A new foreign block for the CNB core model

CZECH NATIONAL BANK

Stanislav Tvrz

Moderné nástroje pre finančnú analýzu a modelovanie
May 30, 2019, National Bank of Slovakia, Bratislava

1. Introduction and motivation
2. Design of the new foreign block
3. Analysis of the foreign economy
4. Integration of foreign block
5. Analysis of the domestic economy
6. Conclusion

g3+ model

- The CNB published an alternative scenario of the forecast in the latest Inflation Report (IR II/2019) which was prepared with the use of the extended version of the current core forecasting model – the g3+ model.
- Since the next Inflation Report (IR III/2019), the extended model will become the main forecasting tool of the bank.
- One of the model changes in comparison to the original g3 model is the extension of the foreign block.
- This presentation introduces the new foreign block and its integration into the g3+ model.
- Presented results are preliminary and may change.

Current state of the foreign block

- Current state:
  - Set of independent AR(1) processes.
  - No interlinkages between foreign variables.
  - No structural interpretation of foreign shocks.

$$n_t^* = f(n_{t-1}^*, \epsilon_t^{n^*})$$
$$\tilde{\pi}_t^* = f(\tilde{\pi}_{t-1}^*, \epsilon_t^{\tilde{\pi}^*})$$
$$i_t^* = f(i_{t-1}^*, \epsilon_t^{i^*})$$

- Goals:
  - Obtain at least a semi-structural model of the foreign sector.
  - Introduce oil price into the model.

General model design principles

- Model structure:
  1. Includes interactions between foreign variables necessary for meaningful "story-telling" interpretation of the development in the foreign sector.
  2. Is comprehensible and operable.

  ⇒ A compromise between complexity and practicality in periodical forecasting applications.

- Integration:
  1. Is independent on the particular form of the foreign block model (unit VAR, structural VAR, two-country model)
  2. Prevents spill-overs from the domestic economy (SOE) into the foreign block model (allows us to work with the foreign block model separately)

Model development framework

- We use anticipated as well as unanticipated shocks to fix the outlook of foreign variables on the forecast horizon.

  $\Rightarrow$ Another dimension of modelling decisions to be made about the design of foreign variables' expectations scheme (not discussed in this presentation).

- Continuous testing of model changes with the use of historic simulations, shock decomposition, impulse response analysis, spectral analysis and variance decomposition.

New model structure

CNB CZECH NATIONAL BANK

- The new foreign block in g3+ has the following form:

$$\begin{aligned}
\hat{y}^*_t &= f(\hat{y}^*_{t-1}, \hat{r}^*_{t-1}, \hat{z}^*_{t-1}, \tilde{\pi}^{\text{brent}}_t, \epsilon^{\hat{y}^*}_t) \\
\tilde{\pi}^{*\text{non-ener}}_t &= f(\tilde{\pi}^{*\text{non-ener}}_{t+1}, \tilde{\pi}^{*\text{non-ener}}_{t-1}, \hat{y}^*_t, \hat{z}^*_{t-1}, \epsilon^{\tilde{\pi}^*}_t) \\
i^*_t &= f(i^*_{t-1}, \tilde{\pi}^{*4}_{t+4}, \hat{y}^*_t, \epsilon^{i^*}_t) \\
\Delta usdeur_t &= f(\Delta usdeur_{t+1}, i^*_t, prem_t, \epsilon^{\Delta usdeur}_t) \\
prem_t &= f(prem_{t-1}, \epsilon^{\text{prem}}_t) \\
\tilde{\pi}^{\text{brent}}_t &= f(\tilde{\pi}^{\text{brent}}_{t-1}, \epsilon^{\tilde{\pi}^{\text{brent}}}_t)
\end{aligned}$$

