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Monetary policy and the oil futures market

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Abstract:

We assess the transmission of monetary policy shocks on oil prices using a VAR model. We identify monetary policy and financial activity shocks disentangled from demand and oil supply shocks using sign restrictions. We obtain the following main findings. (i) Monetary policy and financial activity shocks both have a significant effect on the oil price. (ii) Monetary policy has made large positive contributions to oil price growth in 2008. (iii) Monetary policy affects the oil price primarily through fundamental (supply and demand) channels rather than through financial activity.

Keywords:

Oil prices, monetary policy, financial activity, VAR model, sign restrictions

JEL-Classification:

E52, C32, Q41, Q31

Non-technical summary

The recent years have witnessed ample fluctuations in commodity prices, and most notably in the case of oil. While most of the academic and institutional commentators agree on the fact that price gyrations have been largely determined by fundamentals, a vivid discussion emerged on the role of financial activity and non-commercial investment in commodity markets, and its potential distortive impact on the price setting mechanism. To the extent that non-commercial investors base their investment decisions on factors that are not related to (current and expected) demand and supply, e.g. diversification of portfolios or low yields offered by other assets, flows into commodity futures markets may lead prices to deviate from their 'fundamental' value. Some observers have also argued that financial flows into commodity markets may also have been exacerbated by loose monetary policy and ample liquidity being displaced in search for higher yields.

We assess the transmission of monetary policy shocks on oil prices using a VAR model. We identify a monetary policy shock disentangled from the other fundamental and from financial shocks and then assess how monetary policy and financial activity shocks affect the oil market and, more specifically, through which channels monetary policy primarily affects the oil price (fundamental vs. financial channels). Moreover, we examine how important these shocks were in the recent past for oil price fluctuations.

Our main findings are threefold. First, monetary policy and financial activity shocks both have a significant effect on the oil price. Second, monetary policy has made large positive contributions to oil price growth in 2008. Third, monetary policy affects the oil price primarily through fundamental (supply and demand) channels rather than through financial activity.

Nicht-technische Zusammenfassung

In den vergangenen Jahren wiesen die Rohstoffpreise und vor allem die Ölnotierungen starke Schwankungen auf. Obwohl sich akademische und institutionelle Beobachter weitgehend einig sind, dass diese Preisschwankungen in erster Linie fundamental motiviert waren, ist eine lebhafte Diskussion über die Rolle finanzieller Aktivitäten und spekulativer Investitionen an den Rohstoffmärkten sowie ihre potenziell verzerrenden Auswirkungen auf den Preissetzungsmechanismus aufgekommen. Soweit die spekulativen Anleger ihre Investitionsentscheidungen auf der Grundlage von Faktoren treffen, die nicht mit der (gegenwärtigen oder erwarteten) Entwicklung von Angebot und Nachfrage zusammenhängen, also z. B. zur Portfoliodiversifikation oder vor dem Hintergrund einer niedrigeren Verzinsung anderer Anlageformen, können Mittelzuflüsse an den Warenterminmärkten dazu führen, dass die Preise von ihrem fundamentalen Wert abweichen. Einige Beobachter argumentieren zudem, dass Mittelzuflüsse an den Rohstoffmärkten auch durch die geldpolitische Lockerung und die Verlagerung reichlicher Liquidität angesichts der Jagd nach höheren Renditen hervorgerufen worden sein könnten.

Wir untersuchen die Übertragung geldpolitischer Schocks auf Ölpreise in einem VektorAutoRegressiven (VAR) Modell. Wir identifizieren einen geldpolitischen Schock und trennen ihn von anderen (fundamentalen und Finanzmarkt) Schocks. Wir untersuchen, wie und über welche Kanäle geldpolitische Schocks und Finanzmarktschocks den Ölmarkt beeinflussen. Zudem analysieren wir die Bedeutung dieser Schocks in der jüngeren Vergangenheit für Ölpreisschwankungen.

Unsere Hauptergebnisse sind wie folgt. Erstens, geldpolitische und Finanzmarktschocks beeinflussen den Ölpreis signifikant. Zweitens, die lockere Geldpolitik hat merklich zum Anstieg des Ölpreis in 2008 beigetragen. Drittens, die Geldpolitik beeinflusst den Ölpreis hauptsächlich über fundamental (Angebots- und Nachfrage-) Kanäle und weniger über Finanzmarktaktivität.

