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The response of Brent crude oil to the European central bank monetary policy

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ABSTRACT

This paper examines the impact of European Central Bank (ECB) monetary policy decisions on oil prices and liquidity using an event study with intraday data. We analyse the period from January 1999 to December 2020, which includes the financial crisis that started in August 2007. Our results show a significant response for oil returns only during the financial crisis. Specifically, we find that Brent crude oil futures' returns responded negatively to unexpected variations in the Italian risk premium as a measure of unconventional monetary policy actions – and positively to unexpected variations in short-term interest rates. That is, an unexpected increase in short-term interest rates and reductions in the Italian risk premium are taken as positive signals anticipating the end of the financial crisis. Moreover, as Brent is priced in US dollars, we have tested if the Brent response is due to the exchange rate response. We find that the null hypothesis of equal response from Brent and the exchange rate to ECB monetary policy announcements cannot be rejected. These are important results for monetary policy makers and financial agents.

1. Introduction

Brent oil prices in Europe were around $68 a barrel in January 2020, and they collapsed to below $20 a barrel in April 2020 due to the Covid-19 pandemic (which affected world demand) and the Russia-Saudi Arabia oil price war. By October 2020, the Brent crude oil price was already recovering and was around $40 a barrel. In the various financial, security, or sanitary crises that have occurred in recent decades, oil prices tend to collapse temporarily and then steadily recover to pre-crisis levels. Central banks must obviously be informed about how monetary policy might influence commodity prices. Clearly, oil prices have an important effect on the real economy and inflation, which should be a main concern for policymakers.This paper examines the impact of the European Central Bank (ECB) monetary policy on oil prices and liquidity using an event study with intraday data. By doing so, we reduce the problem of endogeneity and omitted variable bias – as pointed out by Rigobon and Sack (2004) – because this information is the main driver of asset prices in a short period of time around the event. The response of energy markets to unexpected changes in monetary policy rates can be measured in several ways. The most common approach is to find the mean return response to a change in the policy rate. Monetary policy decision announcements and their impacts on stock, bonds, and other assets are typical event study cases. These types of events have a calendar of announcements that is well known in advance. Agents take their positions in financial markets depending on the expected result. Typically, when a few minutes remain before the announcement, most investors will prefer to wait until the uncertainty about the announcement disappears – and then an increase in liquidity will appear to adapt their positions based on

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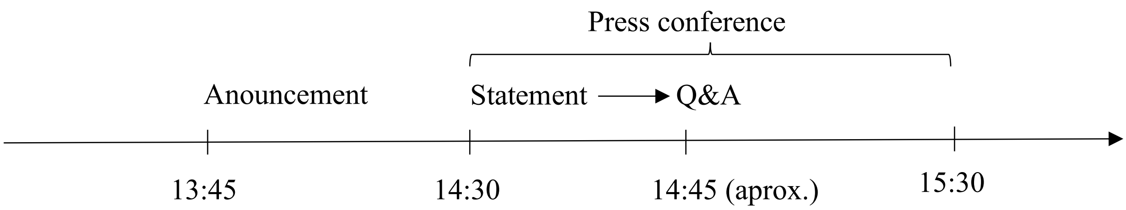

Fig. 1. ECB announcement and press conference.

