



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

## G3 Model

Structural Economic Modelling at the CNB (core DSGE model)

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- Semestral Essay on a chosen topic (either offered or approved own).
- Exam is a discussion about the essay by email.
- Evaluation considers the quality of an essay among others.
- The best essays are stored for a possible employment offer to students.

- 1. 27.9. General Introduction to Macroeconomic Modelling for Monetary Policy: Tibor Hlédik
- 2. 27.9. Specifics of Building Structural Models in Selected Countries: Tibor Hlédik
- 3. 11.10. Short-Term Forecasting Using Factor Models: David Havrlant, Peter Tóth
- 4. 11.10. Selected Topics in Short-Term Forecasting: David Havrlant, Peter Tóth
- 5. 18.10. Two-Country Modelling: Real Convergence: Jan Bruha
- 6. 18.10. Two-Country Modelling: Computational Aspects: Jan Bruha
- 7. 25.10. Structural Economic Modelling at the CNB (core DSGE model): Jaromír Tonner
- 8. 25.10. Tools for Monetary Policy with DSGE Models: Jaromír Tonner
- 9. 1.11. Financial Frictions in DSGE models: general introduction: Jiří Polanský
- 10. 1.11. Financial Frictions in DSGE models: modelling approaches: Jiří Polanský
- 11. 8.11. Quarterly Projection Model: František Brázdk
- 12. 8.11. Getting in touch with QPM: František Brázdk
- 13. February 2012 Overview and Conclusions: Jaromír Tonner

- There are two antagonistic goals in modelling economic reality:
  - to have a simple model in order to interpret its dynamics (SIMPLICITY), but
  - there are always some observed facts we would like to incorporate (COMPREHENSIVENESS).
- We are anywhere between..
- The objective of the talk is to simply explain our framework for forecasting and monetary policy analysis.

- Short description of g3 model
- Identification and interpretation of initial conditions
- Projection simulation conditioned on exogenous variables and judgements
- Scenario analysis and forecast dynamics decomposition
- Communication of the forecast

# Aim of the Presentation

- Provide a brief introduction to the g3 model
- Explain (non-technically) main differences between QPM and g3 models
  - Emphasis on g3's *added value* w.r.t. QPM
  - Introduction to models' mechanisms via impulse response analysis
- Provide a brief overview of analytical and forecasting potential of the g3

- The model follows some recent developments in construction dynamic models for policy analysis
- Nominal frictions enrich the RBC dynamics
- Model is consistent with stock-flow national accounting
- 11 sectors (households, 2 intermediate goods production sectors, 4 final goods production sectors, central monetary policy authority, central fiscal policy authority, forex dealers, rest of the world)

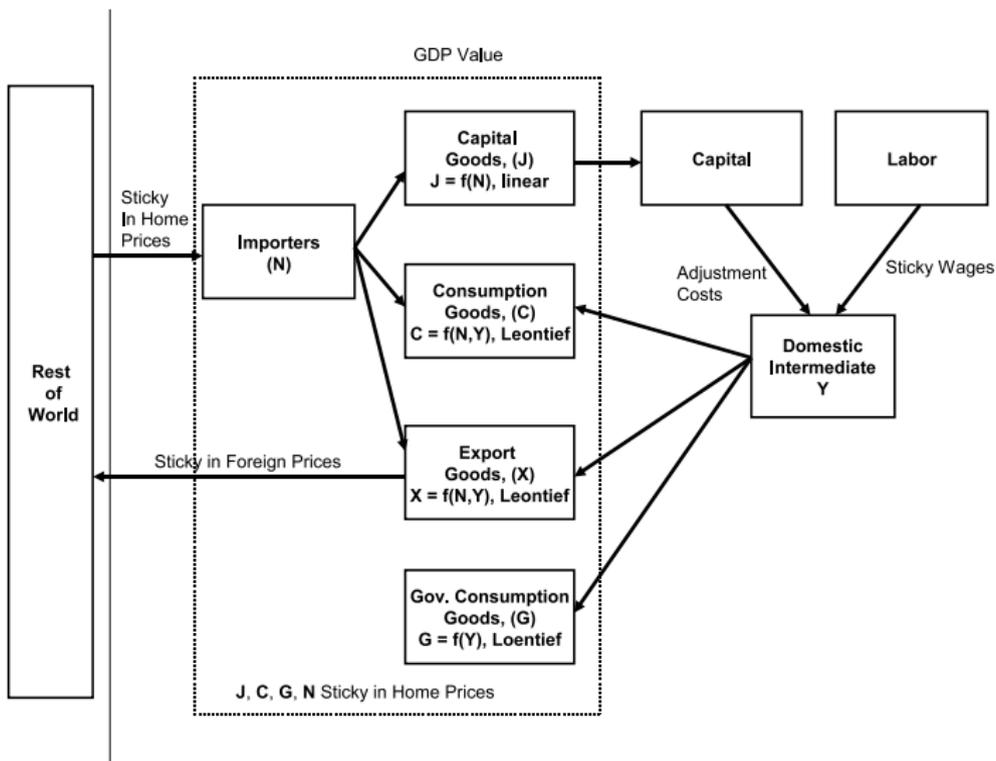
- GE SOE models for the Czech economy (tailor-made for the Czech economy)
- Inflation targeting regime
- Forward-looking monetary policy rule
- Agents are aware of the policy rule (no credibility or communication uncertainties)
- Structural model with forward looking rational expectations

- g3 contains trends (not a reduced-form gap model)
  - Loss of output gap, technologies instead
- Consistent stock-flow national accounting
  - Better communication with NTF about GDP components
- More detailed structure of the model
- More robust determination of initial conditions
- ⇒ provides answers to *more structural* questions (national accounting, structural shocks, dynamics of technologies, structural changes, shocks decomposition etc.)

# Sectors of the g3 model

- A continuum of monopolistically competitive households (labor supply)
- A continuum of monopolistically competitive domestic intermediate firms (single variety of intermediate good)
- Imported intermediate goods producers (a continuum of countries)
- Four final good producers (consumption, export, investment, government)
- Monetary and fiscal authorities
- Closing the model (forex dealers)

# g3 model - structure



# Many words - example is needed

- (2010Y rGDP:  $3000 = 1528 + 788 + 568 + 3375 - 3304$ )
  - 2010Y rGDP:  $3000 = 1500 + 800 + 700 + 3400 - 3400$
  - 2000Y rGDP:  $2200 = 1200 + 700 + 500 + 1400 - 1400$
  - 2010Y nGDP:  $3700 = 1900 + 850 + 850 + 2900 - 2900$
- ↓
- Defl. 2000:  $23 = 26 + 6 + 33 + (-15) - (-15)$
  - Av. Growth:  $3 = 2 + 1.5 + 3 + 8 - 8$
  - GDP shares:  $1 = 0.5 + 0.25 + 0.25 + 1 - 1$
- ↓ ↓
- Imp shares:  $C_M$  20%,  $I_M$  100%,  $X_M$  55%  
 $3000 = 1200 + 300 + 800 + 700 + 3400 - (300 + 800 + 2300)$
  - $3000 = 1200 + 700 + 3400 - 2300$

# Stylized Facts #1- Relevance of the Model

- **Balanced growth path (BGP)**
  - Constant specific nominal expenditure shares on nominal GDP in the steady-state (except export and import)
  - This specification allows for differential growth of real quantities on the BGP, offset by evolution in relative prices
- **Price stickiness cascading**
  - Calvo's setting in wage sector, domestic intermediate goods, imported intermediate goods, consumption final goods, export goods sector, investment goods sector, public spending goods sector
  - nominal wage stickiness is significantly larger than consumer price stickiness
- **Real rigidities and frictions**
  - External habit formation (0.85)
  - Investment adjustment costs

