NBP *Economic Institute*

Fan charts of inflation and GDP growth projections

Bureau of Macroeconomic Forecasts

8 December 2008

Outline

1. Relevance of analysis of the uncertainty of forecasts/projections for the monetary policy
2. Calculation and presentation of uncertainty
3. Existing method of calculating density distributions of forecasts
4. New method of calculating density distributions of forecasts

Relevance of forecasts/projections for the monetary policy (1)

Rationale for publishing inflation forecasts at banks using DIT strategy:

- Easier communication of the central bank-made decisions with the public
- Building up central bank's credibility
- Anchoring inflation expectations – relevance of inflation expectations for the monetary transmission mechanism
- Increasing the resources of entities' information about the economy

Relevance of analysis of uncertainty of forecasts/projections for the monetary policy (2)

Rationale for publishing uncertainty related to inflation forecast:

- Communication of the existing risk of the forecast
- Enables to shift the focus from the central path (of which probability = 0) towards medium-term risks
- Shows whether the balance of risks is on the upside or on the downside
- If central bank loss function is non-symmetrical, distribution of risks is relevant for decisions of monetary authorities
- As a result, monetary policy gets more transparent and communication with the environment is easier which supports building up central bank's credibility

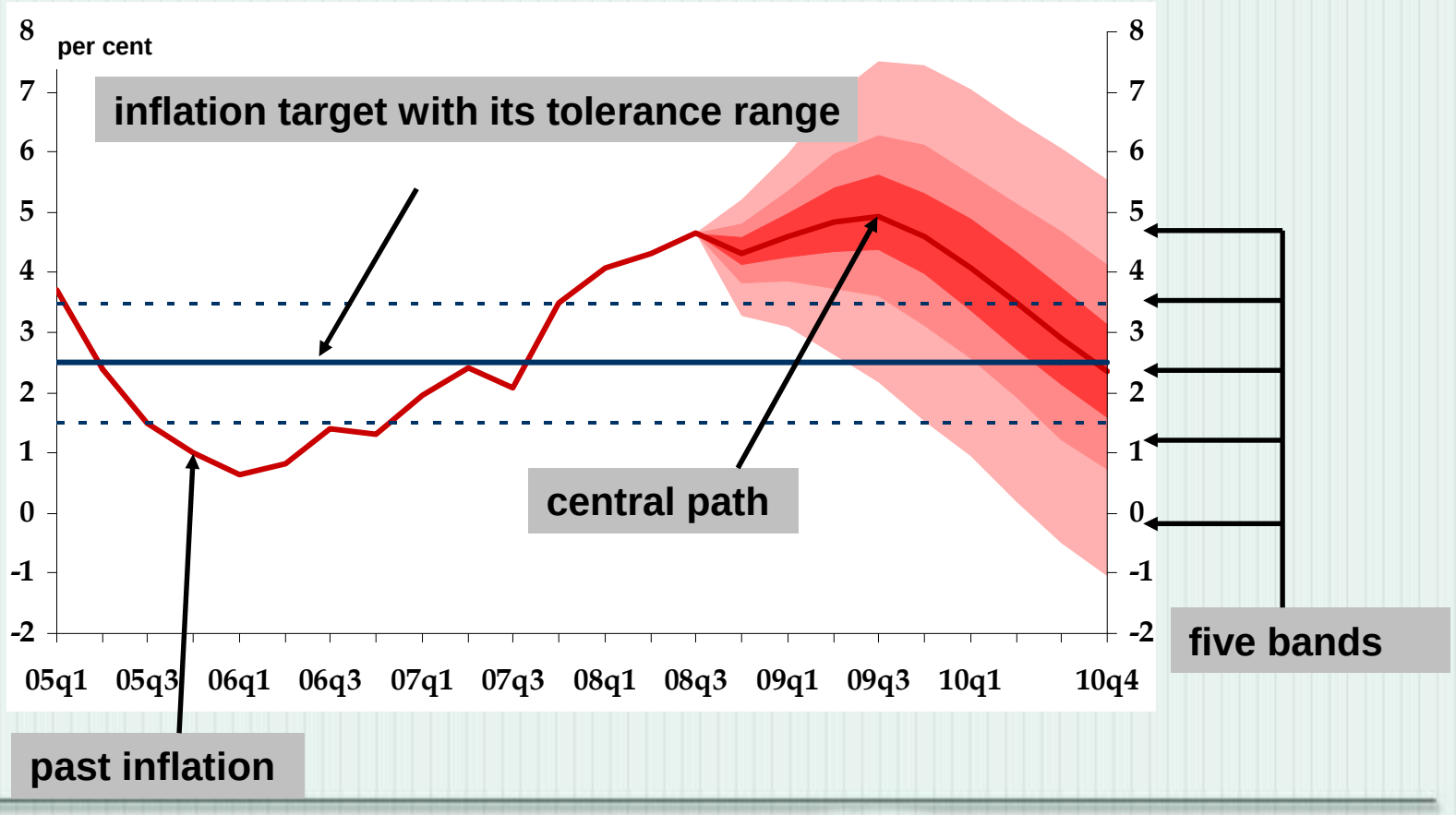
Calculation and presentation of uncertainty (1)

Sources of uncertainty:

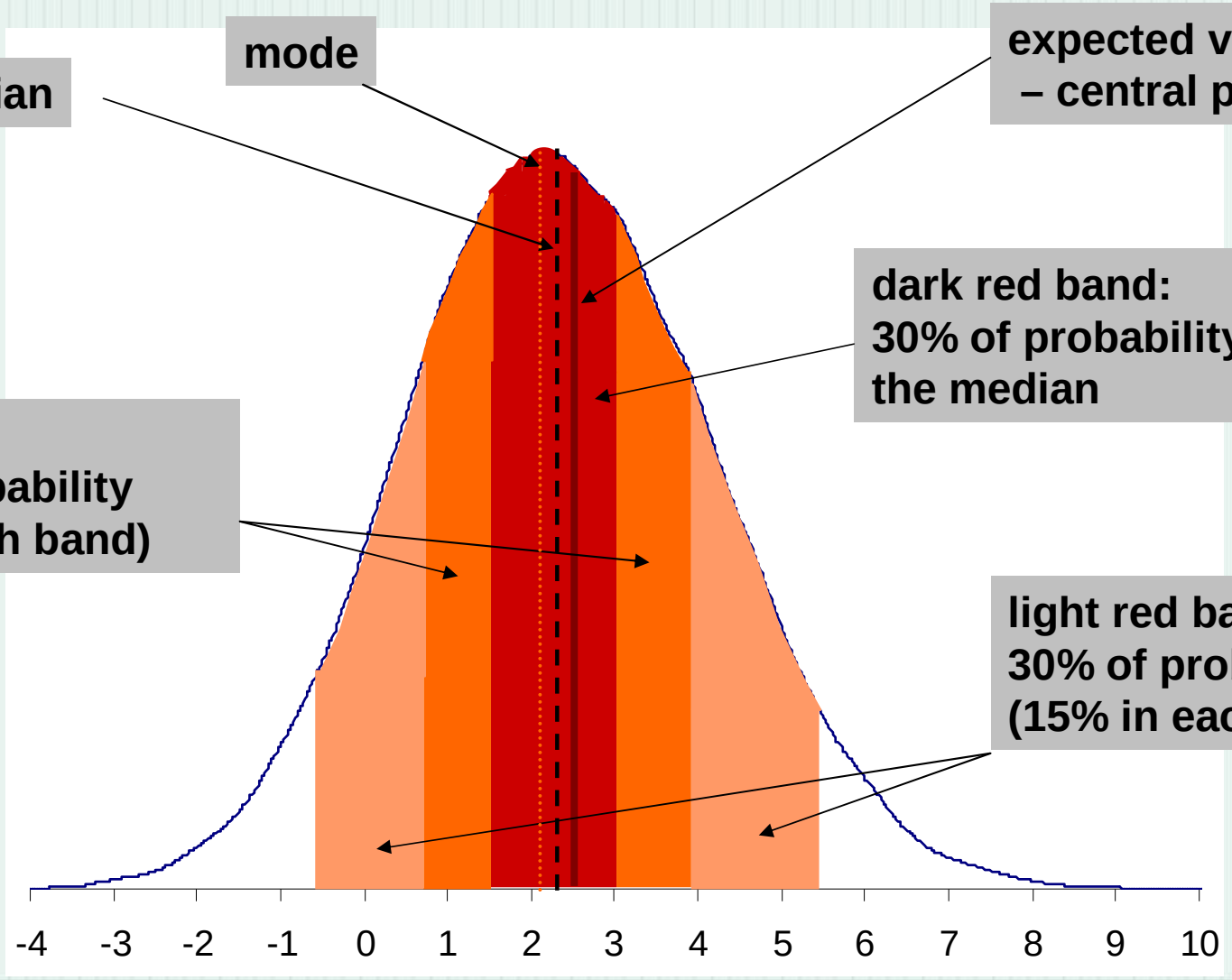
- Change in parameters (i.e. structural changes)
- Incorrect form of the model
- Estimation uncertainty (i.e. parameters are estimated with uncertainty)
- Errors in estimation (measuring, forecasting) of variables:
  - Uncertainty of the starting point
  - Uncertainty of exogenous variables
  - Unjustified assumption of some variables as exogenous variables
- Error of the random component

Calculation and presentation of uncertainty (2)

- Fan chart is a clear method of visualization of quantifiable uncertainty

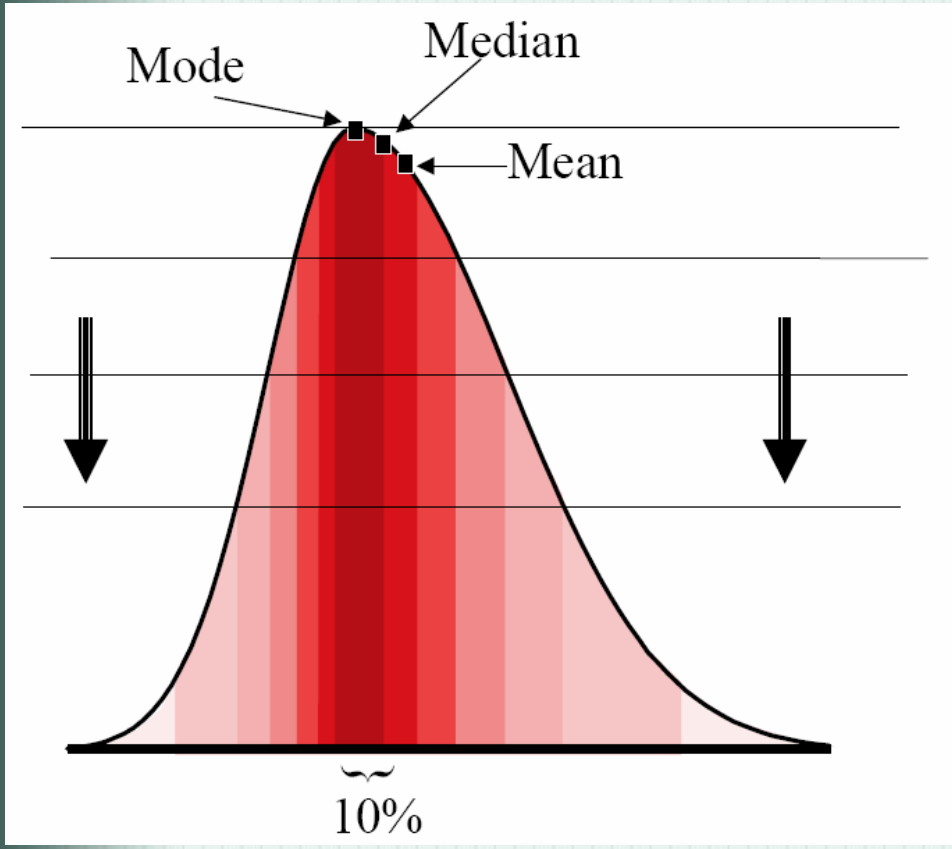


Calculation and presentation of uncertainty (3)



Calculation and presentation of uncertainty (4)

- Fan chart may also be constructed in a different way



Source: P. Robinson, *The fan chart*, The Bank of England

- Each shade includes 10% of total probability
- Width of bands is minimised
- In this method, probabilities for one-colour bands (below / above the median) do not have to be equal (5% / 5%)

Calculation and presentation of uncertainty (5)

Uncertainty of forecast may be determined on the basis of:

- Model describing the economy (analytical description or description based on stochastic simulations)
- Past forecast errors
- Expert opinions
- Market expectations
- Dispersion of forecasts

Calculation and presentation of uncertainty (6)

- Method of preparing fan charts in selected central banks

Central Bank	Fan chart* width	Variables	Method
Chile	0.9	inflation	Based on past forecast errors taking into account subjective assessments of uncertainty developments.
Czech Republic	0.9	inflation, GDP, interest rates	Based on smoothed, past forecast errors.
Israel	0.66	inflation, interest rates	Uncertainty results from shocks to endogenous variables whose distribution is based on their past developments.
Slovakia	0.9	inflation	Based on past forecast errors.
Euro area	-	HICP inflation, GDP and its components	Band forecast – point forecast adjusted for double average error in historical forecasts, no fan chart.

