DIW Berlin

Deutsches Institut
für Wirtschaftsforschung

International Conference
BUSINESS CYCLES AND THE ROLE OF GOVERNMENT IN JAPAN AND GERMANY

Artificial Intelligence in Business Cycle Research

JDZB Berlin, 31 Oct 2005

Dr. Stefan Kooths

Artificial Intelligence

- Knowledge-based Systems (Expert Systems)
- Soft Computing
- Multi-Agent Systems (DAI)

Artificial Intelligence: Focus

- Knowledge-based Systems (Expert Systems)
- Soft Computing
  - Fuzzy Logic
  - Neural Networks (Connectionism)
  - Genetic Algorithms (Evolutionary Systems)
  - Probabilistic Reasoning
  - Multi-Criteria Analytics (ANP)
- Multi-Agent Systems (DAI)

Linguistic „Reasoning“ in Business Cycle Research

Interest Rates to remain low…

We expect that the ECB will keep interest rates constant for some time because the economic expansion will remain modest and the perspectives for inflation will probably not worsen in the near future. All in all, the actual interest rate will be fairly close to the Taylor rate. In our judgment, however, key interest rates will be raised in the medium term because they are lower than the "neutral" rate according to all calculations. We expect that the ECB will start to tighten policy at the end of next year.

..fiscal policy to remain slightly contractionary

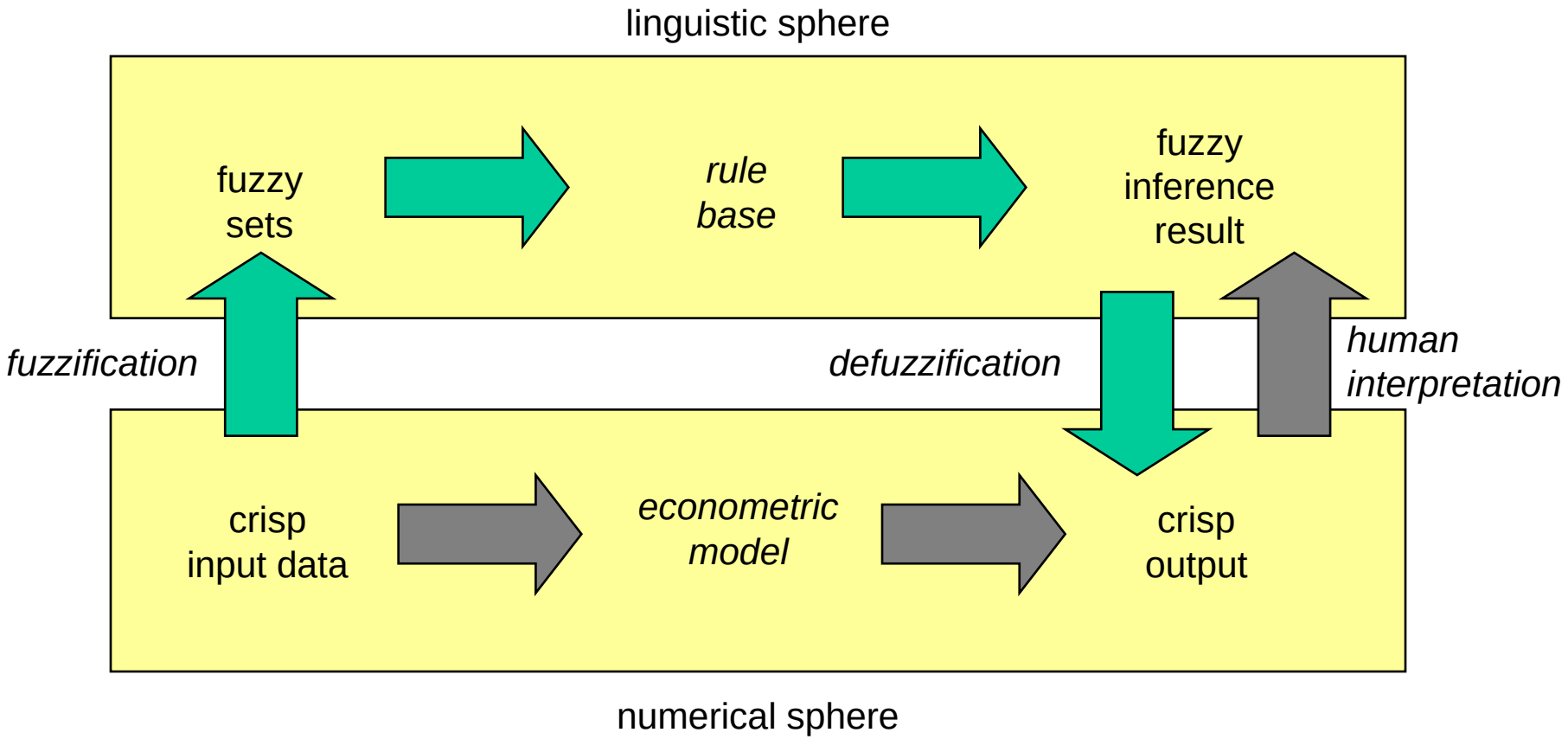
Lower than expected growth for 2005 leads us to anticipate the Euro Area fiscal deficit will be higher by about 0.2 percentage points of GDP this year at 2.8 per cent of GDP, or 3.1 excluding one-off measures, while the fiscal stance will be slightly contractionary. We expect fiscal policy to remain slightly contractionary until 2007 at the euro area level, reflecting somewhat contractionary measures in countries running higher than 3 per cent of GDP deficits, while fiscal policy will be neutral or slightly expansionary in the other countries. But the Euro area government deficits will remain at around 2.4 per cent in 2007, under the moderate expectations for growth.

