time to digest (Rogers et al., 2014). There are other insightful papers using the event-study approach with high-frequency data. For the period preceding the financial crisis, Conrad and Lamla (2010) find a significant effect on the EUR-USD exchange rate in the 30 min following the publication of an ECB press release. Unexpected tightening/easing of monetary policy leads to an immediate appreciation/depreciation of the euro against the US dollar. The authors argue that as price stability is the ECB's main objective, a communication on rising future inflation induces an appreciation of the euro because of the expected rise in future market rates.

For the case of Brent oil and the UK natural gas, it is important to test if the response of these commodities to policy shocks is due to simultaneous changes in the exchange rates.[8] If oil and natural gas prices expressed in euros are unaffected by monetary policy surprises, then when the exchange rates increase (decrease) the commodities prices must increase (decrease) in their original currency. Similarly to Scrimgeour (2015), we will check the influence of the exchange rate in the commodity price response by testing equality in the response to policy surprises on exchange rates and commodity prices. Specifically, the following two equations will be estimated

$$\Delta p_t = \beta_p \Delta i_t + \epsilon_t \quad (4)$$

$$\Delta e_t = \beta_e \Delta i_t + v_t \quad (5)$$

Where e represents the exchange rate. If the commodity expressed in EUR is unaffected by unexpected increases in the ECB policy rate, this may be explained because the increase in the exchange rate EUR-USD or EUR-GBP compensates the increase in the commodity price in USD or GBP. Then, by testing the following null hypothesis.

$$H_0: \beta_p = \beta_e \quad (6)$$

We will verify if the commodity price response to policy surprises comes through the exchange rate effect in the case of Brent oil and UK natural gas. Equations (4) and (5) will be estimated using instrumental variables as in equation (1). In this case, the test proposed in equation (6) will be carried out using the Hausman (1978) test. Equations (4) and (5) will also be estimated on event days using linear regression (with intercepts to avoid introducing a bias in the estimation) consistently estimated as in White (1980) to allow for heteroscedasticity. In this case, the null hypothesis in (6) is contrasted using a Wald test.

3. DATA AND PRELIMINARY ANALYSIS

To identify all the event days, we include all the days in which an ECB press release related to monetary policy was issued. This collection of days includes scheduled and unscheduled meetings and special announcements, as the unconventional measures taken by the ECB in recent years did not always correspond to regular announcement dates. We used all the press releases issued by the ECB even when there was no change in monetary policy as in Haitsma et al. (2016). For the period 4 January 1999 until 11 April 2017 we identified a total of 246 event days. Following Drudi et al. (2012) and Cassola et al. (2010), the crisis period started in August 2007 contains 108 ECB monetary policy decision days.

Some papers use interest rate futures changes to measure short-term interest response to policy surprises.[9] Similarly, we use the 3-month OIS rates. The OIS rates have become the main reference in the European monetary market for measuring market perceptions about ECB monetary policy. The use of the OIS instead of a forward rate on the meeting day to measure unexpected response to policy actions, has some advantages as it reduces the influence of timing shocks – and instead picks up surprises about the level of the expected EONIA rate over the coming 3 months.

Daily time series for the 3-month OIS rates, exchange rates (EUR-USD and EUR-GBP), 10-year bond yields (Italian and German) and front futures prices on Brent, EUAs, natural gas (NBP and title transfer facility [TTF]), coal (ARA and RB), and electricity (Phelix and Endex) were extracted from Reuters.[10] Logarithmic time series returns were obtained for all the assets – but for interest rates and the Italian risk-premium we used realised returns in basis points instead of log-returns.

As we have said in the previous section, Equations (1) and (2) cannot be estimated consistently using OLS due to the presence of simultaneous

8 Brent oil is quoted in USD and the exchange rate EUR-USD is quoted in USDs per one unit of EUR. Therefore, the Brent oil price can be expressed in EUR once the Brent oil price is divided by the EUR-USD exchange rate. UK natural gas is the same case but with GBP.

9 For example, Rigobon and Sack (2004) use the eurodollar futures contract, Rosa (2014) uses the federal funds futures and euribor futures are used in Haitsma et al. (2016).

