Interpreting the oil risk premium: do oil price shocks matter?

Daniele Valenti* Matteo Manera† Alessandro Sbuelz‡

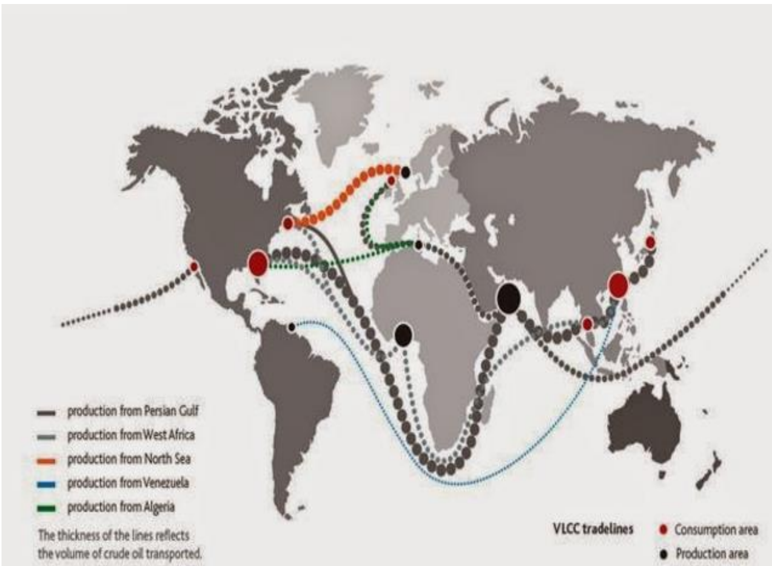
Outline

"Interpreting the oil risk premium: do oil price shocks matter? "
(Daniele Valenti, Matteo Manera and Alessandro Sbuelz)

- Introduction to the "global market for crude oil".
- Motivations
- Literature review
- Research goals
- The oil market players & stylized facts from the observables
- Data and variables
- Econometric method
- Empirical results
- Conclusions

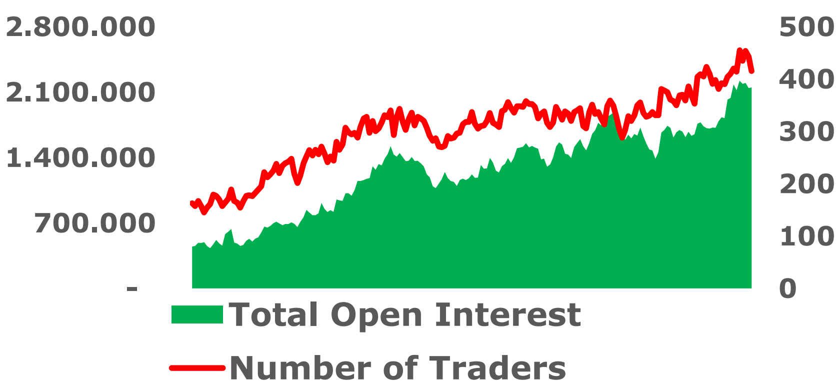
Introduction to the global market for crude oil

- The current market of crude oil is truly global in reach.
- The international market for crude oil includes spot and forward markets



- The aggregate determinants for the analysis of the effects of oil price shocks on macroeconomic and financial variables are the following:

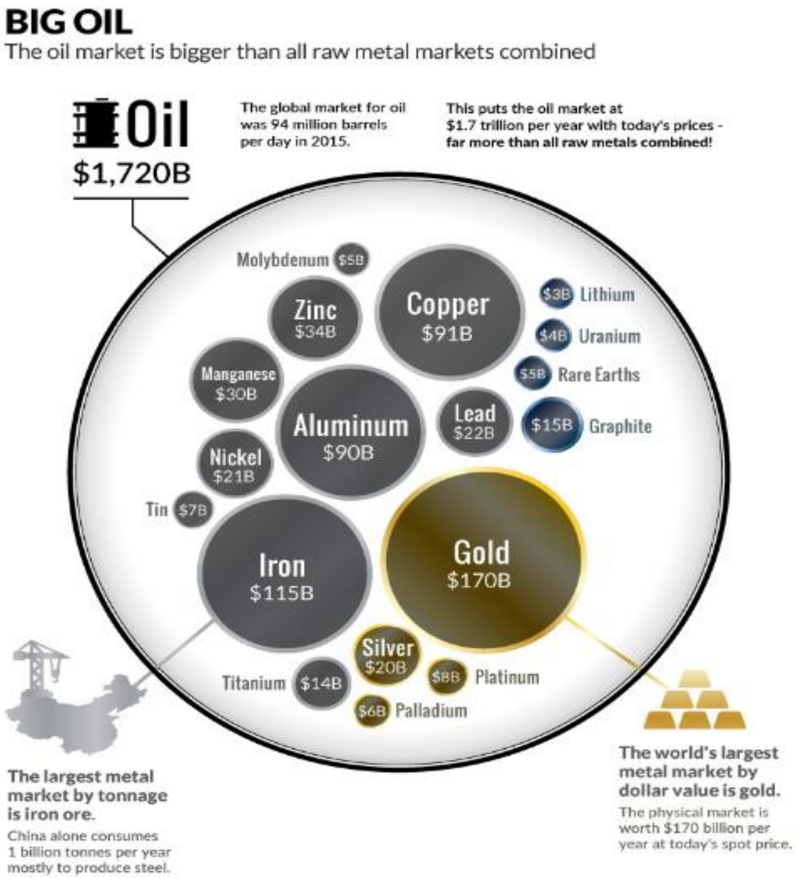
  1. Global crude oil production
  2. Global real economic activity
  3. Global real price of oil



- Pricing of oil is determined by a mix of supply and demand factors which are represented by very aggregate data.

Motivations

- In 2017, the overall physical oil market size reached 1.9 trillion dollars.
- Crude oil is the most important and traded commodity in the world.



- Why is important to analyse the oil risk premium?

✓ It represents an expected cost (or profit) for oil market players.

✓ Higher risk premium move capital from equity and/or bonds markets to crude oil futures market.

✓ It affects the forecasting accuracy of oil prices.

Literature review

- Different empirical studies document the existence of risk premium in the oil futures market:
  - ✓ Bessembinder (1992)
  - ✓ De Roon et. al (2000)
  - ✓ Hamilton and Wu (2014a)

- Commodity specific and macroeconomic variables are important predictors for the risk premium:
  - ✓ Pindyck (2001)
  - ✓ Pagano and Pisani (2009)

- All these empirical works are based on reduced form models

Research goals

- This work investigates the effects of oil price shocks on crude oil risk premium
- Relative to the extent literature on the risk premium, this work provides three main contributions:
- **First**: it shows empirical evidence on whether the compensation for risk depends on the types of the structural shock, the latter are interpreted as shifts in terms of oil demand and oil supply.
- **Second**: it is specific for the crude oil market as opposed to most of the empirical analysis that use a "portfolio approach".
- **Third:** the choice of the methodology based on the Bayesian structural VAR (B-SVAR) model solves two different issues:
  1. Presence of reverse causality between macroeconomic and oil market specific variables.
  2. Dimensionality problems related to the number of explanatory variables used to model the risk premium.

The oil market players

- The aim is to provide evidence of actual changes in the spot price of oil, hedgers' positions and risk premium returns.
- The "Commodity Futures Trading commission (CFTC)" makes distinction between "commercial" and "non-commercial firms".
- The following classification has been improved by reporting the breakdown of traders into 4 categories:

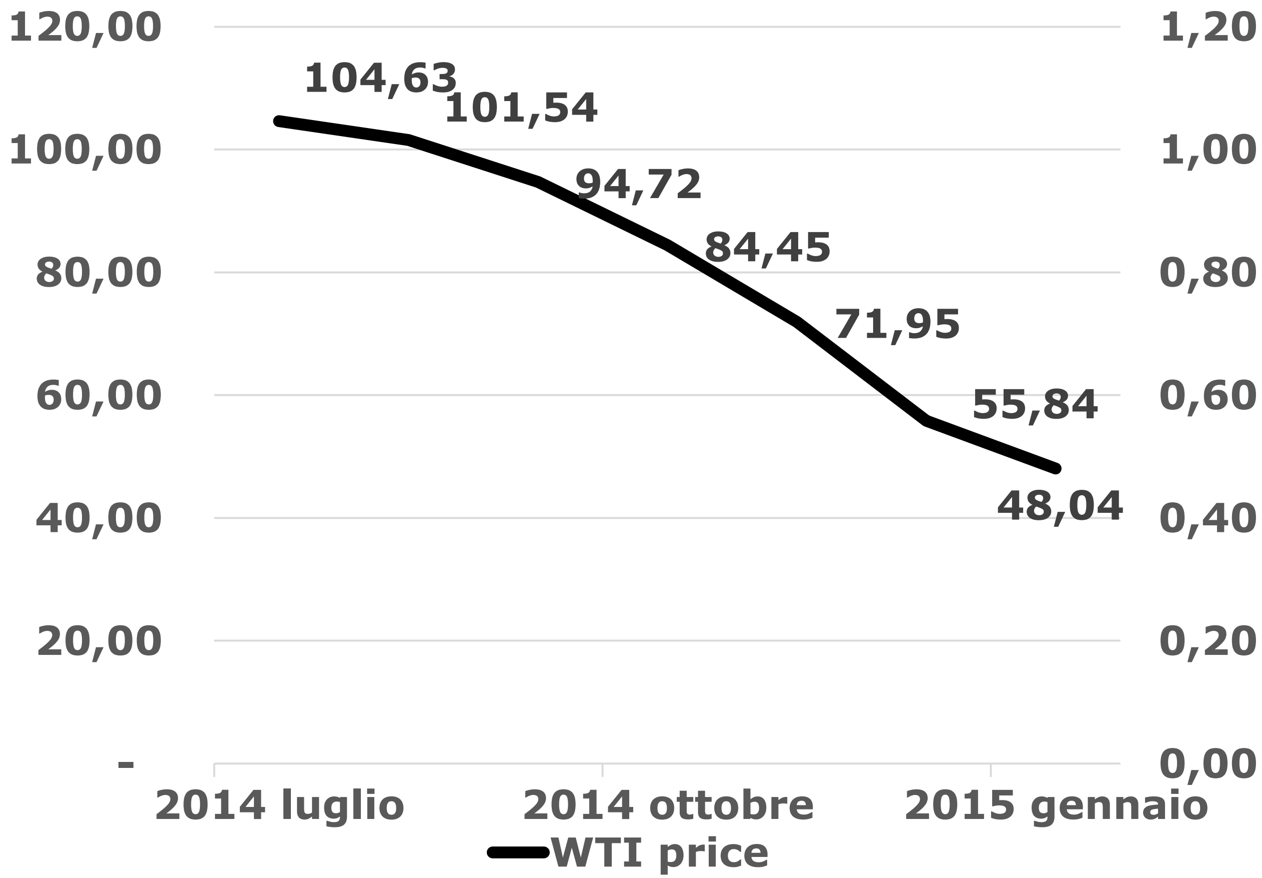
1. "Producers, Merchant , Processor, User" (PMPU)
2. "Swap Dealers" (SD)
3. "Managed Money" (MM)
4. "Other Reportable" (OR)

Commercial Traders

Non Commercial Traders

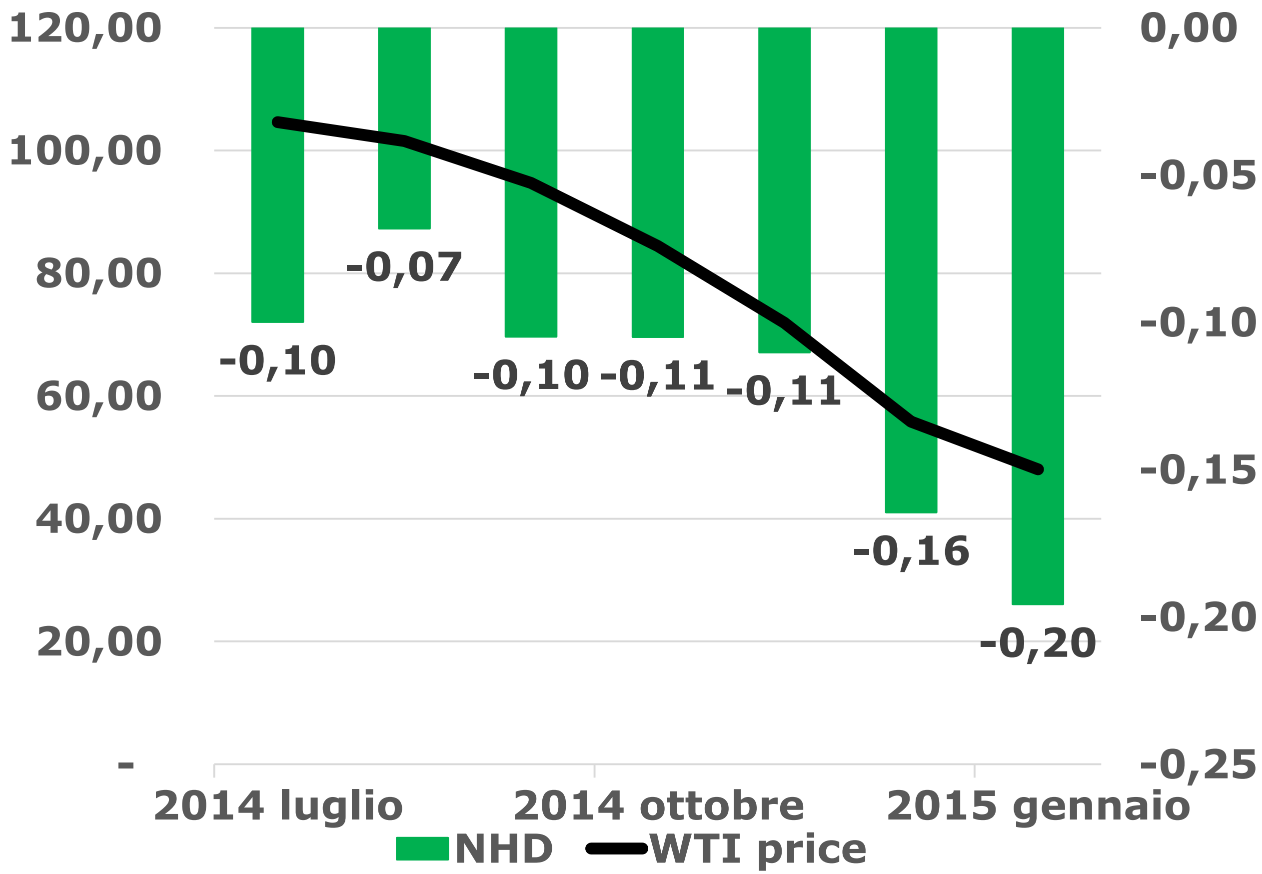
- We define a proxy for "net-hedging demand of commercial traders" as the ratio between the net and gross positions in the NYMEX futures market related to the *PMPU* category.
- We define a proxy for "net-speculative demand of non-commercial traders" as the ratio between the net and gross positions in the NYMEX futures market related to the *MM* category.