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Monetary Policy and the Oil Futures Market¹

1 Introduction

The recent years have witnessed ample fluctuations in commodity prices, and most notably in the case of oil. While most of the academic and institutional commentators agree on the fact that price gyrations have been largely determined by fundamentals, a vivid discussion emerged on the role of financial activity and its potential distortive impact on the price setting mechanism. It is indeed the case that, over the last decade, investors' appetite for commodities has surged. Accordingly, positions in futures markets held by the so-called non-commercials, i.e. agents that are not physically involved with the commodity, have increased substantially. To the extent that non-commercial investors base their interventions on factors that are not related to (current and expected) demand and supply, e.g. diversification of portfolios or low yields offered by other assets, flows into commodity futures markets may lead prices to deviate from their 'fundamental' value. Some observers have also argued that financial flows into commodity markets may also have been exacerbated by loose monetary policy and ample liquidity being displaced in search for higher yields.

Academic research on this theme is relatively recent, and has followed different approaches. One strand has concentrated on examining the impact of positions held by the so-called non-commercial participants in commodity futures market on commodity prices, volatilities and correlations. Stoll and Whaley (2010) and Irwin and Sanders (2010) failed to find evidence that higher non-commercial trading activity increases commodity prices or volatilities. Mou (2010) reports instead that futures prices are significantly higher on the days in which commodity index funds roll over their positions.

Other authors have identified 'speculative shocks' using sign restrictions in VAR frameworks. Kilian and Murphy (2010) identify a speculative shock as an increase in the demand for oil in anticipation of higher prices in the future. This shock is identified by imposing a restriction on the response of inventories. Juvenal and Petrella (2011) build on Kilian and Murphy (2010) by adding an additional shock designed to capture the possibility that producers would defer extraction, thereby accumulating below-ground inventories. Lombardi and van Robays (2011), *LvR* henceforth, argue that financial flows could temporarily unanchor futures prices from the underlying spot price, and define a financial

¹The views expressed in this paper do not necessarily reflect the views of the Deutsche Bundesbank or the Bank for International Settlements. We are grateful to Ine van Robays for very useful comments. Emails: sandra.eickmeier@bundesbank.de, marco.lombardi@bis.org.

shock as a wedge in the no-arbitrage relationship between the two.

The literature on the relationship between commodity prices and monetary policy has instead longer history. Frankel (1986) derives a theoretical link between oil prices and interest rates, showing that low rates generate incentives to accumulate inventories and/or postpone extraction. More recently, Barsky and Kilian (2002) have argued that the oil price is endogenous to the macroeconomic variables and, as such, is prone to be influenced by monetary policy decisions. More specifically, they report that the oil price surge of the seventies could also have been caused by too loose monetary policy. Anzuini et al. (2010) find that, in the setting of a structural VAR, monetary policy shocks have a significant impact on commodity prices.

Informally, LvR and Anzuini et al. (2010) have looked at the relationship between monetary policy and the financialization of commodity markets. LvR find that their financial shock is not significantly correlated with interest rates, while Anzuini et al. (2010), using a simple regression, do not find monetary policy shocks to exert significant effects on non-commercial net long positions. So far, however, to the best of our knowledge, no formal attempt has been made to analyze whether monetary policy has fueled financial activity and distortion in the functioning of oil futures markets. This is somehow surprising since several observers attributed the surge of investors' appetite for commodities to funds flowing into riskier asset classes due to loose monetary policy in the 2000s; this idea is also motivated by the fact that low interest rates lowers the opportunity costs of carrying speculative positions (Frankel 2007).

The starting point of our analysis is broadly the VAR model proposed by LvR, to which we add a global monetary policy interest rate. We identify a monetary policy shock disentangled from the other fundamental and from financial shocks and then assess how monetary policy and financial activity shocks affect the oil market and, more specifically, through which channels monetary policy primarily affects the oil price (fundamental vs. financial channels). Moreover, we examine how important these shocks were in the recent past for oil price fluctuations.

Our main findings can be summarized as follows. (i) Monetary policy and financial shocks both have a significant effect on the oil price. (ii) Monetary policy has made large positive contributions to oil price growth in 2008. (iii) Monetary policy affects the oil price primarily through fundamental (supply and demand) channels rather than through financial activity. These findings are robust against various checks.

2 Empirical strategy and data

Our empirical model is a structural VAR with 12 lags estimated on monthly data (in levels) between January 1991 to February 2010. The starting point is the specification employed by LvR: a four-variable VAR featuring a constant, world oil production Q_{oil} , world economic activity Y_w , the (nominal) USD price of crude oil P_{oil} , and the futures price of oil F_{oil} .²

