

# Using the New Structural Model of the CNB

## Forecasting and Policy Analysis

**Michal Andrle**

Czech National Bank, Forecasting Dept.

michal.andrle(at)cnb.cz, michal.andrle(at)yahoo.com

South African Reserve Bank, 3.–7. Nov 2008

# Outline of the Talk

- ▶ Economic models and its use at the CNB
- ▶ Matching emerging SOE stylised facts with the model
- ▶ Structure of the model and key features
  
- ▶ Forecasting and policy analysis with the model
- ▶ Communication issues
  
- ▶ How to build a central-bank-forecasting DSGE model in your spare time. . .

M. Andrlé, O. Kamenik, J. Vlcek & T. Hledik:  
Putting in Use the New Structural Model of the CNB, 2007–2008

M. Andrlé: Why Emerging Countries Need ‘Trendy’ Models – The Role of Trends and Detrending in DSGE Models, 2008

# Current Core Model

CNB adopted inflation targeting in 1998.

- (i) Since mid 2002 forecasting system (FPAS) based on a *Quarterly Projection Model* (QPM) used with success
- (ii) Semi-structural gap version of a Dynamic New-Keynesian SOE model
- (iii) Board members used to QPM-style communication

## Core Model Principle

- ▶ Common language and communication platform
- ▶ Framework for imposing judgement in a model-consistent way

# Why the New Model?

Good experience with core-model principle, but growing demand for more structural model-based analysis.

- ▶ QPM is difficult to modify/extend since it is a reduced form
- ▶ Need for a model with explicit structure of the Czech economy
- ▶ More emphasis on the supply side required
- ▶ Possibility of simple structural fiscal block
- ▶ Attempt to improve story-telling, without sacrificing forecasting performance
- ▶ Derivation from 'behavioral principles' allows us to handle more complex models

# The King is Dead. Long live the King!

The **g3** model has replaced **QPM** as a core model of the Czech National Bank starting from **July 2008**.

- ▶ CNB is one of the first central banks to use a DSGE (Dynamic Stochastic General Equilibrium) model as a **core policy tool**
- ▶ Joining the “club” with Sveriges Riksbank (RAMSES), Bank of Finland (Aino) or Bank of Canada (ToTEM) . . .
- ▶ The g3’s features & tools provoked interest in the model (BoF, ECB, Riksbank, BoE. . . )
- ▶ CNB used the g3 model since Jan 2007 along with the QPM model for “shadow forecast” and analytical insights
- ▶ The g3 FPAS expands analytical scope and brings brand new, powerful tools while preserving the CNB’s view of the economy



# Digression – A Bestiary of Forecasting Models I.

## (i) Econometric models (time series)

- ▶ Univariate regressions
- ▶ VARs & VECMs, ...
- ▶ DFMs – interesting for ‘nowcasting’
- ▶ no or very little economics of the forecast

## (ii) Ad-hoc ‘Cowless Commission’ models

- ▶ usually built bottom-up
- ▶ often bunch of ad-hoc equations put together
- ▶ little role for expectations, fragile LR dynamics
- ▶ difficult to maintain and work with – wizards needed

# Digression – A Bestiary of Forecasting Models II.

## (i) Reduced-form RE ‘gap’ models

- ▶ story-telling device with good forecasting capabilities
- ▶ top-down design
- ▶ well-defined long-run and expectational properties
- ▶ difficult to extend and/or modify due to reduced form nature
- ▶ CNB’s QPM is an example

## (ii) Full-blown, theory-based DGE models

- ▶ flexible, well-defined story-telling & forecasting device
- ▶ all goodies from reduced-form REH models plus more
- ▶ explicit structural & behavioral assumptions, more easily to adapt to a particular economy
- ▶ behavioral assumptions allow to work larger (more realistic) systems (even to those who value their sanity)
- ▶ still, these models are FAR from perfect!!!

# Bird's Eye View of the Model

- (i) Model of a small open emerging economy
- (ii) Designed for forecasting and policy analysis  
(by forecasters)
  
- (iii) No use of mechanically de-trended and/or pre-filtered data
- (iv) Allows for trends in sectoral relative prices
- (v) Attempts to deal with trade openness issues
  
- (vi) Multiple sectors of final goods
- (vii) Cascade of wage and price rigidities
- (viii) Exchange-rate disconnect
- (ix) Rich set of real rigidities and frictions



# Some Emerging Country Facts

- ▶ nominal expenditure shares relatively stable
- ▶ pronounced trends in sectoral relative prices
  - ▶ fig
- ▶ non-negligible role of administrated prices
- ▶ limited exchange rate pass-through
- ▶ large import-intensity of exports
- ▶ increasing trade-openness (share of imports on GDP)
  - ▶ fig
- ▶ important trend-cycle interactions ▶