10 The references for natural gas are the futures contracts traded at The ICE on the TTF hub in Netherlands and the National Balancing Point hub (NBP) in the UK. The reference for CO2 emissions permits are the European Union Allowances futures contract traded at The ICE with maturity in December of each year. The Euro Coal ARA Futures and Euro Coal RB Futures traded at the European Energy Exchange (EEX) are used as references for coal. The Physical Electricity Index (Phelix) refers to the base load (Phelix Base) price index published daily on the power spot market for the German/Austrian market area and its futures are traded at the EEX. Similarly, futures negotiated in ICE ENDEX are taken for Dutch electricity.

equations and omitted variables. Nevertheless, as Rigobon and Sack (2003) describes, if on the event days the variance of the policy shocks is higher than other times, the pattern of realised observations would then shift to move more closely during the asset price reaction. That shift in the co-movement of interest rates and asset prices on the event days is the basis for the identification. Figures 1 and 2 display Brent and 3-month OIS rate returns on policy dates and the previous day, respectively. From a casual comparison between both scatter plots we can infer that the identification through heteroscedasticity proposed by Rigobon (2003) seems to fit correctly with the hypothesis of the method – as more dispersion in the collection points is observed in event days. We do not observe a visual negative relationship on event days as Scrimgeour (2015) finds for US commodities.

Figure 1: Brent and Overnight Interest Swaps -month OIS rate returns on policy dates

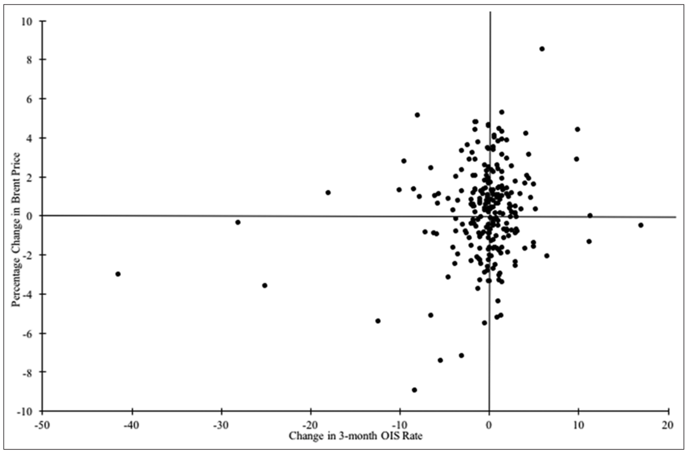

Figure 2: Brent and 3-month OIS rate returns the previous day to policy dates

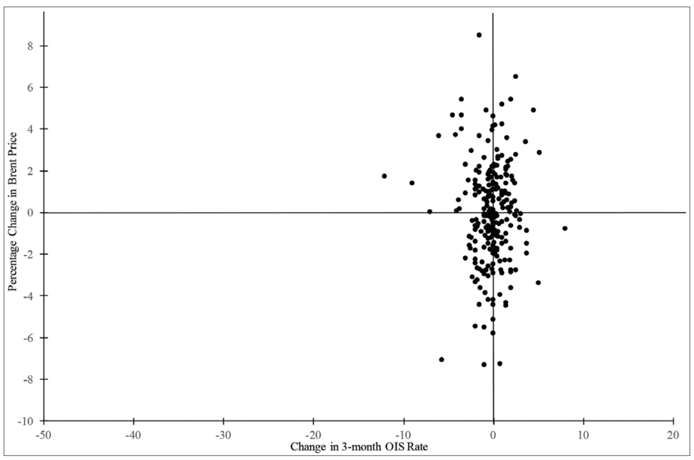

Figure 3 reports the evolution of Brent prices and the 3-month OIS rates. In July 2008, the Brent price reached its highest values. Explanations for why commodity prices were high included growing demand in China and speculative behaviour in financial markets (Scrimgeour, 2015). After July 2008 "the 2008 Oil Bubble" burst (Tokic, 2010) and after September 2008 the ECB started to cut its policy rates as a consequence of the financial crisis. We observe similar patterns on most energy futures included in our data set.

