Short- to medium term forecasting

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OP Vzdělávání pro konkurenceschopnost

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Objectives of the Presentation

- Role of NTF within the macroeconomic projection exercise
- Importance of coherent framework
- Interpreting economic development in a consistent way
- Brief insight into particular forecasting procedures

Main NTF Tasks

- Experts as regards the Czech economy
  - Empirical data, structures, institutional and regulation framework
- Based on theoretical background consistent with
  - Conduct of MP within IT regime
  - Usage of the core projection model (G3)
- Discussion on initial state of the economy
- Comparative benchmark for core model projection
- Providing disaggregated economic outlook
- Cyclical decomposition of the variables
- Research activities

Points of view

- One model is risky - set of methods is better
- Economic theory as basis of analysis
- Emphasis on statistical data
  - Respecting not only economic theory, but also statistical data
- Expert approach : possible corrections
  - Structural changes in economy
  - Theory vs. measurements
  - Revisions of data

Near Term Forecast (NTF)

- Conditional forecast
  - Foreign macroeconomic outlook from The Consensus Forecast
  - CPI, PPI, GDP – effective indices (relevance for Czech economy)
  - World energy and food prices, exchange rate USD/EUR
  - Standardized source – no arbitrarily changes, potential for alternative scenarios
- Near term forecast – 1Q, 2Q ahead with high precision
- Empirical check in mid-term horizon for the core model

NTF - Per Partes

- Labour market
  - Employment, unemployment
  - Economic productivity
  - Average wage
  - Wage bill

- Other Prices
  - Import prices
  - Terms of trade
  - Producer prices

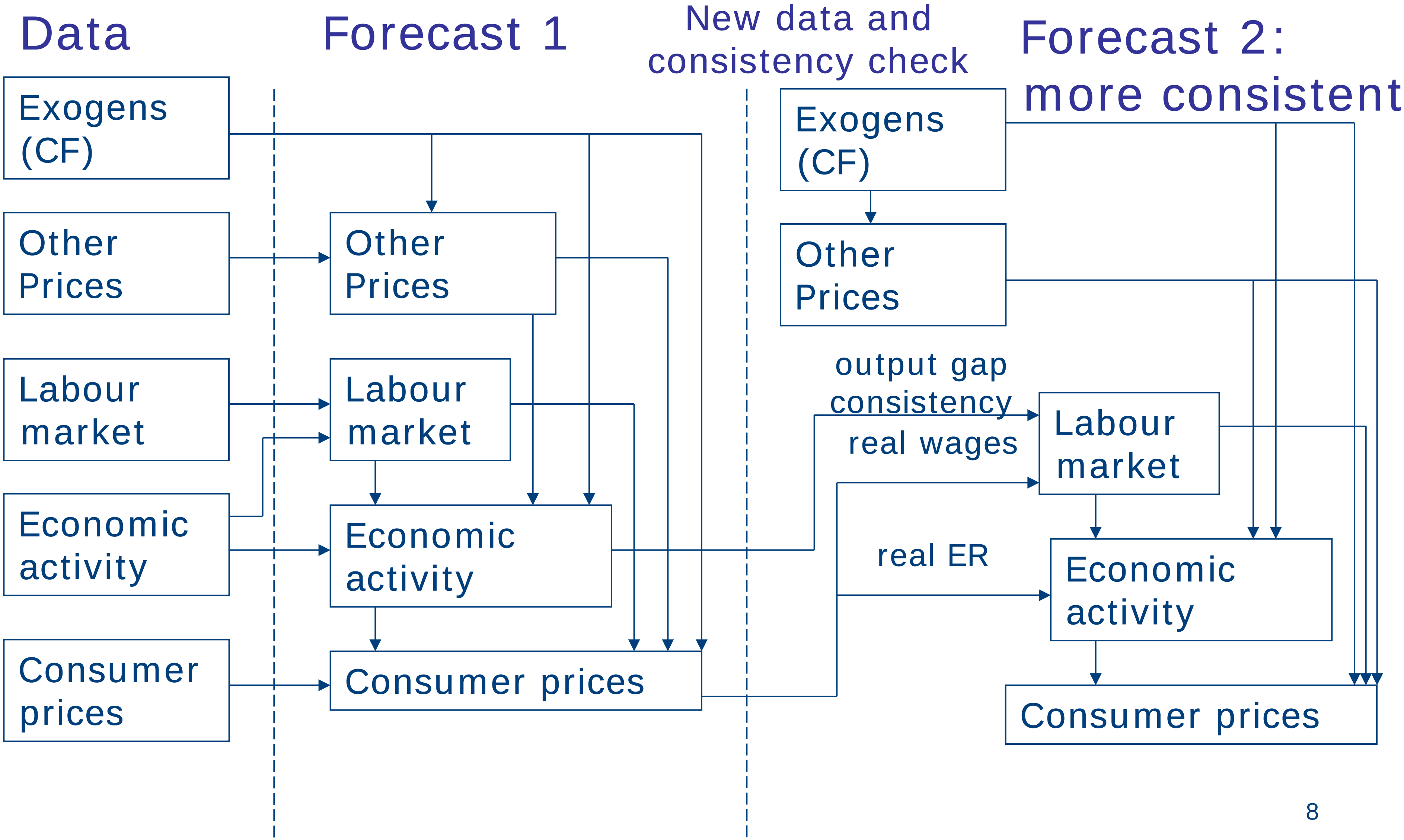
- Real economic activity
  - Domestic demand
  - Exports, imports, net export
  - GDP
  - Trade balance
  - Current account

- Consumer prices
  - Main components of the consumer basket

Consistence through Iteration

- NTF is in principle not an interconnected system
  - Threat of inconsistency of the complex forecast
- Consistence is achieved through:
- Quasi-interconnection
  - One forecast is the input of other forecasts
- Iteration
  - Consistency check
  - New forecasting round if necessary
  - Race against time

Multistage Forecast



Import Prices

- Small opend economy – high importance of foreign prices

Dependent Variable: DLOG(DCADJ)
Sample (adjusted): 1998M03 2011M02
Included observations: 156 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000	0.000	0.167	0.867
DLOG(DCADJ(-1))	0.150	0.037	4.035	0.000
DLOG(EUR)	0.345	0.033	10.460	0.000
DLOG(USD)	0.143	0.015	9.371	0.000
DLOG(PPIEMU)	0.301	0.095	3.155	0.002
DLOG(BRENT)	0.018	0.005	3.986	0.000

R-squared	0.802	Mean dependent var	-0.001
Adjusted R-squared	0.796	S.D. dependent var	0.010
F-statistic	121.637	Durbin-Watson stat	1.938
Prob(F-statistic)	0.000		

DCADJ … import prices

EUR … exchange rate CZK/EUR

USD … exchange rate CZK/USD

PPIEMU … effective PPI in EU

BRENT … oil prices

Import Prices

- All in CZK

Dependent Variable: DLOG(DCADJ)
Sample (adjusted): 1998M03 2011M02
Included observations: 156 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000	0.000	-0.660	0.511
DLOG(DCADJ(-1))	0.207	0.044	4.665	0.000
DLOG(EUR*PPIEMU)	0.516	0.031	16.638	0.000
DLOG(USD*BRENT)	0.017	0.005	3.616	0.000

R-squared	0.704	Mean dependent var	-0.001
Adjusted R-squared	0.698	S.D. dependent var	0.010
F-statistic	120.625	Durbin-Watson stat	2.026
Prob(F-statistic)	0.000		

DCADJ … import prices

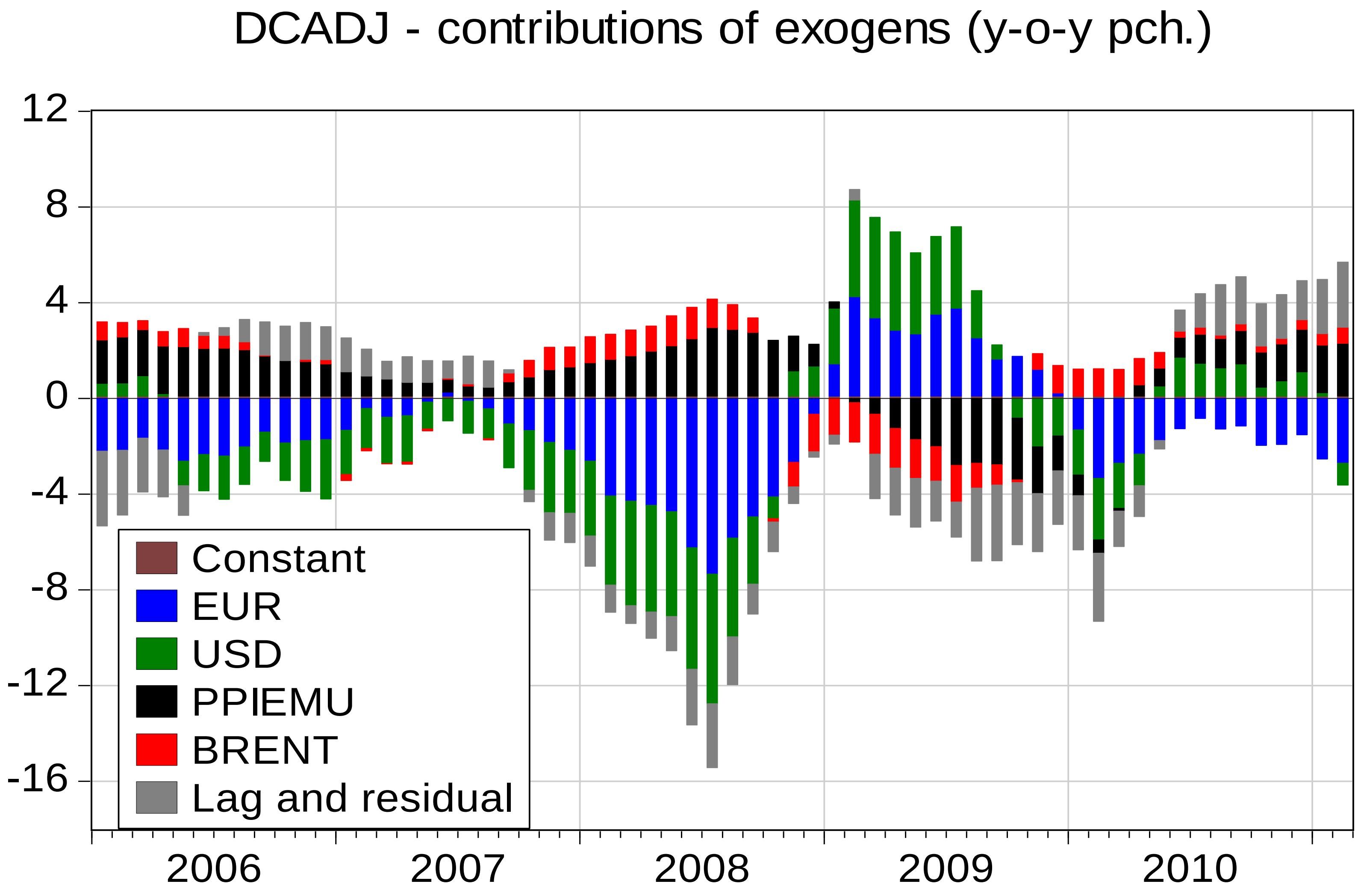
EUR … exchange rate CZK/EUR

USD … exchange rate CZK/USD

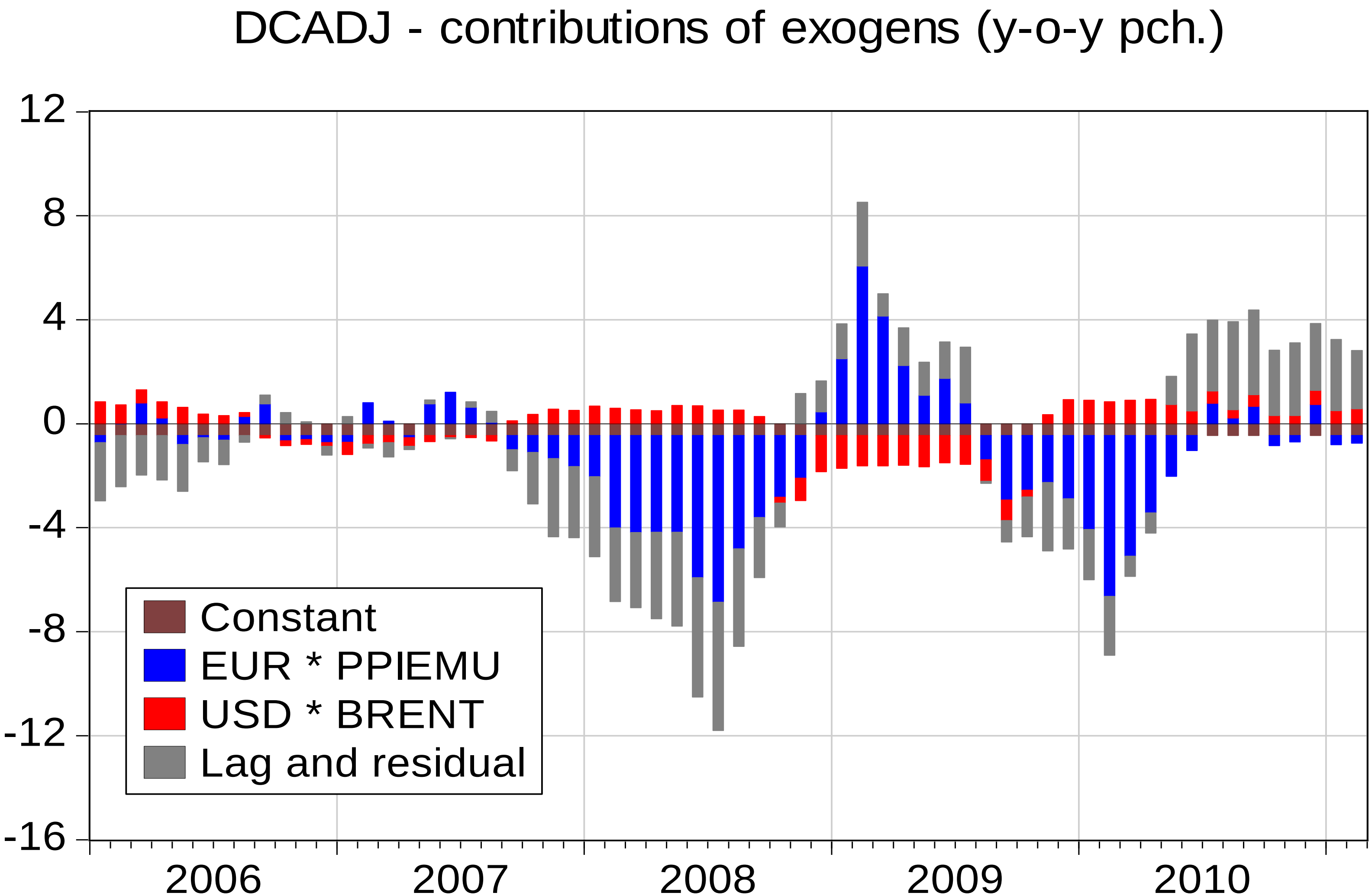
PPIEMU … effective PPI in EU

BRENT … oil prices

Import Prices



Import Prices

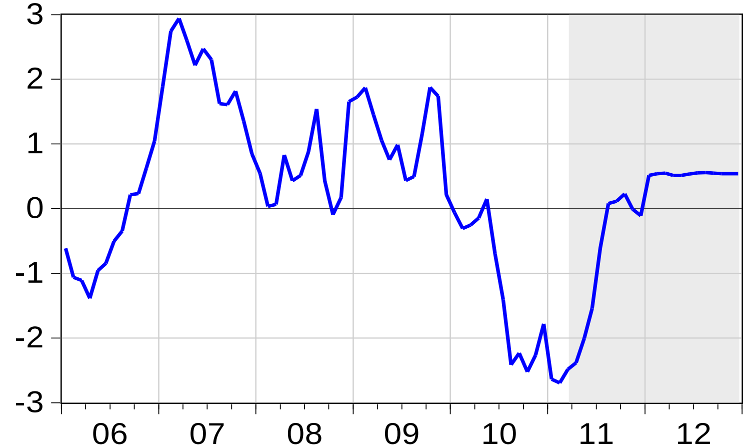


Import Prices

- Other prices and energy prices – impact on terms of trade

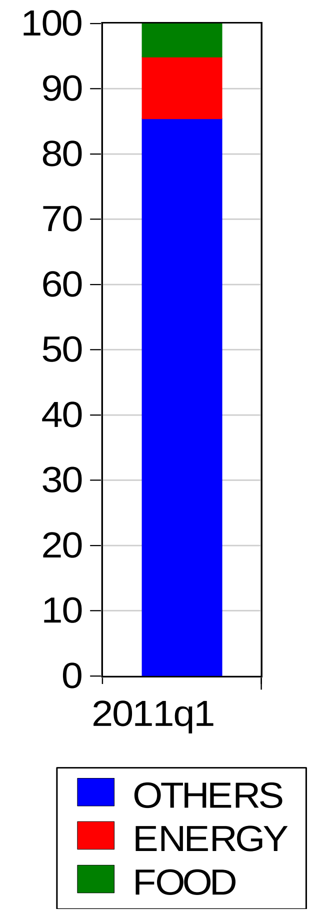
Terms of trade

Terms of trade - DCADJ



Terms of trade - ENERGY

Weights in IP



Producer Prices

- High importance of producer prices

Dependent Variable: DLOG(PPIPRO)
Sample: 1998M01 2010M03
Included observations: 147

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000	0.000	0.360	0.719
DLOG(PPIPRO(-1))	0.361	0.067	5.367	0.000
DLOG(EUR)	0.047	0.022	2.172	0.032
DLOG(USD(-3))	0.014	0.010	1.403	0.163
DLOG(PPIEMU)	0.549	0.079	6.971	0.000
DLOG(BRENT(-1))	0.008	0.003	2.371	0.019

R-squared	0.536	Mean dependent var	0.001
Adjusted R-squared	0.520	S.D. dependent var	0.005
F-statistic	32.615	Durbin-Watson stat	1.879
Prob(F-statistic)	0.000		

PPIPRO … producer prices

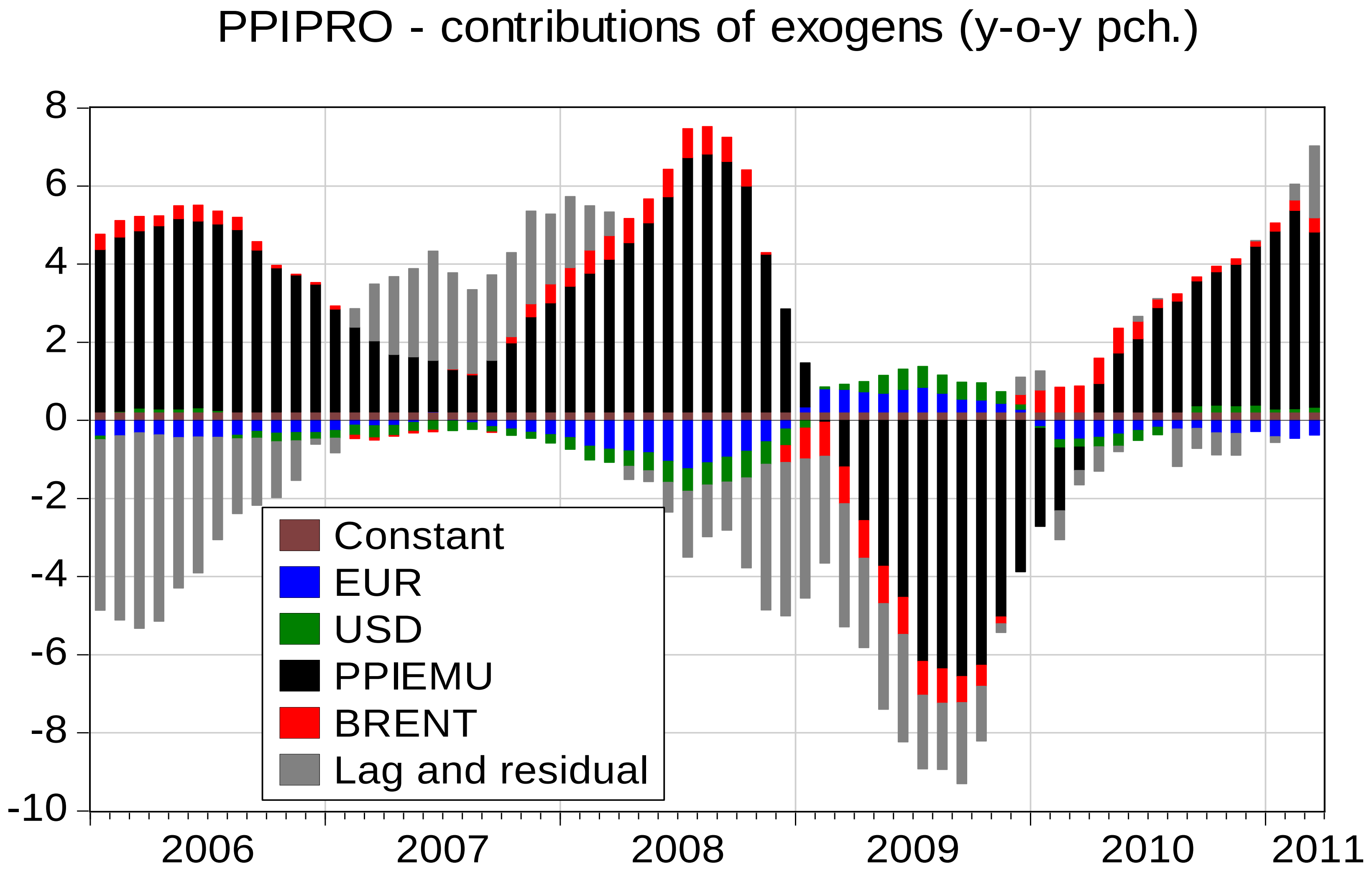
EUR … exchange rate CZK/EUR

USD … exchange rate CZK/USD

PPIEMU … effective PPI in EU

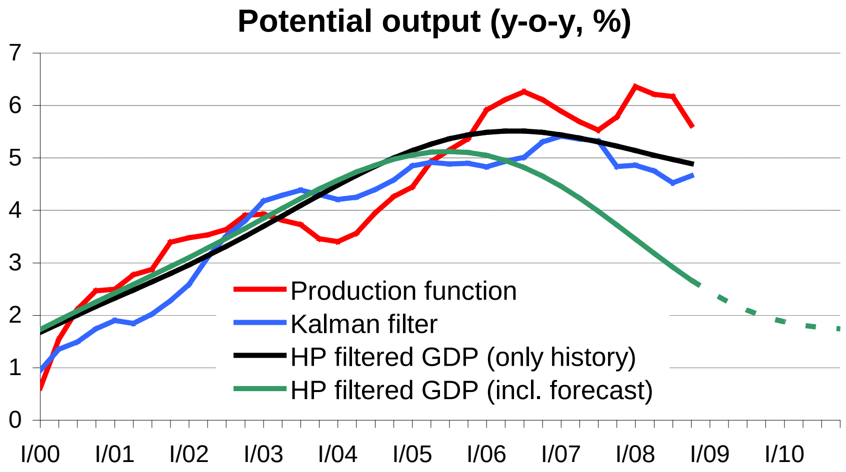
BRENT … oil prices

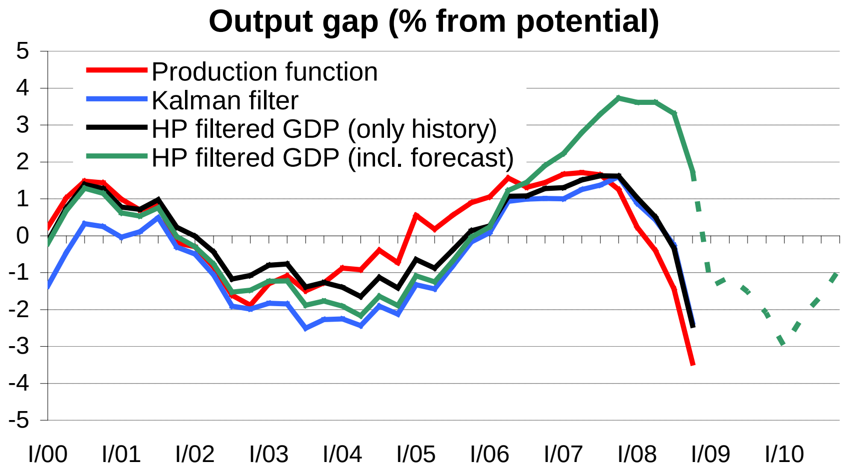
Producer Prices



Potential Output and Output Gap

- Cobb-Douglas production function
- HP filter
- Kalman filter



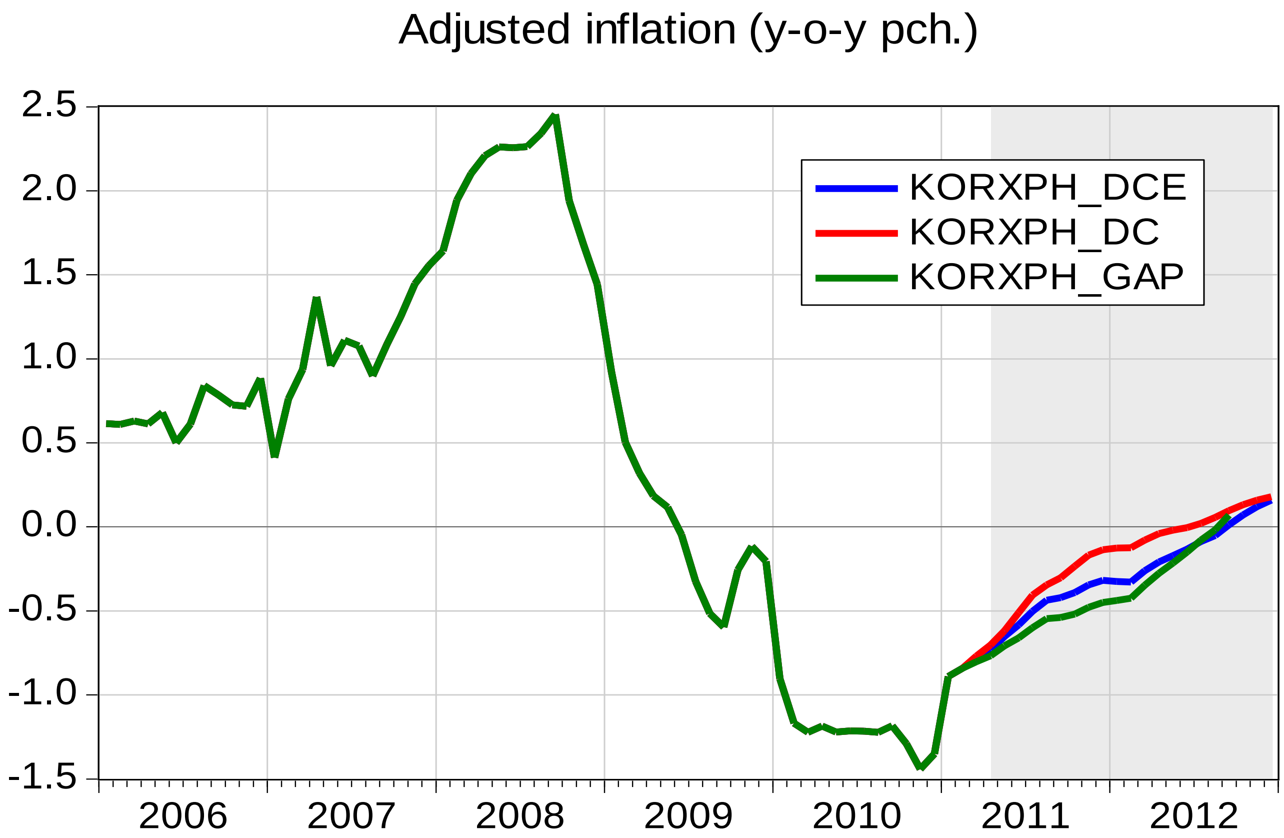


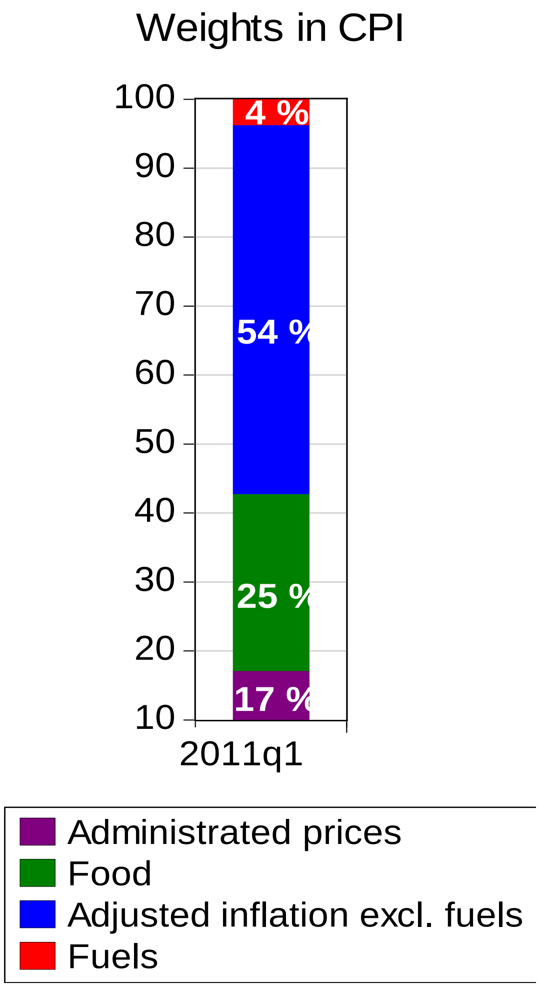
Labour Market

- Expected inflation
- Labour productivity
- Position of the trade unions - collective bargaining
- Position of the economy in the business cycle
- Financial position of companies
- Development and expectations in industry and constructing

Adjusted Inflation

- Forecast of Adjusted inflation with different models, Y-O-Y





Adjusted Inflation

- Model of adjusted inflation, Y-O-Y

Dependent Variable: SK_KORXPH_YOY_NOTXP
Sample (adjusted): 1999M05 2011M02
Included observations: 142 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.240	0.058	-4.142	0.000
KORXPH_YOY_NOTXP(-1)	0.894	0.024	37.655	0.000
EUR_YOY(-8)	0.008	0.003	2.420	0.017
CPIEMU_YOY	0.124	0.027	4.530	0.000
DCADJ_F_YOY(-4)	0.009	0.004	2.415	0.017
ULC_YOY	0.033	0.009	3.558	0.001

R-squared	0.973	Mean dependent var	1.143
Adjusted R-squared	0.972	S.D. dependent var	1.184
F-statistic	982.101	Durbin-Watson stat	1.878
Prob(F-statistic)	0.000		

KORXPH … adjusted inflation

CPIEMU … effective CPI in EU

EUR … exchange rate CZK/EUR

DCADJ_F … import prices

ULC … unit labour cost

Set of models and expert judgment

Food Prices

- Set of models and expert judgment
- Example of NTF Food Prices Equation

FOOD_YOY_NOTXP … food prices inflation

CZV_YOY … agricultural producer prices

DCPOT_YOY … import prices of food com.

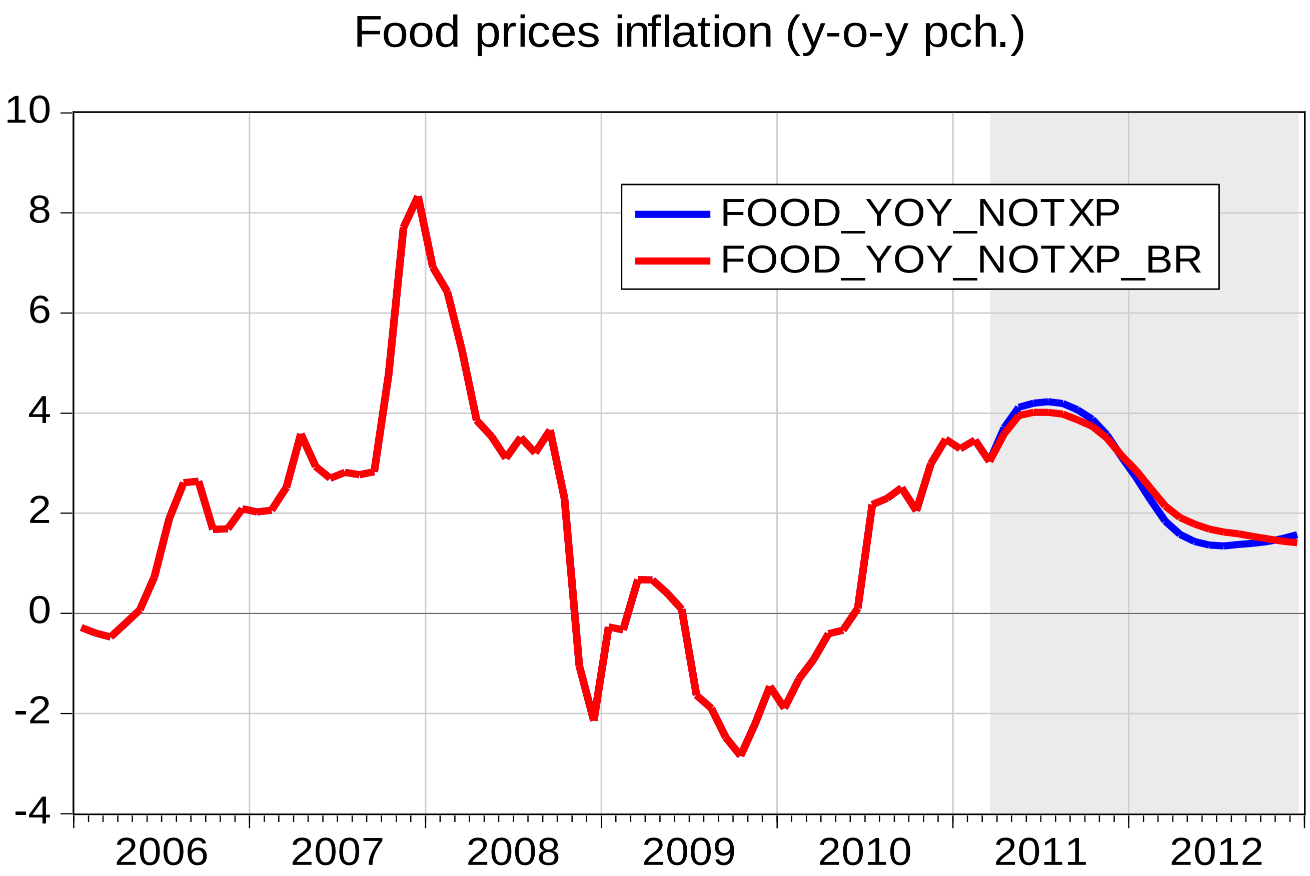
Dependent Variable: FOOD_YOY_NOTXP
Sample (adjusted): 2000M01 2011M03
Included observations: 135 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.296	0.081	3.634	0.000
FOOD_YOY_NOTXP(-1)	0.753	0.040	19.000	0.000
CZV_YOY	0.032	0.007	4.927	0.000
DCPOT_F_YOY	0.085	0.027	3.135	0.002

R-squared	0.918	Mean dependent var	1.366
Adjusted R-squared	0.916	S.D. dependent var	2.662
F-statistic	485.784	Durbin-Watson stat	1.318
Prob(F-statistic)	0.000		

Food Prices

- Set of models and expert judgment

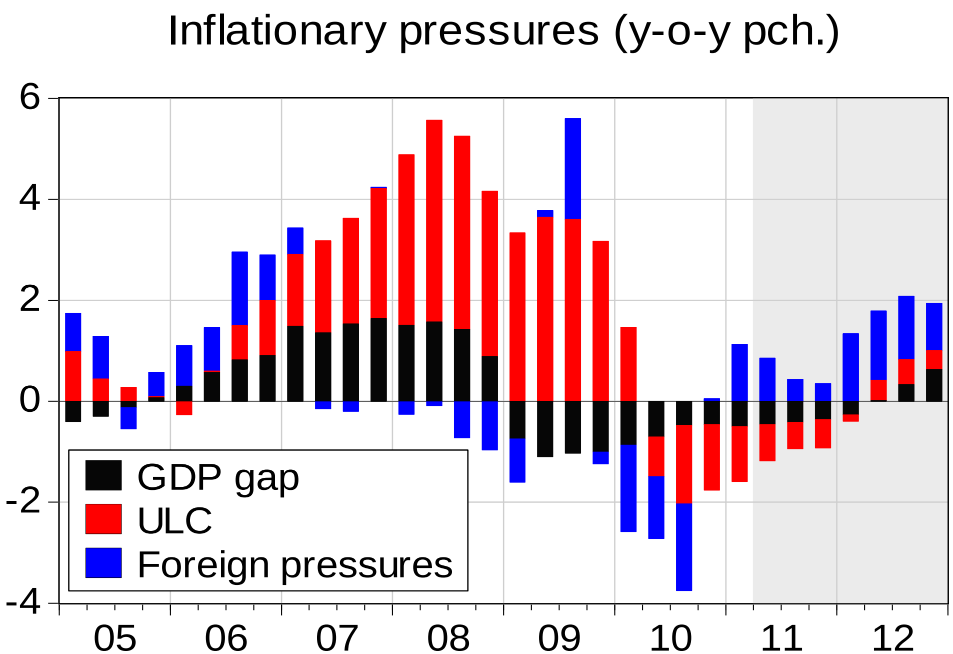


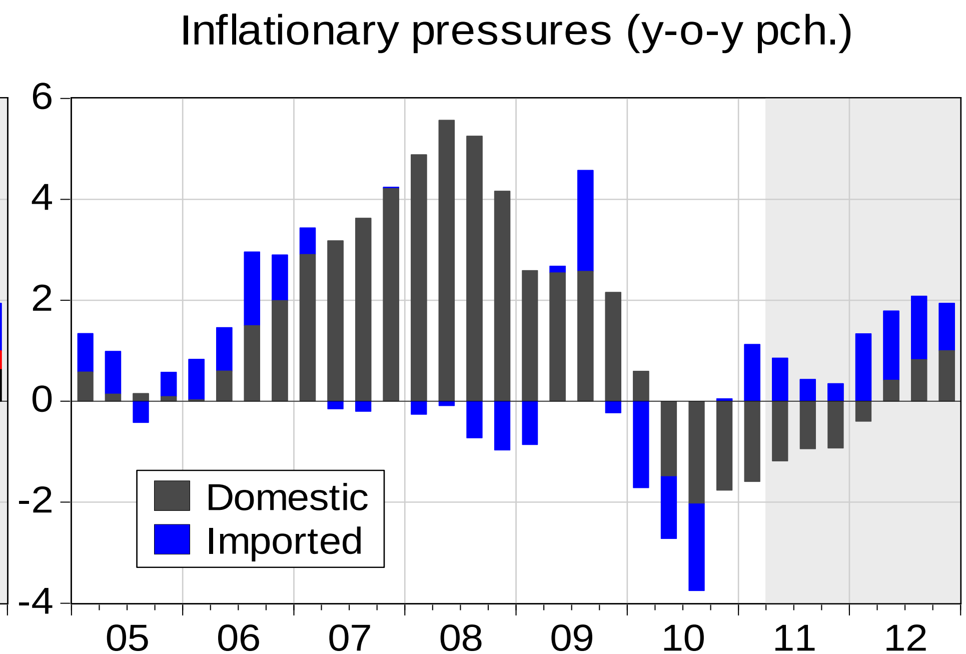
Net inflation

- Calibrated estimate of inflationary pressures

impcost = 0.9*(eur*ppiemu) + 0.1*(0.6*(usd*brent) + 0.4*(usd*gas))

cost = 0.4*gdp_gap + 0.7*ulc(-1) + 0.3*impcost(-2)





M9902: The Quarterly Projection Model

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Outline

1. Trend and cycles
2. Structure of the Quarterly Projection Model
3. Parameters setup
4. Properties of the Model

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Outline

Time series analysis

- Analysis of time series data is based on smoothing past data in order to separate the underlying pattern in the data series from randomness.
- The underlying pattern then can be projected into the future and used as the forecast.
- The underlying pattern can also be broken down into sub patterns to identify the component factors that influence each of the values in a series: decomposition
- Decomposition methods: identify separate components of the basic underlying pattern that tend to characterize economics and business series.