## Stylized Facts #2- Relevance of the Model

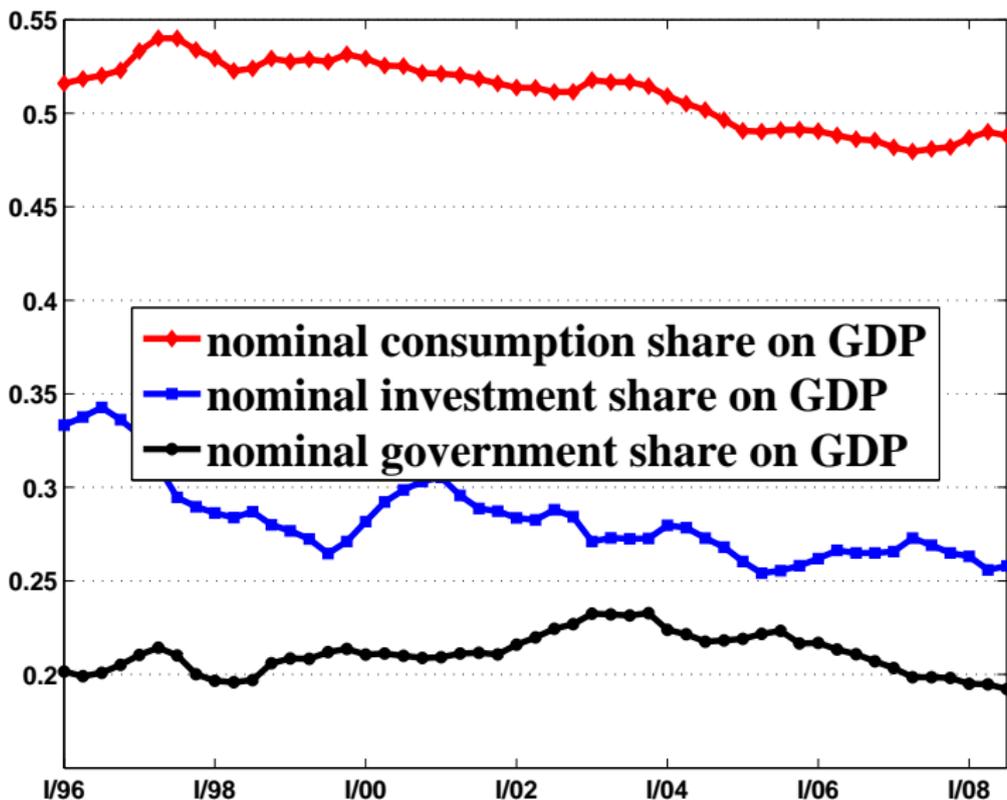
- Import intensity of exports and increase in trade openness of the economy
  - Significant excess in long-run growth of trade volumes with respect to output growth is inconsistent with standard SOE BGP
  - Large part of imports serves as a component for export goods production - massive inflow of foreign direct investment → increase in trade openness
- Gradual exchange-rate pass-through guaranteed by
  - 1 Multiple price rigidities (different parametrization of Calvo's parameters)
  - 2 Local currency pricing (exporters' prices are sticky in foreign currency, importers' prices are sticky in domestic currency)
- Real exchange rate appreciation in consumption prices (Harrod-Balassa-Samuelson Effect)

# Many words - example is needed again

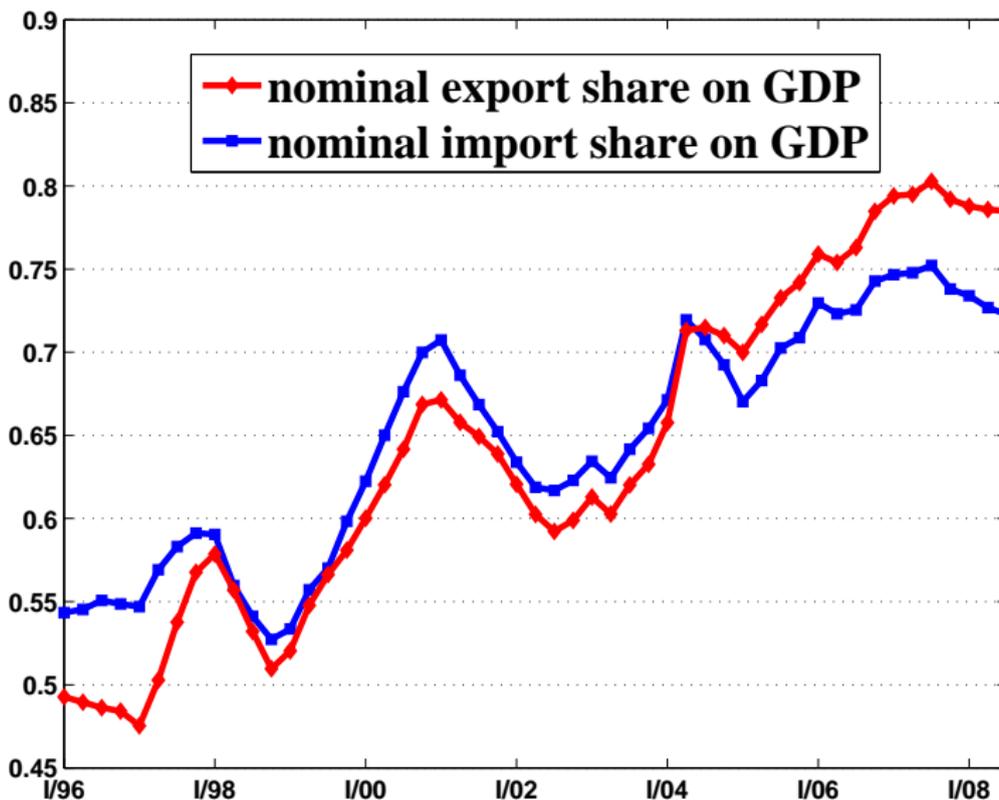
- $P_t^Y Y_t = P_t^C C_t + P_t^J J_t + P_t^G G_t + P_t^X X_t - P_t^N N_t$
- $2.3 = 2.2 + 1.1.5 + 3.3 + (-1) \cdot 8 - (-1) \cdot 8$
- but constant nominal shares except exports and imports....
- $1 = \frac{P_t^C C_t}{P_t^Y Y_t} + \frac{P_t^J J_t}{P_t^Y Y_t} + \frac{P_t^G G_t}{P_t^Y Y_t} + \frac{P_t^X X_t}{P_t^Y Y_t} - \frac{P_t^N N_t}{P_t^Y Y_t}$
- $1 = 0.5 + 0.25 + 0.25 + 0.8 - 0.8$
- technologies are needed to capture this mismatch

$$\begin{aligned}
 \bullet \quad 1 &= \frac{\overbrace{P_t^C}^{2+0} \overbrace{aR_t}^{4+0} C_t \frac{1}{aR_t}}{\underbrace{P_t^Y}_{2\%} \underbrace{Y_t}_{4\%}} + \frac{P_t^J aJ_t J_t \frac{1}{aJ_t}}{P_t^Y Y_t} + \frac{P_t^G aG_t G_t \frac{1}{aG_t}}{P_t^Y Y_t} + \\
 &\frac{\overbrace{P_t^X}^{-0.4+2.4} aX_t X_t \frac{1}{aX_t aO_t aQ_t}}{P_t^Y Y_t} - \frac{P_t^N aX_t N_t \frac{1}{aX_t aO_t aQ_t}}{P_t^Y Y_t}
 \end{aligned}$$