# Model Structure (i)

## Real economy

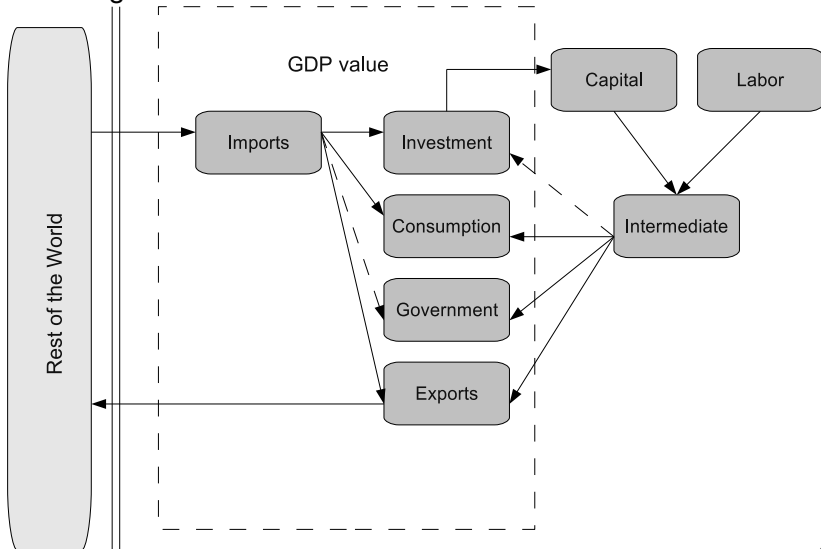
- ▶ multiple final goods sectors
- ▶ external habits, costly investment adjustment
- ▶ imperfect substitution of new & old capital goods
- ▶ liq. constrained households to be tested. . .

## Pricing behavior

- ▶ Calvo pricing/wages with backward-looking indexation
- ▶ each sector possibly different price stickiness (cascade)
- ▶ exporters sticky in foreign currency

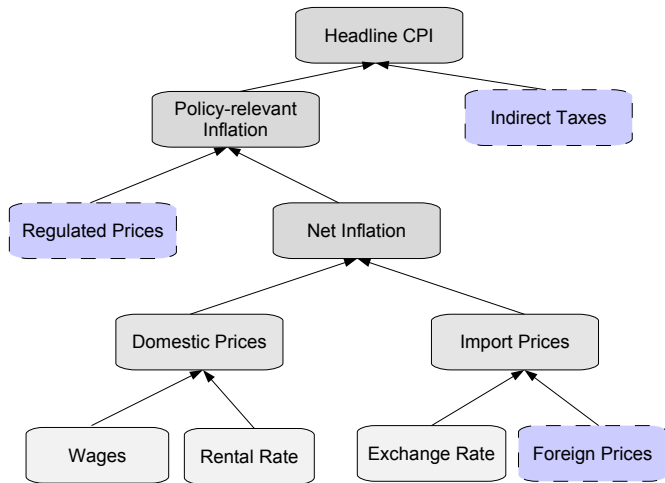
# Model Structure (ii)

Flow of goods & services



# Model Structure (iii)

## Consumption prices – cost structure



Exogenous  
Endogenous

# Model Structure (iv)

## Importance of regulated prices

- ▶ Still important part of overall CPI dynamics
- ▶ CNB targets headline-CPI including regulated prices
- ▶ Due to structural nature of the model, regulated prices require structural interpretation
- ▶ We have tested multiple setups...

## Current setup

- ▶ Explicit treatment of market & regulated consumption goods
- ▶ After regulation shocks cease all goods become 'market' goods
- ▶ Relative prices matter – level drift accommodated
  
- ▶ Scenarios analysis – anticipated/non-anticipated regulated prices shocks with various persistence in expectations

▶ ...figs

# Monetary Policy in the Model

- ▶ Inflation targeting regime via interest rate rule
- ▶ No output-gap in the interest rate rule
- ▶ Forward-lookiness – targeting four period ahead inflation deviation from the target

## Issues:

- ▶ Targeting of headline y-o-y CPI incl. regulated prices...
- ▶ Regulated prices hikes imply net-inflation downward pressures...

## Note:

If you believe in state-of-the art Dynamic New-Keynesian DSGE models, one CANNOT estimate interest rate rules coefficients using single-equation OLS, or so...

