

Business Cycles in an Oil Economy

Lessons from Norway

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Closing conference of the BIS CCA Research Network
The commodity cycle: macroeconomic and financial stability implications
Mexico City, 18-19 August 2016

* Norges Bank. The views expressed are those of the authors and do not necessarily reflect those of Norges Bank.

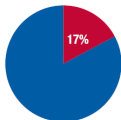
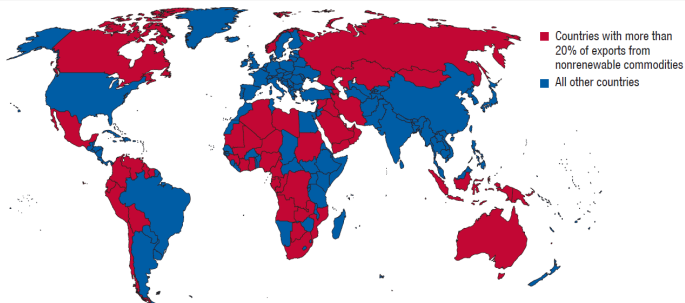
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Research questions

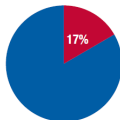
- (a) How important are ToT (oil) shocks for resource economies?
- (b) What are the main transmission channels at play?

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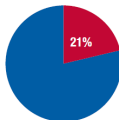
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- (b) What are the main transmission channels at play?



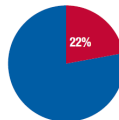
■ Share of GDP



■ Share of Imports



■ Share of Exports



■ Share of FDI

Agenda

What we do

- Estimate two-country DSGE model with endogenous oil price
- Quantify spillover and disentangle transmission channels

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Contributions to existing literature

- Alternative (complementary) identification approach
- Structural assessment of a range of shocks and transmission channels

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Main findings

- Propagation to oil rather than oil shocks are key
- Business cycles amplified by supply chains but dampened by fiscal regime (SWF and spending rule)

Related literature

- **Business cycles in open economies**
 - Adolfson et al. (2007, 2008), Christiano et al. (2011), Jacob and Peersman (2013), Justiniano and Preston (2010)
- **Oil and macro – DSGEs**
 - Bodenstein et al. (2011), Bodenstein and Guerrieri (2012), Kormilitsina (2011)
 - Nakov and Pescatori (2010a,b), Peersman and Stevens (2013), Pieschacon (2012)
- **Oil and macro – VARs**
 - Baumeister and Peersman (2013), Kilian and Murphy (2012), Kilian (2009)
 - Bjørnland and Thorsrud (2014), Charnavoki and Dolado (2014), Dungey et al. (2014), Peersman and Van Robays (2012)

A small VAR

The model:

$$A_0 \tilde{y}_t = \sum_{j=1}^{\mathcal{J}} A_j \tilde{y}_{t-j} + B \varepsilon_t, \quad \tilde{y}_t = [y_t^* \quad p_{o,t}^* \quad e_t \quad y_{o,t} \quad y_{m,t} \quad y_{s,t}]',$$

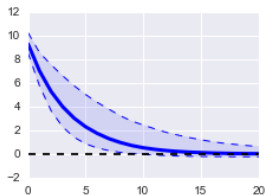
ε_t iid $N(0, 1)$, B diagonal

Assumptions:

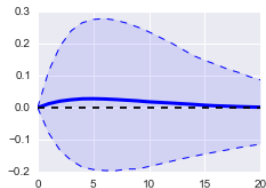
- (i) Cholesky on international block ($A_{0,12} = 0$)
- (ii) Norway does not affect international economy (A_0 and A_j lower block triangular)