Stylised facts from the observables (1/4)



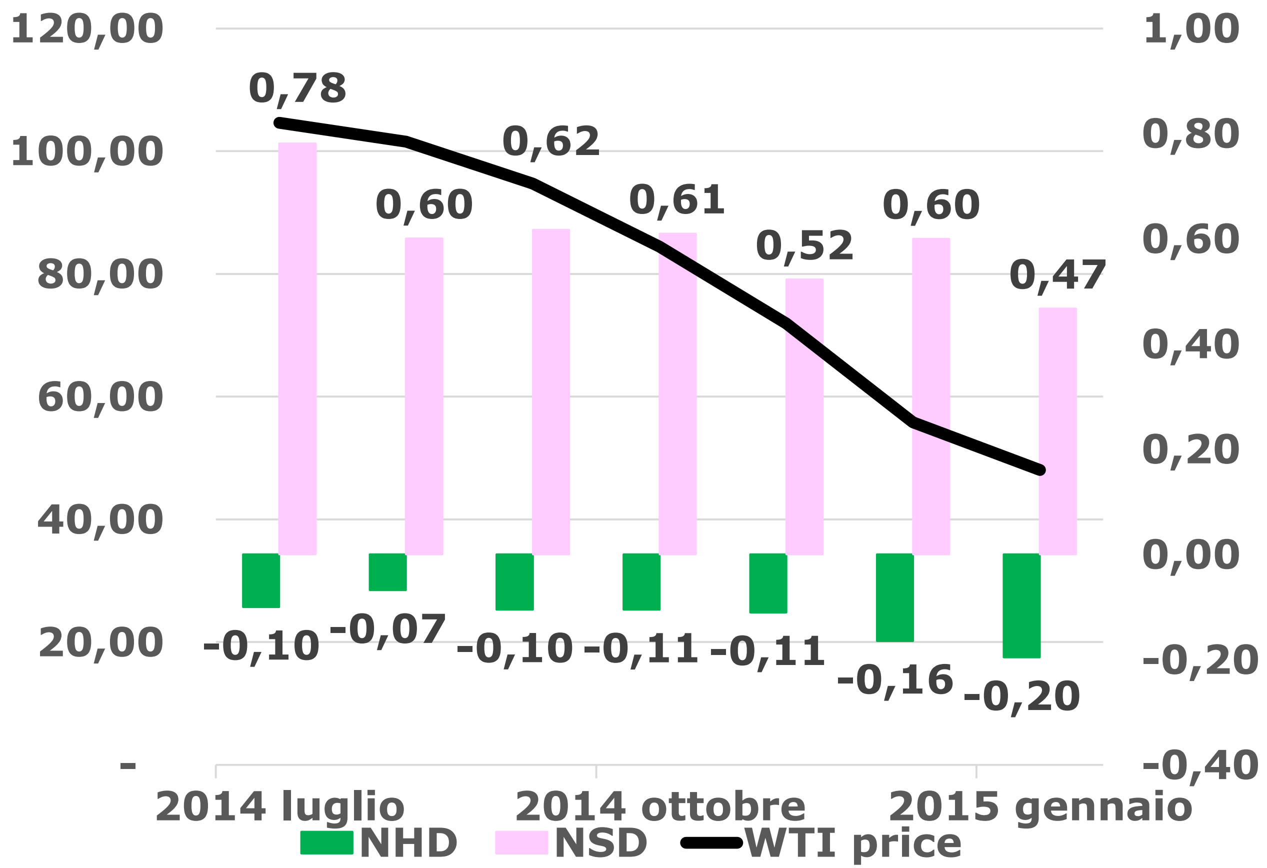
- The large drop in the price of oil between June and December 2014 amounted to $ 56 per barrel.
- In a scenario of bearish market, (a) the spot price declines,

Stylised facts from the observables (2/4)



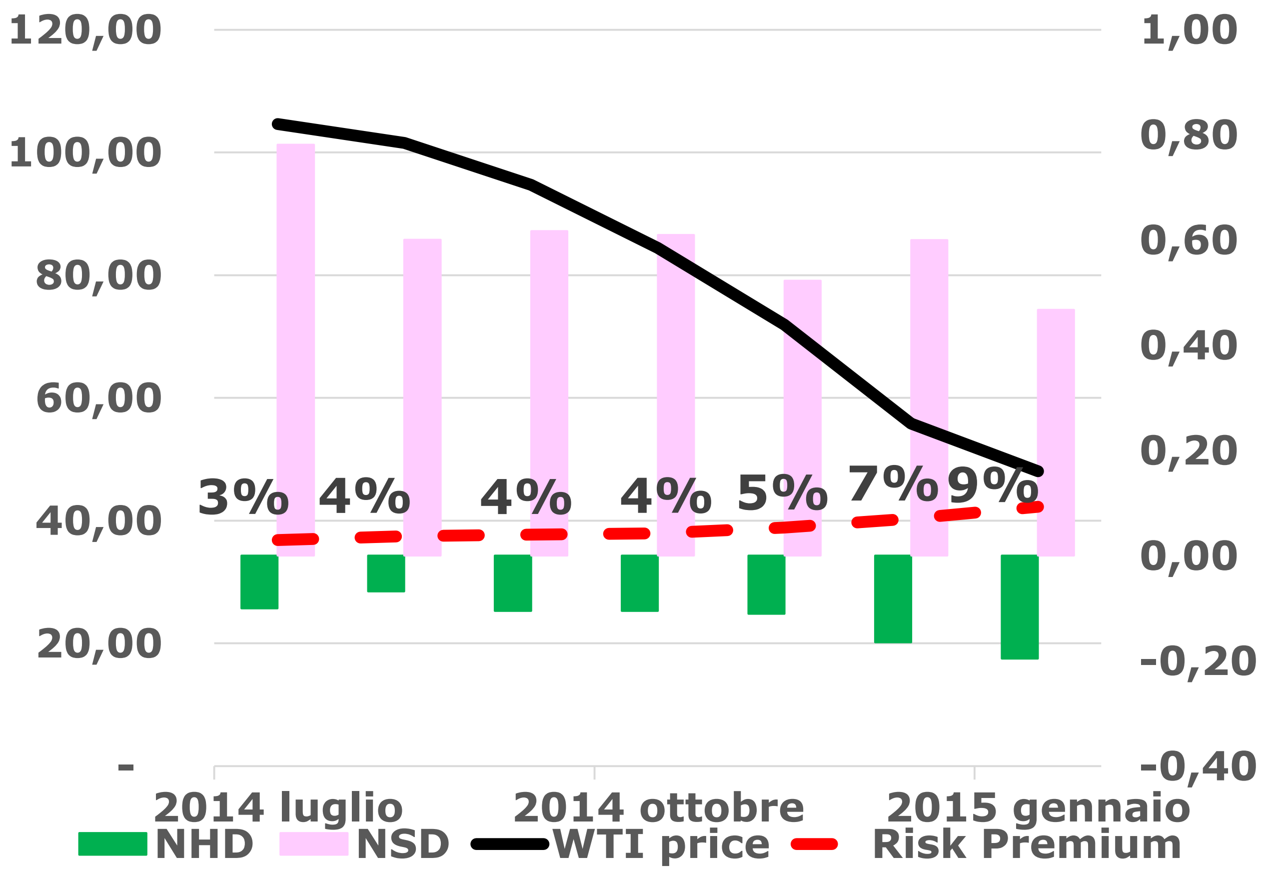
- The large drop in the price of oil between June and December 2014 amounted to $ 56 per barrel.
- In a scenario of bearish market, (a) the spot price declines, (b) the hedging demand increases,

Stylised facts from the observables (3/4)



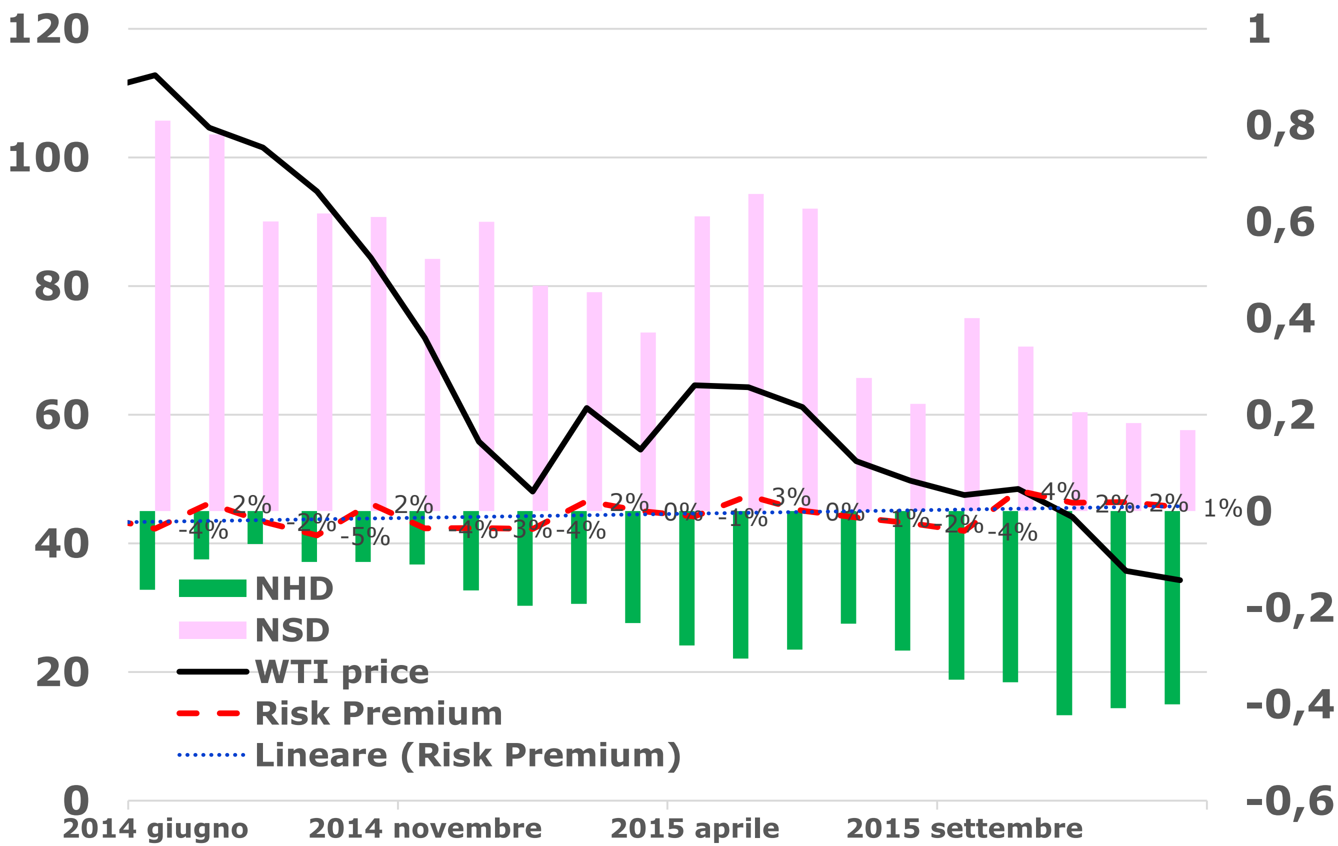
- The large drop in the price of oil between June and December 2014 amounted to $ 56 per barrel.
- In a scenario of bearish market, (a) the spot price declines, (b) the hedging demand increases, (c) the net speculative demand slows down

Stylised facts from the observables (4/4)



- The large drop in the price of oil between June and December 2014 amounted to $ 56 per barrel.
- In a scenario of bearish market, (a) the spot price is falling down, (b) the hedging demand increases, (c) the net speculative demand slows down and (d) the risk premium increases.

Stylised facts from the observables



- In a scenario of bearish market (June 2014-January 2016), (a) the spot price declines, (b) the hedging demand increases, (c) the net speculative demand declines (d) the risk premium increases (from (min:-4%) to (max 4%)) .

