New Forecasting Model of the CNB

Forecasting and Policy Analysis

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MF seminar, Smilovice, 1 - 3 December 2008

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Introduction

- The objective of the talk is to
  - simply explain the model structure,
  - describe all important features incorporated in the model.
- 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).

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Outline of the Talk

(i) Introduction

(ii) Structure of the model

(iii) Motivations for modelling choices

(iv) Forecasting and monetary policy analysis

(v) Calibration and model analysis

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Structure of the model

- GE small open economy model with rational expectations
- RBC model with
  - a consistent stock-flow national accounting,
  - nominal and real rigidities.
- 11 sectors
  - households sector,
  - 2 intermediate goods production sectors,
  - 4 final goods production sectors,
  - central monetary policy authority (central bank),
  - central fiscal policy authority (government),
  - international bonds dealers (forex dealers),
  - rest of the world.

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Common features

- A continuum of monopolistically competitive agents in each sector.
- Each agent produces a variety of a given sector's product
  - using a common CES technology to get inputs together
  - in order to optimise utility function
  - w.r.t common conditions.
- A representative agent paradigm requires
  - special assumptions to incorporate into the model
  - an existence of a perfectly competitive bundler.
- Finally each sector is represented by
  - FOCs (common for all firms in each sector)
  - restrictive constraints
  - Phillips Curve describing a price or a wage rigidity.

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Common features

- $\hat{\Pi}_t = \frac{1}{1+\beta}\hat{\Pi}_{t-1} + \frac{\beta}{1+\beta}\hat{\Pi}_{t+1} + \frac{(1-\xi_W)(1-\xi_W\beta)}{\xi_W(1+\beta)}\hat{mc}$
- The Hybrid Dynamic New Keynesian Phillips Curve contains
  - backward-looking and forward-looking components and
  - a deviation of marginal cost ($\hat{mc}$) from its steady state, so
  - we incorporate an auxiliary variable 'real marginal costs' as
  - $r\hat{mc} = \frac{\hat{mc}}{\hat{P}}$ for expressing
  - inflation pressures if it is positive and disinflation pressures if it is negative.

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Households sector special features

- A cont. of monopolist. compet. households (labour supply)
- Each hosehold
  - consumes a final consumption good,
  - monopolistically supplies labour,
  - rents a capital and
  - trades nominal bonds
- in order to maximise a lifetime utility function w.r.t
  - a budget constraint and
  - a law of motion for capital accumulation (with imperfect elasticity)
- The representative agent's paradigm requires
  - identical preferences of each household,
  - an identical initial wealth endowment and
  - an insurance market to allow households pooling wage risks arising from Calvo wage setting....
  - a bundler who costlessly aggregates all varieties of labour.
- Households sector = FOC + the Phillips Curve.

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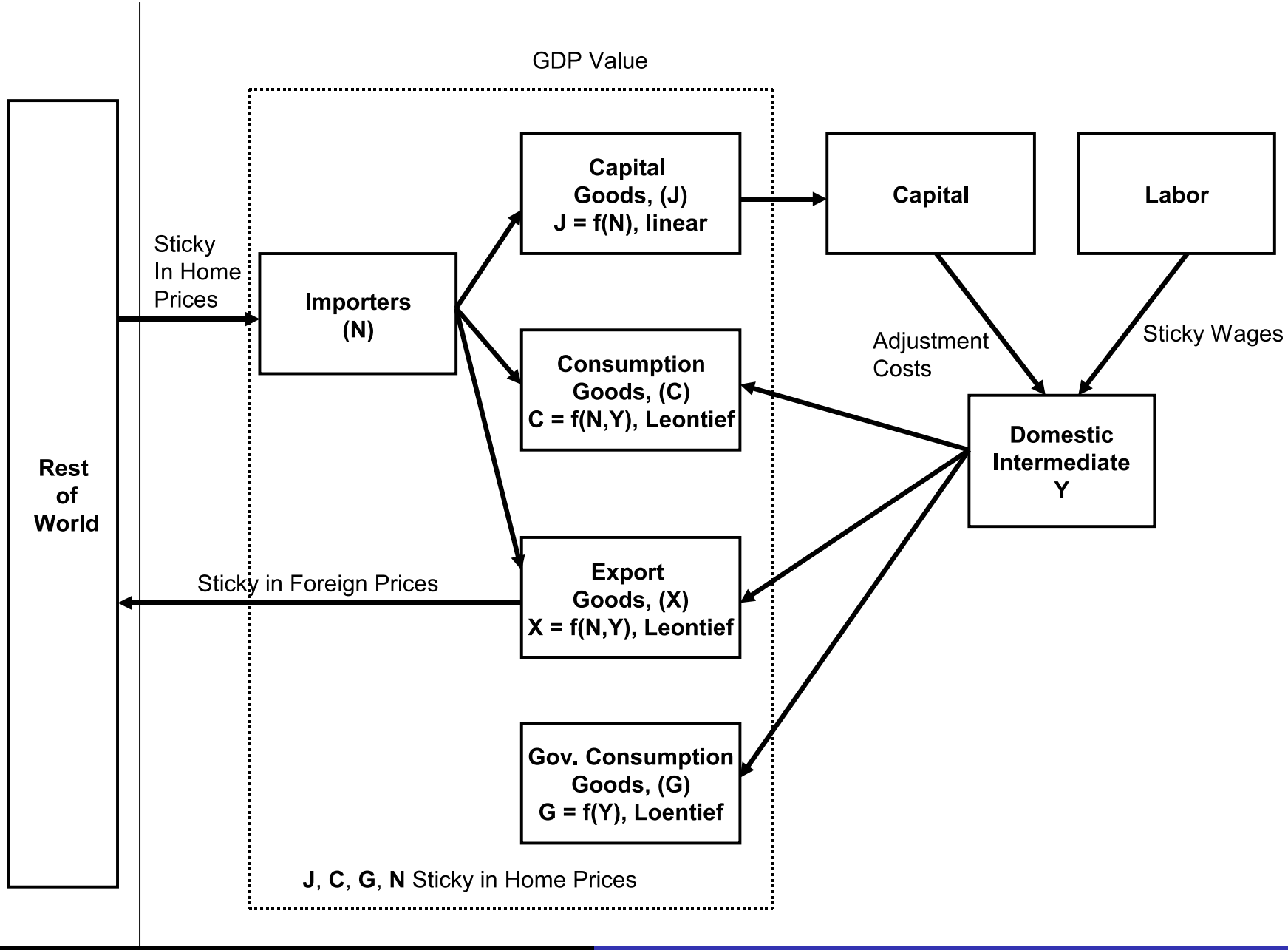
Structure of g3



Forex dealers

- Trading of foreign currency bonds is delegated to
  - perfectly competitive forex dealers who
  - realise their profits from interest rate and exchange rate movements but
  - they must face a trading cost.
- FOC imply a version of uncovered interest rate parity condition (UIP) $I = I^* + \dot{S} + \dot{prem}$, where
- variable $\dot{prem}$ plays a role for offsetting
  - profits from real exchange rate appreciation and
  - costs of trading of international bonds in order to
  - render the model stationary (feature of convenience).