In search for trends

Decomposition Techniques

- Goal: separation of data into several unobservable components, generally in an additive or multiplicative form.
- Components: trend, seasonal pattern, cycle, and residual or irregular pattern
- Seasonal component: the periodic fluctuations of constant length
- Trend-cycle component: long term changes in the level of series

Detrending

- Trend Component: The tendency of a variable to grow over time, either positively or negatively.
- Basic forces in trend: population change, price change, technological change, productivity change, product life cycles
- The long term movements or trend in a series can be described by a straight line or a smooth curve.
- The long-term trend is estimated from the seasonally adjusted data for the variable of interest
- Interpretation:
  - Long run equilibrium: trends
  - Cyclical fluctuations: gaps

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Trend analysis

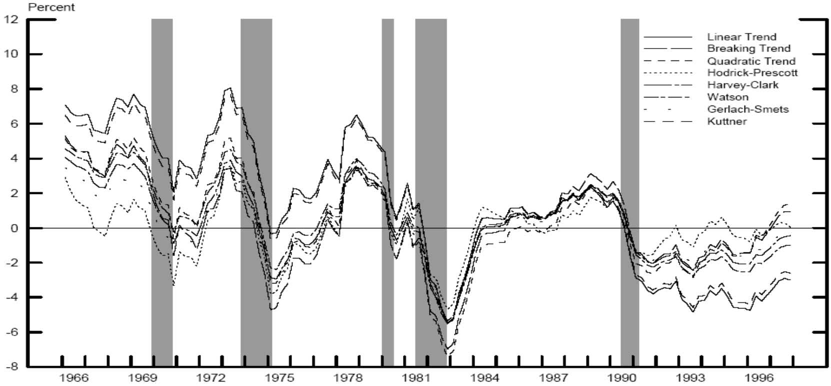
- Assume seasonally adjusted data
- Trend-Cycle decomposition: Series = Trend + Cycle + Noise
- No general-automatic techniques for detrending
- Simple techniques: Smoothing
  - Moving average: The average eliminate some higher frequency noise in the data, and leaves a smooth trend-cycle component. What order to use?
  - Simple centered moving average: can be defined for any odd order. A moving average of order k, is defined as the average consisting of an observation and the m = (k-1)/2 points on either side.
  - Centered moving average: take the simple centered moving average, assign weights and create weighted average
- Advanced techniques of detrending:
  - Fitting a polynomial
  - Using a structural model

Detrending techniques overview I

- Watson detrending: greater business cycle persistence; trend component follows a random walk with drift and cyclical component is a stationary finite order AR process.
- Harvey-Clark detrending: local linear trend model
- Hodrick-Prescott filter: univariate method
- Kalman filter: multivariate method, structural method
- Bandpass filter: not widely used, frequency domain analysis

Detrending techniques overview II

- Detrending comparison: US GDP gap



Outline

Motivation for QPM

- Separate econometric methods: Inconsistencies
- Short experience with FPAS: Forecasting and Policy Analysis System
- State:
  - Insufficient data and experience
  - Participation of other departments
  - Communication of results
- The further step on the way to complex structural models: DSGE
- Research tool

Features of QPM

- Reflects inflation targeting regime:
  - In December 1997: after an exchange rate crisis
  - CNB adopted a series of end-year inflation targets
  - Regime proved very effective in combating inflation and anchoring
  - Evolution toward a more transparent inflation targeting regime where monetary policy is anchored by a medium-term perspective
  - Change to point inflation target: Inflation target band
  - The character of the regime was further enhanced by publication of unconditional forecasts
- Linked to quarterly data
- Small open-economy gap model

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Model of trends and cycle

- Two separate blocks:
  - Long run equilibrium trends
  - Cyclical fluctuations - gaps
  - These blocks are separable

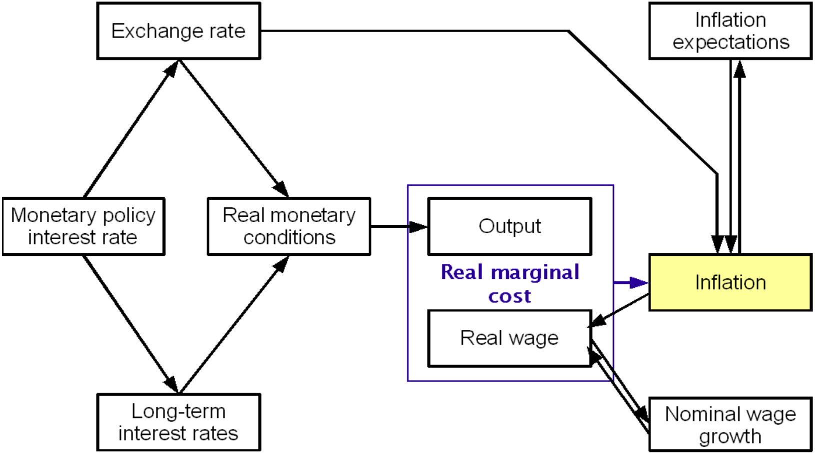
Long Run Trends

- First step: filter trend series
  - History - estimated by a simple statistical model (Kalman filter) and expert judgement
  - Forecast - exogenous (expert judgement), respecting steady state properties of QPM
- Important equilibrium values:
  - Real output growth
  - Real wage growth
  - Real exchange rate appreciation
  - Real interest rate
  - Stationarity is required: growth rates in focus
- Monetary decisions have small impact on long term real trends

Cyclical Part of QPM

- Description of the position of the Czech economy
- Monetary policy characteristics:
  - Inflation targeting regime
  - Forward looking policy
  - Focus on deviations from the target $\longrightarrow$ reaction to expected inflation a year ahead
  - Floating exchange rate - endogenous
- Description of behavior economic agents includes forward looking components
- Price frictions:
  - Wage stickiness
  - Final price stickiness
  - Expectation stickiness

Scheme of model



Real Economy I

IS curve (Aggregate demand):

- Output: function of lagged output, the real interest rate, the real exchange rate and foreign demand
- Includes impact of a change in interest rates with longer maturity on aggregate demand and take into account expectations about yield-curve on the dynamic properties of the model
- Real impact of monetary policy in a sticky-price model of a small open economy
- Marginal costs: cost of producing additional unit of a good

Real Economy II

Real Marginal Costs Gap:

- Approximation of inflationary pressures from the real economy.
- Marginal costs consist of the costs arising from the increasing volume of production (the "output gap") and wage costs (the "real wage gap").
- A positive real marginal cost gap implies an inflationary effect of the real economy

$$\widehat{\mathrm{mc}}_t = \lambda \widehat{\mathrm{y}}_t + \widehat{\mathrm{wr}}_t$$

Output Gap:

Real Economy III

- Standard economic theory: higher real interest rate reduce aggregate demand by increasing the reward to saving
- Output gap: responds negatively to the difference between the real interest rate and its equilibrium value
- Open economy: the exchange rate matters
- Currency appreciation will, all else equal, make domestic goods more expensive in foreign markets and reduce demand for domestic goods abroad; cheaper imports may displace domestic goods

$$\begin{aligned}\widehat{\mathrm{y}}_t &= \alpha_1 \widehat{\mathrm{y}}_{t-1} - \widehat{\mathrm{rmci}}_{t-1} + \alpha_2 \widehat{\mathrm{y}}_t^f + \varepsilon_t^{\widehat{\mathrm{y}}} \\ \widehat{\mathrm{rmci}}_t &= \beta_1 \left(\beta_3 \widehat{\mathrm{rc}}_t + \beta_4 \widehat{\mathrm{r4}}_t + (1 - \beta_3 - \beta_4)\, \widehat{\mathrm{r4}}_t^f \right) + \beta_2 \widehat{\mathrm{z}}_t\end{aligned}$$

Real Wage Gap:

Real Economy IV

- Introduced in January 2007
- Wage costs are above their equilibrium level, they have an inflationary effect
- The effect of a deviation of the current level of the average real wage from its equilibrium level, which in the long run rises at the same rate as equilibrium real output (non-accelerating inflation real output)

$$\widehat{\mathrm{wr}}_t = \widehat{\mathrm{wr}}_{t-1} + \frac{\mathrm{w}_t}{4} - \frac{\pi_t}{4} - \frac{\triangle\overline{\mathrm{wr}}_t}{4} + \varepsilon_t^{\widehat{\mathrm{wr}}}$$

Phillips Curves I

Price Inflation:

- Phillips curve has been modified for a small open economy
- Blocks for various goods
- Import price effects
- Wage setters derive their nominal wage demand real consumer wage

- x for fuel, food, or adjusted excl. fuel inflation
- Administered prices are exogenous in baseline

Phillips Curves II

$$\pi_t^x = \gamma_1^x\left(\pi 4_t^{\mathrm{M}x} + \triangle_4\overline{\mathrm{z}}_t^x\right) + \gamma_2^x\left(\mathrm{E}\pi 4_t + \triangle_4\overline{\mathrm{z}}_t^x - \triangle_4\overline{\mathrm{z}}_t\right) + \left(1 - \gamma_1^x - \gamma_2^x\right)\pi_{t-1}^x + \gamma_3^x\widehat{\mathrm{mc}}_t + \varepsilon_t^{\pi^x}$$

Wage Inflation:

$$\mathrm{w}_t = \delta_1\mathrm{Ew}4_t + (1-\delta_1)\mathrm{w}_{t-1} - \delta_2\left(\widehat{\mathrm{wr}}_t - \delta_3\widehat{\mathrm{y}}_t\right) + \varepsilon_t^{\mathrm{w}}$$

Expectations I

Price Inflation Expectations:

- Expected inflation: a weighted combination of a backward-looking and a forward-looking component (the expected value of overall CPI inflation over the next four quarters)
- Overall CPI: an explicit link between changes in administered and energy prices and pressures on the rate of inflation for market prices

$$\mathrm{E}\pi 4_t \quad = \quad \lambda_1 \pi_{t+1} + \left(1 - \lambda_1\right) \pi_{t-1} + \varepsilon_t^{\mathrm{E4}}$$

Wage Inflation Expectations:

$$\mathrm{Ew4}_t \quad = \quad \lambda_2 \mathrm{w}_{t+1} + \left(1 - \lambda_2\right) \mathrm{w}_{t-1} + \varepsilon_t^{\mathrm{Ew4}}$$

Uncovered interest rate parity

Nominal Exchange Rate:

- UIP condition: arbitrage condition; international investors will equalize effective rates of return on investments in different currencies, allowing for any country-specific risk premiums
- foreign investor expecting a depreciation (appreciation) of the koruna will demand a higher (lower) return from Czech assets
- Moving average form

$$
\begin{aligned}
\mathrm{s}_t \;=\; & \phi \mathrm{s}_{t+1} + (1-\phi)\left(\mathrm{s}_{t-1} + 2\left(\frac{\mathrm{E}_t\pi}{4} - \frac{\mathrm{E}_t\pi^f}{4}\right) + 2 \triangle \bar{\mathrm{z}}_t\right) \\
& + \frac{\mathrm{i}_t}{4} - \frac{\mathrm{i}_t^f}{4} - \mathrm{prem}_t + \varepsilon_t^{\mathrm{s}}
\end{aligned}
$$

Reaction Function

Nominal Interest Rate:

- Forward-looking reaction function
- CPI inflation expecte to be above the target rate: central bank push up the short-term
- Excess demand: the central bank increases short-term interest rate
- Long-term level for rates and some additional dynamic structure
- Interest rate inertia: interest rate smoothing

$$
\begin{aligned}
\mathrm{i}_t &= \psi \mathrm{i}_{t-1} + (1-\psi)\left(\mathrm{i}_t^{neutral} + \mathit{\Pi}_t\right) + \varepsilon_t^{\mathrm{i}} \\
\mathrm{i}_t^{neutral} &= \bar{\mathrm{r}}_t + \pi 4_{t+4} + \varepsilon_t^{\mathrm{i}} \\
\mathit{\Pi}_t &= \kappa_1 \left(\pi 4_{t+4} - \pi 4_{t+4}^{target}\right) + \kappa_2 \widehat{\mathrm{y}}_t
\end{aligned}
$$

Outline

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Calibration vs. Estimation

- QPM is calibrated, partially estimated
- Problems in estimation:
    - Short data sample
    - Structural changes in economy
    - Changes of monetary policy regime
    - It is impossible to estimate some parameters: identification problems

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Calibration of QPM

Parameters setup:

- Restrictions on parameters originating from economic theory
- Parameters are set to mach the properties of data
- Responses to structural shocks

Parameters checks:

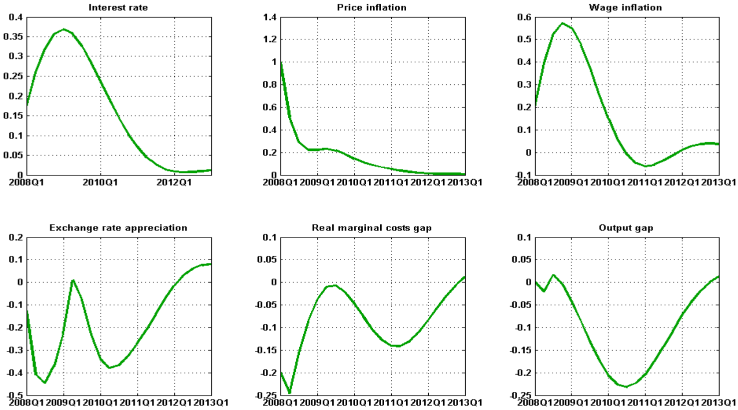
- Reactions to shocks
- Residuals
- In-sample simulations
- Curve-fitting estimates

Outline

Price shock I

- Positive shock to the output gap
- Upward pressure on inflation
- Currency depreciation
- Central bank increases interest rate
- Cumulative effect on output is very close to zero: feature of linear models;
- Offsetting of excess supply to counteract the effects of shocks that create excess demand

Price shock II



Aggregate demand shock I

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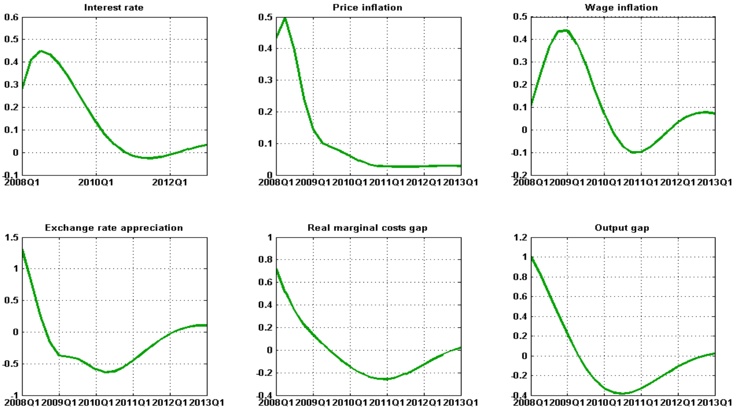
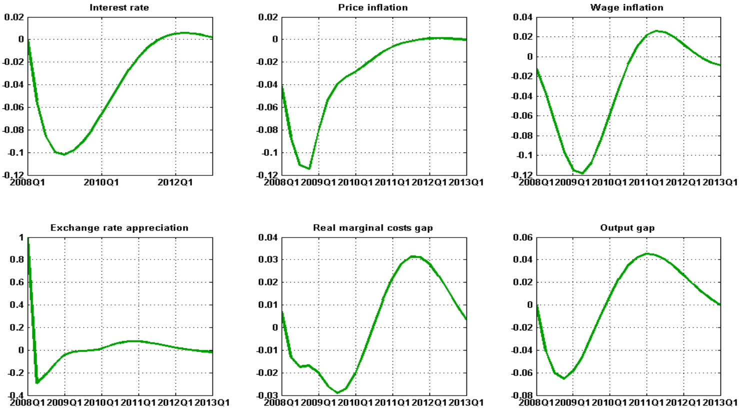
Aggregate demand shock II



Exchange rate shock I

- Depreciation acts to increase aggregate demand, opening a positive output gap

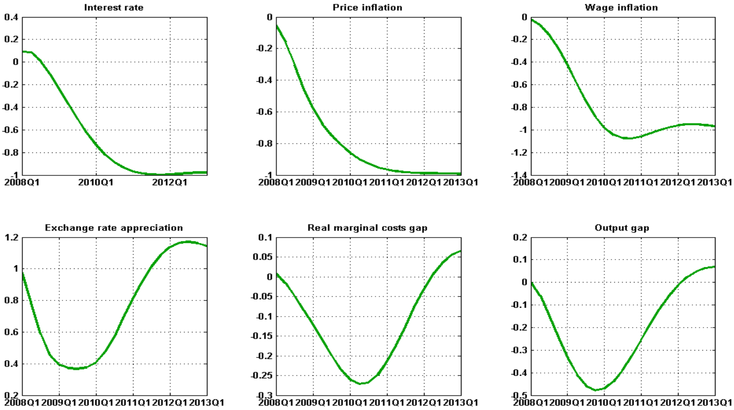
Exchange rate shock II



Inflation target change I

- Lower the target rate of inflation by one percentage point
- To achieve disinflation: raise the short rate
- Appreciation: Import prices fall
- The combined effect of the import price decline and the excess supply gap works to gradually pull down the rate of inflation
- Note: purely nominal shock, and since the model is super-neutral, there is no change to any real equilibrium in this shock, including the real exchange rate. The nominal exchange rate changes, of course, with the cumulative
- Cumulative effects on output and employment
- Sacrifice ratio: a cumulative loss of output vs. lower inflation by a percentage point

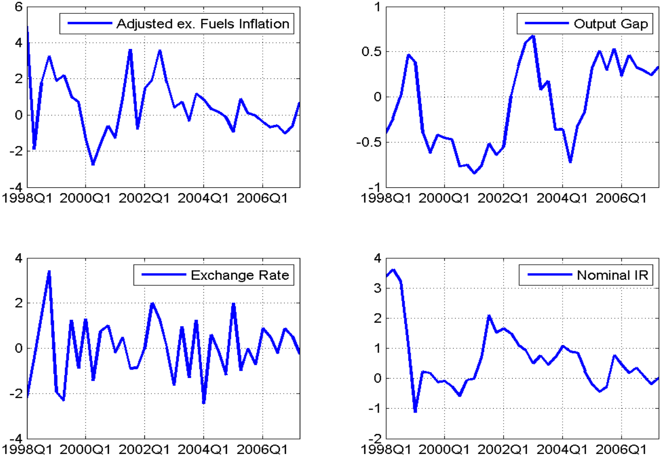
Inflation target change II



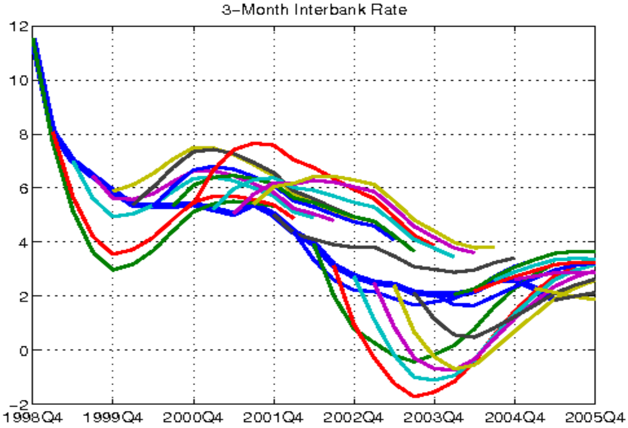
Residuals I

- Conflict between estimated parameters and calibrated
- The parameters have to be chosen so as to give reasonable model behavior
- Examined how well the model performs over the historical sample
- Identify systematic biases

Residuals II



In-Sample Simulations



Modeling tools

- Implementation in Matlab
- IRIS by Jaromír Beneš

Univariate filtering I

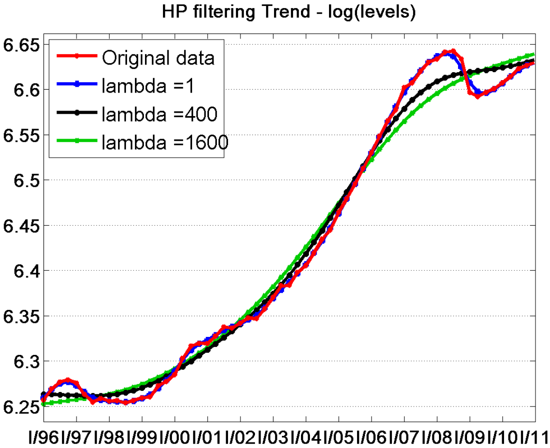
- Hodrick-Prescott filter: optimally extracts a trend which is stochastic but moves smoothly over time and is uncorrelated with the cyclical component
- Mathematics of HP filter:
  - Decomposition: $y_t = \tau_t + c_t$
  - Solve:
    $\min \sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda * \sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2$
  - $\lambda = 100 * (\textit{number of periods in a year})^2$
- Assumption that the trend is smooth is imposed by assuming that the sum of squares of the second differences of τ_t is small
- Sensitivity of the trend to short-term fluctuations is achieved by modifying a multiplier λ

Univariate filtering II

- Drawbacks:
  - One-time permanent shock, split growth rates present: Filter identifies non-existing shifts in the trend
  - It pushes noise in data to Normal distribution
  - Misleading predictive outcome: Analysis is purely historical and static

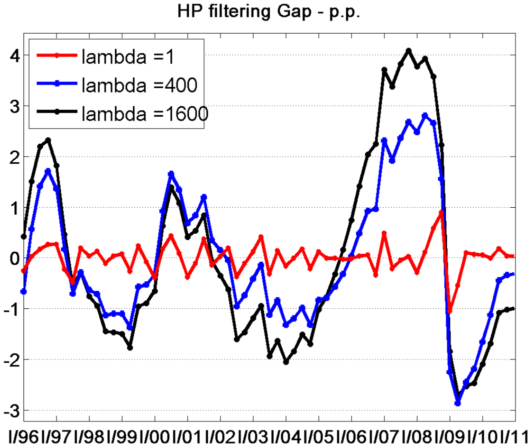
Univariate filtering III

- Trend:



Univariate filtering IV

- Gap:



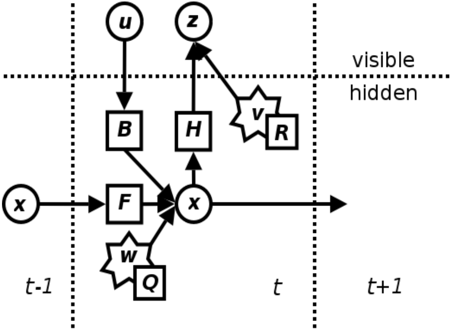
Kalman filter I

- Separate the cyclical component of a time series from raw data
- Can handle more series and exploit relations between them
- Kalman filter is a powerful tool for:
    - Estimation
    - Prediction
    - Smoothing

  Kalman filter:
    - Online estimation procedure
    - States are estimated, when the new observations are coming in

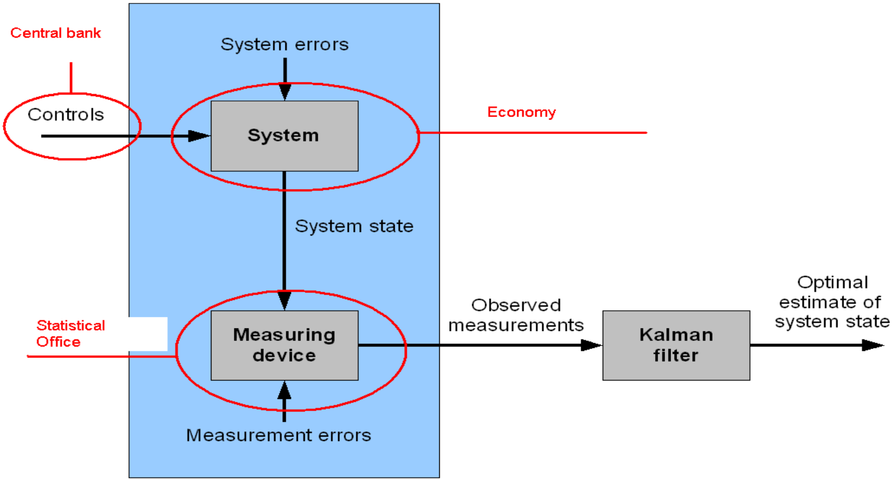
  Kalman smoother:
    - Off-line estimation procedure
    - The state estimation of is not only based on all previous observations, but also on all later observations

Kalman filter II



- F is the state transition model
- B is the control-input model
- H is the observation model
- w is the process noise
- z is the measurement
- v is the measurement error
- u is the exogenous control

Kalman filter structure



Description of variables

- Measurement variables: ΔEU_LGDP, $EU\_LGDPGAP\_EXPERT$
- State variables: ΔEU_LGDP_EQ, MU, $EU\_LGDPGAP$
- Exogenous-variables: $EU\_RMCIGAP$
- Shocks: ν's
- Coefficients: a_1, a_2, a_3 and μ_{SS}
- Variance: $\sigma_1, \sigma_2, \sigma_3, \sigma_4$
- Remark: In the following slides the filtering is actually smoothing

Description of model

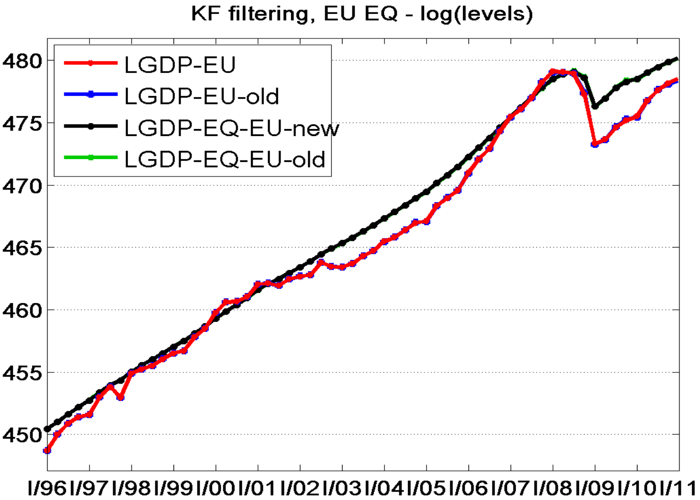
- Measurement equations:

$$\begin{aligned}\Delta EU\_LGDP &= \Delta EU\_LGDP\_EQ + \\ &+ 4 * (EU\_LGDPGAP - EU\_LGDPGAP\{-1\}) \\ EU\_LGDPGAP &= EU\_LGDPGAP\_EXPERT + \sigma_4 * \nu_4\end{aligned}$$

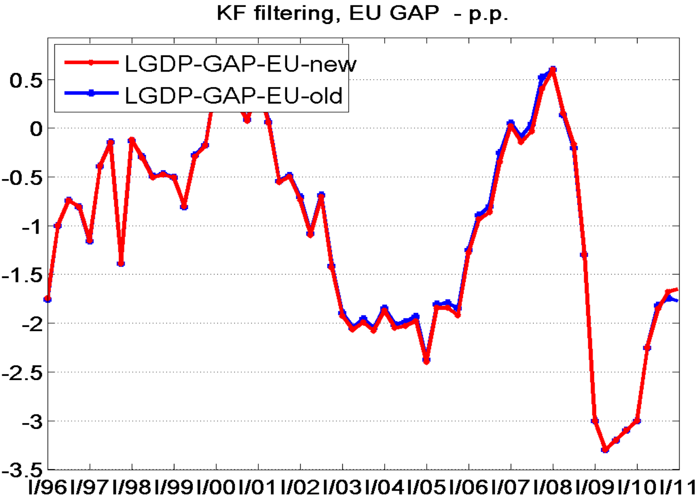
- State equations:

$$\begin{aligned}\Delta EU\_LGDP\_EQ &= \mu + \sigma_1 * \nu_1 \\ \mu &= (1 - a_3) * \mu_{SS} + a_3 * \mu\{-1\} + \sigma_3 * \nu_3 \\ EU\_LGDPGAP &= a_1 * EU\_LGDPGAP\{-1\} + \\ &+ a_2 * EU\_RMCIGAP\{-1\} + \sigma_2 * \nu_2\end{aligned}$$

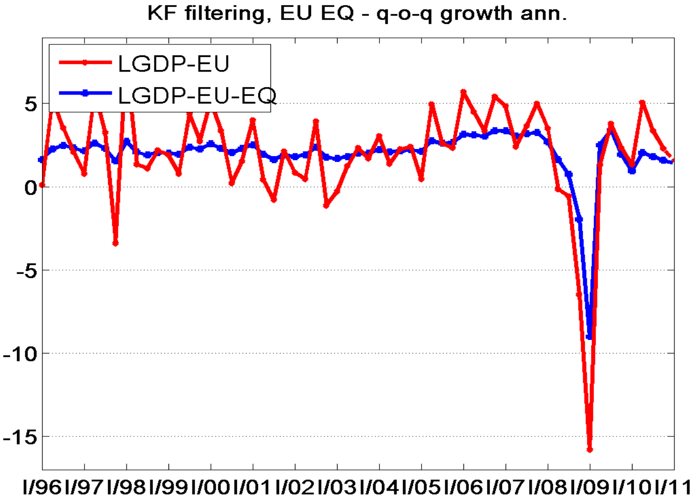
Filtering results: EU Eq. trajectories



Filtering results: EU Gap estimate



Filtering results: Removing volatility



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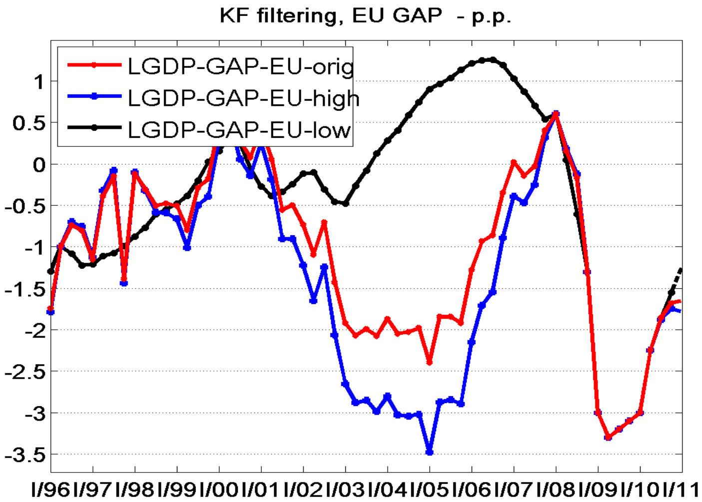
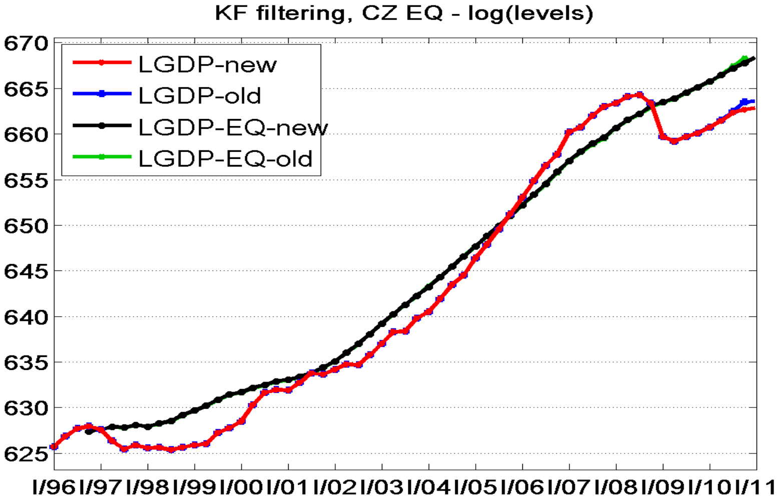
Model setting: Changes in volatility of gap σ_2



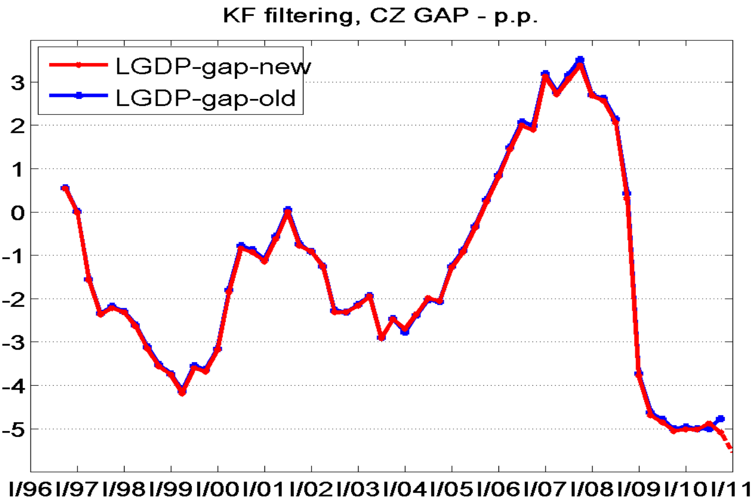
Filtering domestic variables

- First step:
  - Decompose real variables: trend and cycle
  - Simple model for: Real interest rate, Real exchange rate, Exchange risk premium
- Second step:
  - Utilize measurement of inflation and wage growth
  - Fit simple backward-looking Phillips curves: relation between inflation and output gap
  - Fit IS curve: relation between output gap and gaps in real interest and exchange rate
  - Decompose: domestic output, real wage, unemployment

Filtering results: Domestic Eq. trajectory



Filtering results: Domestic output gap



Description: Second step model

- Measurement variables: *DOT_LGDP*, *DOT_UNR*, *PIE_CORE*, *PIE_W*, *DOT_LWR*, *LWR_GAP_EXPERT*, *LGDP_GAP_EXPERT*, *UNR_GAP_EXPERT*
- State variables: *DOT_LGDP_EQ*, *MU*, *LGDP_GAP*, *DOT_UNR_EQ*, *UNR_GAP*, *PIE_CORE_S*, *PIE_W_S*, *DOT_LWR_EQ*, *LWR_GAP*
- Exogenous-variables: *RRC_GAP*, *RR*4*_GAP*, *EU_RR*4*_GAP*, *LZ_GAP*, *EU_LGDP_GAP*, *PIE_M_XENERGY*4, *DOT_LZ_CORE_EQ*4, *DOT_LZ_EQ*4, *E*0*_CORE*4, *E*0*_PIE_W*4, *DOT_LWR_PRIOR*, *E*0*_PIE*4
- Shocks: νs
- Variance: σs

Model I

- Measurement equations:

$$
\begin{aligned}
DOT\_LGDP &= DOT\_LGDP\_EQ + 4 * (LGDP\_GAP - LGDP\_GAP\{-1\}) \\
DOT\_UNR &= DOT\_UNR\_EQ - 4 * (UNR\_GAP - UNR\_GAP\{-1\}) \\
PIE\_CORE &= PIE\_CORE\_S \\
PIE\_W &= PIE\_W\_S \\
DOT\_LWR &= DOT\_LWR\_EQ + 4 * (LWR\_GAP - LWR\_GAP\{-1\}) \\
LWR\_GAP &= LWR\_GAP\_EXPERT + std\_w3 * \nu\_LWR\_GAP\_EXPERT \\
LGDP\_GAP &= LGDP\_GAP\_EXPERT + std\_w1 * \nu\_LGDP\_GAP\_EXPERT \\
UNR\_GAP &= UNR\_GAP\_EXPERT + std\_w2 * \nu\_UNR\_GAP\_EXPERT
\end{aligned}
$$

Model II

- State equations:

$$
\begin{aligned}
DOT\_LGDP\_EQ &= MU\{-1\} + a1 * DOT\_UNR\_EQ + std\_v1 * \nu\_DOT\_LGDP\_EQ \\
LGDP\_GAP &= LGDP\_GAP\_C01 * LGDP\_GAP\{-1\} - RMCI\_GAP\_C02 * (b2 * RRC\_GAP\{-1\} \\
&+ b3 * RR4\_GAP\{-1\} + b4 * EU\_RR4\_GAP\{-1\}) \\
&\quad -RMCI\_GAP\_C01 * LZ\_GAP\{-1\} + \\
&\quad LGDP\_GAP\_C02 * EU\_LGDP\_GAP + std\_v2 * \nu\_LGDP\_GAP \\
MU &= (1 - a3) * MU\_SS + a3 * MU\{-1\} + std\_v3 * \nu\_MU \\
DOT\_UNR\_EQ &= std\_v4 * \nu\_DOT\_UNR\_EQ \\
UNR\_GAP &= UNR\_GAP\_C01 * UNR\_GAP\{-1\} \\
&+ UNR\_GAP\_C02 * LGDP\_GAP + std\_v5 * \nu\_UNR\_GAP \\
PIE\_CORE\_S &= PIE\_CORE\_C01 * (PIE\_M\_XENERGY4 + DOT\_LZ\_CORE\_EQ4) \\
&+ PIE\_CORE\_C02 * (PIE\_CORE\_C05 * E0\_CORE4 \\
&+ (1 - PIE\_CORE\_C05) * E0\_PIE4) \\
&+ (1 - PIE\_CORE\_C01 - PIE\_CORE\_C02) * PIE\_CORE\_S\{-1\} \\
&+ RMC\_GAP\_C01 * PIE\_CORE\_C03 * LGDP\_GAP \\
&+ PIE\_CORE\_C03 * LWR\_GAP \\
&+ std\_v6 * \nu\_PIE\_CORE \\
PIE\_W\_S &= PIE\_W\_C01 * E0\_PIE\_W4 + (1 - PIE\_W\_C01) * PIE\_W\_S\{-1\} \\
&+ PIE\_W\_C02 * (LWR\_GAP - PIE\_W\_C03 * LGDP\_GAP) + std\_v7 * \nu\_PIE\_W \\
DOT\_LWR\_EQ &= DOT\_LGDP\_EQ + DOT\_LWR\_PRIOR + std\_v8 * \nu\_DOT\_LWR\_EQ \\
LWR\_GAP &= f1 * LWR\_GAP\{-1\} + std\_v9 * \nu\_LWR\_GAP
\end{aligned}
$$

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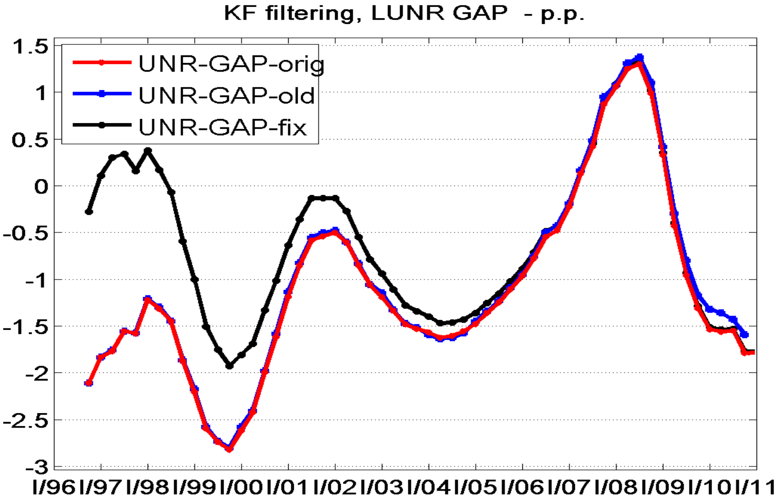
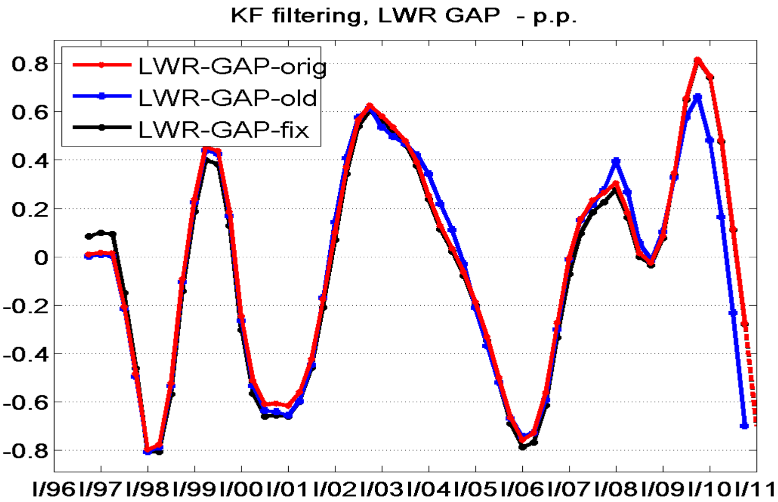
Filtering results: Expert judgement



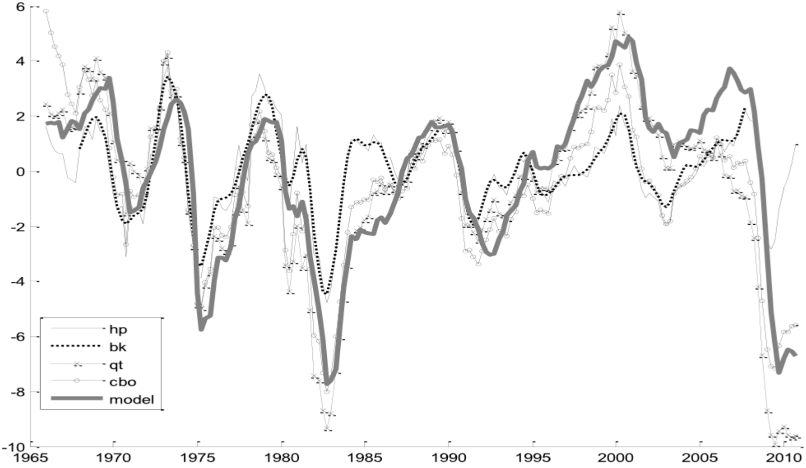
Filtering results: Expert judgement



Advanced filtering

- Criticism of simple models: lack of reference to unemployment
- J. Galí,F. Smets and R. Wouters (2011):
  - Address this issue in an extended model
  - Conclusion: Model-based output gap resembles conventional measures of the cyclical component of log GDP.
  - Comparison of a variety of statistical detrending methods
  - HP filter, band-pass filter, quadratic detrending, and the Congressional Budget Office's measure

Advanced filtering



In search for future trends

List of Variables I

$\widehat{a}$	gap of the variable a
$\bar{a}$	trend (equilibrium) value of the variable a
a^f	variable a for the foreign country
ε^a	residual in the equation for the variable a

mc	real marginal costs
y	real output
rw	real wage
rmci	real monetary condition index
$\mathrm{r4}$	real 1Y interbank rate
r	real 3M interbank rate
rc	real rate of newly-issued bank loans
z	real exchange rate

List of Variables II

$\pi 4^{target}$	inflation target (y-o-y)
π	price inflation (q-o-q)
$\pi 4$	price inflation (y-o-y)
w	wage inflation (q-o-q)
$\mathrm{w4}$	wage inflation (y-o-y)
$\pi 4^{\mathrm{M}}$	imported inflation (y-o-y)
s	nominal exchange rate
prem	risk premium
i	nominal short-term interest rate
$\mathrm{i}^{neutral}$	policy neutral short-term interest rate
$\alpha, \beta, \gamma, \delta, \phi, \psi, \kappa, \lambda$	parameters

For Further Reading I

Cbo'S Method For Estimating Potential Output: An Update,
http://www.cbo.gov/doc.cfm?index=3020&type=0

Jordi Galí and Frank Smets and Rafael Wouters
Unemployment In An Estimated New Keynesian Model,
National Bureau Of Economic Research,vol. 17084, 2011

Peter K. Clark
The Cyclical Component of U.S. Economic Activity,
The Quarterly Journal of Economics,vol. 102,1987

For Further Reading II

Rudolph E. Kalman
A New Approach to Linear Filtering and Prediction Problems
Transactions of the ASME–Journal of Basic Engineering, vol. 82, Series D, 1960

Greg Welch and Gary Bishop
An introduction to the Kalman filter.
University of North Carolina, July, 2006; 2000.