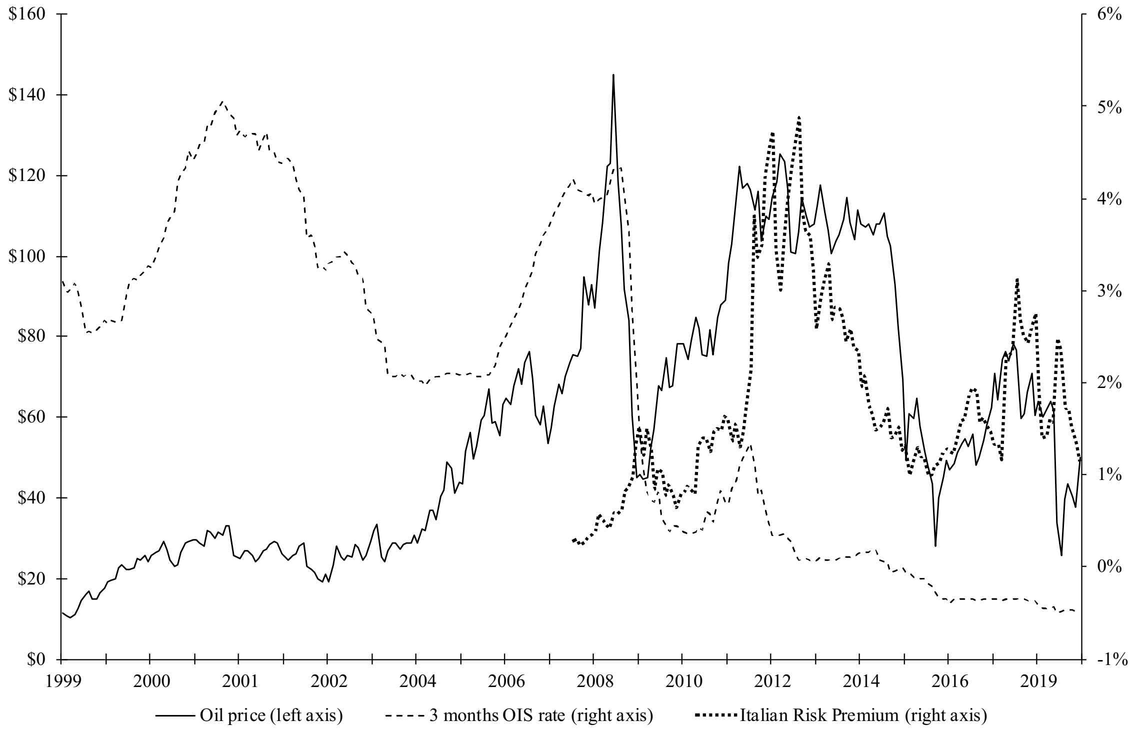

Fig. 2. Brent price, three-month overnight interest swap rate and Italian risk premium
Reported prices, rates, and yields in this figure are taken at 15:30 (CET) on the ECB Governing Council meeting days.

previous expectations to the announcement result or simply because the waiting is over. In the case of European energy assets, the number of studies is very limited. It is important to analyse how the liquidity of energy assets traded as futures contracts in financial markets react after uncertainty about the monetary policy actions is solved. This is an important portfolio management issue for hedgers and investors when designing and timing their strategies.

There are several high-frequency studies on US Federal Reserve monetary policy decisions and the impact of these actions on energy markets (see, for instance, Rosa, 2014, Basistha and Kuron, 2015, Chan and Gray, 2017, and Smales, 2019). However, there are few attemps to anayze this in other international markets. Haitsma et al. (2016), Bahloul and Gupta (2018), Ojea (2019), Torró (2019), and Makrychoriti et al. (2020) use different methodologies to analyse this impact on energy prices using daily or higher frequency data. Rogers et al. (2014) examines the effects of international unconventional monetary policy on bond yields, stock prices and exchange rates. Similarly, Jarocinski and Karadi (2020) separate monetary policy shocks from central bank information shocks in a structural VAR and track the response of key macroeconomic variables.

Finally, as Brent is measured in dollars and we will analyse the Euro area monetary policy, exchange rates may have an important effect on results (Ojea, 2020).

Therefore, the main objective of this paper is to extend the previous literature by analysing the high-frequency response of Brent crude oil to ECB monetary policy. We analyse this response in terms of returns, volatility, and liquidity. As far as we know, this is the first paper to analyse the effect of ECB monetary policy on oil prices and liquidity using an event study with intraday data and considering the exchange rate effect.

Table 1
Summary statistics in event days in the time frame 13:00-15:30.

	Oil return (percentage)	Oil volume (contracts)	Oil BAS (cents)	ΔOIS (b.p.)	ΔRP (b.p.)
Whole sample					
Mean	−0.07	24013	−2.24	0.10	
Median	−0.06	13163	−2.00	0.03	
Std. Dev.	0.79	24099	1.21	2.75	
Max.	2.67	117424	−1.06	17.50	
Min.	−2.79	843	−12.61	−10.85	
Pre-crisis period					
Mean	0.02	6165	−2.39	0.20	
Median	−2.93	5289	−2.16	0.11	
Std. Dev.	0.76	3671	1.18	2.89	
Max.	2.36	20140	−1.16	17.50	
Min.	−2.79	843	−12.61	−9.50	
Crisis period					
Mean	−0.15	41731	−2.09	0.01	0.51
Median	−0.07	39023	−1.74	0.00	−0.15
Std. Dev.	0.81	22667	1.22	2.61	7.00
Max.	2.67	117424	−1.06	10.82	43.65
Min.	−2.36	1278	−9.06	−10.85	−14.35

This table reports some descriptive statistics for the event days during the time frame of the event for oil price returns, oil traded volume, oil bid-ask spread (BAS), interest rate changes in basis points in the three-month overnight interest swap (ΔOIS), and Italian risk premium changes in basis points (ΔRP). The oil return is computed as the difference in log prices from 13:00 to 15:30. Interest rates and risk premium increments are computed as the difference between their values from 13:00 to 15:30 and there are expressed in basis points. Oil volume statistics are computed using the accrued volume for each day between 13:00 and 15:30. Oil BAS statistics are computed using all the five-minute values of the Oil BAS from 13:00 to 15:30 in the event days. These statistics are computed for the whole sample, the pre-crisis period (January 1999 to July 2007), and the crisis period (August 2007 to December 2020).