* Probability that outcomes will range between the smallest and the largest percentile of variable distribution in each period.

Calculation and presentation of uncertainty (7)

Central Bank	Fan chart* width	Variables	Method
Sweden	0.9	inflation, GDP, interest rates	Based on past errors.
United States	dispersion of the Committee's forecasts	GDP, unemployment rate, inflation, core inflation	Based on forecasts of members of the Federal Open Market Committee (7 members of the Federal Reserve Board + Presidents of the Federal Reserve Bank): min-max band is given and a band without three lowest and three highest forecasts
Hungary	0.9	GDP, inflation	Based on past forecast errors taking into account subjective assessments of uncertainty developments.
Great Britain	0.9	inflation, GDP	Based on past forecast errors taking into account subjective assessments of uncertainty developments.
Australia, Canada, New Zealand, Switzerland			Distribution of probability is not published.
* Probability that outcomes will range between the smallest and the largest percentile of variable distribution in each period.			

Source: Official publications of central banks, correspondence with authors of publications.

Method of calculating density distributions of forecasts used at the NBP until June 2008

- Method used at the NBP since the publication of the ECMOD-based projection, i.e. since May 2005
- Method based on stochastic simulations from the ECMOD/NECMOD model (no history of forecasts)
- Takes into account two types of uncertainty:
  - Uncertainty of expert-determined paths of exogenous variables
  - Error of the random component of equations

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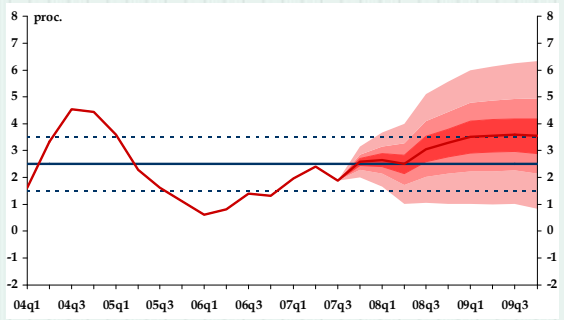
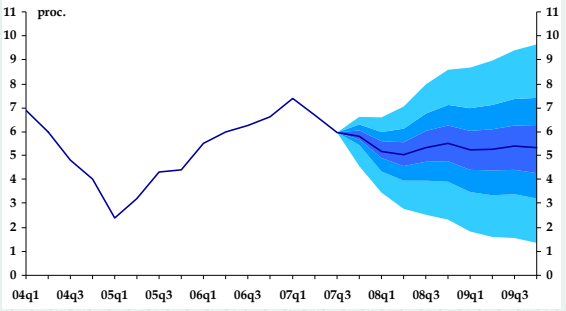
Stochastic simulations

Forecasts of exogenous variables (with their density distributions)

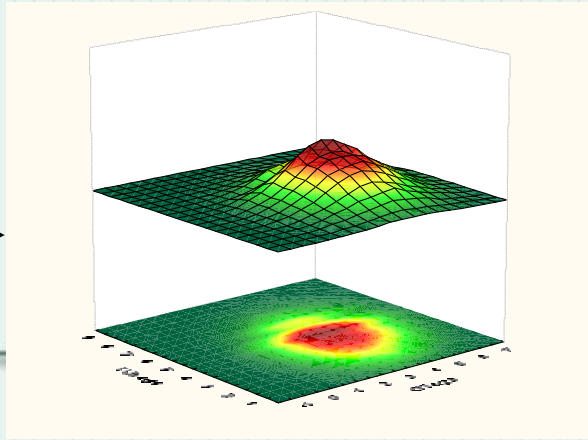
Uncertainty related to endogenous variables (residuals of equations)

Forecasting model (N)ECMOD
(>10 000 of repetitions)