Spillover to Norwegian block freely estimated

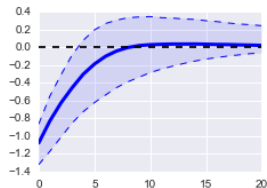
International oil price shock



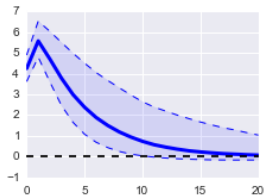
(a) Oil price



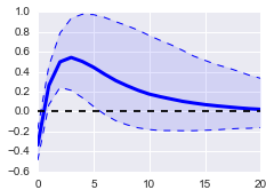
(b) International output



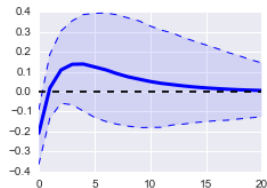
(c) Exchange rate



(d) Oil sector

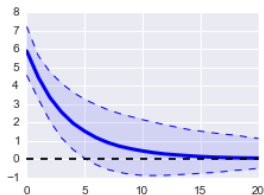


(e) Manufacturing

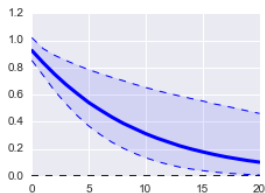


(f) Services

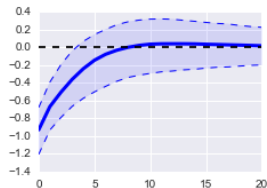
International activity shock



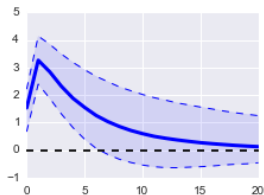
(g) Oil price



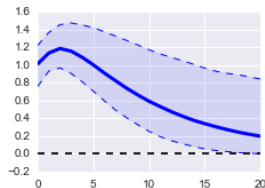
(h) International output



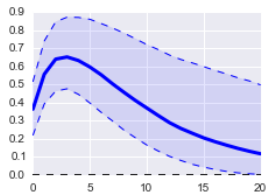
(i) Exchange rate



(j) Oil sector



(k) Manufacturing



(l) Services

Lessons (“stylized facts”)

Positive oil and activity shocks abroad are associated with

- Positive spillover to Mainland Norway
- Exchange rate *appreciates* after both shocks
- Stronger responses in oil than non-oil sectors

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Open questions:

- What are the underlying structural shocks?
- What are the main transmission channels?

⇒ Need a richer, structural model to analyze these questions

The model (Bergholt and Seneca, 2015)

- Two countries: SOE commodity exporter, ROW
- Manufacturing, service and oil industries in both countries
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 - Imperfect international risk sharing, premium associated with NFA position
- SOE:
 - Oil sector and Mainland Norway
 - Mainland Norway linked to oil via supply chain
 - Fiscal policy: tax revenues, sovereign wealth fund, fiscal spending rule
 - Active monetary policy (Taylor rule)

Oil extraction firms

- Discounted stream of cash flows

$$\mathbb{E}_t \sum_{s=t}^{\infty} Z_{t,s} \left[S_t P_{ro,t}^* O_t - P_{ro,t}^Y a(U_{O,t}) F_{O,t} - P_{ro,t}^Y I_{O,t} \right]$$

- Production technology

$$O_t = Z_{O,t} Q_O^{1-\alpha_o} \bar{F}_{O,t}^{\alpha_o}$$

$\bar{F}_{O,t} = U_{O,t} F_{O,t}$ is active rigs and $U_{O,t}$ is the utilization rate

- Rig investments

$$F_{O,t+1} = (1 - \delta_o) F_{O,t} + Z_{F,t} \left[1 - \psi \left(\frac{I_{O,t}}{I_{O,t-1}} \right) \right] I_{O,t}$$

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- Oil supply

- Short run utilization of existing rigs, long run investment in new rigs
- Entire expected oil price path matters rather than current price
- Breaks contemporaneous link between prices and activity

The domestic oil supply schedule

- Log-linearized optimality conditions:

$$\text{Supply:} \quad s_t + p_{ro,t}^* + o_t - u_{o,t} = rmc_{o,t}$$

$$\text{Marginal cost:} \quad rmc_{o,t} = p_{ro,t}^y + \gamma_u u_{o,t} + f_{o,t}$$

$$\text{Production:} \quad o_t = z_{o,t} + \alpha_o (u_{o,t} + f_{o,t})$$

- Combining these, we get the supply schedule:

$$o_t = \eta_o^s (s_t + p_{ro,t}^*) - \eta_o^s p_{ro,t}^y + \eta_o^s \gamma_u f_{o,t} + \eta_o^s \frac{1 + \gamma_u}{\alpha_o} z_{o,t}$$

$\eta_o^s = \frac{\alpha_o}{1 + \gamma_u - \alpha_o} \in [0, 1]$ is the supply elasticity.