# Balanced Growth Path Design (i)

- (i) Nominal shares constant in steady-state  
(i.e. nominal great ratios used)
  - (ii) Multiple sector-specific stochastic trends present
  - (iii) Allows for modelling differential BGP growth of real variables and *trends in relative prices* (e.g. cons/investment)
  - (iv) All trends identified via model-consistent filtering
- 
- ▶ Czech National accounts data – chained indices used
  - ▶ 'Real' volumes are not additive
  - ▶ Working with nominal shares is intuitive!

# Balanced Growth Path Design (ii)

## Trade Openness Issues

- (i) Constant nominal expenditure shares are not enough for SOE
- (ii) Not only value added is traded in reality
- (iii) Pronounced trend in *trade openness*  
(nominal imports to GDP trend difficult to capture in SOE model)
- (iv) Openness-technology introduced to account for increase in trade-openness
- (v) Important for model-consistent filtering to avoid bias

▶ Import share



# Forecasting and Policy Analysis with the Model

- (i) **Since Jan 2007 shadow forecasts being produced and provided to the board**
- (ii) Model built and housed within the Forecasting Division
- (iii) Story of the forecast compared to CNB's Integrated forecast
- (iv) Forecasting and Policy Analysis System (FPAS) for DSGE developed and being developed by the team



## REMINDER

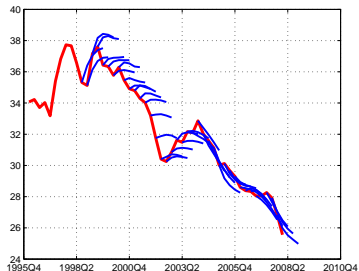
Starting from July 2008 forecast, the new structural model **g3** is replaced the QPM and became the main forecasting tool of the CNB.

# Model Calibration and Evaluation

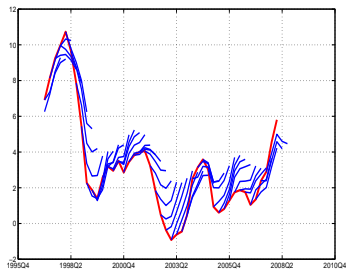
- ▶ Getting model to data is a priority
- ▶ Calibration in a wide sense used
  - ▶ Great ratios and stylized facts matching
  - ▶ Expert knowledge within the forecasting dept.
  - ▶ Identifiability checks & estimation exercises
  - ▶ Separating *dynamic* and *long-run* sets of parameters
- ▶ Model evaluation
  - ▶ Impulse-response analysis, GSA, ...
  - ▶ Time- and *frequency-domain* evaluation
  - ▶ In-sample recursive filtering and forecasting
  - ▶ Evaluation of *story-telling* quality of the model using past data using *structural shocks decomposition*
  - ▶ ...

# Model Calibration and Evaluation (ii)

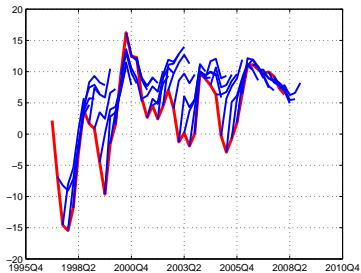
Exchange-rate CZK/EUR (T+4)



Consumer Inflation, YoY % (T+4)



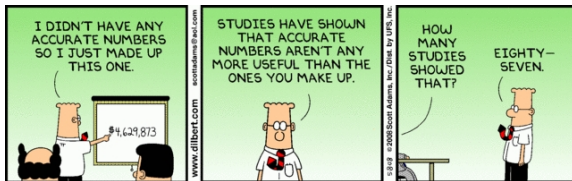
Gross Investment (T+4)



# Using the Model in the Forecasting Process (i)

1. Initial state of the economy identification and interpretation
2. Forecast conditioned on exogenous variables and judgement
3. Forecast dynamics decomposition and scenarios analysis
4. Decomposition of changes between successive projections