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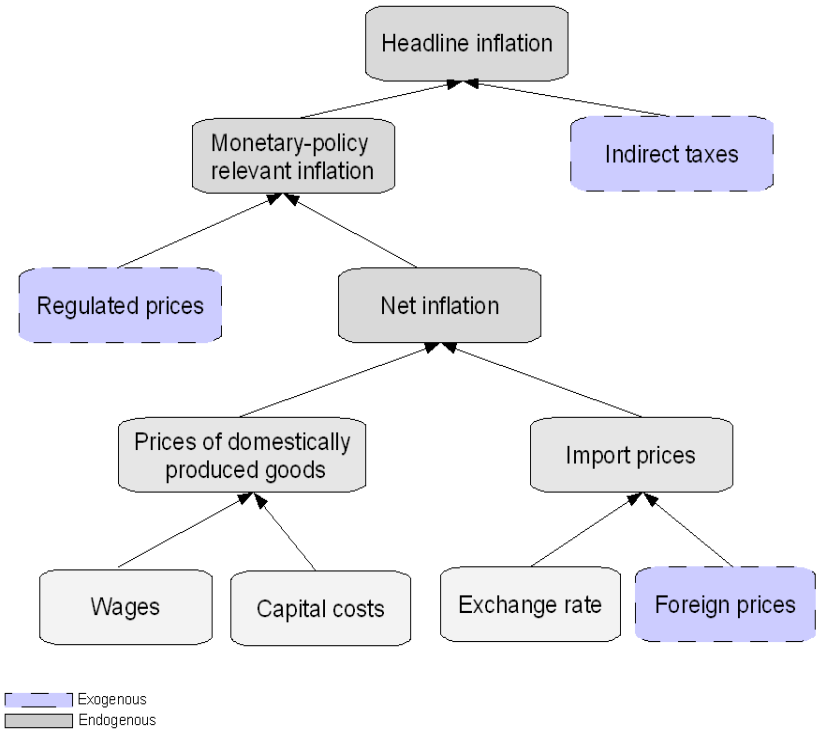
Monetary policy

- implements an inflation targeting regime and
- is credible (no communication or credibility uncertainties).



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Regulated prices

- Motivation: Regulated prices still form a very important part of CPI index dynamics and consist of
  - energy prices (should be modelled endogenously) and
  - housing prices (with uncertain development).
- But a regulated sector modelling brings some difficulties due to the fact that
  - relative prices matter in our model,
  - but CPI index is not co-integrated with reg. prices in levels.
- We have adopted solution via reg. shocks tech. a_t^R that
  - affects both prices and quantities and
  - induces a trend in relative price of net and headline CPI, but
  - keeps the nom. share of consum. on value added constant.
- Regulated prices effect also a monetary policy conduct...rise in the regulated prices thus leads to downward pressures for net inflation.

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Fiscal policy

- Motivations for our simpler treatment of the government:
  - our experiences with the fiscal impulse in the previous model.
  - Results do not correspond with our intuition, but
  - a fiscal sector is necessary w.r.t. a consistent NA.
- We assume a Ricardian economy, so government
  - guarantees its intertemporal solvency via adjusting public transfers, so it
  - collects taxes and fees (transaction costs),
  - distribute lump- sum transfers and
  - consumes public - spending goods,
  - but there are no productive or utility enhancing spending in the model.
- To do: external government sector (principle of model simplicity).

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The rest of the world sector

- The rest of the world sector is represented by the EU and is modelled exogenously.
- There is
  - a continuum of exporters in the EU, (Czech importers bundle all varieties of exported good)
  - a continuum of importers in the EU (they receive a bundle of Czech exports).
  - Importers prices are sticky in domestic currency.
  - Exporters prices are sticky in foreign currency.
- We incorporated a quality technology
  - in order to keep a high level of exports even in case of a huge NER appreciation
  - since foreign customers are endowed with quality perceptions, so
  - they may demand exported good despite its higher price.

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National accounting

- Budget constraints are interlinked in the model
- and deliver the national resource constraint of the open economy $S_t\tilde{B}_t - S_t\tilde{B}_{t-1}\tilde{I}^*_{t-1} = P^X_t X_t - Q^N_t N_t$
- The value added is produced
  - mainly in the domestic intermediate sector (services of capital and labour), and the rest
  - comes from monopolistic profits of other sectors (producers are aggregators and distributors only).

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Getting the model to the data

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The balanced growth path

- No prior detrending procedure, data are filtered using the model structure.
- Our approach is based on the Balanced growth path concept. The BGP means that in a long run all variables are constant or grow at constant pace. The motivation is to
  - reflect common features in the data and
  - capture business cycle and trends interactions.
- Prior filtering may result in
  - an inconsistent assessment of business cycle dynamics and
  - an improper initial position of economy.
  - The reason is that structural shocks spill over to business cycle frequencies.

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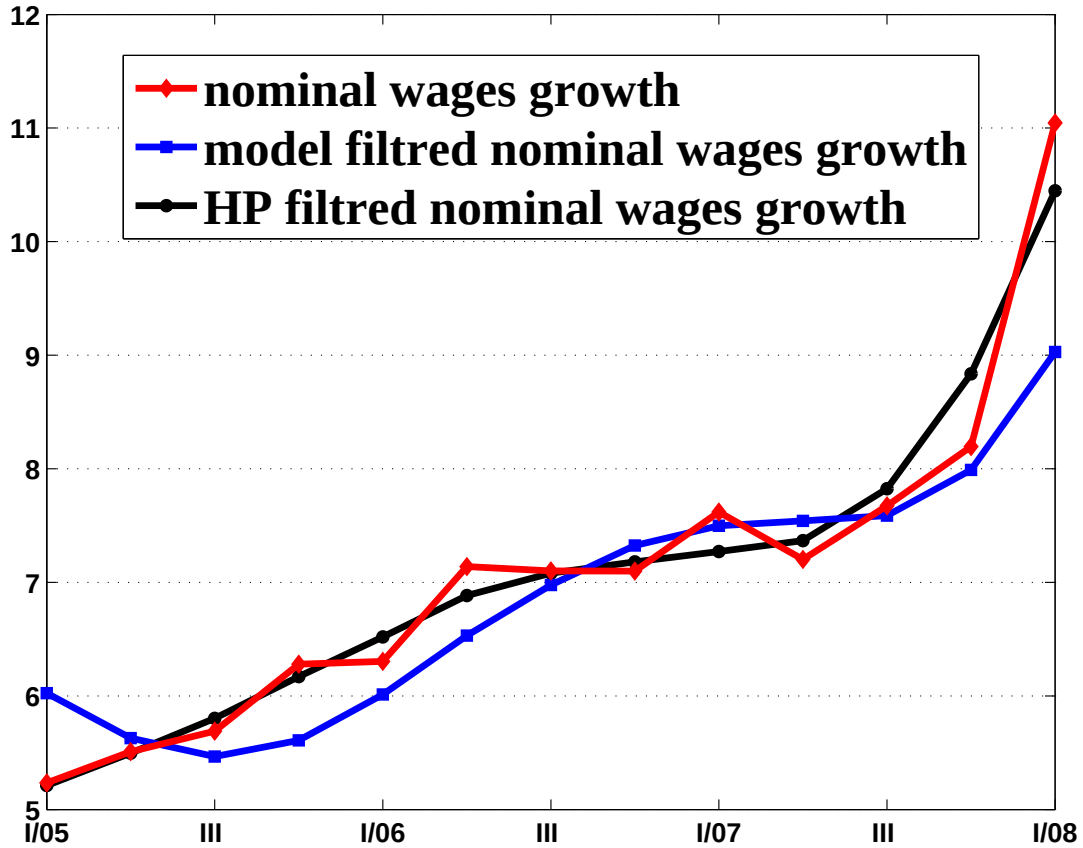
The balanced growth path

Following figure shows a failure of prior filtering, since the wage's inflation was induced by a change in wage distribution in time.