in detail

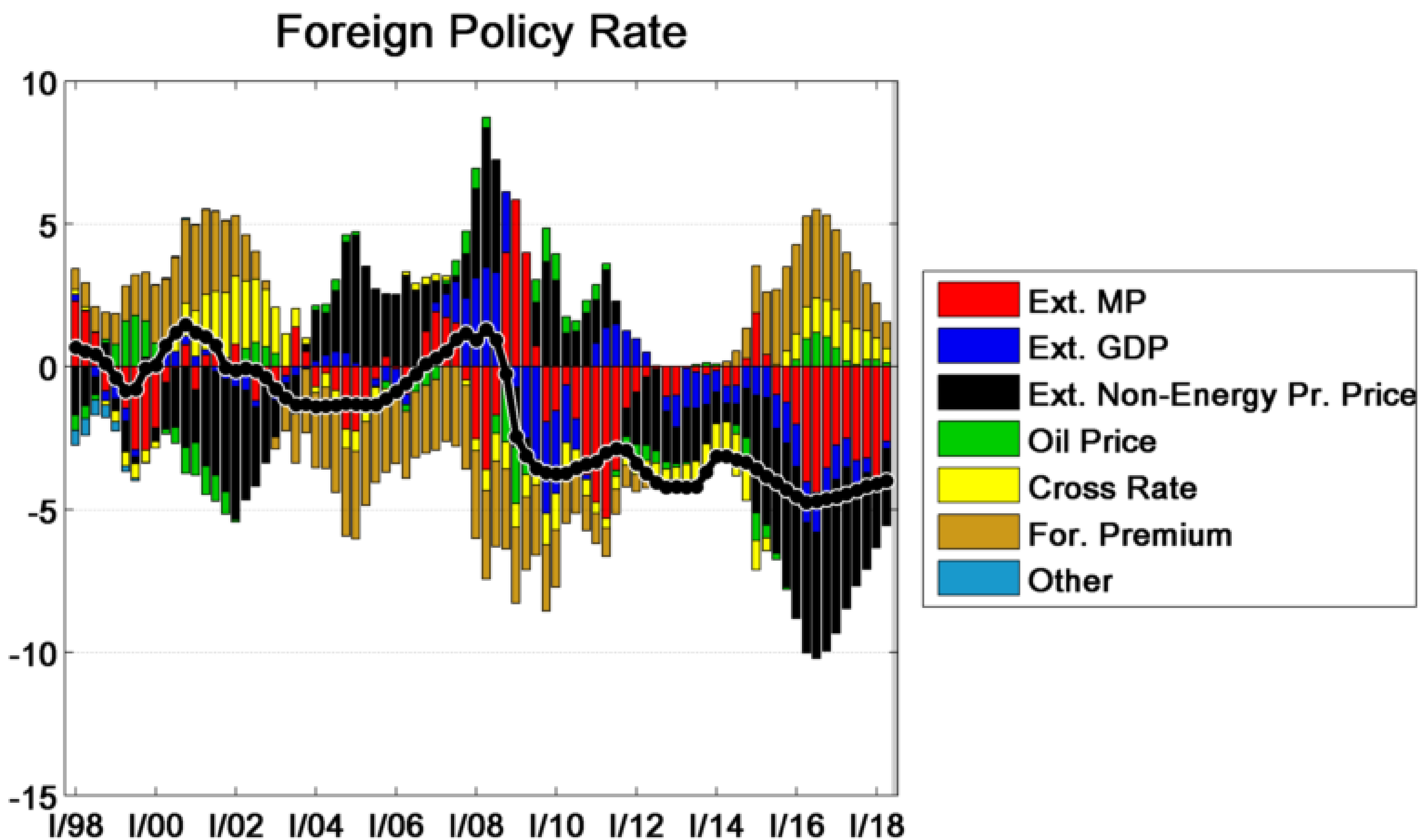
New model structure

- Observed variables:
  - Foreign output – gap and trend (GDP of effective EA)
  - Foreign inflation – energy and non-energy (NE) sector (PPI in effective EA)
  - Foreign interest rates (3M EURIBOR)
  - Oil price (Brent in USD)
  - USD/EUR nominal exchange rate

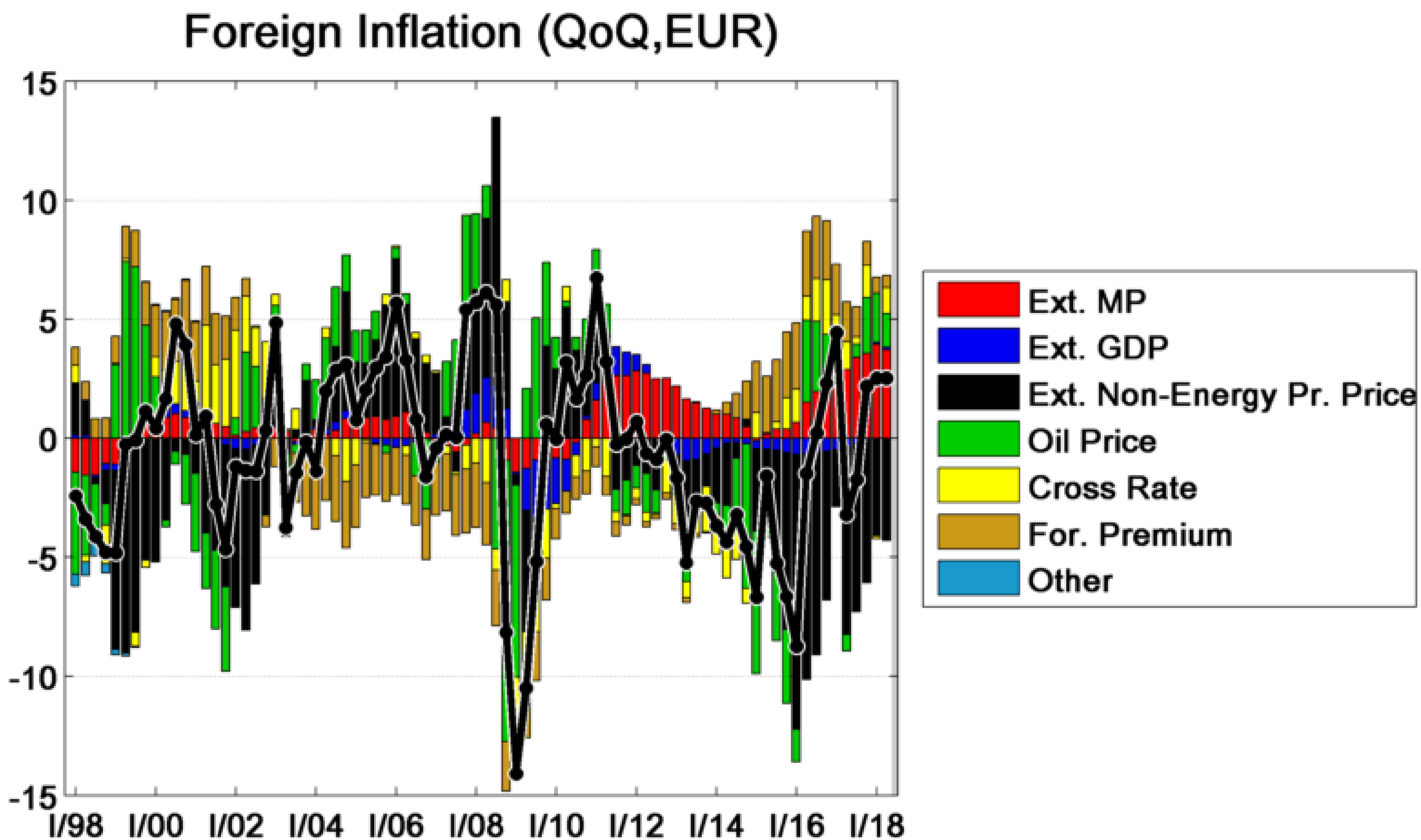
Shock decomposition analysis

- Decompositions of g3+ model with original simple foreign block (but with oil price) are compared to the g3+ model with new foreign block.
- Distinct improvement in the ability to explain foreign output gap and hence foreign demand, but also foreign inflation and interest rates.
- New perspective with consistent and intuitive story behind the development of the foreign variables.