Shocks are identified by imposing sign restrictions on short-run impulse response functions. LvR distinguish between fundamental (i.e. supply, demand driven by economic activity and oil-specific demand) and non-fundamental shocks, i.e. the destabilizing impact of financial activity. Their identification strategy is summarized in Table 1. The identification of fundamental structural shocks to the oil market employs rather standard restrictions (see also Peersman and van Robays 2009), and we will not enter into further details. What is instead less obvious is the strategy employed to tell fundamental from non-fundamental shocks, which rests on a restriction on the spread between futures and spot prices. In a textbook situation, spot and futures prices are tied together by a no-arbitrage relationship, and both respond to movements in fundamentals. However, in real world such a relationship may not hold instantaneously due to various types of frictions, and an exogenous shock to the futures market could in principle transmit to spot prices. The financial shock is indeed defined as a wedge between futures and spot prices, i.e. a deviation from the no-arbitrage condition. Such a deviation, which is not dependent on fundamentals, is attributed to distortive financial activity. For example, a large financial investment into oil futures markets could push up futures prices. LvR show that this type of shock increases the spread between spot and futures prices, whereas fundamental shocks which increase the oil price decrease the spread.

For our main purpose, i.e. to study the interaction between monetary policy and financial activity, we extend the VAR with a global short-term interest rate r , measured as GDP-weighted average over G7 overnight rates. We impose additional restrictions to disentangle the monetary policy shock from fundamental (oil supply and demand) and financial shocks. Specifically, after a monetary policy loosening, the interest rate does not increase, and, consequently, economic activity, the spot and the futures oil price do not decline. Furthermore, we restrict the interest rate not to go down after both oil demand

²World oil production is taken from the US Energy Information Administration. We use as a measure of world economic activity the index provided by Kilian (2009). The spot and 3-month-ahead future prices of Brent crude are taken from Bloomberg. LvR also include oil inventories in their model; we omit it to save on degrees of freedom. Moreover, inventories are not necessary to identify the structural shocks in LvR. At a later stage, we will check robustness with respect to inclusion of inventories in the model.

shocks driven by economic activity and the financial shock. The latter restriction can be justified as follows: a financial shock tends to (temporarily) increase oil price and possibly aggregate inflation. The central bank will respond to this by raising (or at least not lowering) the interest rate. The sign restriction on the interest rate is consistent with Bodenstein et al. (2012). In their DSGE model monetary policy unambiguously reacts to shocks which raise the oil price by increasing interest rates.³ Importantly, we do not restrict the reaction of the spread after the monetary policy shock which is the focus of this study. A monetary policy loosening impacts the spread via two channels: first, it generates expectations of higher growth and inflation, thereby qualifying as an (expansionary) fundamental shock and thus lowering the spread. At the same time, it may generate incentives for investors to shift part of their portfolios towards commodities, in search for higher yields. By doing so, it will play the same role as a financial shock, and then increase the spread. The sign restrictions for the extended VAR are presented in Table 2.

In our empirical application, we only explicitly identify financial shocks (both VARs) and monetary policy shocks (the extended VAR). The other shocks are not identified since they are not the focus of our study. However, we restrict them not to have the same characteristics as the financial and the monetary policy shocks and summarize them as “fundamental” shocks. The restrictions are imposed on the first 12 lags, but the restrictions on the spread after the destabilizing financial shock and on the reaction of the interest rate are imposed only on impact.

To implement the sign restrictions scheme, we use the approach suggested by Rubio-Ramírez et al. (2010). It is well known that sign restrictions do not pin down models uniquely, as more than one model is consistent with the restrictions. We rotate the orthogonalized VAR residuals until we have obtained 100 structural shocks that satisfy the sign restrictions and then apply the “Median Target” method suggested by Fry and Pagan (2007, 2011) to pick the model which yields the closer impulse responses to the median impulse responses.⁴

We show 90% confidence bands. They are computed based on a nonparametric bootstrap with 200 replications and reflect parameter (not model) uncertainty.

³One might argue that world economic activity can be expected to decline following the speculative shock, and that central banks which care not only about inflation, but also about economic activity might respond by lowering the interest rate. This effect, however, in Bodenstein et al. (2012) seems to be compensated by the positive effect of oil price shocks on inflation and the resulting monetary policy reaction. Moreover, we will see below, that world economic activity does not decline significantly after our identified speculative shocks. This further supports our restriction on the interest rate’s reaction.

⁴This means we neglect model uncertainty here, but explore in the robustness check section below to what extent accounting for it would alter our main results.

3 Results

We first report on the results from the small VAR without the interest rate. Figure 1 shows impulse response functions of the variables included in the model to a one standard deviation financial shock. Both futures and spot prices increase temporarily following the shock, and the spread turns positive, as implied by the sign restrictions. The shock takes time to absorb, and in spite of having imposed the positive response of the spread only on impact, it remains significantly positive for nearly one year. Real activity is not significantly affected by the financial shock. These results are consistent with the findings of LvR. In contrast to LvR we find a negative oil supply response (oil supply does not react significantly in LvR). This could be a consequence of the steepening of the futures curve: producers may find it more profitable to postpone extraction and sell on the futures market rather than extracting now and selling on the spot market.⁵

Figure 2 shows the historical decomposition of the spot oil price into financial and fundamental influences before the oil price boom over the period between the mid-late 2000s until the end of the sample. Consistent with LvR, the bulk of the oil price boom is explained by fundamental shocks. (LvR show that of the fundamental shocks, the oil demand shock driven by economic activity seems to dominate.) The financial shock has enhanced the boom, but the contribution is rather modest.

