Monetary policy, terms of trade and exchange rate responses. A Markov-Switching structural investigation

Ragna Alstadheim[1] Hilde C. Bjørnland[2,1] Junior Maih[3]

[1]Norges Bank

[2]BI Norwegian Business School

[3]IMF

Monetary Policy and Commodity Prices Workshop
ECB, 19 November 2012

The views expressed in this paper are those of the authors and do not necessarily reflect the views of IMF or Norges Bank.

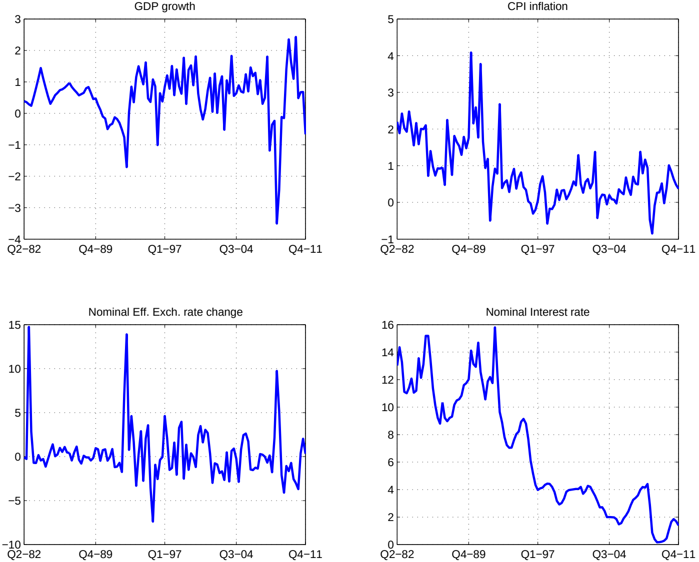
Motivation

- Do Central Banks Respond to Exchange Rate Movements?
- Yes, some do, according to Lubik and Schorfheide (2007) (LS henceforth) who estimate structural general equilibrium models with interest rate rules for monetary policy in small open economies from 1983-2002.
- Domestic business cycle fluctuations in countries that are rich in natural resources (commodities) are likely to have a substantial international relative price component.
- Central banks may have a specific interest in explicitly reacting to and smoothing exchange rate movements as a predictor of domestic volatility.

Motivation

- LS assumes constant-parameter model. Useful approximation when complex dynamics.
- But constant parameter models abstract from considerations of structural changes; recession, policy changes, central bank interventions etc.
    - Exchange rate targeting: Stable exchange rates, but at the cost of output and inflation volatility?
    - Inflation targeting: Inflation expectations anchored, but at the cost of (short term) exchange rate volatility?
- Can one ignore structural change in policy and shocks, yet analyze if monetary policy responds to the exchange rate?

Data for Sweden



What we do

- We estimate a structural general equilibrium model of a small open economy using Bayesian methods, like LS.
- Use a Markov switching set up that explicitly allow changes in both the shocks that hit the economy and in the monetary policy responses.
  - Model is augmented with foreign activity and inflation
  - Do not detrend data
  - Apply to four small open inflation targeting countries; Canada, Norway, Sweden and the UK (three commodity exporters).
- Analyse whether inflation targeting central banks put the same weight on stabilizing the exchange rate as before the regime change.
- Analyse how the different shocks (terms of trade) affect the dynamics in different regimes.

Contribution and results

- First attempt to explicitly model and analyze the implications of a change in the policy reaction function and volatility of shocks in small open economies
- Use alternative new solution algorithms to the ones already available in the literature, see Maih (2012). Use the toolbox (RISE) for implementing the algorithms.
- Find that deep structural parameters and volatility of structural shocks have not stayed constant through the sample period.
  - Monetary policy responds to the exchange rate, but the response is NOT constant over the sample.
  - Policy change has implied less exchange rate responses relative to inflation in Canada and Sweden. Not in Norway.
  - Terms of trade shocks exacerbate the effects on output and inflation in countries that respond strongly to the exchange rate (Norway).

Plan of talk

- A New-Keynesian model
- Regime Swithces
- Estimation
- Results

Model - main equations

Open economy IS curve (from consumption Euler eqt.):

$$y_t = E_t y_{t+1} - (\tau + \lambda)(r_t - E_t \pi_{t+1}) - \rho_z z_t - \alpha(\tau + \lambda) E_t \Delta q_{t+1} + \frac{\lambda}{\tau} E_t \Delta y^*_{t+1}, \quad (1)$$

where α is the degree of openness, $\lambda = \alpha(2 - \alpha)(1 - \tau)$, q_t is terms of trade, y^*_t is exogenous world output, while z_t is the growth rate of an underlying non-stationary world technology process A_t.