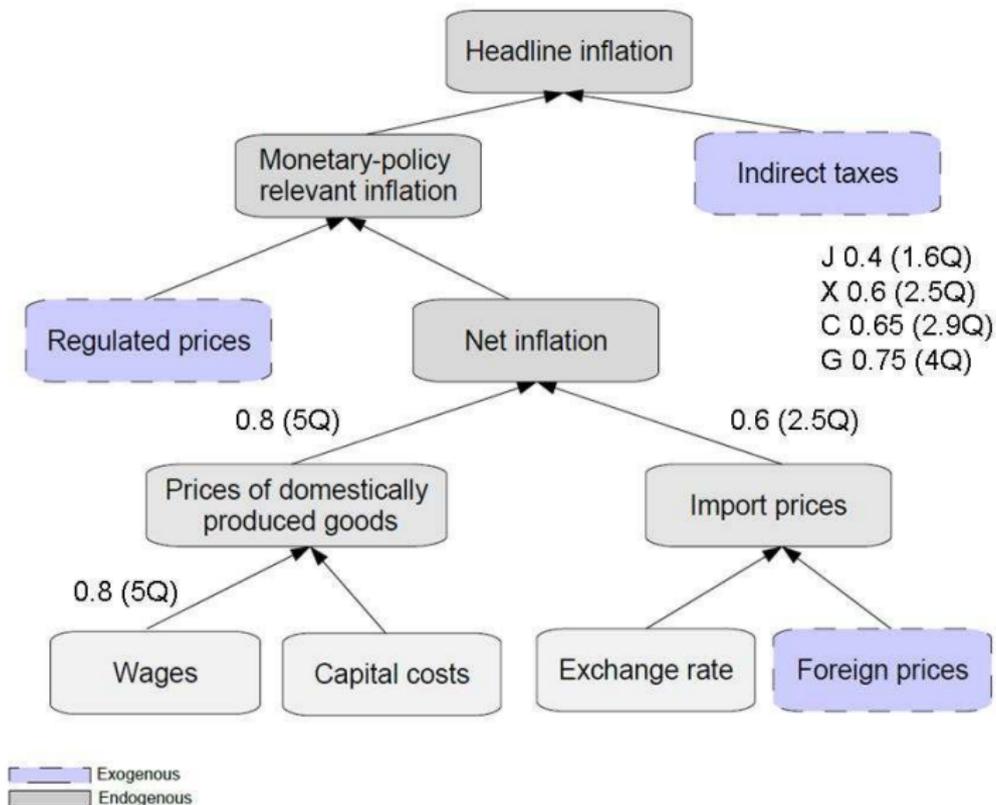
# Nominal shares



# Nominal shares



# Another Example - nominal rigidities



# Another Example - HBS effect

- LoOP:  $1 = \text{EXR} = \text{EX} \frac{\tilde{P}^{M*}}{P^X}$
- constant ToT:  $\dot{P}^X = \dot{P}^M, \tilde{\dot{P}}^{X*} = \tilde{\dot{P}}^{M*}$
- constant ToT:  $\dot{P}^X = \dot{P}^M, \tilde{\dot{P}}^{X*} = \tilde{\dot{P}}^{M*}$
- BB effect:  $\dot{P}^M = \dot{P}^C - a\dot{X}, \tilde{\dot{P}}^{M*} = \tilde{\dot{P}}^{C*} - a\dot{X}^*$
- together

$$0 = \dot{\text{EXR}} = \tilde{\dot{P}}^{M*} + \dot{\text{EX}} - \dot{P}^X = \tilde{\dot{P}}^{C*} - a\dot{X}^* + \dot{\text{EX}} - (\dot{P}^C - a\dot{X})$$

$$0 = \dot{\text{EXR}} = \tilde{\dot{P}}^{C*} + \dot{\text{EX}} - \dot{P}^C + a\dot{X} - a\dot{X}^*$$

$$0 = \dot{\text{EXR}} = \text{EXR}^{PC} + a\dot{X} - a\dot{X}^*$$

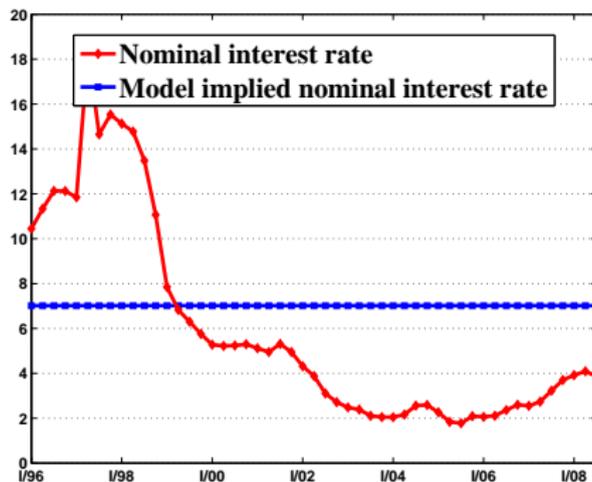
$$\text{EXR}^{PC} = a\dot{X}^* - a\dot{X} = \dot{\text{EX}} = -2.4.$$

## Another Example - regulated prices

- Regulated prices are important part of CPI inflation.
- Relative prices matter in the model.
- The inflation of regulated prices is higher than 2%.
- It implies a permanent divergence of regulated and nonregulated prices levels.
- Simple solution - we assume the same steady state growth.
- It implies the full deregulation in the steady state.
- It is implemented by regulated prices shock.
- It allows for trend in relative prices in the steady state and effects to real quantities while keeping nominal expenditure shares constant as required.

# Risk - free rate puzzle and equity premium puzzle

- There is a gap between the average observed real interest rate and real revenue in the economy
  - the model-implied real IR (discounted real economy growth) and the SS of inflation
  - $\frac{1}{\beta} \dot{Y} = I - \dot{P}^Y + \text{wedge}_{Euler} \Rightarrow \frac{1}{0.997} * 4 = 3 - 2 + \text{wedge}_{Euler}.$



# Model Behavior Via Impulse Response Analysis

- QPM
  - Behavior via key gaps of macro variables
  - Relatively simple story
- g3
  - g3 tells stories about trends, technologies, structural shocks etc. → better and deeper explanation
  - g3 is relatively complex → we check impulse responses very often when analyzing the initial state, forecast, or scenarios ...
  - Responses to anticipated and unanticipated shocks

# Monetary policy shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages — eps mpolicy

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	-0.5	0.4	0.1	-0.0	-0.0	-0.1
Real Consumption	%pa yoy	...	-0.0	0.0	-0.6	0.3	0.1	0.0	-0.0	-0.2
Real Investment	%pa yoy	...	0.0	0.0	0.0	0.1	-0.1	0.0	0.0	0.0
Real Import	%pa yoy	...	0.0	0.0	-0.4	0.6	-0.1	-0.0	0.0	0.0
Real Export	%pa yoy	...	0.0	0.0	-0.6	0.8	-0.2	-0.0	0.0	0.0
Nom. GovtCons.	%pa yoy	...	0.0	0.0	-1.0	-0.3	0.1	0.0	-0.0	-1.3
Real GovtCons.	%pa yoy	...	-0.0	0.0	-0.7	0.4	0.4	-0.0	-0.1	0.0
Real Eurozone Imports	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest rates	%pa yoy	...	0.0	0.0	1.6	-0.0	-0.1	-0.0	-0.0	1.4
CPI inflation	%pa yoy	...	-0.0	-0.0	-0.4	-0.6	-0.0	0.0	-0.0	-1.0
Exchange rate	%pa yoy	...	0.0	0.0	-1.9	1.0	-0.3	-0.0	-0.0	-1.1
Nom. Wage	%pa yoy	...	0.0	0.0	-0.5	-0.6	-0.2	0.0	0.0	-1.3