… oil prices to remain high but inflation and growth at moderate rates

We expect oil prices to remain at around $60 until 2007, and the Euro Area effective exchange rate to remain almost unchanged, at a level more than 25% higher than in 2002. We expect the euro area to record inflation rates at or close to 2 per cent. GDP growth is expected to reach 1.8 in 2006 and 2.0 in 2007, with the unemployment rate decreasing but still in the order of 8.3 per cent in 2007

(EUROFRAME Autumn Report 2005)

Fuzzy Inference and Econometrics



Fuzzy Logic

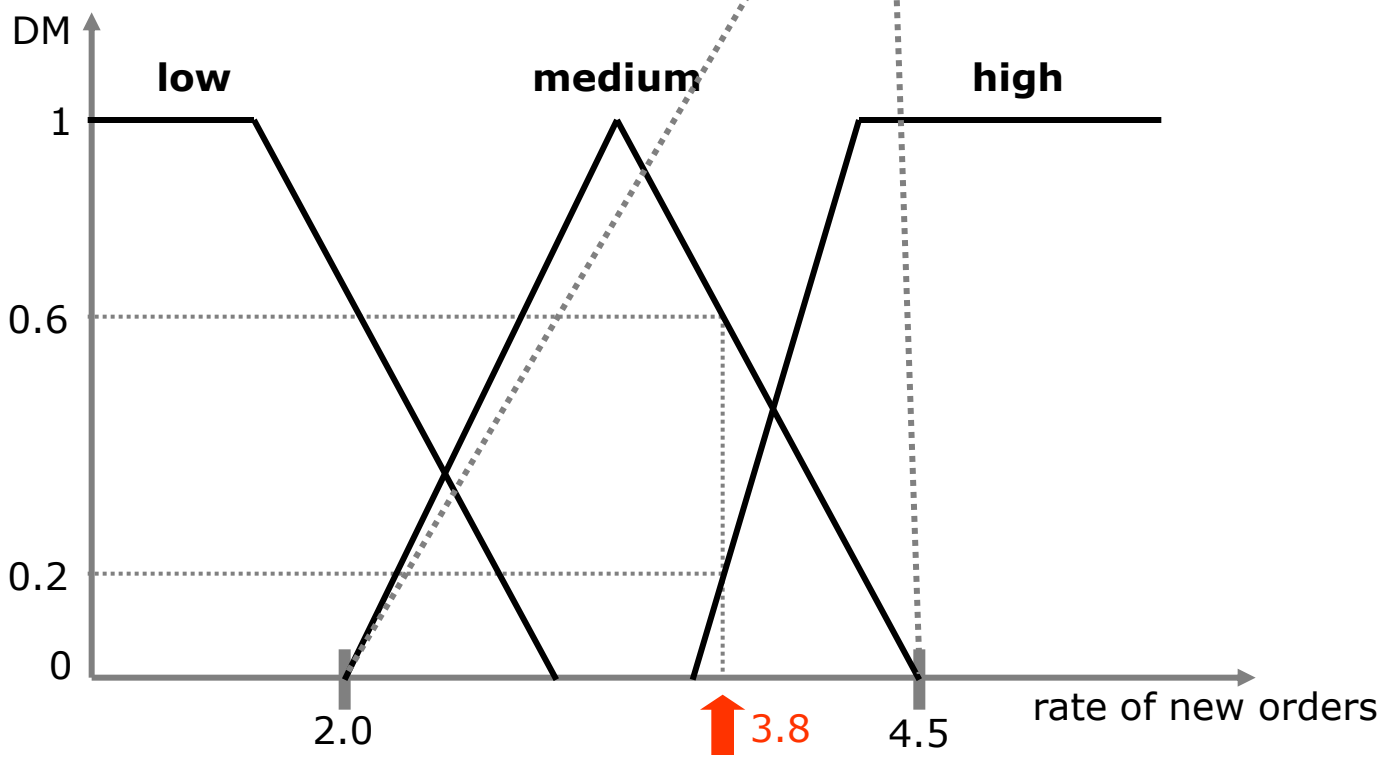
„The unpleasant thing about computers is
that they can say ‚yes' or ‚no' but not ‚maybe'."
B. Bardot

„There is help for this woman."
freely adapted from F. Schiller

- multivalent generalization of classical set theory (gradual degrees of membership)
- linguistic variables (natural vagueness)
- rules (explizit knowledge representation)

Linguistic Rules and Fuzzification

IF rate of new orders is medium AND business climate is very good THEN GDP-growth is high.



Fuzzy AND-Operator (Aggregation)

IF rate of new orders is medium AND business climate is very good THEN GDP-growth is high.