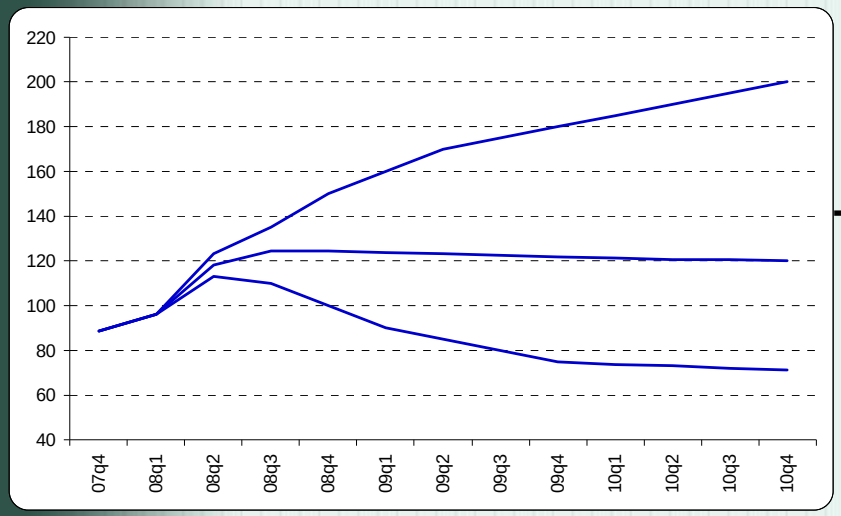




Possibility to construct fan charts for other endogenous variables



Simulating paths of exogenous variables



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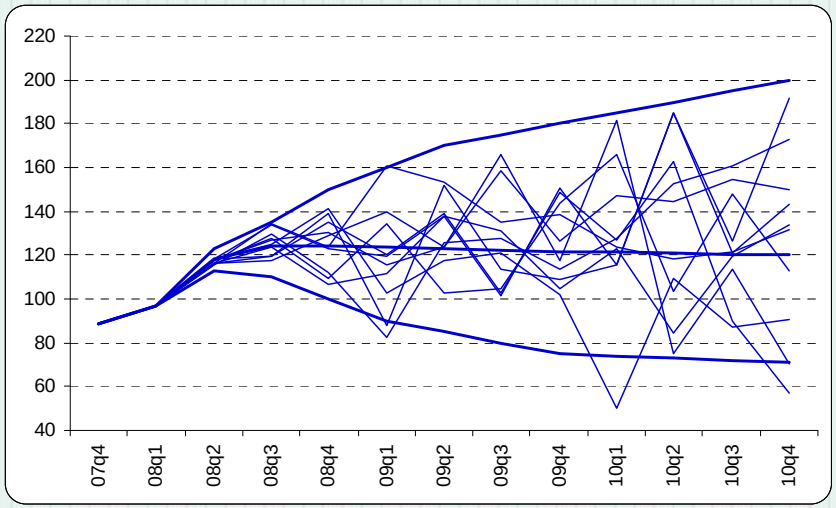
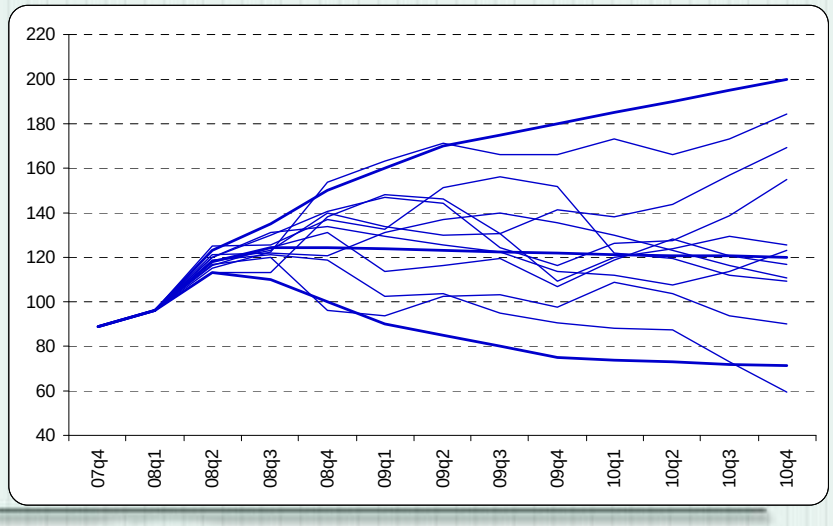
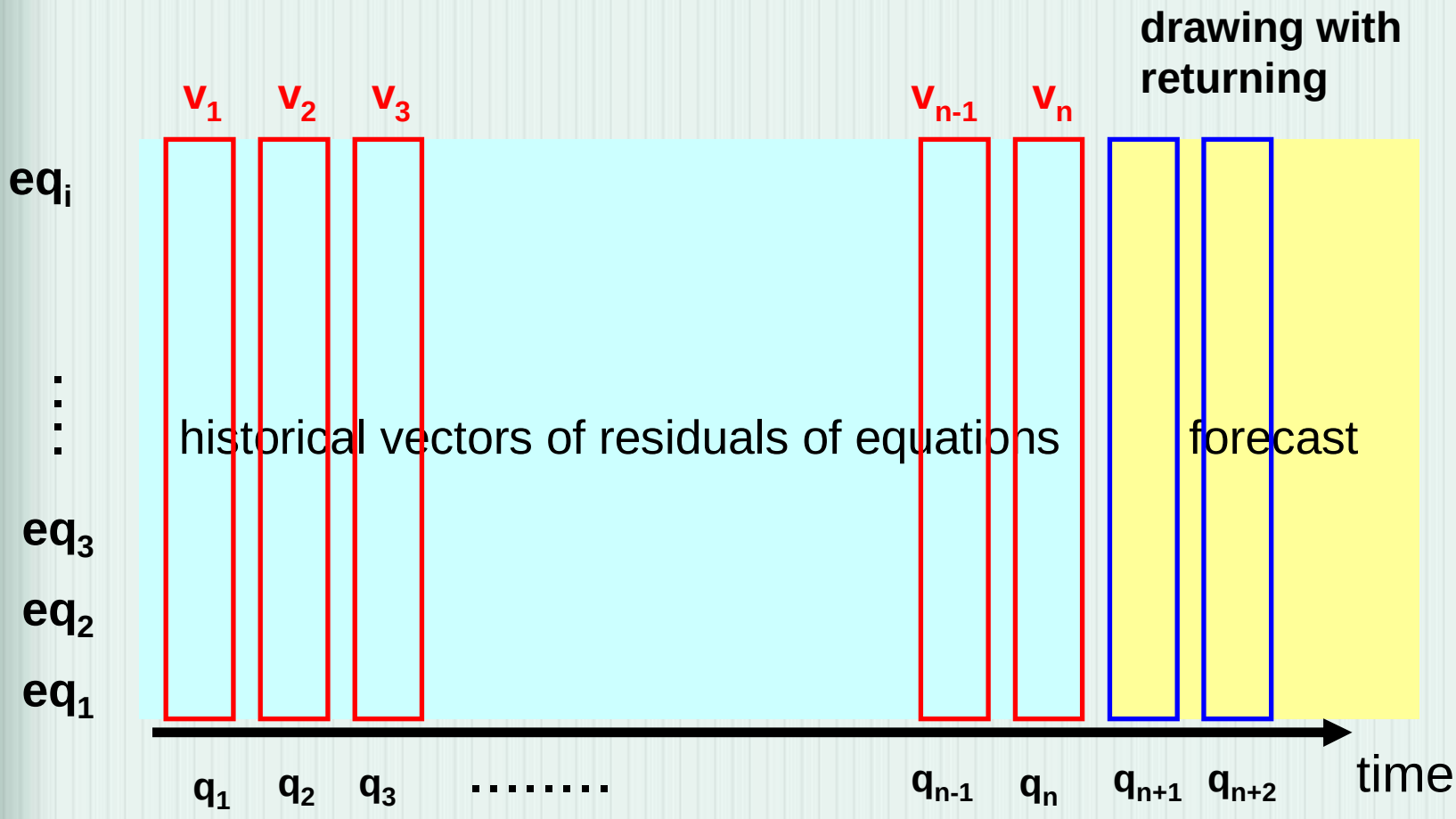




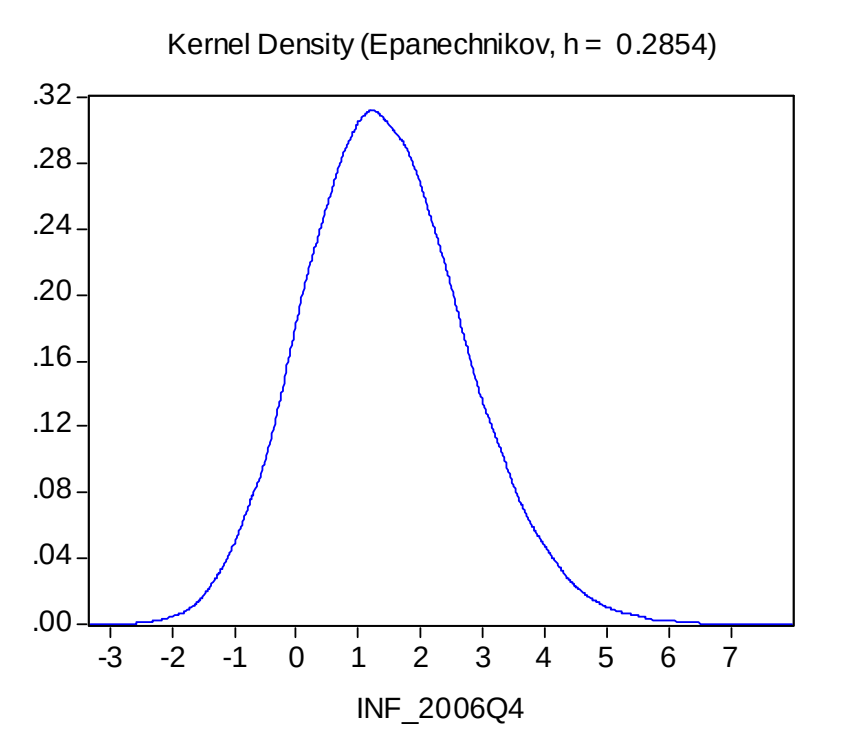
Uncertainty related to endogenous variables