Table 1 Panels A, B and C, report variances, covariances of asset returns with interest rates, and covariances of asset prices with the Italian risk premium, respectively. In these tables, results for Brent and UK natural gas are obtained for the original currency and in euros, once they are converted using the corresponding exchange rate. Some insights are now summarised. Interest rate volatility doubles on meeting days in the three periods (total period, pre-crisis period, and crisis period). Italian-risk premium volatility increases about 17% for the crisis period on event days. In the remaining commodities, we do not find a clear pattern in Table 1, Panel A. Conversely, in Panel B we observe that covariance of assets with the interest rate for Brent and EUAs increases on event days. Covariance with the remaining assets clearly increases in absolute values for the remaining commodities – with the exception of electricity. In Panel C, covariances, in absolute values, with the Italian risk premium in the crisis period, increase for all the

Figure 3: Brent prices and 3-month OIS rates

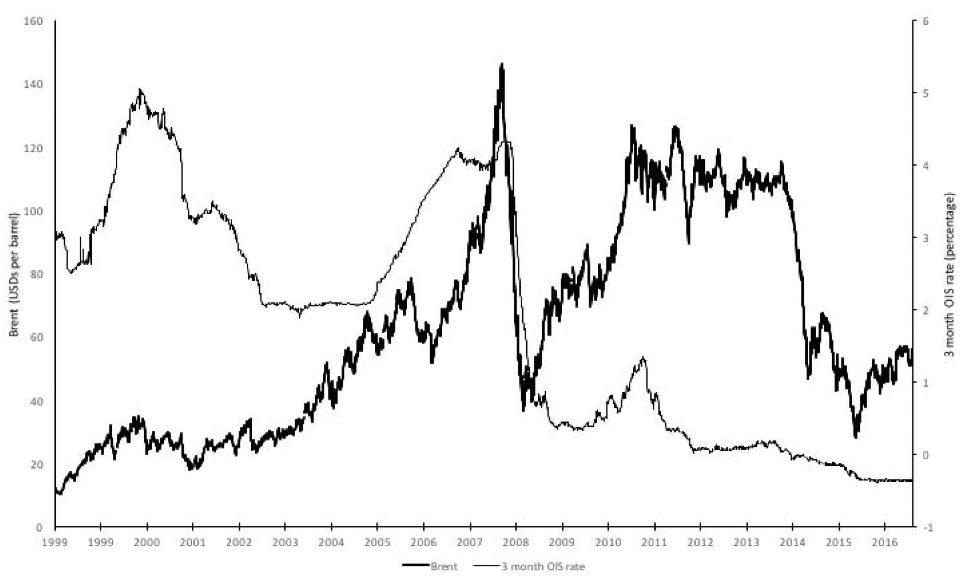

Table 1: Panel A: Variances and covariances

	Whole period		Pre-crisis period		Crisis period	
	Pre-event	Event	Pre-event	Event	Pre-event	Event
Eonia - 3 m	2.45	4.95	2.81	5.36	1.93	4.41
Italian-premium	-	-	-	-	9.05	10.77
Brent (USD)	2.43	2.36	2.71	2.18	2.02	2.57
Brent (EUR)	2.40	2.38	2.70	2.31	1.97	2.46
USD-EUR	0.62	0.58	0.70	0.58	0.50	0.59
NBP (GBP)	3.13	3.35	3.83	4.02	1.90	2.24
NBP (EUR)	3.21	3.39	3.91	4.04	1.99	2.35
GBP-EUR	0.54	0.47	0.58	0.45	0.48	0.48
TTF	3.63	2.61	5.76	3.81	2.35	2.00
EUAs	4.76	4.40	5.39	7.28	4.62	3.43
ARA	-	-	-	-	1.68	1.45
RB	-	-	-	-	1.74	1.37
Phelix	2.18	2.02	3.08	2.80	1.48	1.43
ENDEX	2.75	2.18	4.37	3.19	1.39	1.45