We now turn to the extended VAR model. Figure 3 shows impulse responses to the financial (panel (a)) and the monetary policy shocks (panel (b)). The reactions to the financial shocks are not notably changed compared to the smaller VAR presented above. Interestingly, the interest rate does not seem to react significantly to the financial shock (except marginally on impact). The reason is probably that financial shocks only have temporary effects on the oil market and, hence, on the aggregate price level. Central banks respond to movements in the latter and aim at keeping medium-term inflation stable and, therefore, do not respond to these shocks.

After the monetary policy shock, the spot price increases more than the futures price, and consequently the spread turns negative and remains so for nearly one year. We can take this as evidence that the monetary policy shock mainly affects oil prices via the indirect channel of higher expectations of growth and inflation, as in less formal work by Barsky and Kilian (2002) and Anzuini et al. (2012), rather than through flow of funds into commodity futures. It is also remarkable that oil production declines for the first few months, consistent with the argument (Frankel 2007) that producers may decide

⁵This mechanism is close to what Juvenal and Petrella label a 'speculative shock', i.e. producers deciding to postpone extraction to take advantage of higher expected prices.

to postpone production to avoid investing revenues at lower interest rates. Subsequently, however, production increases due to the economic growth induced by the monetary policy loosening. Finally, world activity moves only temporarily, consistent with long-run real neutrality of monetary policy.

To ascertain the contribution of various shocks to the past evolution of oil prices, we computed the historical decomposition (Figure 3). The contribution of monetary policy shocks to the oil price boom in the 2000s is relatively small and visible only between mid-2007 and end-2009. The contribution of both fundamental and financial shocks are reduced compared to the small VAR. Consequently, monetary policy had an effect over the boom period on the oil price via both channels, fundamental and financial. However, as we have seen from the impulse responses in Figure 2, the former channel seems to dominate over the entire period.

3.1 Robustness checks

We carry out five robustness checks. Results are shown in the Appendix Figures A.1-A.5. First, we explore to what extent accounting for model uncertainty affects our main message. We look at point estimates of impulse responses of the reaction of the spread between the futures price and the spot price of oil from all 100 models that are consistent with the sign restrictions presented in Table 2. All models imply a decline in the spread within the first year after the shocks. Only a very small number of models imply that the spread goes up on impact (before turning below zero) and therefore suggest that monetary policy leads to increase financial activity in the very short run. But overall, the findings support our baseline finding that monetary policy affects the oil market mainly through fundamental rather than through non-fundamental (financial) channels.

Second, we introduce inventories in the baseline (extended) VAR model because inventories are often regarded an important transmission channel. Third, we introduce CPI inflation (averaged over G7 countries) in our baseline model. This is because inflation enters each central bank's reaction function and because we want to address possible criticism that our baseline model lacks inflation which might, in turn, lead to inaccurate identification of the monetary policy shock. The reactions of our two key variables (the oil spot price and the spread) to the monetary policy shock are very similar to those obtained from our baseline model. Most importantly, the spread declines supporting, again, our main results.⁶

⁶It is also worth noting that inventories are found to temporarily rise after the financial shock. This is consistent with the restrictions imposed by Kilian and Murphy (2010) and Juvenal and Petrella (2011) to identify 'speculative shocks' which are, however, fundamentally different from our financial shocks. Also,

Fourth and fifth, we experiment with our identification scheme. We drop the restriction on the oil price after the monetary policy shock which is not necessary for unique identification of the shocks. Moreover, we replace the restriction on the interest rate after the financial shock by the restriction that real activity does not rise on impact after the financial shock which is a consequence of the increased spot price. Our main results remain, again, unaffected. Detailed findings are available upon request.

4 Conclusions

Based on a VAR model and sign restrictions we analyzed the transmission mechanisms of monetary policy shocks on oil prices. We found that monetary policy shocks affect the oil price primarily through fundamental channels.

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after the monetary policy shock, inventories are found to rise after a delay. Moreover, we find consumer prices to not react significantly after the speculative shock, but to rise permanently after the monetary policy shock.