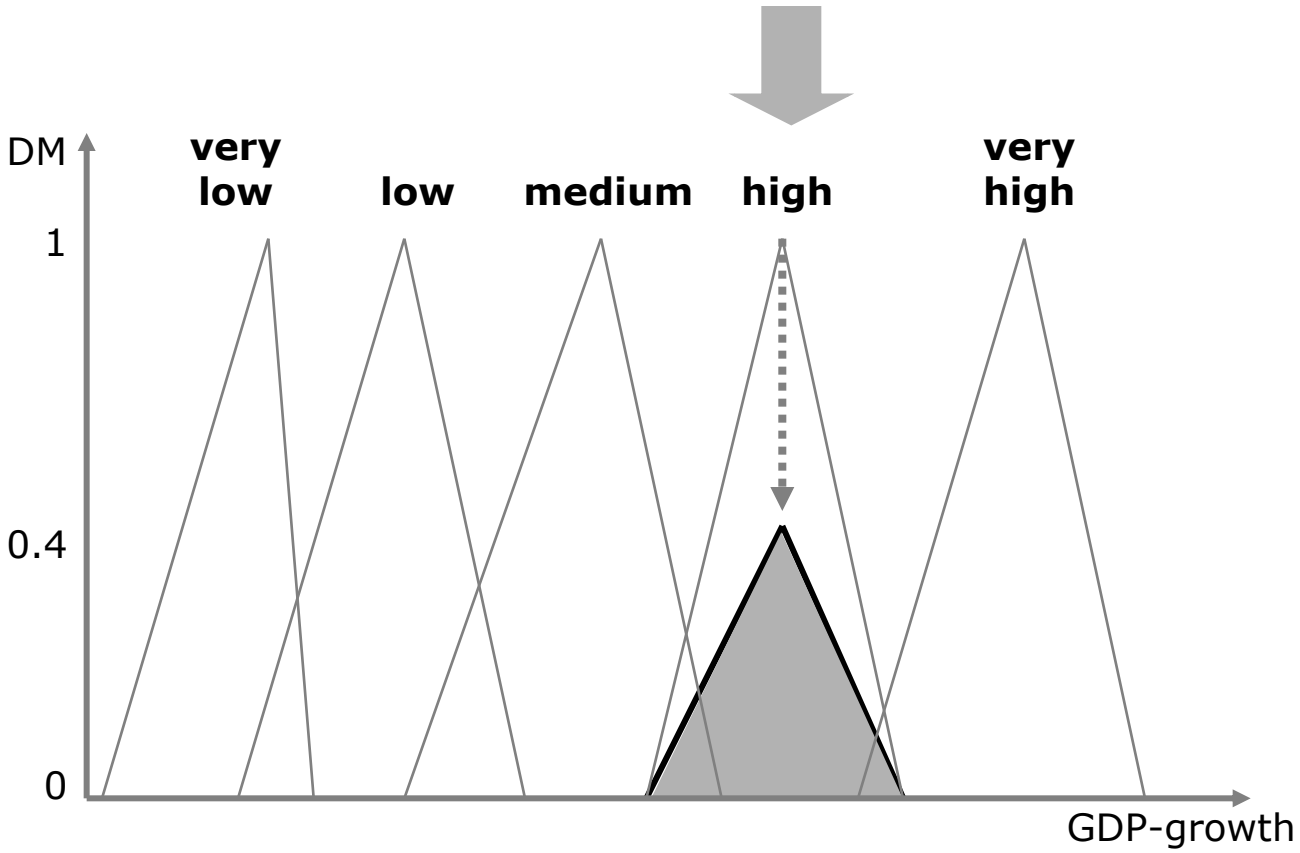
- DM(rate of new orders: mediuml) = 0.6
- DM(business climate: very high) = 0.4

⇨ DM(condition) = 0.4 [Minimum-AND]

⇨ DM(condition) = 0.32 [Product-AND]

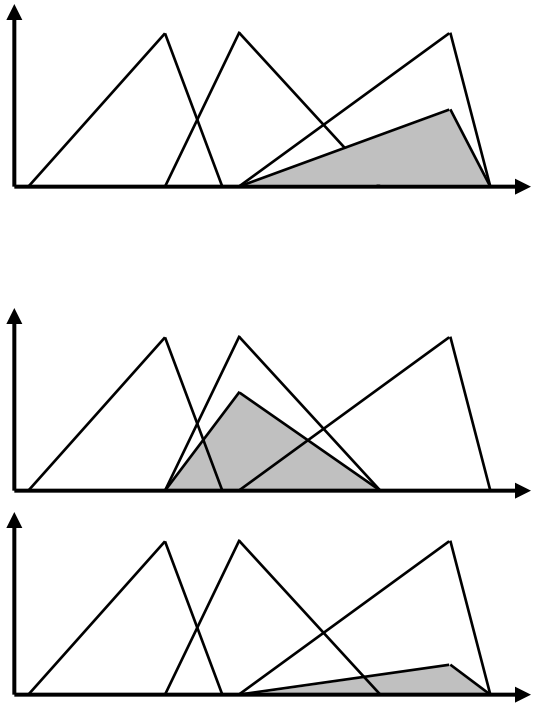
Fuzzy Inference: Single Rule

IF rate of new orders is medium AND business climate is very good THEN GDP-growth is high.