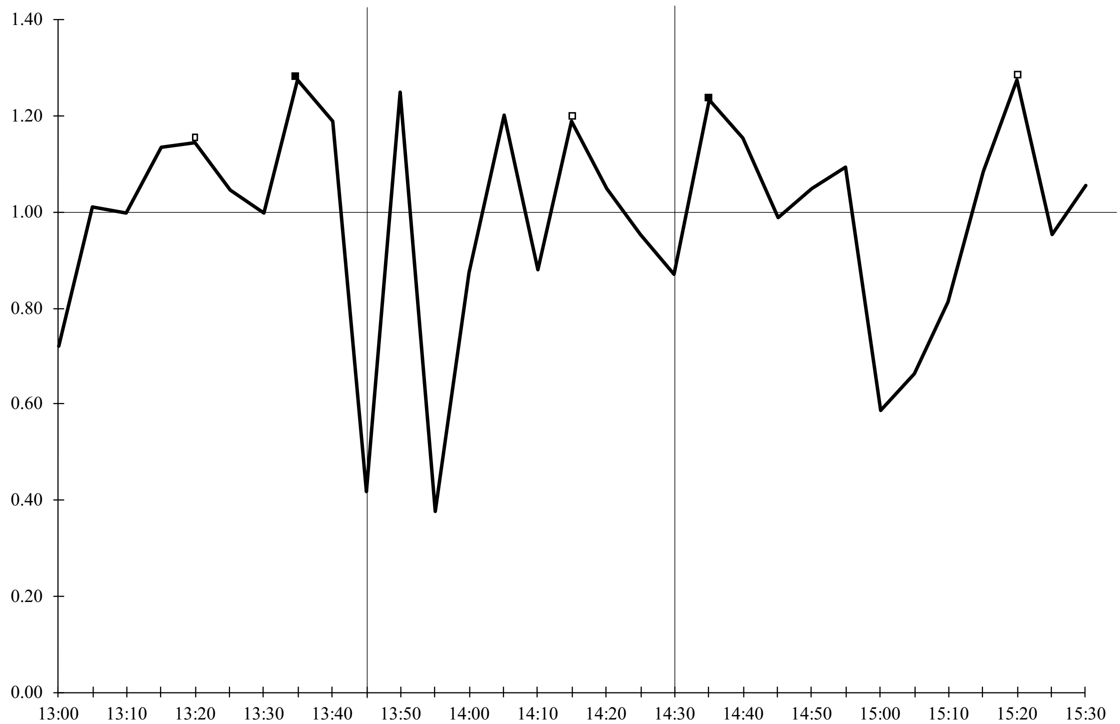

Fig. 3. Oil volatility ratio between event and non-event days
Filled and empty squares represent significance at the 5 and 10 percent level, respectively, of the Levene (1960) test for the null hypothesis of equal variance between the event and no-event days for each five-minute period.

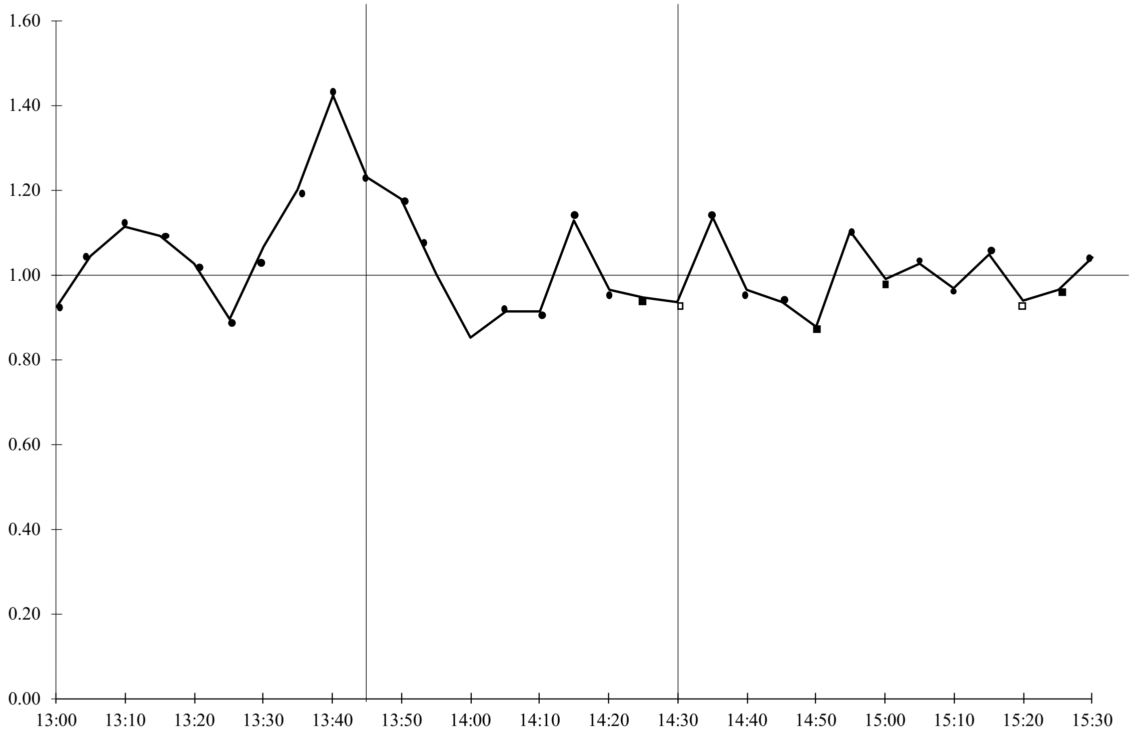

Fig. 4. Oil trading volume ratio between event and non-event days
Filled circles, filled squares, and empty squares, represent significance at 1, 5, and 10 percent levels, respectively, of the Wilcoxon (1945) signed rank test for the null hypothesis of median ratio equals one for each five-minute period.

2. Data and event description

2.1. Monetary policy announcement time frame

Each day in which an ECB press release related to monetary policy was issued is included as an event day. These include scheduled and unscheduled meetings, special announcements dates, and days with no change in monetary policy. During the data period covered, from January 1999 to December 2020, there were 276 announcements. To construct our comparison ratios, days without announcements are taken to be those dates one week before the announcement. Following a pre-set calendar, policy meetings of the ECB governing council are followed by an announcement of the monetary policy decisions at 13:45 CET. Later, at 14:30 CET, the ECB president and vice-president hold a press conference where they read a prepared statement and then answer questions from the press. These questions sometimes lead to unexpected responses that trigger volatility in the market. The statement and questions end at the latest by 15:30 CET (see Fig. 1).