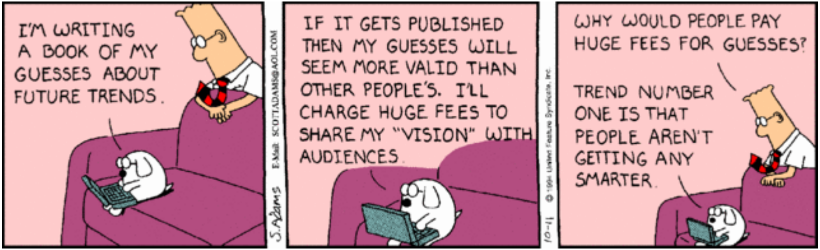
Harvey, Andrew C, 1985
Trends and Cycles in Macroeconomic Time Series
Journal of Business and Economic Statistics, Vol. 3 p. 216

For Further Reading III

Watson, Mark M, 1986
Univariate Detrending Methods with Stochastic Trends
Journal of Monetary Economics, Vol. 18, p. 49

Athanasios Orphanides and Simon van Norden, 2002
The Unreliability of Output-Gap Estimates in Real Time
The Review of Economics and Statistics, Vol. 84, Num. 4

Additional one ...



M9902: Getting in touch with QPM

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Czech National Bank

November 2011

evropský sociální fond v ČR
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OP Vzdělávání pro konkurenceschopnost

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Outline

1. Issues in the forecast
2. Case studies
3. Sensitivity analysis
4. Stress Scenarios

Outline

Forecast issues

- Use of expert judgement
  - Model change
  - Data preparation
- Exogenous shocks
  - Tax changes: First-round and Second-round effects
  - Subsidies
  - Fiscal policy
  - Risk premium: Exchange rate behavior

Forecast evaluation

- Alternative scenarios and sensitivity analysis:
  - Exchange rate sensitivity
  - Alternative scenarios: Exogenous variables forecasts
  - Stress scenarios for financial stability studies
- Forecast effects decomposition:
  - Forecast decomposition: information groups - outlooks for foreign economy, fiscal policy, taxes, etc.
  - Forecast changes decomposition: What changes drive forecast?
  - Evaluation of forecast 6 quarters ago: Fulfilment of inflation target

Outline

Taxes I

Why to Deal with Taxes?

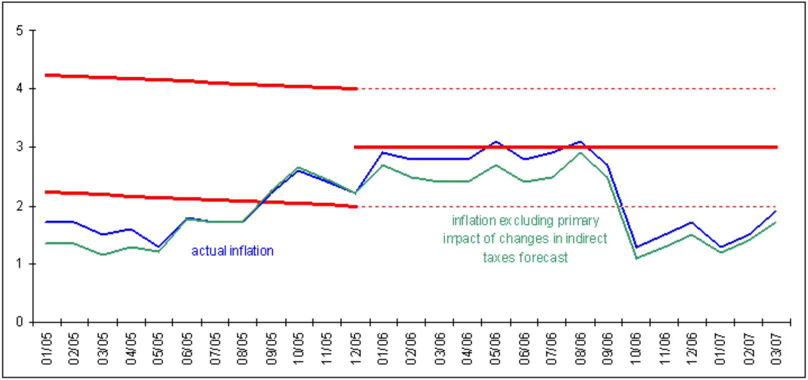
- Tax reforms affect inflation $\longrightarrow$ should be incorporated in inflation projection
- CNB applies escape clauses on first-round impacts of change in taxation $\longrightarrow$ no reaction of policy function

$\Longrightarrow$ Inflation excluding first-round impacts of indirect tax changes, called also **Monetary Policy Inflation**,
or Inflation Relevant for MP)

- Tax changes distort inflation expectations $\longrightarrow$ expectations formation should be adjusted

Taxes II

Inflation and MP Inflation



Indirect Taxes III

Requirements

- Information about planned changes in indirect taxes
- Precise estimation of direct first-round effects
- Estimation of primary effects: use CPI basket to asses
- Estimation of impact on inflation expectations formation (second-round effects): wealth effect
- Good enough estimation of direct second-round effects e.g. margin absorption, price stickiness

Taxes IV

Issue I: Foreign Taxes

- Should be treated similarly
- Typically, not enough information nor good estimates of impact on foreign inflation

Issue II: Real Exchange Rate (RER)

- Within the simple model framework, RER is defined involving CPI rather than PPI inflation rates
- From theory, RER should be adjusted to changes in indirect taxes (domestic and foreign)
- However it is difficult to apply, having usually small effects on projection

Tax changes

Czech Experience:

- From January 2004 - domestic VAT changes incorporated
- From April 2006 - foreign VAT changes incorporated
- From April 2007 - RER adjustment applied

Quantification of effects of tax changes: Time profile and size of impact (volatility of forecast)

More tax issues

1. Foreign tax change
   - Should be treated similarly
   - Typically, not enough information nor good estimates of impact on foreign inflation
2. Real Exchange Rate (RER)
   - Within the simple model framework, RER is defined involving CPI rather than PPI inflation rates
   - From theory, RER should be adjusted to changes in taxes (domestic and foreign)
   - However it is difficult to apply, having usually small effects on projection

Oil price I

Czech Experience:

- Oil price shock started in autumn 2005, peak in summer 2008
- Small weight of fuel prices (around 3% in CPI)
- Expected increase in fuel prices and regulated prices
- Very large increase in oil prices as well as their maintaining at high levels is no longer consistent with behavioral mechanism described in QPM (affects inflation expectations)
- Systematic upward bias of inflation over several periods, especially in adjusted inflation excluding fuels
- At the same time, nominal exchange rate appreciated rapidly in comparison with the forecast
- Outlook of foreign variables affected - use of a global economy model

Oil price II

- Oil Prices - Brent

Implementation I

- Effects to administered prices: energy for households
- Energy price inflation: non-administered portion of consumption basket
- Impact on foreign inflation

Revision of CPI Weights I

Czech Experience:

- New weights introduced from January 2007
- Previous revision in January 2001
- Model framework assumes constant weights in CPI
- QPM forecasts since July 2002: New experience

Revision of CPI Weights II

- Computing q-o-q and y-o-y inflation correctly: Auxiliary indices CPI1 and CPI4 were introduced
- Smooth transition
- Systematic shift in inflation: Structural change in real equilibrium exchange rate

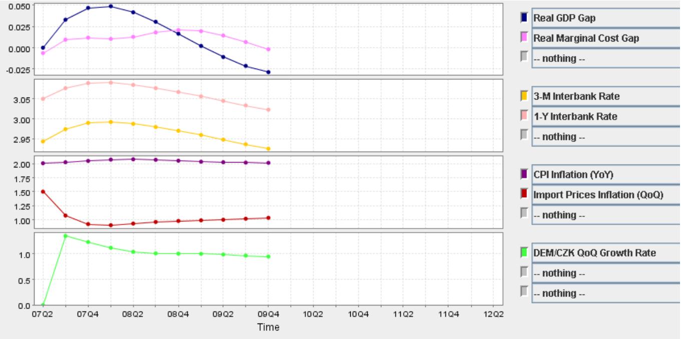
Outline

Analysis I

- Model is not closed in the sense of S. Schmitt-Grohe and M. Uribe (2003)
- What is the difference in scenario of appreciation and depreciation?
- Linear model properties

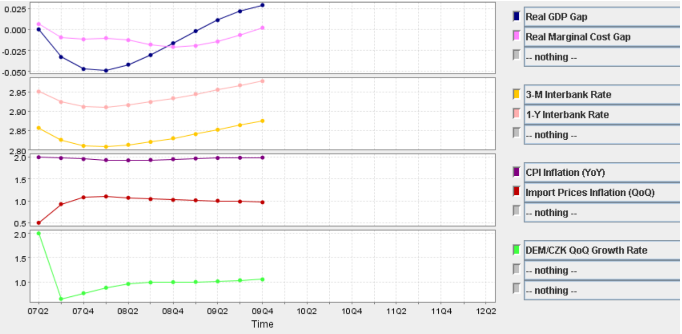
Analysis II

- Depreciation



Analysis III

- Appreciation



- Reporting in the SR:

Analysis IV

- Appreciation by 3%

	07q1	07q2	07q3	07q4	08q1	08q2	08q3	08q4
Celková meziroční inflace (p.b.)								
apreciace kurzu CZK/EUR o 3 %	-0.1	-0.3	-0.7	-1.0	-1.1	-1.0	-0.8	-0.6
3M PRIBOR (p.b.)								
apreciace kurzu CZK/EUR o 3 %	0.0	-0.6	-1.0	-1.2	-1.2	-1.2	-1.1	-0.9
Mezera výstupu								
apreciace kurzu CZK/EUR o 3 %	0.0	-0.5	-0.7	-0.8	-0.7	-0.5	-0.3	-0.1
Kurz (CZK/EUR)								
apreciace kurzu CZK/EUR o 3 %	-0.8	-0.6	-0.4	-0.3	-0.2	-0.2	-0.2	-0.2

Shock persistence I

- Volatile development of exchange rate: January 2007
- Re-simulation of sensitivity scenario
- Standard simulation: No persistence in shock
- Advanced simulation: Various degrees of autocorrelation
- Results:

	07q1	07q2	07q3	07q4	08q1	08q2	08q3	08q4
Celková meziroční inflace (p.b.)								
apreciace kurzu CZK/EUR o 3 %	-0.1	-0.3	-0.7	-1.0	-1.1	-1.0	-0.8	-0.6
3M PRIBOR (p.b.)								
apreciace kurzu CZK/EUR o 3 %	0.0	-0.6	-1.0	-1.2	-1.2	-1.2	-1.1	-0.9
Mezera výstupu								
apreciace kurzu CZK/EUR o 3 %	0.0	-0.5	-0.7	-0.8	-0.7	-0.5	-0.3	-0.1
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apreciace kurzu CZK/EUR o 3 %	-0.8	-0.6	-0.4	-0.3	-0.2	-0.2	-0.2	-0.2

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Outline

Stress testing

- Cooperation with supervision units
- Scenario for financial stability department
- Scenarios for the bank risks evaluations models
- Series used for probability of defaults calculations
- Goals:
  - Usually unfavorable developments to be modeled
  - Probability of defaults calculations: economy wide

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Two country-models in international economics: modeling, applications, and solution

Jan Brůha

Lecture given at the Masaryk University, October, 2011

Outline of the Lecture

1. Motivation
2. International Economics
    - International Trade
    - Balassa-Samuelson effect
3. Application to Central European Countries: Brůha-Podpiera model
4. Numerical Techniques

Goal of the lecture

Goal of the lecture

During this lecture, I will introduce some models from international economics, which may be useful for understanding real convergence, trade flows, or external balance of open economies.

One can investigate these phenomena from different perspectives, such as:

- business-cycle dynamics,
- **trends**,
- .....

Goal of the lecture /2

I will concentrate on modeling **trends**. Hence, most models will be casted in a **perfect-foresight** framework with no aggregate uncertainty. This is distinct from DSGE models in:

- **Goal:** understanding of trends rather than business cycle fluctuations
- **Approach:** perfect foresight rather than rational expectations;
- **Solution:**
  - most DSGE – dynamics around BGP, where trends are exogenous (sometimes even around steady state)
  - this kind of models – dynamics of trends

International trade

The main issues:

1. **Why** there is trade?
2. **What** is traded?
3. **Who** trade with **whom**?
4. At which **price**?

Selected frameworks:

- Comparative advantages (David Ricardo)
- Intra-industry trade (Paul Krugman)
- Intra-industry trade + heterogenous firms (Jacques Melitz)

Ricardian theory of trade

- Countries differ in their technology.
- Key assumption: it is easier to move goods than technologies.
- Motive for trade – it is statically efficient to trade if technologies are different (so-called comparative advantages.)

This theory predicts that:

- Most trade will occur between countries with different technologies (North-South trade should dominate)
- As countries converge, motives for trade fall

Modern version of the model: Eaton and Kortum (2002)

Heckscher-Ohlin model of trade (1933)

- Countries differ in their factor endowments.
- Key assumption: it is easier to trade goods than factors of production.
- Key finding: trade alone may equalize factor prices.
- Motive for trade: endogenous differences in technology.

Countries **must differ** in order to trade:

- **Ricardo model** – technologies differ;
- **HO model** – factor endowments differ.

Empirical challenges to Ricardo and Heckscher-Ohlin

- Countries with similar technologies trade.
- Countries with similar factor endowments trade.
- $\Rightarrow$ North-North trade dominates trade flows (technologically advanced countries, capital abundance)
- A large fraction of trade is two-way **intra-industry trade**.

Krugman model of trade (1980)

Very elegant model, which can explain why countries with **identical technology** and **preferences** trade.

Key ingredients

- monopolistic competition;
- increasing-returns-to scale (product specialization);
- love-for-variety (consumers want to consume all possible goods).

The model relied by the then advances in modeling of imperfect competition (Dixit-Stiglitz approach).

Krugman model – stylized exposition /1

Consumers: utility maximization:

$$\left(\sum_i x_i^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}},$$

s.t.

$$\sum_i p_i x_i = \text{Income}.$$

Parameter $\theta > 1$ measures the elasticity of substitution (if $\theta \to \infty$), goods are perfect substitutes (perfect competition).

Krugman model – stylized exposition /2

Demand function:

$$x_i = \left(\frac{p_i}{P}\right)^{-\theta},$$

$$P = \left(\sum_i p_i^{1-\theta}\right)^{\frac{1}{1-\theta}}.$$

Note:

1. P does not depend on x_i;
2. If $p_i = \bar{p}$, then $P = \bar{p} n^{\frac{1}{1-\theta}}$ – this is called **love-for-variety**.

Krugman model – stylized exposition /3

Firms: Total costs = marginal cost (constant for simplicity) + fixed costs of production:

$$\mathrm{TC}_i = q_i \frac{w}{a} + f,$$

(a is technology, f is fixed costs).

Resulting optimal **supply**:

$$p_i = \frac{\theta}{\theta - 1} \frac{w}{a}.$$

Without trade:

$$\mathrm{Profit}_i = \mathrm{TR}_i - \mathrm{TC}_i = p_i q_i - q_i \frac{w}{a} - f,$$

$$\frac{\mathrm{Profit}_i}{P} = \left(\frac{a}{w/P} \right)^{\theta-1} \frac{1}{\theta} \left(\frac{\theta - 1}{\theta} \right)^{\theta-1} - f,$$

and the zero-profit condition yields the equilibrium real factor price $w/P \propto \frac{a}{f^{\frac{1}{\theta-1}}}$.

Krugman model – stylized exposition /5

Trade: iceberg costs – a fraction of goods sent is lost during transportation $\mathbf{t}$.

Domestic price: $p_i = \frac{\theta-1}{\theta}\frac{w}{a}$;

Foreign price: $p_i^x = (1+\mathbf{t})\frac{\theta-1}{\theta}\frac{w}{a}$

Results:

1. all goods are traded even if countries are perfectly symmetric (love-for-variety effect);
2. specialization (each country produces a subset of goods);
3. trade gains: increase the number of products (increase of profits);
4. decrease in $\mathbf{t}$: effect of P, but not on average of p_i.

Krugman model – stylized exposition /6

Asymmetric countries (n a large market (or in a country with better technology, i.e., lower marginal costs):

- lower price index P, but higher average price $\bar{P}$;
- consumers are less willing to import additional unit of foreign varieties (due to constant elasticity of the demand);
- relative factor price increases (aka currency appreciation)
- higher nominal income, lower price index P – higher real income.

Interesting implications in the economic geography.

Krugman model – empirical problems

- There is a lot of heterogeneity across firms, within any sector.
- Very few firms export (or engage in FDI).
- Exporters are very different from non exporters (usually bigger and more productive).

Melitz model

Heterogeneity:

- Firms differ in productivity

Trade barriers:

- Iceberg costs
- Fixed entry cost to export market

Extensions

- In the original Melitz model, countries are symmetric
- In the original Melitz model, firms differ only by productivity

All these assumptions can be relaxed

Melitz model – implications

Implications:
Three sets of firms:

- non-producers;
- those who produce only for the domestic market,
- exporters.

Sorting is based on productivity.
Original model has labor only, but if capital is added, then exporters would be larger than non-exporters.

Trade liberalization:

- Aggregate productivity is increasing;
- Reallocation to more productive firms;
- The effect of the liberalization can be seen even **before** the liberalization actually happens.

CES preferences

CES preferences are used in most international-trade models:

- Simplicity
- Constant-elasticity of the demand
- No choke prices (even with very large price, there is some demand)

Alternative: linear-quadratic utility:
$U = \alpha \sum_i q_i - \beta \sum_i q_i^2 - \gamma \left(\sum_i q_i\right)^2$

- Demand: $q_i = a - b * p_i + c * P$, with $P = \sum_i p_i$.
- There is a choke price: $p_i = \frac{a+c*P}{b}$
- Elasticity of demand increases with price
- Complicated

Comparison of IT models – based on Baldwin and Harrigan (2007)

Model	Pr (export=0)		
	distance	importer size	remoteness
Eaton-Kortum	+	+	+
Mon. comp. (CES)	0	0	0
Mon. comp. (linear demand)	+	0	+
Hetero. firms (CES)	+	-	+
Hetero. firms (linear demand)	+	+	+
Hetero. firms (CES + quality)	+	-	+

Comparison of IT models – based on Baldwin and Harrigan (2007) / 2

Model	Export price		
	distance	importer size	remoteness
Eaton-Kortum	-	0	+
Mon. comp. (CES)	0	0	0
Mon. comp. (linear demand)	-	0	+
Hetero. firms (CES)	-	-	+
Hetero. firms (linear demand)	-	-	+
Hetero. firms (CES + quality)	+	-	-

Open issues in international trade

Open issues:

- Why trade has increased faster than the GDP?
- The Interplay between FDI and trade?
- Why did trade collapse during the recent recession.

Real exchange rates – some definitions:

Real exchange rate = nominal FX + foreign price level - domestic price level in logs: $q = e + p^* - p$,

Two sectors: tradable and non-tradable. Domestic price level: $p = a * p^T + (1 - a) * p^{NT}$. Hence:

$$q = e + (p^{*T} - p^T) + [(1 - a)(p^{NT} - p^T) - (1 - a)(p^{*NT} - p^{*T})],$$

If PPP holds in the tradable sector, then $e + (p^{*T} - p^T) = 1$, i.e., real terms-of-trade: $q^T = e + (p^{*T} - p^T)$

Supply side with two sectors:

$Y_T = A_T F(K_T, L_T)$ and $Y_{NT} = A_{NT} G(K_{NT}, L_{NT})$.

If F and G are constant-return-to-scale, then in per capita terms ($y_T = Y_T/L_T = f(k_T) = 1/L_T * F(K_T/L_T, 1)$ and so on):
$y_T = A_T f(k_T)$ and $y_{NT} = A_{NT} f(k_{NT})$.

The F.O.C. are given as: $P_T A_T f'(k_T) = r$, $P_{NT} A_{NT} f'(k_{NT}) = r$, and hence: $k_T = k_T(\underbrace{A_T}_{+}, \underbrace{r}_{-})$, $k_{NT} = k_{NT}(\underbrace{A_{NT}}_{+}, \underbrace{r}_{-})$

$P_T A_T [f(k_T) - f'(k_T) k_T] = w$,
$P_{NT} A_{NT} [f(k_{NT}) - f'(k_{NT}) k_{NT}] = w$.

Factor price equalization

If the interest rate r is exogenous (world price) and both factors can freely move across sectors, then: $w = p_T w_T(\underbrace{A_T}_{+}, \underbrace{r}_{-})$ and

$w = p_{NT} w_{NT}(\underbrace{A_{NT}}_{+}, \underbrace{r}_{-})$ and hence:

$$\frac{P_{NT}}{P_T} = \frac{w_T(A_T, r)}{w_{NT}(A_{NT}, r)},$$

i.e., just the relative productivity in both sectors determines the relative price $\frac{P_{NT}}{P_T}$.

This result **does not depend on the demand side** of the model.

Log-linearization implies:

$$p^{NT} - p^T = \frac{\text{Labor share in NT}}{\text{Labor share in T}} a^T - a^{NT}.$$

BS effect:

Recall:

$$q = e + (p^{*T} - p^T) + [(1-a)(p^{NT} - p^T) - (1-a)(p^{*NT} - p^{*T})],$$

and plug in

$$p^{NT} - p^T = \frac{\text{Labor share in NT}}{\text{Labor share in T}} a^T - a^{NT}.$$

If the technological progress is **relatively** biased towards tradable sector, then the real FX rate will appreciate.

Pitfalls:

- Why should be technological progress biased towards the tradable sector?
- The RER is explained by the movements in the non-tradable prices: implications for Terms-of-Trade.

BS effect – evidence for CEE countries

The upper estimates suggest that about 1/3 of the observed RER appreciation is explained by the BS effect.

Explanations:

- Administrative and regulated prices
- Initial undervaluation
- Appreciation in the tradable sector

Motivation

Brůha-Podpiera two-country models

Motivation:

- to mimic a strong pace of the real exchange rate appreciation observed in transition countries,
- to inquire about the necessary model ingredients,

The model aims at long-run trends, not medium frequency deviations, so it is formulated as a perfect-foresight DGE model.

Stylized Facts

Stylized facts related to V4 countries:

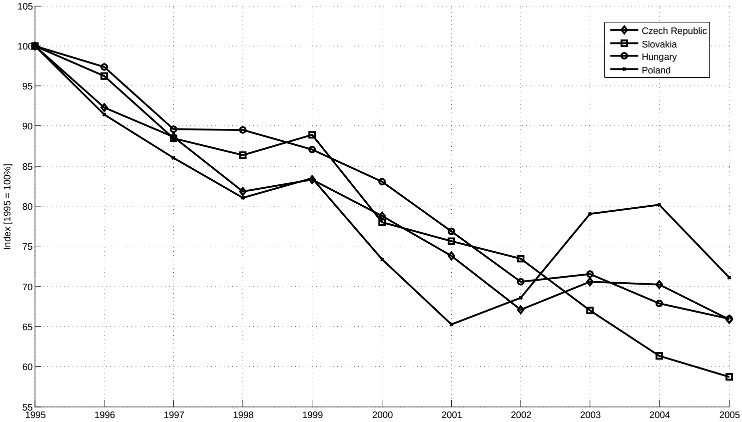
Economic convergence towards the EU average the convergence in GDP per capita towards the EU average about 1 p.p. a year

Trade integration an increase in the export/GDP ratio about 2 p.p. a year

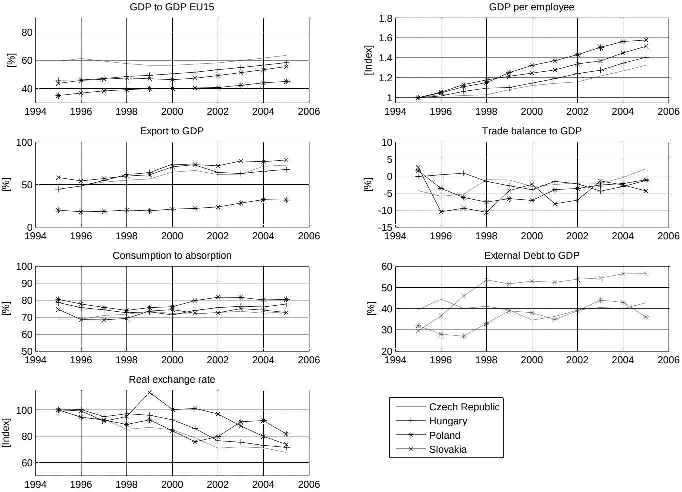
Real exchange rate appreciation about 2% a year (also in the *subindex of manufacturing*).

High-tech production share has gained from 1.5 - 2 p.p. a year

RER appreciation



Stylized facts



How to generate the RER appreciation?

It is not trivial to generate the RER appreciation after an uniform increase in productivity.

Why?

Because of the downward sloping demand curve!

Possible approaches:

1. Horizontal investment (expansion in new varieties)
2. Harrod-Balassa-Samualson story
3. Vertical investment (quality)

Horizontal investments

Love-for-variety

The horizontal investment explanation is based on a dichotomy between welfare-theoretical price indexes and 'average' observable price indexes.

A more productive country has ceteris paribus higher *average* prices, but welfare-theoretical price index is lower because of expansion in varieties.

Krugman (1980), Melitz (2003)

Export Eligibility

The productivity increase may be biased towards tradable goods, then the usual HBS effect causes the RER appreciation.

Why should be productivity biased towards tradables?

The self-selection mechanism, Bergin, Glick, Taylor (2006).

Data – very limited scope for the HBS in the V4 countries: Podpiera, Cincibuch (2006), Égert (2007).

Vertical Investment

The productivity increase vertical margin (quality investment), which implies that more goods can be sell for higher prices.

The RER appreciation after a productivity increase is based on dichotomy between quality- adjusted and quality- unadjusted prices. Price indexes are rarely adjusted for quality: Ahnert, Kenny (2004).

Task

is to integrate the vertical margin in a two-country DGE model and to inquire whether implications are consistent with the facts outlined above.

Framework

- Two countries in discrete time
- Each country endowed with a representative consumer and heterogeneous firms
- Foreign country – big and advanced
- Domestic country – small and converging
  - A metaphor for a transition country (domestic country) versus the Euro area (foreign country)

Vertical Investment Margin

We consider the following production function:

$$q_{jt} = A_t z_j k^{\alpha} l^{1-\alpha},$$

where A_t is the TFP, z_j is the idiosyncratic productivity, k is the quality input, l is labor and $\alpha \in [0\ 1)$.

If $\alpha = 0$, the production function is linear and all types goods have the same quality (as is standard e.g. in Ghironi, Melitz 2005).

If $\alpha > 0$, then it is optimal to choose $k > 0$. The optimal amount of invested capital $k = k(\underbrace{A_t}_{+}, \underbrace{z_j}_{+})$.

Firms

Firms are NPV optimizers and choose:

- labor input (variable);
- export eligibility (fixed at entry, sunk costs);
- quality level (fixed at entry).

Think of firms as of projects!

Backward induction used for solution of firms' problem:

1. labor is chosen as to equalize MPL with real wage;
2. the quality level is increasing in z_j and is higher for exporters;
3. there is a cut-off of z_j, which determines the exporter status.

Market structure – Dixit-Stiglitz

The aggregate good is defined as:

$$Q_t = \left(\sum_{\tau \le t} (1-\delta)^{t-\tau} \left[n_\tau \int q_{j\tau t}^{d\,\frac{\theta-1}{\theta}} \,\mathrm{d}G(j) + n_\tau^* \int \mathbf{1}_{j\tau}^{x*} q_{j\tau t}^{m\,\frac{\theta-1}{\theta}} \,\mathrm{d}G(j) \right] \right)^{\frac{\theta}{\theta-1}},$$

where n_τ is the number of entrants.
The market structure implies the aggregate price index:

$$P_t = \left(\sum_{\tau \le t} (1-\delta)^{t-\tau} \left[n_\tau \int p_{j\tau t}^{d\,1-\theta} \,\mathrm{d}G(j) + n_\tau^* \int \mathbf{1}_{j\tau}^{x*} p_{j\tau t}^{m\,1-\theta} \,\mathrm{d}G(j) \right] \right)^{\frac{1}{1-\theta}}.$$

Today, I would experiment with the linear-quadratic utility.

Households

The household maximizes

$$\max U = \sum_{t=0}^{\infty} \beta^t u(C_t),$$

subject to

$$B_t = (1+r^*_{t-1})B_{t-1} + \frac{-1}{\eta_t}(C_t - \mathbb{W}_t \mathcal{L}) + \frac{1}{\eta_t}(\Xi_t - \widetilde{c}_t n_t) - \frac{\Psi_B}{2} B_t^2 + \mathcal{T}_t,$$

$$\Xi_t = \sum_{s \leq t} (1-\delta)^{t-s} n_s \widetilde{\mathbb{P}}_{s,t}.$$

FOC: $(1+\Psi_B B_t) = \frac{\eta_{t+1}}{\eta_t}(1+r^*_t)\mu_t^{t+1}$,
$\widetilde{c}_t = \sum_{v \geq 0} (1-\delta)^v \mu_t^{t+v} \widetilde{\mathbb{P}}_{t,t+v}$.

General Equilibrium

General Equilibrium

is a sequence of prices and quantities such that all agents maximize and all market clears.

- Labor Markets clear
- Goods Markets clear (GDP identity in the two countries)
- Consistency of Portfolios

Computational experiments

We use a computer-intensive sampling scheme to understand the implications of the various modeling assumptions.

Parameter	Lower bound	Upper bound
exit shock δ	0.050	0.750
CES parameter θ	3.500	7.500
icebergs $\mathbf{t}$	0.025	0.150
investment cost c^n	2.000	10.00
export-eligibility costs c^e	1.050	5.000

Implications

Is there a combination of parameters which could generate the reasonable REER appreciation?

No

under the standard assumptions (i.e. $\alpha = 0$).

Yes

if the model framework is extended by the quality investments.

Implications of Different Investment Margins

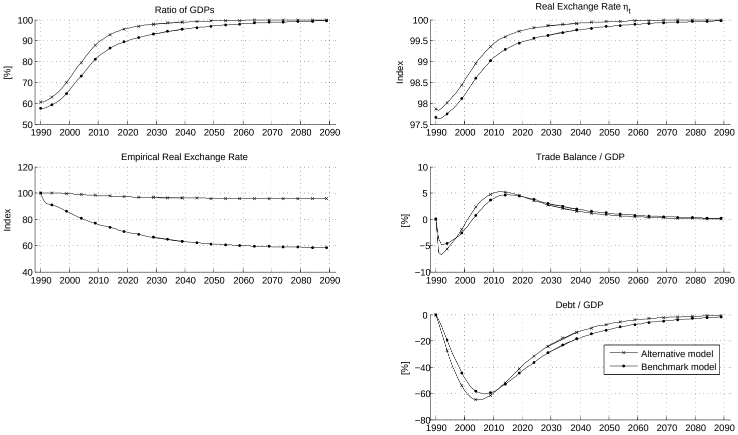
Export self-selection and horizontal margin helps ...

Export self-selectiveness can explain why more productive economies have higher price levels and help to explain why the 'observed' real FX rate of a converging economy is expected to appreciate.

... but they are alone insufficient

Quality investment needed to explain the observed pace.

The convergent trajectory



Applications

The modeling framework has been applied in a different context:

The assessment of the EMU inflation criterion by Brůha and Podpiera (2007), ECB WP 740

The calibration of the Czech economy by Brůha, Podpiera and Polák (2010), The Convergence Dynamics of a Transition Economy: The Case of the Czech Republic, Economic Modelling 27, January 2010, pp. 116-124.

The assessment of the EMU inflation criterion

RER decomposition:

$$\widehat{\eta}_t^e = \widehat{s}_t + \pi_t^* - \pi_t,$$

Conditional on stable nominal exchange rate $\widehat{s}_t = 0$, and the price

stability of the EA, $\pi_t^* = 0.02$, we evaluate the dynamic path for the trend inflation of the converging country as follows:$\pi_t = \pi_t^* - \widehat{\eta}_t^e$.

The path can be in turn compared against the benchmark inflation (average inflation in the three best performing EU Member states plus 1.5 percentage points), i.e., $\pi_t^{**} = \pi_t^* + 0.015$

Probability of fulfillment of the criterion: $\text{Prob}(\pi_t^{**} > \pi_t | \sigma, \widehat{s}_t = 0, \widehat{\eta}_t^e)$. Historical evaluation using detrended (Hodrick-Prescott filter $\lambda = 100$) inflation (CPI index) over period 1995-2010.

Table: Parameters of the model

Parameter		CZ	HU	PO	SK
Elasticity of intra. subst.	θ	6.32			
Utility function	ϵ	0.50			
Production function	α	0.20			
Exit shock	δ	0.05			
Iceberg costs	$\mathbf{t}$	0.27			
Sunk cost of exporting	c^x	0.50			
Portfolio adj. costs	ψ_B	10.0			
Productivity	m	1.72	1.79	2.31	1.18
Productivity	n	6.28	7.37	8.97	6.58
Productivity	A^*	1.35	1.35	1.23	1.43
Productivity	τ	9.33	9.33	11.70	9.33
Relative country size	$\mathcal{L}^*/\mathcal{L}$	30	30	10	60

Domestic productivity: $A_t = A^* \frac{1+m\exp(-(t-1995)/\tau)}{1+n\exp(-(t-1995)/\tau)}$.

Figure: Czech Republic

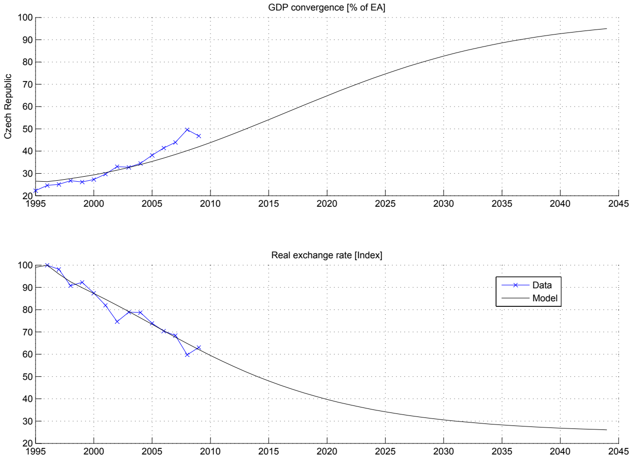


Figure: Hungary

Figure: Poland

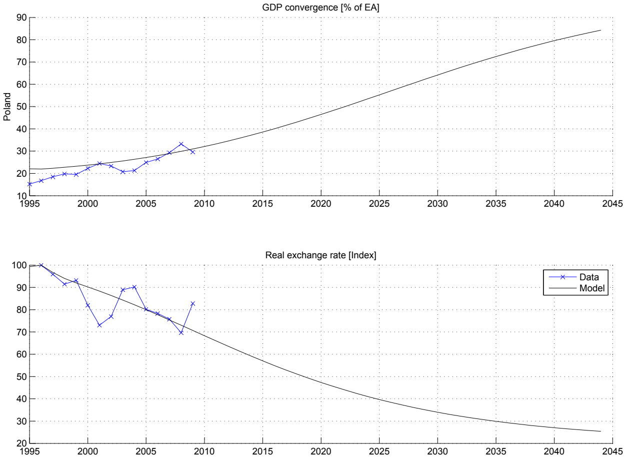


Figure: Slovakia

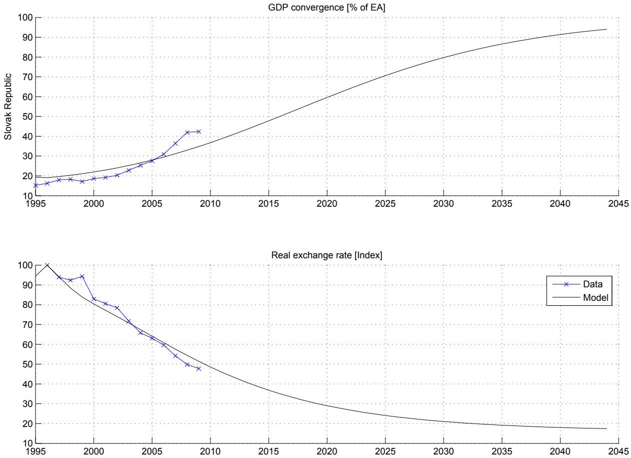
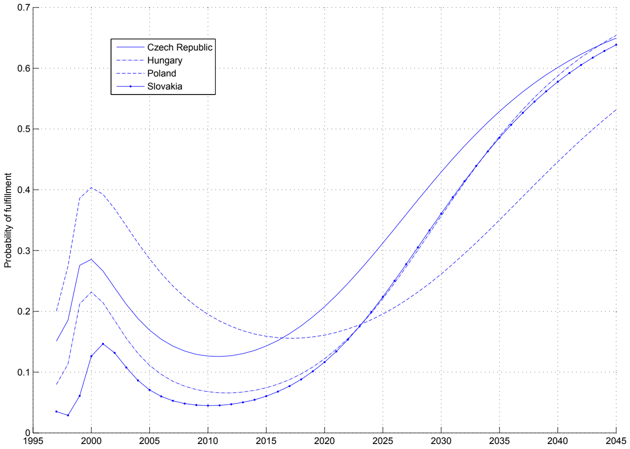


Figure: Probability of fulfillment of the inflation criterium



How to solve perfect-foresight models

This part of the lecture will overview selected solution techniques for perfect-foresight discrete-time economic models.

Problem statement

Two-point boundary value problem (with infinite horizon)

Two difficult points:

- **perfect-foresight:** what agents do today depends on the current state (what they did yesterday) and their expectations on what would happen tomorrow (what they will do in future);
- **infinite-horizon:** equilibrium is an infinite-dimensional system (policy function is of no help, if the model is not autonomous).

Problem statement

General problem statement:

1. Initial condition for state variables (e.g., capital and technology): k_1, A_1 given;
2. Law of motion for exogenous states (e.g. productivity): $\{A_t\}_{t=1}^{\infty}$ – agents know this;
3. Law of motion for endogenous states (such as capital accumulation: $k_{t+1} = (1-\delta)k_t + I_t$);
4. Equilibrium conditions (agents' decisions, market clearing) $F(k_t, c_t, A_t) = 0$ for all $t \in \mathbb{Z}_+$;
5. Transversality conditions (usually in the form of $\lim_{t\to\infty} \beta^t u(c_t, k_t) = 0$).

The goal is to find $\{k_t\}_{t=1}^{\infty}$ and $\{c_t\}_{t=1}^{\infty}$ consistent with conditions above.

Simple example – a growth in an open economy: model

- Two countries in discrete time;
- One country big and advanced, the other country small and converging;
- In each country, there is a representative consumer with recursive utilities: $U_t = \sum_{\tau=t}^{\infty} \beta^{\tau-t} u(c_t)$,
- Budget constraint: $C_t = (1 + r_t)W_t - W_{t+1} - \mathcal{T}(\Delta W_{t+1}) + Y_t - i_t$
- Production technology $Y_t = f(k_t, A_t)$, the market clearing $Y_t = c_t + i_t + x_t$;
- Capital accumulation $k_{t+1} = (1 - \delta)k_t + i_t$;
- Balance-of-payments $W_{t+1} = (1 + r_t)W_t + x_t$;
- Initial conditions k_1, W_1.
- Terminal conditions $\lim_{t\to\infty} \beta^t u'(c_t)k_t = 0$, $\lim_{t\to\infty} \beta^t u'(c_t)w_t = 0$.