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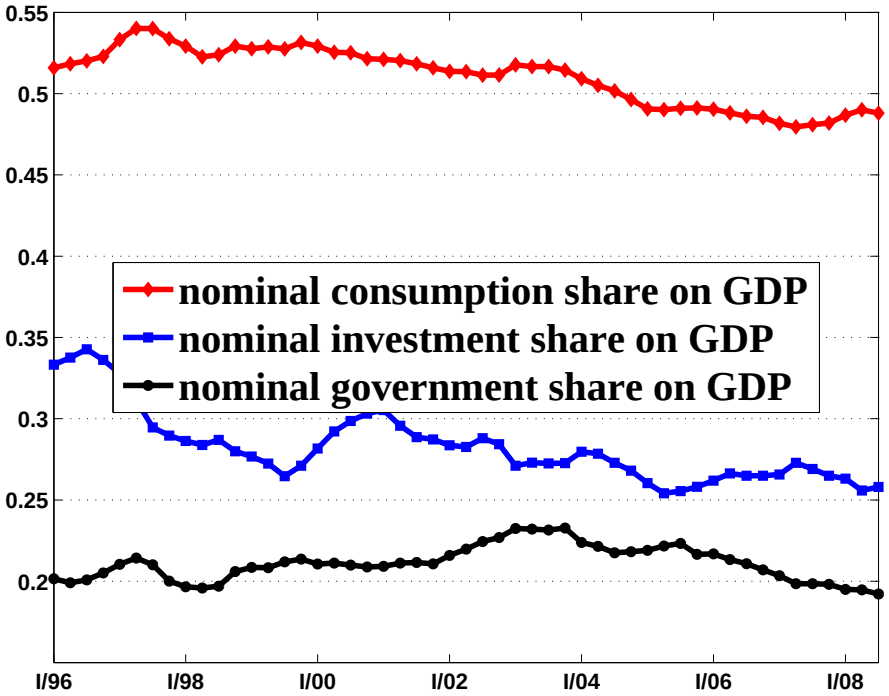
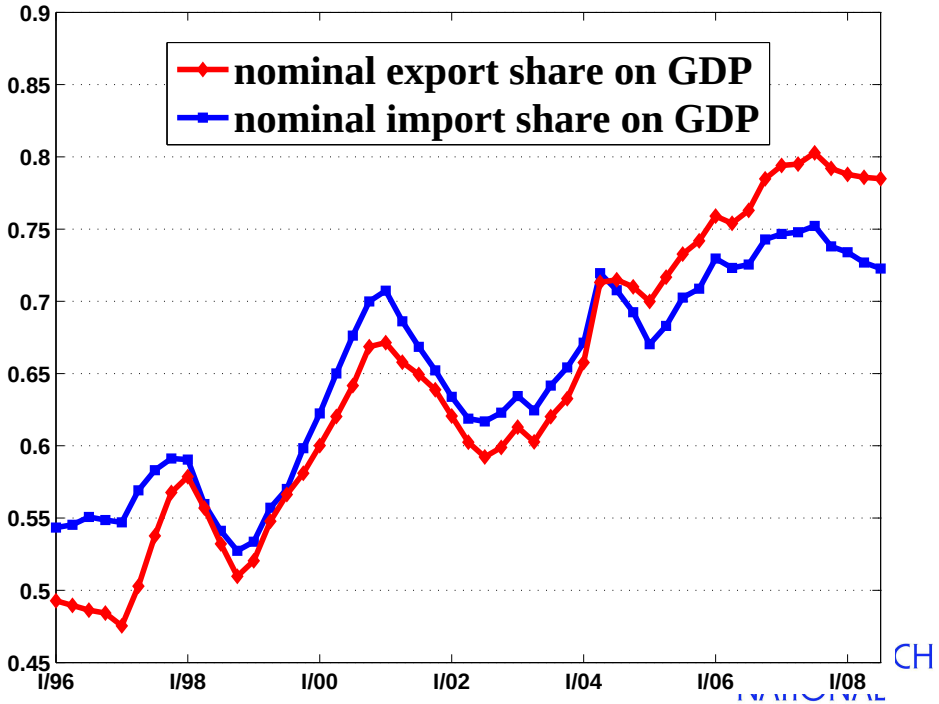
Expenditure shares

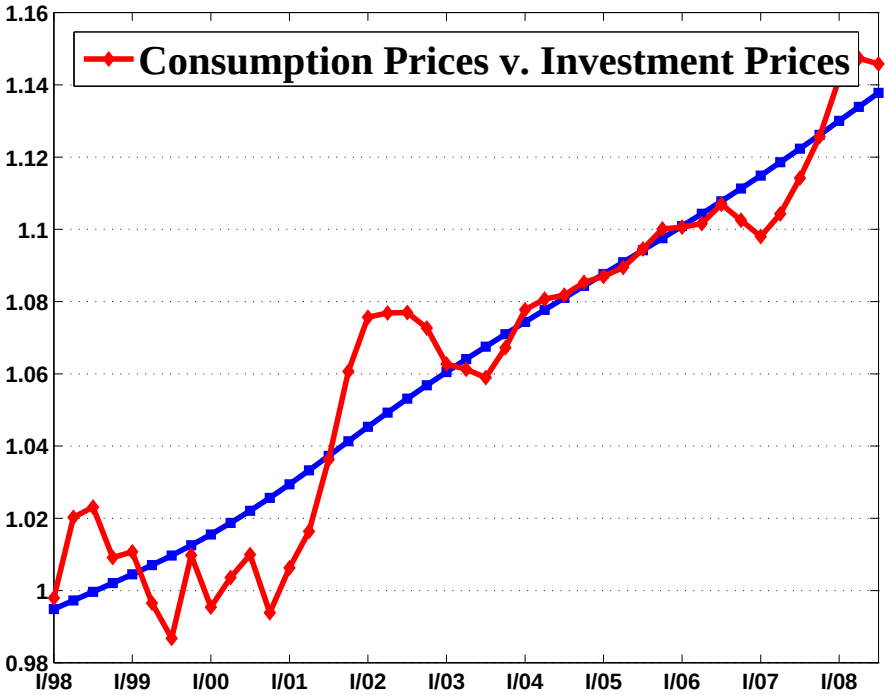
- Empirical evidences prove that
  - nominal expenditure shares on nominal GDP (except from export and import, see below) are constant, so
  - we incorporated the assumption of constant nominal expenditure shares in the steady state.