As ECB announcements are made at 13:45 CET, our data set consists of data from 13:00 CET to 15:30 CET, as in Conrad and Lamla (2010) in their study on the response of the EUR-USD exchange rate to ECB communications. This way, we cover the period from 45 minutes before the announcement to one hour after the press conference has started.

2.2. Oil price data

Approximately 70% of the world's traded crude is priced relative to Brent. As Brent can be shipped and stored globally it is much more flexible than WTI regarding delivery and storage. Therefore, Brent prices are less likely to go negative. Therefore, Brent oil ICE futures contracts traded on the ICE (Intercontinental Exchange) are a global benchmark for oil prices.

The high-frequency energy prices consist of 5-min quotes of futures data on crude oil and cover the period from January 1999 to December 2020. Bid-ask averages observed at the end of each 5-min interval are used to create the series of returns. A single futures price series is obtained by considering the front month futures contract and rolling over to the next front month contract on expiry date. Brent price is quoted in US dollars, so we need to analyse to which extent the oil price response to monetary policy comes from the simultaneous response of USD-EUR exchange rates. All data is obtained from Refinitiv.

2.3. Interest rates, exchange-rates, and risk premiums

Following previous literature, we use interest rate derivatives to measure short-term interest response to policy surprises. For the

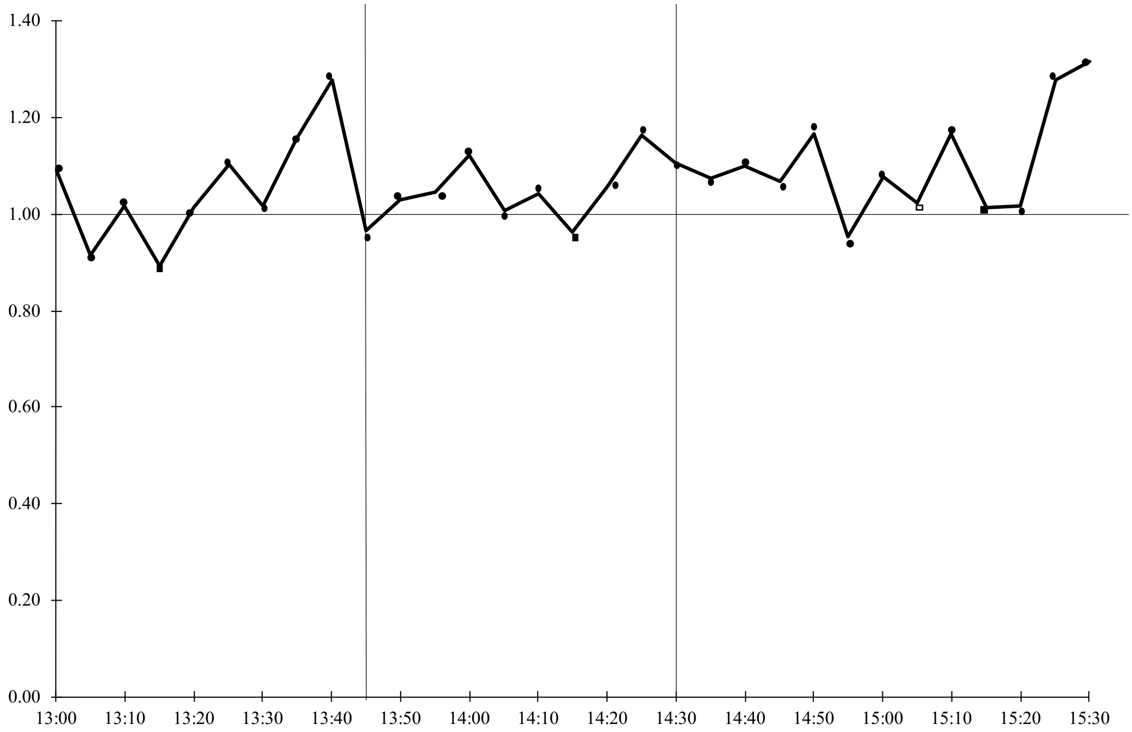

Fig. 5. Bid-ask spread ratio for oil
Filled circles, filled squares, and empty squares, represent significance at 1, 5, and 10 percent levels, respectively, of the Wilcoxon (1945) signed rank test for the null hypothesis of median ratio equals one for each five-minute period.

whole sample period we use the three-month OIS rates. These rates have become one of the main references in Europe for measuring market perceptions about ECB monetary policy. After August 2007, central banks started to apply expansionary quantitative easing monetary policies and in the case of the Eurozone the focus of this policy was on reducing the differences between sovereign bond yields and the cost of capital. Following other studies such as Rogers et al. (2014) and Haitsma et al. (2016), we have compiled the Italian risk premiums as a market measure of these unconventional monetary policy actions. The ECB's aim was to reduce intra-euro area sovereign spreads during this period. We obtained five-minute time series for the three-month OIS rates, exchange rates (EUR-USD), and ten-year German and Italian bond yields from Refinitiv. Logarithmic time series returns were obtained for oil and exchange rates, but realised returns were computed for short-term rates and risk premiums (both computed in basis points). Fig. 2 displays the time series used.