Government

- Management of government's oil revenues

Tax revenues: $TR_t^o = \tau_o \Pi_{o,t}$

GPFG: $SWF_t = (1 - \rho_o) R_{t-1}^* \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} \Pi_t^{-1} SWF_{t-1} + TR_t^o$

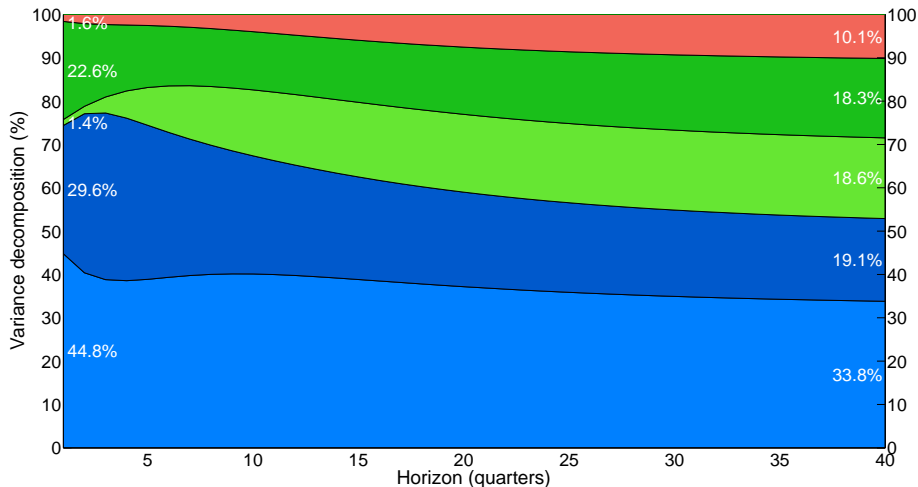
Budget deficit: $SBD_t = \rho_o R_{t-1}^* \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} \Pi_t^{-1} SWF_{t-1}$

- Public budget: $P_{r,t}^g G_t - D_t = T_t - R_{t-1} D_{t-1} \Pi_t^{-1} + SBD_t$
- Public spending: $G_t = G$ ("economic state_t")
- Monetary policy: $R_t = R$ ("economic state_t")

Estimation

- **Data: Norway and EU28, 2000Q1-2014Q4**
 - Standard macro variables: manufacturing and services value added, aggregate private consumption, investment, wage and price inflation (y-on-y), interest rate, exchange rate
 - Oil variables: output, investments, Brent price
- **Estimation**
 - Bayesian inference: RWMH \Rightarrow posterior distribution of parameters & macro moments
 - 18 observables, Kalman filter for remaining variables
- **Model fit: reasonable for most variables, but ...**
 - ... understates oil price volatility and persistence
 - ... overstates domestic consumption volatility and persistence
 - ... tension between oil price and oil investments

What drives the business cycle in Mainland Norway?



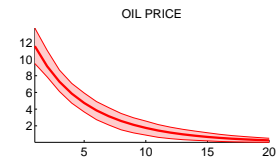
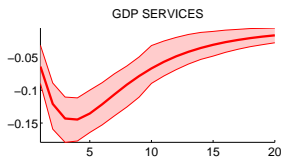
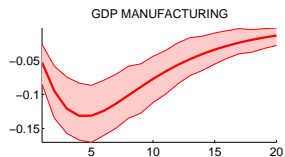
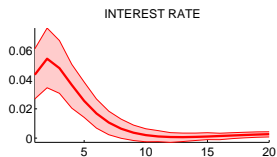
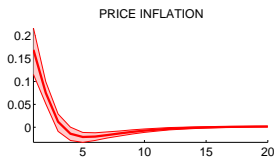
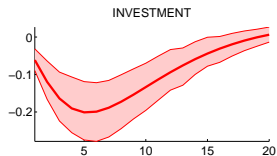
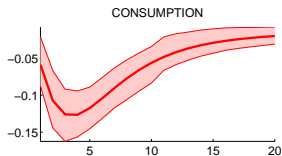
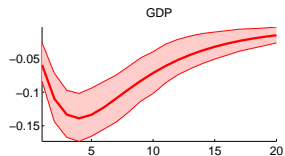
Note: Forecast error variance decomposition of GDP in Mainland Norway. Calculated at the posterior mean. Shocks are decomposed as follows: Domestic supply shocks (light blue), domestic demand shocks (dark blue), international supply shocks (light green), international demand shocks (dark green), and shocks in oil markets (light red). Numbers in white at the left and right hand side are decompositions at the 1 and 40 quarters horizons, respectively.