Panel B: Covariance with the Eonia 3 m

	Whole period		Pre-crisis period		Crisis period	
	Pre-event	Event	Pre-event	Event	Pre-event	Event
Italian-premium	-	-	-	-	−0.90	−6.03
Brent (USD)	0.08	1.98	−0.28	1.10	0.54	3.09
Brent (EUR)	−0.10	1.87	−0.58	1.08	0.50	2.91
USD-EUR	0.15	0.08	0.24	−0.02	0.05	0.21
NBP (GBP)	−0.24	−0.26	−0.36	−0.47	−0.07	0.00
NBP (EUR)	−0.33	−0.35	−0.55	−0.46	−0.04	−0.22
GBP-EUR	0.06	0.04	0.16	−0.10	−0.07	0.22
TTF	−0.13	−0.41	−0.95	−0.59	0.12	−0.36
EUAs	−0.33	0.46	−1.55	0.69	−0.06	0.38
ARA	-	-	-	-	−0.69	1.72
RB	-	-	-	-	−0.44	1.94
Phelix	0.15	0.29	−0.26	0.53	0.38	0.14
ENDEX	0.21	−0.04	0.03	−0.41	0.28	0.11

Panel C: Covariance with the Italian risk premium

Crisis period		
	Pre-event	Event
Brent (USD)	−3.89	−4.85
Brent (EUR)	−2.42	−3.54
USD-EUR	−1.48	−1.16
NBP (GBP)	−2.35	3.28
NBP (EUR)	−1.61	4.49
GBP-EUR	−0.59	−1.21
TTF	−1.16	3.87
EUAs	−2.14	4.01
ARA	−2.17	−0.22
RB	−0.76	−1.60
Phelix	0.20	2.91
ENDEX	0.17	1.87

The total period runs from January 1999 to March 2017. The crisis period corresponds to August 2007 to March 2017. The event sample corresponds to the 246 announcements of the ECB related to the monetary policy. The pre-event sample corresponds to the sample of the day prior to each announcement.

commodities on event days with the exception of the ARA coal. We can conclude for our preliminary analysis that energy commodity seems to react to monetary policy actions in the crisis period. In contrast, for the pre-crisis period the evidence is in favour of taking European energy commodity prices as predetermined and so they cannot be regarded as an investment asset.

The identification through heteroscedasticity approach requires change in the covariance between interest rates (or Italian risk premium) and asset price increases as the variance of policy shock changes (Rigobon and Sack, 2003). Results in Table 1 enable us to apply this method with confidence for the crisis period.

4. RESULTS

Tables 2-4 present the main results of this research for Brent, natural gas in UK, and the remaining energy commodities (natural gas, EUAs, coal and electricity) in the Eurozone, respectively. In Table 2, three panels are reported. In Panel A, Equation (1) is estimated expressing its price both in USD and EUR. We find in both cases a similar, positive, and significant response in the crisis period. Specifically, using the Rigobon and Sack (2004) estimation method, we find that an increase in the 3-month OIS rate of 100 basis point would imply an increase in the oil Brent futures of 16.216%. The Brent price expressed in euros obtains

Table 2: Estimated effect of ECB policy announcements on Brent prices

Panel A: Brent in USD and Brent in EUR using interest rates as instrumental variable

Sample	Event-study	Rigobon-Sack
January 1999-March 2017		
Brent in USD	0.08115 (2.82)***	0.09789 (2.16)**
Brent in EUR	0.07683 (2.63)***	0.10259 (2.26)**
Test equality (sig.level)	0.022035 (0.88)	1.10208 (0.29)
January 1999-July 2007		
Brent in USD	0.03866 (1.19)	0.05923 (0.96)
Brent in EUR	0.03674 (1.01)	0.07144 (1.13)
Test equality (sig.level)	0.00281 (0.96)	0.13268 (0.72)
August 2007-March 2017		
Brent in USD	0.16042 (1.97)**	0.16216 (2.47)**
Brent in EUR	0.15160 (2.09)**	0.15438 (2.43)**
Test equality (sig.level)	0.01482 (0.90)	0.04429 (0.83)