The total period runs from January 1999 to December 2020. We have defined a 'crisis period', corresponding to the unstable years starting after the financial crisis when monetary policy became unconventional (including negative interest rates). This crisis period runs from August 2007 to December 2020. Moreover, as a robustness check, we have also studied two alternative definitions of the crisis period. The sub-sample crisis period May 2009-December 2020 is defined to exclude the spectacular fall in oil prices and interest rates after the Lehman Brothers bankruptcy. The sub-sample crisis period May 2009-August 2014 excludes the fall in oil prices and interest rates – but ends before interest rates fell below zero. We conducted Bai and Perron (2003) structural break tests and results supported our subsample definition.

Table 1 reports descriptive statistics from the data time series in event days during the time frame of the event. It can be observed that the volatility of oil returns increased somewhat in the crisis period and an increase in the liquidity of oil futures contracts is observed (volume increase and bid-ask spread reduction). Looking at the three-month overnight interest swaps in Table 1, interest rates variations in event days seem – if we look at the standard deviation – to have quite stable properties across the whole sample.

3. Brent response to monetary policy

3.1. Comparing event and non-event days

In this section, we analyse how the ECB monetary policy announcements affect oil futures prices, volatility, and liquidity. Firstly, a graphical analysis of oil log-return volatility, trading volume, and bid-ask spread is shown in Figs. 3, 4, and 5, respectively.

To find out whether ECB monetary policy affects oil prices, we look at whether, and to what extent, the volatility and liquidity-related measures of oil futures are higher on days of ECB meetings compared to non-event days for the sample period. If monetary policy decisions cause market participants to revise their expectations, this should then be reflected in higher volatility and liquidity

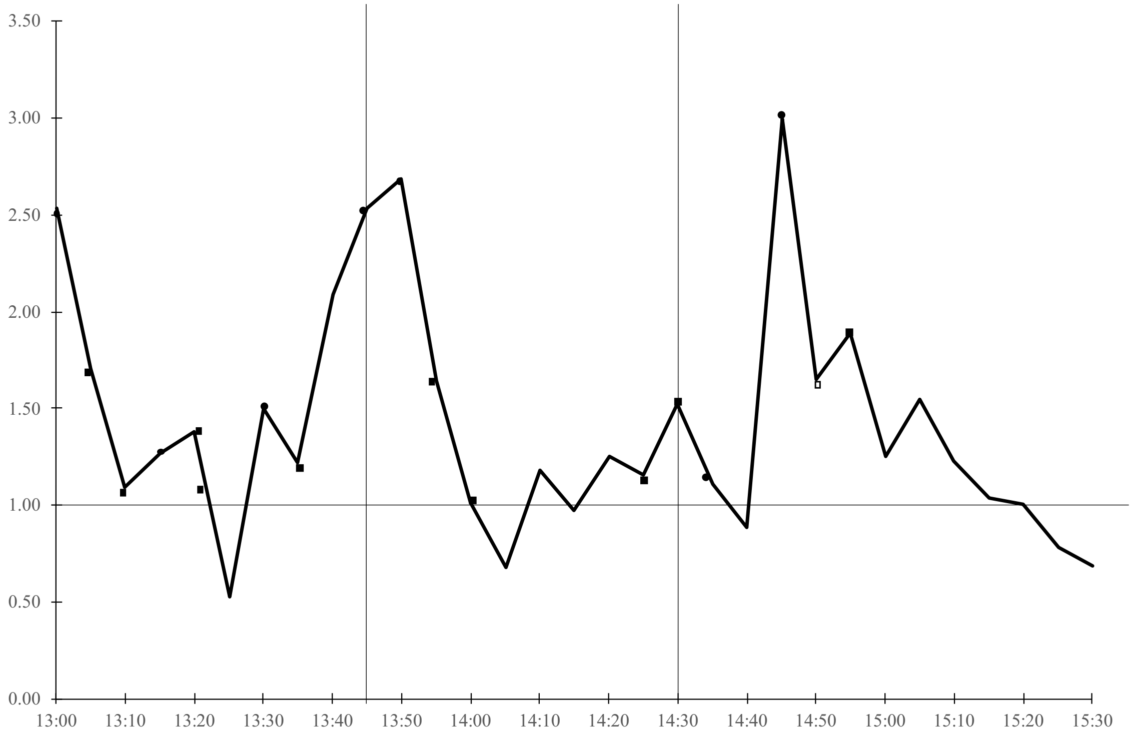

Fig. 6. Interest rate standard deviation ratio
Filled circles, filled squares, and empty squares represent significance at the1, 5, and 10 percent level, respectively, of the Levene (1960) test for the null hypothesis of equal variance between the event and no-event days for each five-minute period.

compared with a period without such an event (Rosa, 2014). From a visual inspection and the tests carried out, we observe that volatility on event days is significatively higher than no-event days for a few time points along the time frame of the event. It can be observed that volatility sharply decreases with the press release publication at 13:45.

The trading volume takes its highest value five minutes before the press release, being about 40 percent higher than usual, and after 15 minutes it takes values visually similar to the control sample.

Finally, the bid-ask spread also reaches a very high value five minutes before the press release (reaching values around 30 percent higher than the usual values at that time). Therefore, it seems that agents take their positions before the press release is published – but with a high level of uncertainty.