Data and Variables

- Time-series monthly data (1983:4-2016:7).
- Two types of variables are employed the: *aggregate oil market variables* the *risk premium oil market predictors*
- **Aggregate oil market variables:**
  1. The percent change in global crude oil production (q_t)
  2. The real economic activity measure (rea_t) - Kilian's index
     - ✓ proxy for changes in volume of shipping of industrial materials
     - ✓ "*global*", "*leading*" and "*monthly*"
  3. Global real price of crude oil (p_t)
     - ✓ US Refiner's Acquisition Cost for crude oil imported (RACi)
  4. The risk premium (rp_t) refers to WTI futures market
     - ✓ It is not observable but it can be estimated from the data through two different methods:
       1. Gaussian affine term-structure model as developed by Hamilton and Wu (2014)
       2. Multivariate linear regression model

Data and Variables (2/3)

- **Risk premium oil market variables:**
- Dependent variable is the excess long return $er_{t+3} = ln\left(\frac{S_{t+3}}{F_{t,3}}\right)$
  1. S_{t+3} is the spot price of crude oil in three month time
  2. $F_{t,3}$ is the current oil futures price with maturity 3 months
- Predictors:
  1. Composite leading indicator (cli_t)
  2. US change in industrial production index (cip_t)
  3. Junk bond spread (jbs_t) (Baa-Aaa)
  4. Change default premium (cdp_t) (Baa-10yTcmr)
  5. Change term structure (cts_t) (10yTcmr-TB3m)
  6. US Inflation ($infl_t$)
  7. US Unexpected inflation (ui_t)
  8. US Expected inflation (ei_t)
- The risk premium regressions are based on these three specifications:

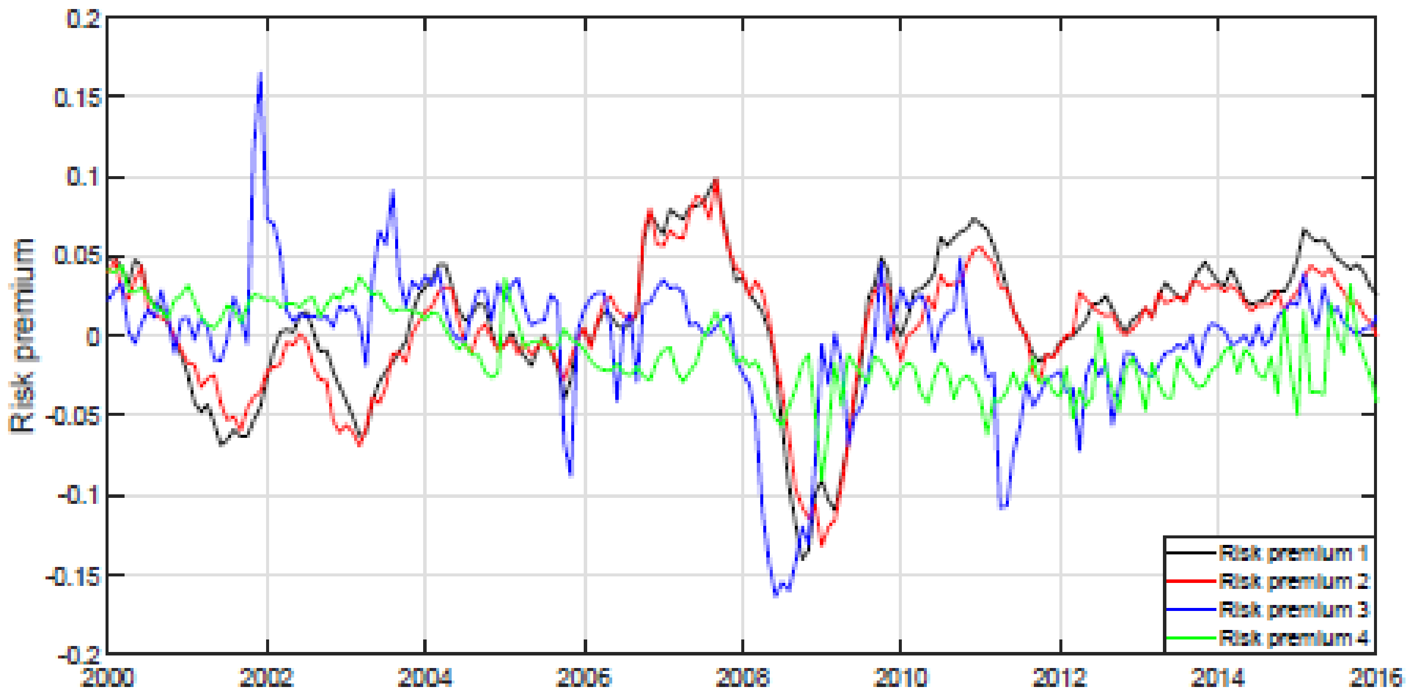
$$rp_{t+3}{}^{(1)} \equiv \widehat{er_{t+3}} = \hat{\alpha}^{(1)} + \widehat{\beta_1}^{(1)} inf_t + \widehat{\beta_2}^{(2)} jbs_t + \widehat{\beta_3}^{(3)} cli_t \qquad for\ t = 1, \dots, 400$$

$$rp_{t+3}{}^{(2)} \equiv \widehat{er_{t+3}} = \hat{\alpha}^{(2)} + \widehat{\beta_1}^{(2)} ui_t + \widehat{\beta_2}^{(2)} cts_t + \widehat{\beta_3}^{(2)} cli_t \qquad for\ t = 1, \dots, 400$$

$$rp_{t+3}{}^{(3)} \equiv \widehat{er_{t+3}} = \hat{\alpha}^{(3)} + \widehat{\beta_1}^{(3)} ei_t + \widehat{\beta_2}^{(3)} cdp_t + \widehat{\beta_3}^{(3)} cip_t \qquad for\ t = 1, \dots, 400$$

Data and Variables (3/3)

- $\hat{\alpha}$ and $\hat{\beta}$ represent are coefficients consistently estimated by OLS.
- All p-values reject the null hypothesis of the Clark and West (2007) test.



- Two basic features emerge:
  - ✓ First, significant similarities between the pairs of risk premium estimates.
  - ✓ Second, on average risk premia document a systematic downward shift in their level.

Methodology – Bayesian Structural VAR model

- The B-SVAR model with 24 lags is the following:

$$Ay_t = \mathrm{c} + \sum_{j=1}^{24} B_j \, y_{t-j} + v_t$$

- A is a (4X4) matrix of instantaneous structural parameters
- y_t is a (4X1) vector of endogenous variables that is $y_t = (q_t, rea_t, p_t, rp_t)'$
- c is a (4X1) vector of constant terms
- B_j is a (4X4) matrix of lagged coefficients

- v_t is a (4X1) vector of structural shocks with the following meaning:
  - ✓ v_{qt} : unexpected oil supply shock.
  - ✓ v_{reat}: unexpected aggregate demand shock.
  - ✓ v_{pt}: unexpected precautionary demand shock.
  - ✓ v_{rpt}: unexpected residual shock

Methodology – Meaning of the structural shocks

1. A *"negative supply shock"* represents a shift to the left of the contemporaneous oil supply curve along the oil demand curve.
   - ✓ Example: wars, strikes instability of oil supply in the Middle East. OPEC strategic decisions.

2. *A "positive aggregate demand shock"* represents a shift to the right of the contemporaneous oil demand curve along the oil supply curve mainly driven by fluctuations in the global business cycle.
   - ✓ Example: crude oil demanding from China and India

3. A *"positive precautionary demand shock"* represents a shift to the right of the contemporaneous oil demand curve along the oil supply curve mainly driven by an increase in the demand for storage.
   - ✓ Example: Expectations on rises in oil prices cause an upward shift of the demand for storage, for precautionary/speculative purposes.

4. A *"positive risk premium shock"* is the residual shock
   - ✓ Example: increase in the price of risk due to changes in the preferences of oil speculators.

Methodology – Bayesian Structural VAR model

- For the empirical analysis we use a Bayesian SVAR model, with 24 lags proposed by Baumeister and Hamilton (2015b):

$$Ay_t = \mathrm{c} + \sum_{j=1}^{24} B_j\, y_{t-j} + v_t$$

- The structural VAR system representation is the following:

$$\begin{cases} q_t = c_{(q)} + a_{qp} p_t + \widetilde{b_1} x_{t-1} + v_{qt} & (1) \\ rea_t = c_{(rea)} + a_{rea,q} q_t + a_{rea,p} p_t + \widetilde{b_2} x_{t-1} + v_{rea,t} & (2) \\ p_t = c_{(p)} + a_{pq} q_t + a_{p,rea} rea_t + \widetilde{b_3} x_{t-1} + v_{pt} & (3) \\ rp_t = c_{(rp)} + a_{rp} q_t + a_{rp,rea} rea_t + a_{rp,p} p_t + \widetilde{b_4} x_{t-1} + v_{rpt} & (4) \end{cases}$$

  - ✓ $\widetilde{b_1}$ … $\widetilde{b_4}$ are row vectors of structural lagged coefficients referred to the whole system
  - ✓ x_{t-1} is column vector including all lagged values of the observables.

- Following the Bayesian approach we need to specify a set of economic priors beliefs on the element of matrix A.
- Priors on the structural parameters consists of Student t density function.

Methodology – Identification

$$A = \begin{pmatrix} 1 & 0 & -a_{q,p} & 0 \\ -a_{rea,q} & 1 & -a_{rea,p} & 0 \\ -a_{pq} & -a_{p,rea} & 1 & 0 \\ -a_{rp,q} & -a_{rp,rea} & -a_{rp,p} & 1 \end{pmatrix}$$

Parameters	Meaning	Prior mode	scale	Sign restriction
$a_{q,p}$	Short run price elasticity of supply	0.1	0.2	$+$
$a_{rea,q}$	Effect of global oil production on the real economic activity	0	0.1	no
$a_{rea,p}$	Effect of real price of oil on the real economic activity	0	0.5	$-$
$a_{p,q}$	Reciprocal of the short run price elasticity of demand	-3	0.1	$-$
$a_{p,rea}$	Effect of real economic activity on the real price of oil	1.4	0.2	no
$a_{rp,q}$	Effect of production, real economic activity, price of oil On risk premium	0	100	no
$a_{rp,rea}$		0	100	no
$a_{rp,p}$		0	100	no

Empirical Results (1/3)

"Median impulse responses of global oil production, real economic activity and price of oil to oil market shocks."

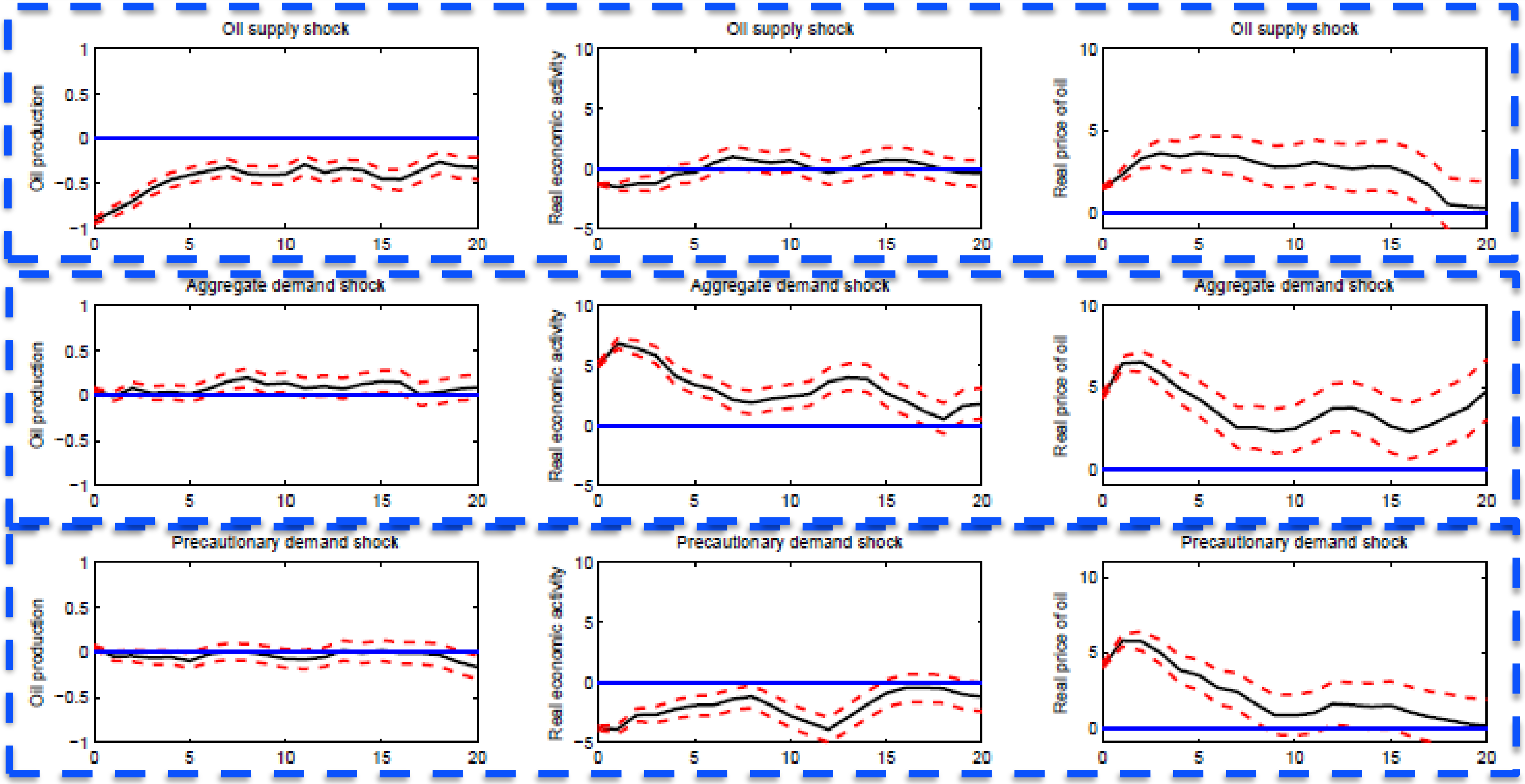


Figure 2. Black lines indicate the Bayesian posterior median path-responses to one-standard deviation structural shocks. Dashed lines indicate the corresponding 68% posterior credible sets

Empirical Results(2/3)

"Median impulse responses of oil risk premium to each shock"