Simple example – a growth in an open economy: equilibrium equations

- Optimal investments$(u'(c_t) = \beta u'(c_{t+1})[f_k(k_{t+1}, A_{t+1}) + (1-\delta)]$, $(1 + \mathcal{T}'(\Delta W_{t+1}) = \beta(1 + r_{t+1})\frac{u'(c_{t+1})}{u'(c_t)}$
- Production technology $Y_t = f(k_t, A_t)$, the market clearing $Y_t = c_t + i_t + x_t$;
- Market clearings $x_t = -x_t^*$ and $W_t = -W_t^*$
- Capital accumulation $k_{t+1} = (1-\delta)k_t + i_t$;
- Balance-of-payments $W_{t+1} = (1 + r_t)W_t + x_t$;
- Initial conditions $k_1,\ W_1,\ k_1^*,\ W_1^*$.
- Terminal conditions $\lim_{t\to\infty} \beta^t u'(c_t)k_t = 0$, $\lim_{t\to\infty} \beta^t u'(c_t)w_t = 0$.

Three possible approaches

1. Domain-truncation techniques
   1. First-order iterations (Fair-Taylor)
   2. Quasi-Newton techniques (L-B-J)
2. Projection techniques

Domain truncation techniques solve the model for T periods with the hope that for $t > T$, endogenous variables will be at the constant levels (hence the infinite dimensionality is approximated by the dynamics with finite horizon).

Projection techniques approximate the equilibrium dynamics by a (linear) combination of few elements (basic functions).

Fair-Taylor approach

Fair-Taylor:

1. choose T and guess $\{k_t^0, c_t^0\}_{t=1}^T$
2. set $i = 1$ and for $t = 1, \dots T$, compute k_t^i and c_t^i using k_{t-1}^i and c_{t-1}^i and k_{t+1}^{i-1} and c_{t+1}^{i-1};
3. check the convergence, if the convergence is not achieved, increase $i \leftarrow i + 1$ and go to 2.

Advantages:

- economic intuition – learning;

Disadvantages:

- it may not converge – Gauss-Seidel method;
- sometimes a dampening factor is helpful ($k_t^i = \mu k_t^{i*} + (1 - \mu) k_t^{i-1}$);
- even if it converges, it is slow (linear convergence).

L-B-J approach

L-B-J (due to Lafargue, 1990, Boucekkine, 1995, and Juillard et al., 1998):

1. choose T and form a huge (really huge) system $H(k_1, c_1, \ldots, k_t, c_t, \ldots, k_T, c_T) = 0$ (and set k_{T+1} equal to k_T when appropriate.
2. apply a (quasi-) Newton techniques.
3. if you are clever, you can make this approach efficient (the Jacobian is usually tri-diagonal, clever ways of updating of the Jacobian, ...)

Advantages:

- if it converges, it is fast (quadratic convergence);

Disadvantages:

- it is really a huge system: a system of equations with TM unknowns (M being the number of endogenous variables);
- How to choose T? T should be much larger than the horizon of projection.

Projection techniques /1

Projection techniques (due to Judd, 2002):

- Approximate the path of endogenous variables by a (linear) combination of basis functions: $k_t \cong \sum_i a_i^k f_i(t)$.
- Choose a_i^k so that equilibrium conditions are satisfied.
- The infinite dimensional problem is reduced to find coefficients a_i^k.
- Basis functions can be: (orthogonal) polynomials, splines, radial basis functions, finite elements, ...

Judd (2002) recommends:

$$k_t \cong e^{-\lambda t}\left(k_0 + \sum_i a_i^k f_i(t)\right) + (1 - e^{-\lambda t})k_{SS},$$

where $f_i(t) = L_i(2\lambda t)e^{-\lambda t}$ and L_i are Laguerre polynomials, λ governs the speed of convergence to the new steady state k_{SS} and could (actually should) be computed based on the linearization of the model.

Projection techniques /2

How to choose coefficients a?

- Set residual function $R(t, a)$.
- **Brut force:** solve the optimization problem $\min_a \sum_{t=1}^{T} \|R(t, a)\|_p$ for suitable p.
- If $p = 2$, then you solve a non-linear least-square problem.
- you still have to truncate the time to compute the sum, but instead of T coefficients, you need only I.

It is possible to combine L-B-J with projection techniques:

- If the trajectory of endogenous variables is not smooth (abrupt, unexpected changes), then it is hard to approximate it with smooth basis functions (such as polynomials) – you would need a large I.
- The idea is to approximate for first t by L-B-J and then use projection.

.

Projection techniques /3

There are better ways to chose the coefficients a: **Galerkin method**

- consider the integral $\int_0^\infty R(t,a)\psi_j(t)dt$, where $\psi_j(t)$ are test functions.
- if you choose $\psi(t) = R(t,a)$ you are back to non-linear least-square problem.
- Hope is that if you chose test functions $\psi_j(t)$ cleverly, then $\int_0^\infty R(t,a)\psi_j(t)dt$ will be zero if $R(t,a)$ is.
- use a quadrature to approximate $\int_0^\infty R(t,a)\psi_j(t)dt \cong \sum_k R(t_k,a)\psi_j(t_k)w_k$.
- Therefore, you need not to compute the residual function $R(t,a)$ for all $t = 1,\dots,T$, but only for (rounded) values t_k.

Not always applicable.

Application to Brůha-Podpiera model

The model is rewritten into the first-order form and the idea is to rewrite all variables in term of 7 endogenous variables – a great reduction in the dimensionality of the problem. It has its costs as the Jacobian for L-B-J is no longer tridiagonal and all $1 \leq t \leq T$ should be computed even for the Galerkin method.

- **Fair-Taylor**: the method failed;
- **L-B-J**: in general it works, but it is relatively slow during first iterations ;
- **Projections**: safe and method, but sometimes difficult to obtain precise results (slow last iterations);
- The best way seems to use projections to get relatively accurate results (error about 10^{-6}) and then use L-B-J if further accuracy is required.

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Financial Frictions in DSGE Models

Jiří Polanský

Brno, Faculty of Science
November 8, 2011

Outline of the Talk

1. Brief Introduction to DSGE Models
2. Monetary Transmission Channels
3. Financial Frictions Modeling
4. Financial Accelerator

Brief Introduction to DSGE Models (i)

- DSGE models are powerful tools for macroeconomic analysis and practical forecasting.
    - They eliminate logical inconsistencies (as other models).
    - They are useful for explaining the behavior of an economy (initial conditions, forecasting).
    - But they cannot anticipate shocks (ex-post forecasting errors).
- DSGE models have several advantages:
    - Derivation from optimization problems (w.r.t. older Keynesian models).
    - Based on economic theory (w.r.t. non-structural models like VARs).
    - More-detailed story (w.r.t. gap models).

Brief Introduction to DSGE Models (ii)

- Dynamic stochastic general equilibrium models.
  - GE theory: describes the behavior of the whole economy (interaction of many markets - demands, supplies, prices, policies etc.)
  - Stochastic: the model economy is hit by various shocks.
  - Dynamic: the model shows the interactions among markets and variables over time.
- DSGE models are widely used today.
  - Tools for macro research (laboratories).
  - Tools for policymakers to conduct their policies.

Brief Introduction to DSGE Models (iii)

- Models derived from micro principles.
  - Optimizations of various agents on basis of their tastes, preferences, production capacities etc.
  - $\Rightarrow$ Parameters of these models are structural (supported from economic theory).
    - Non-structural models exploit reduced-form correlations in observed data (VAR, Box-Jenkins etc.).
- Model-consistent forward-looking rational expectations.
  - But: some critics today for ”ideal rational world” (no learning, herding behavior, asymmetric information etc.).

Building Blocks of DSGE Models

- Many agents (sectors) in the economy.
  - Households, firms, central bank, government, bundlers etc.
- Private agents solve optimization problems.
  - Households are maximizing utility.
  - Firms are maximizing profits or minimizing costs.
- Policy agents are not optimizing ... (e.g. a ”prescribed” monetary policy rule).
  - But sometimes optimal policy rules.

Features of Modern DSGE Models

- Apart from RBC features...
  - Intertemporal optimization, rational expectations, ”tastes and technologies”.
- ...these models contain some features to fit the data.
  - Real rigidities (habit formation, capital adjustment costs, imperfect substitutions between inputs etc.).
  - Monopolistic competition, markups.
  - Nominal rigidities.
  - Features for country-specific data.
    - Core models of central banks should be tailor-made.
    - Sector-specific features (technologies).
- Credible monetary policy is important for the real activity.
  - MP matters because of price and wage stickiness.

Some Current Issues of DSGE Models

- Financial frictions
  - Models for monetary policy and financial stability.
- Fiscal policy
- Unemployment etc.

Monetary Transmission Channels

- How MP instruments affect the real economic activity.
- Policy rate setting affects
  - $\Rightarrow$ short-term nominal rates and inflation expectations.
  - $\Rightarrow$ short-term real rates (prices are sticky in short-run) and lending rates (long-term and client rates).
- Usually two groups:
  - Traditional (focused by majority of DSGE models).
  - Asset price channels (focused by models with financial frictions).

Traditional Channels (i)

Real interest rate channel

- Nominal rigidities $\Rightarrow$ nominal interest rate changes imply real interest rate changes
  - $\downarrow$ real interest rate $\rightarrow$ $\uparrow$ investment
- Works also with nominal interest rate near the zero floor (money expansion raises expected inflation).

Nominal interest rate channel

- Effects due to credit-debt structure of an economy.
  - $\uparrow$ nominal interest rate $\rightarrow$ worsening the cash-flow of indebted agents.

Traditional Channels (ii)

Exchange rate channels

1. Direct channel via import prices
   - Depreciation $\rightarrow \uparrow$ import prices $\rightarrow \uparrow$ CPI.
2. Indirect channel via terms of trade
   - Depreciation $\rightarrow \downarrow$ relative price of domestic goods $\rightarrow \uparrow$ net export.
3. Balance of payments
   - Depreciation $\rightarrow$ worsening a financial position of net foreign liabilities holders (higher payments in domestic currency).

Inflation expectations channel

- Public declaration of inflation target anchors inflation expectations $\rightarrow$ price- and wage-setting.

Asset Prices Channels

- Work through wealth effects, balance sheets positions, bank lending etc.
- Captured by financial frictions models.
- Asset prices determine the value against agents can borrow.
  - Net worth (financial accelerator approach).
  - Value of collateral (collateral constraints approach).
- Two main groups
  - Balance sheets channels.
  - Lending channels.

Balance Sheets Channels

- Net worth is one of banks' indicators for extending loans.
- MP expansion $\rightarrow \uparrow$ equity prices $\rightarrow \uparrow$ firms' net worth $\rightarrow \uparrow$ bank loans.
  - $\downarrow$ interest rate $\rightarrow$ bonds are less attractive relative to equities $\rightarrow \uparrow$ equity prices.
  - Monetary expansion $\rightarrow$ people have more money than demanded $\rightarrow \uparrow$ equity purchases $\rightarrow \uparrow$ equity prices.
- Unanticipated price level movements affect financial position of indebted agents.
  - $\uparrow$ price level $\rightarrow \downarrow$ value of firms' liabilities in real terms $\rightarrow \downarrow$ debt burden $\rightarrow \uparrow$ net worth.
- Also for households' expenditures
  - $\uparrow$ asset prices $\rightarrow \uparrow$ net worth $\rightarrow \uparrow$ consumption.
  - Also, higher housing value increases construction.

Bank Lending Channel

- Bank credit is important source of firms' funding.
- Bank lending depend on net worth of borrowers.
    - Banks monitor the financial situation of borrowers.
    - Loans can be collateralized by net worth.
- $\uparrow$ policy rates $\rightarrow$ $\uparrow$ interbank and lending rates $\rightarrow$ $\downarrow$ volume of credit.
- Lending channel crucial for smaller firms as large firms have usually access to funding from stock and bond markets.

Objectives of Financial Frictions Modeling

- Understanding interactions between real and financial sectors.
- Implementation for policy purposes.

Understanding Interactions between Real and Financial Sectors

- ”The deteriorating of credit market conditions is not simply a passive reflection of a declining real economy but is itself a major factor depressing the economic activity.” (Bernanke et al., 1999).
- Assessing the role of asset prices transmission channels.
- Amplification (acceleration) effects of shocks during financial crises.
- ”New types” of shocks during financial crises - riskiness, bubbles etc.
- Different behavior during financial crises - non-linearities due to significant shocks.

Implementation for Policy Purposes

- Satellite models vs. core models.
- Simulations for monetary policy and financial stability purposes (sensitivity scenarios, forecasting).
- Implementation into core models for countries where asset prices matter continually (e.g. New Zealand).
- During financial crises, the policymaking process is more complex and a central bank should "have" appropriate tools for evaluating the current state of an economy and forecasting.

Approaches of Financial Frictions Modeling (i)

- Financial frictions modeling is not a new issue.
  - Papers before the mid-2008-2009 crisis.
  - After the crisis, the interest has intensified and turned to more practical questions.

Approaches of Financial Frictions Modeling (ii)

1. Financial accelerator (e.g. Bernanke et al., 1999).
   - Costly state verification and default risk.
2. Collateral constraints (e.g. Kiyotaki and Moore, 1999; Iacoviello, 2005).
   - Limited contracts enforcement and collateralized debt.
3. Banking sector modeling (e.g. Edwards and Végh, 1997).
   - Banking services as costly activities.

- (1),(2) - focus on ”essence” of asset prices channels (costly state verification, limited contracts enforcement)
- (3) - rather stylized description of stylized facts
- Some models combine assumptions $\rightarrow$ (probably) sometimes to large to control (black boxes)

Incorporating Financial Frictions (i)

Standard DSGE models

- Complete financial markets with perfect information for all agents.
  - $\Rightarrow$ Risk-averse representative household which trades only government (risk-free) bonds to smooth consumption.
  - $\Rightarrow$ No borrowing/lending among agents.
  - $\Rightarrow$ One interest rate (for risk-free bonds).
- Modigliani-Miller theorem holds
  - The market value of a firm is independent of its capital structure and is given by capitalizing its expected return.
  - The real economic activity is independent of the financial structure and it does not matter how a firm is financed.

Incorporating Financial Frictions (ii)

Information asymmetries in financial markets.

- Motivates incorporation of financial frictions.
- Affect the behavior between borrowers and lenders.
- $\Rightarrow$ Interactions between real and financial sectors matter as the Modigliani-Miller theorem does not hold.
- E.g. entrepreneurs have better knowledge about their projects than lenders.
  - $\Rightarrow$ Investors prefer projects where entrepreneurs are engaged in or provide sufficient collateral.

Incorporating Financial Frictions (iii)

- The introduction of borrowing/lending.
  - Requires heterogenous agents with different preferences (FA and CC approaches).
  - Costly banking assumption
- Financial accelerator
  - Risk-averse households.
  - Risk-neutral entrepreneurs (linear utility in consumption).
- Collateral constraints
  - Patient households.
  - Impatient households - (i) different value of the discount parameter and (ii) liquidity constrained.

Financial Accelerator

- BGG - (Bernanke, Gertler and Gilchrist 1999).
- Currently the most used approach.
- Focus on balance sheets effects.
  - How an endogenous development in balance sheet positions of borrowers can significantly amplify (accelerate) shocks.
- Model for understanding the role of credit market frictions within business cycles.
  - Accelerator can transform small shocks into significant fluctuations in real economic activity.
- Friction is placed on a non-financial side of the economy (entrepreneurs).

Financial Accelerator - Mechanism

- Link between net worth of entrepreneurs and the external finance premium (EFP).
  - EFP - the difference between external and internal costs of funds (alternatively, additional costs above a risk-free interest rate).
- EFP depends inversely on the borrowers' net worth.
  - Net worth of borrowers is procyclical (profits, asset prices etc.) $\Rightarrow$ EFP varies endogenously and countercyclically within business cycles.
  - E.g. if a shock lowers net worth $\Rightarrow$ EFP will increase $\Rightarrow$ lower internal funding (lower profits) and lower demand for external funding (higher EFP).

Financial Accelerator - Sectors

- Risk-averse households.
- Risk-neutral entrepreneurs.
  - Purchase capital from capital good producers at the beginning of t, rent it to firms, and sell it back at the end of t.
  - Entrepreneurs' net worth is not sufficient. $\Rightarrow$ They must combine their net worth with bank lending.
  - They cannot accumulate enough equity for internal financing.
- Capital goods producers.
  - To simplify the model (households and entrepreneurs cannot store the capital).
- Bank (financial intermediary).
  - Transfers deposits from households to entrepreneurs.

Financial Accelerator - Debt Contracts

- The costly state verification (CSV) assumption.
  - Information asymmetry between borrowers and lenders.
    - Entrepreneurs observe the realized return on capital costlessly.
    - Bank must pay fixed monitoring costs to observe entrepreneurs' returns.
  - Given the possibility of default and monitoring costs, lenders charge the external finance premium over the riskless rate.
  - EFP is increasing with the leverage ratio of entrepreneurs (debt to net worth).
- $\Rightarrow$ Optimal (not collateralized) contracts where
  - The positive EFP (and monitoring costs) limits tho borrowing.
  - The bank receives the expected return which is equal to the opportunity cost of its funds (the riskless rate).

Collateral Constraints

- Similar approach to the financial accelerator.
- Based on the limited contract enforcement assumption.
    - Repayment is secured by restricting the amount of loans to borrowers' collateral.
    - Lender requires a collateral when extending a loan (a bank expects possible problems of repayments when entrepreneurs declare default and secures the loan).
    - Lender does not need to care about the borrower's willingness to pay since the loan is secured by debtor's assets (lower moral hazard).
- $\Rightarrow$ Some durable assets serve as (i) production factors and (ii) collateral for loans (capital, housing, land).

Collateral Constraints - Mechanism (i)

- Supply of durable assets is limited $\Rightarrow$ Variation of asset prices. $\Rightarrow$ Investment expenditures are sensitive to the net worth of credit-constrained agents.
- The interaction between credit limits and assets prices.
  - $\Rightarrow$ Amplification of shocks.
  - $\Rightarrow$ Shocks are more persistent.

Collateral Constraints - Mechanism (ii)

- Acceleration for demand shocks (implying higher consumer and asset prices)
  - Higher consumer prices $\rightarrow \downarrow$ real value of debt obligations $\rightarrow \uparrow$ net worth of indebted agents.
  - Higher asset prices $\rightarrow \uparrow$ possible collateral of credit-constrained agents (higher borrowing capacity).
  - Higher consumption and investment further increase the borrowing capacity.
  - $\Rightarrow$ Given assumption that borrowers have higher propensity to spend than lenders, the demand shock amplifies responses of real variables relatively to the frictionless case.

Collateral Constraints - Mechanism (iii)

- Decelerator mechanism for supply shocks (shocks with negative correlation between output and inflation)
  - A negative supply shock increases debtors' net worth (for debt obligations in nominal terms).
- MP shock (higher interest rate)
  - Standard real interest rate channel.
  - Decrease of assets prices which leads to lower borrowing.
  - Moreover, a deflation raises the cost of debt service.

Collateral Constraints - Sectors

- Patient households.
- Credit-constrained sectors.
  - Impatient households.
    - Lower discount parameter - they discount the future more heavily (with higher discount rate).
    - (The more heavily discounting means that they demand higher returns from their investment to save instead of consuming today.)
    - Net borrowers.
  - Entrepreneurs - similar assumptions as impatient households.
- Note that credit-constrained agents are more productive comparing to unconstrained agents as they do not hold optimal level of assets for production purposes.

FA and CC Models - Similarities

- Both stress the balance sheet channel.
- Mechanisms through the net worth and asset prices.
- No explicit need for the financial intermediary.

FA and CC Models - Differences

- CC models assume the limited availability of funds: Loans must be collateralized by the net worth of debtors. FA models assume increasing EFP with no explicit upper bound.
- CC models assumes constant EFP (lending rate moves identically with the riskless rate).
- CC borrowers do not face idiosyncratic risks (no default).
- FA - the borrowers' net wealth is influenced by current (and past) conditions. CC - the value of collateral also reflects expected future values via varying asset prices.

Banking Sector Modeling

- Banking sector does not have an important role in canonical financial accelerator and collateral constraints models.
  - Frictions are on households' or non-financial firms' side.
  - Bank transfers funds from depositors to lenders.
- Several approaches for the incorporation of the banking sector into DSGE models.
  - Perfectly competitive banking sector.
  - Monopolistic banking sector.

Costly Banking (i)

- The perfectly competitive representative bank collects deposits from households and extends loans to borrowers.
- Banking services must be costly activities for achieving non-trivial role in the model.
  - In a model: A bank must use resources to produce deposits and loans.
  - In reality: Managing assets and liabilities, monitoring creditors, maintaining building etc.
- The costs of banking services are increasing functions of volume of provided services.

Costly Banking (ii)

- The bank's optimization problem results in first order conditions of the form $R_t^D = R_t - f_D'(\cdot)$ and $R_t^L = R_t + f_L'(\cdot)$.
  - $R^L \geq R$ as bank can always lend to the rest of the world at R.
  - $R^D \leq R$ as bank can always borrow from the rest of the world.
- Costless banking $\Rightarrow$ Both functions are zero (zero costs and zero profits by perfect competition).
- Costly banking $\Rightarrow$ Marginal costs of taking deposits and extending loans are positive $\Rightarrow$ Time-varying deposit and lending spreads.
- Procyclical lending spread (higher demand for loans during booms).
- Costly banking stabilizes an economy (higher costs during booms which lowers the lending).

Uncertainties of Financial Frictions (i)

- Financial sector and frictions cover a wide variety of mechanisms.
  - Several frictions in a single model $\Rightarrow$ hardly feasible and probably black box.
  - Different initial assumptions of frictions.
  - $\Rightarrow$ Usually focus on a single friction (accelerator on firms, constraints on households etc.).
- No workhorse model.
  - Various approaches (based on various assumptions) with different effects of FF for the real economic activity.
  - Moreover, combinations of frictions imply strengthening or weakening of the former effects (e.g. adding banking sector into a FA model can stabilizes accelerator's effects).

Uncertainties of Financial Frictions (ii)

- Financial crises have serious consequences for the real economic activity.
  - Their frequency is rare.
  - Crises might have different behavior and effects.
  - $\Rightarrow$ Calibration uncertainties, regular using of the model more uncertain.
- Unavailability of some time series and seeking proxy variables.
  - E.g. different housing indices with different correlation with business cycles.
  - Short series for the Czech economy (lending rates etc).

State Contingent Contracts

- (Bernanke et al., 1999)
- Risk-neutral entrepreneurs and risk-averse banks
    - Banks run zero profits and simply transfer funds from households to entrepreneurs.
    - Lending rates are adjusting ex post in response to aggregate shocks to compensate for the defaulted entrepreneurs and the monitoring costs.
    - $\Rightarrow$ different lending rates R^L_{t+1} for each the next-period possible future aggregate return on capital R^K_{t+1}. The bank always receives $R_t L_t$ in the $t+1$ whatever R^K_{t+1}.

State Non-Contingent Contracts

- (Beneš-Kumhof, 2011).
- Risk-neutral entrepreneurs and risk-neutral banks (banks also bear the risk of the contracts).
- Lending rate fixed ex ante.
- Banks run profits or looses.
    - Bank capital needed.
    - Or assumption that households receive profits and compensate for looses.

Entrepreneurs - Timing at t

- Entrepreneurs (who survived from $t-1$) purchase physical capital combining internal funds (net worth) and external funds (borrowing). The amount of loans is chosen

$$L_t = P_t^K K_t - E_t$$

- Banks intermediate funds from households to entrepreneurs.

Entrepreneurs - Timing at $t+1$ (i)

- The aggregate return on capital R^K_{t+1} is observed which determines the application of an appropriate lending rate R^L_{t+1}.
- Each entrepreneur observes his own return on capital $\omega R^K_{t+1} P^K_t K_t$ affected by idiosyncratic productivity ω.

Entrepreneurs - Timing at $t+1$ (ii)

- There is a cutoff productivity level which divides entrepreneurs into defaulting and surviving.
  - Defaulting entrepreneurs with insufficient return: $\omega R^K_{t+1} P^K_t K_t < R^L_{t+1} L_t \Rightarrow$

$$\bar{\omega} \equiv \frac{R^L_{t+1} L_t}{R^K_{t+1} P^K_t K_t}$$

  - Surviving entrepreneurs with sufficient return: Repay the loan to the financial intermediary and keep the difference as their net worth.
- Banks receive payments
  - From defaulting: The bank pays the monitoring costs and receives $(1-\mu)\omega R^K_{t+1} P^K_t K_t$. The entrepreneur receives nothing.
  - From surviving: The bank receives $R^L_{t+1} L_t = \bar{\omega} R^K_{t+1} P^K_t K_t$.

Entrepreneurs - Aggregate Return on Capital (i)

The aggregate return on capital is

$$R_{t+1}^{K} P_t^K K_t \int_0^{\infty} \omega f(\omega) d\omega$$

where $E(\omega) \equiv \int_0^{\infty} \omega f(\omega) d\omega = 1$

Entrepreneurs - Aggregate Return on Capital (ii)

The return of defaulting entrepreneurs

$$R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega =$$

$$\underbrace{\mu R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega}_{\text{Private loss in the model}} + \underbrace{(1-\mu) R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega}_{\text{bank's payoff}}$$

The return of surviving entrepreneurs

$$R^K_{t+1} P^K_t K_t \int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega =$$

$$\underbrace{\bar{\omega} R^K_{t+1} P^K_t K_t \int_{\bar{\omega}}^{\infty} f(\omega) d\omega}_{\text{bank's payoff}} + \underbrace{R^K_{t+1} P^K_t K_t \left[\int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega - \bar{\omega} \int_{\bar{\omega}}^{\infty} f(\omega) d\omega \right]}_{\text{entrepreneur's payoff}}$$

Entrepreneurs - Profit Maximization (i)

The expected profit of entrepreneur is maximized

$$\max_{K_t, R^L_{t+1}} E_{R^K_{t+1}} \left[\underbrace{R^K_{t+1} P^K_t K_t}_{\text{ag. return on K}} - \underbrace{R^L_{t+1} L_t \int_{\bar{\omega}}^{\infty} f(\omega) d\omega}_{\text{payment from surv. to B}} - \underbrace{R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega}_{\text{loss from def.}} \right]$$

s.t. a continuum of banks' constraints for each R^K_{t+1}

$$\underbrace{R^L_{t+1} L_t \int_{\bar{\omega}}^{\infty} f(\omega) d\omega}_{\text{from surviving entr.}} + \underbrace{(1-\mu) R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega}_{\text{from defaulting entr. less monitoring}} = R_t L_t$$

where $L_t = P^K_t K_t - E_t$ and $\bar{\omega} \equiv \frac{R^L_{t+1} L_t}{R^K_{t+1} P^K_t K_t}$

Entrepreneurs - Profit Maximization (ii)

After substitution

$$\max_{K_t, \bar{\omega}_t} E_{R^K_{t+1}} \left[R^K_{t+1} P^K_t K_t (1 - \Gamma(\bar{\omega})) \right]$$

s.t.

$$R^K_{t+1} P^K_t K_t [\Gamma(\bar{\omega}) - \mu G(\bar{\omega})] = R_t (P^K_t K_t - E_t)$$

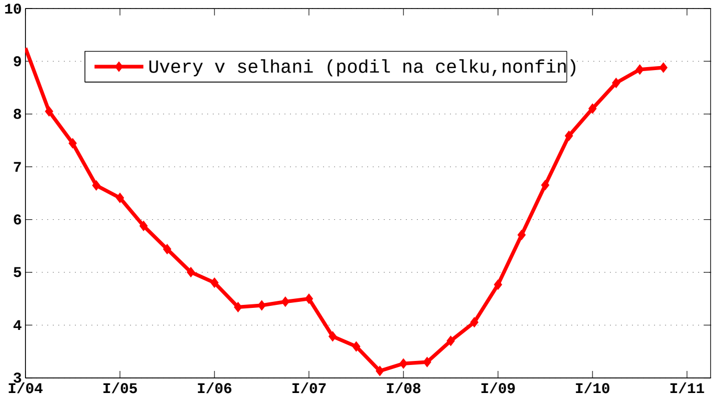
where the expected gross share of profits going to the lender is

$$\Gamma(\bar{\omega}) \equiv \int_0^{\bar{\omega}} \omega f(\omega) d\omega + \bar{\omega} \int_{\bar{\omega}}^{\infty} f(\omega) d\omega$$

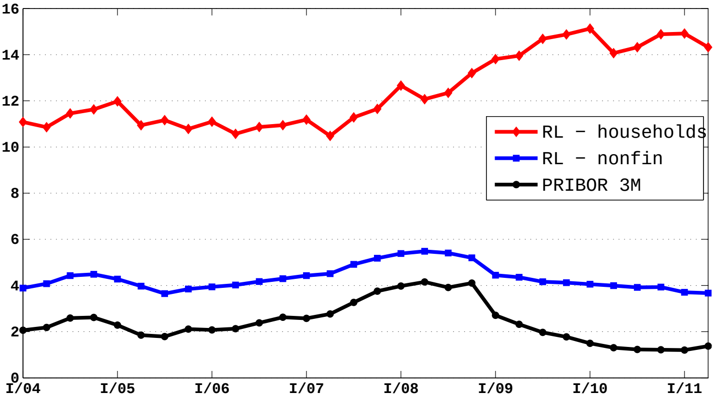
and the expected monitoring costs

$$\mu G(\bar{\omega}) \equiv \mu \int_0^{\bar{\omega}} \omega f(\omega) d\omega$$

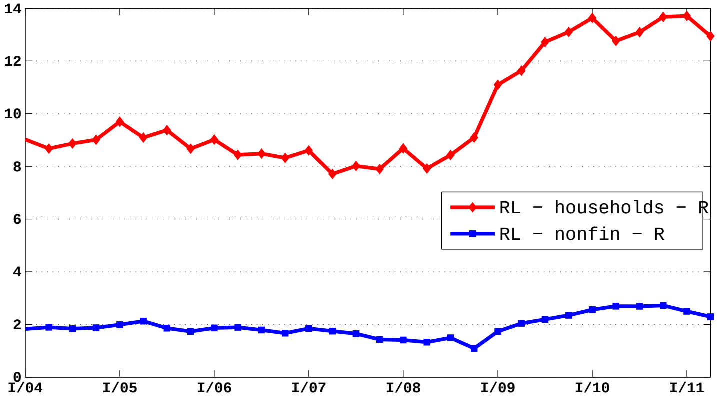
Data (i) - Non-Performing Loans



Data (ii) - Interest Rates



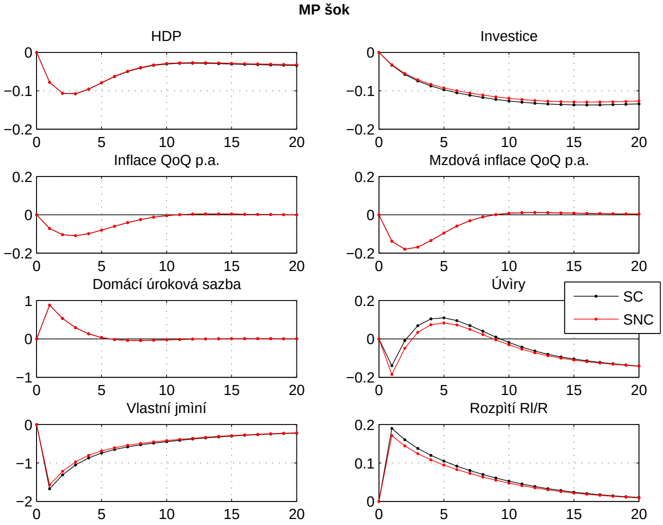
Data (iii) - Spreads



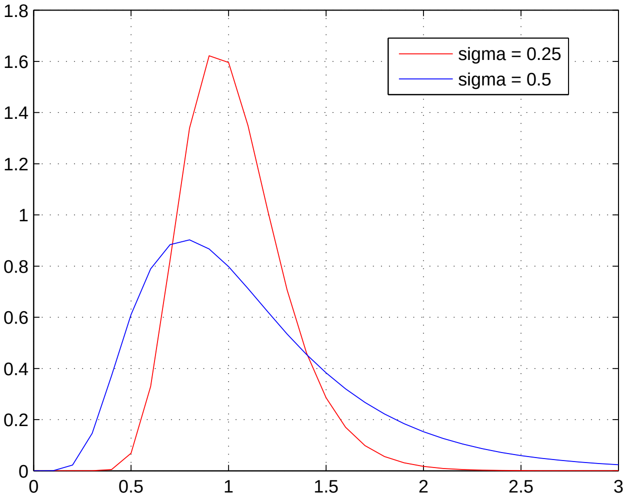
Shocks in the Model

- Standard shocks.
- Specific shocks (fin.crises, bubbles, significant cycles).
    - Focus on ”true exogenous” shocks (e.g. no direct shock to lending rate but shock which increases the lending rate).
    - One of model’s objectives.
    - E.g. higher riskiness during crises (temporarily increased standard deviation of the log-normal distribution of the idiosyncratic shock $\longrightarrow$ high number of defaulting entrepreneurs).

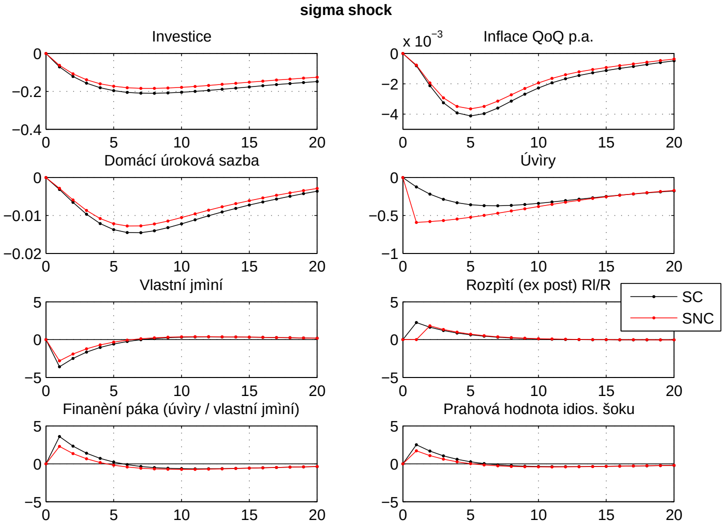
MP Shock


MP šok
HDP
Investice
Inflace QoQ p.a.
Mzdová inflace QoQ p.a.
Domácí úroková sazba
Úvìry
Vlastní jmìní
Rozpìtí Rl/R
SC
SNC

Sigma Shock (i)



Sigma Shock (ii)



Thank you for your attention

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Near-Term Forecasting of GDP at the CNB

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NTF of GDP at the CNB

Overview

1. NTF of GDP at the CNB: users, goals, models
2. Expert forecasts within the core framework
3. Models within the core framework

1. NTF of GDP at the CNB

- Users:
  - GDP + exp. components forecast 1Q ahead is treated “as history” in the medium-term model (g3)
  - Further Q-s ahead (1-2 years) serves as a benchmark for the medium-term model (g3)
- Goals and requirements:
  1. forecast precision a few (1-3) quarters ahead
  2. relatively smooth components forecast in q-o-q growths (required by g3)
  3. story-telling based on expenditure components
  4. good benchmark for g3 1-2 years ahead

1. NTF of GDP at the CNB

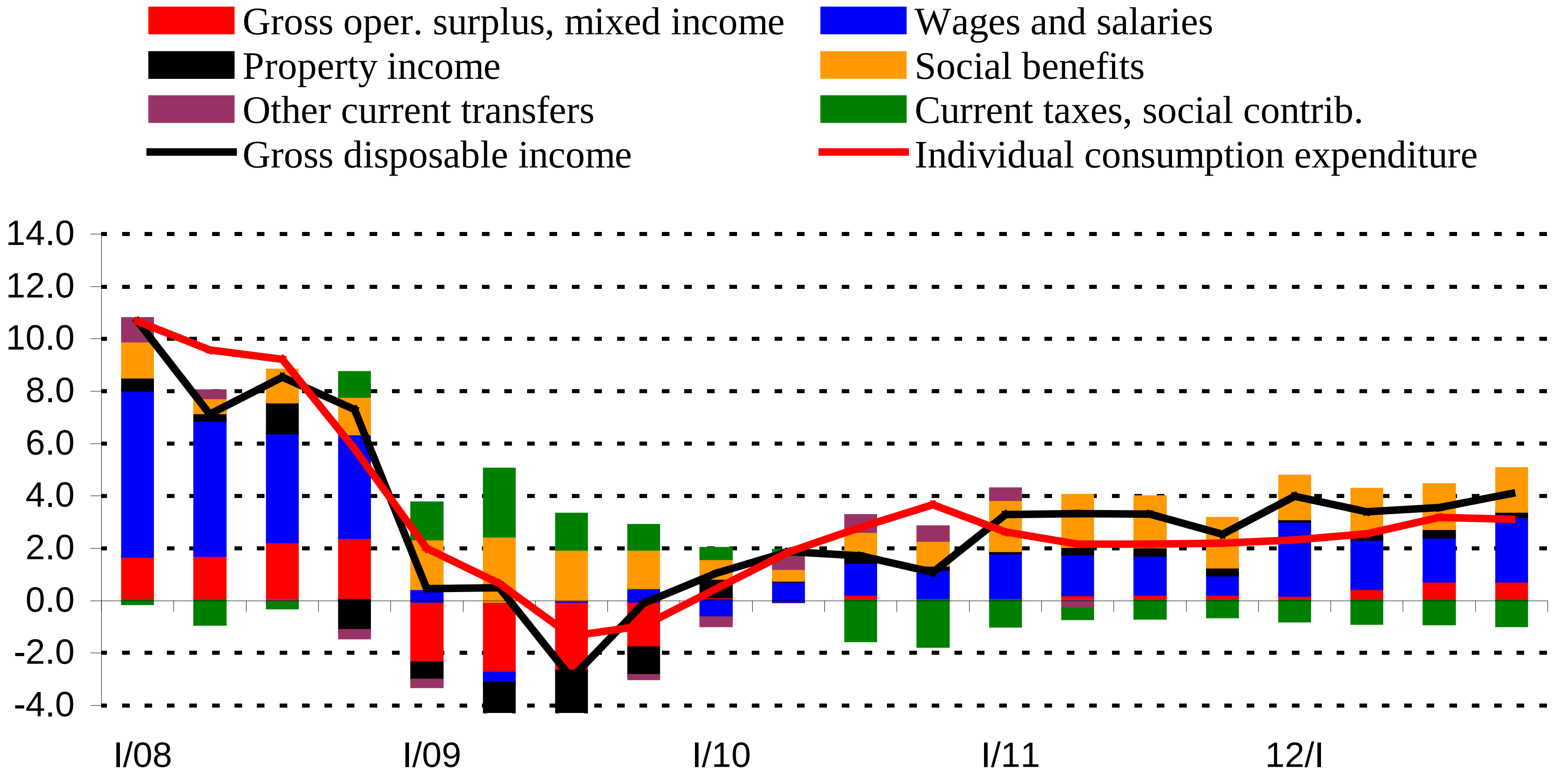
- Models:
  - Core framework:
    - Single-equation econometric models for I, X, M + all deflators (C, I, G, X, M)
    - Quarterly interpolation of G based on a nominal annual forecast (made at another department) + quarterly forecast of the deflator
    - Expert forecast of private consumption with disposable income broken down into components + smoothing by the savings rate and some components of disp. income
  - Benchmark models:
    - Near-term models of GDP using monthly leading indicators: principal components, dynamic factor models, bridge equations, and averaged bivariate VARs.

