Non-linear effects of oil supply news shocks

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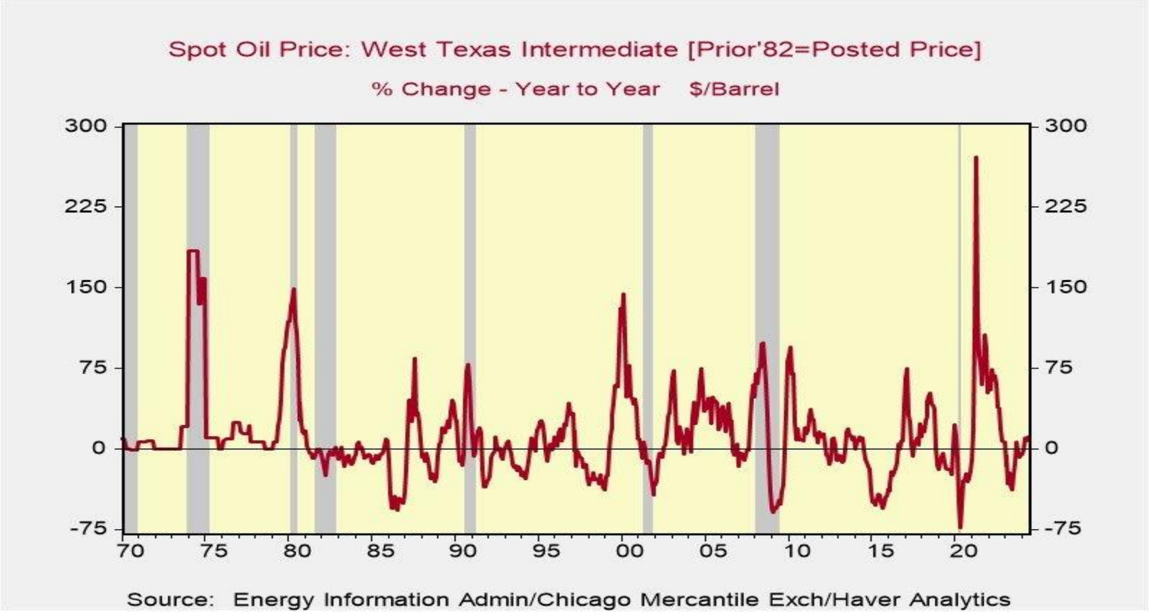
MathWorks Finance Conference
Octomber 2024

We would like to thank Christian Matthes, Lorenza Rossi, Roman Sustek, and Francesco Zanetti for their valuable insights. We also thank the participants of the CEMAP Darham 2024, Lancaster Univerity, and ESM workshops for their comments and suggestions. Konstantinos Theodoridis wants to thank especially Edu Benet Cerda from Mathworks for making Dynare compatible with the Matlab Job Scheduler.

The views expressed in this presentation are those of the authors and do not necessarily represent those of the ESM or ESM policy

Motivation I



Motivation II

Monetary Policy in the Face of Large Shocks. Speech by Silvana Tenreyro, July 2023, BoE

Differences in the size, as well as in the timing of the energy shock, are a primary reason for different inflation dynamics across regions.

Big Shocks Travel Fast: Why Policy Lags May Be Shorter Than You Think. Speech by Christopher J. Waller, FED Board, July 2023

There are a lot of reasons to think that "big shocks travel fast" meaning they elicit a change in economic behaviour that would not be associated with small shocks

Geopolitics: New Era

Especially for the euro area

Questions

- Are Small (favourable) versus sizeable (adverse) oil shocks alike?
- If not, what explains the different transmission of the shocks?
- Do large oil supply shock leads to (proportionally) larger increases in CPI?
- What are the monetary policy implications (if any)?

What we do in this paper

1. We assess the nonlinear transmission of oil supply news shocks
2. We introduce a novel algorithm for a (Bayesian) Threshold VAR model, identified with instrumental variables
3. Employing the instrument proposed by Känzig (2021), we identify oil news shocks
4. We develop a theoretical model and Predictive Prior Analysis to identify the transmission mechanism of stylised facts

Findings

1. We find that adverse oil shocks have a (size and sign) non-linear impact on the economy

2. Real activity and labour market (extensive margin) variables display non-linearities consistently

3. Interestingly (and in contrast to our prior beliefs), prices, financial variables, uncertainty and monetary policy display no nonlinearities

4. A Model with Epstein-Zin Preferences, Search & Matching frictions (endogenous separation) and "rare disaster" concerns is able to replicate the pattern of nonlinearities seen in the data (Petrosky-Nadeau et al. (2018a))

5. Search & Matching frictions give rise to size shock-dependent precautionary saving motives due to the risk of becoming unemployed

Relation to the literature

1. **Empirical Studies:** Hamilton (1983), Mork (1989), Kilian and Vigfusson (2011), Herrera et al. (2015), Hamilton (1994), Hamilton (1996), Bernanke et al. (1997), Kilian and Murphy (2014), Baumeister and Hamilton (2019), Caldara et al. (2019), Känzig (2021).