Figs. 6, 7, and 8 show the standard deviation ratio between event and non-event days for each five-minute lapse for interest rates, exchange rates, and risk premium. We observed that exchange rate volatility takes its highest values at press release time. The pattern of interest rate volatility is quite similar. Interest rate volatility also increases sharply at 14:45, just when the governor is answering questions in the press conference. The risk premium volatility is also higher than usual on event days and takes its highest values in the time lapse between the press release and the press conference.

3.2. Regression analysis

To estimate the response of oil prices to unexpected changes in monetary policy, we have also estimated several linear regressions. These regressions are estimated using ordinary least squares (OLS) with White-t statistics to account for heteroskedasticity in the residuals. We use different sample periods. Furthermore, as Brent is priced in US dollars, we have also estimated an equation for the EUR-USD exchange rate to compare and test if the exchange rate and the oil price responses differ significatively.

Table 2 reports the estimation results. In Panel A, the equation is estimated using only the short-term interest rate as an explicative variable. Panel B shows the estimation results but using only the risk premium as an explicative variable and considering only the crisis period. In Panel C, results using both explanatory variables are reported for the crisis period. The response of oil and exchange rates is only significant in the crisis period. This is consistent with Kilian and Vega (2011) and Scrimgeour (2015), who find that energy prices are predetermined with respect to macroeconomic news. It is also consistent with intertemporal arbitrage being more challenging for oil, compared with other commodities. Furthermore, we cannot reject the hypothesis of equality in the response in both assets. For the crisis period, both assets responded positively to interest rates and negatively to risk premiums. For example, for the crisis period, for an unexpected 100 basis points increase in the short-term interest rates in an event day, Brent increases by 8.63 percent and the exchange rate by 10.09 percent. The estimated response to a 100-basis points unexpected increase in the risk premium on an event day

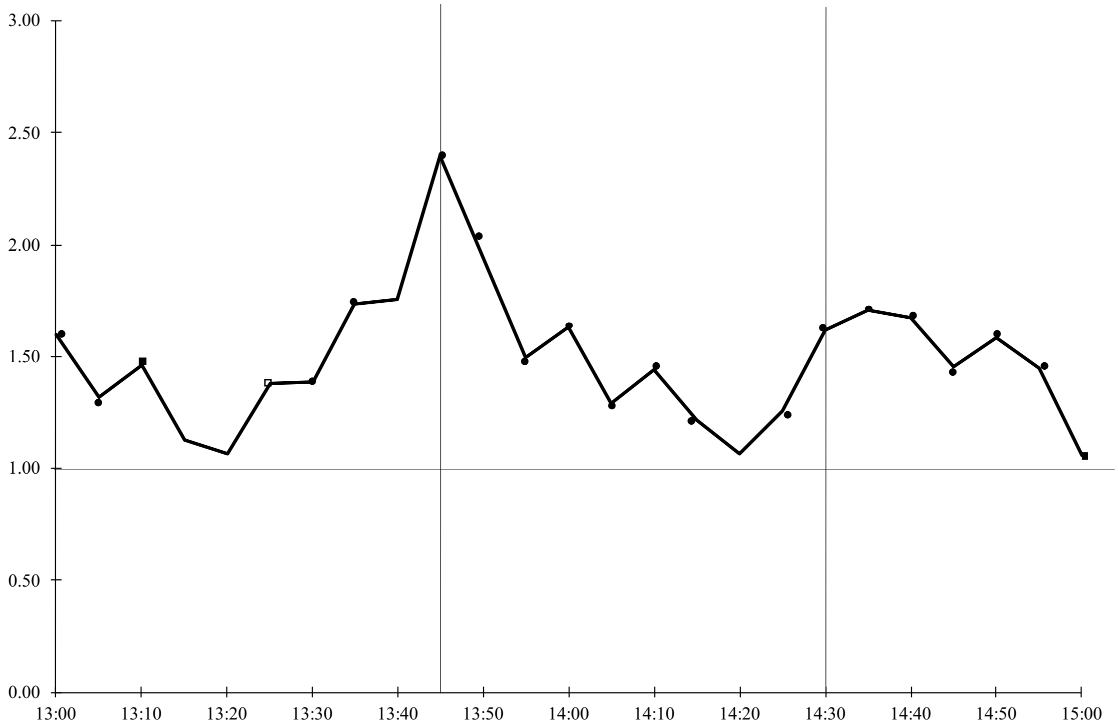

Fig. 7. Standard deviation ratio for exchange rates
Filled circles, filled squares, and empty squares represent significance at the 1, 5, and 10 percent level, respectively, of the Levene (1960) test for the null hypothesis of equal variance between the event and no-event days for each five-minute period.

is -2.40 and -2.17 percent for the Brent and the exchange rate, respectively. Therefore, as Rogers et al. (2014) and Haitsma et al. (2016) mention, during the crisis period unexpected increases in the short-term interest rates and reductions in the peripherical risk premiums were positively responded to by investors anticipating the survival of the Euro as a currency and anticipating the end of the crisis. It is also interesting to highlight the considerable explicative power attained in the estimated linear regression proposed for the crisis period. For the whole crisis period, the coefficient of determination (R^2) is 10.04 percent for Brent and 24.36 percent for the exchange rate. But if we reduce the sample for the crisis period following the Lehman Brothers bankruptcy and before short-term interest rates took negative values, the coefficients of determination increase to 17.92 percent for oil and 30.65 for the exchange rate. In Rosa (2014) these values are much lower for the Federal Reserve monetary news and its impact on the WTI oil futures for the period January 1999 to June 2011. Specifically, the highest coefficient of determination obtained in Rosa (2014) was 8.20 percent.