Panel B: Brent in USD and EUR-USD exchange rate using interest rates as instrumental variable

Sample	Event-study	Rigobon-Sack
January 1999-March 2017		
EUR-USD	0.00342 (0.45)	−0.00397 (−0.35)
Brent in USD	0.08115 (2.81)***	0.10259 (2.26)**
Test equality (sig.level)	102.57859 (0.00)***	16.32740 (0.00)***
January 1999-June 2007		
EUR-USD	−0.00007 (−0.08)	−0.01291 (−0.81)
Brent in USD	0.03866 (1.19)	0.07144 (1.13)
Test equality (sig.level)	21.75755 (0.00)***	0.13268 (0. 03)**
July 2007-March 2017		
EUR-USD	0.01111 (0.64)	0.01090 (0.68)
Brent in USD	0.16042 (1.97)**	0.15438 (2.43)**
Test equality (sig.level)	76.04879 (0.00)***	18.42810 (0.00)***

Panel C: Rigobon-Sack estimation using the Italian risk premium as instrumental variable

Sample	Event-study	Rigobon-Sack
July 2007-March 2017		
Brent in USD	−0.04221 (−2.15)**	−0.03151 (−0.34)
Brent in EUR	−0.03084 (−1.70)*	−0.03588 (−0.40)
Test equality (sig.level)	0.39584 (0.53)	0.02420 (0.98)
July 2007-March 2017		
Brent in USD	−0.04221 (−2.15)**	−0.03151 (−0.34)
EUR-USD	−0.01018 (−1.71)*	0.00887 (0.38)
Test equality (sig.level)	28.91787 (0.00)***	0.79277 (0.43)

Table 3: Estimated effect of ECB policy announcements on UK natural gas prices

Panel A: NBP in GBP and NBP in EUR using interest rates as instrumental variable

Sample	Event-study	Rigobon-Sack
January 1999-March 2017		
NBP in GBP	−0.01070 (−0.39)	−0.00571 (−0.09)
NBP in EUR	−0.01460 (−0.45)	−0.00633 (−0.10)
Test equality (sig.level)	0.01981 (0.89)	0.01624 (0.98)
January 1999-June 2007		
NBP in GBP	−0.01602 (−0.37)	−0.01088 (−0.11)
NBP in EUR	−0.01634 (−0.43)	−0.00153 (−0.02)
Test equality (sig.level)	0.00001 (0.99)	0.02632 (0.87)
July 2007-March 2017		
NBP in GBP	−0.00005 (−0.00)	0.00289 (0.05)
NBP in EUR	−0.01183 (−0.25)	−0.01430 (−0.22)
Test equality (sig.level)	0.08464 (0.77)	0.18509 (0.66)

Panel B: NBP in GBP and EUR-GBP exchange rate using interest rates as instrumental variable

Sample	Event-study	Rigobon-Sack
January 1999-March 2017		
NBP in GBP	−0.01070 (−0.39)	−0.00571 (−0.09)
EUR-GBP	−0.00184 (0.25)	0.00004 (0.00)
Test equality (sig.level)	2.89160 (0.09)***	0.03507 (0.85)
January 1999-June 2007		
NBP in GBP	−0.01634 (−0.43)	−001188 (−0.11)
EUR-GBP	−0.00341 (−0.39)	−0.01180 (−0.90)
Test equality (sig.level)	2.14330 (0.14)	0.00032 (0.98)
July 2007-March 2017		
NBP in GBP	−0.00005 (−0.00)	0.00289 (0.05)
EUR-GBP	0.01163 (0.81)	0.01973 (1.39)
Test equality (sig.level)	0.66837 (0.41)	0.34513 (0.55)

Panel C: Rigobon-Sack estimation using the Italian risk premium as instrumental variable