2. **RANK DSGE Models:** Rotemberg and Woodford (1996), Davis and Haltiwanger (2001), Blanchard and Gali (2007), Krause and Lubik (2007), Leduc and Sill (2004), Leduc et al. (2023), Gagliardone and Gertler (2023)

3. **Endogenous Uncertainty:** Petrosky-Nadeau et al. (2018b), Mumtaz and Theodoridis (2020), Bernstein et al. (2024) and Bernstein et al. (2024)

4. **Addressing Shimer' critic:** Hall (2017), Kilic and Wachter (2018), Kehoe et al. (2023)

5. **HANK DSGE Models & Precautionary Savings:** Auclert et al. (2023), Gnocato (2024a), Gnocato (2024b)

A Theshold Proxy VAR model

$$Y_t = \sum_{j=1}^{M} \left(B_j X_t\right) \mathscr{I}\left(S_t = j\right) + u_t \tag{1}$$

$$var\left(u_t\right) = \Sigma_t = \sum_{j=1}^{M} \mathscr{I}\left(S_t = j\right) \odot \Sigma_j \tag{2}$$

$$S_t = 1 \Longleftrightarrow \tilde{o}_{t-d} \leq o^* \tag{3}$$

$$S_t = 2 \Longleftrightarrow o^{**} \geq \tilde{o}_{t-d} > o^* \tag{4}$$

$$S_t = 3 \Longleftrightarrow \tilde{o}_{t-d} > o^{**} \tag{5}$$

where the threshold variable $\tilde{o}_t$ is the annual growth in real oil price o_t.

Identification with instruments

$$\Sigma_t = (A_t q)(A_t q)' \tag{6}$$

$$\varepsilon_t = A_{0,t}^{-1} u_t, \tag{7}$$

where $A_{0,t} = A_t q$.

- Following Känzig (2021) we identify an oil supply news shock.
- To do this, we employ an instrument m_t described by the following equation:

$$m_t = \beta \varepsilon_{1t} + \sigma v_t, \quad v_t \sim \mathcal{N}(0,1) \tag{8}$$

where $\mathbb{E}(v_t \varepsilon_t) = 0$. The instrument is assumed to be relevant ($\beta \neq 0$) and orthogonal to other structural shocks ($\mathbb{E}(m_t \varepsilon_{\cdot t}) = 0$).