Foreign interest rates decomposition



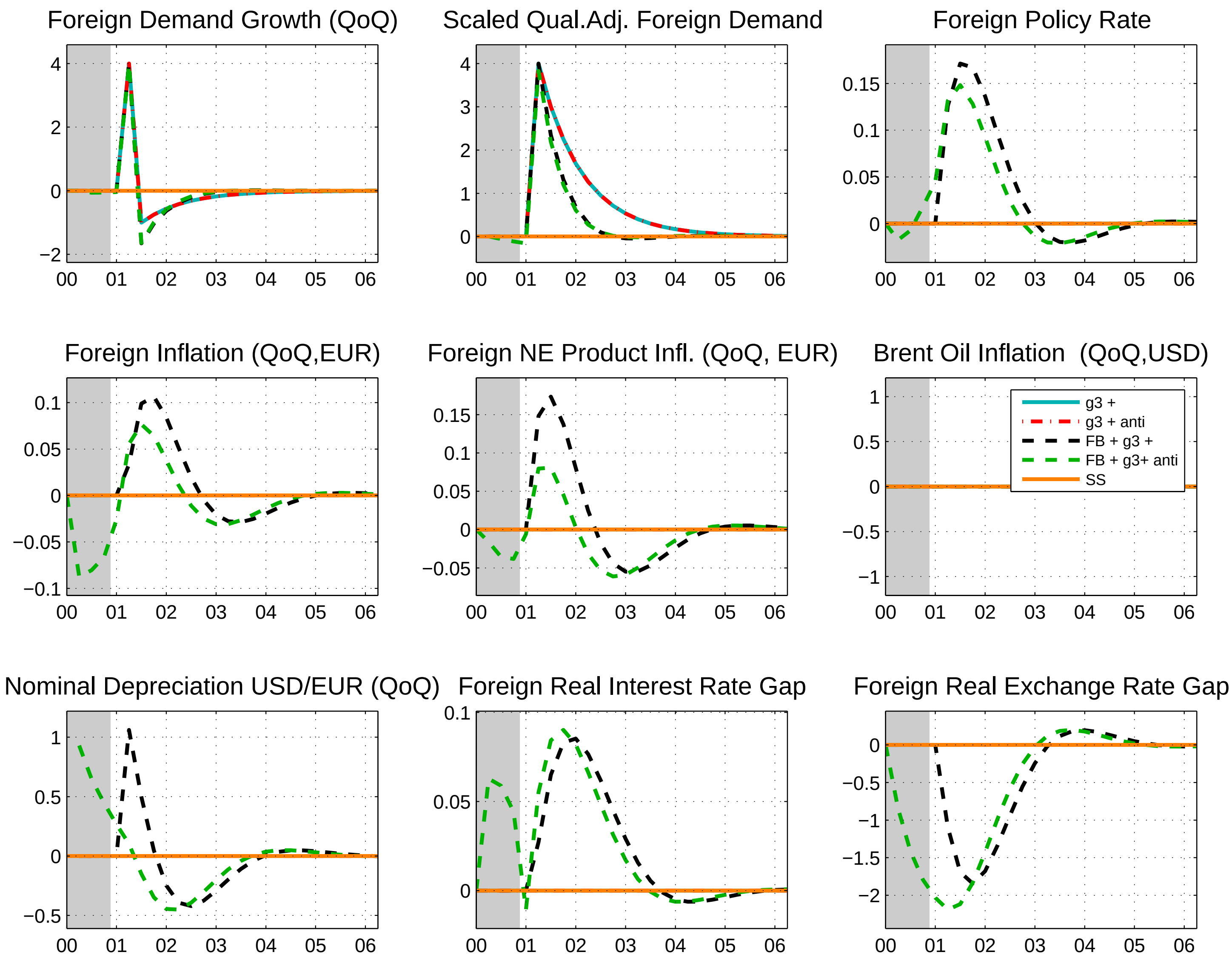
Foreign inflation decomposition



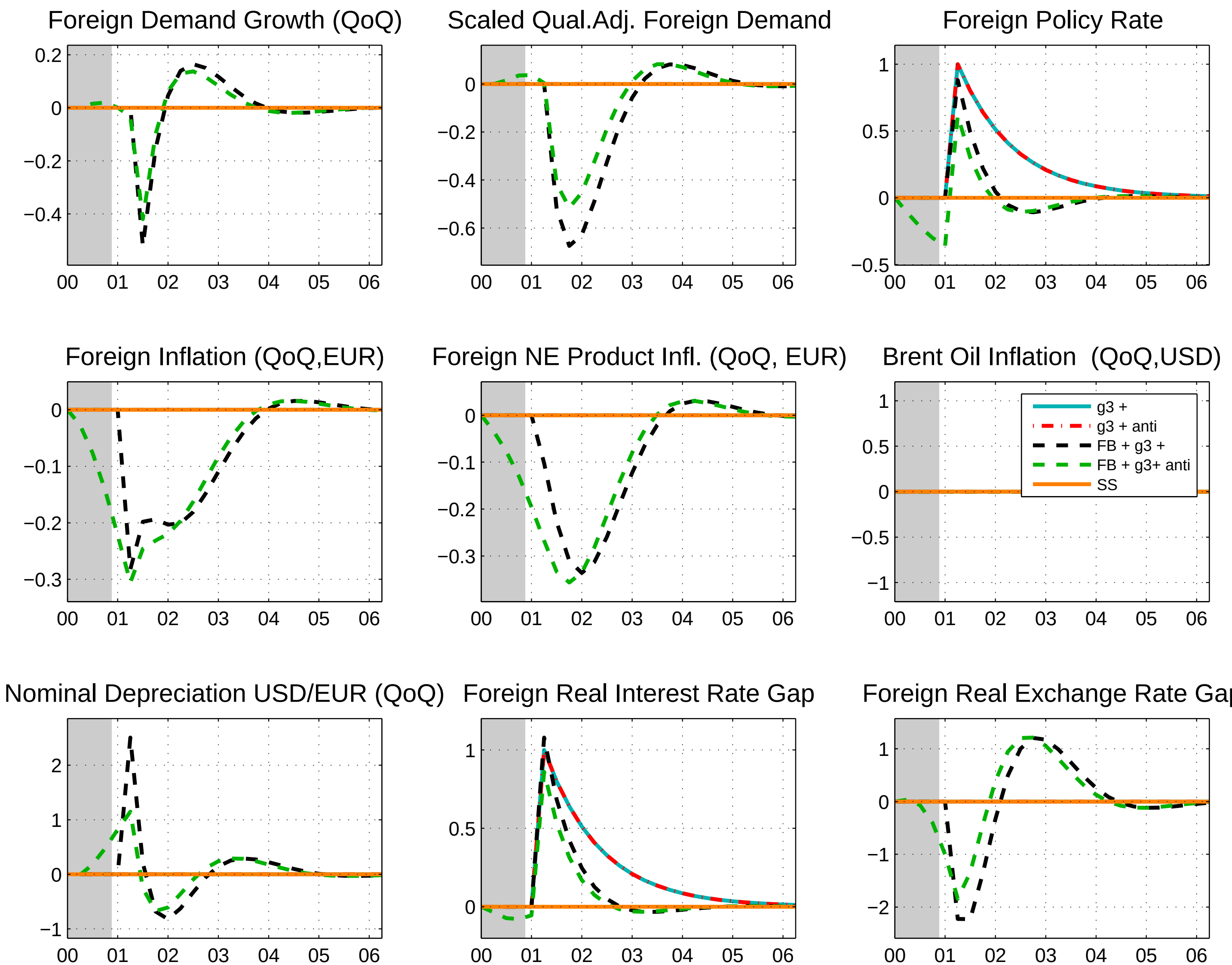
Impulse responses of the foreign block

- Shocks of 1 p.p. in given variable, y-axis shows percentage deviation from SS, x-axis shows years.
- The foreign demand shock increases foreign interest rates, inflation, while the exchange rate of euro appreciates with respect to U.S. dollar.
- The foreign interest rate shock decreases foreign output gap and inflation and leads to an appreciation of euro.