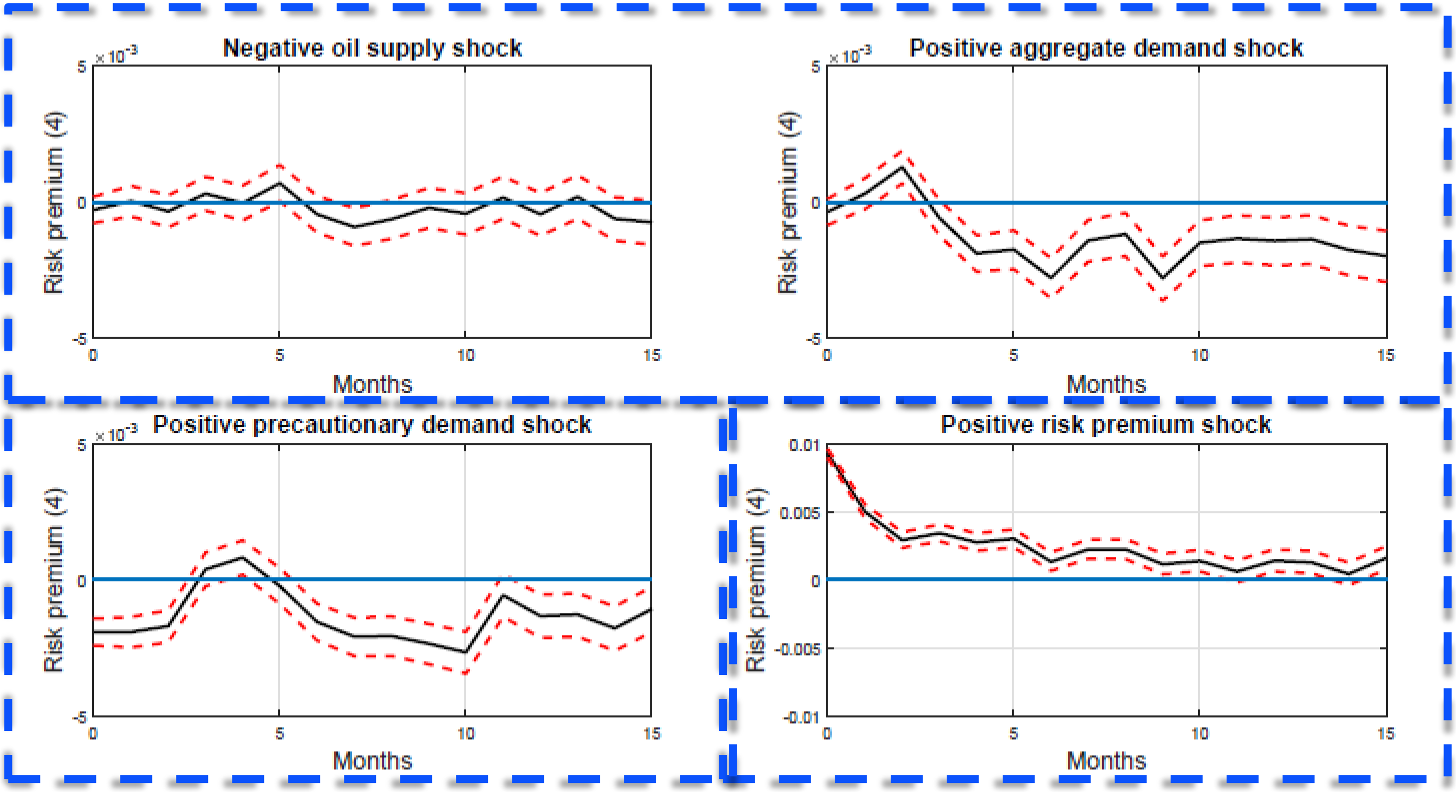
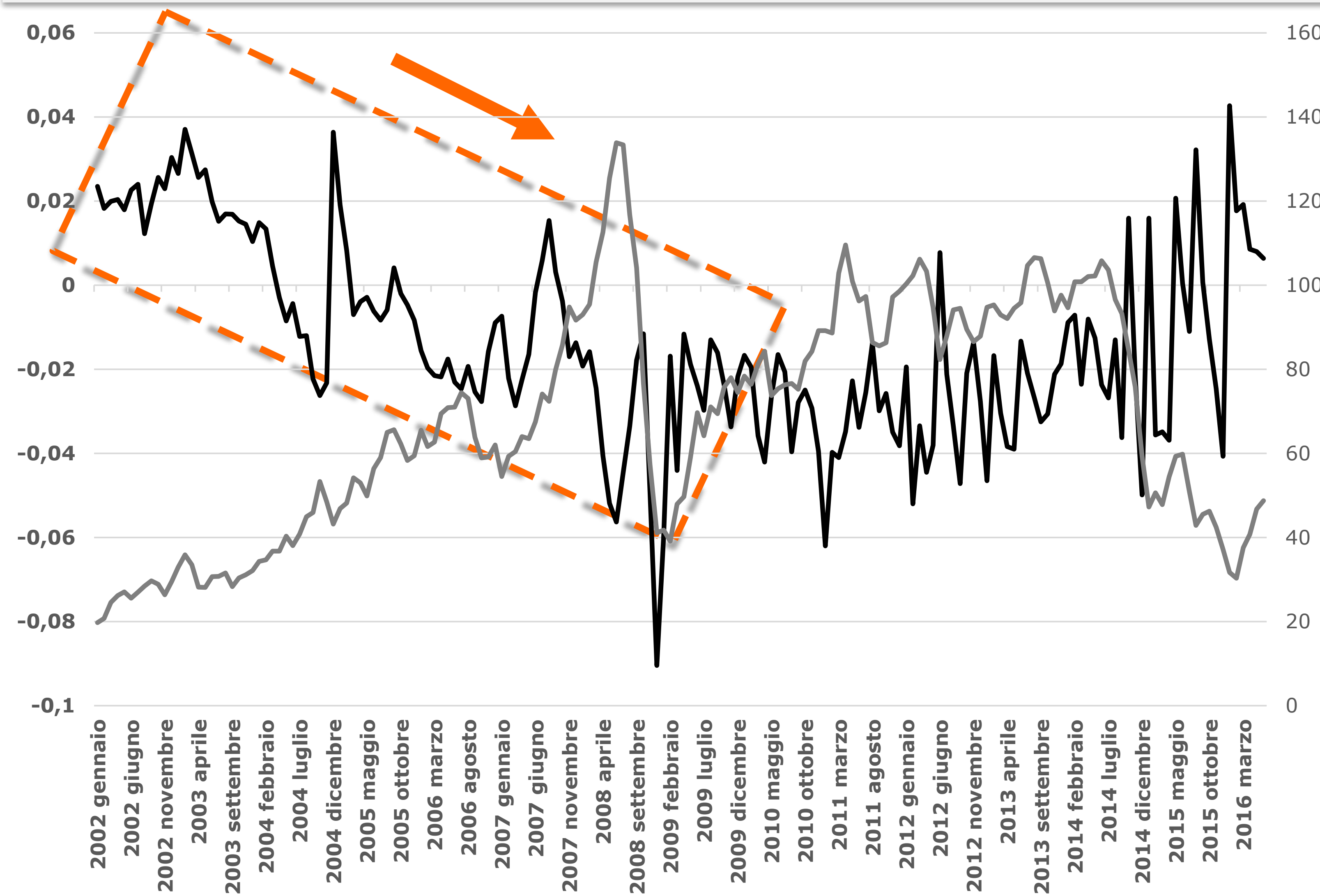


Figure 3. Note: Black lines indicate the Bayesian posterior median path-responses to one-standard deviation structural shocks. Dashed lines indicate the corresponding 68% posterior credible sets

Empirical Results (3/3)

Crude oil risk premium (Hamilton and Wu) vs WTI spot price



Empirical Results (3/3)

"Historical decomposition of crude oil risk premium"

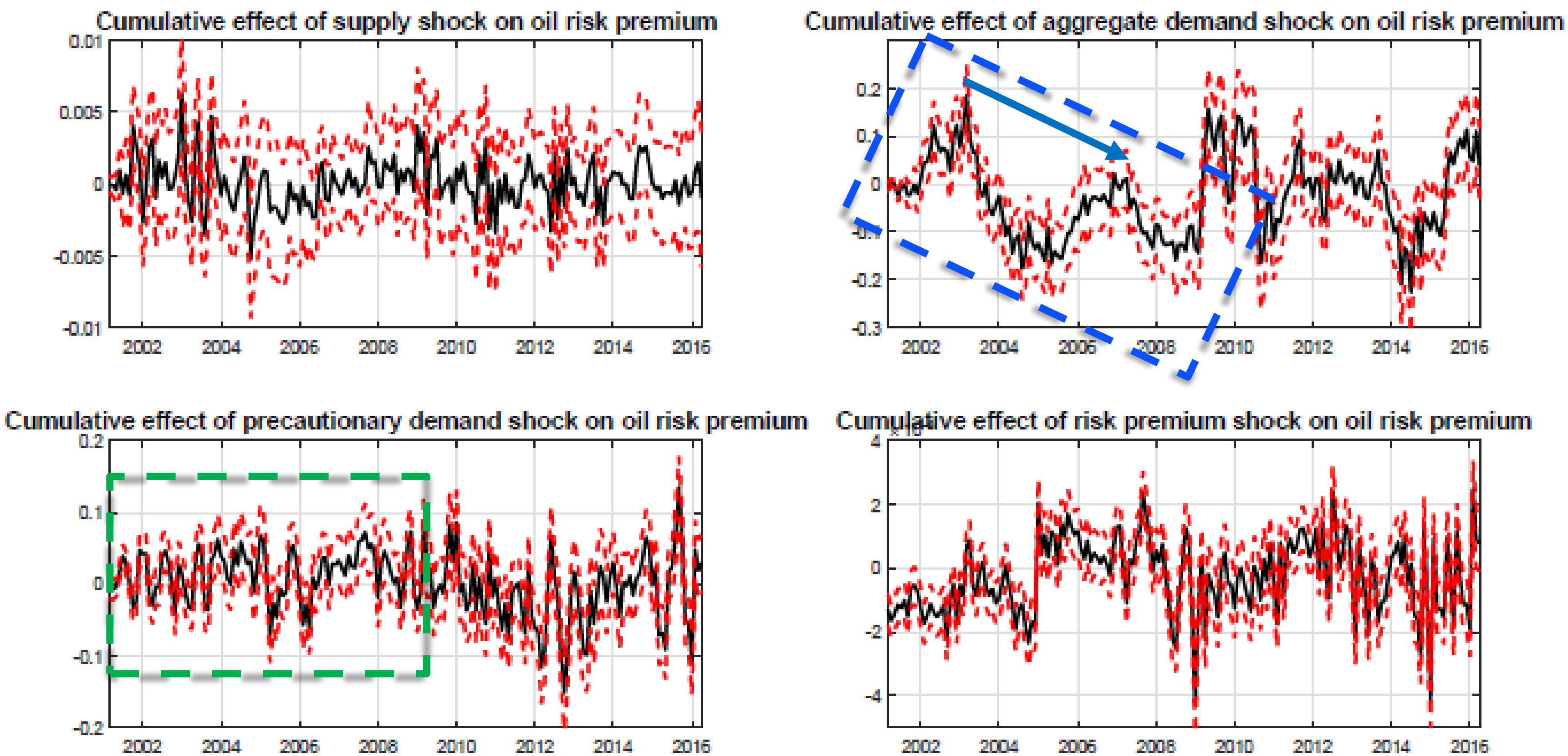
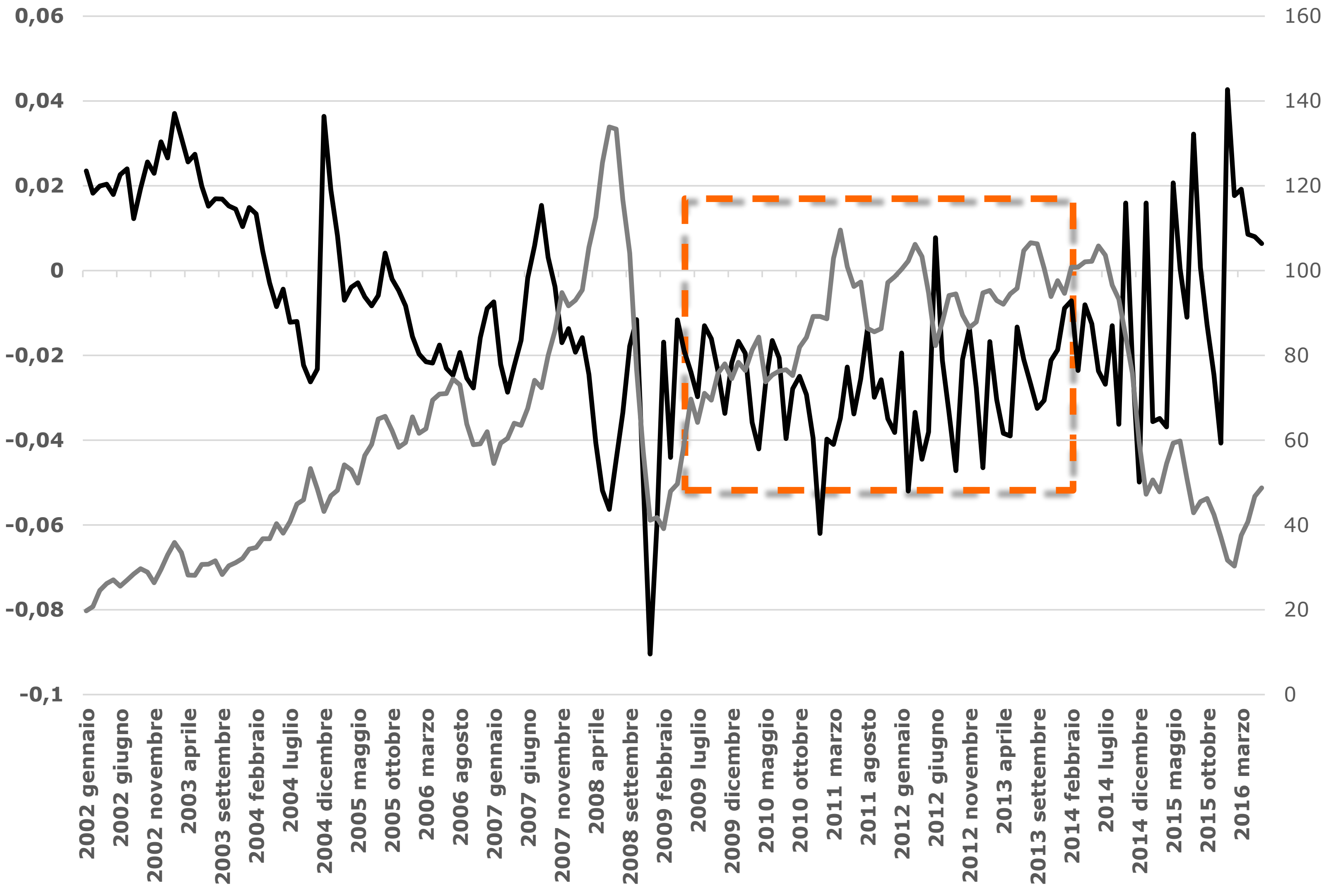


Figure 4. Note: Historical contribution of the structural shocks (black lines) with 64% posterior credible sets (red-dashed lines).