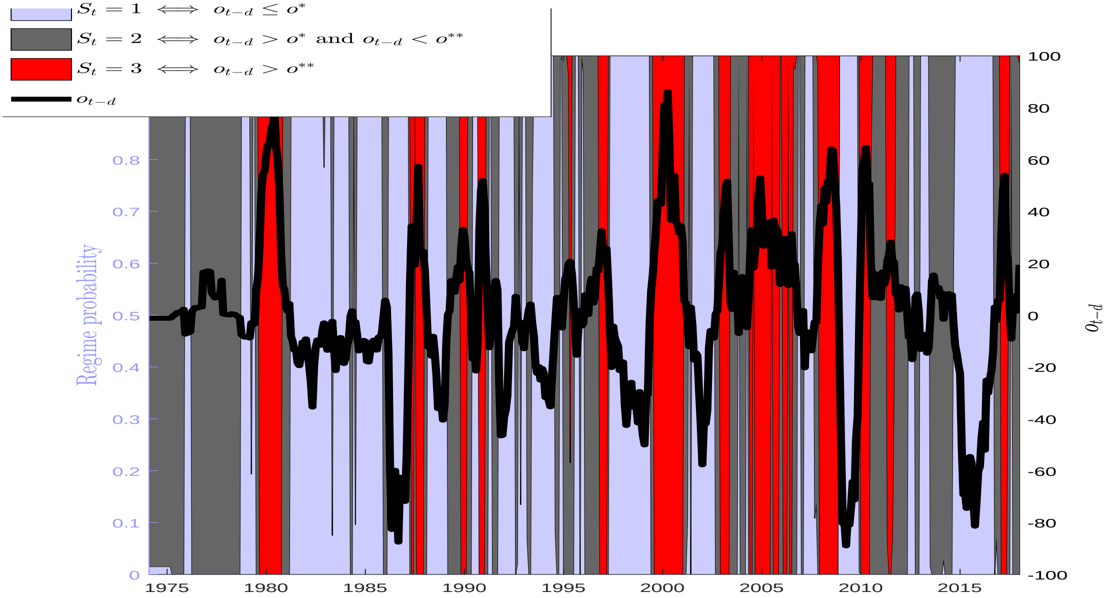
Estimation and Model selection

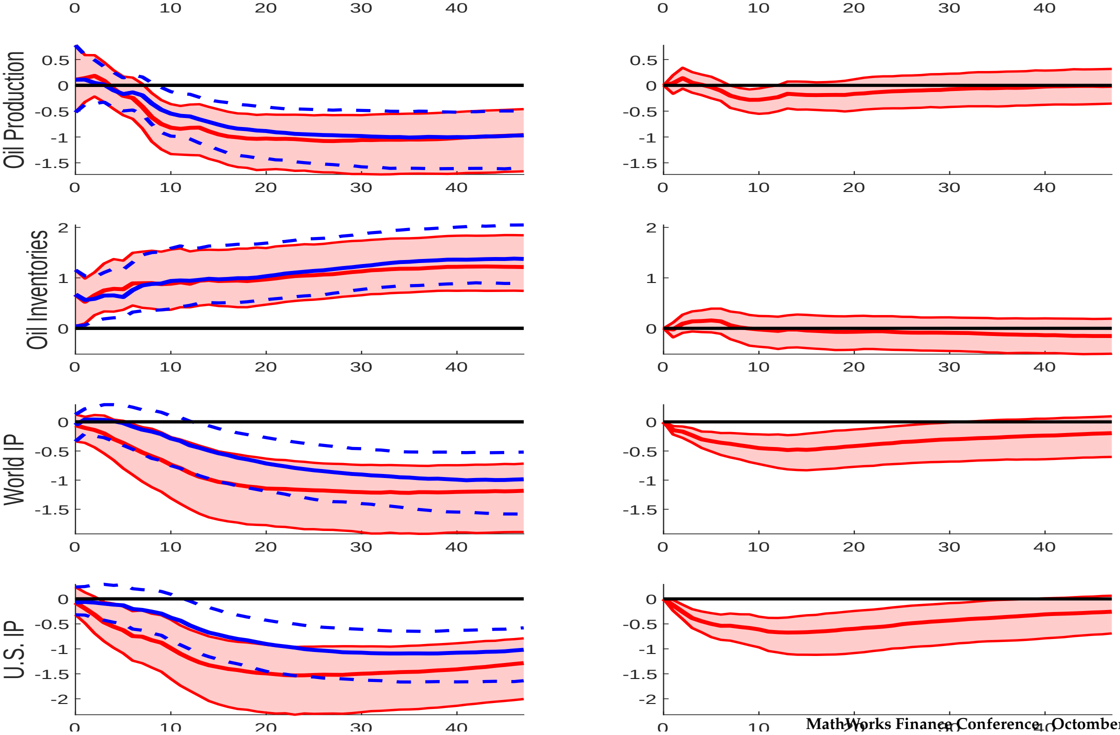
- The model is estimated using Bayesian methods.
- The algorithm exploits the fact that conditional on the value of the thresholds o^* and o^{**}, the model collapses to a sequence of Bayesian Proxy SVARs.
- We apply the algorithm of Caldara and Herbst (2019) to the regime-specific models
- The thresholds are sampled from their conditional posteriors using a Metropolis Hasting step.
- We select the type and number of regimes by using the predictive likelihood (see Geweke and Amisano, 2010).
- The three oil price regimes model is preferred over the linear model, the two oil price regimes, and the three boom-bust regimes model.