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Table 1: Sign restrictions from LvR

	Qoil	Yw	Poil	Foil	S
Oil supply	-	-	+	+	-
Oil dem, driven by eco activity	+	+	+	+	-
Oil-specific dem	+	-	+	+	-
Financial				+	+

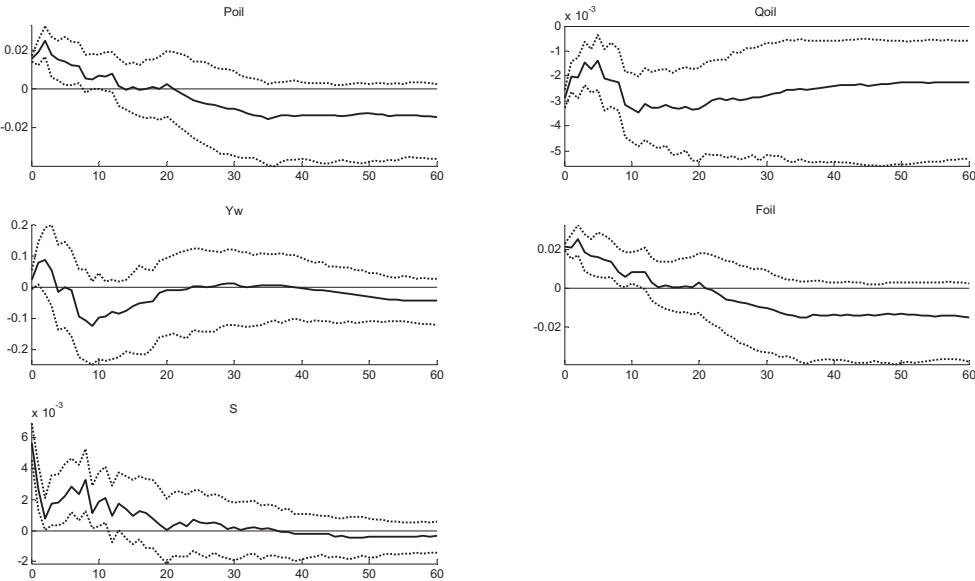
Notes: Restrictions are implemented as \geq or ≤ 0 . All restrictions are imposed on the first 12 lags, except for the restriction on the spread after the destabilizing financial shock which is imposed on impact only. See LvR for details. Qoil: oil production, Yw: economic activity, Poil: crude oil price, Foil: futures price of oil, S: spread between futures price and spot price of oil.

Table 2: Sign restrictions from LvR and for the monetary policy shock

	Qoil	Yw	Poil	Foil	S	R
Oil supply	-	-	+	+	-	
Oil dem, driven by eco activity	+	+	+	+	-	+
Oil-specific dem	+	-	+	+	-	
Financial				+	+	+
Monetary policy		+	+	+		-

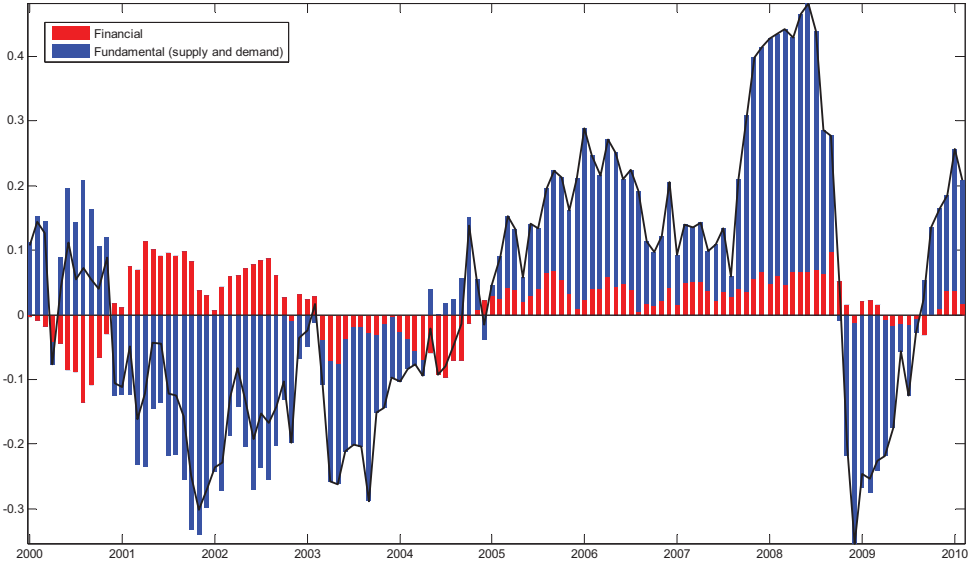
Notes: Restrictions are implemented as \geq or ≤ 0 . All restrictions are imposed on the first 12 lags, except for the restrictions on the spread and on the interest rate after the destabilizing financial shock which are imposed on impact only. Qoil: oil production, Yw: economic activity, Poil: crude oil price, Foil: futures price of oil, S: spread between futures price and spot price of oil, R: global overnight rate.