Forecasting round structure broadly similar to QPM's forecasting round



# Using the Model in the Forecasting Process (ii)

## Identification:

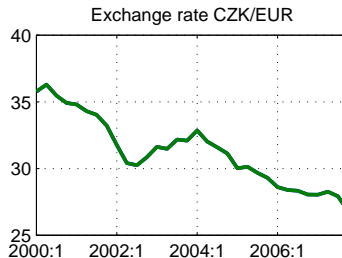
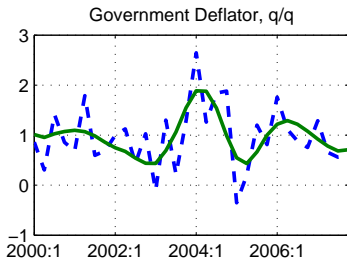
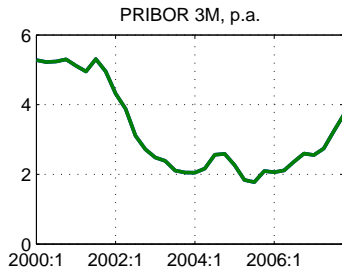
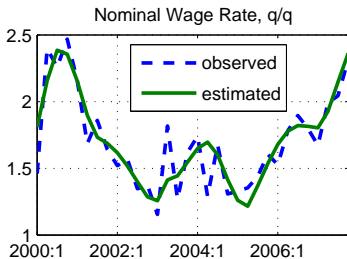
- ▶ Filtering using the complete model structure
- ▶ Concept of *measurement errors* used
- ▶ All unobserved technology-trends identified here
- ▶ Observables may be non-stationary

## Interpretation:

- ▶ We interpret identified structural shocks, devs from BGP, . . .
- ▶ Analysis of revisions in filtered variables (*interpreting news*)
- ▶ We communicate using real marginal costs 'gaps', changes in technology processes, . . .

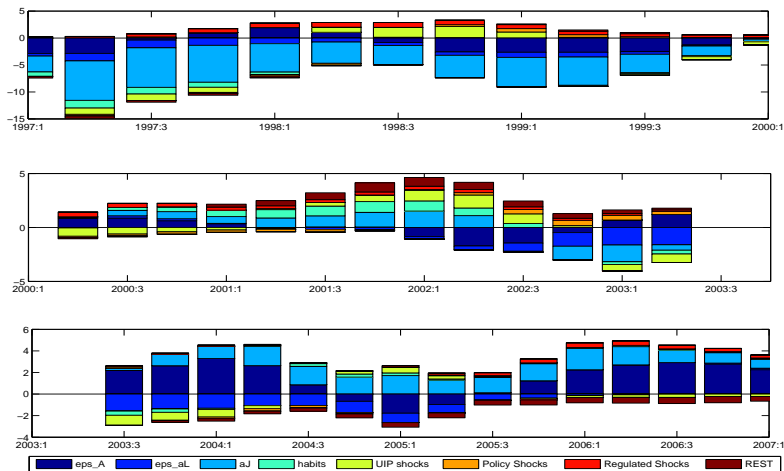
# Using the Model in the Forecasting Process (iii)

Initial conditions identification. . .



# Using the Model in the Forecasting Process (iv)

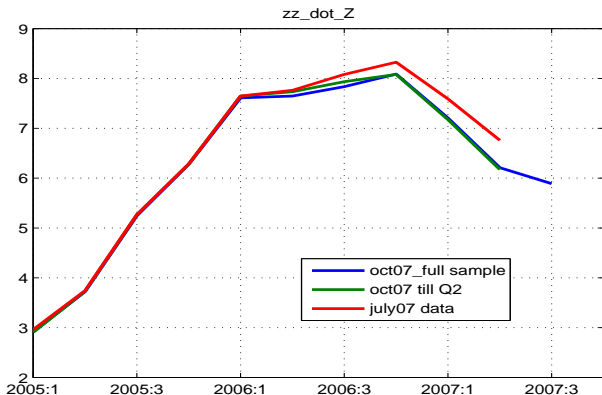
## Interpretation of initial conditions and the economic story



# Using the Model in the Forecasting Process (v)

## Revisions of technologies – decompose in 3 steps

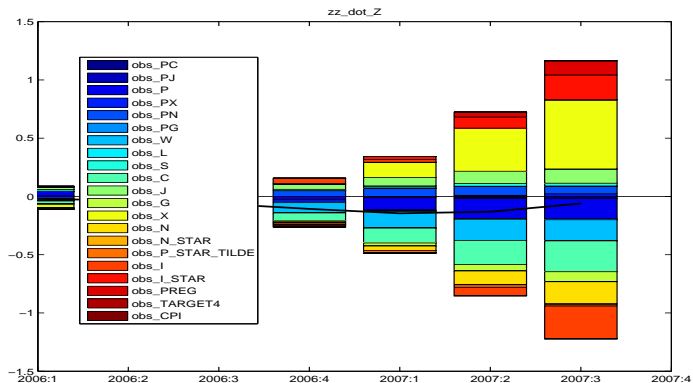
1. Change in the data (identical range)
2. Contribution of the new quarter observation (expanded range)
3. Change in the model