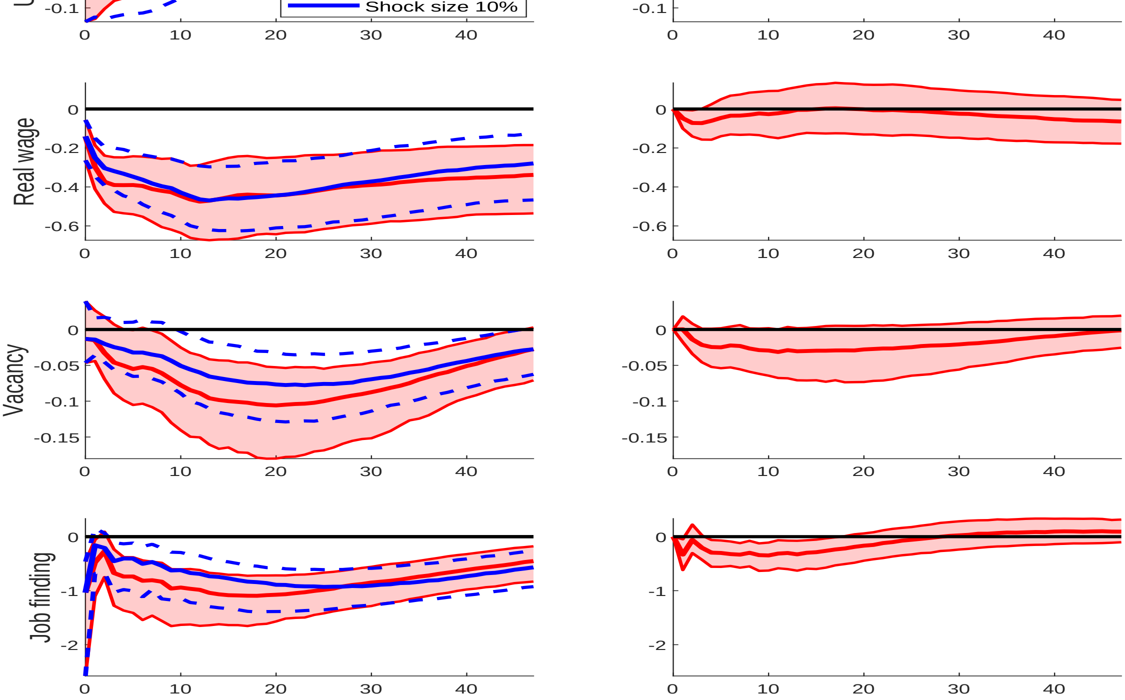
Data

- The baseline model follows Känzig (2021) and consists of six variables: the real price of oil, global oil production, global oil inventories, global industrial production, US industrial production, and the US consumer price index (CPI).
- We augment the baseline model with additional variables, including labour market indicators, housing prices, consumer confidence, short and long-term interest rates, financial variables and uncertainty.
- All variables are at a monthly frequency and cover the sample from January 1974 to December 2017.
- The VAR is estimated in log levels, and the lag length is set to 12.

Oil price regimes

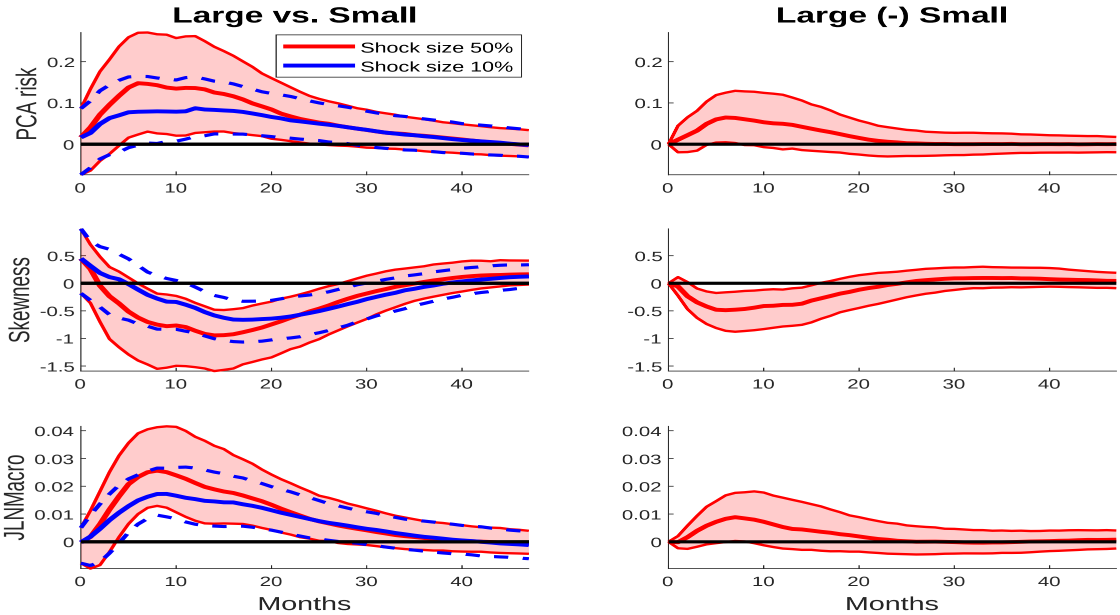



Oil Production
Oil Inventories
World IP
U.S. IP



Shock size 10%
Real wage
Vacancy
Job finding

Risk GIRFs



Large vs. Small
Large (-) Small
Shock size 50%
Shock size 10%
PCA risk
Skewness
JLNMacro
Months
Months