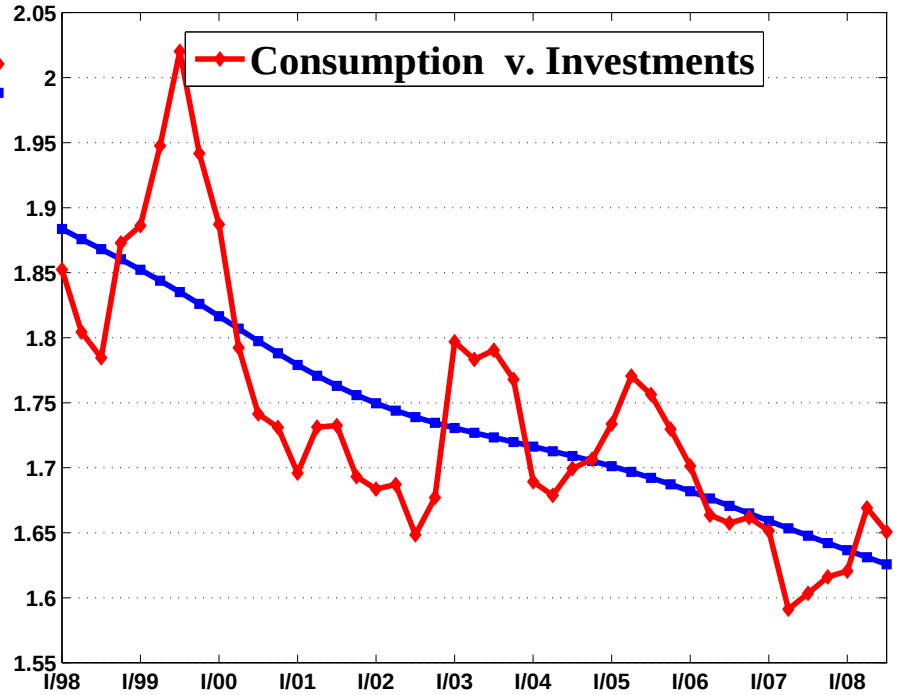




Trends in relative prices

- Trends in relative prices
  - are also observed and
  - imply that trends in real economy must offset an evolution in relative prices trends.





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The balanced growth path

- Each variable can grow at its specific degree, but
- Constant NES in SS require that
  - nominal variables grow at the same pace as nominal output, so
  - we have to incorporate special technologies in order to
    - get the model to the data and
    - keep model assumptions.
- Table shows set SS values of main variables (in per., YoY growths) and equations ensuring constancy.

var.	val.	var.	val.	eq.
$\dot{P}^C$	2	$\dot{C}$	5	$\dot{P}^Y + \dot{Y} = \dot{P}^C + \dot{a}^R + \dot{C} - \dot{a}^R$
$\dot{P}^J$	2	$\dot{J}$	5	$\dot{P}^Y + \dot{Y} = \dot{P}^J + \dot{a}^J + \dot{J} - \dot{a}^J$
$\dot{P}^G$	3	$\dot{G}$	4	$\dot{P}^Y + \dot{Y} = \dot{P}^G + \dot{a}^G + \dot{G} - \dot{a}^G$
$\dot{P}^X$	-0.4	$\dot{X}$	9	$\dot{P}^Y + \dot{Y} = \dot{P}^X + \dot{a}^X + \dot{a}^O + \dot{X} - \dot{a}^X$
$\dot{P}^N$	-0.4	$\dot{N}$	9	$\dot{P}^Y + \dot{Y} = \dot{P}^N + \dot{a}^X + \dot{a}^O + \dot{N} - \dot{a}^X$
$\dot{P}^Y$	2	$\dot{Y}$	5	$\dot{P}^Y + \dot{Y} = G\dot{D}P^{nom}$

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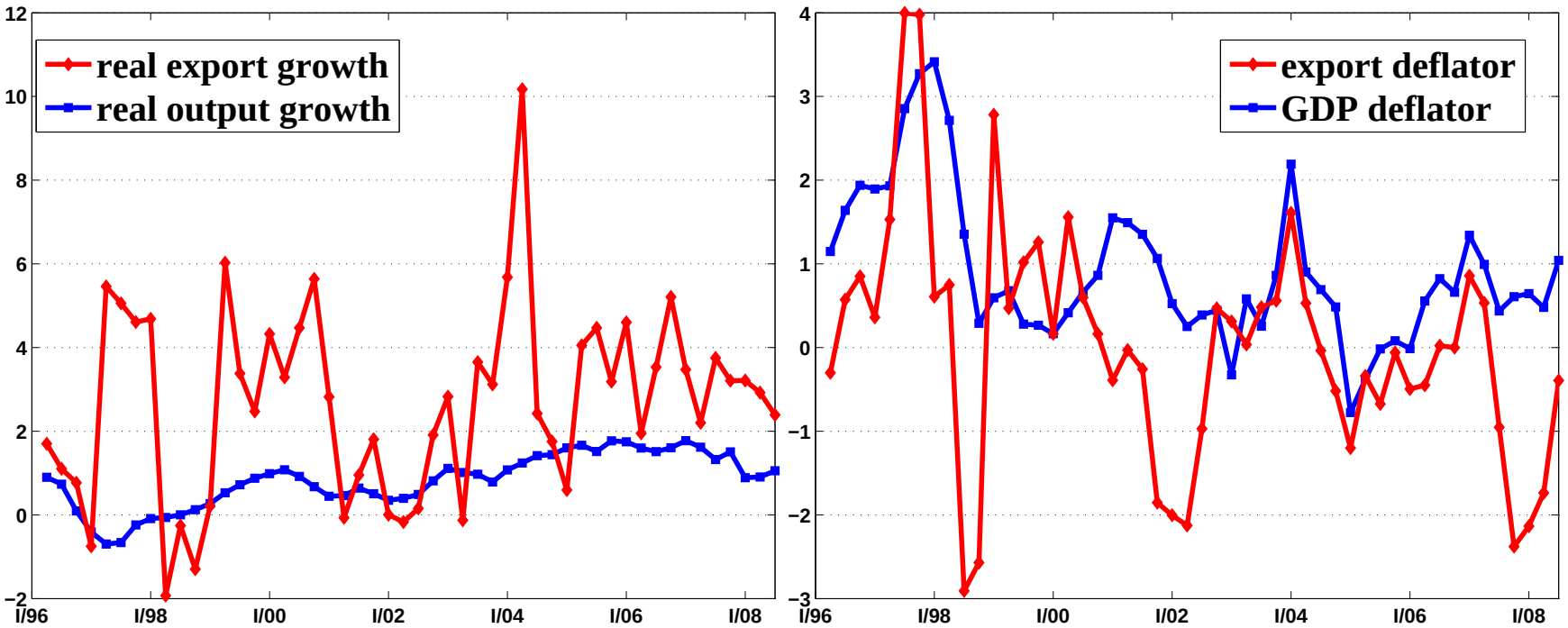
Trade openess and import intensity of exports

- The excess in long-run real growth of trade volumes w.r.t real output growth is not fully offset by an opposite evolution of relative prices of exports and imports to GDP deflator ($9 + (-2.4) = 6.6 \neq 5$).