# Using the Model in the Forecasting Process (vi)

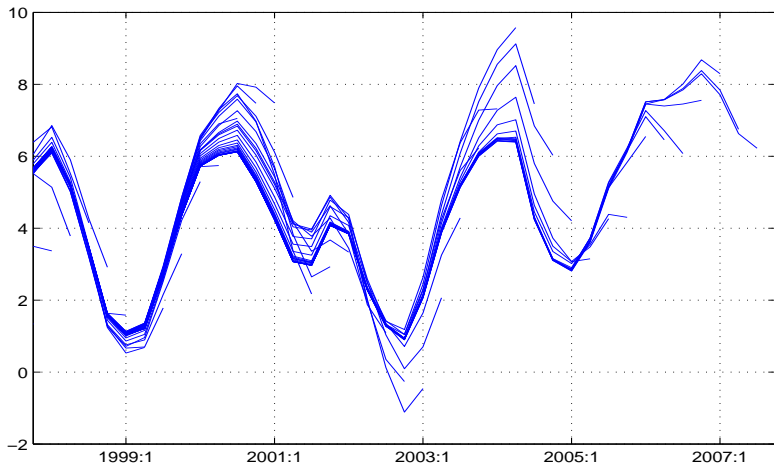
Decomposing filtering step into factors. . .



Note: **artificial run**

## Using the Model in the Forecasting Process (vi-b)

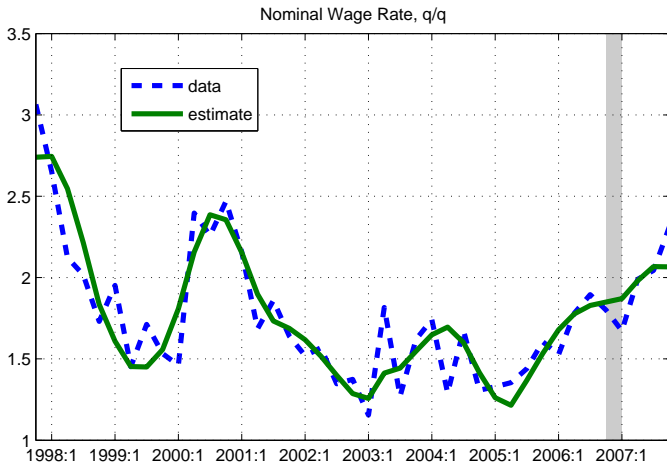
Can we tell when the party is over...? A signal extraction aspect of monetary policy...



# Using the Model in the Forecasting Process (vi-c)

Simple example: nowcasting & data checks

Imagine nominal wage rate would be unobserved in 2007:1–2007:4, we can obtain model-consistent estimate conditioned on other series...



# Using the Model in the Forecasting Process (vii)

The forecast uses endogenous interest-rate rule  
(unconditional fcast)

Forecast simulation conditioned mainly on

- ▶ Foreign policy variables – policy rate, inflation, foreign demand
- ▶ Inflation target of the CNB
- ▶ Near Term Forecast (NTF) of *regulated prices*
- ▶ Near Term Forecast of nominal government spending
- ▶ Projection of technology trends. . .

Issues:

- ▶ We may condition using mix of anticipated and unanticipated shocks
- ▶ What is the best practice. . . ?

# Using the Model in the Forecasting Process (viii)

## Imposing judgement into the model

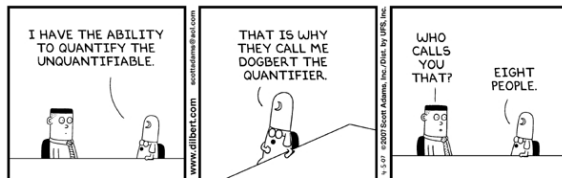
- ▶ We exogenize variables and endogenize shocks
- ▶ We use exogenization both with anticipated and unanticipated shocks
  
- ▶ Stimulates discussion with sectoral experts by which structural shocks the desired path of exogenized variables is to be obtained. . .
- ▶ Also useful for interest rate path conditioned simulations (unanticipated and anticipated simulations differ, modest pol. intervention issues, etc.)
  