Figure 1: Impulse responses to a financial shock (model without the interest rate)



Notes: Median and 90% confidence bands. Qoil: oil production, Yw: economic activity, Poil: crude oil price, Foil: futures price of oil, S: spread between futures price and spot price of oil.

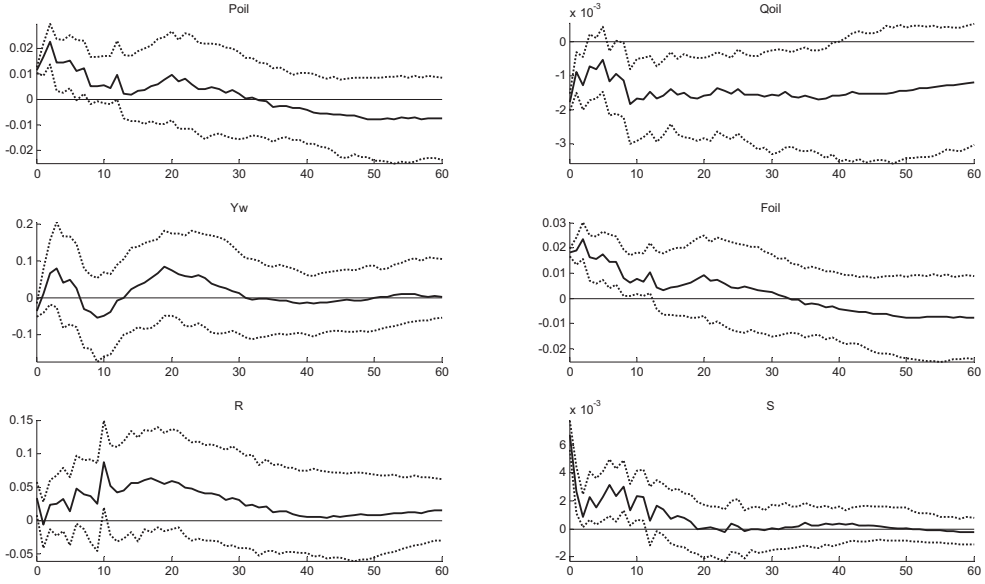
Figure 2: Historical decomposition of the crude oil price (model without the interest rate)



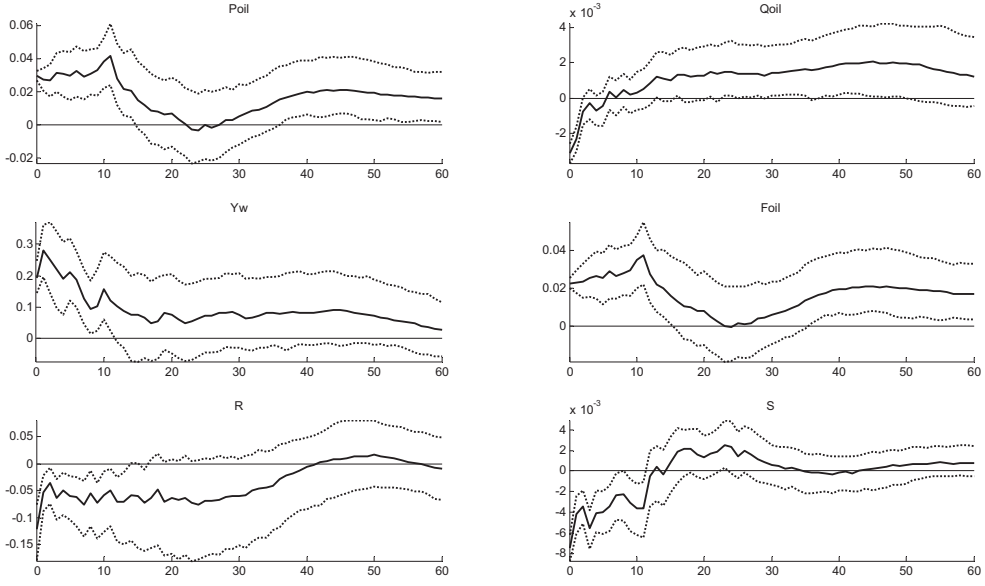
Notes: The black line refers to the oil price’s deviation from its deterministic component. The bars reflect the median historical contributions of financial and other shocks. These are computed for period 0 as the shock estimate at period 0 times the contemporaneous impulse response functions, for period 1 as the shock estimate at period 0 time the impulse response function at horizon 1 plus the shock estimate at period 1 times the contemporaneous impulse response function etc. Thus, the forecast horizon is 0 for the first observation, 1 for the second, ... and T-1 for the last observation.