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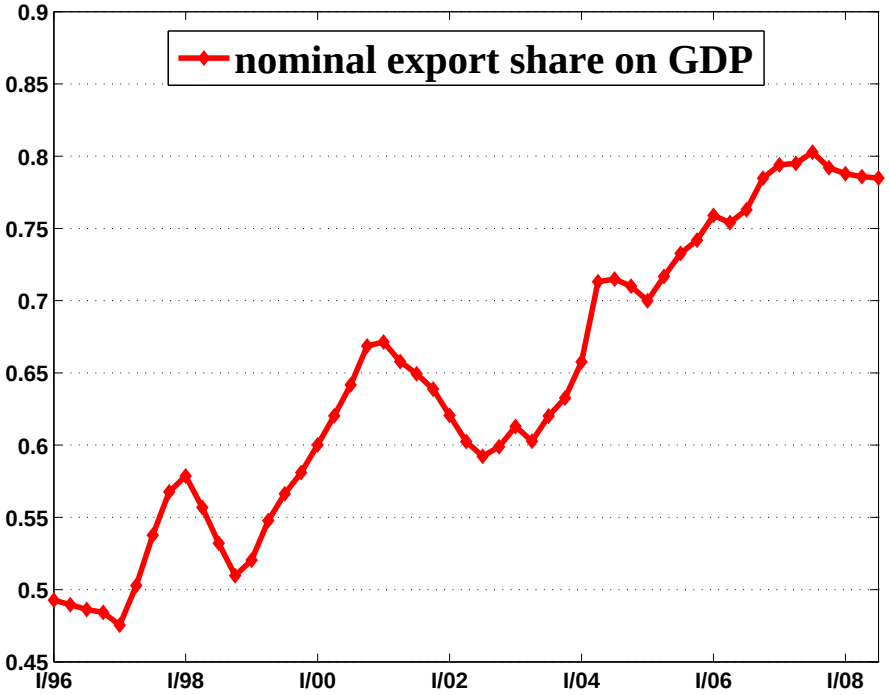
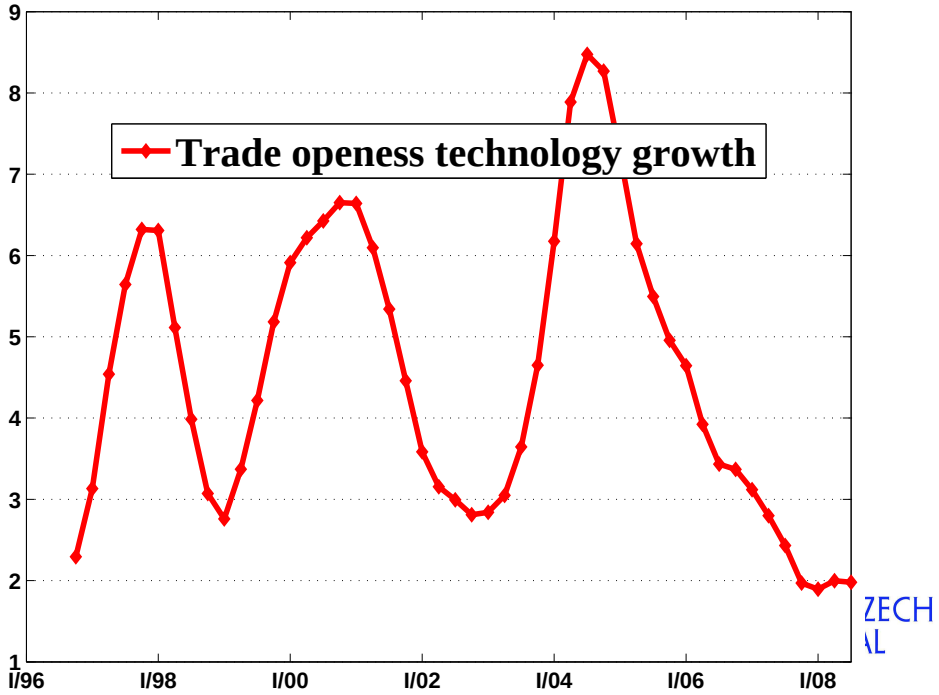
Trade openess and import intensity of exports

It implies an inconsistency with the constant NES, so

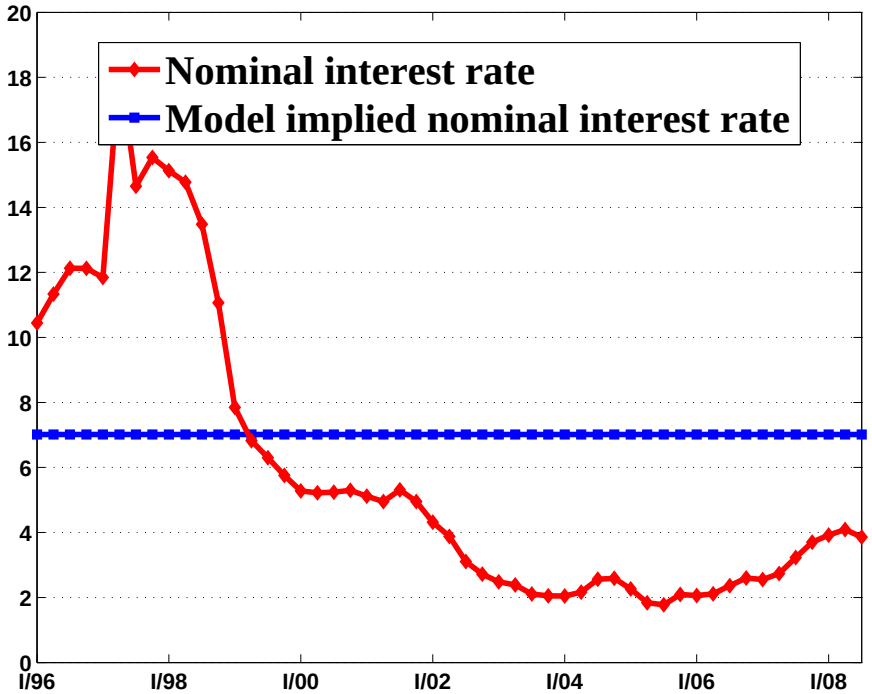
- this fact can not be modelled endogenously in SOE,so
- we incorporate a new trade openness technology a_t^O which
- does not effect prices, but
- explains the fact that not only VA is traded in real economy.





Risk - free rate puzzle and equity premium puzzle

- There is a gap between the average observed IR and the model-implied nominal IR in SS which is given by
  - the model-implied real IR (discounted real economy growth) and the SS of inflation
  - $\frac{1}{\beta}\dot{Y} + \dot{P}^{Y} = I + \dot{wedge}_{Euler} \Rightarrow \frac{1}{0.997} * 5 + 2 = 3 + \dot{wedge}_{Euler}$.