Sample	Event-study	Rigobon-Sack
July 2007-March 2017		
NBP in GBP	0.03912 (1.88)***	0.16405 (1.56)
NBP in EUR	0.02855 (1.57)	0.17696 (1.62)
Test equality (sig.level)	0.33859 (0.56)	0.00238 (0.96)
July 2007-March 2017		
NBP in GBP	0.02855 (1.57)	0.16405 (1.56)
EUR-GBP	−0.01052 (−2.24)**	−0.01758 (−0.90)
Test equality (sig.level)	69.04427 (0.00)***	13.24677 (0.00)***

a similar result. Furthermore, OLS estimates are also similar.[11] In Panel B, we test if the response of Brent in USD is caused by the EUR-USD exchange rate. The response of the exchange rate to monetary policy actions is very small and insignificant; and the Hausman (1978) test rejects the equality of the response at any significance level and for any period. Finally, in Panel C we explore the alternative use of the Italian risk premium as a variable reflecting monetary policy action for the crisis period. We obtain significant results only in the event-study methodology. In this case, the response is negative. An increase in the risk premium of 100 basis points triggers a response in the Brent futures of −4.221%. The Wald test cannot reject the hypothesis of equal response of Brent in USD and EUR and rejects the hypothesis that Brent and EUR-USD responses are equal.

Table 3 present a similar analysis to the previous table applied to the NBP natural gas futures. We find no significant response

11 Results in the crisis period are robust to several sub-sample periods. Firstly, the crisis period is redefined to begin a few months after the Lehman Brothers bankruptcy to exclude the spectacular fall in oil prices and interest rates (May 2009–March 2017). In this sub-sample, the coefficient estimation using the Rigobon and Sack (2004) approach for Brent in USD, Brent in EUR and its t-statistics between brackets are 0.20888 (2.07)** and 0.17880 (1.85)*, respectively. The Hausman (1978) equality test (significance level between brackets) cannot reject the equality between both coefficients: 0.31829 (0.57). Alternatively, the crisis period is defined again to begin after the fall in oil and interest rates and finishing before interest rates fell below zero (May 2009 – August 2014). In this case, coefficients for Brent in USD, Brent in EUR, and its t-statistics are: 0.23478 (2.43)** and 0.22267 (2.42)**. Again, the Hausman (1978) equality test cannot reject the equality between both coefficients: 0.05172 (0.82). Consequently, the conclusions do not change if the crisis period is defined differently. Asterisks are read as in Table 2.

Table 4: Estimated effect of ECB policy announcements on Eurozone energy commodities

Commodity	Sample	Event-study	Rigobon-Sack	Instrument
TTF	January 2004-March 2017	−0.02797 (−0.50)	−0.02650 (−0.29)	Interest rates
TTF	January 2004-July 2007	−0.21188 (−0.59)	0.10551 (0.13)	Interest rates
TTF	July 2007-March 2017	−0.01848 (−0.42)	−0.03242 (−0.51)	Interest rates
TTF	July 2007-March 2017	0.03369 (2.05)**	0.14813 (1.44)	Italian risk premium
EUA	June 2005-March 2017	0.02804 (0.29)	0.05661 (0.42)	Interest rates
EUA	June 2005-June 2007	0.18124 (0.24)	0.85548 (0.76)	Interest rates
EUA	July 2007-March 2017	0.01968 (0.26)	0.02526 (0.21)	Interest rates
EUA	July 2007-March 2017	0.03496 (1.57)	0.18217 (1.02)	Italian risk premium
ARA	July 2007-March 2017	0.08959 (2.29)**	0.14993 (3.15)***	Interest rates
ARA	July 2007-March 2017	−0.00192 (−0.19)	0.04995 (0.73)	Italian risk premium
RB	July 2007-March 2017	0.10081 (3.54)***	0.14662 (3.13)***	Interest rates
RB	July 2007-March 2017	−0.01393 (−1.14)	−0.03429 (−0.53)	Italian risk premium
Phelix	July 2002-March 2017	0.02058 (0.50)	0.01016 (0.17)	Interest rates
Phelix	July 2002-June 2007	0.11951 (0.69)	0.23491 (0.86)	Interest rates
Phelix	July 2007-March 2017	0.00707 (0.22)	−0.01586 (−0.37)	Interest rates
Phelix	July 2007-March 2017	0.02524 (2.01)**	0.08477 (1.31)	Italian risk premium
Endex	January 2003-March 2017	−0.00255 (−0.05)	−0.02382 (−0.33)	Interest rates
Endex	January 2003-June 2007	−0.12107 (−0.51)	−0.21585 (−0.42)	Interest rates
Endex	July 2007-March 2017	0.00606 (0.19)	−0.01053 (−0.25)	Interest rates
Endex	July 2007-March 2017	0.01638 (1.27)	0.05153 (0.87)	Italian risk premium