Empirical Results (3/3)

Crude oil risk premium (Hamilton and Wu) vs WTI spot price



Empirical Results (3/3)

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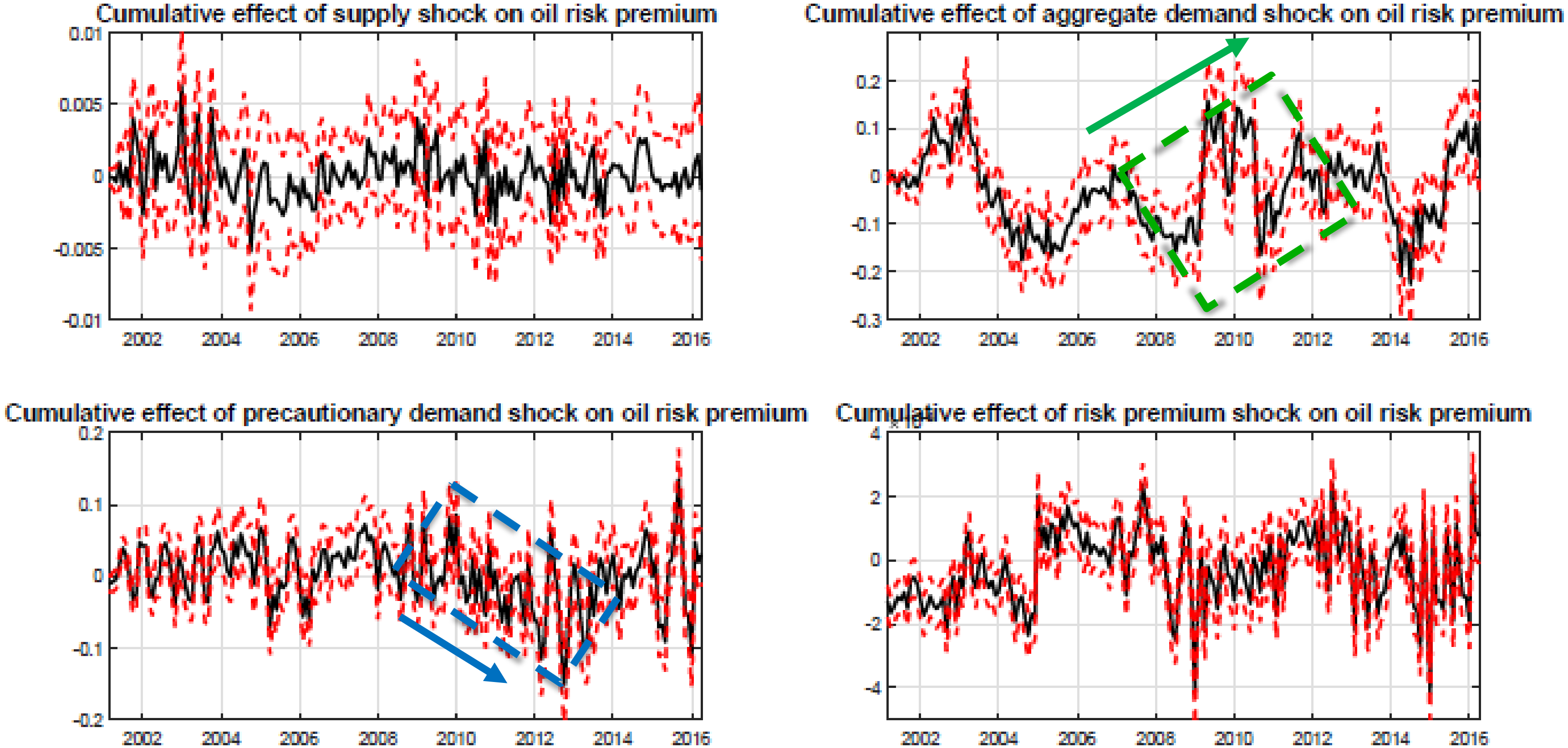

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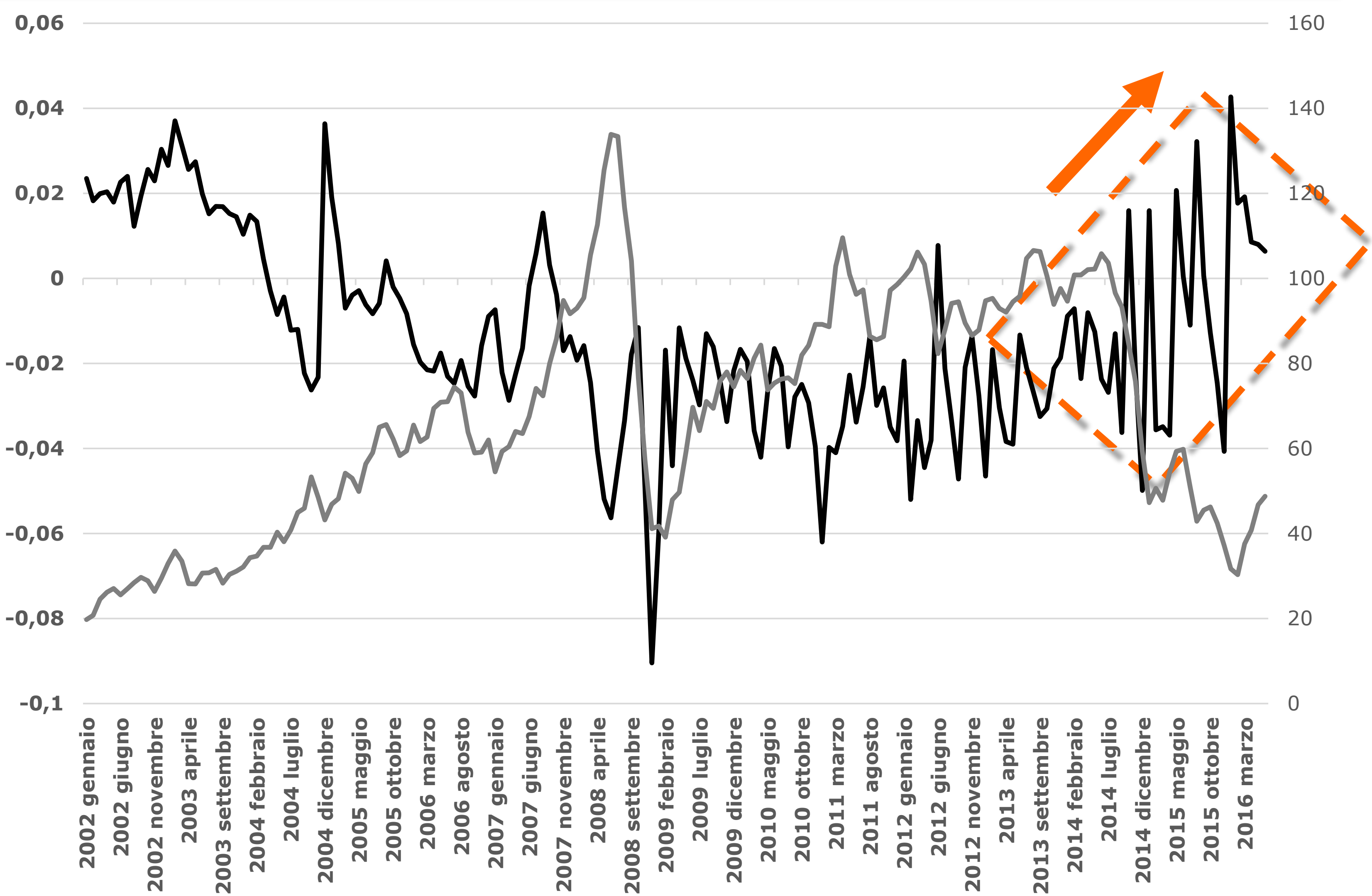

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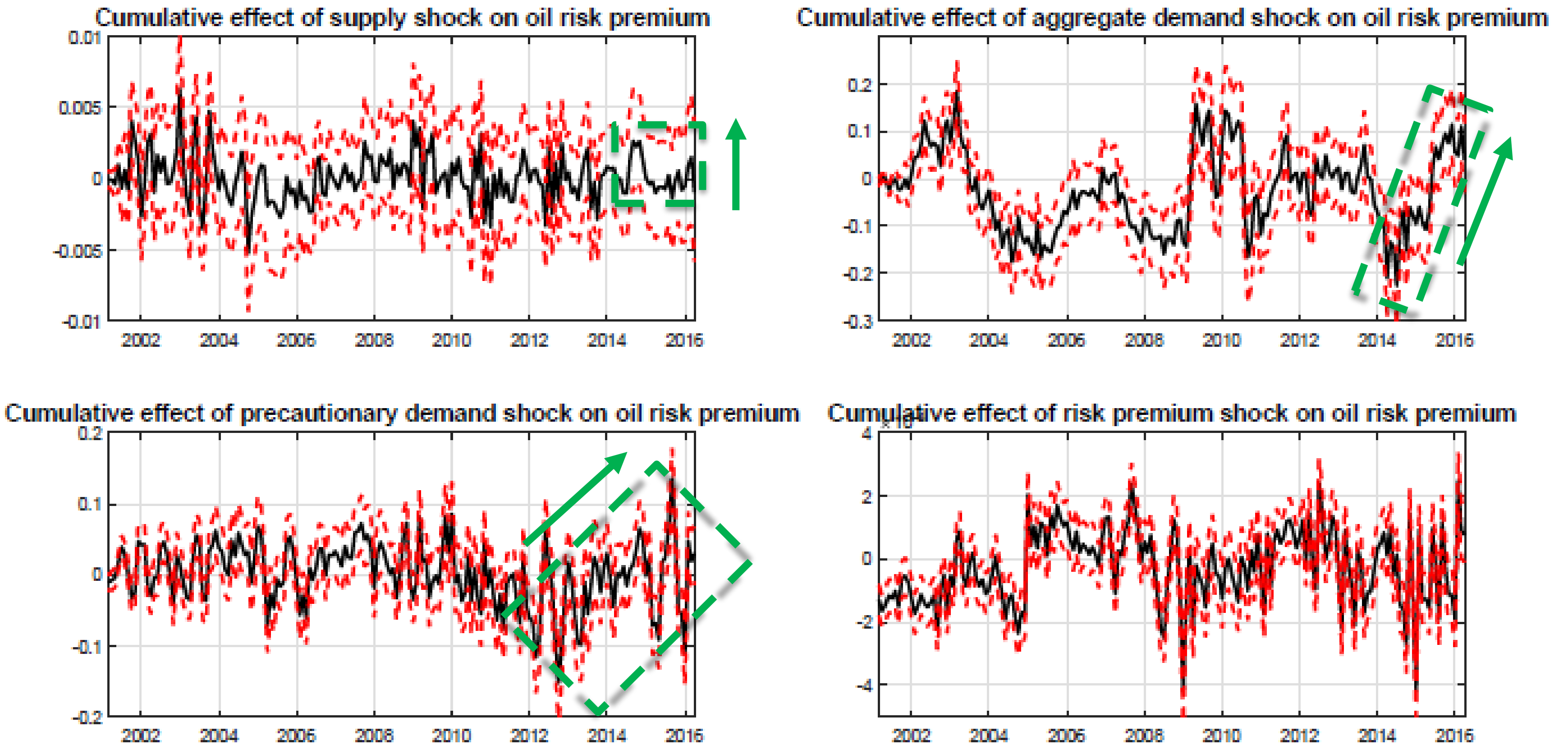

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Empirical Results (3/3)

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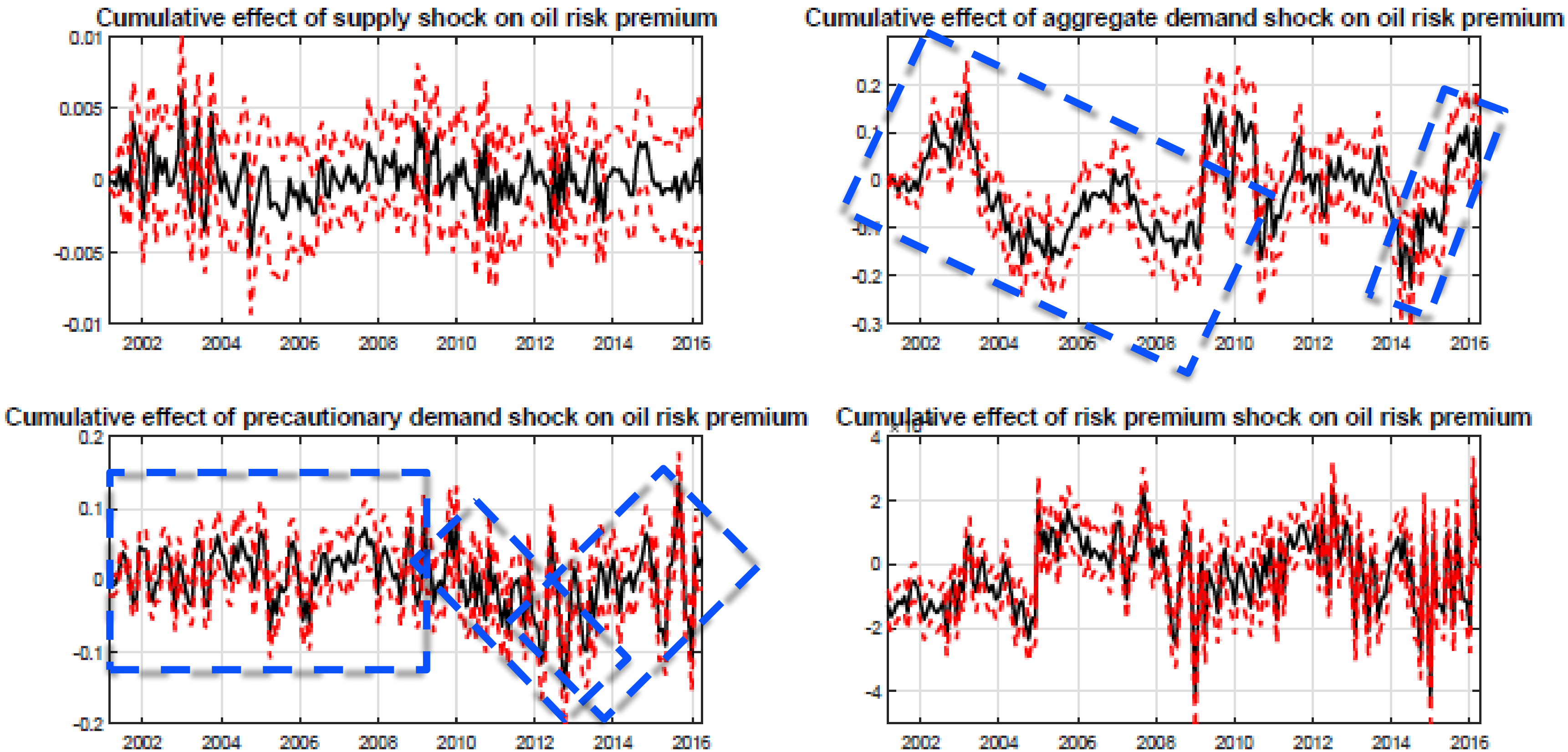

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Conclusions

- Three main conclusions:

- First, we document a negative relationship between changes in oil prices and risk premium. (It holds only for fundamentals shocks)

- Second, on average
  - ✓ The response of oil risk premium to demand shocks are greater (magnitude and persistency) than supply shocks.
  - ✓ The risk premium driven by supply shocks is short-lived
  - ✓ Aggregate and precautionary demand shocks have very similar impact on the oil risk premium.
  - ✓ The risk premium shocks have an instantaneous impact only on the level of the oil risk premium component.