- ▶ Judgement imposed in determining the role of measurement errors
- ▶ Assumptions on technology trends evolution is important

# Using the Model in the Forecasting Process (ix)

## Scenarios Analysis

### Forecast dynamics decomposition and analysis. . .

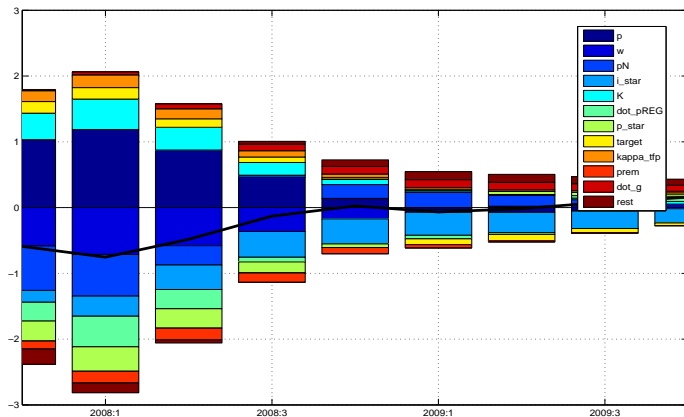
- ▶ Tools created to analyze linear and non-linear models
- ▶ Different from scenario analysis – decomposition into factors
- ▶ We use it for
  - ▶ Decomposition of the simulation dynamics
  - ▶ Comparison of alternative scenarios by factors
  - ▶ Comparing successive forecasts (forecast update)



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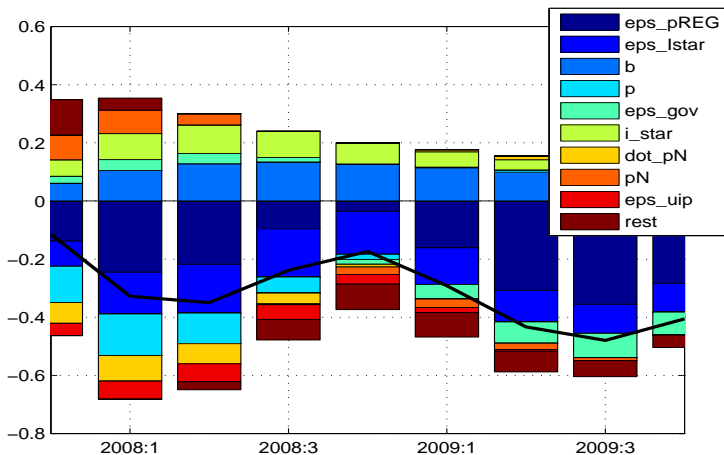
# Using the Model in the Forecasting Process (x)

Decomposition of IR dynamics. . .



# Using the Model in the Forecasting Process (xi)

Decomposition of Oct07 - Jul07 forecast difference...





# Communication of the Forecast and the Model

## Communication of the forecast

- ▶ Compatible reporting with official CNB forecast
- ▶ Not all technical & analytical details communicated (yet)
- ▶ Communication in terms of the *economic story* and (circular)-causalities
- ▶ Highlights of the story:
  - ▶ real marginal costs in cons., intermediates, etc. wrt BGP
  - ▶ development and revision of technology processes and its effects on inflation, etc.

## Communication of the modelling framework

- ▶ Series of seminars for colleagues & members of the board initiated
- ▶ **Series of technical and non-technical papers coming soon or later...**

# Switching from QPM to g3 – a Challenge



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- ▶ **Personal aspects** – g3 team (3 pers) instructs & help QPM team (5 pers) to get familiar with the model
- ▶ **Organisational aspects** – forecasting process broadly similar, new tools, new form of a Situation report is being created
- ▶ **Communication issues** – the g3 model does not involve output gap and time-varying “qpm-like” equilibria, new terms & techniques, larger emphasis on filtering

## How to Build a Structural Core Policy in Your Spare Time I.

- (i) Building a core policy model and a FPAS is not a ‘one-shot, single-research-paper game’
- (ii) It is difficult to start with a beast with hundreds of equations
- (iii) In our humble experience, parsimony is a virtue
- (iv) Build an infrastructure and tools to your model
  - ▶ flexible modelling & scripting environment
  - ▶ database management
  - ▶ automated reporting tools
- (v) Ideally, you like economics, econometrics and programming

## How to Build a Structural Core Policy in Your Spare Time II.

Czech republic is not USA – like it or not. . . so the literature on US is not always informative for us

(i) In contrast with literature we worked on:

- ▶ Multisectoral nominal-shares BGP, trends in rel. prices
- ▶ Increase in trade openness. . .
- ▶ Trend-cycle interactions, regulated prices & indirect taxes
- ▶ Use of frequency-domain methods and GSA to learn about the model
- ▶ Intensive use of filtering & signal processing theory

(ii) Academics need not to forecast, but we do. New tools needed!

- ▶ Decomposition of the filter, analyzing revisions & news
- ▶ Numerical decomposition of the forecast into bits and pieces
- ▶ Mixing anticipated & unanticipated shocks
- ▶ Decomposition of forecast differences
- ▶ ...

## How to Build a Structural Core Policy in Your Spare Time III.

Some software comes also useful. . .

(i) What we are using. . .