Not all oil price “shocks” are alike

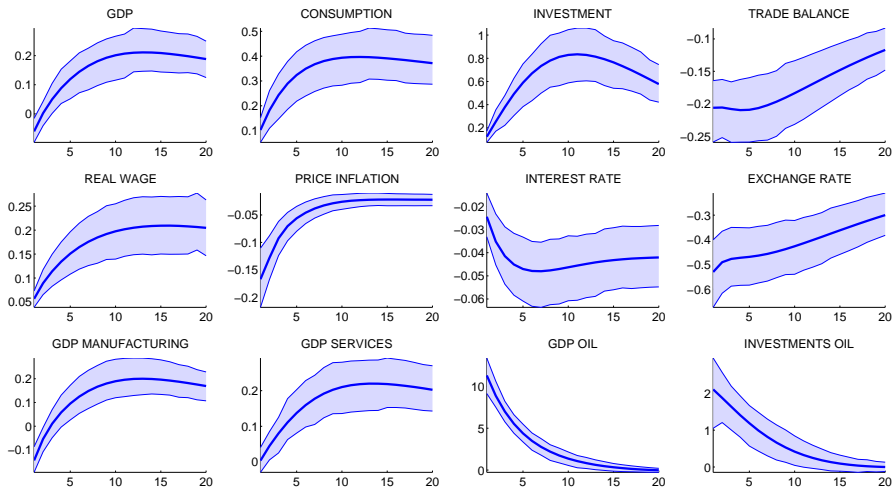
<i>Underlying international shock</i>	<i>Response of Mainland GDP</i>		
	<i>Mean</i>	<i>HPD interval</i>	<i># lags</i>
Oil supply	0.18	(0.13-0.25)	13
Manufacturing productivity	2.51	(0.98-3.82)	4
Service productivity	1.43	(-0.13-2.83)	7
Investment demand	1.46	(0.93-2.05)	8
Consumption demand	0.51	(0.39-0.63)	2
Labor market	1.94	(1.07-2.73)	7
Manufacturing markup	1.39	(0.12-2.65)	3
Service markup	1.20	(0.41-2.00)	6
Monetary policy	0.84	(0.50-1.20)	6

Note: Posterior pass-through from oil price to Mainland GDP. Defined as the peak response of GDP when the oil price increases 10%, conditional on a given shock.