using the Rigobon and Sack (2004) method. With the event-study method, we obtain some significant and positive response to ECB monetary surprises measured with the Italian risk premium for the crisis period – but we obtain no conclusion about this commodity.

Finally, Table 4 presents the results for the remaining European energy commodities. We obtain only significant results for coal (ARA and RB futures contracts). For the crisis period and using the interest rates as instrumental variables we obtain a significant and positive response whose size is similar to the response of the Brent case. Any further explanation for the coal case would require further research that we do not investigate in the present study.

The estimated responses of energy prices under the heteroscedasticity-based method are always larger than the corresponding estimates under the event-study approach when both coefficients are significant. The difference likely reflects the bias in the event-study estimates. The equality between both coefficients has been tested using the Hausman (1978) test. The test results, not reported to save space, show that the equality hypothesis between the estimated coefficients is accepted in almost all cases. There are only three exceptions in which this hypothesis is not accepted at 5% of significance level. Specifically, for NBP in EUR in Panel C in Table 3, and ARA and RB coal in Table 4 when interest rates are used as instrument variable. The differences between coefficient values suggest that other types of news are also present on those days. If this is true, the heteroscedasticity based estimation will provide a more accurate measure of the energy price response to monetary policy shocks.

In Rogers et al. (2014), it is found that during the financial crisis period, the euro exchange rate had a contrarian behaviour to the dollar, yen and sterling pound. Unexpected expansionary monetary policy actions by the ECB lead to an appreciation of the euro – contrary to economic intuition and to what was happening in the US, UK and Japan. We do not find any significant EUR-USD exchange rate response to policy shocks measured as interest rates, and consequently, oil price response seems not to be caused by exchange rate response. When the Italian risk premium is used as a measure of policy shocks, we find some evidence on Panel C in Table II and Panel C in Table III that the exchange rate inversely responds to unexpected monetary shocks measured with the Italian risk premium, but the Hausman (1978) test rejects equality between the commodity and exchange rate response.

Estimation of the Equation 1 coefficient is reported. The event-study methodology estimates the coefficient using OLS estimation with t-statistics, between brackets, computed with the Newey-West consistent estimators. The Rigobon-Sack estimation method is described in Section 2. In the equality test, the Hausman (1978) method is applied in the Rigobon and Sack method and the Wald test is applied in the event-study method. Significance of the coefficients at the 1%, 5% and 10% or *p*-values in the equality tests below 1%, 5% and 10% are indicated with one (*), two (**) and three (***) asterisks, respectively.

Comments are identical to those of Table 2 and 3

5. CONCLUSIONS

There are many studies on how asset prices respond to monetary policy actions. The general agreement is that asset returns respond negatively to short-term interest rate returns reflecting the monetary policy stance. Studies on the commodity price response to monetary policy surprises in the US depict a similar pattern for the remaining financial assets, especially in the last decade. This result is obtained for all the periods and for all financial areas, but with an exception: The Eurozone in the financial crisis. European financial assets during the crisis period responded positively to expansionary conventional and unconventional ECB monetary policies. The present study tries to cover the existing void in similar studies applied to the EU and its energy commodities.

Using the Rigobon and Sack (2003) identification through the heteroscedasticity method, we find only a significant and positive response during the crisis period for Brent and coal. This result reinforces the idea that during this period of time, financial assets (and some commodities) positively responded to expansionary conventional and unconventional monetary policy measures, increasing confidence in the survival of the European monetary union. The remaining European energy commodities (electricity, EUAs and natural gas prices) seem unaffected by monetary policy actions, both during and before the crisis. We believe these results are of interest to financial agents and institutions, and are especially important for the ECB when predicting the consequences of its monetary policy on the inflation objective.