2. Expert Forecasts within the Core Framework

- Household Consumption
  - Decompose disposable income (DI) to components: operating surplus, wages and salaries, social contributions, transfers, taxes, etc.
  - Most components are forecast by our colleagues (quarterly or annually), others are judged
  - Get an idea of the new consumption forecast based on where the labor market and the fiscal forecast are moving
  - Taking into account the assumptions on DI components, smoothen consumption forecast by the savings rate and some DI components that are highly uncertain

2. Expert Forecasts within the Core Framework

- Household Consumption



2. Expert Forecasts within the Core Framework

- Government Consumption (G)

  - Get the annual fiscal forecast from colleagues
  - Interpolate nominal G into quarters by matching the annual sums (levels) in the fiscal forecast (quadratic interpolation from annual to quarterly data in E-Views)
  - Forecast the quarterly G deflator and deflate the forecast of nominal G to get real terms

3. Models in the Core Framework

- Export (EX):

Dependent Variable: QSA_EX_HP
Method: Least Squares
Date: 09/20/10 Time: 18:18
Sample (adjusted): 1996Q3 2010Q2
Included observations: 56 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
QSA_EX_HP(-1)	0.579	0.116	4.997	0.000
QSA_HDPEU_HP	2.118	0.491	4.311	0.000
Q_RERPPI_HP	0.403	0.125	3.217	0.002
DUM_EX	0.781	0.723	1.080	0.285

R-squared	0.750	Mean dependent var	2.271
Adjusted R-squared	0.735	S.D. dependent var	2.370

– q-o-q growths

– seasonally adjusted

– HP smoothed (λ=1)

– export (EX) linked to:

eurozone GDP (HDPEU)

real exchange rate deflated by relative PPI-s (RERPPI)

dummy: period of EU entry

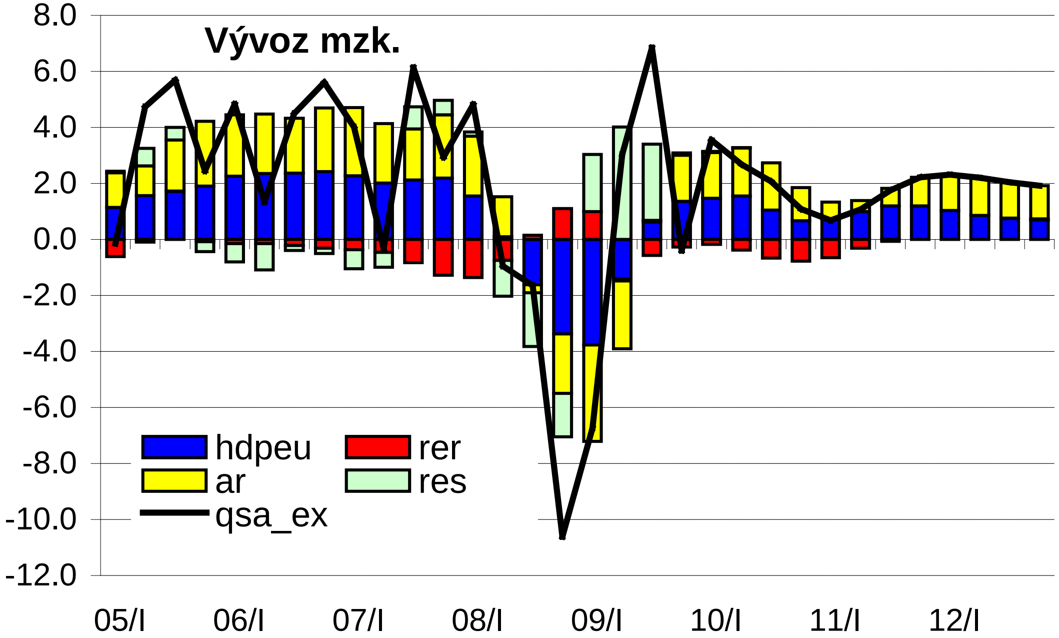
– HDP_EU and RER_PPI are forecast by colleagues

– this model is quite robust to new observations included

– the relationship was first researched without HP smoothing

3. Models in the Core Framework

- Export (EX):



– eurozone GDP is most important

– effect of real exchange rate is typically small

– quite significant persistence (AR term)

– quite a lot of unexplained variation during the recession (periods ’08-’09)

– some of the variation is cut off by the HP smoother (effects don’t add up to the black line)

3. Models in the Core Framework

- Investment (HTK):

Dependent Variable: QSA_HTK_HP
Method: Least Squares
Date: 09/20/10 Time: 18:36
Sample (adjusted): 1996Q3 2010Q2
Included observations: 56 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
QSA_HTK_HP(-1)	0.636	0.088	7.213	0.000
QSA_EX_HP_F(-1)	0.198	0.069	2.864	0.006

R-squared	0.607	Mean dependent var	0.365
Adjusted R-squared	0.600	S.D. dependent var	2.497

– q-o-q growths

– seasonally adjusted

– HP smoothed (λ=1)

– investment (HTK) linked to:

export (EX)

– difficult to find any other robust relationship between investment and other variables

– the relationship was first researched without HP smoothing

3. Models in the Core Framework

- Import (IM)

Dependent Variable: QSA_IM_HP
Method: Least Squares
Date: 09/29/10   Time: 14:05
Sample (adjusted): 1996Q2 2010Q2
Included observations: 57 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
QSA_SDSV_HP	0.377	0.093	4.058	0.000
QSA_HTK_HP	0.236	0.027	8.759	0.000
QSA_EX_HP	0.762	0.023	32.738	0.000

R-squared	0.949	Mean dependent var	2.113
Adjusted R-squared	0.947	S.D. dependent var	2.101

– q-o-q growths

– seasonally adjusted

– HP smoothed (λ=1)

– import (IM) linked to:

the sum of C+G (SDSV)

investment (HTK)

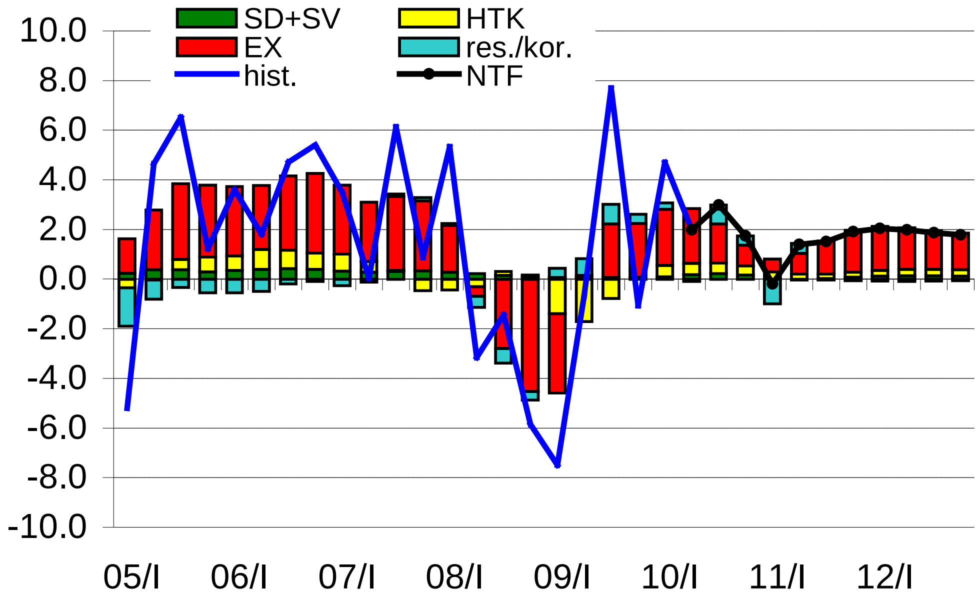
export (EX)

– forecasts of the C, G, I and EX are used

– the relationship was first researched without HP smoothing

3. Models in the Core Framework

- Import (IM)



– in our open economy, export is most important for the demand of imported goods

– the effects of investment and consumption (C+G) are small

– some of the variation is cut off by the HP smoother (effects don't add up to the blue line)

3. Models in the Core Framework

- Deflator of C:
  - linked to CPI forecast and an AR(1) term, seasonally adjusted q-o-q growths
- Deflator of G:
  - linked to CPI forecast, wages in the non-business sector (colleague's forecast) and an AR(1) term, seasonally adjusted q-o-q growths
- Deflator of I:
  - Linked to forecasts of import deflator, CPI and AR(1) term, seasonally adjusted y-o-y growths
- Deflator of X and M:
  - Forecast by colleague (D. Havrlant). Linked to the forecasts of import and export price indexes.
- GDP deflator:
  - Linked to forecasts of CPI, X and M deflators, AR(1) term, seasonally adjusted y-o-y growths

3. Models in the Core Framework

- Compilation of the GDP forecast:
  - Compute weighted average of year-on-year growth rates of GDP components
  - weights: nominal weights of components in the same period of the preceding year
  - ex-post smoothening of the GDP forecast by adding expert judgement into some components, mainly investment (uncertainty) or import (has big weight)
  - Possibly reflect on the GDP forecast of benchmark models

Short-term Forecasting of Czech Quarterly GDP Using Monthly Indicators

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11th of Oct, 2011

evropský sociální fond v ČR
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STF of GDP by MI

Overview

A. Motivation
B. Tested models
C. Data
D. Results

A. Motivation

- Quarterly data of GDP – national accounts
  - published cca. 10 weeks after the end of the quarter
- A lot of monthly indicators are available (~70–100)
  - published early, i.e. end of a month or just a few weeks later
- Several models recently available in the literature can:
  - deal with mixed frequency data and unbalanced panels
  - condition the forecast on a large set of indicators
  - reduce forecast errors as opposed to univariate models
- A comprehensive study of recent short-term models for Czech GDP is missing. It is useful for forecasting at CNB.

B. Tested models

We follow the ECB study Barhoumi etal. (2008):

1.	Moving average (naive model)	
2.	NTF framework of CNB	
3.	Averaged bivariate VAR-s	**VAR**
4.	Bridge equations	**BEQ**
5.	Static principal components	**PC**
6.	DFM ala Doz etal. 2007	**DFM**
7.	GDFM ala Forni etal. 2005	**GDFM**

B. Tested models

1. Moving averages (naive model)

   average of last 4 quarters

2. Near-Term Forecasting (NTF) framework of CNB
   - GDP forecast = smoothed sum of expenditure components

Note: GDP will be henceforth denoted as “y“

B. Tested models

3. Bivariate VAR-s

$$x_{i,t}^{Q} = \frac{1}{3}\sum_{s=0}^{2} x_{i,\tau-s}$$

quarterly aggregation of N indicators

$$z_{i,t}^{Q} = \left\{ y_{t}^{Q},\ x_{i,t}^{Q} \right\}$$

for all pairs of y and $x_{i,t}$, i = 1..N

$$z_{i,t}^{Q} = \mu_i + \sum_{s=0}^{p_i} A_s\, z_{i,t-s}^{Q} + \varepsilon_{i,t}^{Q}$$

we estimate a VAR(2,p_i)

$$\hat{y}_{t+h|t}^{Q} = N^{-1}\sum_{i=1}^{N} \hat{y}_{i,t+h|t}^{Q}$$

pairwise GDP forecasts are averaged

B. Tested models

4. Bridge equations (BEQ)

$$x^Q_{i,t+h} = \frac{1}{3}\sum_{s=0}^{2} x_{i,\tau+H-s}$$ quarterly aggr. of forecasted x-s (H=3h)

$$y^Q_t = \mu_i + \sum_{s=0}^{q_i} \beta_{i,s}\, x^Q_{i,t-s} + \varepsilon_{i,t}$$ BEQ for all pairs i of N

$$\hat{y}^Q_{t+h|t} = N^{-1}\sum_{i=1}^{N} \hat{y}^Q_{i,t+h|t}$$ pairwise GDP forecasts are averaged

B. Tested models

5. Static principal components (PC)

$$x_{i,\tau} = \sum_{j=1}^{r} \lambda_{i,j} F_{j,\tau} + \upsilon_{i,\tau}$$

estimation of static factors (PC)

$$F_{j,t}^{Q} = \frac{1}{3} \sum_{s=0}^{2} F_{j,\tau-s}$$

quarterly aggregation of factors

$$y_{t+h}^{Q} = \mu + \beta' f_t^{Q} + \varepsilon_{i,t}$$

forecasting GDP (OLS)

„bridging with factors“

B. Tested models

6. Alternative principal components (PC-Q)

Differs from PC in three ways:

- PCs estimated on the quarterly aggregates
- # of static factors is selected by the Kaiser criterion (PC eigenvalues > 1)
- Incomplete quarters of monthly indicators are simply omitted

B. Tested models

7. DFM ala Doz etal. 2007

a) we estimate static factors by principal components, number of factors based on Bai and Ng (2002)

b) we estimate the parameters of dyn. factors by OLS

   (number of dyn. factors based on Bai and Ng)

c) given parameters from the previous step, we estimate dynamic factors and idiosyncratic terms by Kalman filter

   (flexible assumptions on the idiosyncratic terms)

d) we aggregate forecasted factors to quarterly freq.: f^Q_t

e) we regress y_{t+h} on f^Q_{t+h} by OLS

   (on quarterly data; h is the forecast horizon)

B. Tested models

7. DFM ala Doz etal. 2007

$$x_{it} = \lambda_i F_t + \omega_{i,t}$$

estimate static factors (PC)

$$f_t = \sum_{k=1}^{P} A_k f_{t-k} + B v_{i,t}$$

estim. & forecast dyn. factors (KF)

$$f_{j,t+h}^{Q} = \frac{1}{3} \sum_{s=0}^{2} f_{j,\tau+H-s}$$

quarterly aggreg. of factors (H=3h)

$$y_{t+h}^{Q} = \mu + \beta' f_{t+h}^{Q} + \varepsilon_{i,t}$$

forecasting GDP (OLS)

„bridging with factors“

B. Tested models

8. One-sided GDFM ala Forni etal. 2005

   a) monthly indicators are aggregated to quarterly frequency

      (balancing by EM algorithm)

   b) GDFM is estimated on the combined database of quarterly indicators and GDP

      (max. no. of dyn. and stat. factors fixed, actual numbers selected by information criteria of Bai and Ng)

   c) GDP forecast is derived directly from the factor model as the forecast of common components

B. Tested models

8. One-sided GDFM ala Forni etal. 2005

$$x_{i,t}^{Q} = \frac{1}{3}\sum_{s=0}^{2} x_{i,\tau-s}$$

quarterly aggregation of indicators

$$z_t^Q = \left\{ y_t^Q,\ x_t^Q \right\}$$

y is GDP

$$z_t^Q = \Lambda\, f_t^Q + \upsilon_t$$

estimate GDFM on quarterly data

$$z_{1,t+h}^Q = \lambda_1\, f_{t+h}^Q + \upsilon_t$$

forecast (z_1 = y = GDP)

C. Data

Monthly indicators (98 series):

- Industry, construction and services (43)
- Labour market (5)
- Foreign trade (4)
- Price data (11)
- Financial indicators (19)
- Czech confidence indicators (6)
- Foreign leading indicators (9)
- Czech electricity consumption (1)

Adjustment of GDP and monthly data:

- Seasonal adjustment, quarterly growth rates
- Some of monthly indicators further differenced to achieve stationarity

C. Data

Indicator pre-selection – our rule of thumb:

- Used only for large-scale models (5.-8.)
- Goal: focus on indicators with most relevant information for GDP when estimating factor models
- Include if abs(corr.) with GDP growth > 0.5
- If abs(corr.) between any two indicators is > 0.9, only the one more correlated with GDP is kept
- From the full set of 98 only 27 series survive
- Result: reduced forecast errors for models 5.,7.,8.

C. Data

Series No.	Name	Correlation with GDP*	Included in factor models?	Number of log differences**
1	IPI manufacturing	0.57	Y	1
2	IPI leather	0.51	Y	1
3	IPI machinery	0.63	Y	2
4	IPI motor vehicles excl. motorcycles	0.51	Y	1
5	Industry sales	0.55	Y	1
6	Sales - wholes., retail, service and maint. of motor vehicles	0.63	Y	2
7	Sales - services total	0.86	Y	2
8	Sales - accommodation, catering and hospitality	0.52	Y	2
9	Sales - information and communication services	0.51	Y	2
10	Sales - professional, scientific and technical services	0.58	Y	2
11	Sales - administrative and complementary activities	0.63	Y	2
12	Free vacancies	0.73	Y	1
13	Newly registered unemployed (inflows)	-0.77	Y	2
14	Unemployment rate (total)	-0.72	Y	2
15	Export (current prices)	0.53	Y	1
16	Import (current prices)	0.57	Y	1
17	Eurozone PPI (effective)	0.64	Y	1
18	PPI manufacturing	0.57	Y	1
19	3M PRIBOR	0.52	Y	2
20	ECB 1Y rate	0.75	Y	1
21	Confidence indicator index (entrepreneurs)	0.61	Y	1
22	Industry survey - overall economic situation	0.71	Y	2
23	Industry survey - demand	0.60	Y	1
24	The Ifo Business Climate for Germany - Business Situation	0.67	Y	2
25	OECD Composite Leading Indicator - Germany	0.81	Y	1
26	New car registrations - Germany	-0.54	Y	1
27	Euro area Business Climate Indicator	0.52	Y	1

Notes: * Correlation coefficients were calculated from q-o-q growth rates of the quarterly aggregates

** Monthly indicators were log-differenced before estimation to achieve stationarity

D. Results

<u>Time interval:</u>	2001:q1 – 2009:q4
<u>Evaluation interval:</u>	2005:q1 – 2009:q4
<u>Forecast horizon:</u>	1 to 3q ahead
<u>Number of indicators:</u>	up to 27 (98)

D. Results

The smallest RMSE overall: PC

Smallest RMSE 1Q ahead: NTF of CNB

Relat. RMSE	+1Q	+2Q	+3Q	Average
NTF	**0.67**	0.80	0.91	0.81
VAR	0.97	1.11	1.18	1.09
BEQ	0.69	0.92	1.06	0.90
PC	0.69	**0.68**	**0.90**	**0.76**
PC-Q	0.80	1.09	1.27	1.06
DFM	0.75	0.79	0.99	0.85
GDFM	1.04	0.93	0.98	0.98

Note: relative RMSE is calculated vis-à-vis the RMSE of the moving average model

D. Results

Relat. RMSE	+1Q	+2Q	+3Q	Average
Average forecast	0.81	0.86	0.95	0.88
PC - full panel	0.92	0.82	0.95	0.89
DFM - full panel	1.06	1.10	1.04	1.07
GDFM - full panel	1.09	0.98	1.01	1.02
AR(1)	1.10	1.14	1.09	1.11
historical mean	1.13	1.02	0.97	1.03

Relat. RMSE	+1Q	+2Q	+3Q	Average
NTF	**0.67**	0.80	0.91	0.81
VAR	0.97	1.11	1.18	1.09
BEQ	0.69	0.92	1.06	0.90
PC	0.69	**0.68**	**0.90**	**0.76**
PC-Q	0.80	1.09	1.27	1.06
DFM	0.75	0.79	0.99	0.85
GDFM	1.04	0.93	0.98	0.98

D. Results

Ranks of 7+4	+1Q	+2Q	+3Q	Average
Average forecast	6	5	3	4
PC - full panel	7	4	4	5
DFM - full panel	10	10	8	10
GDFM - full panel	11	8	7	11

Relative ranks	+1Q	+2Q	+3Q	Average
PC - full panel	-5	-3	-3	-4
DFM - full panel	-6	-8	-2	-7
GDFM - full panel	-2	-1	-2	-1

Ranks: model ranking based on RMSE, out of the 7 main models + 4 additional models listed in the table above

Relative rank, for example: = rank of PC – rank of PC full panel

Diebold-Mariano Test Statistic for the H0 of Equal Squared Forecast Errors

	VAR	BEQ	PC	DFM	GDFM	4Q average
VAR		2.01*	3.81**	3.28**	1.87*	2.05*
BEQ	-2.01*		2.95**	1.44	-0.41	-0.41
PC	-3.81**	-2.95**		-2.63**	-3.25**	-3.21**
DFM	-3.28**	-1.44	2.63**		-3.17**	-3.03**
GDFM	-1.87*	0.41	3.25*	3.17*		-0.02
4Q average	-2.05*	0.41	3.21**	3.03**	0.02	

Note: negative statistics indicate smaller forecast errors for the model in the row. * and ** denote significance at the 95 % and 99 % levels. Degrees of freedom equals 159.

D. Results

Results of the ECB study

Countries:	7 of the eurozone
Time period:	1991:q1 – 2005:q3
Evaluation period:	2000:q1 – 2005:q3
Forecast horizon	1 to 3q ahead
Number of indicators:	76 - 393 by country

RMSE vis-à-vis the naive model:

Relat. RMSE	+1Q	+2Q	+3Q	Average
AR	0.99	0.99	1.00	0.99
VAR	0.97	0.99	1.01	0.99
BEQ	0.93	0.96	1.00	0.97
PC	0.86	0.92	**0.94**	0.91
DFM	**0.83**	**0.90**	0.95	**0.89**
GDFM	0.91	0.92	0.98	0.94

D. Results

Results of the ECB study

Countries:	LT, HU, PL
Time period:	1995:q1 – 2005:q3
Evaluation period:	2002:q1 – 2005:q3
Forecast horizon:	1 to 3q ahead
Number of indicators:	80 – 103 by country

RMSE vis-à-vis the naive model:

Relat. RMSE	+1Q	+2Q	+3Q	Average
AR	0.91	0.95	0.99	0.95
VAR	0.95	**0.94**	**0.95**	**0.90**
BEQ	0.94	0.98	0.98	0.96
PC	1.24	1.06	1.07	1.09
DFM	1.14	1.06	1.01	1.05
GDFM	**0.90**	**0.94**	0.99	0.94

D. Results

- On CZ data, most models are more accurate than the naive model
- PC performs best overall, thus it is a good idea to condition the forecast on “many” but relevant monthly series
- Expert forecast (NTF) did at least as well as the best model (PC) 1Q ahead
- Factor models did quite well overall (PC and DFM better than VAR and BEQ)
- Factor models improved in precision if the indicator set was reduced to the most relevant subset
- Looking at errors of PC and PC-Q, timeliness of information is key
- Results (model rankings) are not quite generalizable across countries

Questions

Forecasting and Policy Analysis System in the Czech National Bank

Macroeconomic Forecasting Division
Monetary and Statistics Department

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27 September, 2011

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Outline

- The motivation for FPAS and main objectives
- The elements of the system
- The forecasting process and its organization
- Conclusion

The motivation for FPAS and main *objectives (i)*

- FPAS is most importantly a *system!*
- Its main goals:
  1. All know-how at department level should be channeled into the analysis and forecast
  2. Clear division of responsibilities
  3. Effective execution of specialized tasks but…emphasis on high quality synthesis
  4. Good coordination of mutually linked activities
  5. Transforming the technical results into a digestible story
  6. Meeting tight deadlines

The motivation for FPAS and main *objectives (ii)*

- The difference between forecasting in a CB compared, for instance, with the academia:
  1. Individual vs. Team work
  2. Own views vs. Communication within the forecasting team and with policy makers
  3. Snap-shot vs. Regular task
  4. Medium-term research vs. Real-time pressures
  5. “No memory” vs. Last forecast relative to the actual one
  6. Broad picture vs. Details
  7. Technical language vs. Macroeconomic story
  8. Target groups for “external” communication are different

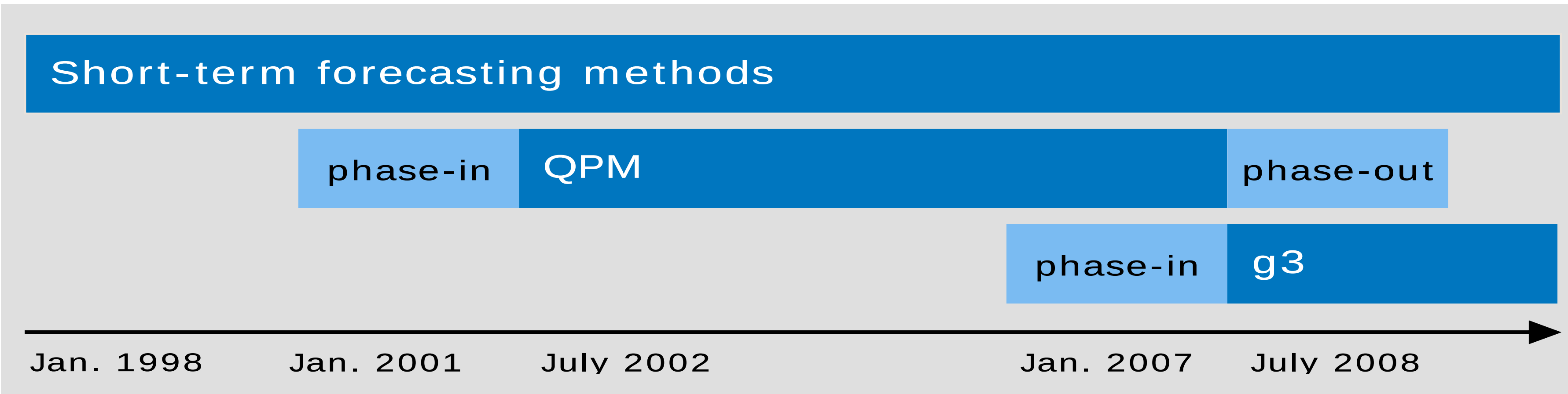
The motivation for FPAS and main *objectives (iii)*

- Medium-term approach
- Reactive MP and unconditional inflation forecast
- Insight into decision making of economic agents and monetary authority
- The process organized around a relatively simple (QMP) resp. less simple (g3) core structural model:
  - How important it is to have a state-of-the art core model?
  - Communication aspects
- Departmental forecasting team: responsible for the successful conduct of the process and co-operation of all divisions

The motivation for FPAS and main *objectives (iv)*

- To have consistent and clear methodology to derive a consistent macroeconomic forecast
- To shape inflation expectations and behave systematically in line with the inflation forecast
- To communicate the basic massage of the forecast:
  - where the economy is and what the current trends are
  - what is the likely evolution in the future
  - what are the implicit risks
  - what are the underlying pressures in terms of MP

The Elements of the System (i)



- CNB relied on near-term methods when the IT introduced
- QPM introduced into forecasting in mid-2002
- Switch from constant IRs assumption to endogenous IRs
- Successful switch to ‘g3’ in mid-2008
- Integration with near-term forecast
  - nowcasting + robustness check + expert judgments

The Elements of the System (ii)

- Core model (g3)
- Multisectoral SOE model
- *No ad-hoc detrending*, explicit treatment of sectoral trends
- BGP with constant nominal expenditure shares and trends in relative prices

- Cascade of price and wage rigidities
- Real frictions (habit formation, new vs. old capital, ...)
- Imperfect exchange rate pass-through
- Import intensity of exports, increase in trade openness
- Regulated prices included

The Elements of the System (iii)

- Core model (g3) (cont.)
  - Definition of the key features of the economy
  - The structure of the model ▶
  - Stock-flow equilibrium
  - Calibration
  - Kalman filtering, identification of structural shocks ▶
  - The model generates an interest rates trajectory consistent with the overall projection ▶
  - Some other use: alternative scenarios, MP experiments, stochastic simulations of shocks etc. ▶

The Elements of the System (iv)

- Near-term forecast (NTF)
  - Model (g3) mechanisms are valid for medium-term horizon
  - The nowcast and 1Q ahead forecast are based on a wide range of high frequency information
  - Identification of short-run idiosyncratic shocks
  - High degree of detail and structural insight
  - Economic intuition based on accumulated expert knowledge ▶
  - An important role of empirical evidence, statistical data and econometric methods
  - Irreplaceable task: NTF benchmark for the model forecast
  - Example (Kalman filter based forecast decomposition) ▶

The Elements of the System (v)

- <u>Departmental forecasting team:</u>
  - Why a separate forecasting team?
  - Forecast is made by the staff not by the model
  - Inclusivity and collective view are essential
  - Responsible for a conduct of the forecasting process
  - Specifies deadlines and responsibilities
  - Disposes with technical background with a seamless database - and prediction system

The Elements of the System (vi)

- Composition of the forecasting team (FT):
  - Head of the forecasting team, representative of the Macroeconomic Forecasting Division (MAFD)
  - Representative of the near-term forecasting team (MAFD)
  - 2 representatives of Monetary Policy and Strategy Division (Editor + Fiscal expert)
  - Representative of External Economic Relations Divisions
  - 1 model operator (MAFD)
  - Potentially some other members of the department (training)

Forecasting Process and Its Organisation (i)

- The process ▶
- Departmental forecasting team builds up a macroeconomic forecast as a main support for MP decision
- Provides an unconditional medium term forecast using the model, NTF and own judgment
- Incorporating out-of-model information (fiscal policy, indirect taxes, structural insight etc.)
- The main goal: a macroeconomic story consistent with economic theory, empirical evidence and judgment

Forecasting Process and Its Organisation (ii)

• Issues meeting	W1
• Meeting on forecasting techniques	W2
• **Meeting with the BB** on initial cond. and IT fulfillment	W3
• **Meeting with the BB**: first version of the forecast + alter. Meeting on the final approval of the forecast	W4
• Drafting of the Inflation Report	W5
• **Official** MP BB meeting ⇨ MP decision	W6
• Post mortem meeting	W7

Forecasting Process and Its Organisation (iii)

- Issues Meeting:
  - Collective and intuitive view among the staff where the economy is and what the current economic issues are
  - Designed to address a wide range of questions
  - Broad participation of the staff encouraged
  - Examples

Forecasting Process and Its Organisation (iv)

- <u>Meeting on Forecasting Techniques:</u>
    - Properties of main forecasting tools are reintroduced and re-examined
    - Opportunity to introduce changes and assess their significance
    - Refreshes the staff´s and forecasting team´s familiarity with the techniques
    - Examples (change in the model calibration, extension of the model, etc.)

Forecasting Process and Its Organisation (v)

- Meeting on Initial Conditions and Inflation Forecast Fulfillment
  - Identification of structural shocks ▶
  - Out-of-model information (examples)
  - Is there any significant change in underlying sectoral productivity trends?
  - External assumptions (CF) and their expected impact on the forecast
  - Initial exchange rate scenario for NTF - mix of model consistent UIP and order flow forecast (BoP)
  - Inflation forecast fulfillment
  - Meeting on “Initial Conditions” with the Bank Board
  - Examples

Forecasting Process and Its Organisation (vi)

- 1. Forecast Round:
  - NTF is already incorporated into the model forecast (residuals)
  - The first draft of the forecast introduced
  - Response of management and experts
  - Room for modification or tuning the message of the baseline scenario
  - Discussing the motivation for alternatives
  - Meeting with the Bank Board on alternative scenarios: which risks are to be quantified

Forecasting Process and Its Organisation (vii)

- Final Forecast Round:
  - Approval of the baseline scenario of the forecast
  - Final consistency check and fine-tuning
  - Preparing alternatives and MP experiments

Forecasting Process and Its Organisation (viii)

- Post Mortem Meeting:
  - Opportunity to systematically asses what went wrong and what should be improved (technically vs. in terms of organization of the process)
  - Broad participation of the department is encouraged
  - Efficient tool to transform fresh emotions into immediate measures for the next time
  - Examples

Forecasting Process and Its Organisation (ix)

		2nd SR 2011 and 3rd SR 2011 schedule			Documents	
24-III.	Thu		9:00	2nd Situation Report - Bank Board meeting		
		5P 123	13:00	Issue meeting 3rd Situation Report		
		5P 123	14:00	Meeting: exchange rate near-term forecast, fulfilment of the inflation target		
25-III.	Fri					
28-III.	Mo				16:00	Text distribution: Fulfilment of the inflation target
29-III.	Tu					
30-III.	We	4P 321	13:00	Meeting - techniques of forecast and fulfilment of the inflation target		
31-III.	Thu					
1-IV.	Fri					
4-IV.	Mo	4P 321	13:00	Presentation - Near Term Forecast (412 dep.)		
5-IV.	Tu					
6-IV.	We	4P 321	13:00	Initial conditions meeting		
7-IV.	Thu	4P 321	15:30	Meeting: Boxes and annexes for 3rd SR / II.Inflation Report		
8-IV.	Fri		*10:00*	*Consensus Forecasts*	12:00	Documents for Bank Board: Initial conditions, Fulfilment of the inflation target, external scenarios
11-IV.	Mo		*9:00*	*Inflation (march 2011)*		
		2P 318	14:00	Initial meeting with Bank Board: Initial conditions, Fulfilment of the inflation target, external scenarios		
12-IV.	Tu					
13-IV.	We	4P 321	14:00	1st version of forecast, breefing with NTF team and BoP experts		
14-IV.	Thu					
15-IV.	Fri		*9:00*	*Foreign trade prices (February 2011)*		
			13:00	Second exchange rate near-term forecast meeting	12:00	Documents for Bank Board: choice of atlternantives and sensitivity scenarios
18-IV.	Mo	2P 318	14:00	Meeting with Bank Board - choice of atlternantives and sensitivity scenarios	16:00	Final text. II.1 to editors
19-IV.	Tu					
20-IV.	We	4P 321	13:00	Forecast approval	16:00	Final boxes and annexes to editors
					16:00	Final text. III to editors
21-IV.	Thu				16:00	Final text. II.2 to editors
22-IV.	Fri				15:00	Final text. II.3 anf II.4 to editors
					15:00	Distribution chapter III. in M&S dept.
25-IV.	Mo					
26-IV.	Tu	4P 321	8:30	Discussion in M&S dept.: Chapter III.	15:00	Distribution chapter I II.1–3 a II.5 in M&S dept.
27-IV.	We	4P 321	8:30	Discussion in M&S dept.: Chapter II.1–3 a II.5	15:00	Distribution chapter I. a II.4 in M&S dept.
28-IV.	Thu	4P 321	8:30	Discussion in M&S dept.: Chapter I. and II.4	17:00	3rd Situation Report delivery to M&S dept. director
29-IV.	Fri				13:00	3rd Situation Report delivery to Bank Board (9:00 in M&S dept.)
2-V.	Mo					
3-V.	Tu	4P 320	10:30	M&S dept. Directors meeting - Monetary Policy Recomendation		
4-V.	We	2P 318	14:00	Macrofinancial panel		
5-V.	Thu			3. Situation Report - Bank Board meeting		
6-V.	Fri		*9:00*	*ILO emloyment and unemployment (1.Q 2011)*		

Conclusion

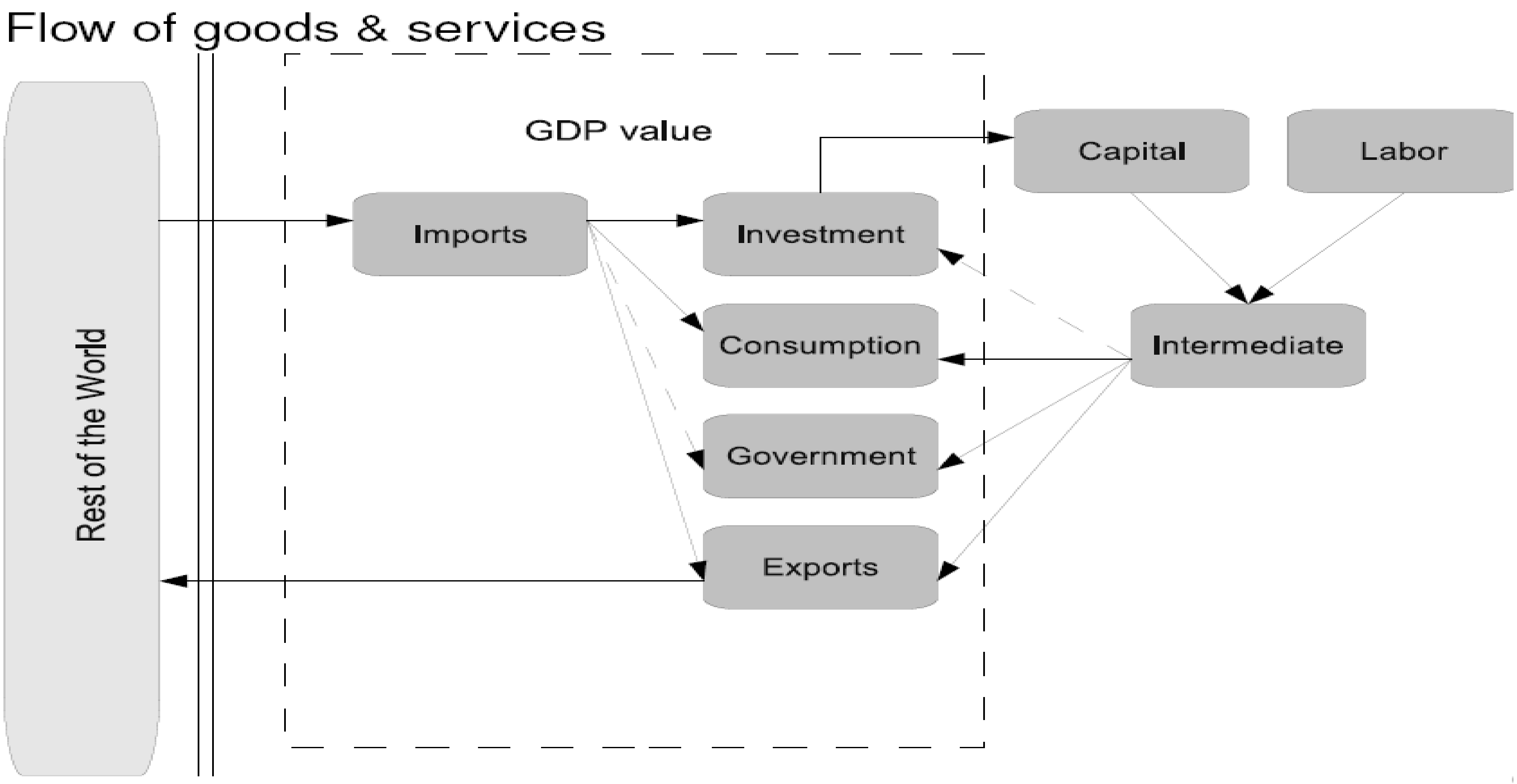
- Structured debate about risks and policy issues enabled due to common language
- Forecast with active MP (includes rates trajectory consistent with forecast)
- Involvement of MSD resources but manageable discussion: FT
- Consistently incorporated judgment
- Real time pressures well tackled due to automatisation
- Story-centered discussion
- High level of transparency

Thank you for your attention !