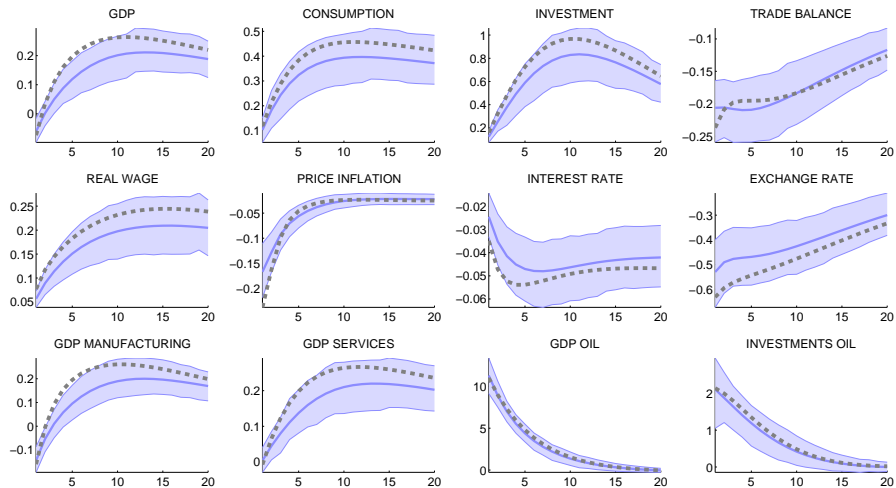
International oil supply shock



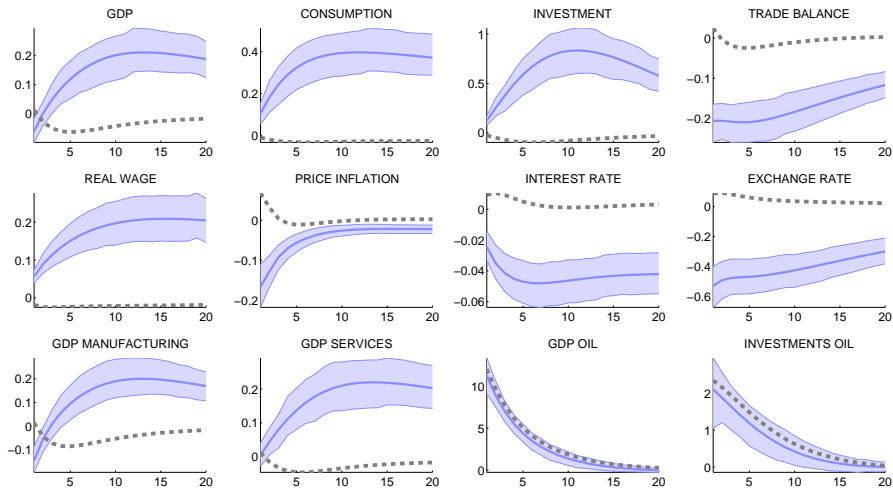
Domestic spillover



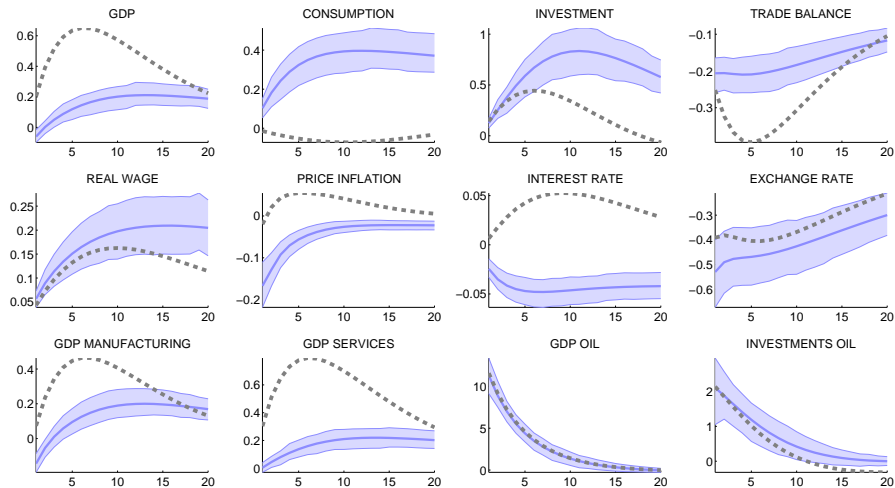
Counterfactual I: no feedback to world economy



Counterfactual II: no supply chain



Counterfactual III: no sovereign wealth fund



Concluding remarks

What drives the business cycle in a prototype oil economy?

- Estimation of joint dynamics in oil markets, international economy, and Norway
 - Identification based on fully specified DSGE for international economy
 - Structural interpretation

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 - Elasticities are shock dependent
 - External shocks are (i) amplified due to supply chain, but (ii) dampened due to fiscal regime (SWF and spending rule)

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 - Elasticities are shock dependent
 - External shocks are (i) amplified due to supply chain, but (ii) dampened due to fiscal regime (SWF and spending rule)
- Left for future research
 - Depletion problem (Hotelling, 1931; Pindyck, 1978)
 - Policy implications (Catão and Chang, 2013; Hevia and Nicolini, 2013)
 - Financial frictions (Alberola and Chang, 2016; Hamann et al. 2016)

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