# Disinflation Shock (QPM)

- Central bank lowers target for inflation (unanticipated shock) → CB must raise the interest rate to achieve a disinflation
- → appreciation (→ fall of import prices) → AD drop results in gradual worsening of output gap (because of higher real rates and appreciation)
- Second period and thereafter: Combined effect of import prices and negative output gap pull down inflation → CB must begin to lower interest rates → the economy settles down (lower inflation and nominal interest rates)

# Exchange rate shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages —eps uip

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	0.1	-0.2	0.1	0.0	0.0	0.1
Real Consumption	%pa yoy	...	-0.0	0.0	-0.2	0.1	0.1	0.0	0.0	0.1
Real Investment	%pa yoy	...	0.0	0.0	-0.6	0.2	0.3	0.1	0.0	0.0
Real Import	%pa yoy	...	0.0	0.0	0.5	-0.8	0.3	0.0	0.0	0.0
Real Export	%pa yoy	...	0.0	0.0	1.3	-1.6	0.3	-0.0	-0.0	0.0
Nom. GovtCons.	%pa yoy	...	0.0	0.0	0.2	0.4	0.0	0.1	0.0	0.7
Real GovtCons.	%pa yoy	...	-0.0	0.0	0.1	0.0	-0.3	-0.0	0.1	0.0
Real Eurozone Imports	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest rates	%pa yoy	...	0.0	0.0	0.8	0.5	-0.1	0.0	0.0	1.2
CPI inflation	%pa yoy	...	-0.0	-0.0	0.4	0.2	-0.1	0.0	0.0	0.5
Exchange rate	%pa yoy	...	0.0	0.0	3.6	-2.6	-0.1	-0.0	0.1	0.9
Nom. Wage	%pa yoy	...	0.0	0.0	0.1	0.4	0.3	-0.0	-0.0	0.7

# Exchange rate shock (QPM)

- Nominal depreciation (e.g.: asset preferences)
- → 2 pressures on inflation: (i) opening positive output gap, (ii) more significantly, effects through an increase of import prices → CB increases interest rate to resist inflationary pressures ...

# Shock to habit (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages —eps habit

		1	2	3	4	5	6	7	8	100
Real GDP	% pa yoy	...	0.0	0.0	5.2	-3.5	-1.1	-0.4	-0.1	0.2
Real Consumption	% pa yoy	...	-0.0	0.0	8.9	-5.5	-2.0	-0.7	-0.2	0.7
Real Investment	% pa yoy	...	0.0	0.0	-0.2	-0.3	-0.3	-0.0	0.1	0.0
Real Import	% pa yoy	...	0.0	0.0	1.1	-0.7	-0.4	-0.2	0.0	0.0
Real Export	% pa yoy	...	0.0	0.0	-0.5	0.6	0.1	-0.1	0.1	0.0
Nom. GovtCons.	% pa yoy	...	0.0	0.0	9.5	-5.4	-2.1	-0.7	-0.2	1.3
Real GovtCons.	% pa yoy	...	-0.0	0.0	8.7	-5.5	-1.6	-0.6	-0.3	0.6
Real Eurozone Imports	% pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest rates	% pa yoy	...	0.0	0.0	0.7	0.6	0.1	0.1	0.1	1.9
CPI inflation	% pa yoy	...	-0.0	-0.0	0.3	0.2	-0.1	0.0	0.0	0.6
Exchange rate	% pa yoy	...	0.0	0.0	-0.7	1.6	0.3	-0.0	-0.0	0.7
Nom. Wage	% pa yoy	...	0.0	0.0	-0.2	0.0	0.3	0.2	0.1	0.7

- A positive shock to output gap (without a direct model reference to GDP components) → upward pressure on inflation
- → CB reacts immediately and raises the interest rate → appreciating currency
- A quick reaction, inflation is below target before direct influence from excess demand (due to import prices channel), then jumps upward due to demand effects

# Costpush shock - Aggregate supply shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages —eps costpushC

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	0.3	-0.2	-0.1	0.0	0.0	0.1
Real Consumption	%pa yoy	...	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Real Investment	%pa yoy	...	0.0	0.0	0.1	-0.1	-0.0	-0.0	-0.0	0.0
Real Import	%pa yoy	...	0.0	0.0	0.1	-0.1	-0.1	0.1	-0.0	0.0
Real Export	%pa yoy	...	0.0	0.0	0.1	-0.1	-0.1	0.1	0.0	0.0
Nom. GovtCons.	%pa yoy	...	0.0	0.0	0.8	0.1	0.0	0.0	0.0	1.0
Real GovtCons.	%pa yoy	...	-0.0	0.0	0.6	-0.5	-0.3	0.1	0.1	0.0
Real Eurozone Imports	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest rates	%pa yoy	...	0.0	0.0	0.2	-0.0	0.0	0.0	0.0	0.3
CPI inflation	%pa yoy	...	-0.0	-0.0	0.7	0.0	0.0	0.0	-0.0	0.8
Exchange rate	%pa yoy	...	0.0	0.0	0.5	0.3	-0.0	0.1	0.0	0.9
Nom. Wage	%pa yoy	...	0.0	0.0	0.3	0.6	0.2	-0.0	-0.0	1.0

# Costpush shock - Aggregate supply shock (g3)

- $\uparrow \text{costpushC} \rightarrow \uparrow \dot{\text{cpi}} \rightarrow \uparrow i \rightarrow \downarrow \dot{\text{pY}} \dot{\text{pN}} \rightarrow \uparrow \dot{\text{g}} \rightarrow \downarrow \text{t bal} \rightarrow \downarrow \text{b} \rightarrow \uparrow \text{prem} \rightarrow \uparrow \dot{\text{s}}$

# Aggregate supply shock (QPM)

- A positive shock to prices (via a residual in the Phillips curve)
- → CB increases the interest rate → appreciation of exchange rate largely offsets the shock via import prices
- Negative output gap is closing with easing of monetary conditions

# Regulated prices shock (g3)

g3behavior

2009-06-29

**G3 Forecast U Summary – Yearly Averages —eps pREG**

		1	2	3	4	5	6	7	8	100
Real GDP	% pa yoy	...	0.0	0.0	-0.2	-0.1	-0.1	-0.1	-0.0	-0.5
Real Consumption	% pa yoy	...	-0.0	0.0	-0.6	-0.5	-0.2	-0.1	-0.0	-1.4
Real Investment	% pa yoy	...	0.0	0.0	-0.1	0.0	-0.0	0.0	0.0	0.0
Real Import	% pa yoy	...	0.0	0.0	-0.1	0.2	-0.0	-0.0	0.0	0.0
Real Export	% pa yoy	...	0.0	0.0	-0.2	0.3	-0.0	-0.0	0.0	0.0
Nom. GovtCons.	% pa yoy	...	0.0	0.0	0.1	-0.4	-0.2	-0.1	-0.0	-0.7
Real GovtCons.	% pa yoy	...	-0.0	0.0	0.2	-0.0	0.0	-0.1	-0.1	0.0
Real Eurozone Imports	% pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest rates	% pa yoy	...	0.0	0.0	0.3	0.0	-0.0	-0.0	-0.0	0.3
CPI inflation	% pa yoy	...	-0.0	-0.0	0.7	0.1	-0.0	0.0	-0.0	0.7
Exchange rate	% pa yoy	...	0.0	0.0	-0.7	0.3	-0.1	-0.1	-0.0	-0.6
Nom. Wage	% pa yoy	...	0.0	0.0	-0.3	-0.4	-0.1	0.0	0.0	-0.7

# Regulated prices shock (QPM)

- CB tries to prevent the increase in regulated prices spilling over into CPI inflation
- CB raises interest rates → effects of appreciation on import prices are not sufficient to offset overall CPI effects (net CPI below target whereas overall CPI above target)