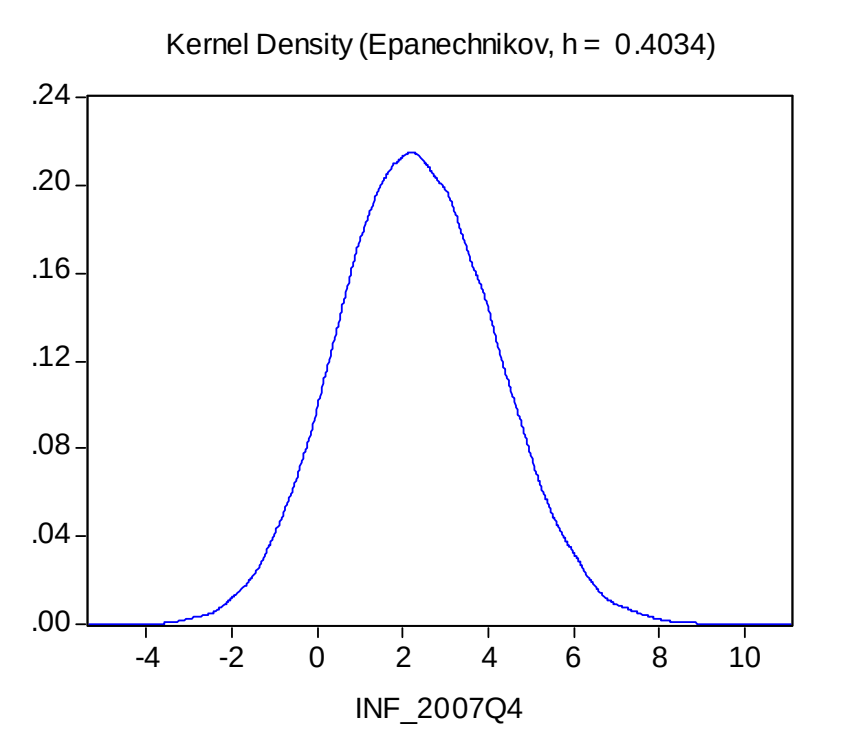
- Based on residuals of equations of the model
- Bootstrap procedure, i.e. in each period of each stochastic solution a randomly chosen historical vector of residuals of the model is added to equations of the model
- Such an approach ensures preserving historical variances and co-variances of residuals of the model
- There is no need to preserve residual autocorrelations as for correctly specified equations, residual autocorrelations should be close to 0.

How bootstrapping works



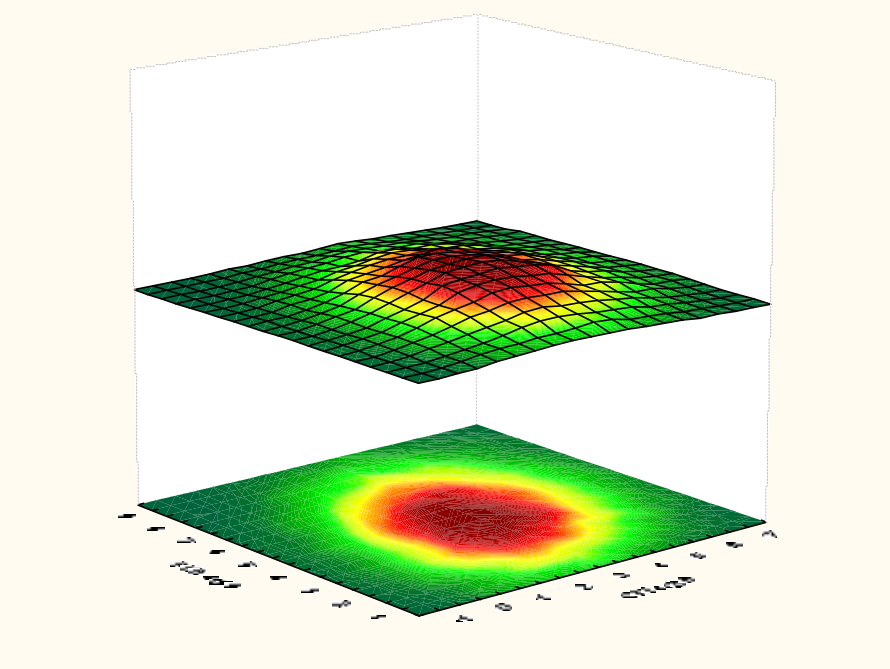
Examples of density distributions obtained with the use of the previous method

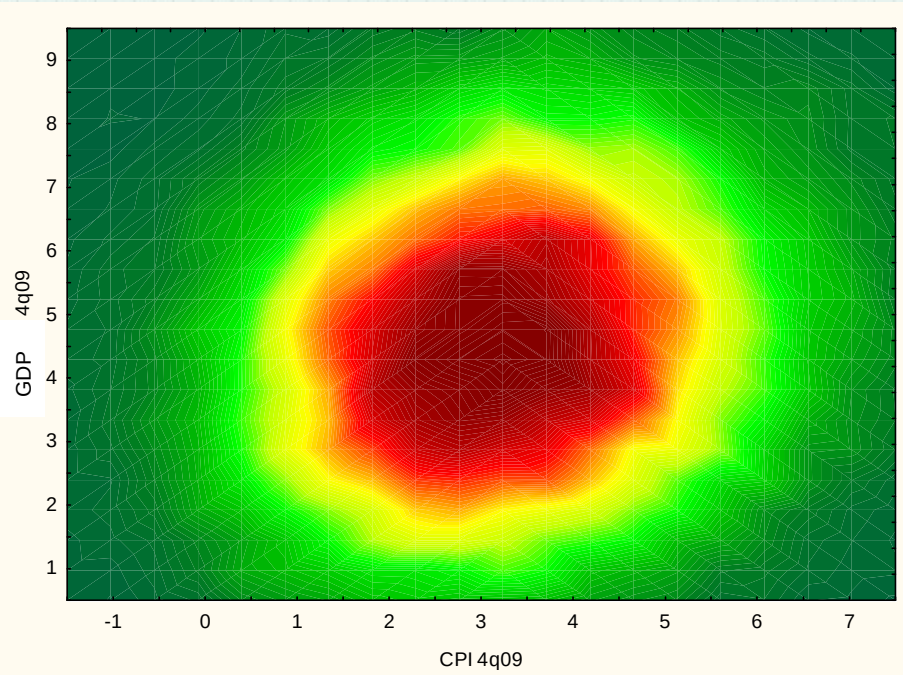




Joint density distributions

- The previous method of uncertainty estimation makes it possible to derive joint density distributions for inflation and GDP growth and, if needed, for other endogenous variables