- Third, there is empirical evidence that the historical decline in crude oil risk premium was mainly explained by shocks to aggregate and precautionary demand for oil.

Thank for your attention

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Empirical Results (3/3)

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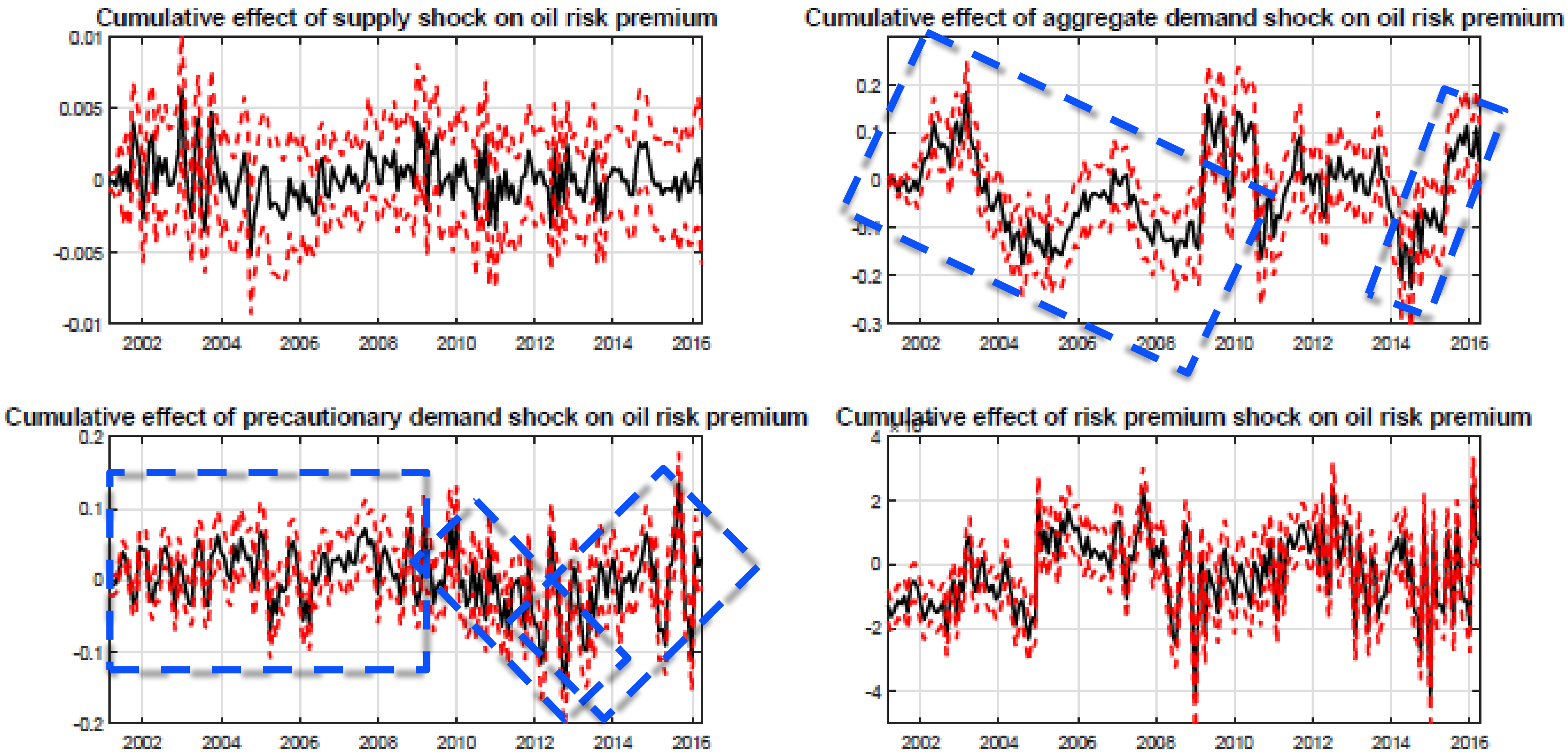

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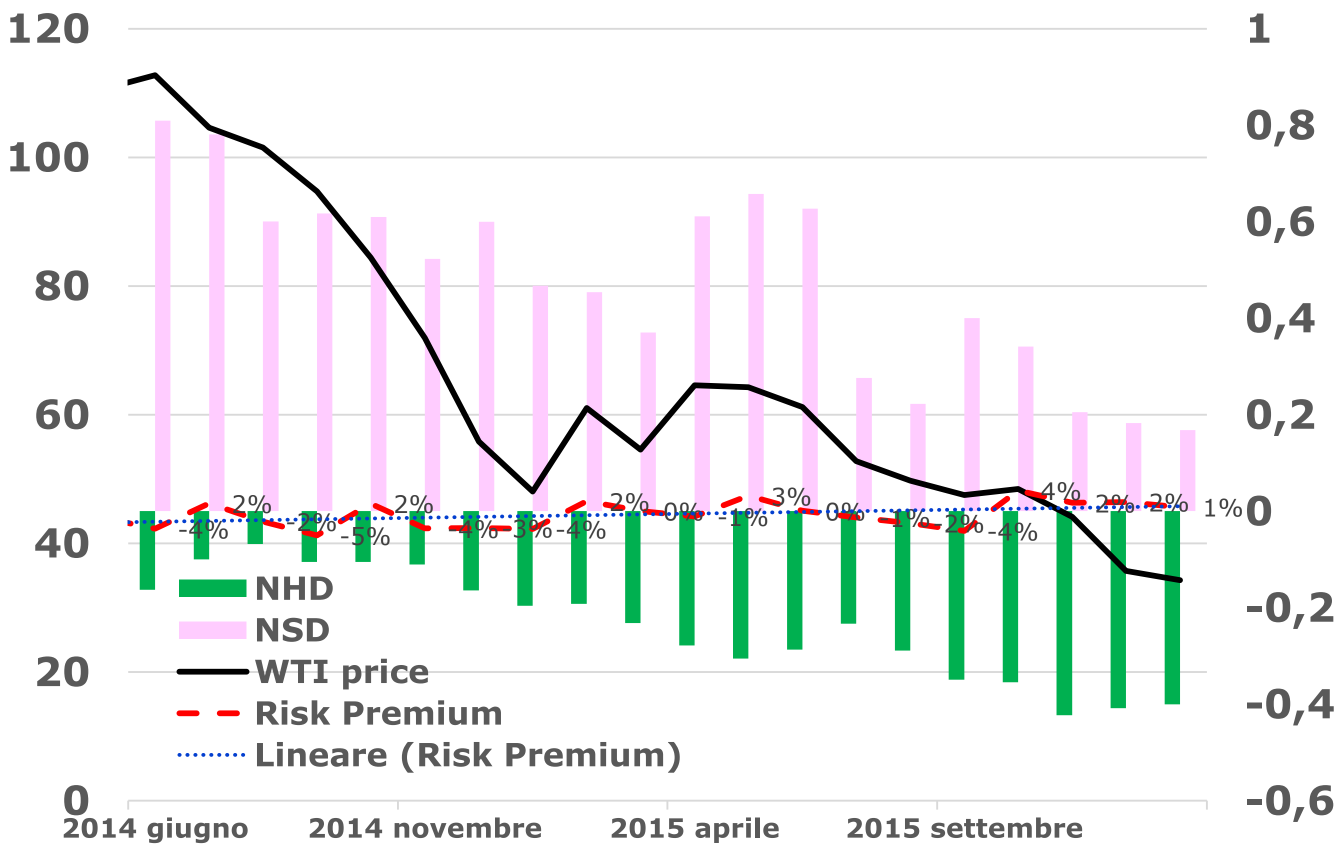
Stylised facts from the observables



- In a scenario of bearish market (June 2014-January 2016), (a) the spot price declines, (b) the hedging demand increases, (c) the net speculative demand declines (d) the risk premium increases (from (min:-4%) to (max 4%)) .

Appendix

Robustness checks

Robustness checks (1/6)

- The first robustness check relies on different estimates of crude oil risk premium.

- Specifically, robustness checks of impact responses of crude oil risk premium to oil market driven shocks show that:
  - ✓ impact responses of crude oil risk premium estimate to demand shocks are greater than supply shocks, consistent with the baseline results.
  - ✓ precautionary and aggregate demand shocks cause qualitatively similar results on the first-three estimates of risk premium.

- Specifically, robustness checks of endogenous variables to different proxies for a positive risk premium shock shows that:
  - ✓ The risk premium is the only variable to increase in response to unanticipated positive risk premium shocks

- The second robustness check relies on a different proxy for global real economic activity

Robustness checks (2/6)

"Median impulse responses of risk premium to oil market shocks"

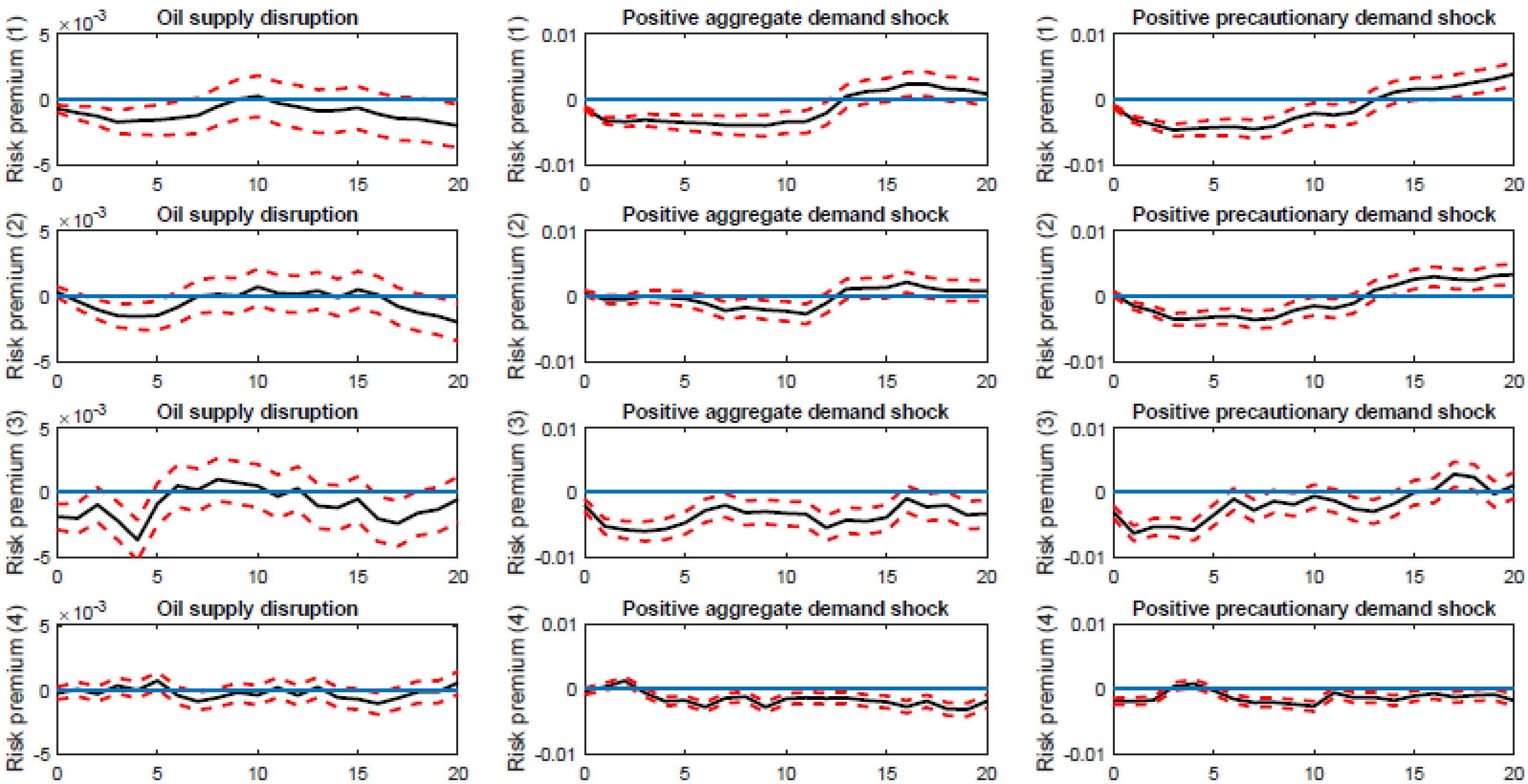


Figure 5. Note: Black lines indicate the Bayesian posterior median path-responses to one-standard deviation structural shocks. Dashed lines indicate the corresponding 68% posterior credible sets