# Foreign demand shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages —eps Nstar

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	0.5	-0.2	-0.1	-0.0	-0.0	0.0
Real Consumption	%pa yoy	...	-0.0	0.0	0.1	0.1	0.0	-0.0	-0.0	-0.0
Real Investment	%pa yoy	...	0.0	0.0	0.4	0.3	0.0	-0.1	-0.1	0.0
Real Import	%pa yoy	...	0.0	0.0	1.3	-0.7	-0.2	-0.1	-0.0	0.0
Real Export	%pa yoy	...	0.0	0.0	2.0	-1.5	-0.4	-0.1	-0.0	0.0
Nom. GovtCons.	%pa yoy	...	0.0	0.0	0.2	0.1	0.0	-0.0	-0.0	-0.1
Real GovtCons.	%pa yoy	...	-0.0	0.0	0.0	-0.1	-0.0	0.1	0.0	0.0
Real Eurozone Imports	%pa yoy	...	0.0	0.0	2.3	-1.5	-0.5	-0.2	-0.0	0.0
Interest rates	%pa yoy	...	0.0	0.0	-0.0	-0.1	-0.0	-0.0	-0.0	-0.4
CPI inflation	%pa yoy	...	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Exchange rate	%pa yoy	...	0.0	0.0	-0.5	-0.1	0.1	0.1	0.1	-0.1
Nom. Wage	%pa yoy	...	0.0	0.0	0.1	0.2	-0.0	-0.1	-0.1	-0.1

# Foreign interest rate shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages —eps Istar

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	-1.1	-0.1	0.6	0.4	0.3	0.3
Real Consumption	%pa yoy	...	-0.0	0.0	-2.2	-0.1	1.3	0.9	0.5	0.4
Real Investment	%pa yoy	...	0.0	0.0	-3.8	-0.9	2.6	2.2	1.0	0.2
Real Import	%pa yoy	...	0.0	0.0	0.5	-1.5	0.2	0.6	0.3	0.0
Real Export	%pa yoy	...	0.0	0.0	3.8	-2.1	-1.5	-0.3	-0.2	0.1
Nom. GovtCons.	%pa yoy	...	0.0	0.0	-1.3	1.0	1.3	0.9	0.5	2.4
Real GovtCons.	%pa yoy	...	-0.0	0.0	-0.9	1.2	-0.3	-0.9	0.0	0.0
Real Eurozone Imports	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest rates	%pa yoy	...	0.0	0.0	3.0	4.0	0.9	0.3	0.2	8.0
CPI inflation	%pa yoy	...	-0.0	-0.0	0.9	1.1	-0.1	-0.0	0.0	1.9
Exchange rate	%pa yoy	...	0.0	0.0	9.9	-2.9	-2.9	-1.8	-0.3	2.8
Nom. Wage	%pa yoy	...	0.0	0.0	-0.9	0.4	2.2	1.2	0.2	2.4

# Foreign prices shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages —eps Pstar

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	0.2	-0.3	0.1	0.0	0.0	0.0
Real Consumption	%pa yoy	...	-0.0	0.0	-0.1	-0.0	0.0	0.0	0.0	0.0
Real Investment	%pa yoy	...	0.0	0.0	-0.2	-0.1	0.0	0.0	0.0	0.0
Real Import	%pa yoy	...	0.0	0.0	0.9	-1.2	0.2	0.0	-0.0	0.0
Real Export	%pa yoy	...	0.0	0.0	1.7	-2.0	0.4	0.1	-0.0	0.0
Nom. GovtCons.	%pa yoy	...	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	0.1
Real GovtCons.	%pa yoy	...	-0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0
Real Eurozone Imports	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest rates	%pa yoy	...	0.0	0.0	0.1	0.1	-0.0	0.0	0.0	0.3
CPI inflation	%pa yoy	...	-0.0	-0.0	0.1	0.0	-0.0	0.0	0.0	0.1
Exchange rate	%pa yoy	...	0.0	0.0	-3.3	-0.5	-0.1	-0.0	-0.0	-4.0
Nom. Wage	%pa yoy	...	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	0.1

# Labour augmented technology shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages — eps A

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	10.2	6.4	1.9	1.3	0.7	21.8
Real Consumption	%pa yoy	...	-0.0	0.0	9.4	6.5	2.1	1.2	0.7	21.5
Real Investment	%pa yoy	...	0.0	0.0	12.4	10.4	3.8	0.3	-0.5	22.4
Real Import	%pa yoy	...	0.0	0.0	12.1	6.8	2.5	1.1	0.1	22.8
Real Export	%pa yoy	...	0.0	0.0	12.3	4.7	1.9	1.5	0.2	22.7
Nom. GovtCons.	%pa yoy	...	0.0	0.0	8.6	5.7	2.5	1.4	0.7	20.7
Real GovtCons.	%pa yoy	...	-0.0	0.0	8.7	4.2	0.4	1.9	1.9	21.3
Real Eurozone Imports	%pa yoy	...	0.0	0.0	12.9	7.6	1.8	0.4	0.1	22.9
Interest rates	%pa yoy	...	0.0	0.0	-2.2	-2.1	0.8	0.6	0.1	-1.5
CPI inflation	%pa yoy	...	-0.0	-0.0	-0.8	-0.8	0.3	0.1	-0.0	-1.0
Exchange rate	%pa yoy	...	0.0	0.0	-2.1	-6.6	-0.0	2.3	1.0	-0.8
Nom. Wage	%pa yoy	...	0.0	0.0	7.5	11.1	2.3	-0.9	-0.5	21.1

# Labour augmented technology shock (g3)

- $\uparrow \dot{A} \rightarrow \uparrow \dot{Z} \rightarrow \uparrow \dot{N}^* \rightarrow \uparrow n^* aQ \rightarrow \uparrow x \rightarrow \uparrow t$   
 $\text{bal} \rightarrow \uparrow b \rightarrow \downarrow \dot{S} \rightarrow \downarrow \text{prem} \rightarrow \downarrow i \rightarrow \downarrow E \dot{S}$

# Investment specific technology shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages —eps aJ

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	2.9	1.1	0.4	0.2	0.1	5.0
Real Consumption	%pa yoy	...	-0.0	0.0	1.0	0.6	0.2	0.1	0.0	2.3
Real Investment	%pa yoy	...	0.0	0.0	6.3	5.4	1.5	0.1	-0.2	10.6
Real Import	%pa yoy	...	0.0	0.0	0.3	1.4	0.6	0.1	0.0	2.4
Real Export	%pa yoy	...	0.0	0.0	1.3	-0.4	0.2	0.1	0.1	2.4
Nom. GovtCons.	%pa yoy	...	0.0	0.0	0.9	0.5	0.2	0.1	0.0	2.2
Real GovtCons.	%pa yoy	...	-0.0	0.0	0.4	-0.6	-0.2	0.5	0.4	2.3
Real Eurozone Imports	%pa yoy	...	0.0	0.0	2.4	0.0	0.0	0.0	0.0	2.4
Interest rates	%pa yoy	...	0.0	0.0	-0.3	-0.3	0.0	0.0	-0.0	-0.1
CPI inflation	%pa yoy	...	-0.0	-0.0	-0.1	-0.1	0.0	0.0	-0.0	-0.1
Exchange rate	%pa yoy	...	0.0	0.0	-2.5	-1.2	0.1	0.5	0.3	-0.1
Nom. Wage	%pa yoy	...	0.0	0.0	0.8	1.1	0.1	-0.2	-0.1	2.2