DSGE Model I

- Households (Epstein-Zin Preferences)

$$
\begin{aligned}
V_t(h) &= u\left(\tilde{C}_t(h), \tilde{Z}_t, L_t(h)\right) + \beta\left(E_t V_{t+1}(h)^{1-\gamma}\right)^{\frac{1}{1-\gamma}} \quad (EZ\ \ pref.) \\
u\left(\tilde{C}_t(h), \tilde{Z}_t, L_t(h)\right) &= \frac{\left(\tilde{C}_t(h) - b\tilde{C}_{t-1}\right)^{1-\sigma_C}}{1-\sigma_C} - \chi_0 \tilde{Z}_t^{1-\sigma_C} \frac{L_t(h)^{1+\sigma_L}}{1+\sigma_L} \quad (U\ \ function) \\
\tilde{P}_t^C \tilde{C}_t(h) + \frac{\tilde{D}_t(h)}{R_t} + T_t(h) &= \tilde{P}_t^C \tilde{W}_t L_t(h) + (1 - L_t(h)) \tilde{P}_t^C \tilde{B}_t + \tilde{D}_{t-1}(h) + \tilde{\Xi}_t(h) \quad (BC) \\
\frac{1}{R_t} &= \beta E_t \left(\frac{\tilde{C}_t(h) - b\tilde{C}_{t-1}}{\tilde{C}_{t+1}(h) - b\tilde{C}_t}\right)^{\sigma_C} \frac{\tilde{P}_t^C}{\tilde{P}_{t+1}^C} \left(E_t V_{t+1}^{1-\gamma}\right)^{\frac{\gamma}{1-\gamma}} V_{t+1}^{-\gamma} \quad (EE)
\end{aligned}
$$

- Labour Market (Search and Matching Frictions, Endogenous Separation, Firing Cost)

$$
\begin{aligned}
\mathscr{M}_t &= \frac{U_t \Upsilon_t}{\left(U_t^{\mu} + \Upsilon_t^{\mu}\right)^{\frac{1}{\mu}}} \quad (Matching\ \ function) \\
L_t &= \left\{1 - \bar{\delta}_{N,t}(\bar{\alpha}_t)\right\}\left(L_{t-1} + Q_{t-1}^{\Upsilon} \Upsilon_{t-1}\right) \quad (Employment) \\
\bar{\delta}_{N,t}(\bar{\alpha}_t) &= \delta_N^x + (1 - \delta_N^x)\, \delta_{N,t}(\bar{\alpha}_t) \quad (Separation\ \ rate) \\
\delta_{N,t} &= P(\alpha_t > \bar{\alpha}_t) = G(\bar{\alpha}_t) \quad (Endog.\ \ separation)
\end{aligned}
$$

DSGE Model II

- Value Added Producers (Calvo Contracts and Indexation Price Setting Rules)

$$\tilde{Y}_t(f) = \tilde{Z}_t L_t(f) \int_{\bar{\alpha}_{f,t}}^{\infty} a \frac{g(\alpha)}{1 - G(\bar{\alpha}_{f,t})} d\alpha$$

- Final Good Producers

$$\begin{aligned} \tilde{X}_t &= \left[(1-\phi_o)^{\frac{1}{\mu_o}} \tilde{Y}_t^{\frac{\mu_o - 1}{\mu_o}} + \phi_o^{\frac{1}{\mu_o}} \tilde{O}_t^{\frac{\mu_o - 1}{\mu_o}} \right]^{\frac{\mu_o}{\mu_o - 1}} \\ P_t^C &= (1-\phi_o)(P_t)^{1-\mu_o} + \phi_o (P_t^o)^{1-\mu_o} \end{aligned}$$

- Real Wage

$$\begin{aligned} \tilde{\tilde{W}}_t^{Nash} &= \eta \left\{ MC_t Z_t H(\alpha_t) + \kappa_h \tilde{Z}_t \frac{\Upsilon_t}{U_t} - \frac{(1-\delta_N^x)\delta_{N,t}}{(1-\delta_N^x)(1-\delta_{N,t})} \kappa_f \tilde{Z}_t W \right\} + (1-\eta) \left\{ \tilde{B}_t + \chi_0 \tilde{Z}_t^{1-\sigma_C} L_t^{\sigma_L} \left(\tilde{C}_t - b\tilde{C}_{t-1} \right)^{\sigma_C} \right\} \\ \tilde{\tilde{W}}_t^{Norm} &= \iota_w \tilde{\tilde{W}}_t^{Nash} + (1-\iota_w) \tilde{\tilde{W}} \end{aligned}$$