Advantages of the previous method

- Uncertainty is estimated on the basis of the same model which is used for constructing the projection
- Sources of uncertainty of the projection are precisely determined
- Decomposition of uncertainty is possible
- Uncertainty depends on the current uncertainty of exogenous variables
- No history of forecasts from the model is needed

Disadvantages of the previous method

- Significant sensitivity to the form of the forecasting model
- Possible burden on uncertainty estimation
  - the role of experts intentionally improving the quality of the forecast
  - limited sources of uncertainty
  - data uncertainty is not accounted for
- Independence from past forecast errors

Method of calculating density distributions of forecasts used at the NBP since October 2008 (1)

Postulates:

- Width of fan chart consistent with the expert-adjusted, historical forecast errors from the ECMOD/NECMOD model
- Fan chart should reflect changes in uncertainty between forecasting rounds
- Fan chart is constructed under the assumption of exogenous monetary policy
- Revisions of variables (national accounts) are accounted for

Method of calculating density distributions of forecasts used at the NBP since October 2008 (2)

Solution:

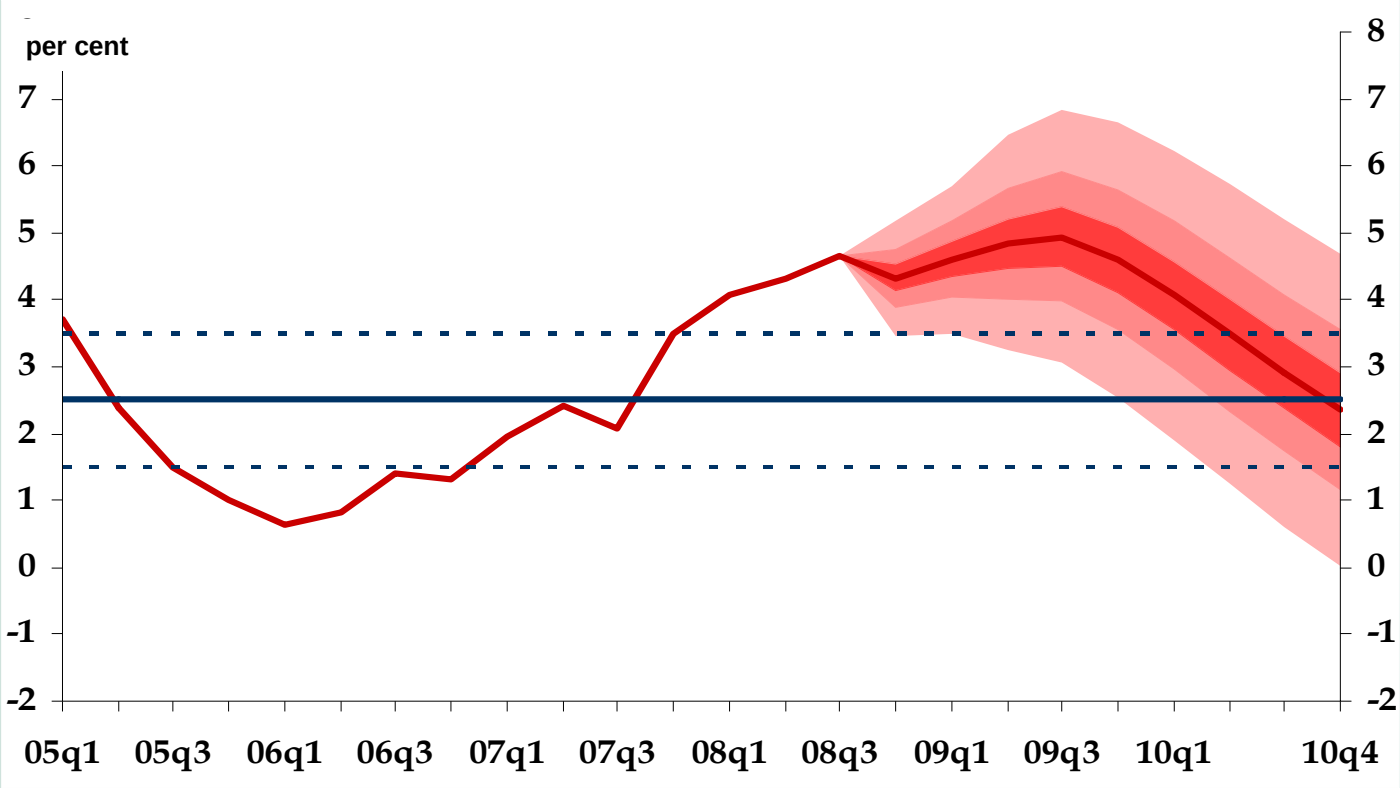
- Historical errors from the ECMOD/NECMOD model determine **historical** uncertainty of inflation and GDP **forecasts**
- Based on the simulation from the NECMOD model, adjustment of the historical uncertainty of the forecast is determined to ensure estimation of the **current** uncertainty of inflation and GDP **projections**

Method of calculating density distributions of forecasts used at the NBP since October 2008 (3)