Figure 3: Impulse responses to a financial shock and a monetary policy shock (base-line model)

(a) Financial shock

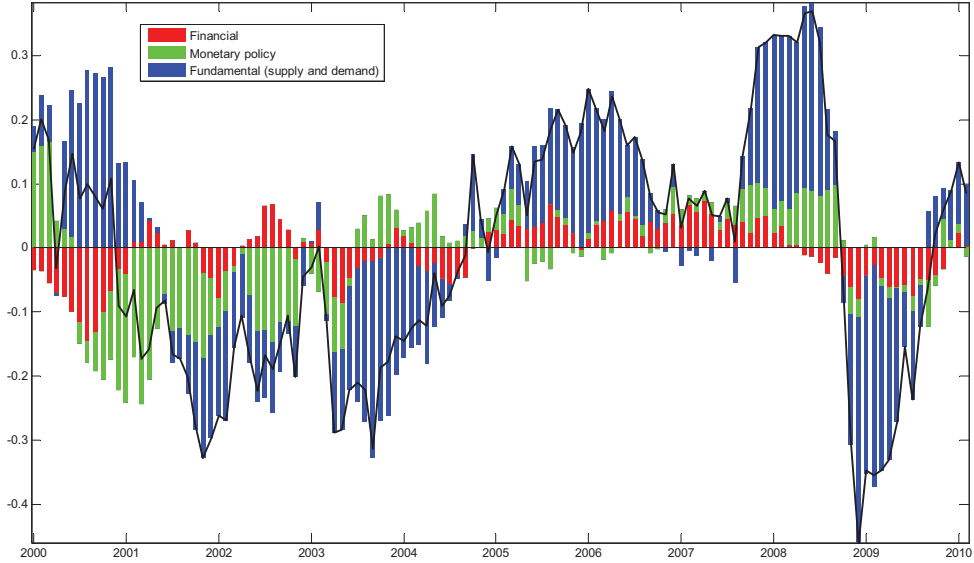


(b) Monetary policy shock



Notes: Median and 90% confidence bands. Qoil: oil production, Yw: economic activity, Poil: crude oil price, Foil: futures price of oil, S: spread between futures price and spot price of oil, R: global overnight rate.

Figure 4: Historical decomposition of the crude oil price (baseline model)



Notes: The black line refers to the oil price's deviation from its deterministic component. The bars reflect the median historical contributions of financial, monetary policy and other shocks. These are computed for period 0 as the shock estimate at period 0 times the contemporaneous impulse response functions, for period 1 as the shock estimate at period 0 time the impulse response function at horizon 1 plus the shock estimate at period 1 times the contemporaneous impulse response function etc. Thus, the forecast horizon is 0 for the first observation, 1 for the second, ... and T-1 for the last observation.

Appendix

Figure A.1: Robustness I (model uncertainty) – point estimates of impulse responses of the futures spread to the monetary policy shock (baseline model)