IRF – Foreign demand shock



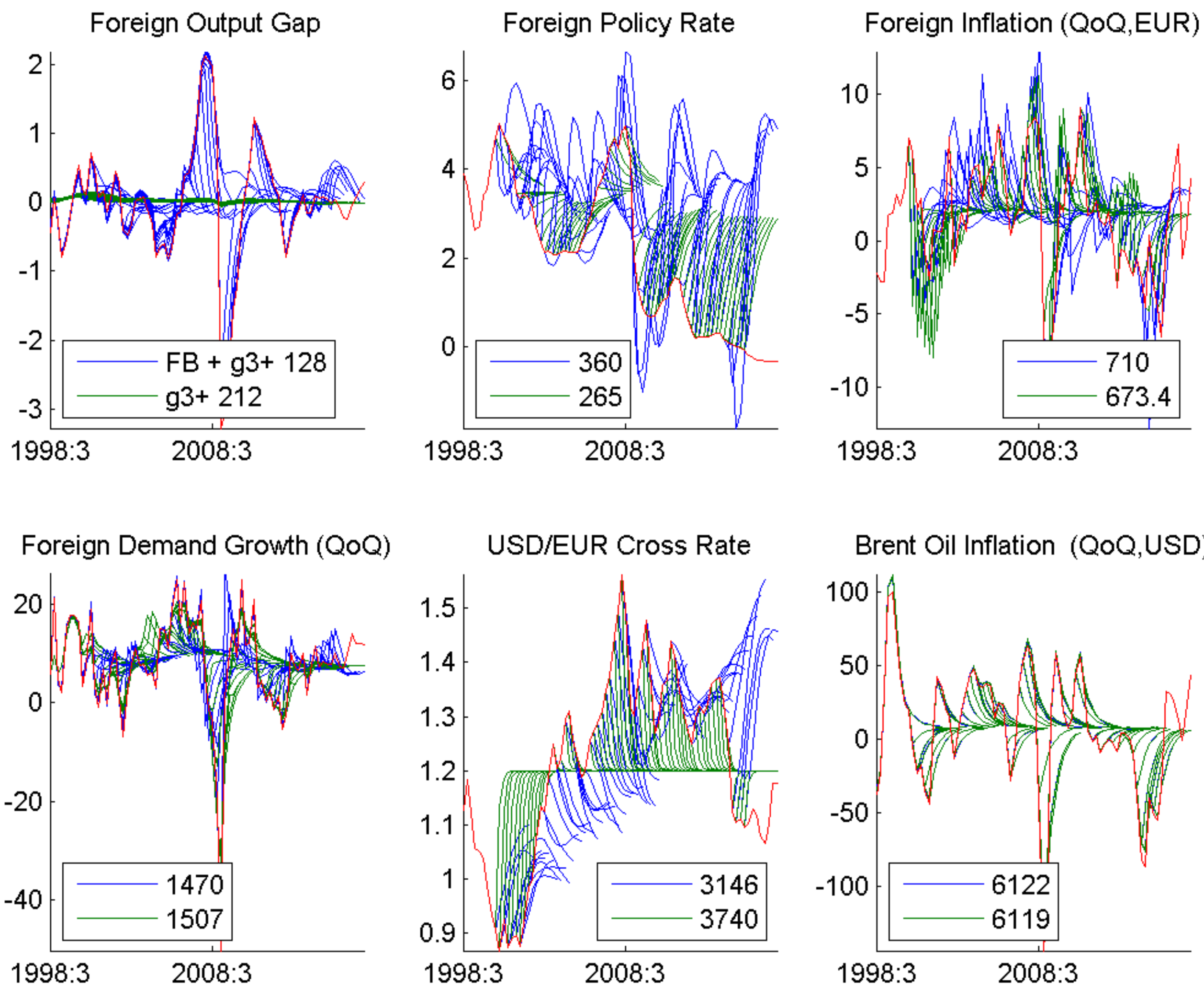
IRF – Foreign interest rate shock



Free simulations of stand-alone foreign block

- Recursive unconditional model forecast is compared to the actually observed development.
- Distinct improvement of simulations of foreign output gap.
- In comparison to the simple AR processes, the historic simulations of foreign interest rates worsened, but on the other hand, the forecast trajectories are now consistent with the foreign inflation forecast.
- Simulations of foreign inflation did not improve or worsen significantly.

Free simulations of stand-alone foreign block



Outline of the presentation

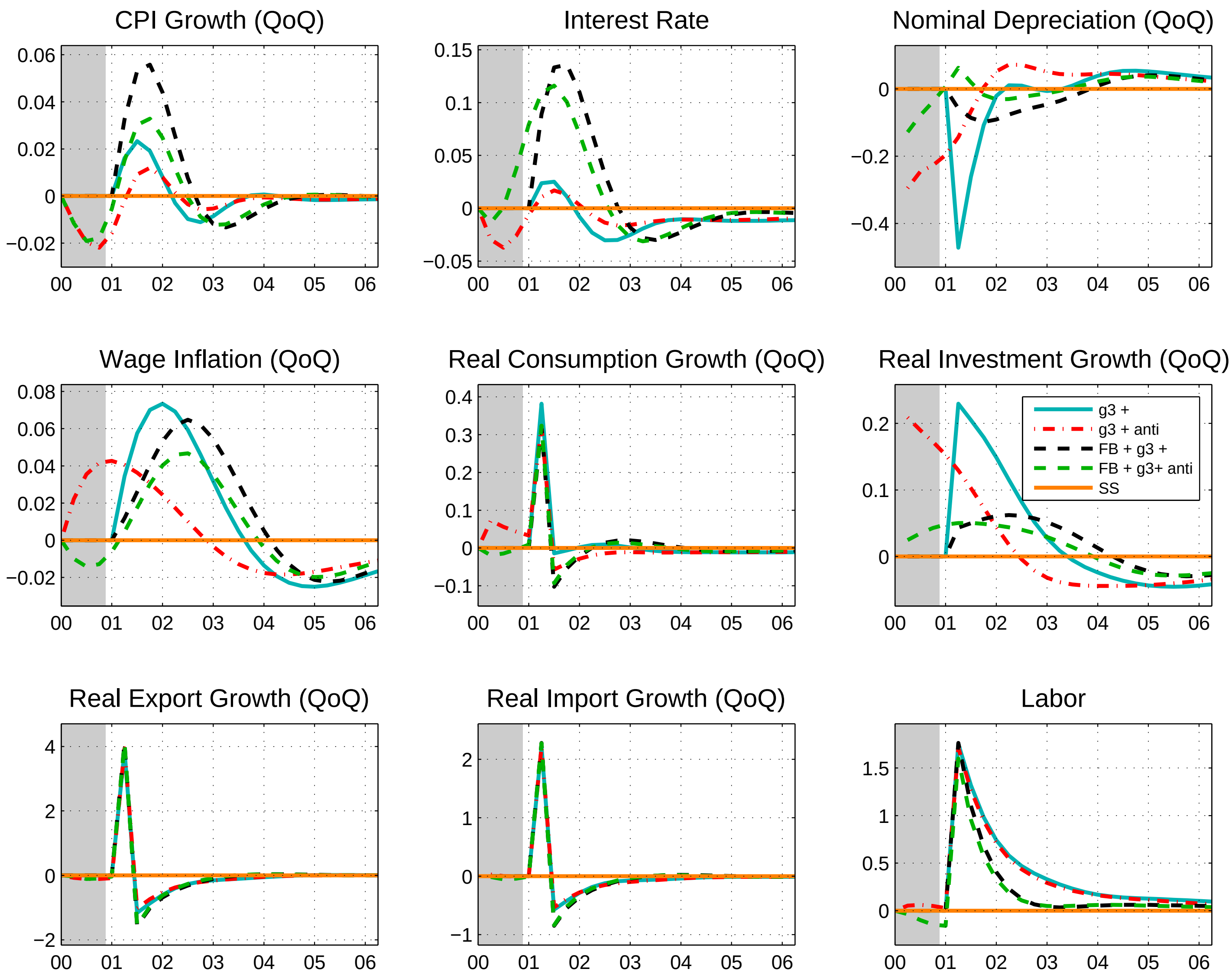
- These foreign variables are linked to the domestic economy:
  - Foreign output – gap and trend (GDP of effective EA)
  - Foreign inflation – energy and non-energy (NE) sector (PPI in effective EA)
  - Foreign interest rates (3M EURIBOR)
- Linking foreign GDP to the rest of the model represents a challenge because its counterpart from the domestic point of view – the foreign demand – is influenced by domestic technology processes. This link would imply spill-overs from domestic economy into the foreign block.
- The foreign GDP is linked to the foreign demand through the following transformation:
  - $foreign\,demand\,gap = foreign\,output\,gap^4$
  - $foreign\,demand\,growth = technology * (output\,gap\,change * potential\,growth)^4$