Open economy Philips curve:

$$\pi_t = \beta E_t \pi_{t+1} + \alpha \beta E_t \Delta q_{t+1} - \alpha \Delta q_t + \frac{\kappa}{(\tau + \lambda)} (y_t - \bar{y}_t), \quad (2)$$

where $\bar{y}_t = -\alpha(2 - \alpha)(1 - \tau)/\tau y^*_t$ is potential output in the absence of nominal rigidities.

Model - main equations

Relative PPP:

$$\Delta e_t = \pi_t - (1-\alpha)\Delta q_t - \pi_t^*, \tag{3}$$

Taylor rule:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)(\gamma_\pi \pi_t + \gamma_y y_t + \gamma_e \Delta e_t) + \epsilon_{r,t}, \tag{4}$$

Instead of solving endogenously for terms of trade, we add a law of motion for their growth rate to the system:

$$\Delta q_t = \rho_q \Delta q_{t-1} + \epsilon_{q,t} \tag{5}$$

- Assume y_t^* and π_t^* evolve according to univariate AR(1) processes
- Autoregressive coefficients ρ_{y^*} and ρ_{π^*} respectively.

The MS general framework

$$E_t \left\{ A^{+}_{s_{t+1}} x_{t+1} \left(\bullet, s_t \right) + A^{0}_{s_t} x_t \left(s_t, s_{t-1} \right) + A^{-}_{s_t} x_{t-1} \left(s_{t-1}, s_{t-2} \right) + B_{s_t} \varepsilon_t \right\} = 0$$

- x_t is a $n \times 1$ vector including all the endogenous (predetermined and non-predetermined) variables
- $\varepsilon_t \sim N(0, I)$, is the vector of structural shocks
- $s_t = 1, 2, ..., h$
- (s_t, s_{t-1}) denotes the state today s_t and the state in the previous period s_{t-1}

The general framework II

- We have a transition matrix with entries $p_{s_t,s_{t+1}}$ denoting the prob of going from state s_t in the current period to state s_{t+1} next period. $s_t = 1, 2, ..., h$, $s_{t+1} = 1, 2, ..., h$
- This allows us to define the expectation

$$E_t A^{+}_{s_{t+1}} x_{t+1} (\bullet, s_t) \equiv A^{+}_{s_{t+1}} \sum_{s_{t+1}=1}^{h} p_{s_t,s_{t+1}} E_t x_{t+1} (s_{t+1}, s_t)$$

The solution method

- We apply a Newton-based algorithm to find MSV solutions of the form

$$x_t\left(s_t, s_{t-1}\right) = T_{s_t} x_{t-1}\left(s_{t-1}, s_{t-2}\right) + R_{s_t} \varepsilon_t$$

- The algorithm extends Farmer, Waggoner and Zha (2011).

Estimation approach

- Filtering and likelihood computation: combination of
  - Hamilton (1994) filter
  - modification of Kim and Nelson (1999) filter
- Bayesian priors to get the posterior kernel
- Smoothing: Adapt the Durbin and Koopman (2001) smoother for constant-parameter models.

Data and priors

- Observations on nominal interest rate, GDP growth (domestic and foreign), CPI inflation (domestic and foreign), nominal exchange rate, terms of trade.
- Dataset run from 1982:2-2011:4. Quarterly, s.a.
- With the exception of the parameter α, we allow for loose priors to entertain the idea that there has been multiple regime changes in the sample.
- α, which is the import share, is tightly centered around 0.2, as in Lubik and Schorfheide (2007).

Switching parameters

- Parameter in policy rule $(\rho_r, \gamma_\pi, \gamma_y, \gamma_e)$ can follow an independent two-state Markov process. Denote the low response regime as $(coef, 1)$ and the high response regime as $(coef, 2)$.
  - Normalize $(coef, 2)$ to be the regime with **high response to the exchange rate**, i.e. $\gamma_e(coef, 1) < \gamma_e(coef, 2)$.

- Volatility of structural and foreign shocks (σ_r, σ_z, $\sigma_{y^*}, \sigma_{\pi^*}$ and σ_q) can follow an independent two-state Markov process. Denote the low volatility regime as $(vol, 1)$ and the high volatility regime as $(vol, 2)$.
  - Normalize $(vol, 2)$ to be the regime where the **volatility (in productivity) is highest**, i.e. $\sigma_z(vol, 1) < \sigma_z(vol, 2)$