- Kalman Filter Learning

$$\begin{aligned} log\left(\bar{P}_t^{o,obs}\right) &= log\left(\bar{P}_t^o\right) + \sigma_o^{obs} \omega_t^{o,obs} \\ log\left(\bar{P}_t^o\right) &= \rho_o log\left(\bar{P}_{t-1}^o\right) + \sigma_o \omega_t^o \end{aligned}$$

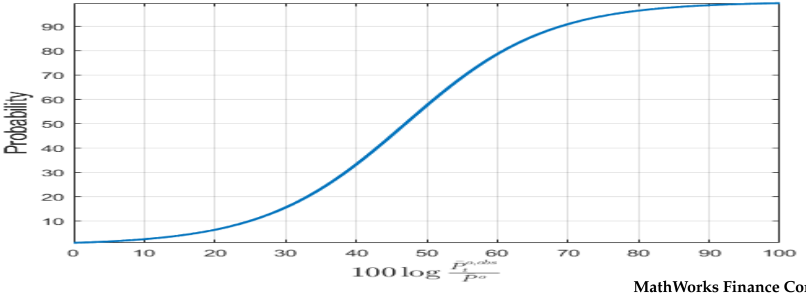
DSGE Model III

Concerns about Long Lasting Term of Trade Deterioration after a Large Oil Supply Shock

$$\begin{aligned}
\Delta \log Z_t &= (1-\rho_Z)(\Delta \log Z - d_t \log \varpi_t) + \rho_Z \Delta \log Z_{t-1} + \sigma_Z \omega_{Z,t} \\
\log \varpi_t &= (1-\rho_\varpi)\varpi + \rho_\varpi \log \varpi_{t-1} \\
d_t &= \begin{cases} 1 & \text{with probability} \quad \rho_t \\ 0 & \text{with probability} \quad 1-\rho_t \end{cases}
\end{aligned}$$

$$\rho_t = \frac{1}{1+\upsilon_c e^{-\upsilon_v log\left(\bar{P}_t^{o,obs}\right)}} \tag{9}$$

Figure: Rare Disaster Probability



DSGE Model IV

Two Measure Of Model Implied Risks

- The Hansen-Jagannathan Bound

$$\mathscr{HJB}_t = \frac{\sigma_t\left(M_{t+1}\right)}{E_t\left(M_{t+1}\right)} \tag{10}$$

- The probability of being unemployed the next period

$$\mathscr{R}_t = E_t\left(\bar{\delta}_{N,t+1}\left(\bar{\alpha}_{t+1}\right)\left(1 - Q^U_{t+1}\right)\right) \tag{11}$$

Predictive Prior Analysis

- Draw from $p(\theta|\mathscr{M})$ and accept the draws that satisfy $(p(\mathscr{IRFS}(\theta|\mathscr{M})))$:
  - The responses of selected variables to a 1 and 5 standard deviation shocks satisfy specific sign restrictions ($\mathscr{R}^{L}_{signs}$, Table 1)
  - The difference between selected variables between a 5 and 1 standard deviation shock satisfy again sign restrictions ($\mathscr{R}^{D}_{signs}$, Table 2)

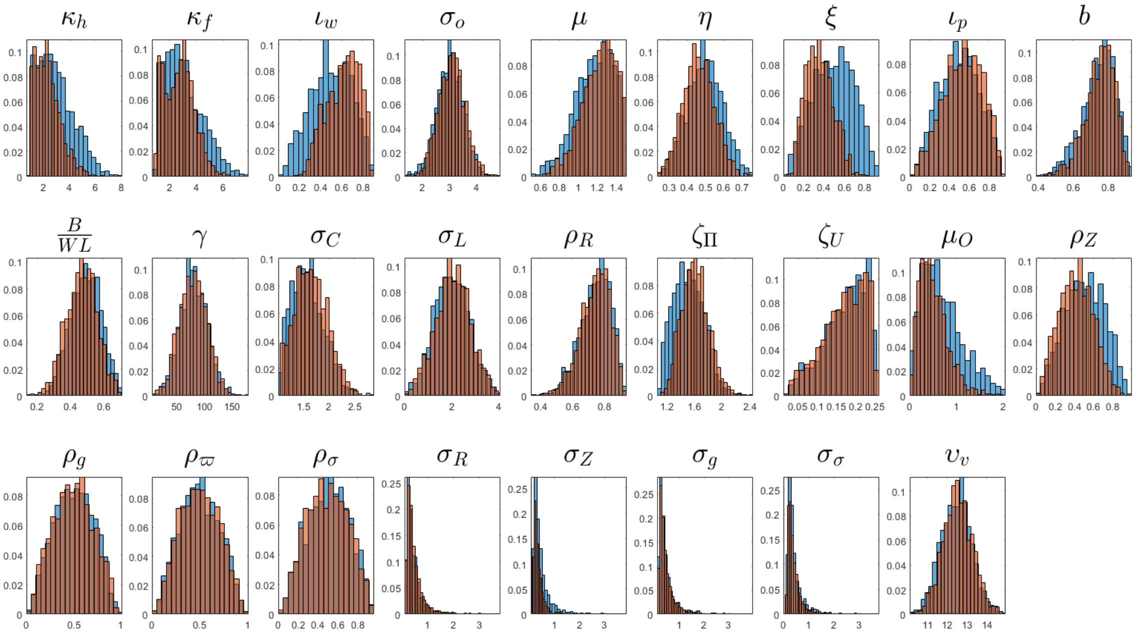
Table: Sign Restrictions on the Responses