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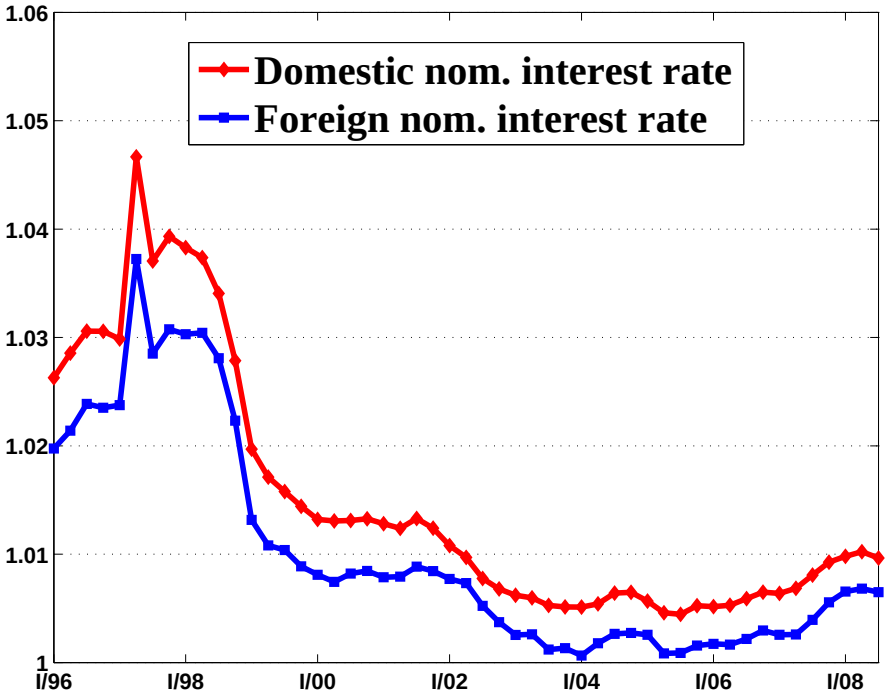
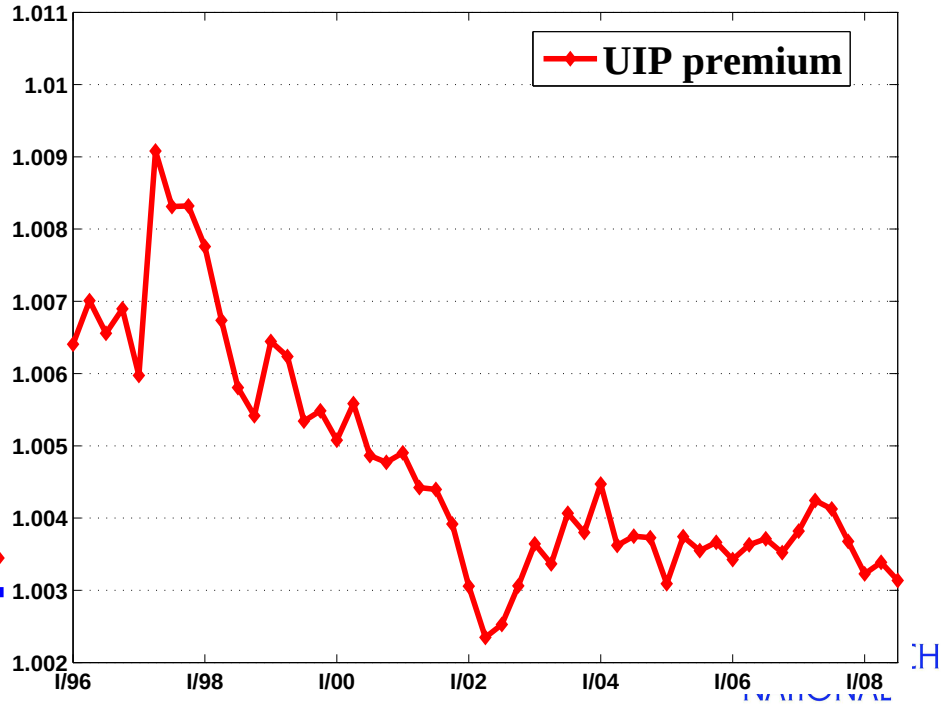
Uncovered interest rate parity

- The gap between nominal domestic IR and nominal foreign IR results from
  - the observed RER appreciation and
  - so we have to implement 'uncovered interest rate' premium
  - $I = I^* + \dot{S} + prėm.$





Real exchange rate appreciation

- NER and RER appreciation is closely related to B-B and H-B-S effects.
- B-B effect captures the fact that
  - due to technology improvements in traded sector, prices in non-traded become higher, so
  - we incorporate a_t^X technology in Home country.
  - The same process in the R-o-W (a_t^{X*}).
- Keeping an assumption of constant T-o-T in SS,
  - a difference between a_t^X and a_t^{X*} implies RER and implies
  - a convergence to more developed countries (H-B-S effect).
- $\dot{\text{RER}}_{PC} = \dot{a}^{X*} - \dot{a}^{X*} = \dot{P}^{C*} + \dot{S} - \dot{P}^{C} = \dot{P}^{C*} + I - I^* - \text{prém} - \dot{P}^{C}$
- The above equation with UIP delivers a relation between
  - domestic and foreign real interest rate,
  - UIP premium and
  - H-B-S effect (represented by a diff in a^X technologies),
  - $I^* - \dot{P}^{C*} + \dot{\text{RER}}_{PC} = I - \dot{P}^{C} - \text{prém}$

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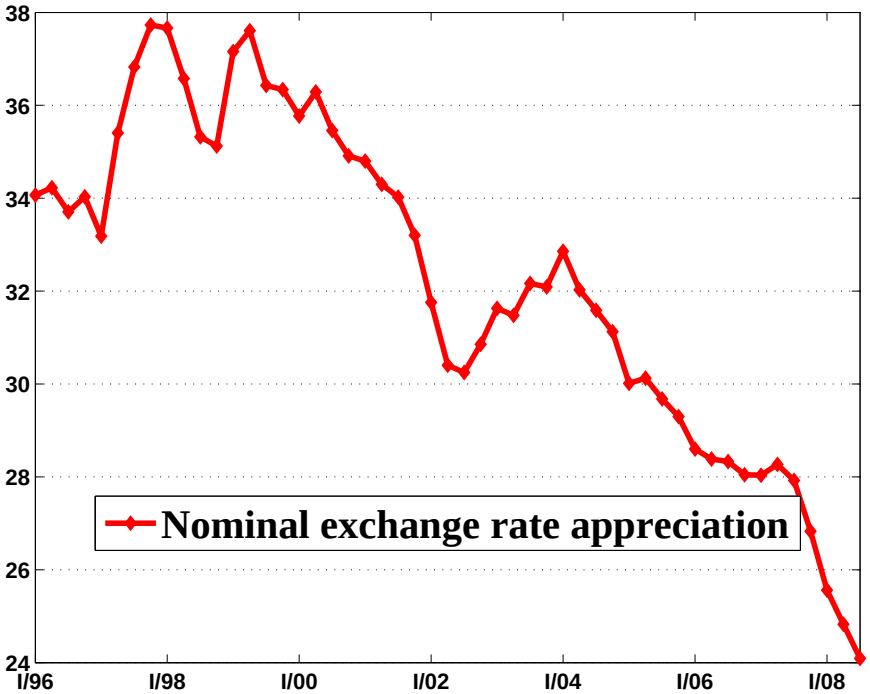
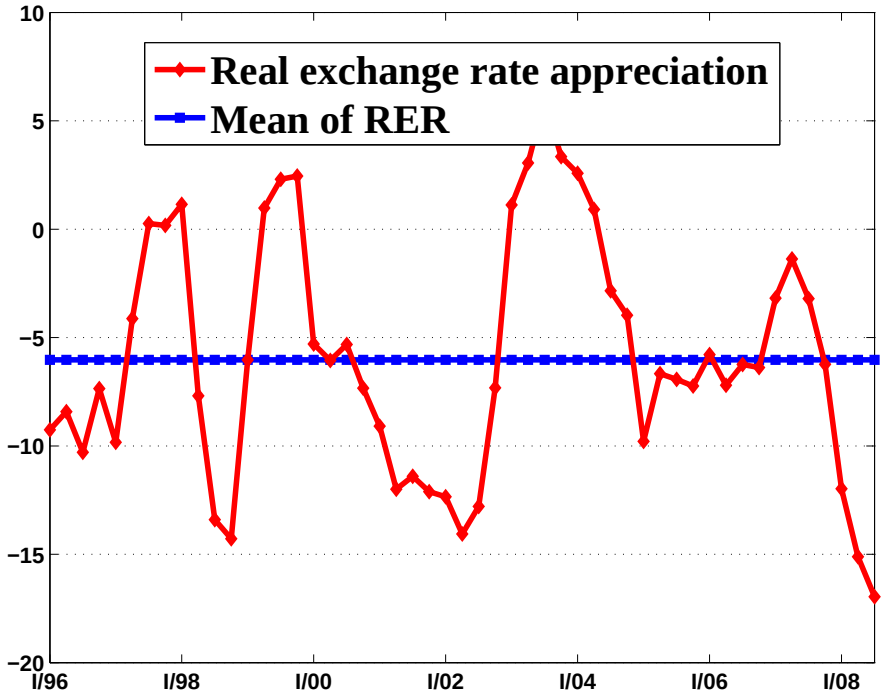
Real exchange rate appreciation