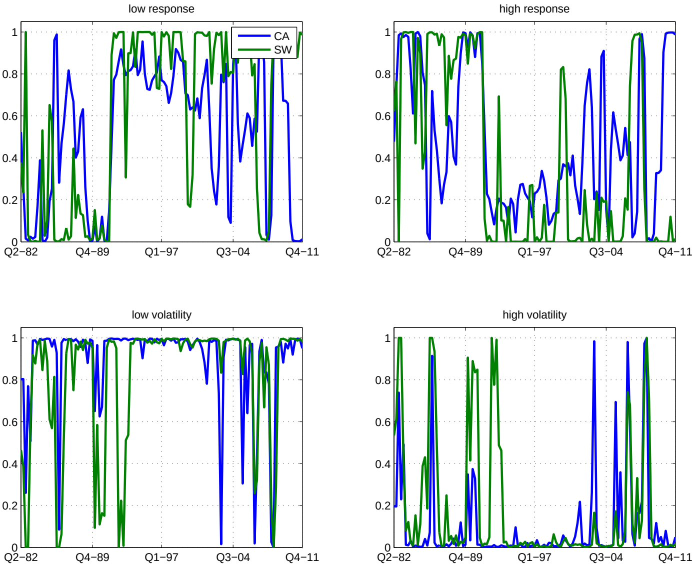
Regime switches - Posterior mode

Param	Prior distr	Canada	Norway	Sweden	UK
τ	Beta	0.62	0.25	0.28	0.41
κ	Gamma	3.60	3.94	1.76	2.79
α	Beta	0.19	0.28	0.10	0.21
ρ_q	Uniform	0.37	0.28	0.30	-0.14
ρ_{y^*}	Beta	0.97	0.96	0.98	0.98
ρ_{π^*}	Beta	0.36	0.22	0.36	0.39
ρ_z	beta	0.53	0.80	0.75	0.69
$\rho_r(coef, 1)$	Beta	0.81	0.86	0.93	0.93
$\rho_r(coef, 2)$	Beta	0.85	0.90	0.56	0.61
$\gamma_\pi(coef, 1)$	Gamma	0.63	1.20	2.89	1.29
$\gamma_\pi(coef, 2)$	Gamma	1.37	1.60	4.25	1.10
$\gamma_y(coef, 1)$	Gamma	2.1	0.83	1.77	1.13
$\gamma_y(coef, 2)$	Gamma	0.0001	0.0001	0.0001	0.0001
$\gamma_e(coef, 1)$	Gamma	**0.91**	**0.0001**	**0.0001**	**1.26**
$\gamma_e(coef, 2)$	Gamma	**6.67**	**10.81**	**4.02**	**1.82**

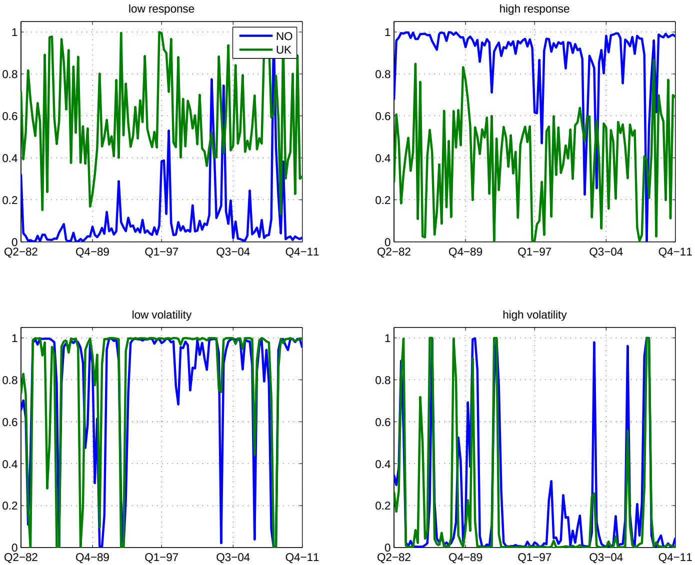
Regime switches - Posterior mode

Param	Prior distr	Canada	Norway	Sweden	UK
$\sigma_r(vol, 1)$	InvGam	2.69	4.07	2.32	1.64
$\sigma_r(vol, 2)$	InvGam	3.92	4.04	4.42	4.29
$\sigma_q(vol, 1)$	InvGam	1.28	4.49	0.88	0.86
$\sigma_q(vol, 2)$	InvGam	2.95	7.73	1.95	1.97
$\sigma_z(vol, 1)$	InvGam	**0.40**	**0.34**	**0.43**	**0.49**
$\sigma_z(vol, 2)$	InvGam	**0.87**	**0.67**	**0.46**	**0.98**
$\sigma_{y^*}(vol, 1)$	InvGam	0.30	0.29	0.23	0.33
$\sigma_{y^*}(vol, 2)$	InvGam	0.32	0.61	0.62	1.08
$\sigma_{\pi^*}(vol, 1)$	InvGam	1.13	1.11	1.34	1.28
$\sigma_{\pi^*}(vol, 2)$	InvGam	4.66	3.67	3.18	3.59