Variable	GDP	Consumption	Wage	Unemployment	Vacancies
Signs	-	-	-	+	-
Variable	Job Finding Probability	Separation Rate	CPI inflation	Policy Rate	$\mathscr{HJB}$
Signs	-	+	+	+	+

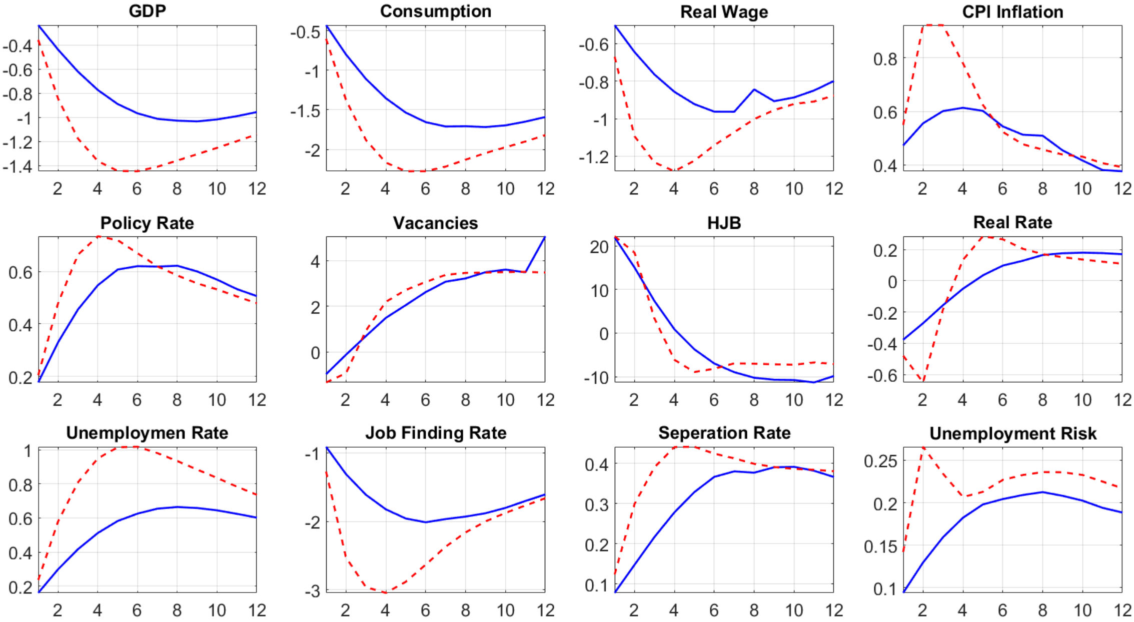
Table: Sign Restrictions on the difference between Large and Small Shocks Responses

Variable	GDP	Consumption	Wage	Unemployment	Vacancies
Signs	-	-	-	+	-
Variable	Job Finding Probability	Separation Rate	CPI inflation	Policy Rate	$\mathscr{HJB}$
Signs	-	+	?	?	+