- ▶ **Win XP** and **GNU/Linux**
- ▶ **Matlab** – programmable, fast, easy-to-learn, extensible by C/C++ or Fortran, allows for OOP
- ▶ **T<sub>E</sub>X** – free, programmable, extensible, used for automated reporting
- ▶ **SVN** (Subversion) – powerfull version control system, free

(ii) In case Matlab is unreachable for you. . .

- ▶ **Octave** – free Matlab-clone, very similar syntax, easy to port most Matlab scripts to Octave
- ▶ **Python** – free, powerfull and extremely flexible, full-blown OOP programming environment, *SciPy* (Scientific Python) matrix manipulations similar to Matlab

Ideally, the software environment (i) has a nice language, support for matrices and speed, (ii) interactive shell, (iii) object-oriented featurers. . .

## How to Build a Structural Core Policy in Your Spare Time IV.



photo by rudolf schuba

# Some Conclusions

- ▶ Structural economic models within a DSGE framework are extremely useful tools for forecasting and policy analysis
- ▶ Behavioral foundations and explicit derivation offers economic insight, extensibility and consistency (no free lunch. . . almost)
- ▶ Using the model for forecasting and policy is different from writing a research paper (not easier, not harder. . . just different)
- ▶ If the the ultime criterion is a one-step ahead forecast RMSE, then structural models are not needed

Thank You for Your Attention

**micah.andrle(at)cnb.cz**

M. Andrle, O. Kamenik, J. Vlcek & T. Hledik:  
Putting in Use the New Structural Model of the CNB, ver. March 2008  
(still being updated, available upon request)

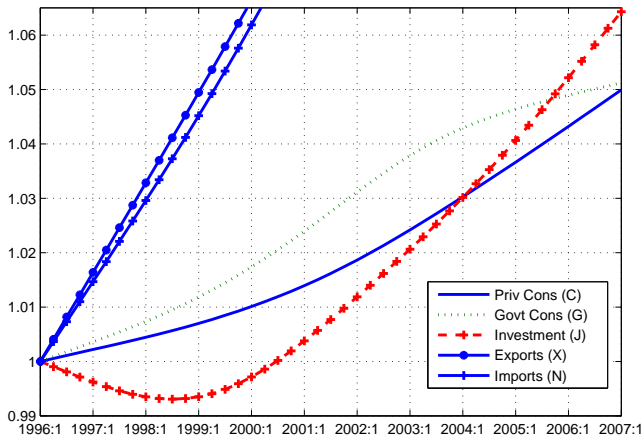


# Jump Slides

# Some Emerging Country Facts

Need to capture medium- to long-run growth stylised facts

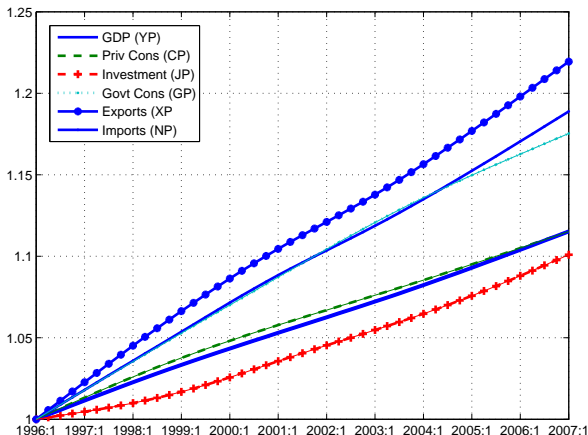
*Trends of Real Volumes*



# Some Emerging Country Facts

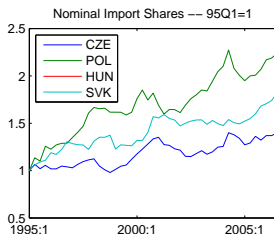
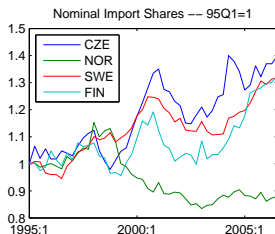
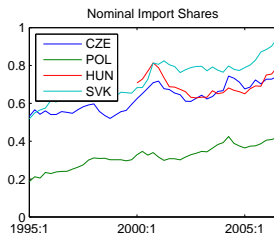
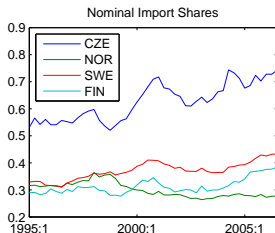
Need to capture medium- to long-run growth stylised facts