# Export specific technology shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages —eps aX

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	-0.1	0.1	-0.0	-0.0	0.0	0.0
Real Consumption	%pa yoy	...	-0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
Real Investment	%pa yoy	...	0.0	0.0	-0.2	0.2	0.1	-0.0	-0.0	0.0
Real Import	%pa yoy	...	0.0	0.0	3.6	0.7	0.0	-0.1	0.0	4.1
Real Export	%pa yoy	...	0.0	0.0	3.4	0.9	-0.0	-0.1	0.0	4.1
Nom. GovtCons.	%pa yoy	...	0.0	0.0	0.3	0.1	-0.0	0.0	-0.0	0.4
Real GovtCons.	%pa yoy	...	-0.0	0.0	0.2	-0.2	-0.2	0.1	0.1	0.0
Real Eurozone Imports	%pa yoy	...	0.0	0.0	3.9	0.3	0.0	0.0	0.0	4.2
Interest rates	%pa yoy	...	0.0	0.0	0.2	-0.0	-0.0	0.0	-0.0	0.2
CPI inflation	%pa yoy	...	-0.0	-0.0	0.3	0.0	-0.0	0.0	-0.0	0.3
Exchange rate	%pa yoy	...	0.0	0.0	-2.9	-0.3	-0.1	0.1	0.0	-3.3
Nom. Wage	%pa yoy	...	0.0	0.0	0.1	0.3	0.0	-0.0	-0.0	0.4

# Trade openness technology shock (g3)

g3behavior

2009-06-29

G3 Forecast U Summary – Yearly Averages —eps aO

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.8
Real Consumption	%pa yoy	...	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0
Real Investment	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0
Real Import	%pa yoy	...	0.0	0.0	21.1	14.8	4.4	1.4	0.4	42.4
Real Export	%pa yoy	...	0.0	0.0	21.1	14.8	4.4	1.4	0.4	42.4
Nom. GovtCons.	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0
Real GovtCons.	%pa yoy	...	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Real Eurozone Imports	%pa yoy	...	0.0	0.0	21.1	14.8	4.4	1.4	0.4	42.4
Interest rates	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CPI inflation	%pa yoy	...	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Exchange rate	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nom. Wage	%pa yoy	...	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0

G3 Forecast U Summary – Yearly Averages —eps aQ

		1	2	3	4	5	6	7	8	100
Real GDP	%pa yoy	...	0.0	0.0	0.0	-0.0	-0.0	0.0	-0.0	0.0
Real Consumption	%pa yoy	...	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0
Real Investment	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Import	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Export	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	0.0
Nom. GovtCons.	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real GovtCons.	%pa yoy	...	-0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0	-0.0
Real Eurozone Imports	%pa yoy	...	0.0	0.0	-30.2	-1.0	-0.0	-0.0	-0.0	-31.2
Interest rates	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CPI inflation	%pa yoy	...	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Exchange rate	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0
Nom. Wage	%pa yoy	...	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	0.0

# Comparison with QPM

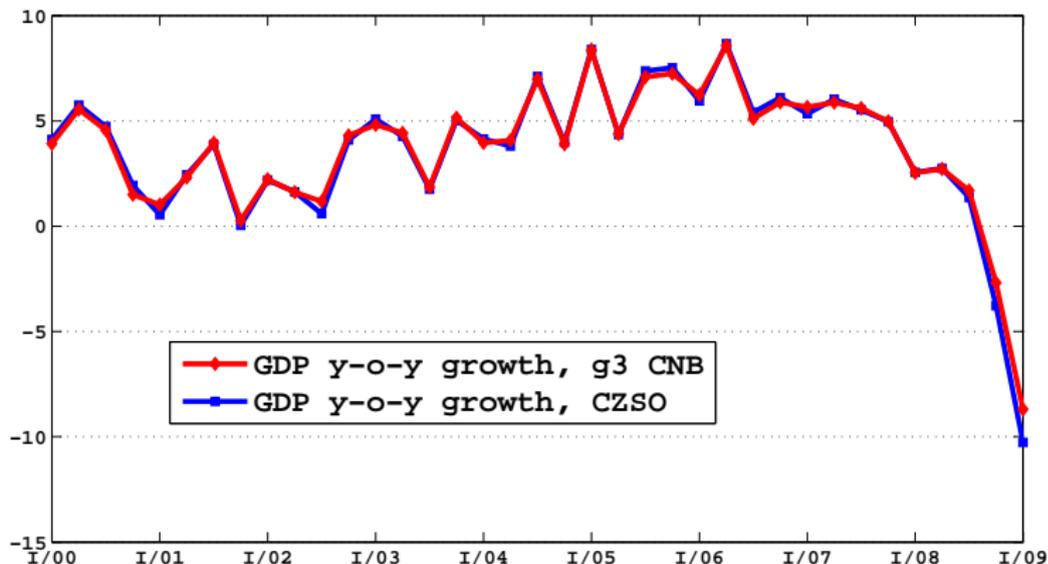
- The idea is the same (Phillips curves - relation between nominal and real vars).
- But g3 is structural model (with consistent stock- flow NA), it must have 11 sectors.
- QPM is gap model, g3 filters data using the model structure.
- Because of model filtering we incorporated 'technologies' to capture trends which we do not want to model:
  - openness tech. - to remove reexports from trend (it is not value added that is produced inside the model)
  - quality - to adjust foreign demand when exports are high and ER appreciates
  - regulated tech. - to describe a trend between regulated and non-regulated sector
  - export sp. tech. - to capture H-B-S effect
  - investment and government tech. - to impose judgments

# Identification and interpretation of initial conditions

- Seasonal adjustment
- Structural shocks
- Measurement errors
- Structural shocks decomposition
- Interpreting news and revisions of the data

# Seasonal adjustment

Problems with CSZO data ( $GDP^{sa} \neq C^{sa} + I^{sa} + G^{sa} + X^{sa} - N^{sa}$ )



The assessment of initial position of the economy via DSGE model is based on

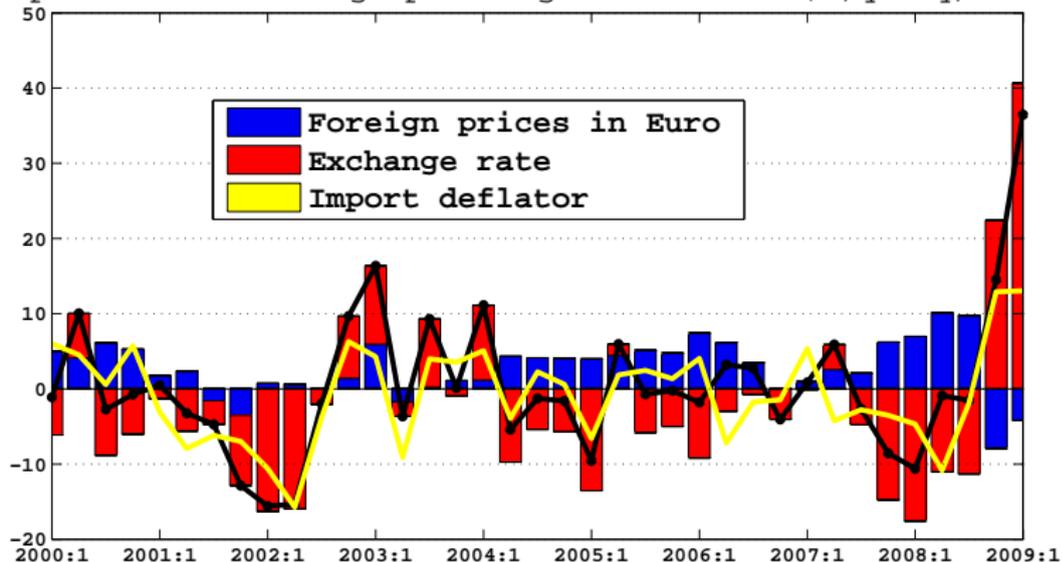
- identification structural shocks,
- interpretation of structural shocks.