DSGE Parameters: Prior Distribution

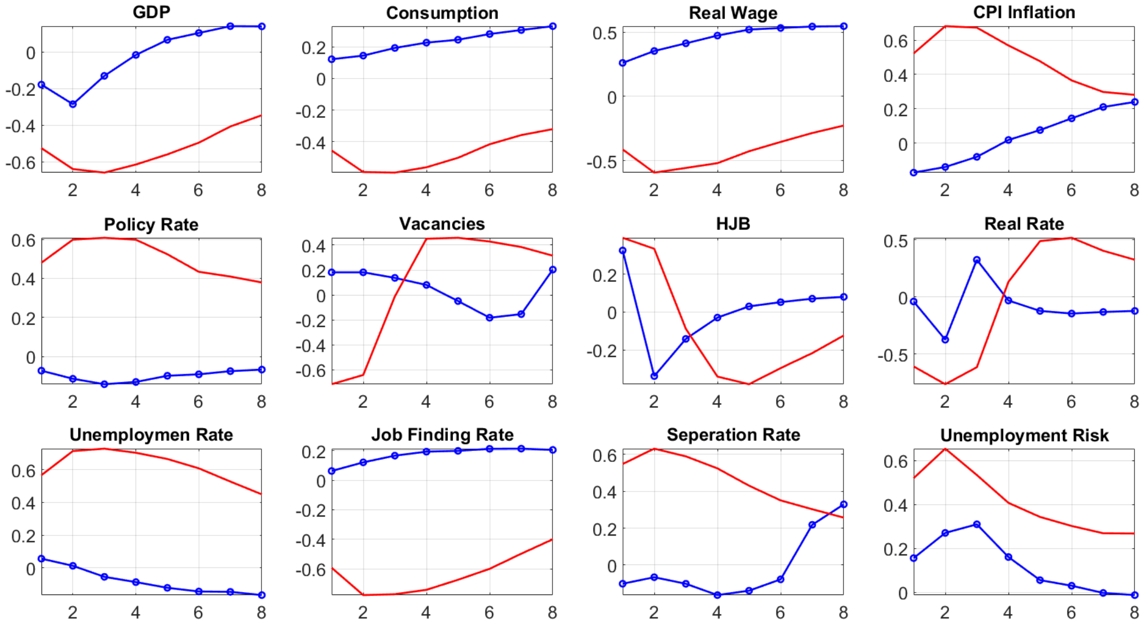


DSGE IRFs: Level

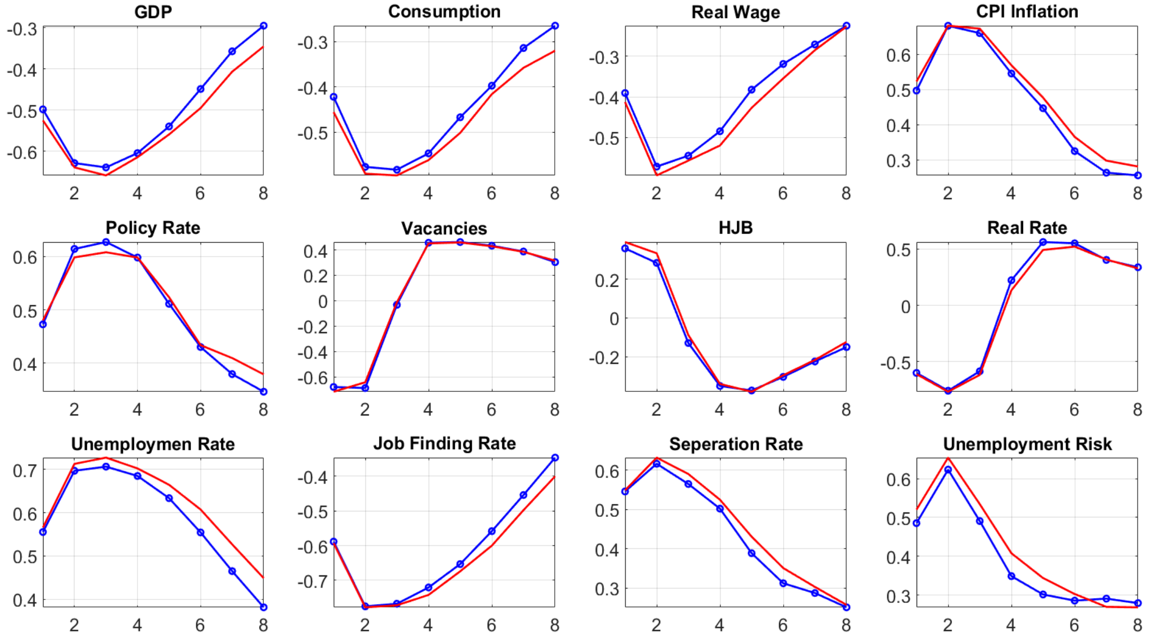


DSGE IRFs: Differences

Kelley Skewness: SaM



Kelley Skewness: EZ Preferences



Conclusions

- Do large and adverse oil shocks travel fast?
- We develop a novel algorithm to estimate a Proxy TVAR model
- We document that oil supply news shocks have a non-linear effect on real economic activity but not on prices and financial variables
- These non-linearities are related are related to extensive margin labour market frictions
- The empirical findings appear to be consistent with a NK-SaM DSGE model for a wide range parameters

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