*Trends of Nominal Data (values)*



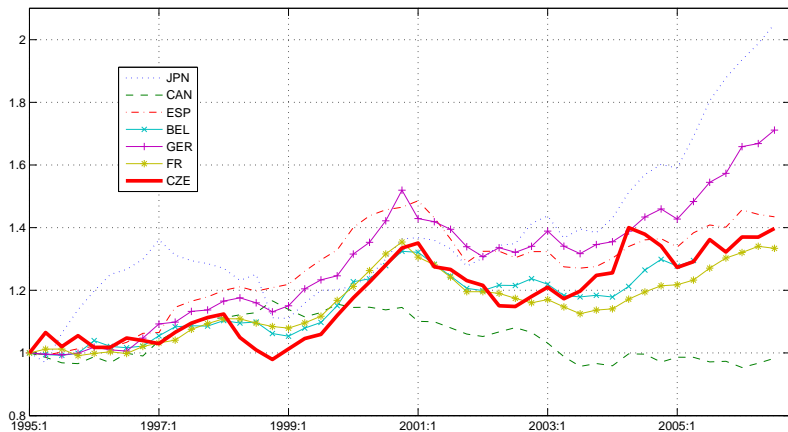
# Some Emerging Country Facts

## Nominal Import Shares



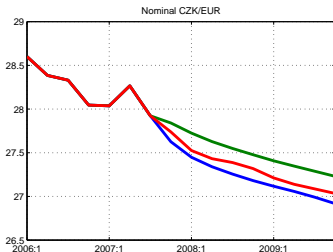
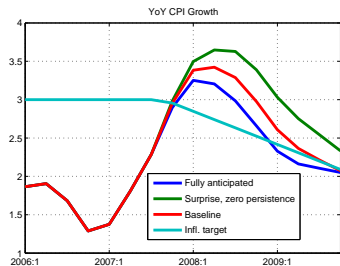
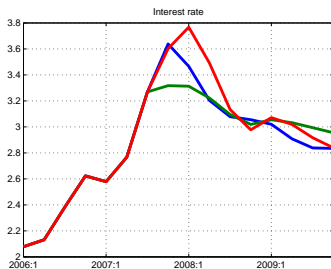
# Some Emerging Country Facts

*Nominal Import Shares (normalised, 95=1)*



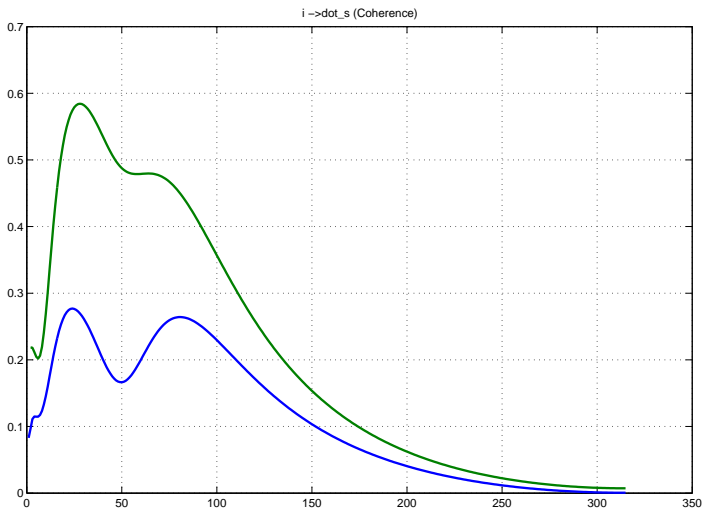
# Regulated Prices Scenarios

Importance of regulated prices [◀ ... back](#)



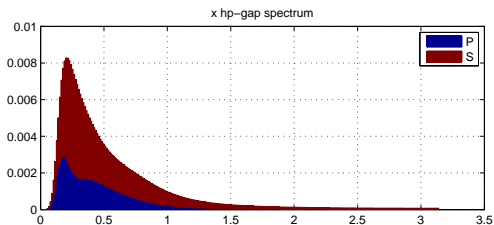
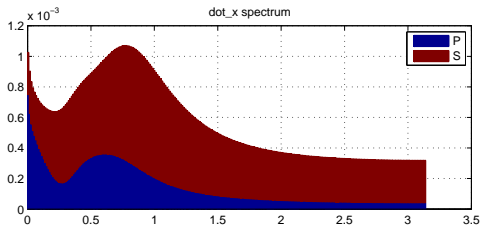
# Trend/Cycle Interactions (i)

Switching-off some permanent shocks affects business-cycles frequencies



## Trend/Cycle Interactions (ii)

Permanent shocks pervade into business cycle frequencies. . . !  
viz Andrle (2008)







# Czech Import Share