As a robustness check, following referees' suggestions, we have analyzed the brent oil response to different types of monetary policy announcements using Altavilla et al. (2019) methodology. However, we did not find a significant response from oil to the four factors they identified: target, timing, forward guidance and quantitative easing factors. These results are available upon request.

We also studied the asymmetric impact of monetary policy on oil price. There seems to be an asymmetric reaction of oil prices to positive and negative shocks in the Italian risk premium: brent oil was significantly responsive to reductions in the risk premium during the crisis period but not to increments. Similarly, interest rates seem to have an asymmetric effect on oil prices only during the crisis period. Easing policies that reduce interest rates seem to make oil prices fall, while tightening policies do not seem to have an effect. Results are also available upon request.

4. Conclusions

In this paper, we have focused our attention on the Eurozone and the response of Brent oil prices to ECB monetary policy decisions. As Brent oil is priced in dollars, we have integrated the USD-EUR exchange rate in our study. We have carried out an event study on the ECB governing council meeting days in which monetary decisions are taken. Using high frequency intraday data, we isolated monetary policy surprises and the response of short-term interest rate, exchange rate, risk premium, and Brent futures price. We have also given special attention to the crisis period that began in August 2007. During this period, conventional monetary policy was shown to not be enough to steer the ECB monetary stance to financial markets – and so unconventional monetary tools, such as forward guidance and asset purchases, were necessary to re-establish the monetary policy transmission mechanism and ensure the survival of the Eurozone. We have used two measures of monetary policy stance during this period: the short-term interest rates and the Italian risk premium. As Rogers et al. (2014) mentioned, during the crisis period unexpected increases in short-term interest rates and reductions in peripherical

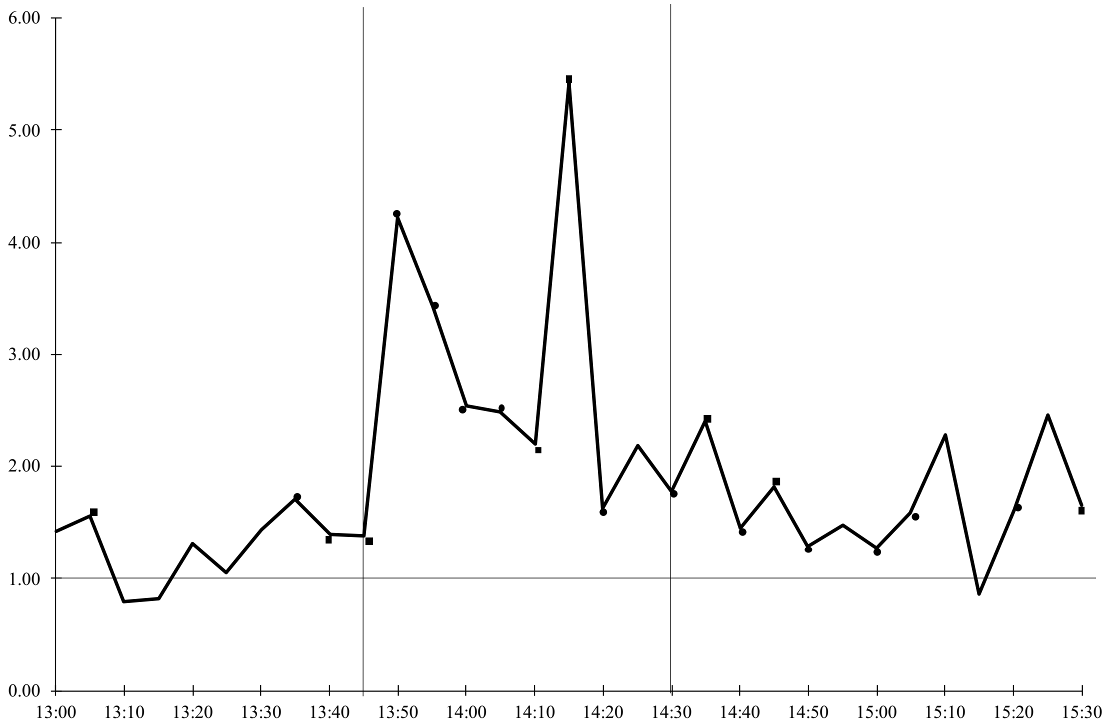

Fig. 8. Standard deviation ratio for Italian risk premiums
Filled circles and filled squares represent significance at the 1 and 5 percent level, respectively, of the Levene (1960) test for the null hypothesis of equal variance between the event and no event days for each five-minute period.

risk premiums met a positive response from investors anticipating the survival of the Euro as a currency and anticipating the way out of the crisis. This supports the existence of the central bank "information effect" suggested by Nakamura and Steinsson (2018), who found that when the Federal Reserve raises interest rates, this leads to increased optimism about economic fundamentals. During the crisis period, we found that the pass-through of monetary policy surprises to Brent price is statistically significant and quantitively important. As Brent crude oil futures are priced in dollars, we have further studied the USD-EUR exchange rate response to monetary policy actions. Our results show that the null hypothesis of equal response between Brent oil and exchange rate responses cannot be rejected. Therefore, the pass-through of monetary policy to the oil Brent price is mostly due to the exchange rate response on event days.