The modelling approach is used to

- analyse observed time series while allowing us
- to put more weight on the data with less noise or revision tendencies.

# Tune of import prices

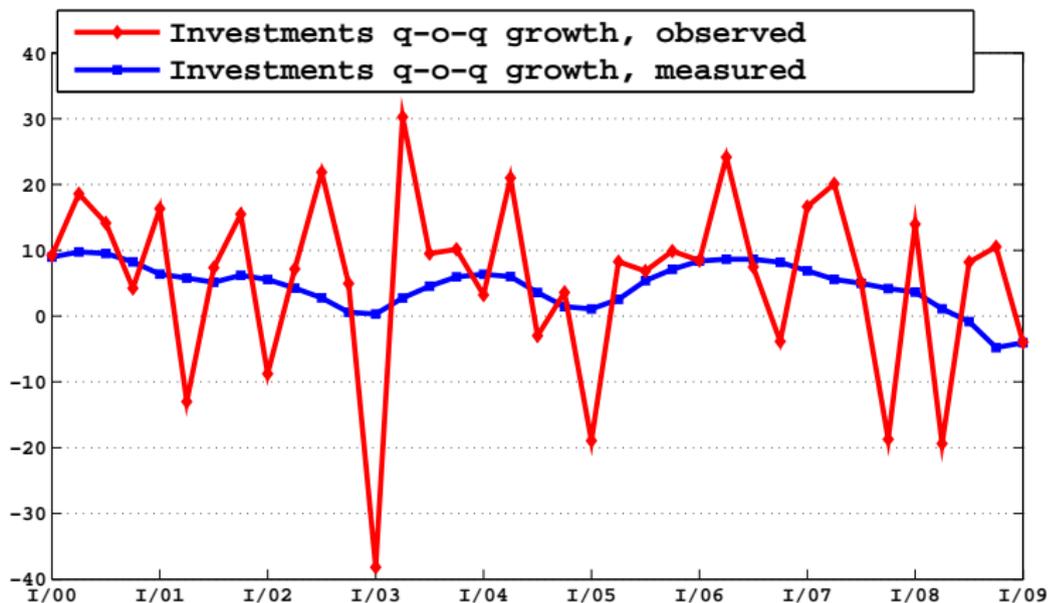
Decomposition of foreign prices growth in CZK (% ,q-o-q, annual.)



# Measurement errors

- ME reflect our priors concerning data reliability.
- ME brings some problems in distinguishing between structural shock and measurement error.
- Even in case of ME, a significant portion of information can be used by the model.
- Another problem is that filtered vars need not match exactly raw data, so then ...
- ...we investigate factors for that discrepancy...what are models or data deficiencies.

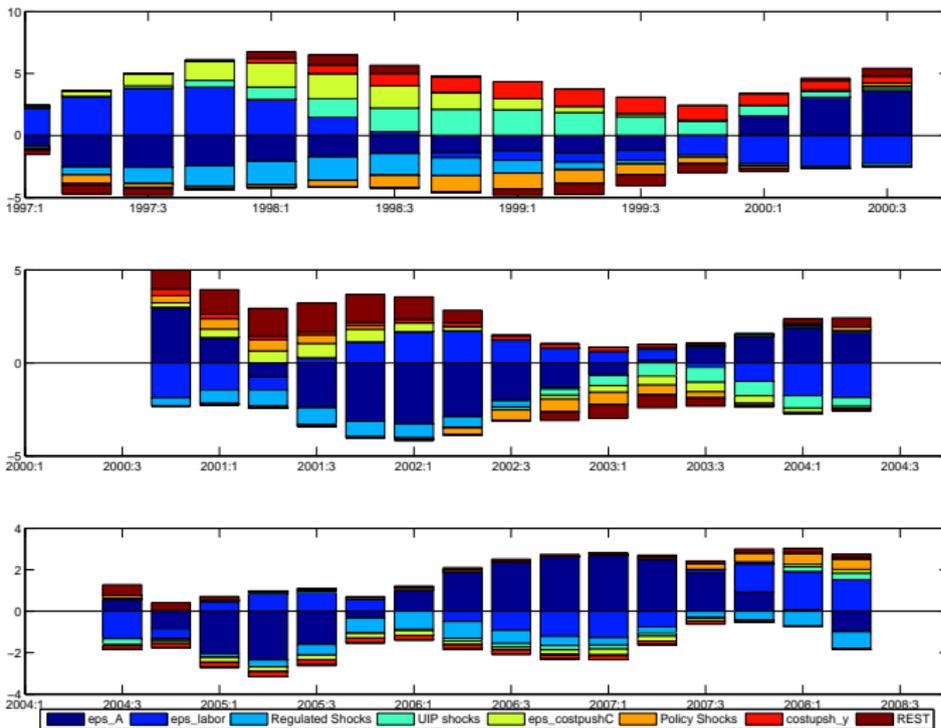
# Error measured investments



## SSD is used

- To fully understand a story behind the observed data (if we believe that the model is plausible).
- To compare our intuition with the model dynamics.
- To find out which shocks are responsible for a deviation of a given variable from its steady state.

# SSD example



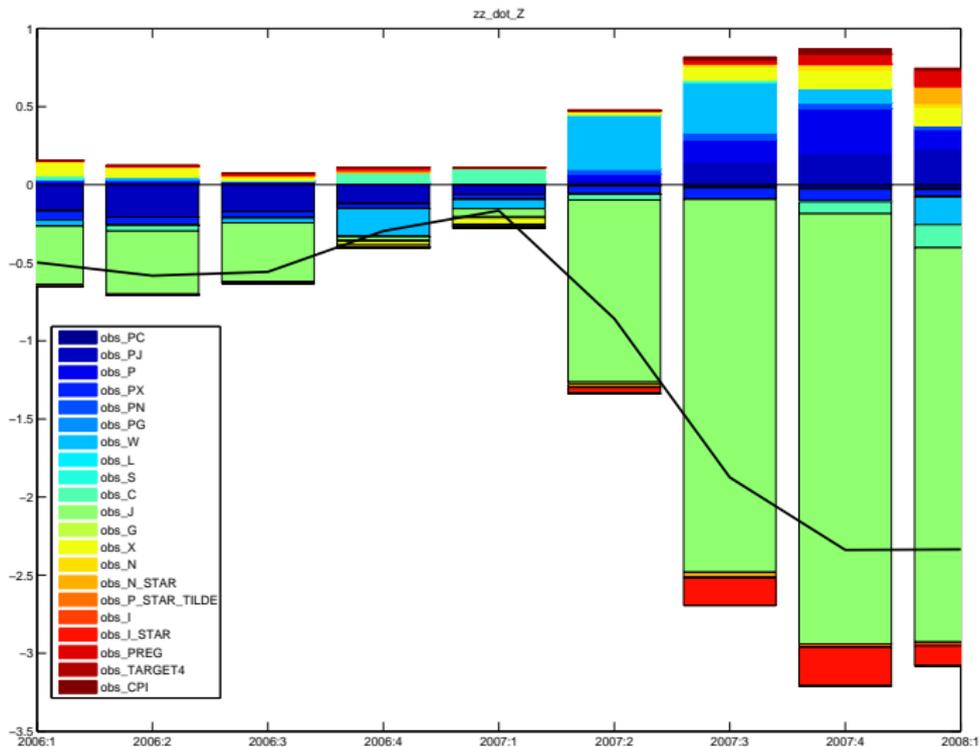
To understand changes in the assessment of the initial position of the economy due to

- data revisions,
- new period observations.