Robustness checks (3/6)

"Median impulse responses of endogenous variables to risk premium shocks"

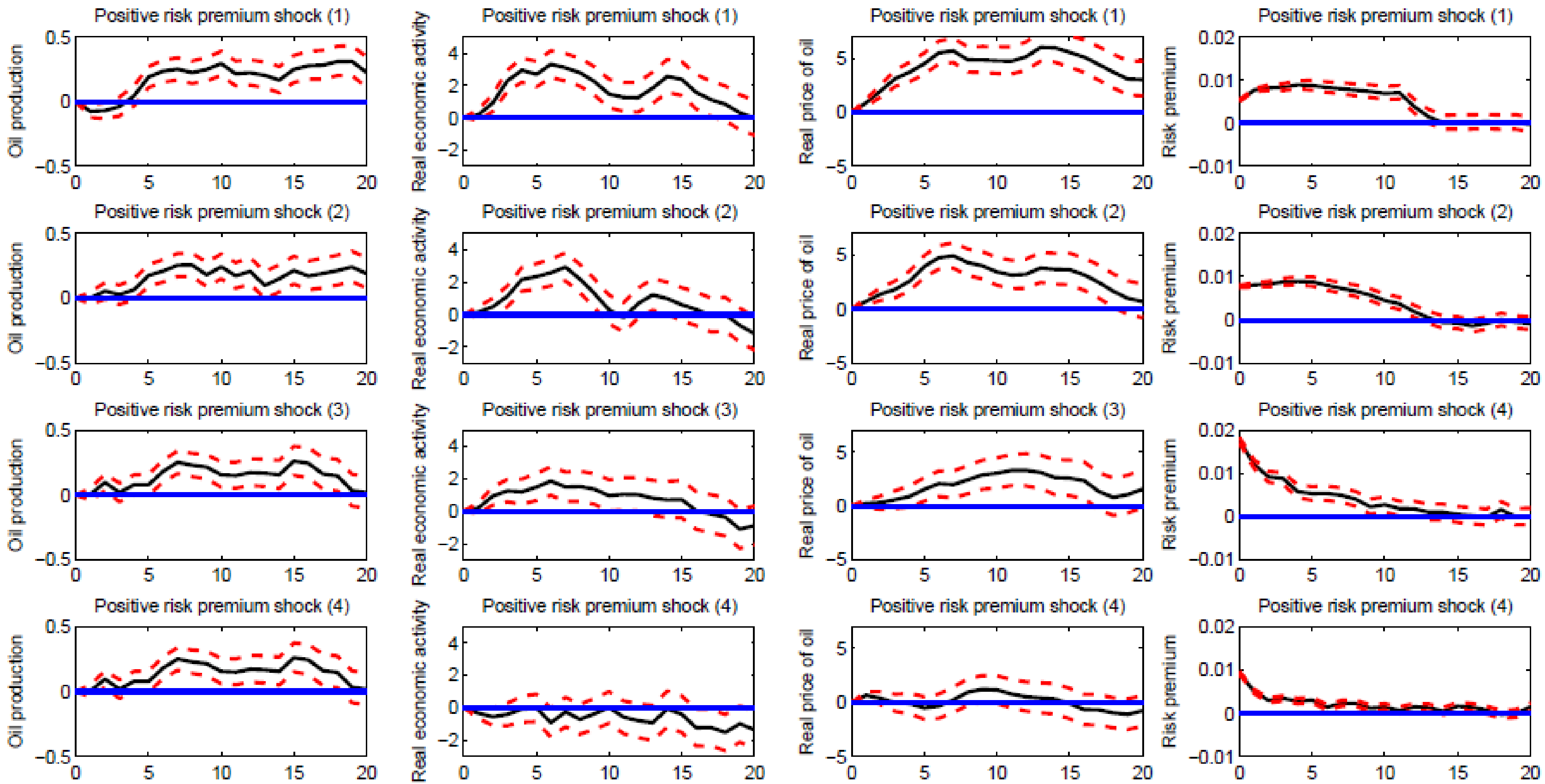


Figure 6. Note: Black lines indicate the Bayesian posterior median path-responses to one-standard deviation structural shocks. Dashed lines indicate the corresponding 68% posterior credible sets

Robustness checks (4/6)

- For the second robustness check we estimate the model by replacing the Kilian's index (rea) with the growth rate of OECD+6 world industrial production index (wip).
- The latter allows us to exploit some prior beliefs on the income elasticity of oil demand given the methodology applied to recover the structural shocks.
- The contemporaneous structural matrix has the following form:

$$A = \begin{pmatrix} 1 & 0 & -a_{q,p} & 0 \\ -a_{wip,q} & 1 & -a_{wip,p} & 0 \\ -a_{pq} & -a_{p,wip} & 1 & 0 \\ -a_{rp,q} & -a_{rp,wip} & -a_{rp,p} & 1 \end{pmatrix}$$

- $a_{wip,q} \rightarrow (c_{wip,q} = 0,\ \sigma_{wip,q} = 0.2,\ \upsilon_{wip,q} = 3)$
- $a_{wip,p} \rightarrow (c_{wip,p} = -0.05,\ \sigma_{wip,p} = 0.2,\ \upsilon_{wip,p} = 3)$
- $a_{p,wip} \rightarrow (c_{p,wip} = 2.1,\ \sigma_{p,wip} = 0.2,\ \upsilon_{p,wip} = 3)$
- $a_{rp,wip} \rightarrow (c_{p,wip} = 0,\ \sigma_{p,wip} = 100,\ \upsilon_{p,wip} = 3)$

Robustness checks (5/6)

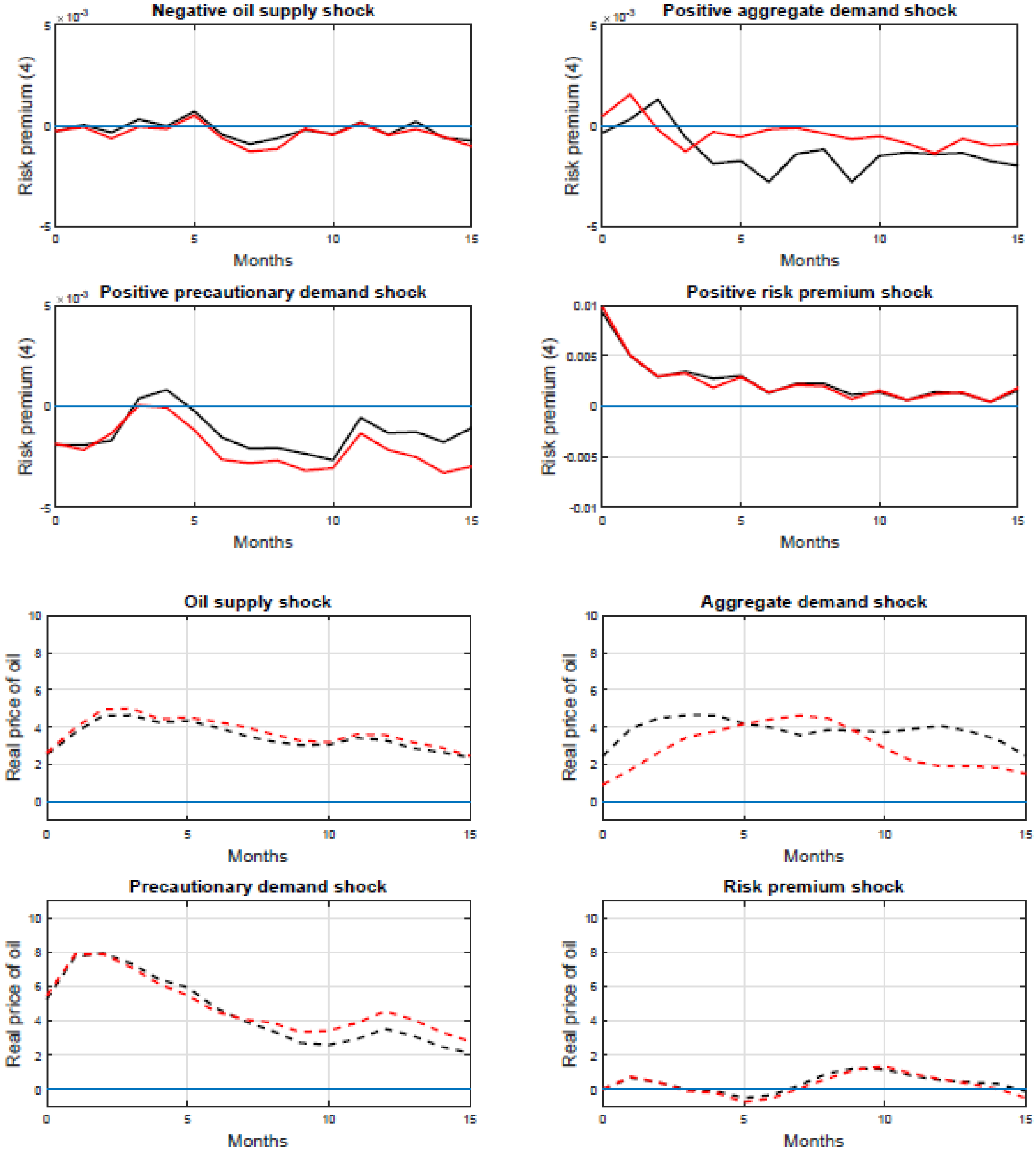


Figure 7.

Robustness checks (6/6)

"Historical decomposition of crude oil risk premium"

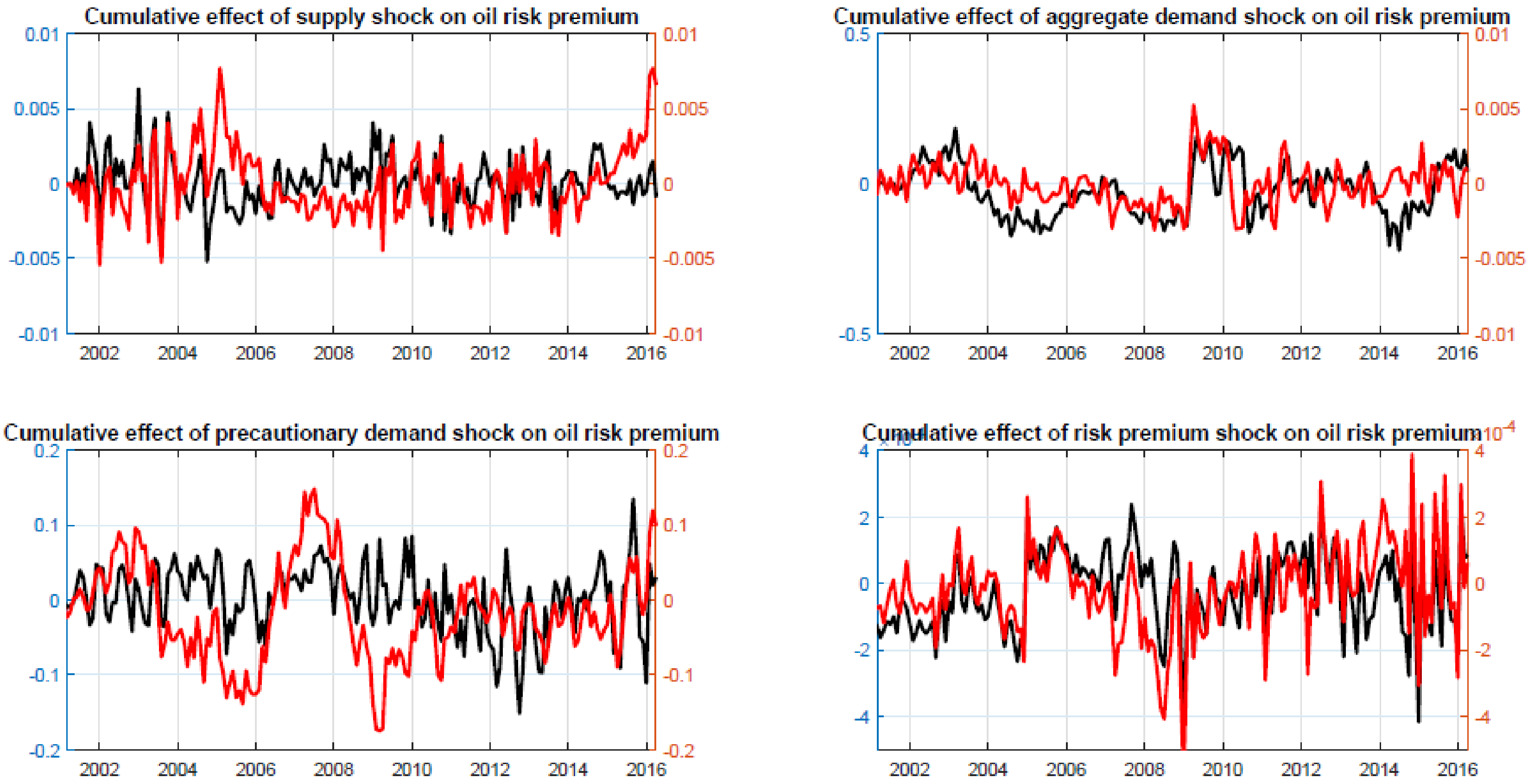
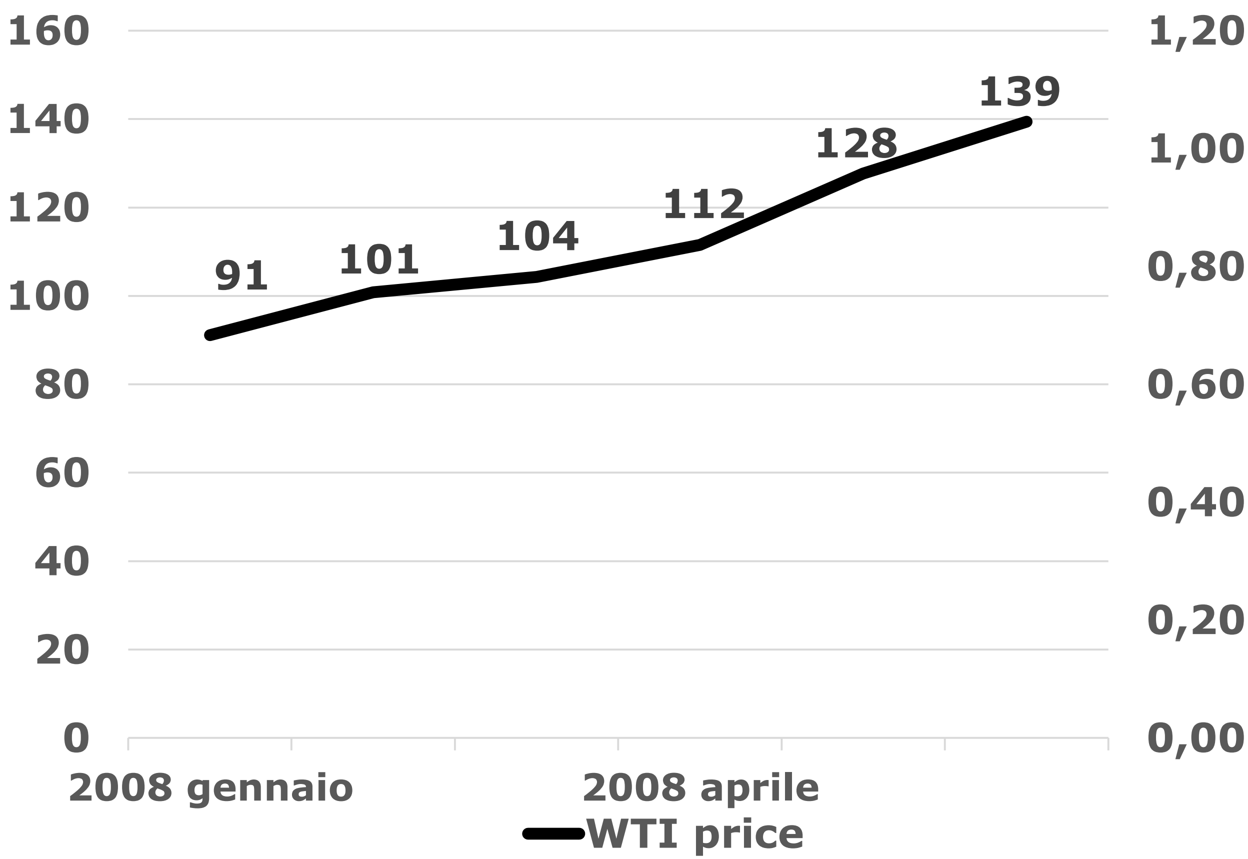