Tibor.Hledik@cnb.cz

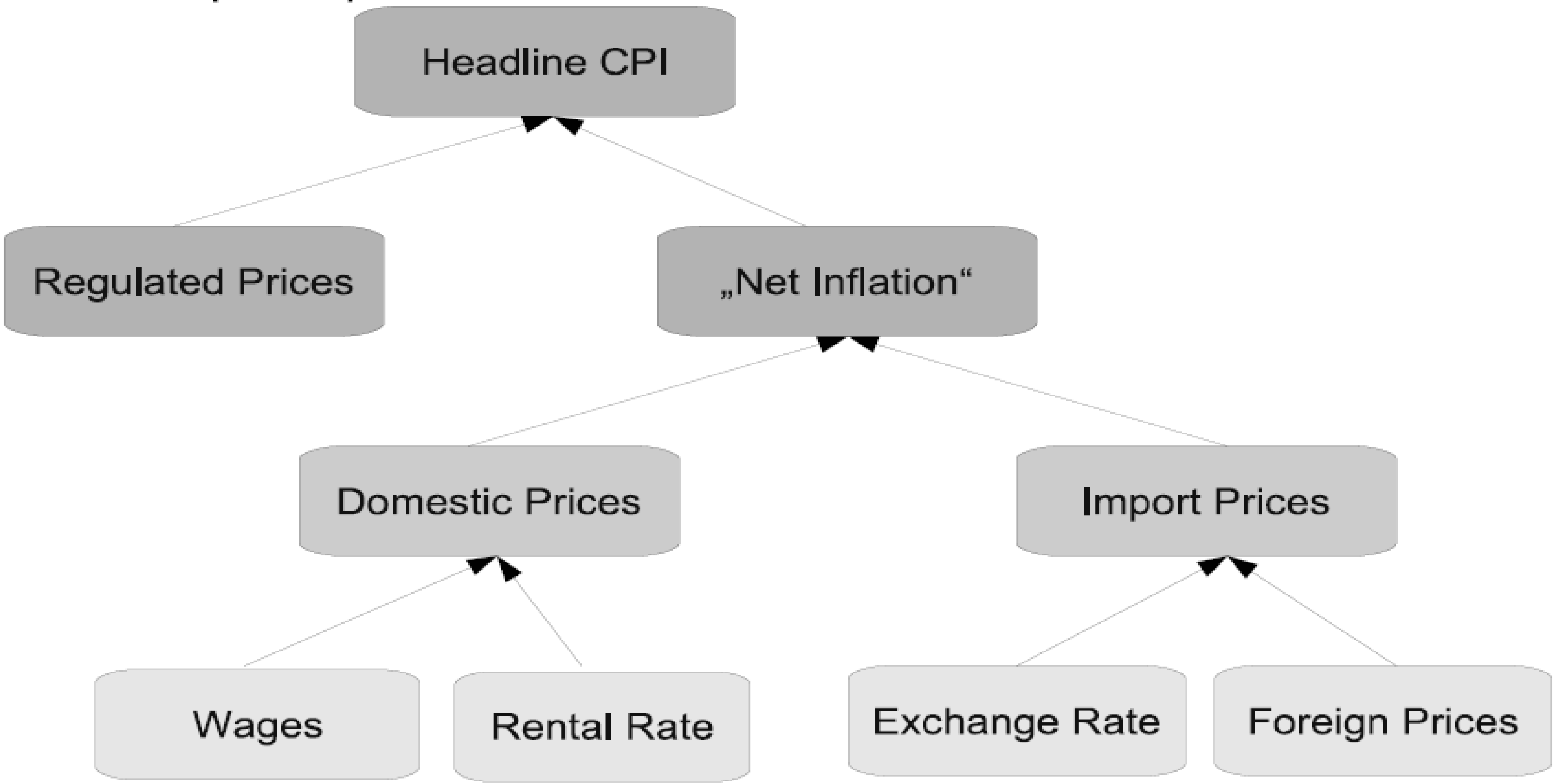
Backup slides

Production structure – g3

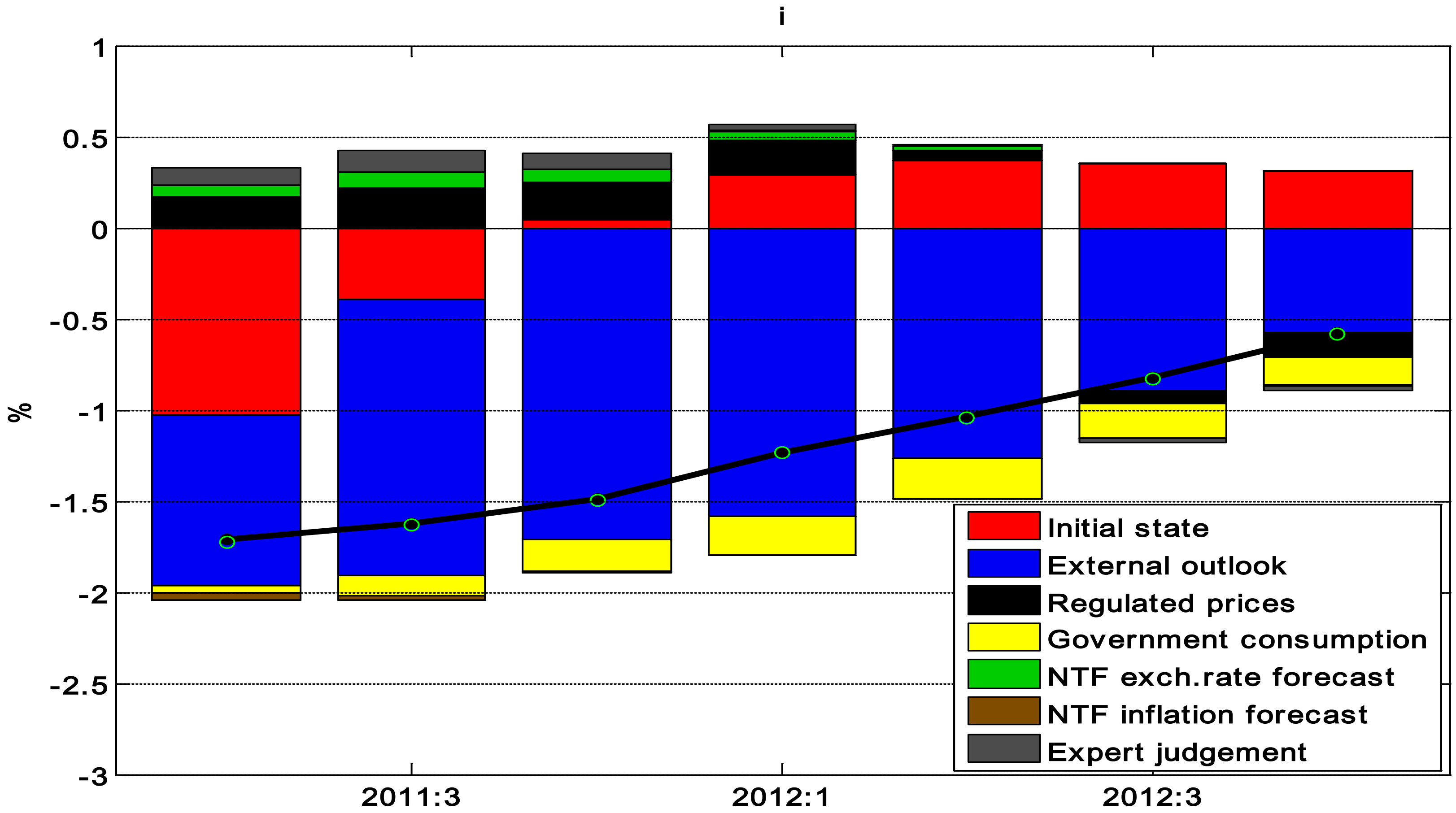


Price structure – g3

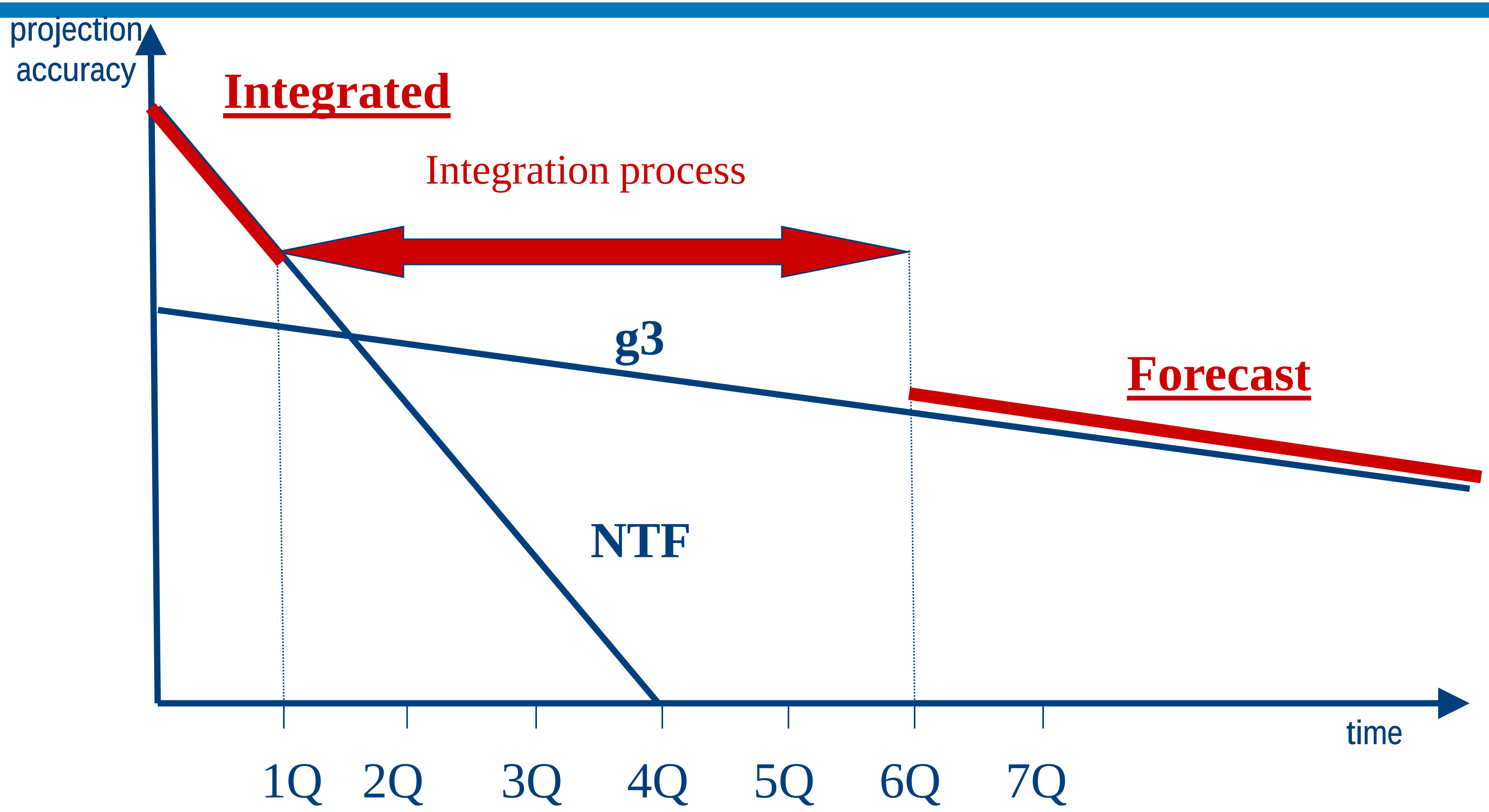
Consumption prices – cost structure



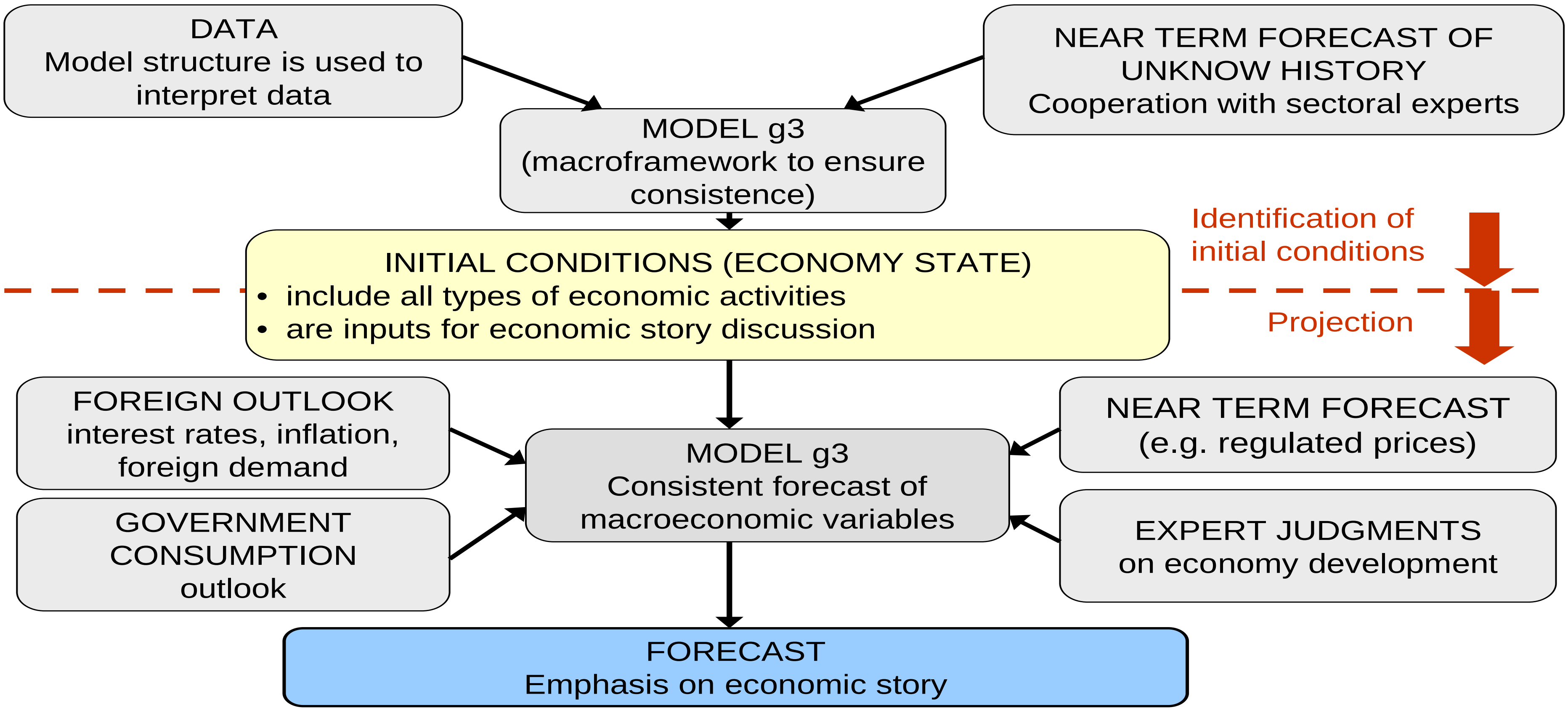
Identification of structural shocks



The forecasting process (i)

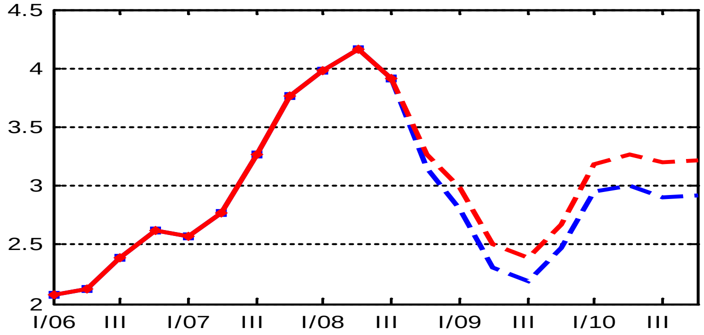


The forecasting process (ii)

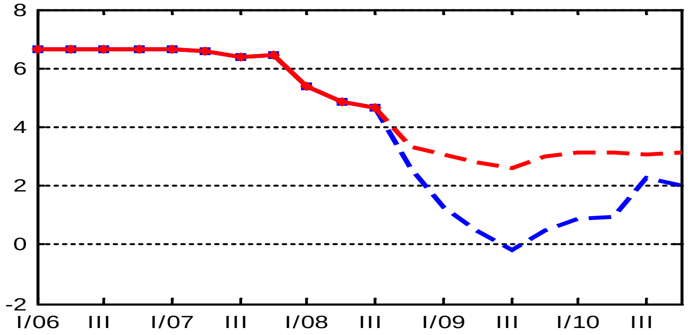


Sensitivity to foreign demand assumption

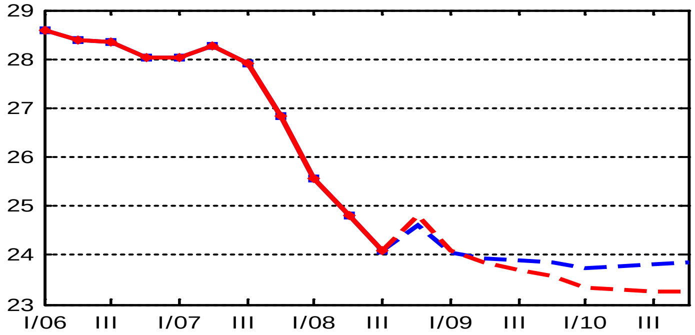
PRIBOR 3M (%, p.a.)



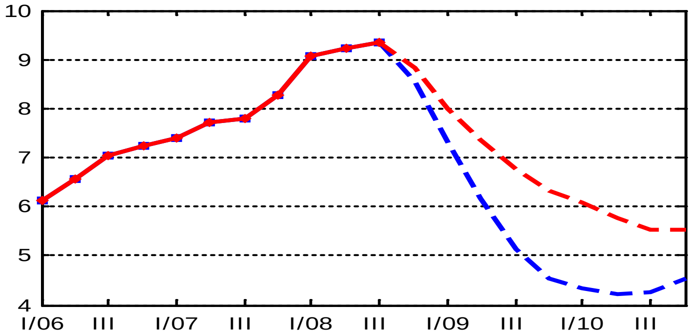
Real GDP growth (y-o-y, %)



Nominal exchange rate (CZK/EUR)

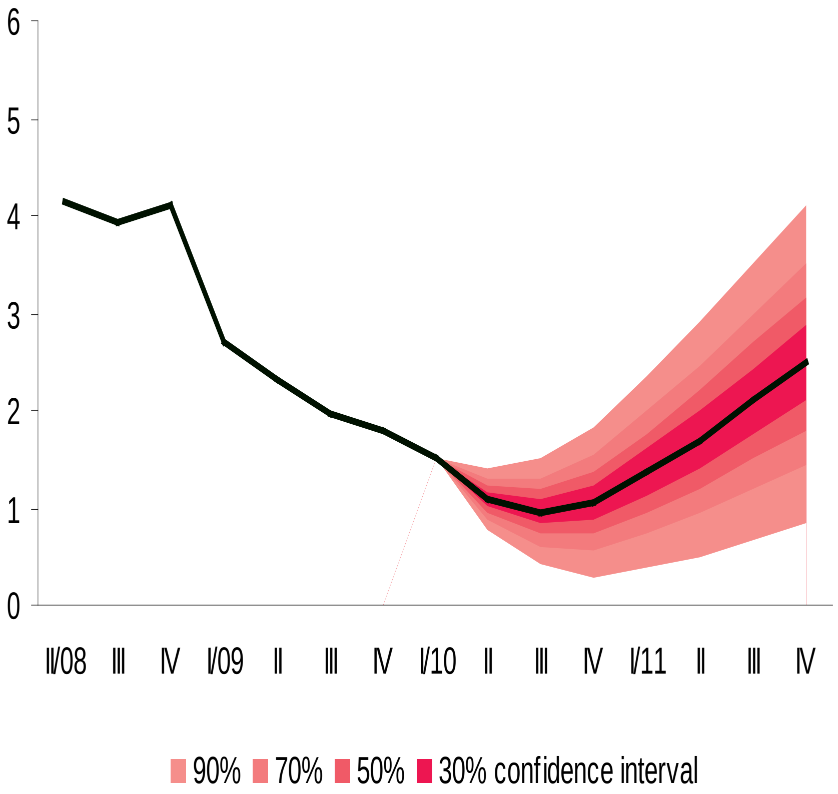


Nominal wages growth (y-o-y, %)

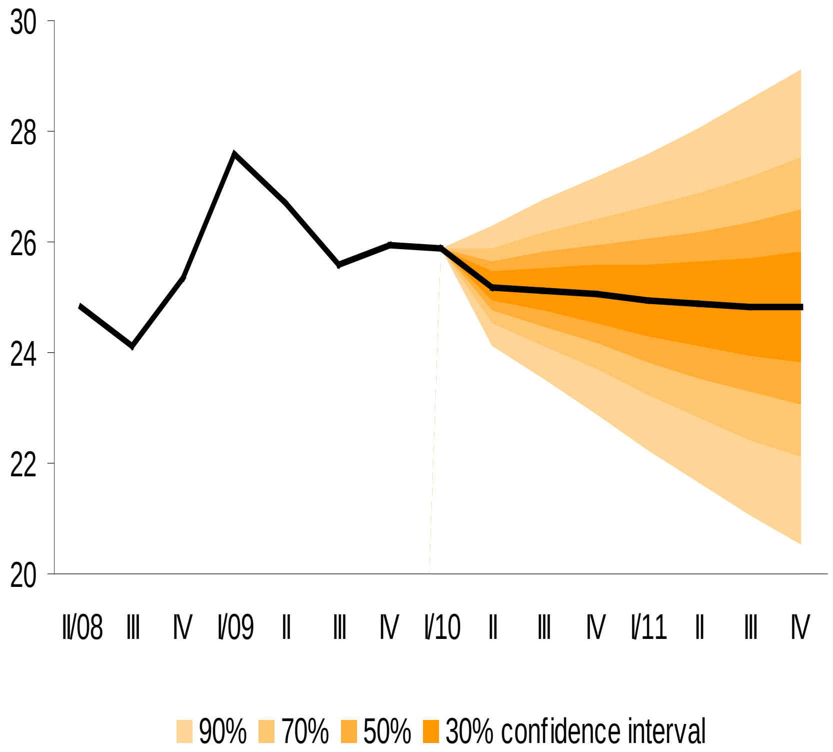


Endogenous interest- and exchange rates

3M PRIBOR forecast

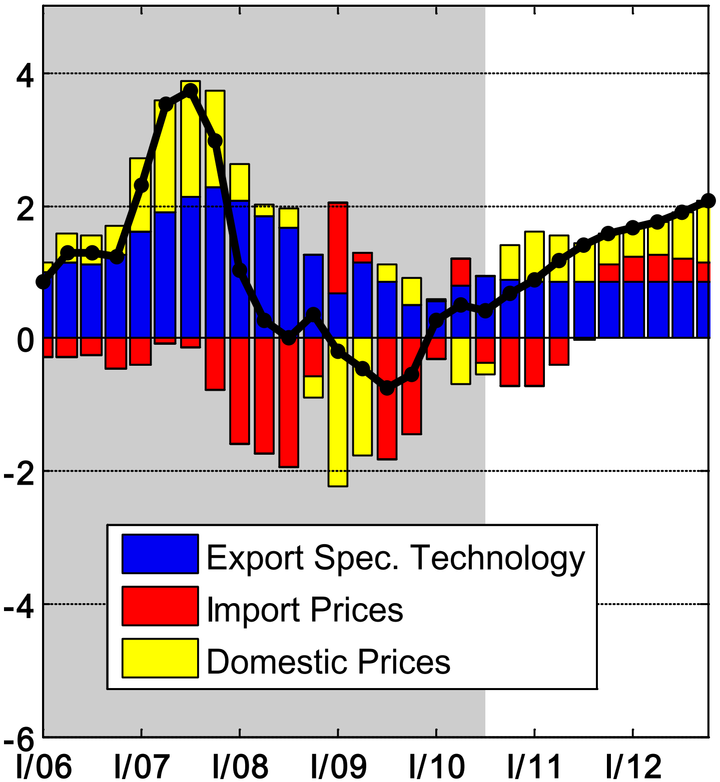


Exchange rate forecast

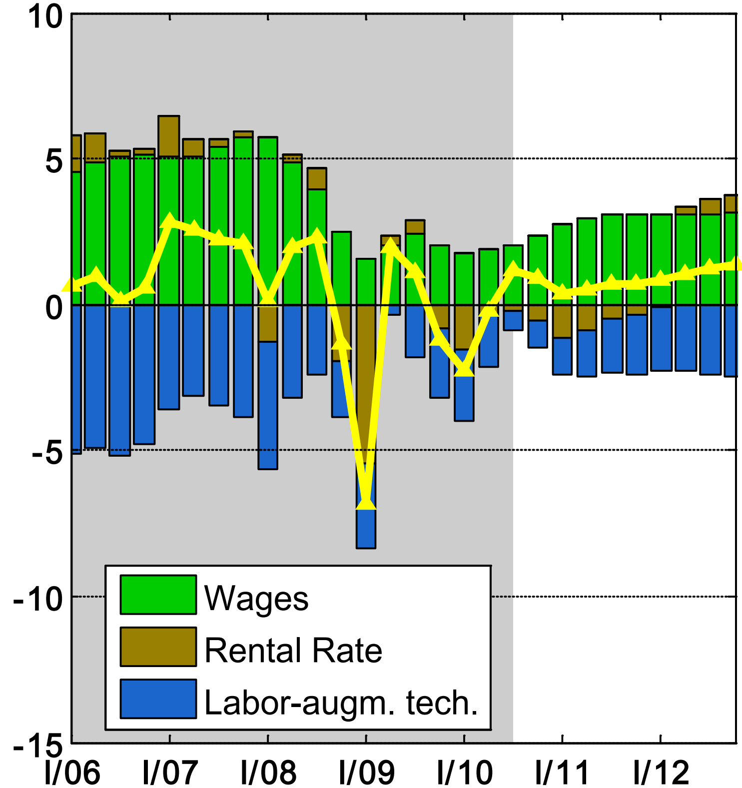


Identification of structural shocks – initial conditions

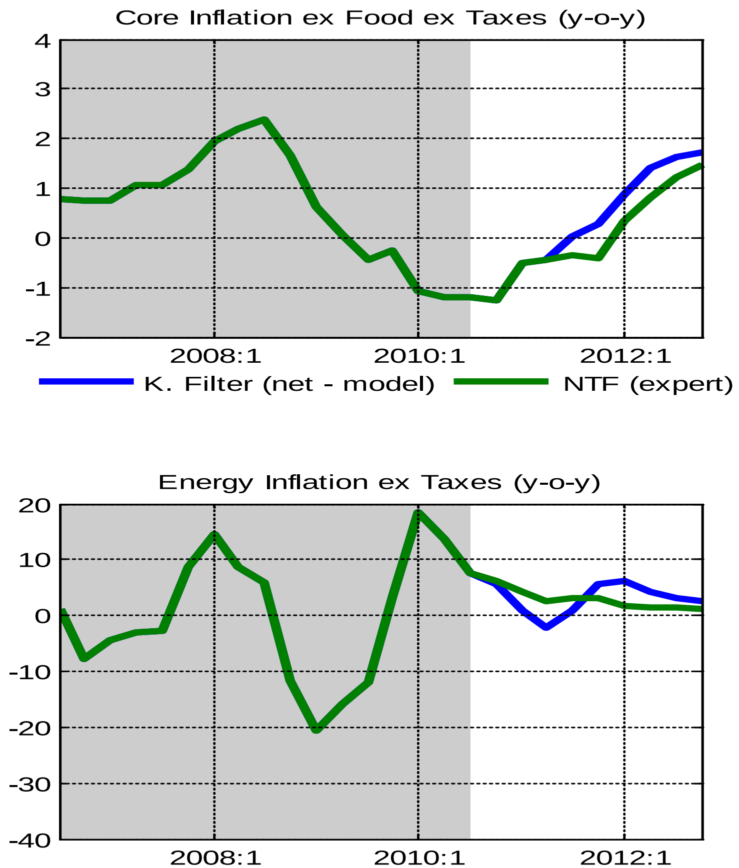
Nominal Marginal Cost in Consumption Sector
(q/q, in %, ann.)



Nominal Marginal Cost in Domestic Sector
(q/q, in %, ann.)

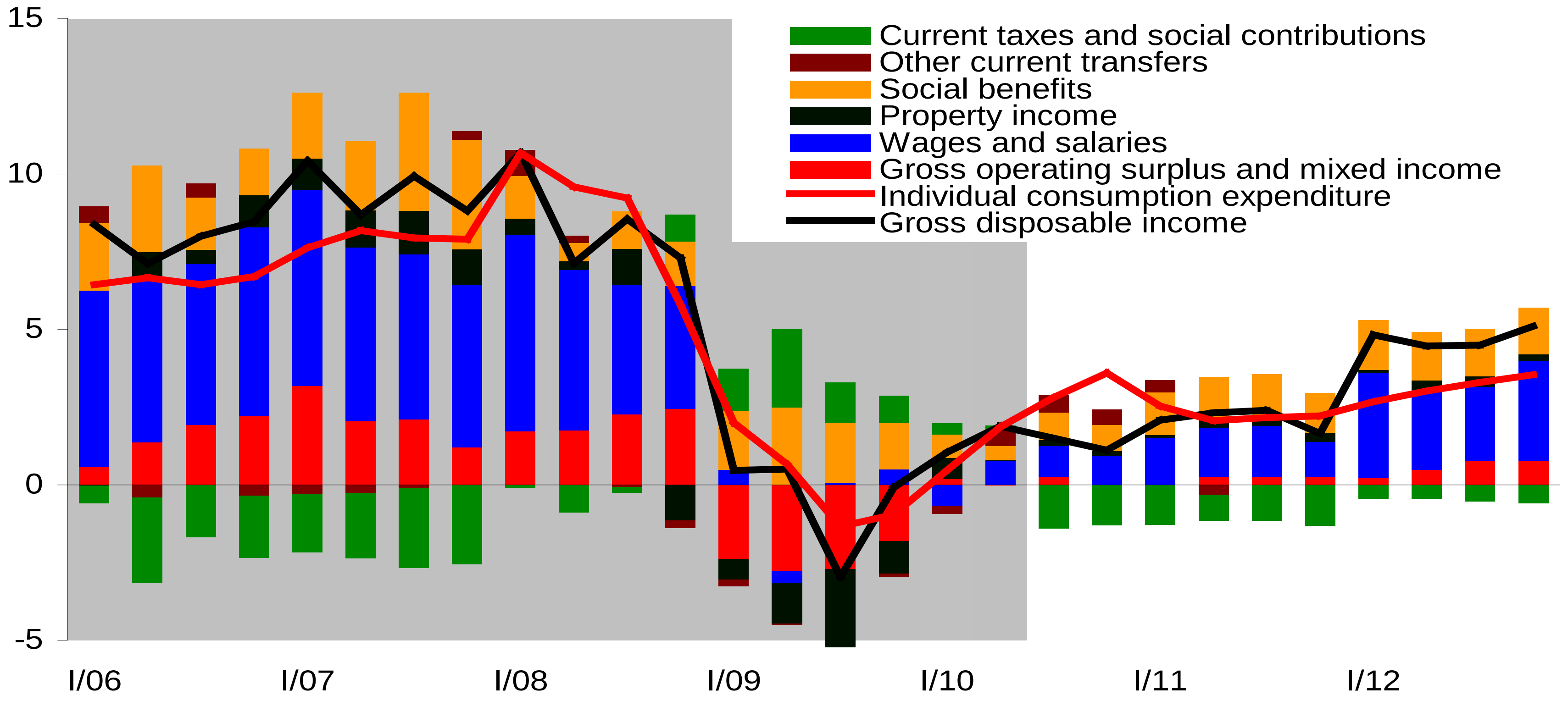


Decomposition tools

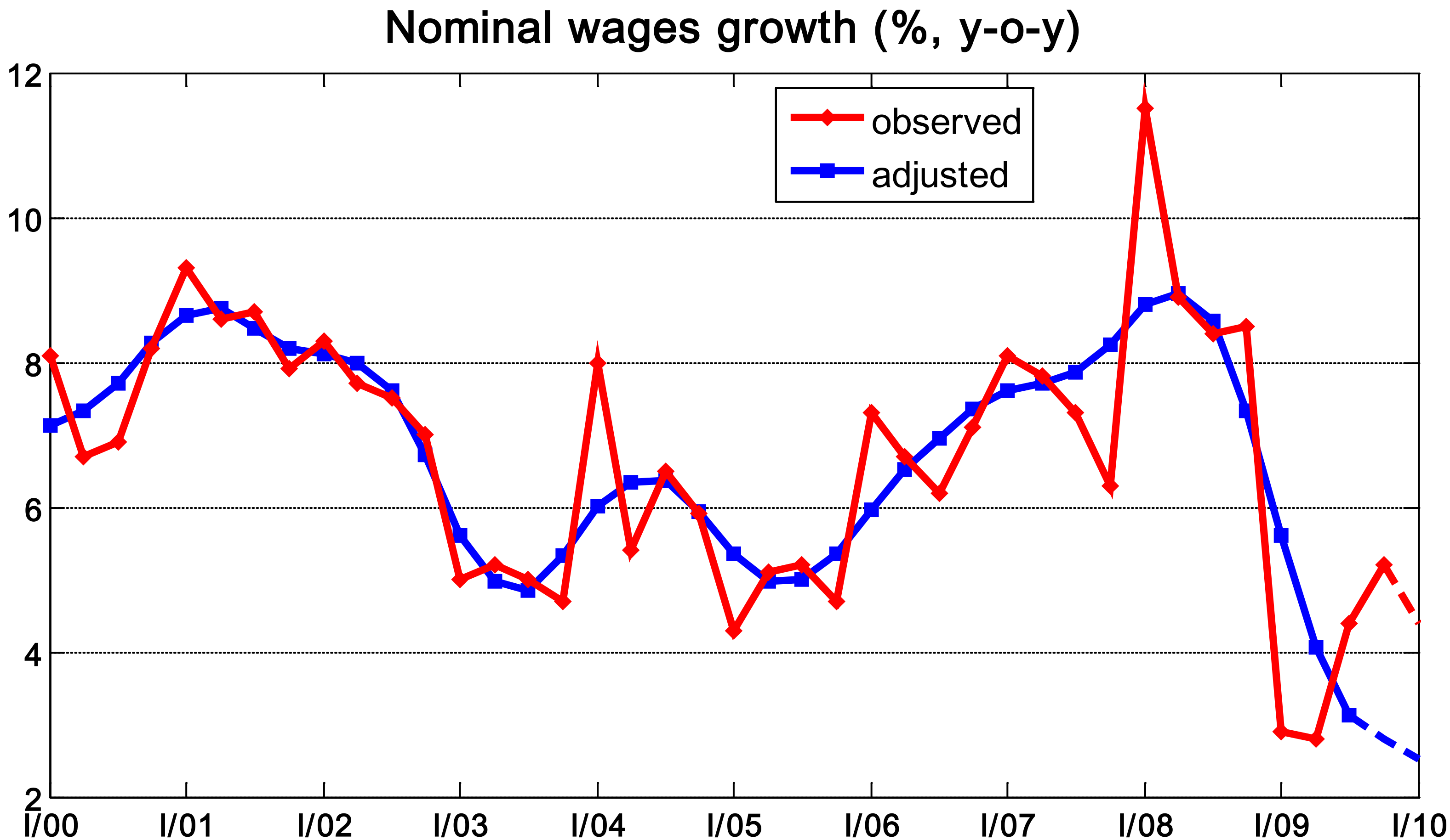


The structure of nominal disposable income

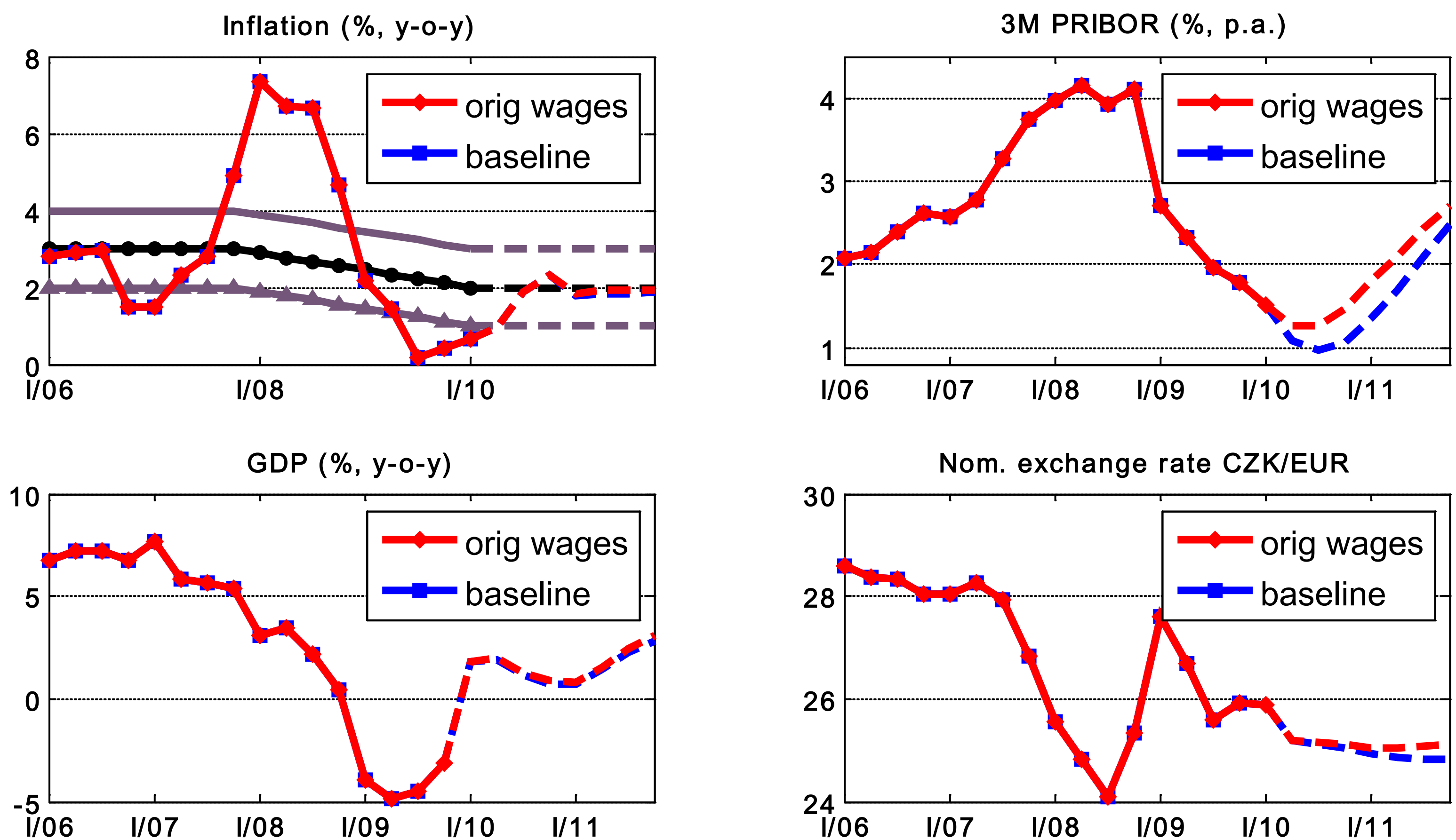
Gross disposable income
(annual percentage changes; contributions in percentage points)



The analysis of nominal wage growth (i)



The analysis of nominal wage growth (ii)



The Transmission Mechanism of Monetary Policy

Macroeconomic Forecasting Division
Monetary and Statistics Department

Tibor Hlédik

Masaryk University

Brno

27 September, 2011

evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Outline

- The monetary transmission mechanism (MTM)
- Various channels of the MTM
- The simultaneity problem
- MTM in a model of a small closed economy MTM in a model of a small open economy with floating exchange rate regime
- MTM in a model of a small open economy with a fixed exchange rate regime
- Conclusions

The Monetary Transmission Mechanism

Definition promoted by J. Taylor (1995):

„…*the process through which monetary policy decisions are transmitted into changes in real GDP and inflation*“

Source: „The Monetary Transmission Mechanism: An Empirical Framework“, Journal of Economic Perspectives 9, 11-26

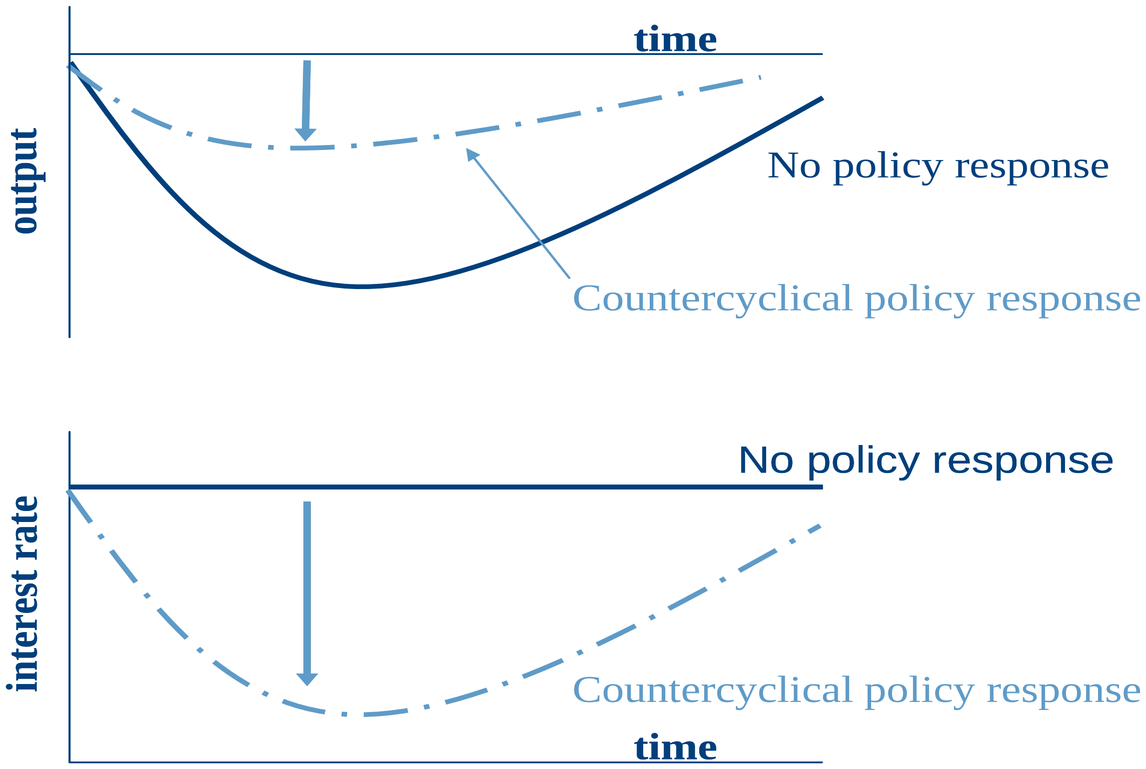
Various Channels of the MTM

- The Interest Rate Channel
- The Exchange Rate Channel
- Expectational Channel
- The Credit Channel

The Simultaneity Problem

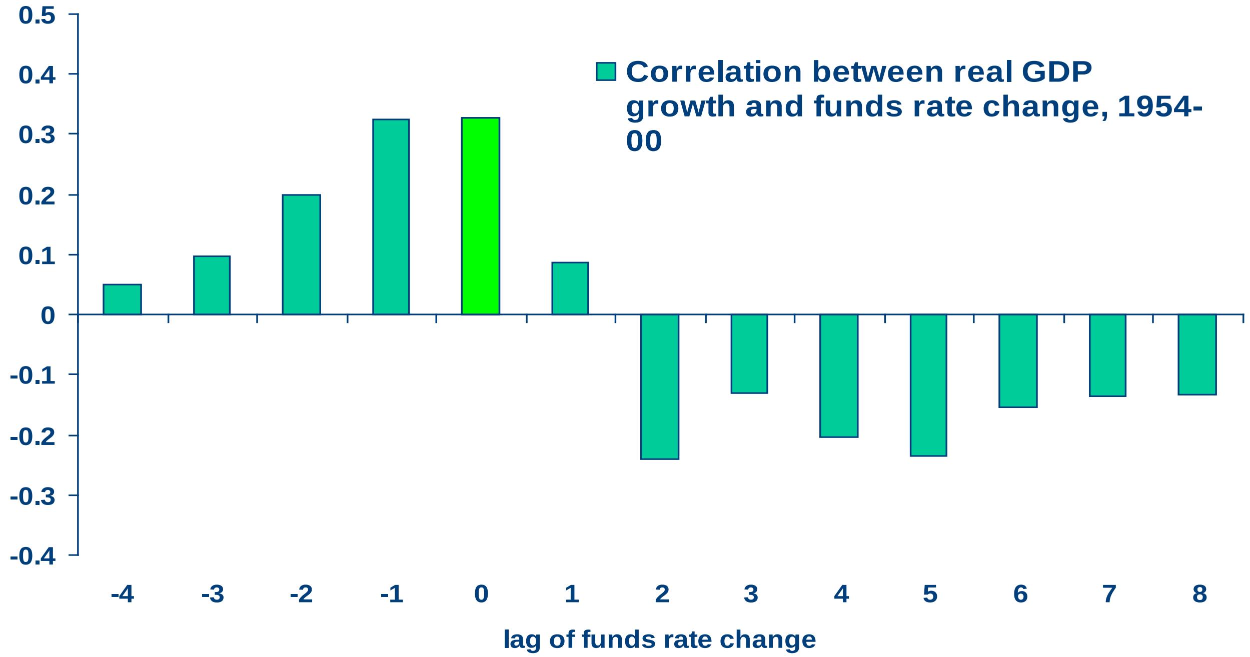
- *Simultaneity*: the endogenous response of policy to the economy makes it hard to measure policy's effects.
- Because various transmission channels operate at the same time, it is hard to isolate the effect of any particular channel.
- The simultaneity problem in theory and practice
- Estimation versus calibration

The Simultaneity Problem in Theory



With countercyclical policy, the interest rate and output both fall.