- Figure shows H-B-S effect in the data ...
- $\dot{\text{RER}}_{PC} = \dot{P}^{C*} + \dot{S} - \dot{P}^{C}$





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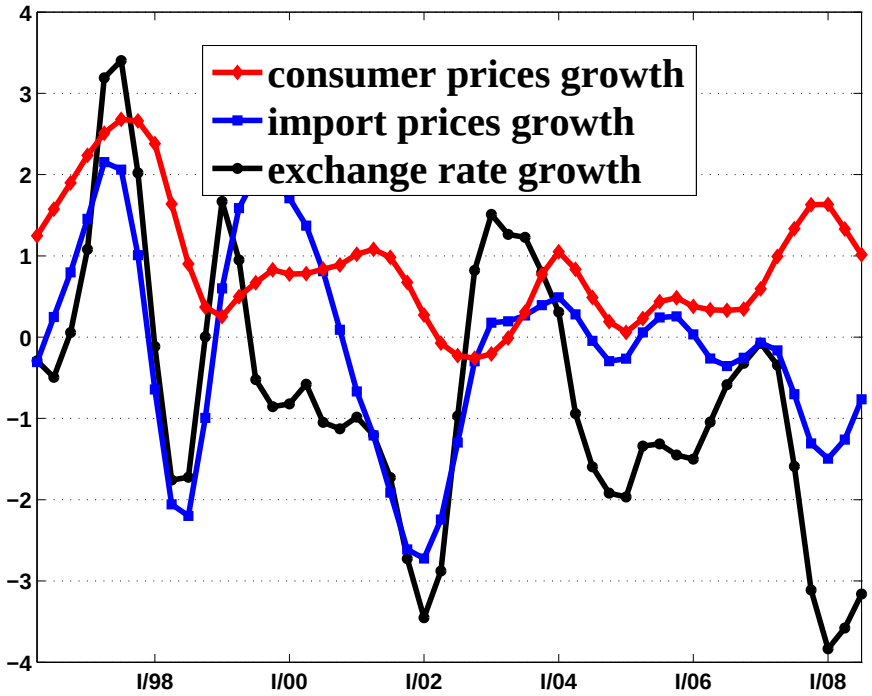
Nominal rigidities and exchange rate pass-through

- The model mechanism of price and wage rigidities following Calvo pricing delivers
  - desirable interactions among model variables and
  - multiple stages of exchange rate pass-through.

$\dot{P}^N$		$\dot{P}^X$		$\dot{P}^Y$		$\dot{P}^C$		$\dot{P}^W$	
ξ_N	0.6	ξ_X	0.6	ξ_Y	0.8	ξ_C	0.65	ξ_W	0.8



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Nominal rigidities and exchange rate pass-through

- Importers prices are sticky in domestic currency, exporters prices are sticky in foreign currency ('local currency pricing') in order to
  - achieve the observed structure of price rigidity and
  - the observed effects of exchange rate into all prices.
- There is a difference between the value added price and the consumer's price, since
  - wage stickiness is significantly larger than consumer prices stickiness (0.8 resp. 0.65)
  - prices of intermediate goods (P_t^y) are less rigid than consumer prices (P_t^c) (0.6 resp. 0.65), it implies
  - a wedge in RCW ($\frac{W_t}{P_t^c}$) and RCL ($\frac{W_t}{P_t^y}$).
  - $\frac{W_t}{P_t^y}$ are pro-cyclical, $\frac{W_t}{P_t^c}$ are anti-cyclical.

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Real persistence and business cycle dynamics

- External habit formation of households.
  - Motivation: smoothing of household's consumption.
- Investment adjustment costs.
  - Motivation: an obsolete technology endowment.
- Imperfect elasticity of substitution between new and old capital goods.
  - Motivation: an obsolete technology endowment.

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Forecasting and monetary policy analysis

Remark: Following figures serve illustrative purposes and are NOT based on real CNB data.

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The concept of our regular forecast

- Identification and interpretation of initial conditions
  - Measurement errors
  - Structural shocks decomposition
  - Interpreting news and revisions of the data
- Projection simulation conditioned on exogenous variables and judgements
  - Endogenous monetary policy - unconditional forecast
  - Conditions, Exogenisation and Imposing judgements
  - Modest policy interventions vs. Anticipated shocks
- Scenario analysis and forecast dynamics decomposition
  - Decomposition w.r.t. steady states
  - Decomposition of alternative forecasts
  - Analysis of two successive forecasts
- Communication of the forecast
  - Natural equilibrium
  - Technology processes and structural shocks

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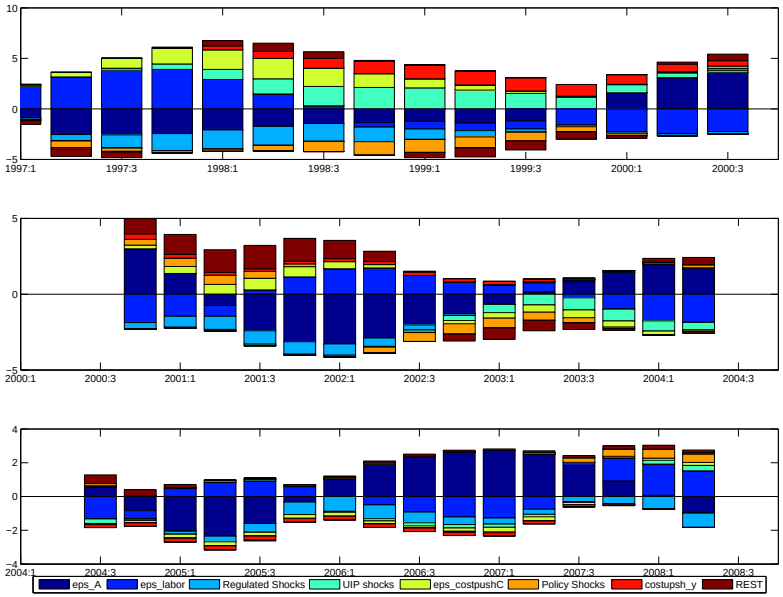
Structural shocks decomposition

- To find out which shocks are responsible for a deviation of a given variable from its steady state, we carry out a structural shocks decomposition....