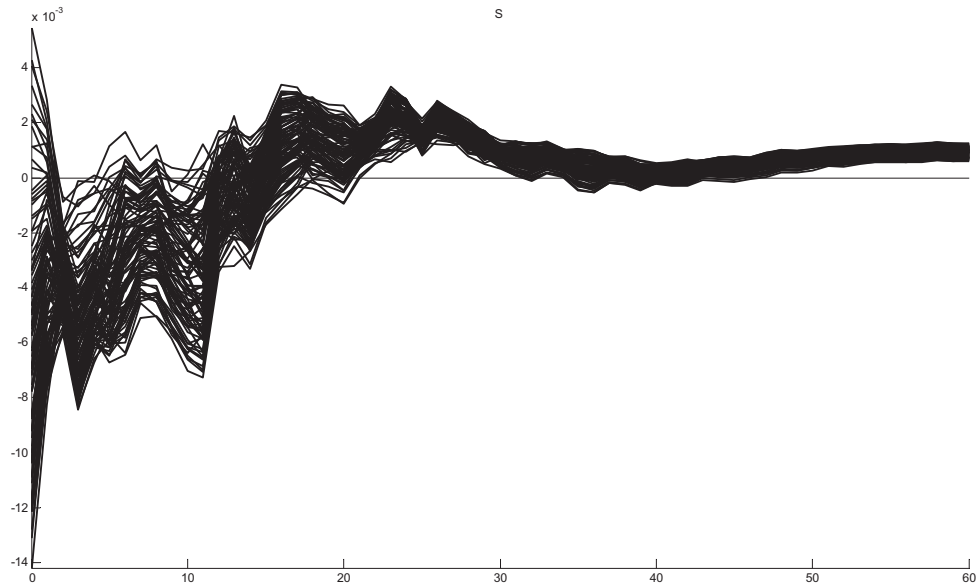
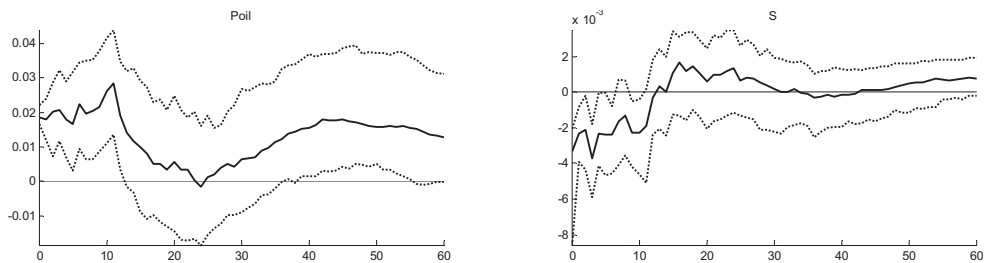
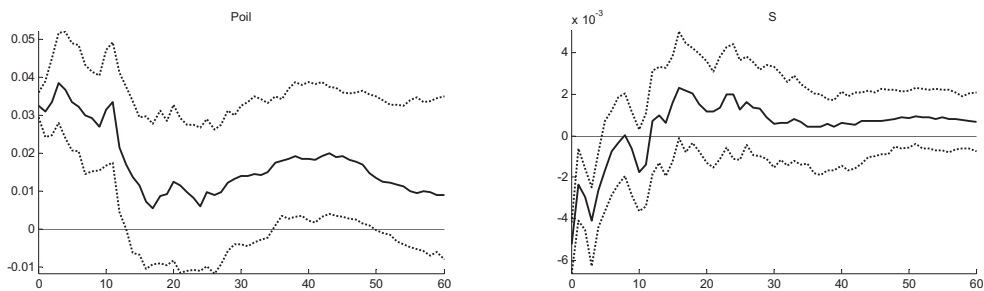


Figure A.2: Robustness II (including inventories in the model) – impulse responses of the oil price and the futures spread to the monetary policy shock



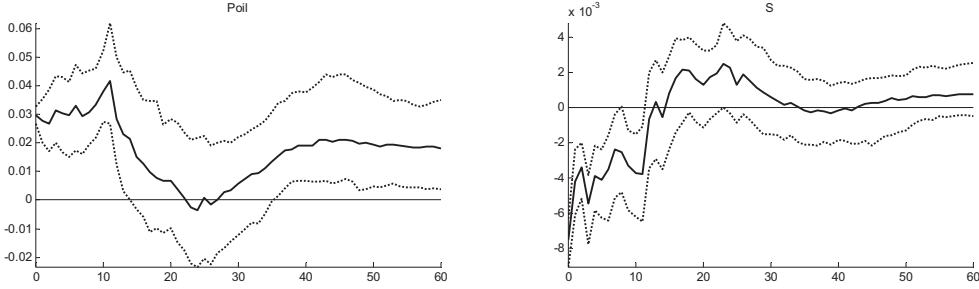
Notes: Median and 90% confidence bands.

Figure A.3: Robustness III (including CPI inflation in the model) – impulse responses of the oil price and the futures spread to the monetary policy shock



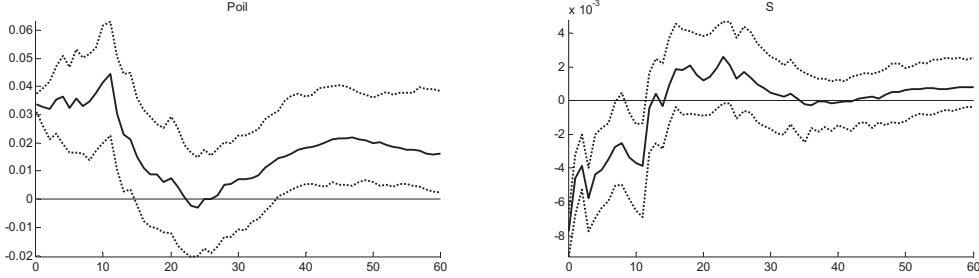
Notes: Median and 90% confidence bands.

Figure A.4: Robustness IV (removing the restriction on Poil after the monetary policy shock) – impulse responses of the oil price and the futures spread to the monetary policy shock



Notes: Median and 90% confidence bands.

Figure A.5: Robustness V (removing the restriction on R after the financial shock and restricting Yw not to increase on impact after the financial shock) – impulse responses of the oil price and the futures spread to the monetary policy shock



Notes: Median and 90% confidence bands.

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