The Simultaneity Problem in Practice



- The contemporaneous correlation between real GDP growth and funds rate change is *positive*.
- Are rate hikes therefore *expansionary*?

MTM in a Model of a Small Closed Economy

A simple three-equation model:

IS-Curve:

y_gap=0.8*y_gap(-1)-0.15*r_gap;

where: r_gap=i-pi(+1)-r_eq

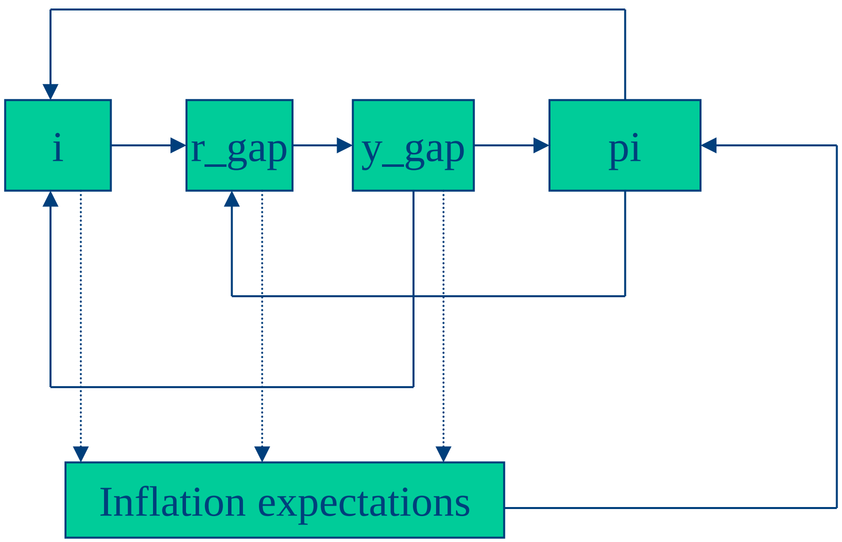
Phillips-Curve:

pi=0.5*pi(+1)+(1-0.5)*pi(-1)+0.2*y_gap;

The Policy Rule (Taylor-Rule)

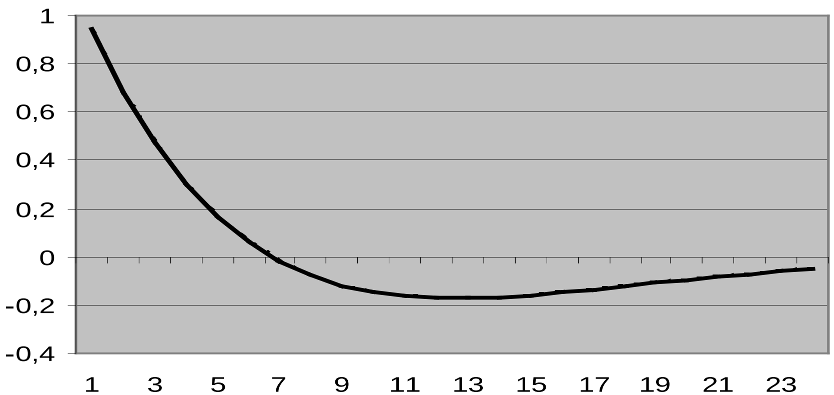
i=i_eq+1.5*(pi-pi_tar)+0.5*y_gap;

The Transmission Mechanism in a Closed Economy

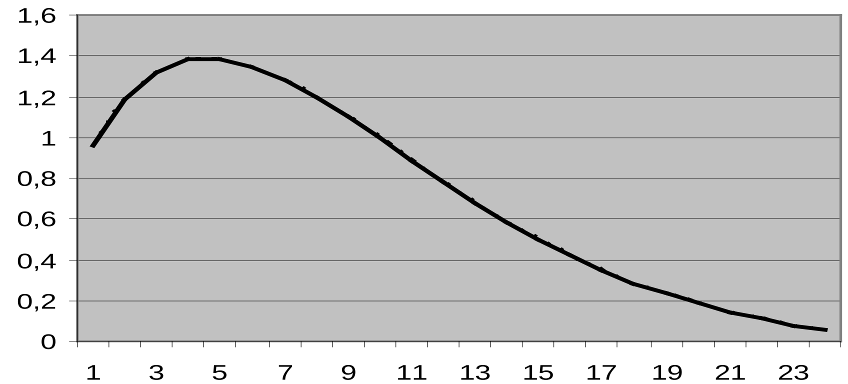


Demand Shock in a Closed Economy

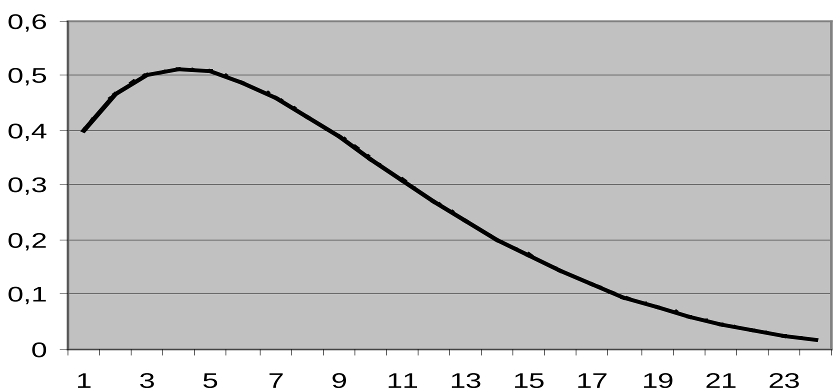
Output



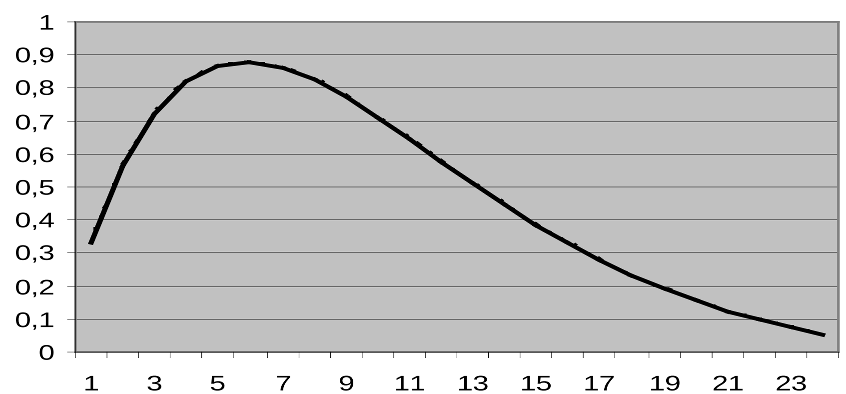
Nominal Interest Rate



Real Interest Rate

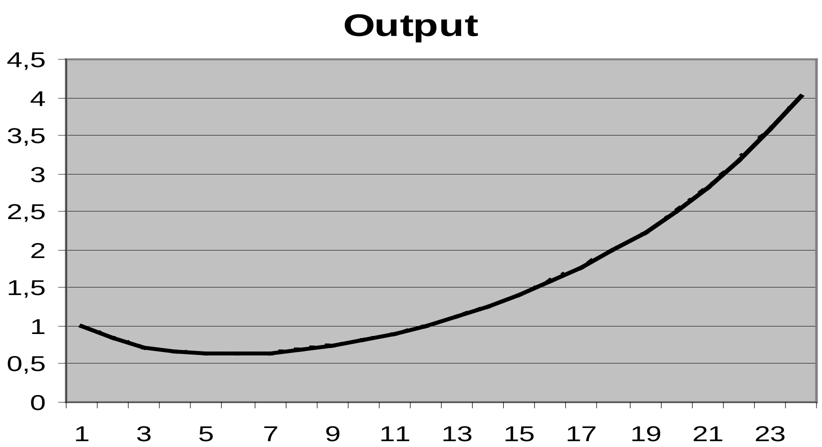


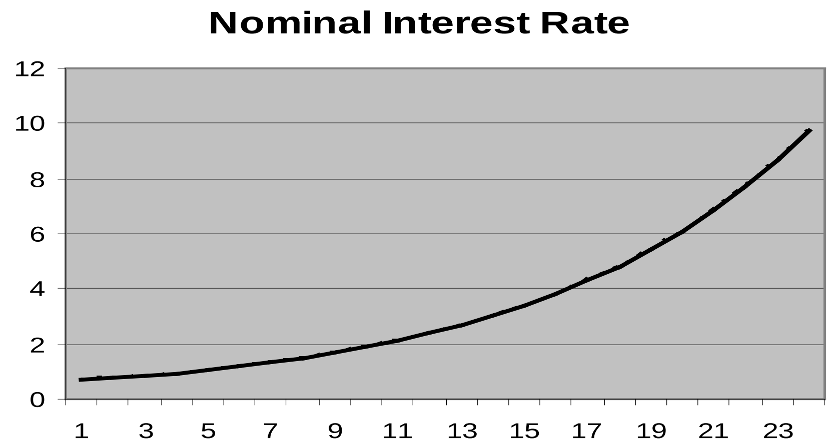
Domestic Inflation

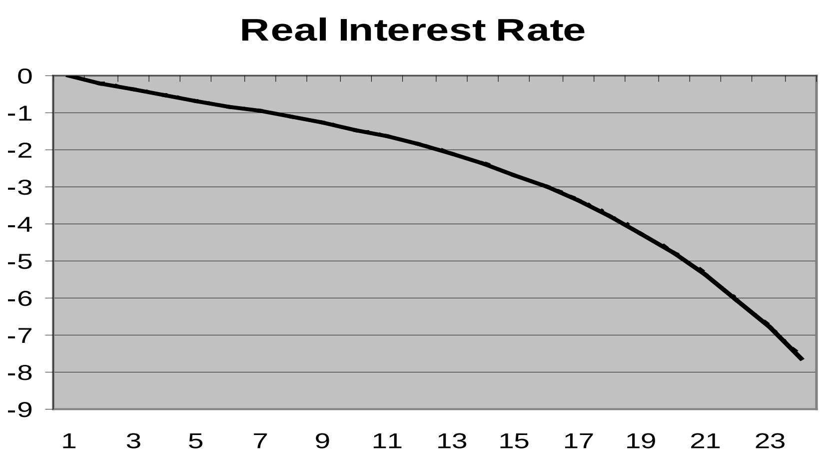


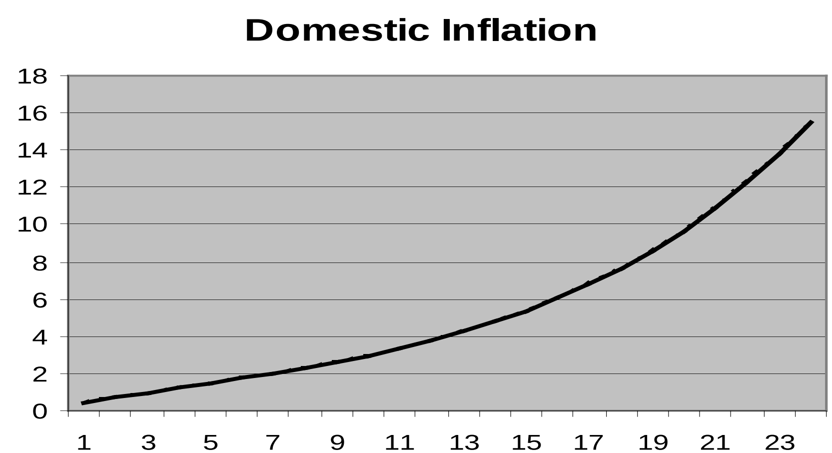
The Stabilizing Role for Monetary Policy

Change in the Policy Rule









MTM in a Model of a Small Open Economy

IS-Curve:

y_gap=0.8y_gap(-1)-0.15r_gap+0.1q_gap;

where: r_gap=i-pi4_cpi-r_eq

q_gap=q-q_eq

Phillips-Curve:

pi_d=0.25*pi_d(+1)+(1-0.25)*pi_d(-1) +0.2*y_gap;

pi_cpi=0.8*pi_d+(1-0.8)*(e-e(-1))

UIP + Real Exchange Rate:

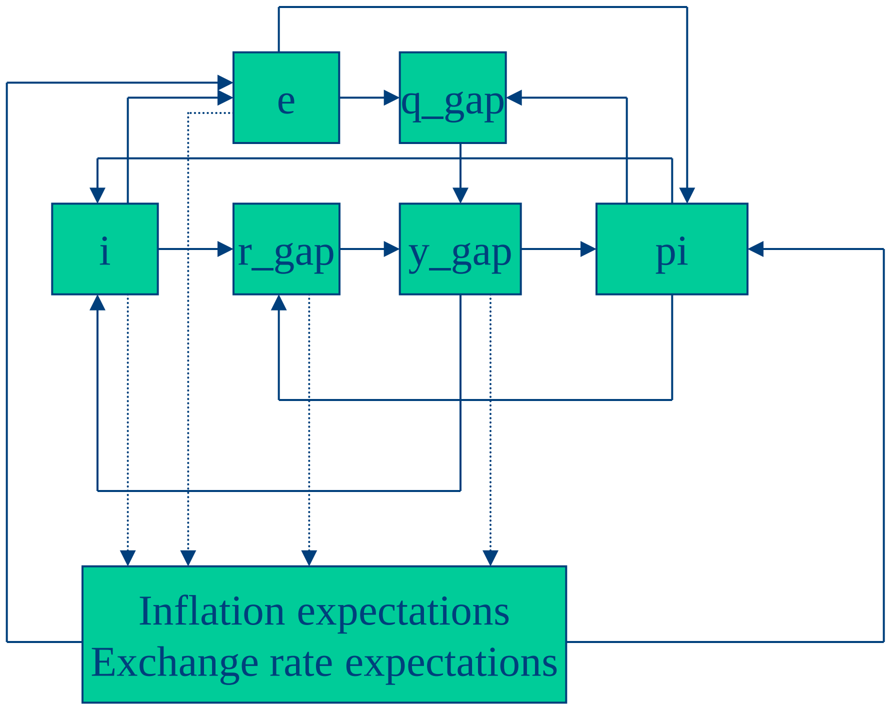
e=0.6*e(+1)+(1-0.6)*e(-1)-(i-i*)/4

q=e-p_d where p_d=pi_d+p_d(-1)

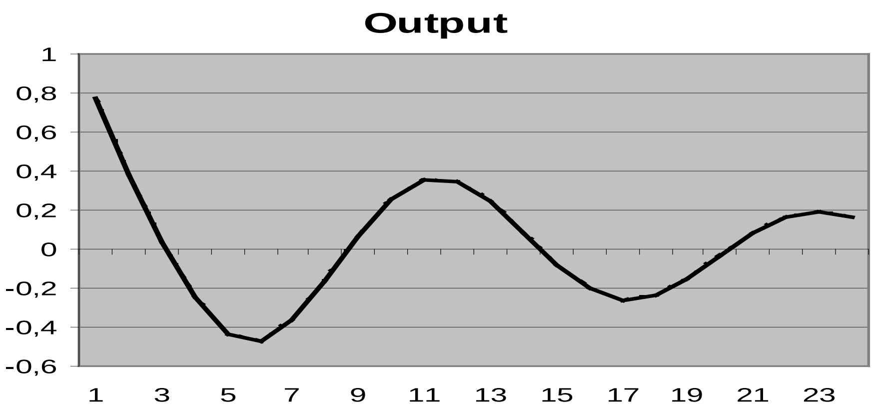
The Policy Rule (Taylor-Rule)

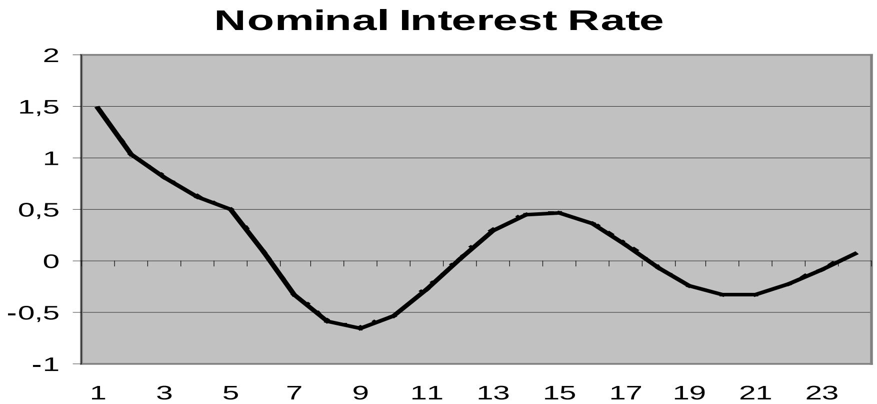
i=i_eq+1.5*(pi4_cpi-pi_tar)+0.5*y_gap;

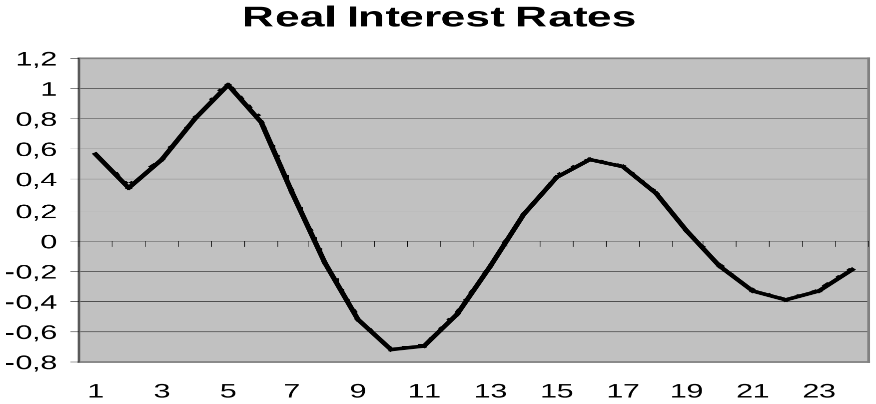
The Transmission Mechanism in an Open Economy

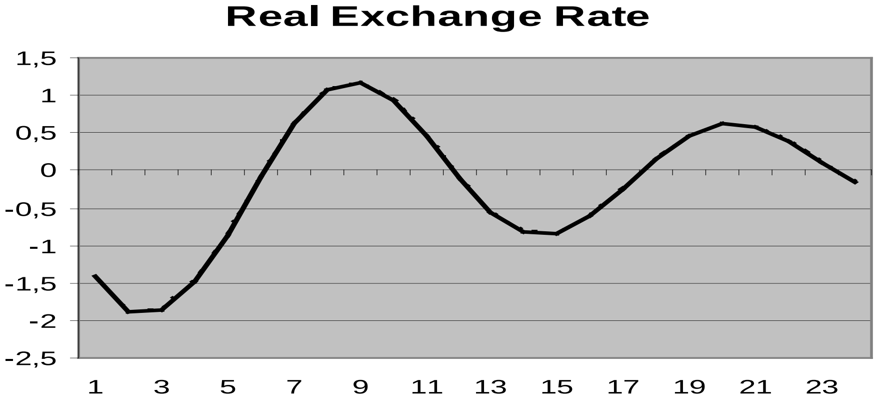


Demand Shock in an Open Economy (I.)

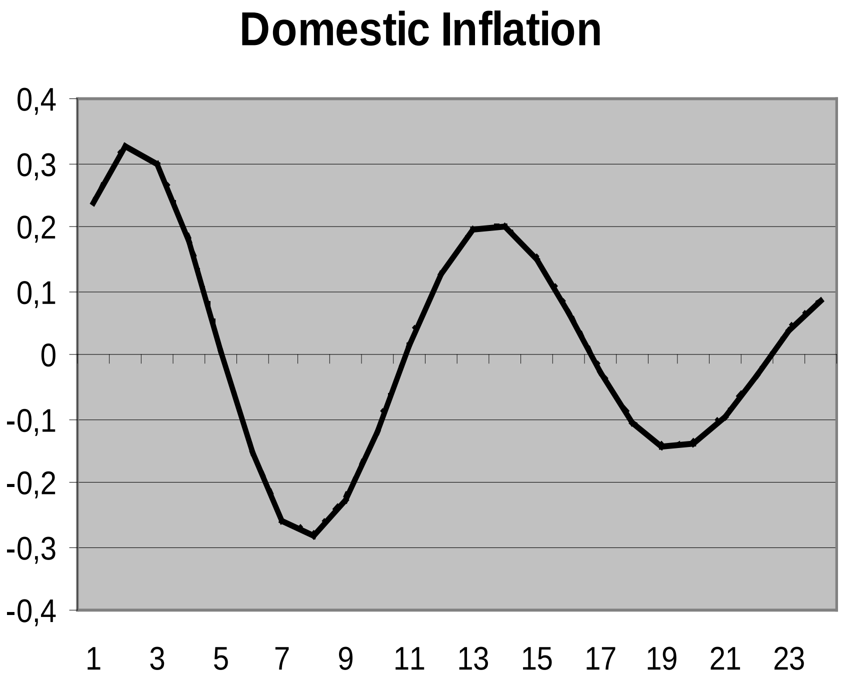


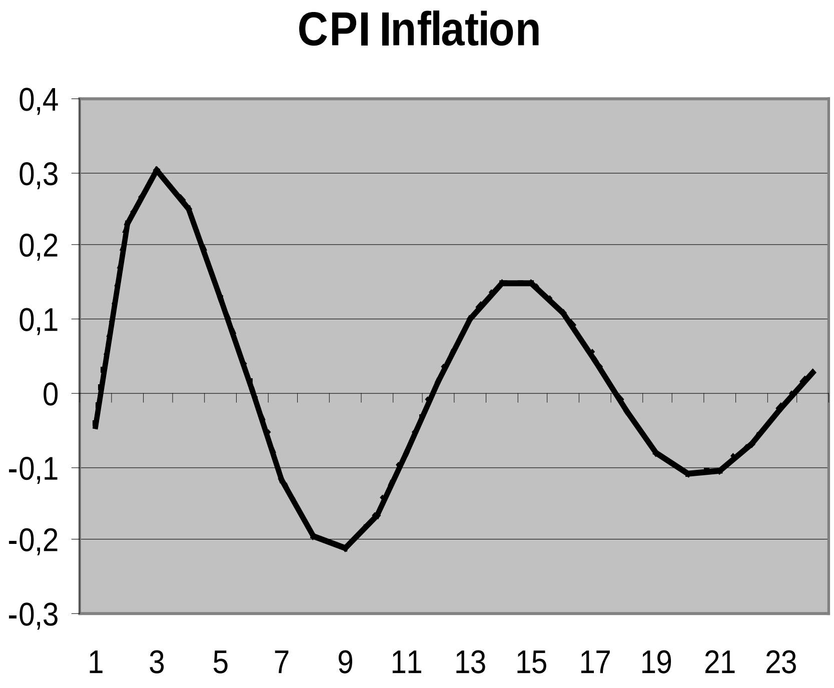






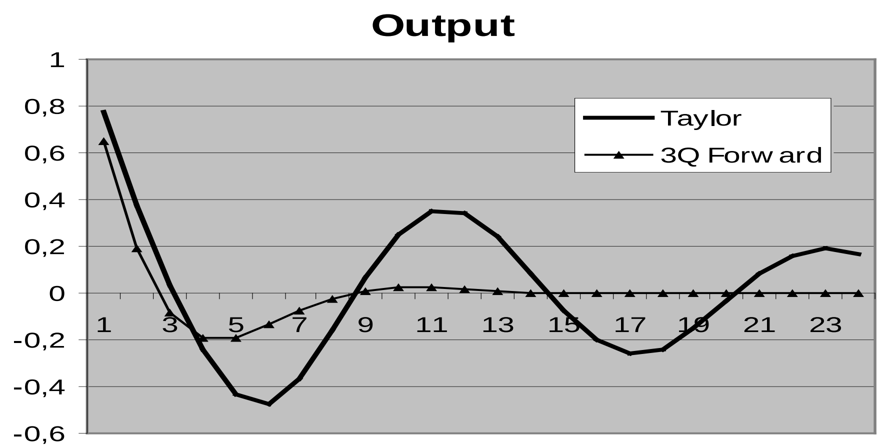
Demand Shock in an Open Economy (II.)

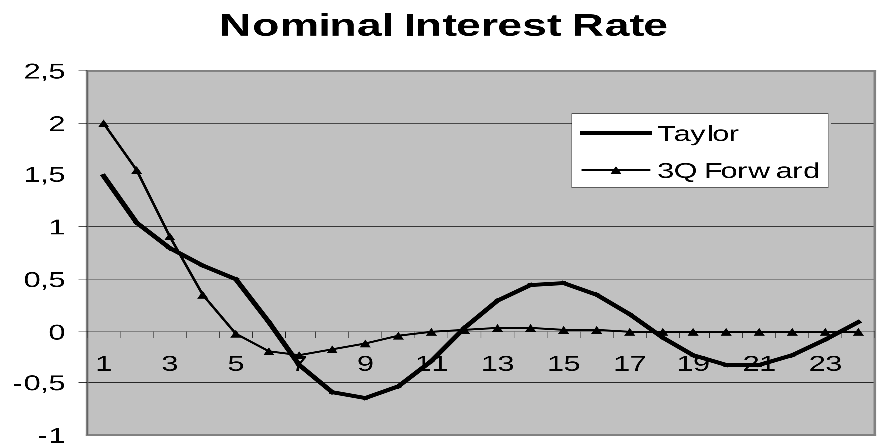


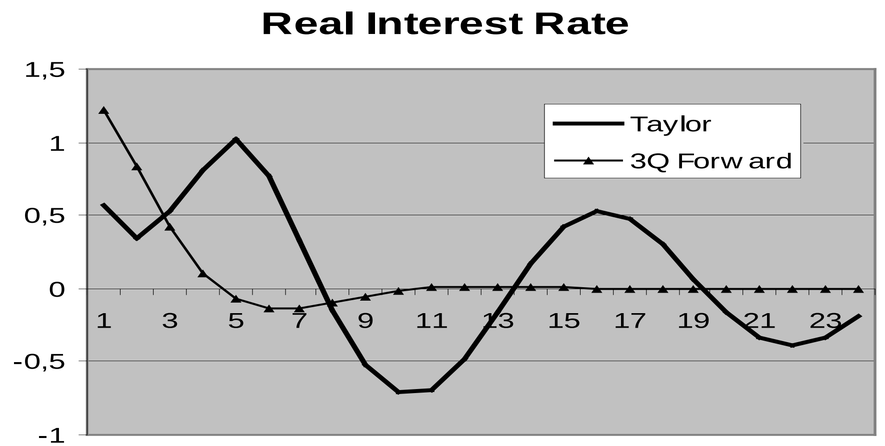


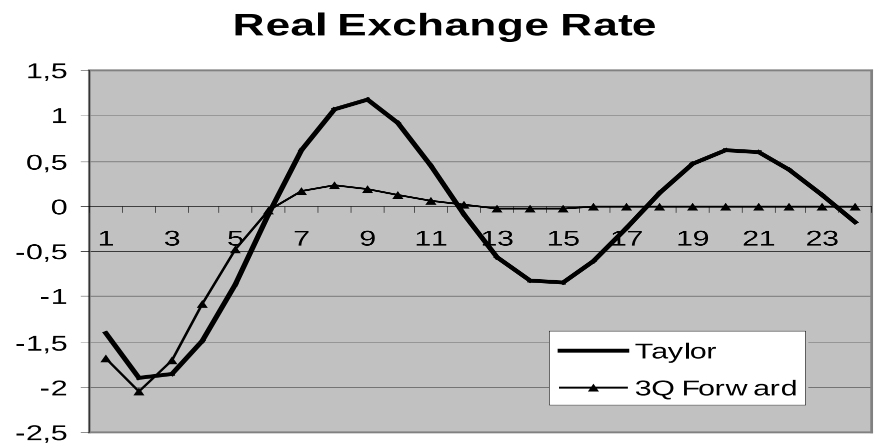
The Stabilizing Role for Monetary Policy I.

The Case for a Forward-Looking (3Q) Policy Reaction



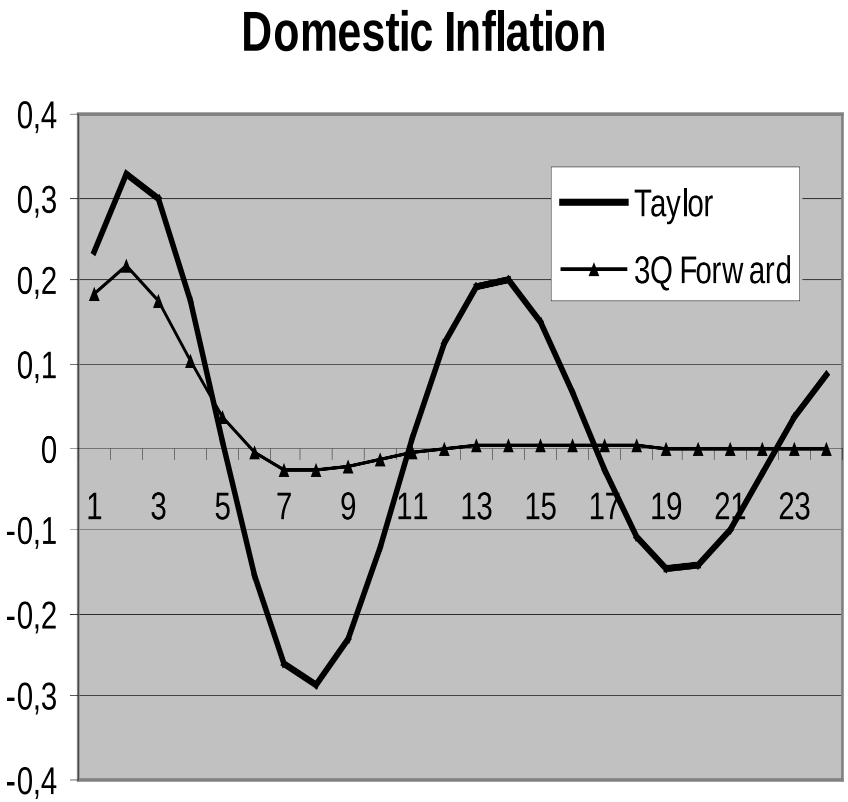


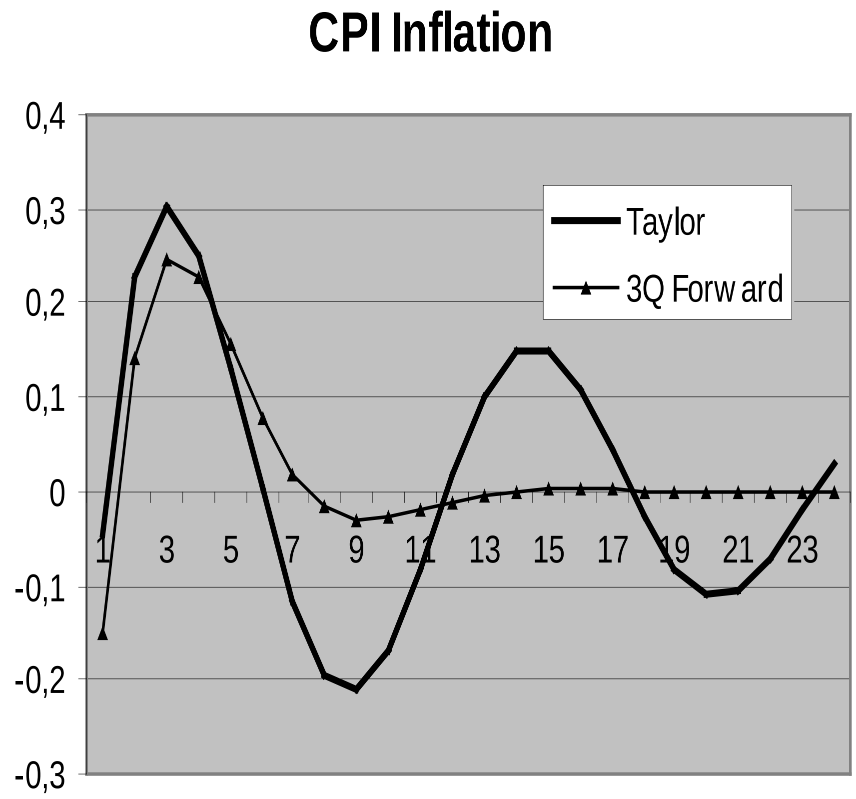




The Stabilizing Role for Monetary Policy II.

The Case for a Forward-Looking (3Q) Policy Reaction





MTM in a Model of a Small Open Economy With Fixed Exchange Rate

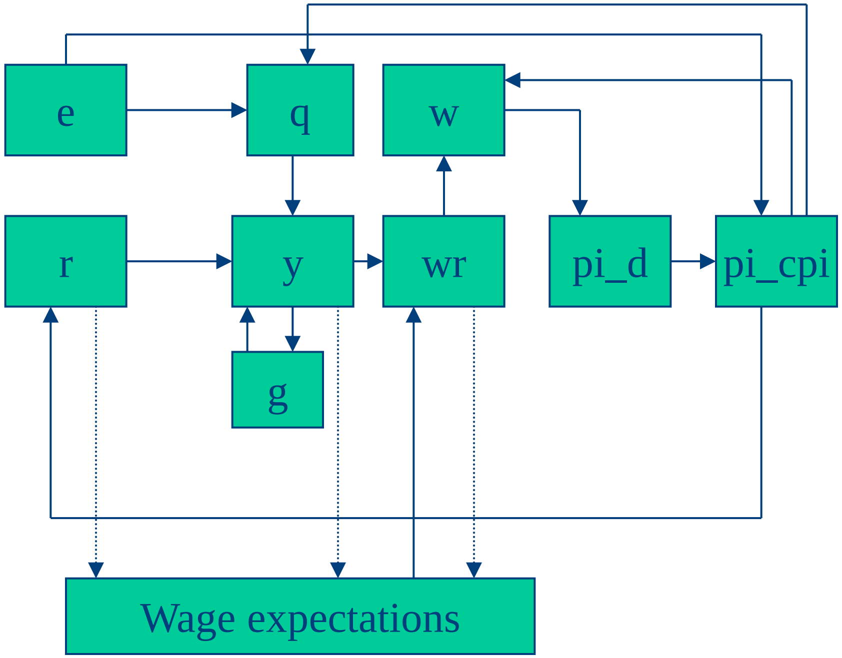
IS-Curve:
y=0.8*y(-1)-0.1*r(-2)+0.2*q+g;
g=0.5*g(-1)-0.08*y(-1);
wr=0.2*wr(+1)+(1-0.2)*wr(-1)+0.15*y_gap(-1);
w=wr+p_cpi;
p_d=0.5*w+(1-0.5)*w(-1);
pi_d=p_d-p_d(-1);

Phillips-Curve:
pi_cpi=0.7*pi_d+(1-0.7)*(e-e(-1))

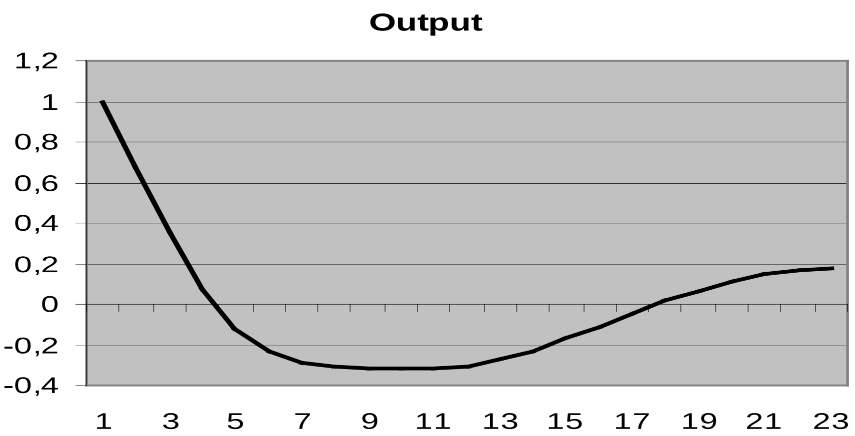
Exchange Rate:
e=e_tar   or e=0.5*e(+1)+0.5*e(-1)-i/4
q-q(-1)=e-e(-1)+pi_d*-pi_d

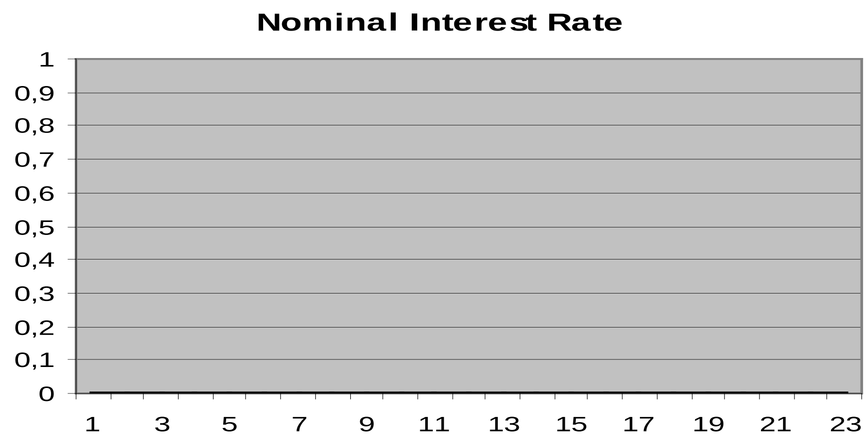
The Policy Rule (Taylor-Rule)
i=i*+prem or i=1.5*pi4_cpi(+4)+0.5*y;
r=i-pi4_cpi;

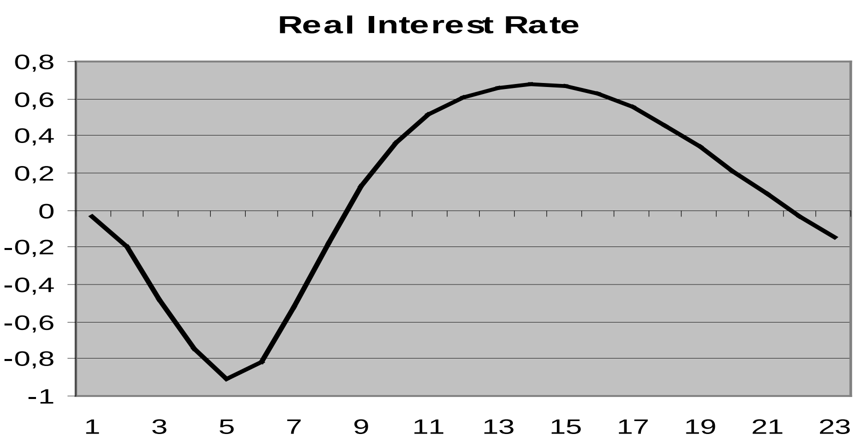
The Transmission Mechanism in a Fixed Exchange Rate Regime

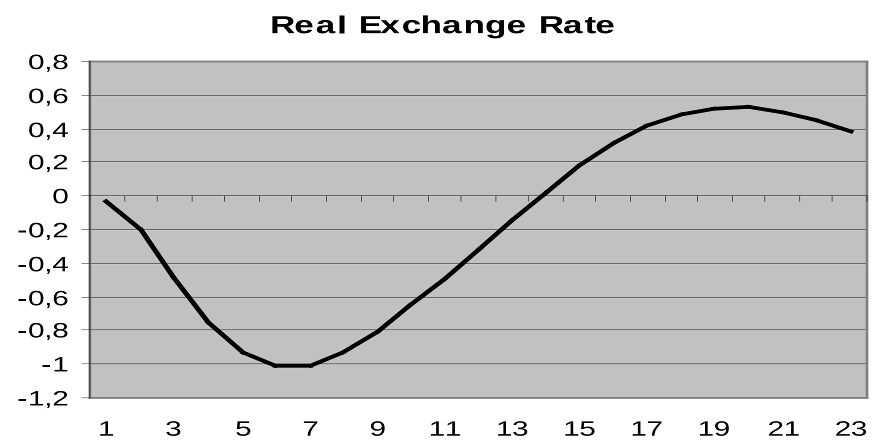


Demand Shock in a Fixed Exchange Rate Regime (I.)