This is an important result for monetary policymakers when they observe the response of financial assets to their actions, as they must focus their attention on the exchange rate. Obviously, oil prices have an important effect on the real economy and inflation. Policy makers should also keep in mind that oil prices do not respond to the factorial decomposition nor the distinction between press release and press conference made in Altavilla et al. (2019). Our results support the assumption of predetermined oil prices. Future research should examine the discrepancy between intraday and longer-term impact. Regulators now know the short-term effects of news announcements on asset prices, and the benefits of some unconventional monetary policies during crisis times. Therefore, in line with Haitsma et al. (2016), our results imply that the impact of ECB policy changes is not stable across time but differs across the crisis and non-crisis period. However, our results are more relevant for hedgers and speculators, looking to trade crude oil futures in the period around ECB announcements. They will be able to jointly manage exchange rate and price risks during the ECB Governing Council meeting days with monetary policy decisions, as it is shown that both assets are highly correlated those days.

Author statement

Pilar Soriano: Funding acquisition, Investigation, Validation, Visualization, Writing- Original draft preparation, Writing-Reviewing and Editing Hipòlit Torró: Funding acquisition, Conceptualization, Data curation, Methodology, Software, Writing-Reviewing and Editing.

Declarations of Competing Interest

None.

Table 2
Brent return response (%) to 100 basis points increase in the OIS3M.
Frame time 13:00-15:30 CET (January 1999 to December 2020)

$$\Delta Brent_t = \alpha + \beta \Delta OIS3M_t + \varepsilon_t$$
$$\Delta ER_t = \alpha' + \beta' \Delta OIS3M_t + \varepsilon'_t$$

PANEL A	β(*p.value*) *Brent*($)	R^2(%)	β′ (*p.value*) *ER*($/€)	R^2(%)	β = β′(*p.value*) Wald Test
All sample	3.89 (0.03)	1.84	3.13 (0.05)	3.24	0.21 (0.64)
Pre-crisis	0.76 (0.76)	0.08	−1.71 (0.13)	1.76	4.77 (0.03)
Crisis period	7.49 (0.00)	5.85	9.06 (0.00)	17.43	0.35 (0.55)
May09-Dec20	4.54 (0.07)	2.04	8.93 (0.01)	13.35	1.39 (0.23)
May09-Aug14	6.21 (0.08)	5.92	9.01 (0.00)	21.10	1.62 (0.20)

$$\Delta Brent_t = \alpha + \beta \Delta RP_t + \varepsilon_t$$
$$\Delta ER_t = \alpha' + \beta' \Delta RP_t + \varepsilon'_t$$

PANEL B	β(*p.value*) *Brent*($)	R^2(%)	β′(*p.value*) *ER*($/€)	R^2(%)	β = β′(*p.value*) Wald Test
Crisis period	−1.83 (0.09)	2.51	−1.50 (0.01)	3.43	0.29 (0.58)
May09-Dec20	−1.70 (0.10)	2.87	−1.39 (0.03)	3.24	0.24 (0.62)
May09-Aug14	−2.84 (0.01)	11.88	−1.94 (0.00)	9.37	2.42 (0.12)

$$\Delta Brent_t = \alpha + \beta_1 \Delta RP_t + \beta_2 \Delta OIS3M_t + \varepsilon_t$$
$$\Delta ER_t = \alpha' + \beta'_1 \Delta RP_t + \beta'_2 \Delta OIS3M_t + \varepsilon'_t$$

PANEL C		β(*p.value*) *Brent*($)	R^2(%)		β′(*p.value*) *ER*($/€)	R^2(%)	β = β′(*p.value*) Wald Test
Crisis period	β_1	−2.40 (0.00)	10.04	β'_1	−2.17 (0.00)	24.36	0.51 (0.77)
	β_2	8.63 (0.00)		β'_2	10.09 (0.00)		
May09-Dec20	β_1	−2.19 (0.01)	6.53	β'_1	−2.23 (0.00)	21.18	2.38 (0.30)
	β_2	8.63 (0.03)		β'_2	10.69 (0.00)		
May09-Aug14	β_1	−2.85 (0.00)	17.92	β'_1	−1.96 (0.00)	30.65	5.44 (0.07)
	β_2	6.26 (0.07)		β'_2	9.05 (0.00)		

This table reports OLS robust estimates using the Newey-West consistent estimators of the Brent and the exchange rate ($/€) responses to changes in the three-month OIS rates ($\Delta OIS3M$) and Italian risk premium (ΔRP), from 13:00 to 15:30 CET. The Italian risk premium is only considered in the crisis period (August 2007 to December 2020). The crisis sub-period May 2009-December 2020 is defined to exclude the spectacular fall in oil prices and interest rates after the Lehman Brothers bankruptcy. The crisis sub-period May 2009-August 2014 excludes the fall in oil prices and interest rates but ends before the interest rates fell below zero. Panel A includes only the responses to the three-month OIS rates, Panel B reports only the response to the Italian risk premium in the crisis period, and Panel C displays the response to both variables in the crisis period and sub-periods. The last column shows the equality test on the Brent and exchange rate response using the Wald test.

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