Smoothed probabilities - Canada and Sweden



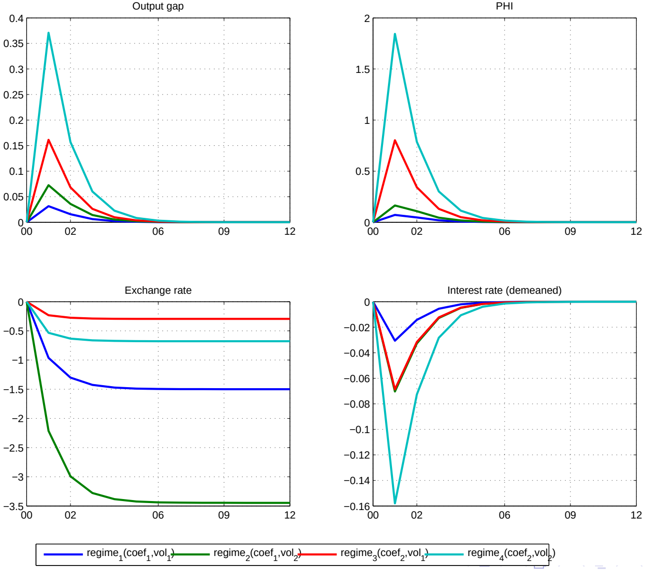
Smoothed probabilities - Norway and UK



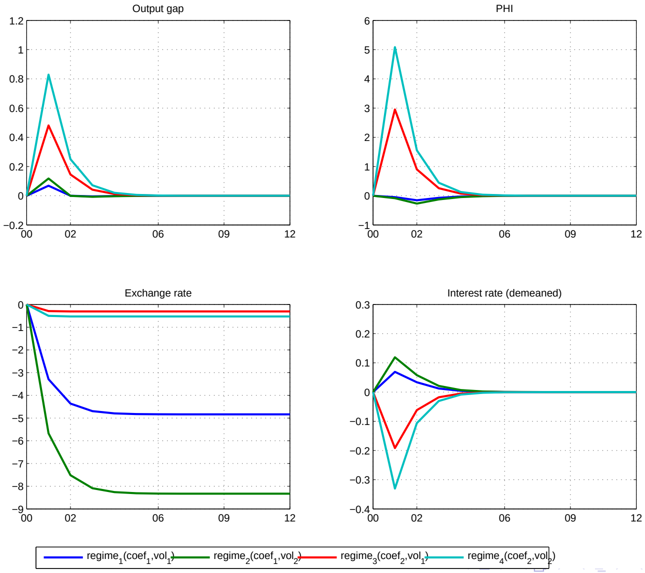
Duration time

	Canada	Norway	Sweden	UK
const				
state 1	Inf	Inf	Inf	Inf
Policy response				
Low	9.407	1.713	8.657	3.246
High	1.712	**3.33**	2.579	1.384
Volatility				
Low	11.58	10.19	11.68	11.94
High	1.367	2.09	2.262	1.869

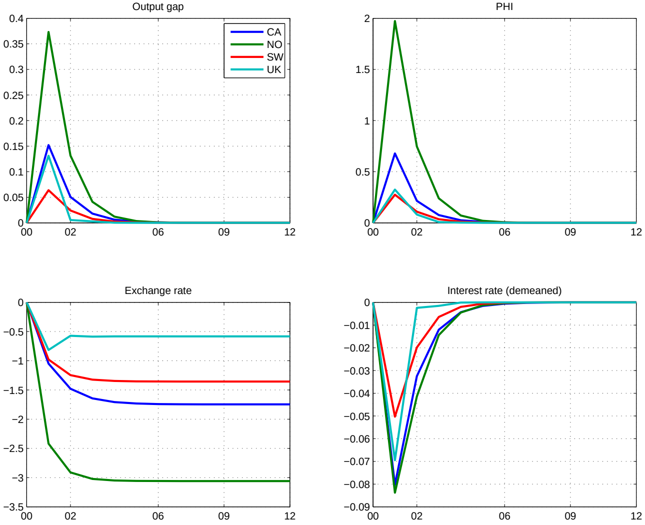
Impulse responses to Terms of trade shocks - Canada



Impulse responses to Terms of trade shocks- Norway



Generalized impulse responses - Terms of trade shocks



Conclusion

- Find strong evidence that deep structural parameters and the volatility of structural shocks have not stayed constant through the sample period in any of the four countries.
- Canada and Sweden have put less weight on stabilizing the exchange rate since inflation targeting was adopted in the early 1990s.
- For Norway, a net exporter of oil and gas, we do not observe a systematic change in the response to the nominal effective exchange rate. For the UK, on the other hand, there has been little exchange rate responses overall.
- In countries that respond strongly to the exchange rate, the effects of terms of trade shocks on output and inflation are exacerbated.