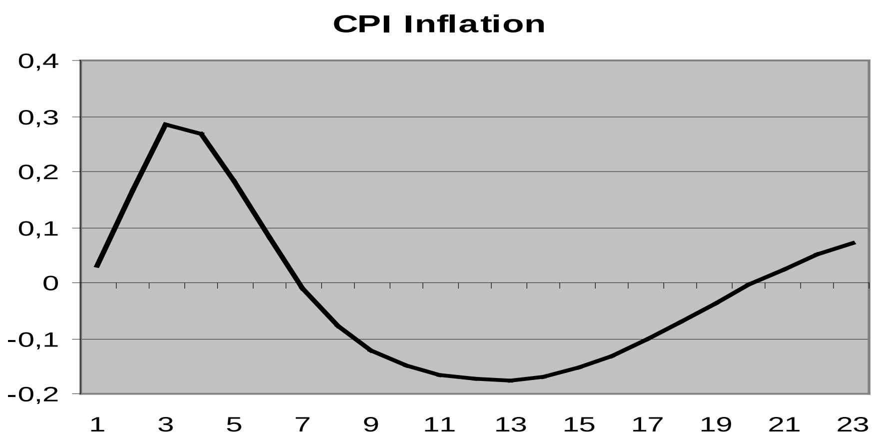


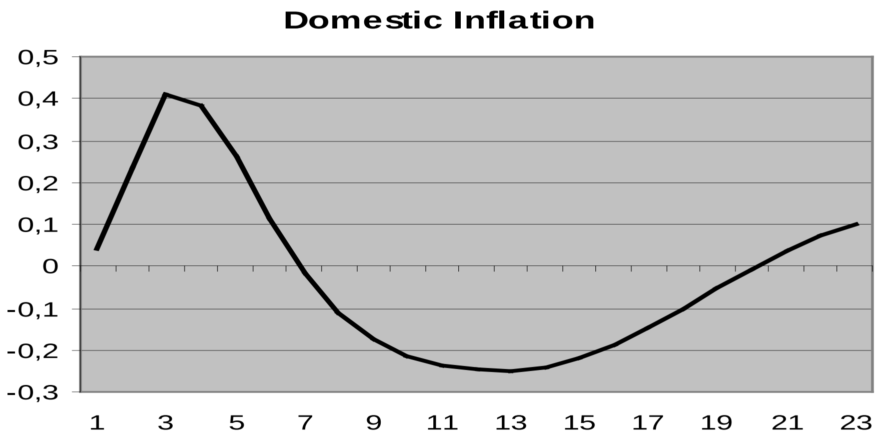


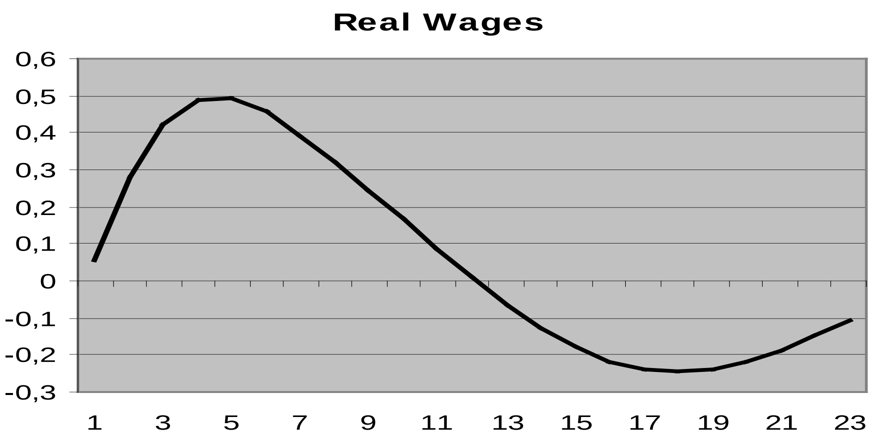


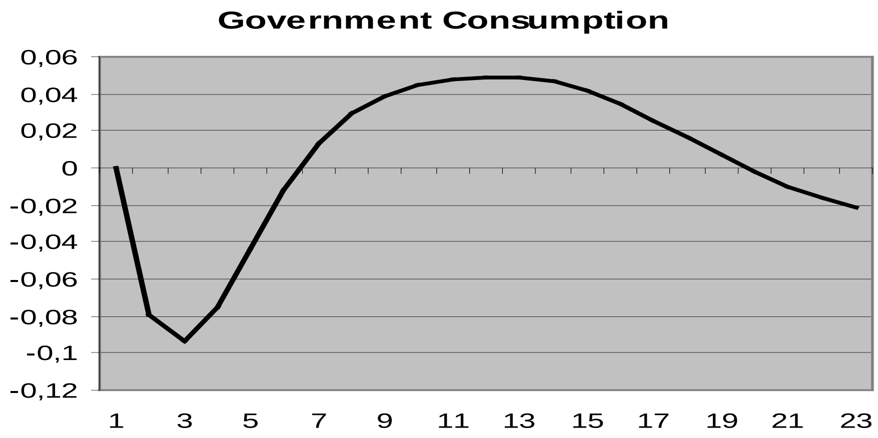


Demand Shock in a Fixed Exchange Rate Regime (II.)

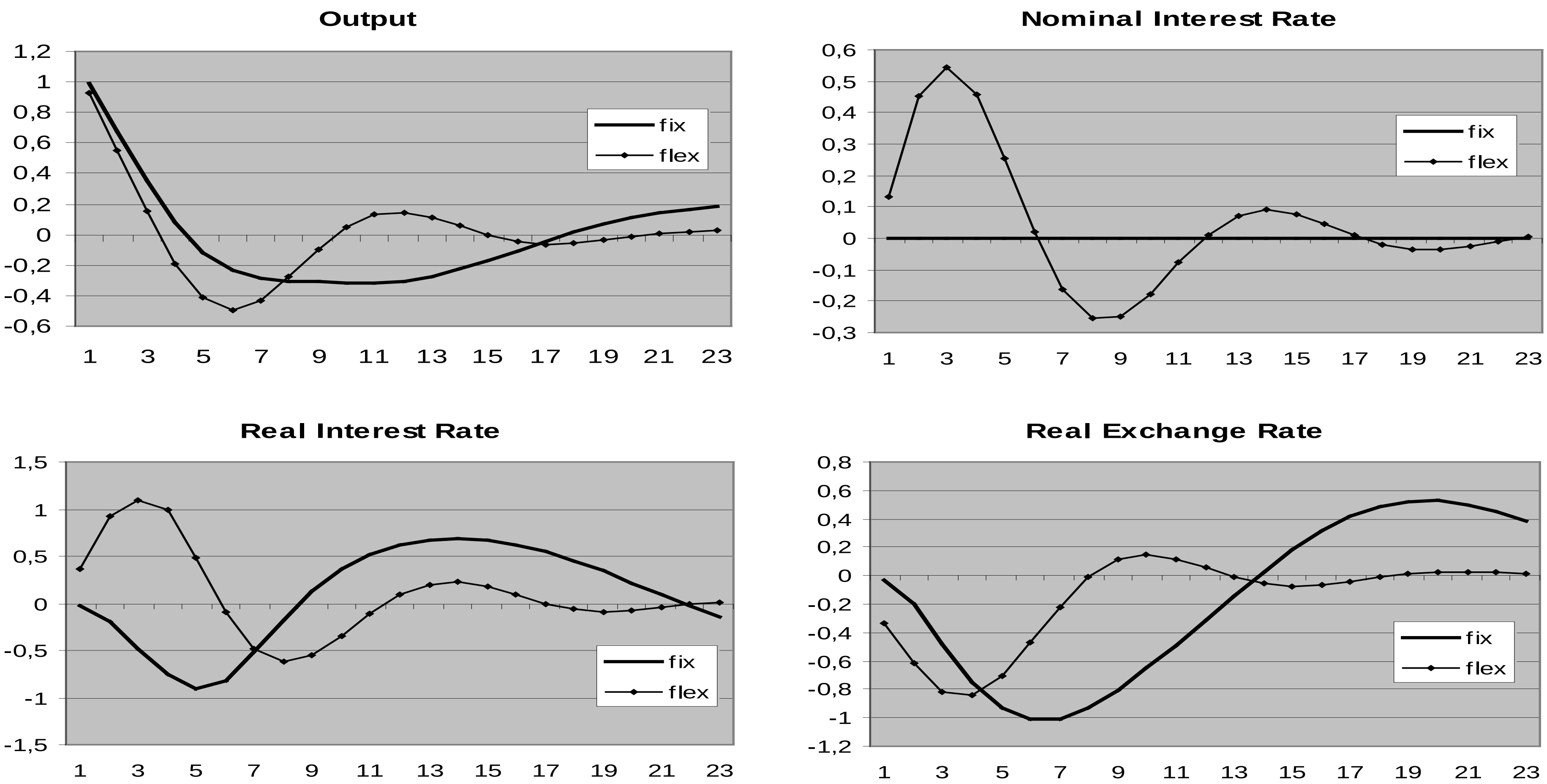




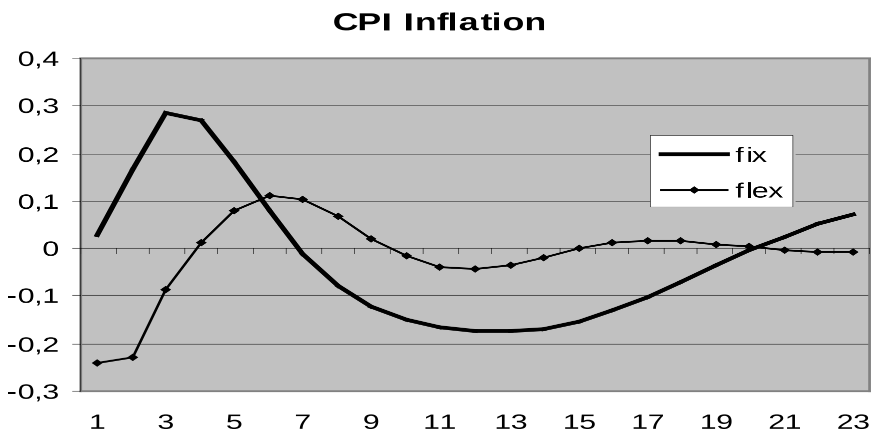


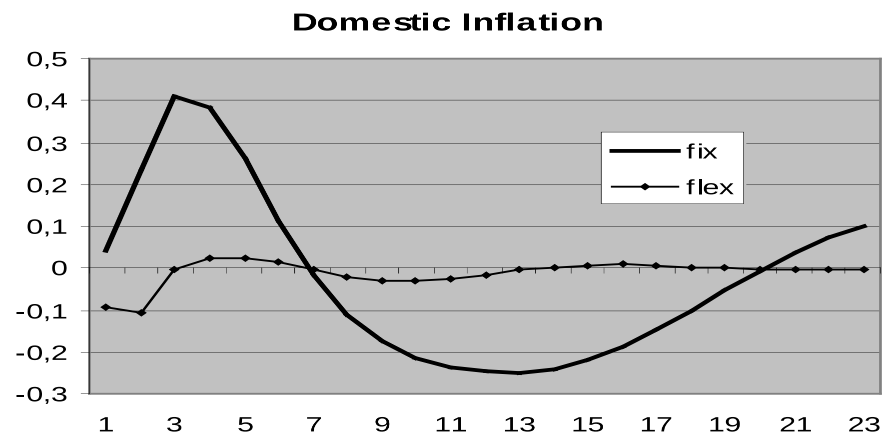


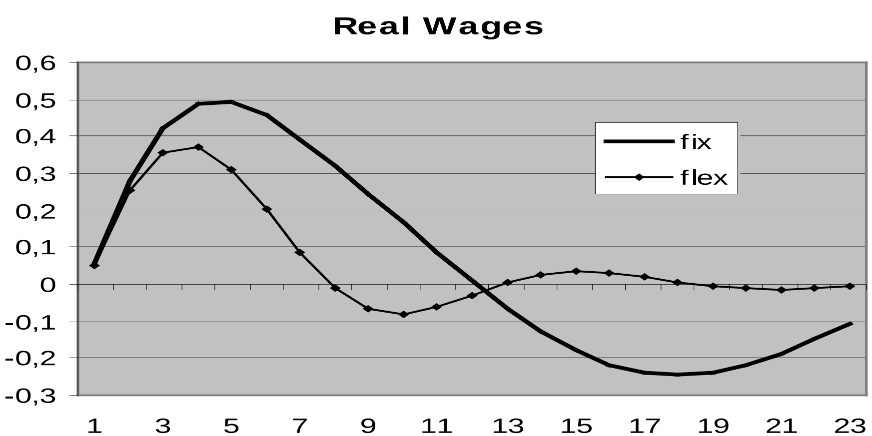
Comparing the Impact of a Demand Shock in a Fixed and Floating Exchange Rate Regime (I.)

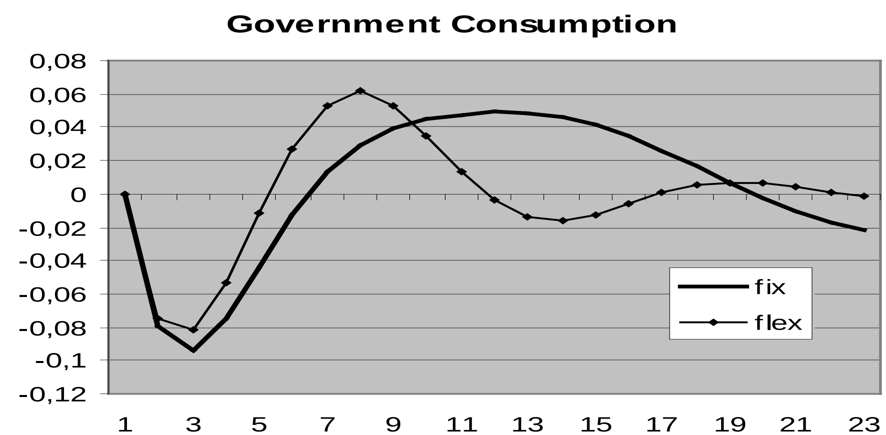


Comparing the Impact of a Demand Shock in a Fixed and Floating Exchange Rate Regime(II.)









Conclusions

- There is no *single* transmission mechanism, but there are several (legitimate) alternative approaches to quantify the main channels of the MTM.

- The way how the central bank reacts to shocks in a floating exchange rate regime is crucial for stabilising the economy: forward - looking monetary policy might - compared with a myopic MP behaviour - significantly mitigate the potentially negative impact of shocks on the economy.

- In a fixed exchange rate regime only fiscal and structural policies can improve the economy‘s response to shocks.

The Interest Rate Channel

- Higher interest rates lead to:
  - a reduction of **household consumption** due to
    - increased savings (postponed consumption);
    - the fall in asset prices (shares, long-term bonds, etc.);
  - decrease in **investment** due to higher financing costs;
- The decline in consumption and investment results in a deceleration of **domestic demand**.
- Lower demand pressures lead to lower resource utilization, which in turn, mitigates wage and price pressures in the economy (Phillips curve relationship)

The Exchange Rate Channel

- The increase in short-term interest rates makes domestic assets more attractive than investments into other currencies → capital inflows and increased demand for domestic currency → appreciation of the XR
- Two important channels of the exchange rate appreciation:
  - **Direct import price channel:** the exchange rate appreciation makes foreign goods cheaper compared with domestically produced goods. Since imported goods enter directly into the consumer price index, the exchange rate appreciation leads to a fall in CPI inflation.
  - **Indirect demand channel:** due to nominal and real rigidities the nominal exchange rate appreciation leads to real XR appreciation. The change in price competitiveness results in a decline in exports and increase in imports. Lower demand for domestic goods dampens subsequently inflationary pressures.

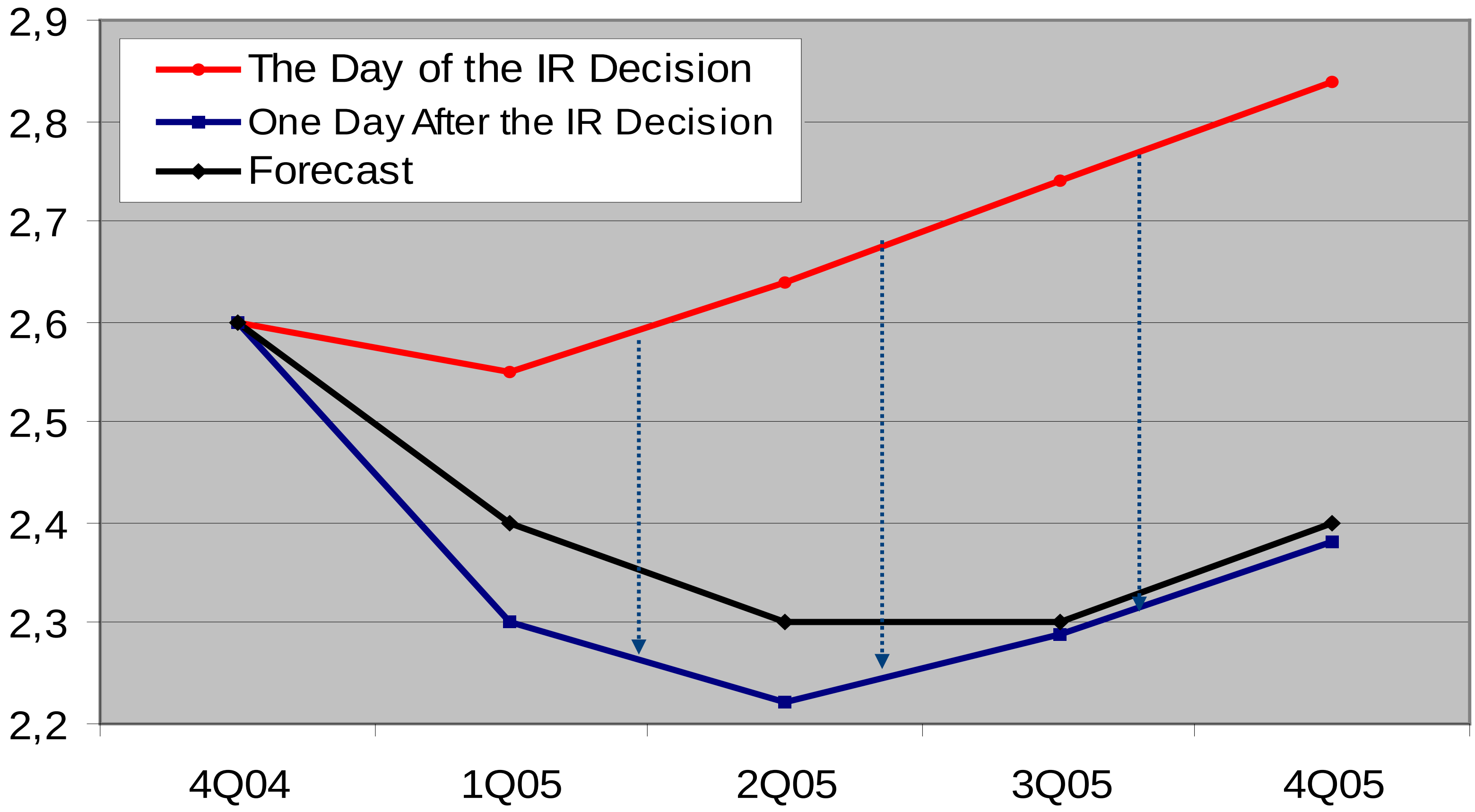
The Expectational Channel

- The probably most important expectational channel relates to **inflationary expectations**.
- If economic agents believe that inflation will be kept low, they will - for instance in the case of a temporary shock – consider changing their pricing strategy less often than in an opposite case.
- Similarly, low inflationary expectations result in moderate wage increases.
- Other important expectational channels to mention: **expectations on financial markets** (exchange rate expectations, yield curve, etc.)
- Example: changes in the slope of the yield curve after changes in short-term interest rates

The Credit Channel

- The credit (or balance sheet) channel is actually not an alternative view to the MTM. It is a set of factors that propagate the conventional interest rate channel.
- **The credit channel**: refers to the way in which MP affects demand via banks and other credit institutions. When market rates rise, lending rates will (probably) rise too. This reduces the availability of credit for certain borrowers esp. for small and medium-size businesses. Subsequently expected profitability of firms decline → lower demand → companies' ability to service their debt decreases further.
- At the same time, banks can mitigate the effects if monetary policy by deciding not to rise their lending rates for their most trusted customers. This behavior can weaken but does not lead to a closing off of the credit channel since there always borrowers with less established bank relationships.

Change in the Slope of the Yield Curve



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

G3 Model

Structural Economic Modelling at the CNB (core DSGE model)

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Monetary and Statistics Dept

General Conditions

- 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.

Course Overview

- 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 Brázdik
  12. 8.11. Getting in touch with QPM: František Brázdik
- 13. February 2012 Overview and Conclusions: Jaromír Tonner

Introduction

- 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.

Outline

- 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 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

g3 - General Characteristics

- 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)

g3 - Some Common Features with QPM

- 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

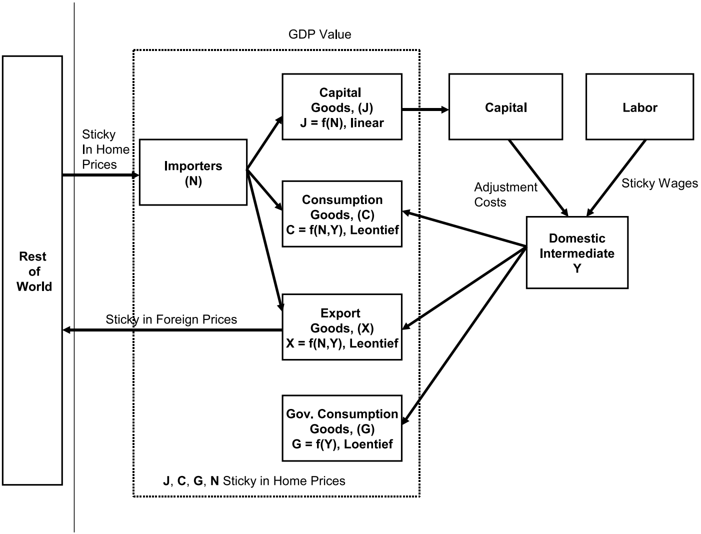
g3's Improvements w.r.t. QPM

- 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
- $\Rightarrow$ 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 a 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
  $\downarrow$
- 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
  $\downarrow\downarrow$
- 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

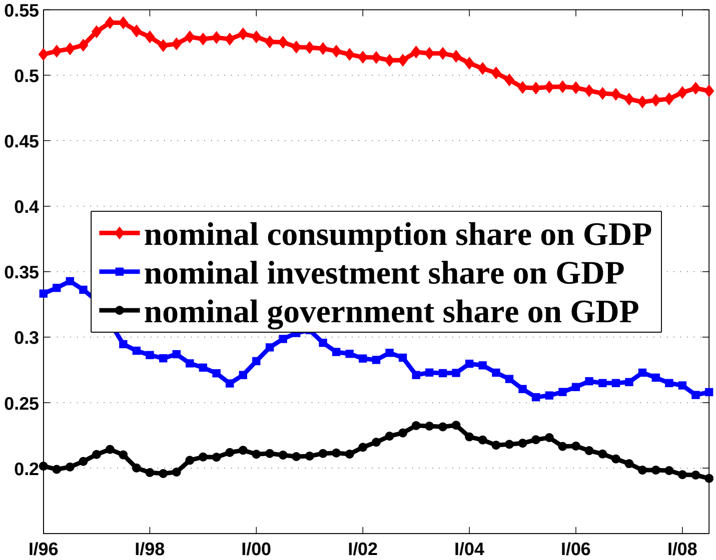
- Import intensity of exports and increase in trade openness of the economy
  - Significant excess in long-run growth of trade volumes with respect to output growth is inconsistent with standard SOE BGP
  - Large part of imports serves as a component for export goods production - massive inflow of foreign direct investment $\longrightarrow$ 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

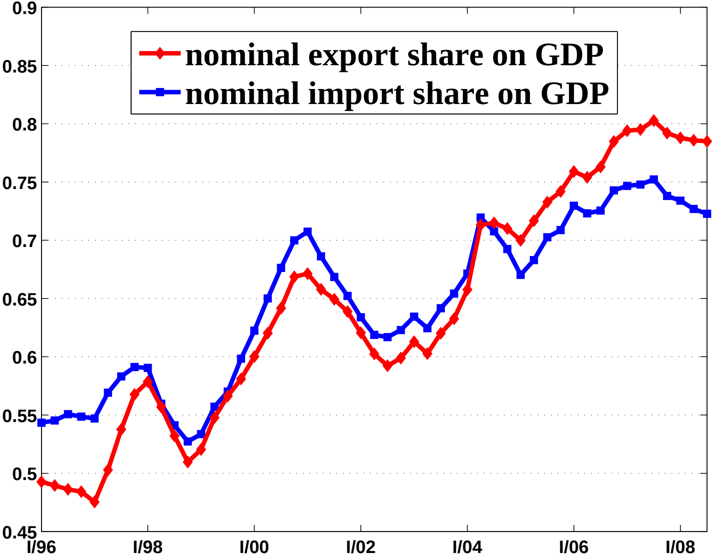
- $P_t^Y Y_t = P_t^C C_t + P_t^J J_t + P_t^G G_t + P_t^X X_t - P_t^N N_t$
- 2·3 = 2·2 + 1·1.5 + 3·3 + (-1)·8 - (-1)·8
- but constant nominal shares except exports and imports....
- $1 = \frac{P_t^C C_t}{P_t^Y Y_t} + \frac{P_t^J J_t}{P_t^Y Y_t} + \frac{P_t^G G_t}{P_t^Y Y_t} + \frac{P_t^X X_t}{P_t^Y Y_t} - \frac{P_t^N N_t}{P_t^Y Y_t}$
- 1 = 0.5 + 0.25 + 0.25 + 0.8 - 0.8
- technologies are needed to capture this mismatch
- $1 = \frac{\overbrace{P_t^C aR_t}^{\text{2+0}} \overbrace{C_t \frac{1}{aR_t}}^{\text{4+0}}}{\underbrace{P_t^Y}_{\text{2\%}} \underbrace{Y_t}_{\text{4\%}}} + \frac{P_t^J aJ_t J_t \frac{1}{aJ_t}}{P_t^Y Y_t} + \frac{P_t^G aG_t G_t \frac{1}{aG_t}}{P_t^Y Y_t} +$

$$\frac{\overbrace{P_t^X aX_t}^{\text{-0.4+2.4}} \overbrace{X_t \frac{1}{aX_t aO_t aQ_t}}^{\text{8-2.4-1.6-0}}}{P_t^Y Y_t} - \frac{P_t^N aX_t N_t \frac{1}{aX_t aO_t aQ_t}}{P_t^Y Y_t}$$

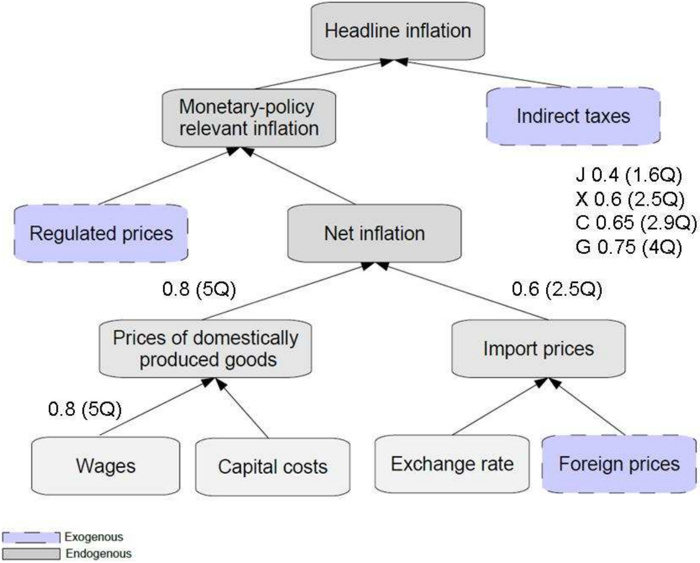
Nominal shares



Nominal shares



Another Example - nominal rigidities



Another Example - HBS effect

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

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

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

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

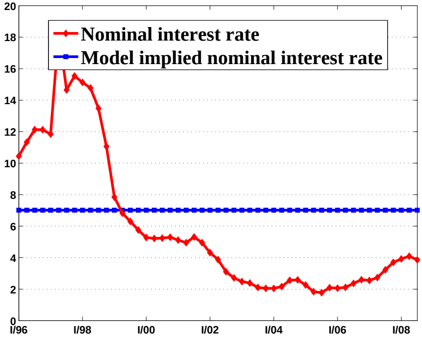
$$\dot{\text{EXR}}^{PC} = a\dot{X}^* - a\dot{X} = \dot{\text{EX}} = -2.4.$$

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
  - $\frac{1}{\beta}\dot{Y} = I - \dot{P}^Y + \dot{wedge}_{Euler} \Rightarrow \frac{1}{0.997} * 4 = 3 - 2 + \dot{wedge}_{Euler}$.



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. $\rightarrow$ better and deeper explanation
  - g3 is relatively complex $\rightarrow$ we check impulse responses very often when analyzing the initial state, forecast, or scenarios ...
  - Responses to anticipated and unanticipated shocks

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) $\longrightarrow$ CB must raise the interest rate to achieve a disinflation
- $\longrightarrow$ appreciation ($\longrightarrow$ fall of import prices) $\longrightarrow$ 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 $\longrightarrow$ CB must begin to lower interest rates $\longrightarrow$ the economy settles down (lower inflation and nominal interest rates)

Exchange rate shock (g3)

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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)
- $\longrightarrow$ 2 pressures on inflation: (i) opening positive output gap, (ii) more significantly, effects through an increase of import prices $\longrightarrow$ CB increases interest rate to resist inflationary pressures ...

Shock to habit (g3)

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

AD shock (QPM)

- A positive shock to output gap (without a direct model reference to GDP components) $\longrightarrow$ upward pressure on inflation
- $\longrightarrow$ CB reacts immediately and raises the interest rate $\longrightarrow$ 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)

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)

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

Aggregate supply shock (QPM)

- A positive shock to prices (via a residual in the Phillips curve)
- $\rightarrow$ CB increases the interest rate $\rightarrow$ 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)

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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 $\longrightarrow$ 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)

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)

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)

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

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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)

- $\uparrow$ dotA $\rightarrow$ $\uparrow$ dotZ $\rightarrow$ $\uparrow$ dotNstar $\rightarrow$ $\uparrow$ n star aQ $\rightarrow$ $\uparrow$ x $\rightarrow$ $\uparrow$ t bal $\rightarrow$ $\uparrow$ b $\rightarrow$ $\downarrow$ dotS $\rightarrow$ $\downarrow$ prem $\rightarrow$ $\downarrow$ i $\rightarrow$ $\downarrow$ E dotS

Investment specific technology shock (g3)

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)

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)

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

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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

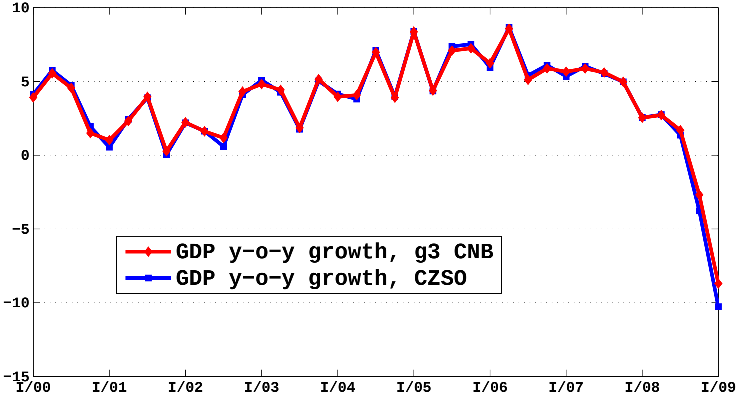
- The idea is the same (Phillips curves - relation between nominal and real vars).
- But g3 is structural model (with consistent stock- flow NA), it must have 11 sectors.
- QPM is gap model, g3 filters data using the model structure.
- Because of model filtering we incorporated 'technologies' to capture trends which we do not want to model:
  - oppeness 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 ($GDP^{sa} \neq C^{sa} + I^{sa} + G^{sa} + X^{sa} - N^{sa}$)



Structural shocks

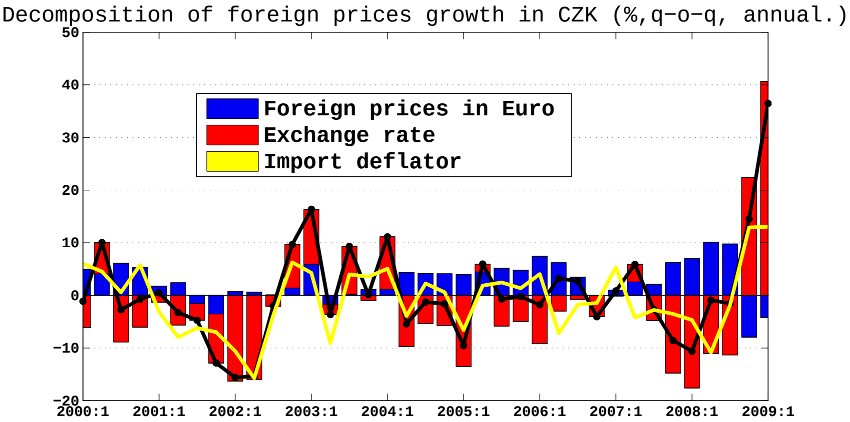
The assessment of initial position of the economy via DSGE model is based on

- 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.

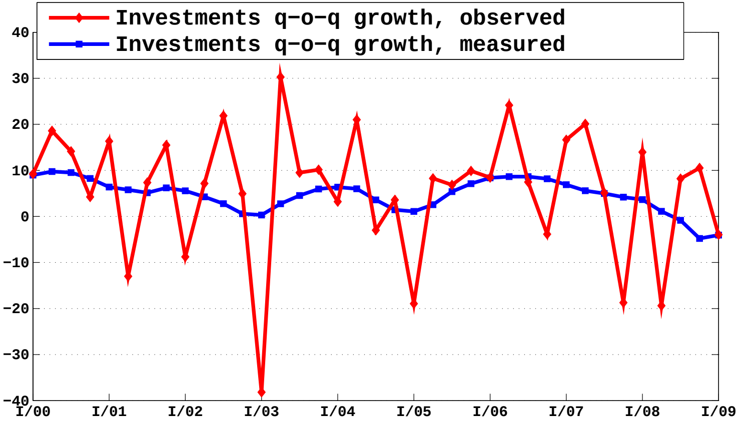
Tune of import prices



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

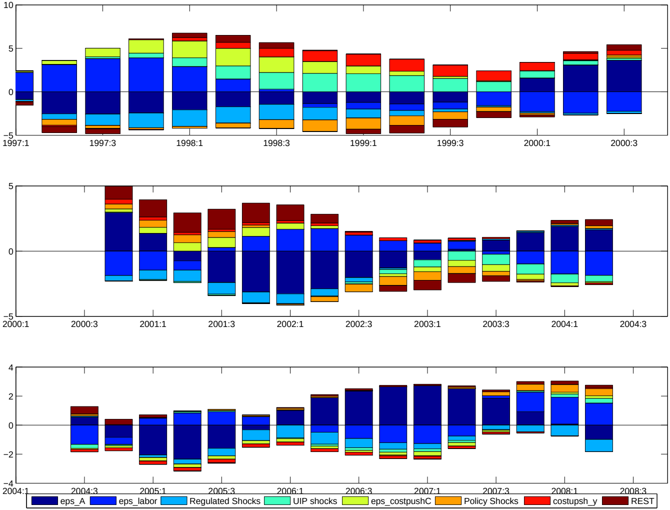


Structural shocks decomposition

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



10
5
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−5
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1997:3
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1999:1
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4
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2005:1
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2006:1
2006:3
2007:1
2007:3
2008:1
2008:3
eps_A
eps_labor
Regulated Shocks
UIP shocks
eps_costpushC
Policy Shocks
costupsh_y
REST

Interpreting news and revisions

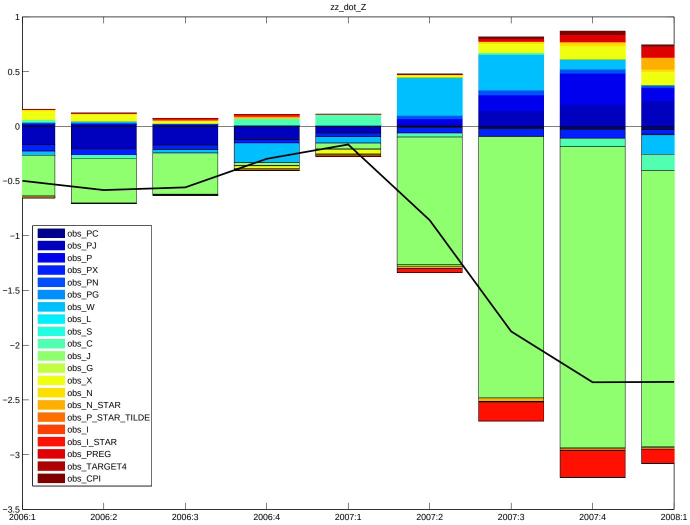
To understand changes in the assessment of the initial position of the economy due to

- 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.

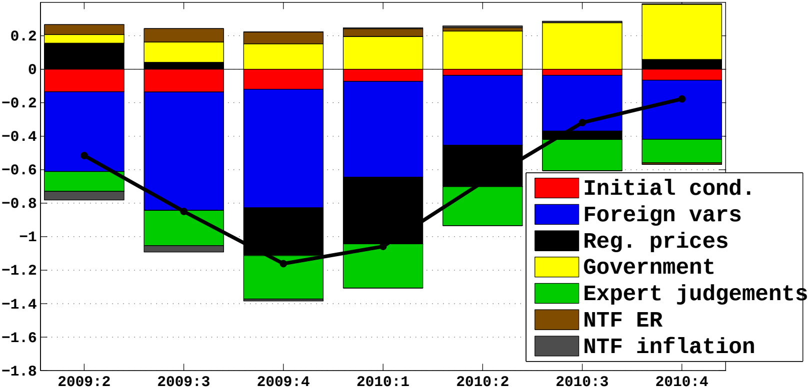
Scenario analysis and forecast dynamics decomposition

- 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



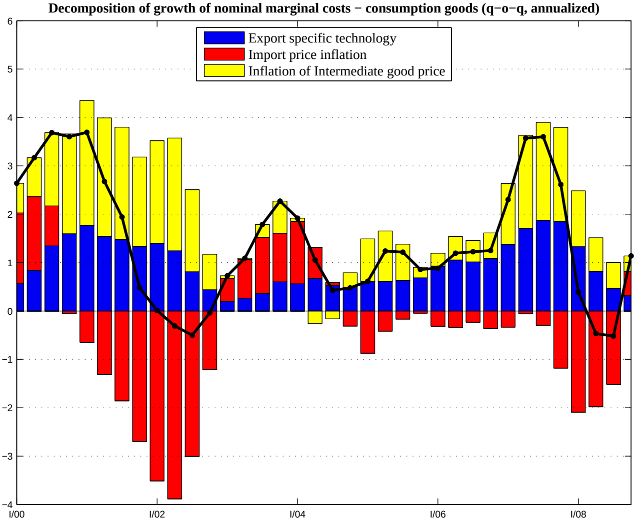
Communication of the forecast

- 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



Communication issues

- 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 :

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