We use a decomposition of a given endogenous variable into observables. It is based on

- filtering apparatus (Linear Kalman filter) and on
- structure of the model (linear or log-linearized DSGE model).

# Example of decomposition into observables



# Projection simulation conditioned on exogenous variables and judgements

- Endogenous monetary policy - unconditional forecast
- Conditions, Exogenisation and Imposing judgements
- Modest policy interventions vs. Anticipated shocks

# Unconditional forecast

- Forecasts are produced assuming endogenous monetary policy responses.
- MP operates via setting a trajectory for nominal interest rate in the regime of inflation targeting...
- ...in this respect our forecast is unconditional, but it is based on the initial conditions and on the assumptions of exogenous variables:
  - foreign variables
  - government
  - inflation target
  - regulated prices.
- We allowed for mixing both anticipated and fully unanticipated shocks and a persistence of shocks driving processes also matters...

# Imposing judgments

- All forecasts are judgemental forecast (calibration of the model, filtering setup, trajectories of structural shocks), but
- we may impose judgements on the development of a particular variable by endogenizing structural shocks innovations, but....
- the question is... what shock or set of shocks to choose and whether these shocks should be treated as anticipated or unanticipated...in which periods
- A special case represents explaining of a current development of a given variable by future innovations...these must be treated as anticipated by all agents in the economy...
- A solution is not unique, we can choose the set of shocks that is the most likely...

# Modest policy interventions vs. Anticipated shocks

- Our forecast is unconditional w.r.t a pre-specified interest rate, but fixing IR is a possible alternative.
- Simulating constant nominal interest rate by its exogenizing and endogenizing monetary policy shocks assuming unanticipated innovations is not in line with rational expectations, on the other hand
- Same exercise with anticipated innovations is an interesting simulation option (s.c. credible announcement).
- Agents understand that whatever will happen it is going to be buffered by a monetary policy shock.

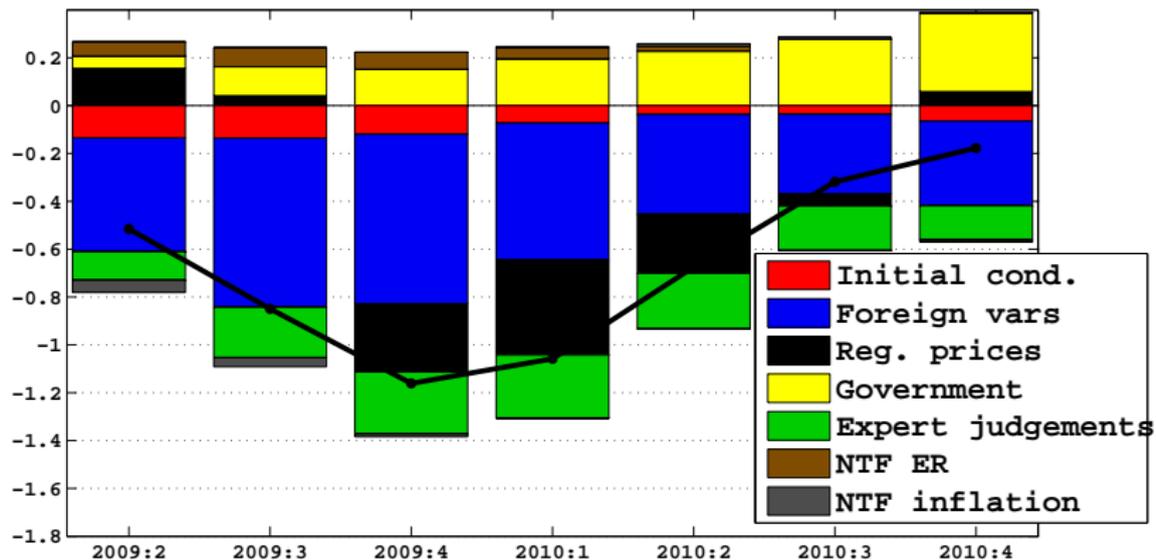
# Scenario analysis and forecast dynamics decomposition

- Decomposition w.r.t. steady states
- Decomposition of alternative forecasts
- Analysis of two successive forecasts

# Scenarios analysis and forecast dynamics decomposition

- Scenario vs. Fan charts (graphs with confidence intervals)
- Scenario analysis is constructed to capture uncertainty of the produced forecast.
- Scenario analysis also serves the purpose of gaining better intuition.
- Scenarios may differ not only in alternative paths of exogenous variables but also whether and what variables are anticipated or unanticipated.
- Our decomposition tools are:
  - decomposition of alternative scenarios into factors,
  - analysis of sources of a difference between two successive forecast,
  - dynamics decomposition of a forecast w.r.t the steady state.

# Example of forecast analysis



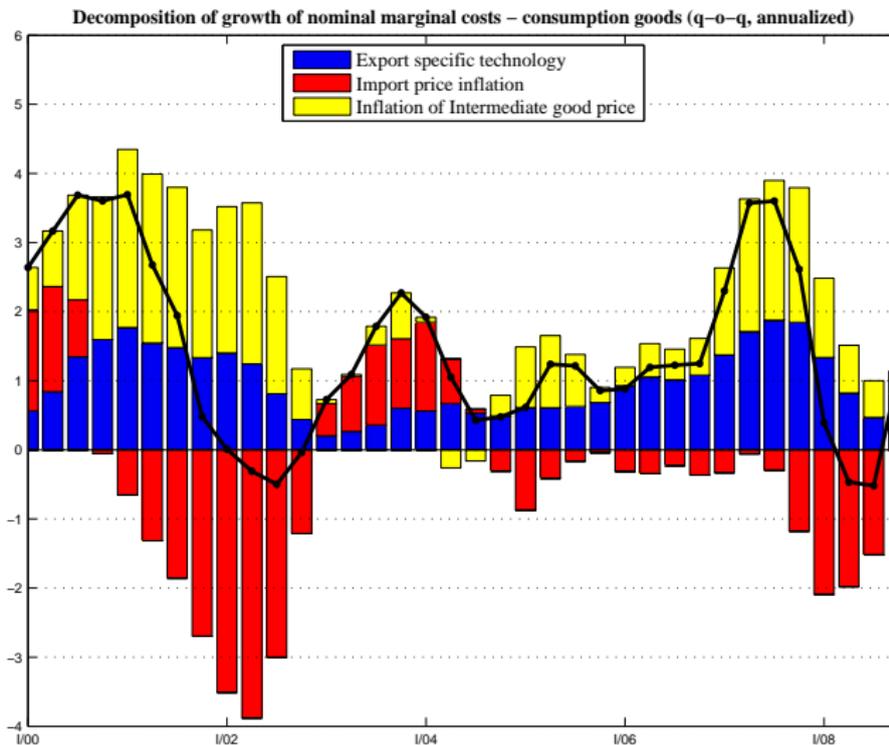
# Communication of the forecast

- Transformation of technical 'model' results to 'human' speech
- Unconditional forecast
- Technology processes and structural shocks
- Natural equilibrium

# Communication of the forecast

- All results and story can be communicated without explicit reference to a model
- Communication in a clear and transparent way is our goal.
- To avoid confusion it should be clear what questions can be answered using the model and which cannot.
- The model is 'only' a tool in the forecasting process.
- External and internal aspects of communication.

# Transformation of forecasts to human speech



- Unconditional forecast ...
- Technology processes and structural shocks are used to represent many real world events, but changes in their development must be viewed in this reduced form.
- A concept of natural equilibrium can be understood as the BGP concept as well as the fully-flexible prices concept...

# Thank you for your attention

Related papers of the new structural model are available on :

[jaromir.tonner@cnb.cz](mailto:jaromir.tonner@cnb.cz)