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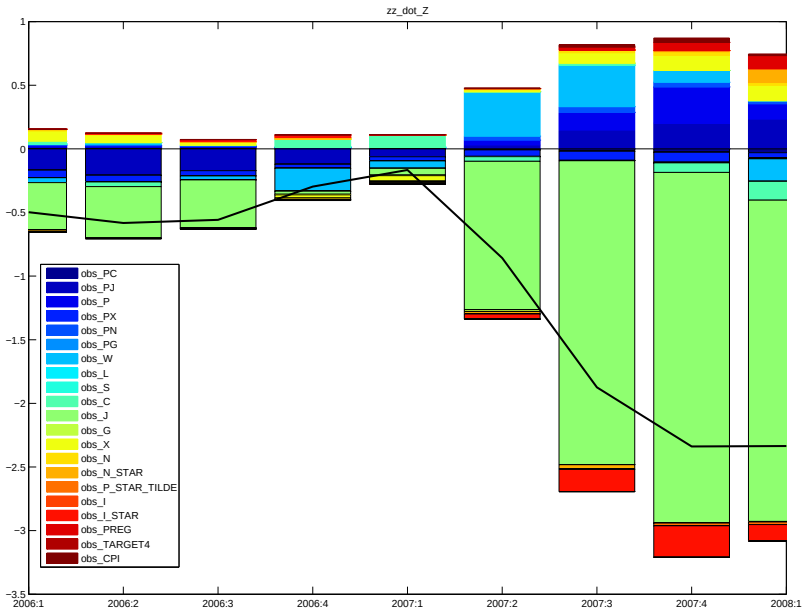
Interpreting news and revisions

- To interpret how data revisions and new period observed variables effect an assessment of initial position of economy, we use a decomposition of a given variable into observables....



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Imposing judgements

- 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...

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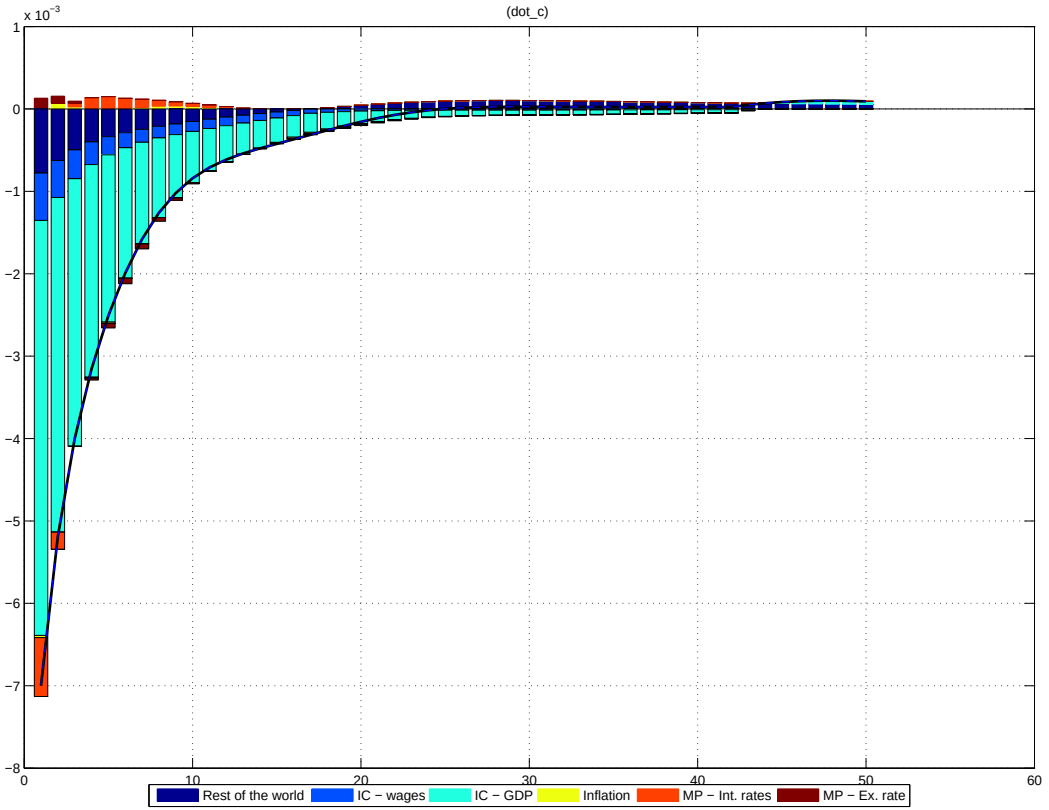
Scenarios analysis and forecast dynamics decomposition

- To fully understand the dynamics of the forecast or a difference in two successive forecast, we can decompose these into individual factors...



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Natural equilibrium

- A concept of natural equilibrium can be understood as the BGP concept as well as the-fully-flexible prices concept...
- 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...

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Calibration and model analysis

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Calibration and model analysis

- We follow a minimal econometric approach to DSGE models (Geweke, 2006) due to
  - the model stylized nature and its inherent misspecification and
  - mainly because of very short and poorly reliable data.
- We focus mainly on population properties and story-telling potential of the model.
- Analytical form of stationarized steady - state of the model to work transparently with setting long-run growths of main variables and with 'great' ratios.
- Parameters are divided into two groups: determining steady-state and determining short-run dynamics

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Calibration and model analysis

- Model is inspected by
  - impulse response analysis (both anticipated and unanticipated shocks),
  - time and frequency domain analysis of model's moments,
  - filtering methods.

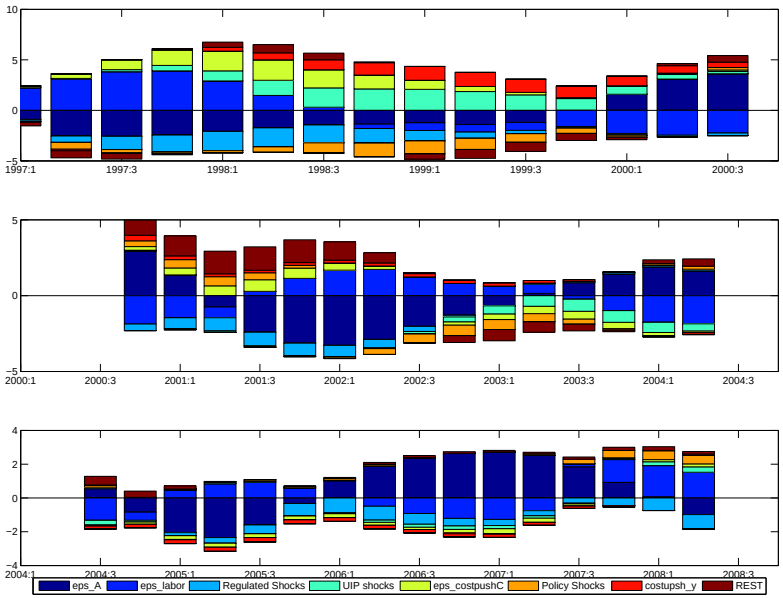

Figure: Structural shocks decomposition

Thank you for your attention

Related working paper of the new structural model will be soon available at :

www@cnb.cz

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