Figure 8. Note: Historical contribution of the structural shocks. Black and red lines refer to cumulative effect of structural shocks on the risk premium implied by the baseline model and alternative model, respectively.

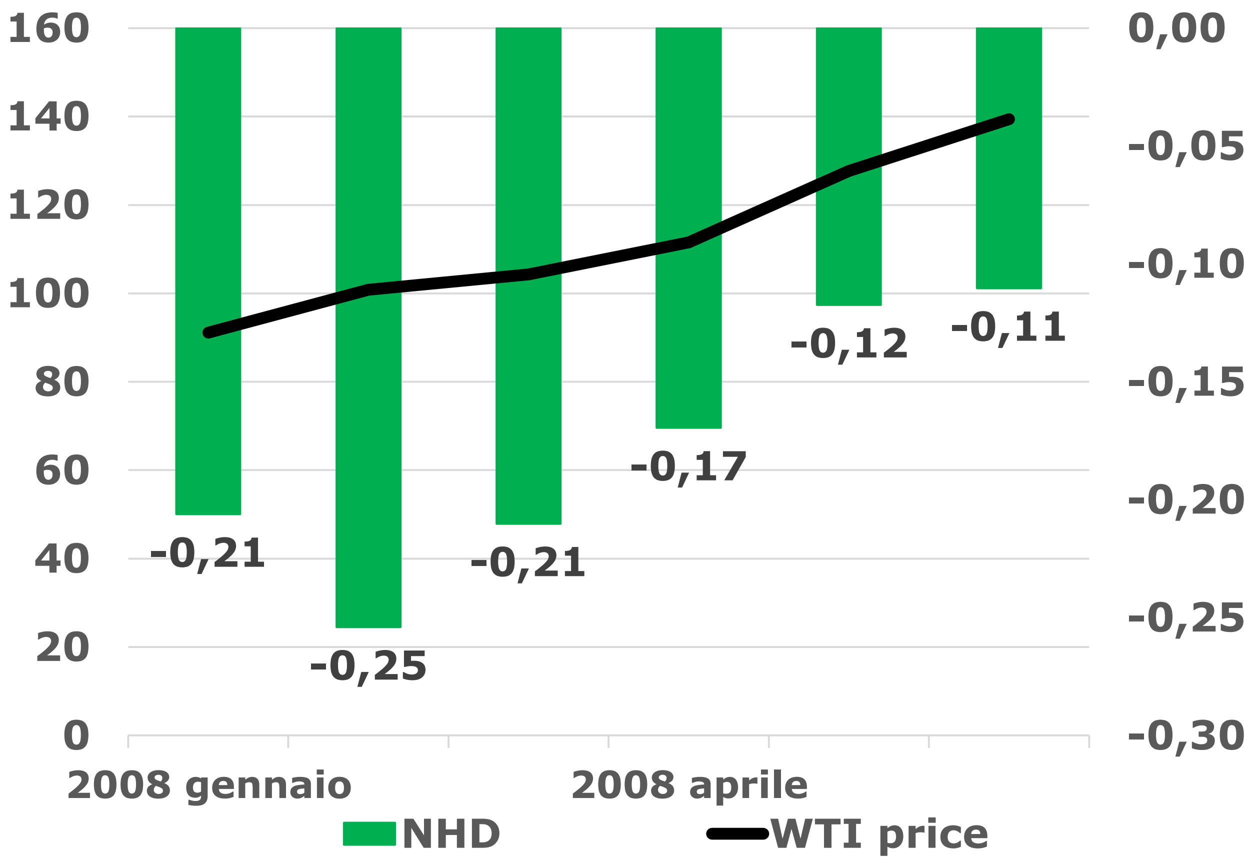
Stylised facts from the observables

Stylised facts from the observables (1/4)



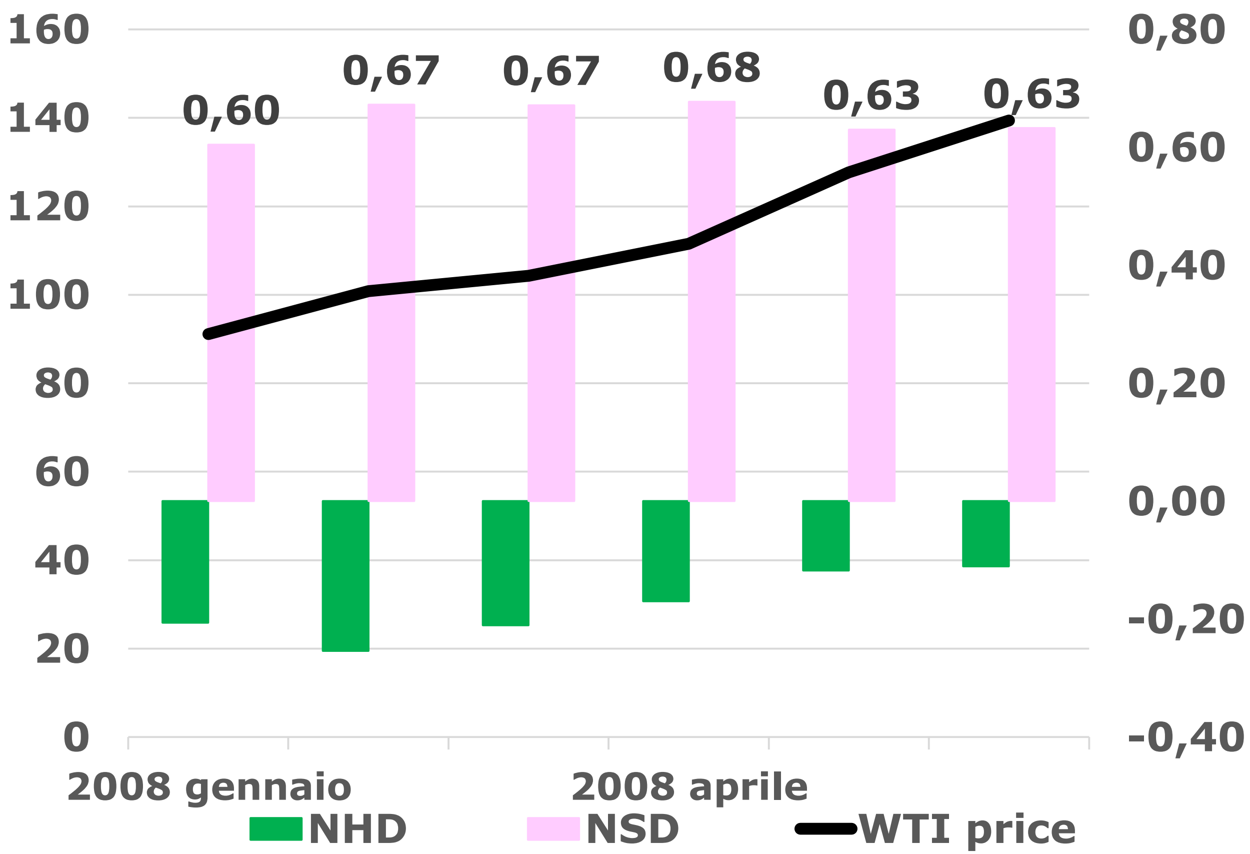
- In the first semester of 2008 the spot price of oil rose sharply and it reached $145 per barrel by July, an all-time high.
- In a scenario of bull market, (a) the spot price is rising

Stylised facts from the observables (2/4)



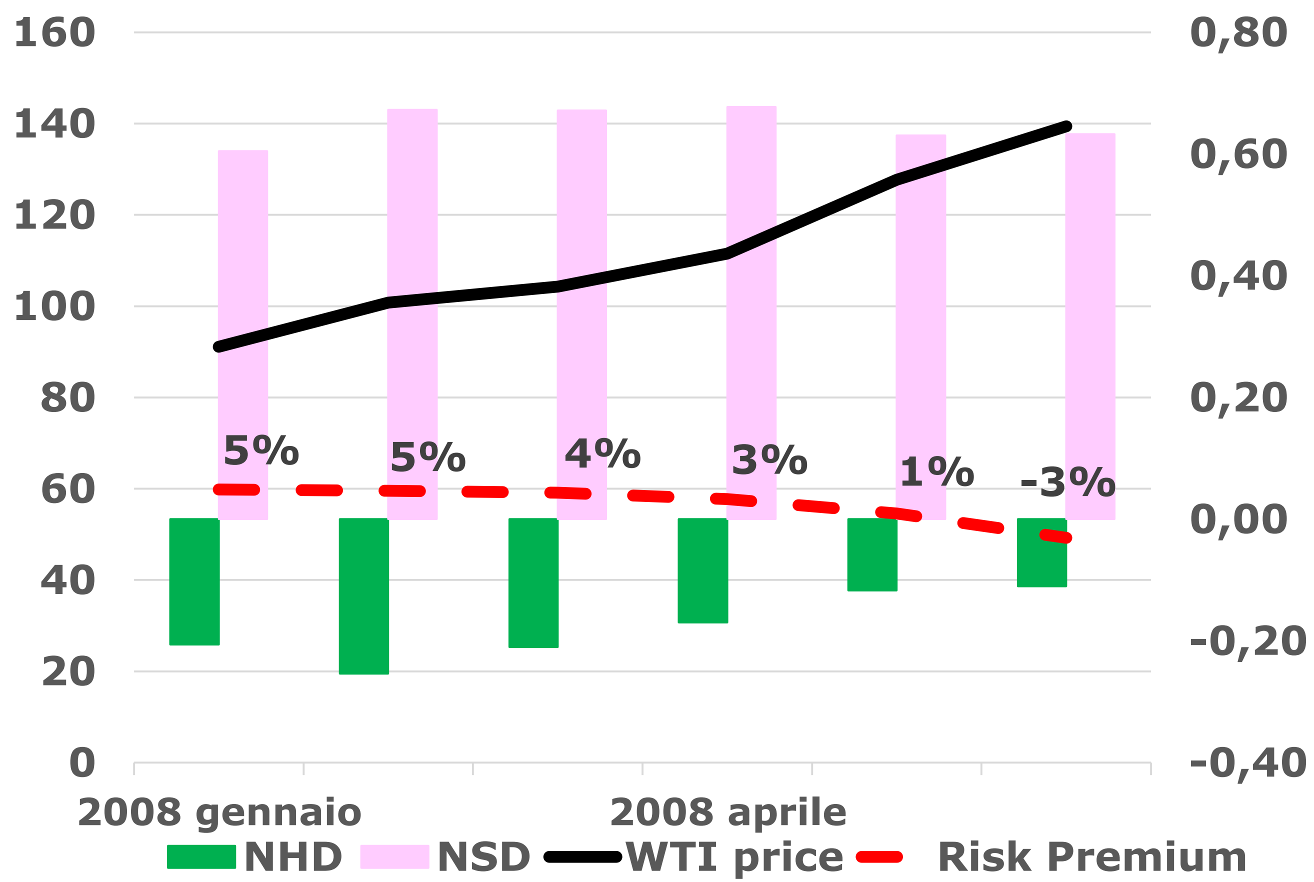
- In the first semester of 2008 the spot price of oil rose sharply and it reached $145 per barrel by July, an all-time high.
- In a scenario of bull market, (a) the spot price is rising, (b) the hedging demand declines

Stylised facts from the observables (3/4)



- In the first semester of 2008 the spot price of oil rose sharply and it reached $145 per barrel by July, an all-time high.
- In a scenario of bull market, (a) the spot price is rising, (b) the hedging demand declines, (c) the net speculative demand is unchanged

Stylised facts from the observables (4/4)



- In the first semester of 2008 the spot price of oil rose sharply and it reached $145 per barrel by July, an all-time high.
- In a scenario of bull market, (a) the spot price is rising, (b) the hedging demand declines, (c) the net speculative demand is unchanged and (d) the risk premium (cost of hedging) declines