REFERENCES

Álvarez, L.J., Hurtado, S., Sánchez, I., Thomas, C. (2011), The impact of oil changes on Spanish and euro area consumer price inflation. Economic Modelling, 28(1-2), 422-431.

Arai, N. (2016), The effects of monetary policy announcements at the zero lower bound. International Journal of Central Banking, 12(3), 161-195.

Basak, S., Pavlova, A. (2016), A model of financialization of commodities. The Journal of Finance, 71(4), 1511-1556.

Basistha, A., Kurov, A. (2015), The impact of monetary policy surprises of energy prices. The Journal of Futures Markets, 35(1), 87-103.

Cassola, N., Durré, A., Holthausen, C., 2010. Implementing monetary policy in crisis times: The case of the ECB. In: 6th ECB Central Banking Conference, 18-19.

Chan, K.F., Gray, P. (2017), Do scheduled macroeconomic announcements influence energy price jumps? The Journal of Futures Markets, 37(1), 71-89.

Choi, S., Furceri, D., Loungani, P., Misha, S., Poplawski-Ribeiro, M. (2017), Oil Prices and Inflation Dynamics: Evidence from Advanced and Developing Economies. International Monetary Fund Working Paper, WP/17/196.

Confitti, C., Cristadoro, R. (2018), Oil Prices and Inflation Expectations. Occasional Papers. Questioni di Economia e Finanza, #423, Banca d'Italia.

Conrad, C., Lamla, M.J. (2010), The high-frequency response of the EUR-USD Exchange rate to ECB communication. Journal of Money, Credit and Banking, 42(7), 1392-1417.

Drudi, F., Durré, A., Mongelli, F. P. (2012) The interplay of economic reforms and monetary policy: the case of the eurozone. Journal of Common Market Studies, 50(6), 881-898.

Eser, F., Schwaab, B. (2016), Evaluating the impact of unconventional monetary policy measures: Empirical evidence from the ECB's securities markets programme. Journal of Financial Economics, 119(1), 147-167.

Gilchrist, S., Zakarajsek, E. (2013), The impact of the federal reserve's large-scale asset purchase programs on corporate credit risk. Journal of Money, Credit and Banking, 45(2), 29-57.

Haitsma, R., Unalmis, D., de Haan, J. (2016), The impact of the ECB conventional and unconventional monetary policies on stock markets. Journal of Macroeconomics, 48(C), 101-116.

Hausman, J.A. (1978), Specification tests in econometrics. Econometrica, 46(6), 1251-1272.

Kilian, L., Vega, C. (2011), Do energy prices respond to U.S. macroeconomic news? A test of the hypothesis of predetermined energy prices. The Review of Economics and Statistics, 93(2), 660-671.

Rigobon, R. (2003), Identification through heteroskedasticity. The Review of Economics and Statistics, 85(4), 777-792.

Rigobon, R., Sack, B. (2004), The impact of monetary policy on asset prices. Journal of Monetary Economics, 51(8), 1553-1575.

Rogers, J.H., Scotti, C., Wright, J.H. (2014), Evaluating asset-market effect of unconventional monetary policy: A multi-country review. Economic Policy, 29(80), 749-799.

Rosa, C. (2014), The high-frequency response of energy prices to US monetary policy: Understanding the empirical evidence. Energy Economics, 45(C), 295-303.

Scrimgeour, D. (2015), Commodity price responses to monetary policy surprises. American Journal of Agricultural Economics, 97(1), 88-102.

Tokic, D. (2010), The 2008 oil bubble: Causes and consequences. Energy Policy, 38(10), 6009-6015.

White, H. (1980), A heteroskedasticity-consistent covariance matrix estimator and direct test for heteroskedasticity. Econometrica, 48(4), 817-838.

Wright, J.H. (2014), What does monetary policy do to long-term interest rates at the zero lower bound? The Economic Journal, 122(564), 447-466.