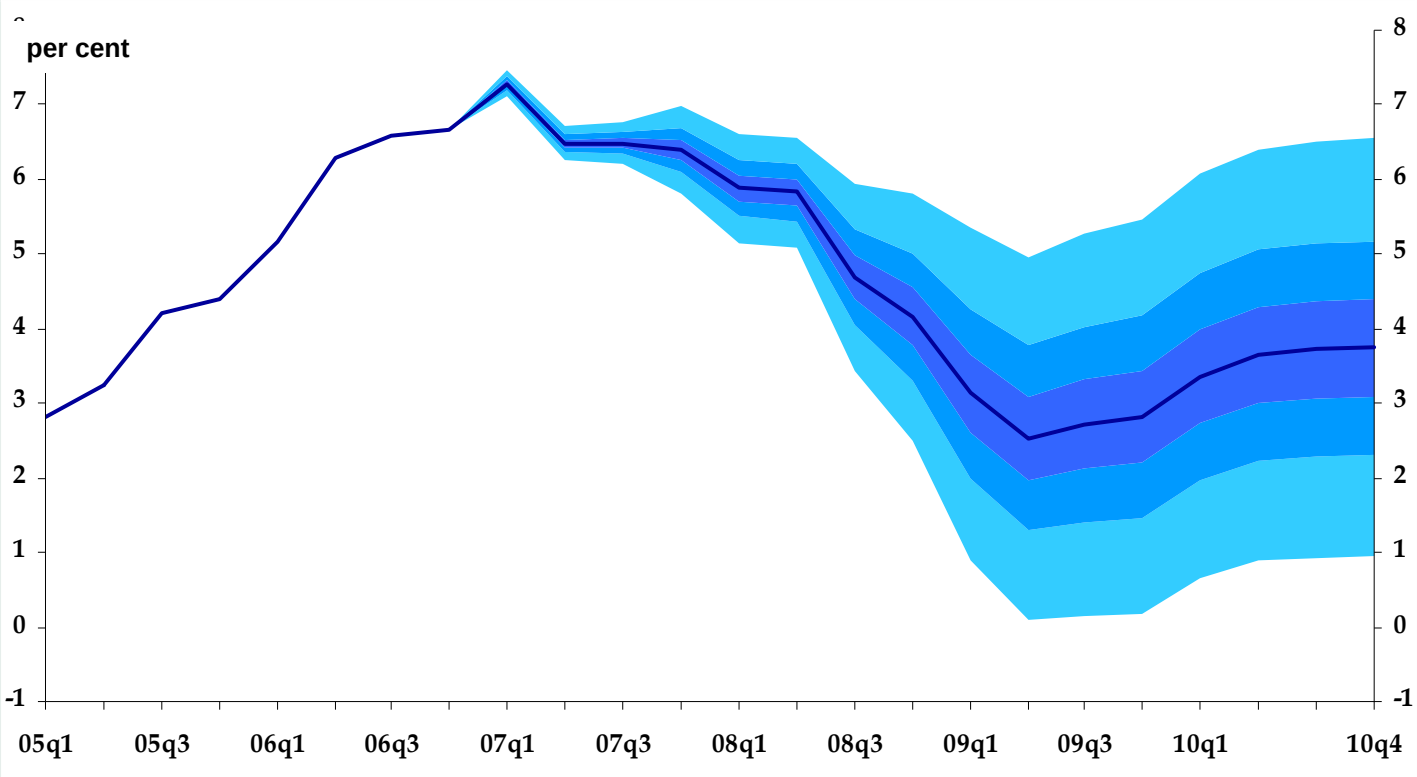
Procedure:

1. Calculating distributions of past errors of GDP and inflation forecasts
2. Simulations from the NECMOD model
3. Calculating current uncertainty of GDP and inflation projections

Step 1: Calculating distributions of historical errors of forecasts – CPI inflation



Step 1: Calculating distributions of historical errors of forecasts– GDP growth



Step 2: Simulation from the NECMOD model: specifying the paths of exogenous variables (1)

Postulates:

- Expected value consistent with central paths given by experts
- Preserved autocorrelation of variables observed in the sample
- Preserved cross-correlations of shocks between particular variables
- Variables simulated in two variants:
  - with historical uncertainty
  - with current uncertainty

Step 2: Simulation from the NECMOD model: specifying the paths of exogenous variables (2)

- List of exogenous variables in the new method*:
  - world prices of oil,
  - world prices of natural gas,
  - world prices of coal,
  - world prices of food,
  - GDP growth abroad,
  - GVA deflator abroad,
  - foreign interest rates,
  - proportion of the number of persons working in agriculture to the number of the economically active (in Poland).

* List of shocked exogenous variables may change in future prognostic rounds.

Step 2: Simulations from the NECMOD model (3)

- Aim: Calculate adjustment, i.e. impact of:
  - changes in the assessment of uncertainty of exogenous variables,
  - assumption of exogeneity of monetary policy

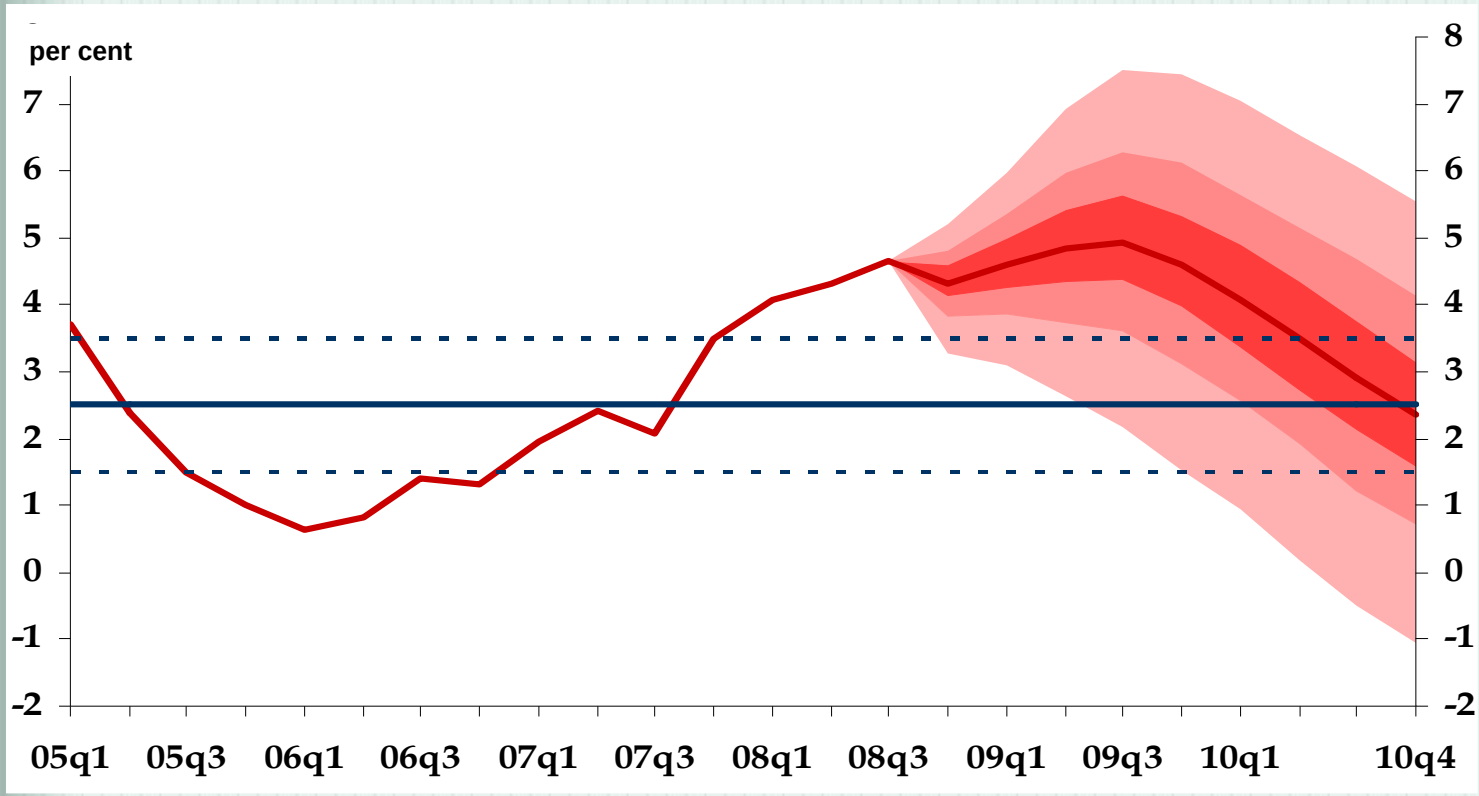
  on uncertainty of GDP and inflation forecasts.