- Foreign GDP (gap and trend) is an input for the model and from the domestic perspective it is observed/given assumption of the forecast.
- Since the foreign variables make an interlinked and independent model, spill-overs from domestic economy to the foreign block are excluded.
- This allows an expert analysis of the foreign developments using only the stand-alone foreign block model without the domestic part of g3+ (external environment unit at the CNB)

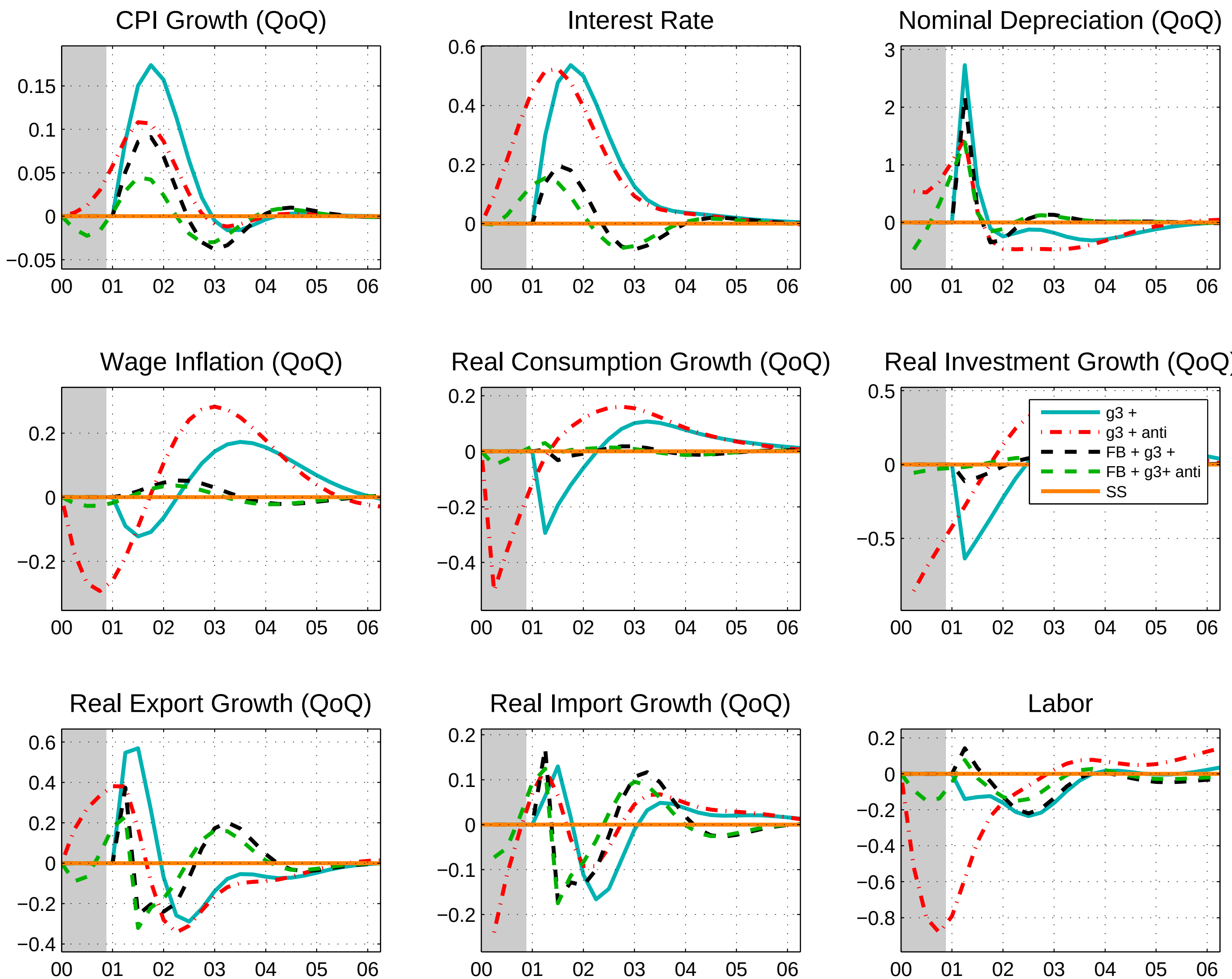
Impulse responses of the domestic economy

- Reaction of domestic variables to the foreign shocks presented earlier.
- Since the variables now react to the foreign shocks simultaneously, the response of the domestic economy to the foreign shocks can be qualitatively different to the original AR(1) foreign block setup.
- Foreign demand shock causes an increase of domestic inflation and interest rates, CZK/EUR exchange rate slightly depreciates due to higher foreign interest rates.
- Foreign interest rate shock does not lead to that significant increase of exports as before (via exchange rate depreciation) because now, the foreign demand declines simultaneously.
- Oil price shock leads to koruna depreciation against the euro.