- Procedure: Two variants of simulation:
  - historical uncertainty of exogenous variables, endogenous interest rates (Taylor's rule),
  - current uncertainty of exogenous variables, exogenous interest rates

Step 3: Calculating current uncertainty of GDP and inflation (1)

Fan chart based on past forecast errors is subject to adjustment based on the NECMOD model simulations, taking into account the assumption of exogenous nature of interest rate and changes in the risk of exogenous variables forecasts

Step 3: Calculating current uncertainty of CPI inflation (2)



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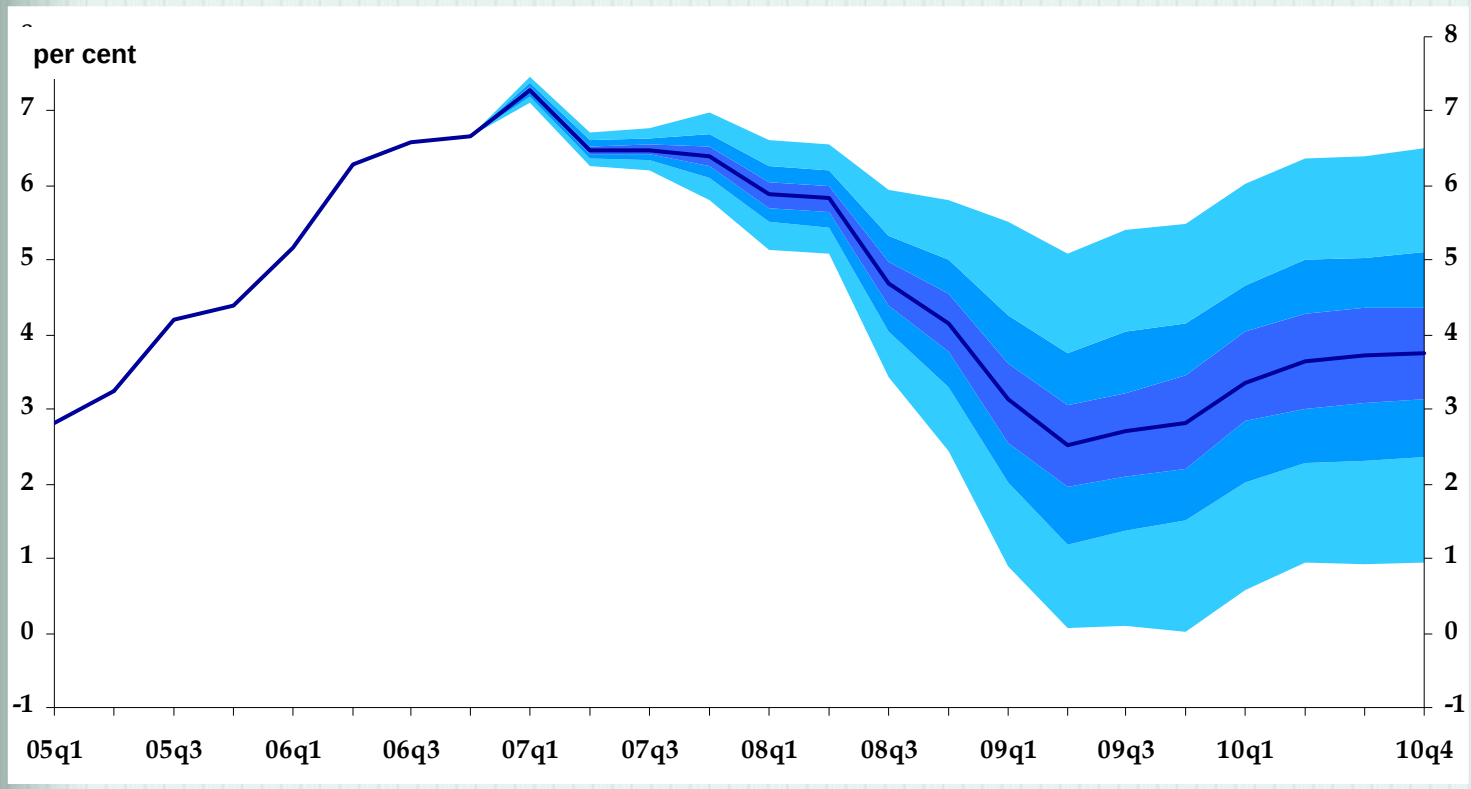
Step 3: Calculating current uncertainty of GDP growth (3)



Step 3: Calculating current uncertainty of GDP and inflation (4)

Outcomes in the last forecasting round:

- Assumption of the exogeneity of interest rate largely increases uncertainty of inflation and slightly impacts uncertainty of GDP
- Increase in uncertainty of projection related to uncertainty of commodity price indices and foreign interest rate
- Slight change in uncertainty of foreign prices and GDP

Method of calculating density distributions of forecasts used at the NBP since October 2008: summary

Advantages:

- Meeting the postulates (see slide 21)
- Flexibility

Disadvantages:

- Changes in ”endogenous” uncertainty are not accounted for in the method (e.g. current rise in uncertainty of investment developments)
- Consequences of improvement/deterioration of the model/forecasts and expert adjustments are not accounted for in the model
- Construction of fan charts for the model’s endogenous variables other than GDP and inflation made difficult (as compared with the previous method)