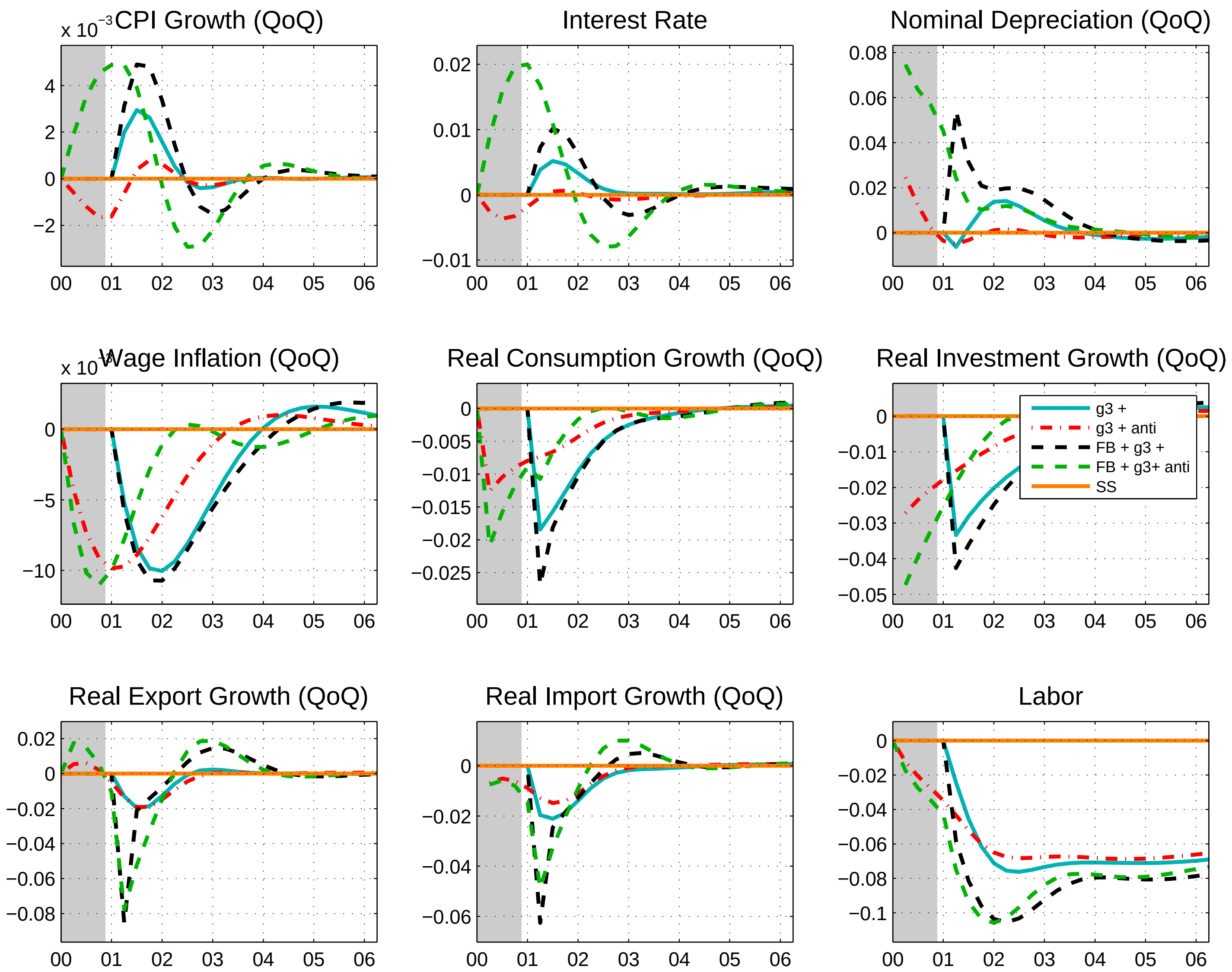
IRF – Foreign demand shock



IRF – Foreign interest rate shock



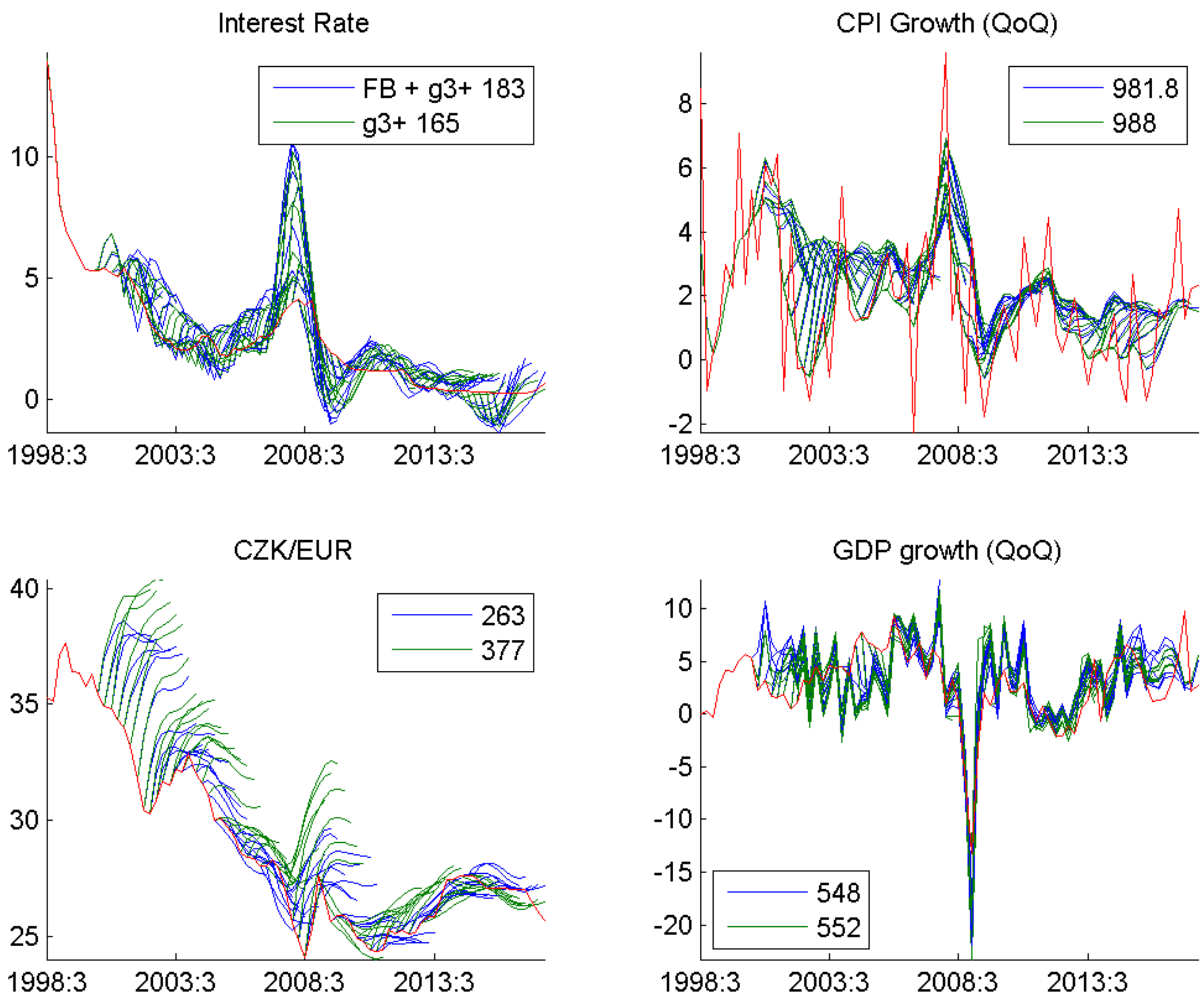
IRF – Oil price shock



Historic simulations of domestic economy

- Recursive model forecast of domestic variables conditional on the development of foreign variables.
- Distinct improvement of historic simulations of exchange rate, and hence domestic deflators.
- Slightly worse forecast of wages and consumption.

Historic simulations with new/old foreign block



Outline of the presentation

Conclusion

- The new foreign block meets the criteria for feasible model change, i.e.
  - Overall improvement of forecast capacity of the model (mainly exchange rate, and hence deflators; prediction of wages slightly worsens).
  - Intuitive impulse responses.
  - Intuitive shock decompositions.
- New integration of the foreign block works fine and can be used for any other (gap) model of the foreign environment.
- Still a work in progress, therefore, the results are not final.
- Further development of the foreign block model towards a two-country model of EA and US is planned.

Contact

Stanislav Tvrz
Economist

Czech National Bank
Na Příkopě 28
115 03 Praha 1
Czech Republic

Phone:
+420 22441 3736

Email:
Stanislav.Tvrz@cnb.cz

Backup slides

Model change in detail

CNB CZECH NATIONAL BANK

Original foreign block in g3 model

$$\begin{bmatrix} \log(\frac{n_t^*}{n^*}) \\ \log(\frac{\tilde{\pi}_t^*}{\tilde{\pi}^*}) \\ \log(\frac{i_t^*}{i^*}) \end{bmatrix} = \begin{bmatrix} 0.75 & 0 & 0 \\ 0 & 0.30 & 0 \\ 0 & 0 & 0.80 \end{bmatrix} \begin{bmatrix} \log(\frac{n_{t-1}^*}{n^*}) \\ \log(\frac{\tilde{\pi}_{t-1}^*}{\tilde{\pi}^*}) \\ \log(\frac{i_{t-1}^*}{i^*}) \end{bmatrix} + \begin{bmatrix} 0.01 & 0 & 0 \\ 0 & 0.01 & 0 \\ 0 & 0 & 0.01 \end{bmatrix} \begin{bmatrix} \epsilon^{n^*} \\ \epsilon^{\tilde{\pi}^*} \\ \epsilon^{i^*} \end{bmatrix}$$

is replaced with

$$\log(\hat{y}_t^*) = 0.60\ \log(\hat{y}_{t-1}^*) - 0.10\ \log(\hat{r}_{t-1}^*) + 0.01\ \log(\hat{z}_{t-1}) - 0.02\,(\log(\tilde{\pi}_t^{\text{brent}}) - \log(\tilde{\pi}^{\text{brent}})) + \epsilon_t^{y^*}(0.04)$$

$$\log(\tilde{\pi}_t^{*\text{non-ener}}) = 0.55\ \log(\tilde{\pi}_{t-1}^{*\text{non-ener}}) + (1-0.55)\ \log(\tilde{\pi}_{t+1}^{*\text{non-ener}}) + 0.07\ \log(\hat{y}_t^*) + 0.01\ \log(\hat{z}_{t-1}) + \epsilon_t^{\tilde{\pi}^{*\text{non-ener}}}(0.02)$$

$$\log(i_t^*) = 0.70\ \log(i_{t-1}^*) + (1-0.70)\,(\log(i^*) + 0.25\ \log(\hat{y}_t^*) + 2.00\left(\frac{\log(\tilde{\pi}_{t+4}^{*4})}{4} - \log(\tilde{\pi}^{*4})\right) + \epsilon_t^{i^*}(0.02)$$

$$\log(\hat{r}_t^*) = \log(i_t^*) - \log(\tilde{\pi}_{t+1}^*) - (\log(i^*) - log(\tilde{\pi}^*))$$

$$\log\left(\frac{\hat{z}_t}{\hat{z}_{t-1}}\right) = -\log(prem) - \log(\Delta usdeur) - log(\tilde{\pi}_t^*) + log(\tilde{\pi}^*)$$

$$0 = 0.60\ \log(\Delta usdeur_{t+1}) - (1-0.60)\,log(\Delta usdeur_t) + (\log(i_t^*) - log(i^*) - \log(prem)) + \epsilon_t^{\Delta usdeur}(0.$$

$$\log(prem_t) = 0.70\ \log(prem_{t-1}) + \epsilon_t^{prem}(0.00)$$

Return.

Integration in detail

CNB CZECH NATIONAL BANK

$$\widehat{n^*}_t = \widehat{y^*}_t^{\,4}$$

$$\Delta n_t^* = \frac{\Delta a C^*{}_t}{\Delta a Q_t} \left(\frac{\widehat{y^*}_t}{\widehat{y^*}_{t-1}} \Delta y_t^{*\text{trend}} \right)^4$$

Return.