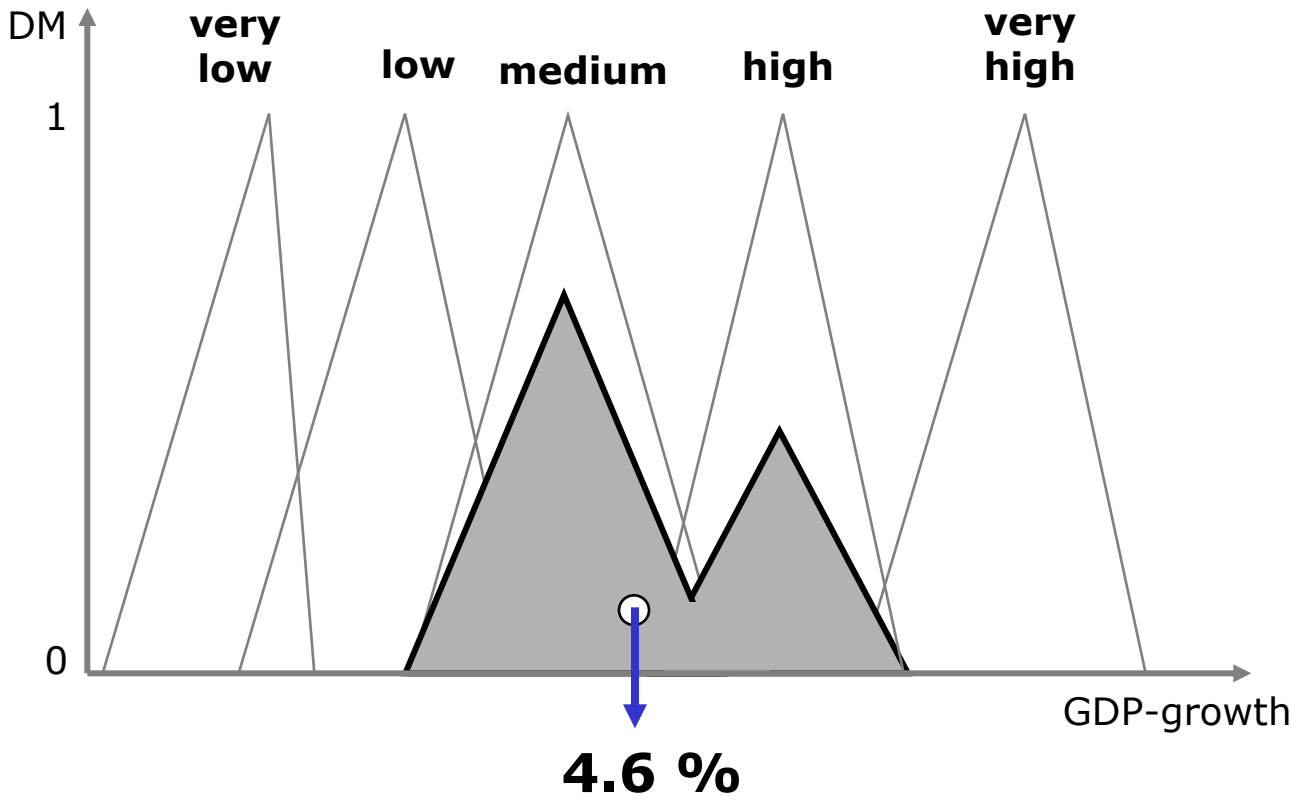


Fuzzy Inference: Rule-Base

- IF ... AND ... THEN ...
- IF ... AND ... THEN ...
- IF ... AND ... THEN ...
- IF ... AND ... THEN ...
- IF ... AND ... THEN ...
- IF ... AND ... THEN ...
- IF ... AND ... THEN ...
- IF ... AND ... THEN ...
- IF ... AND ... THEN ...
- IF ... AND ... THEN ...



Fuzzy Inference Result, Deffuzzification

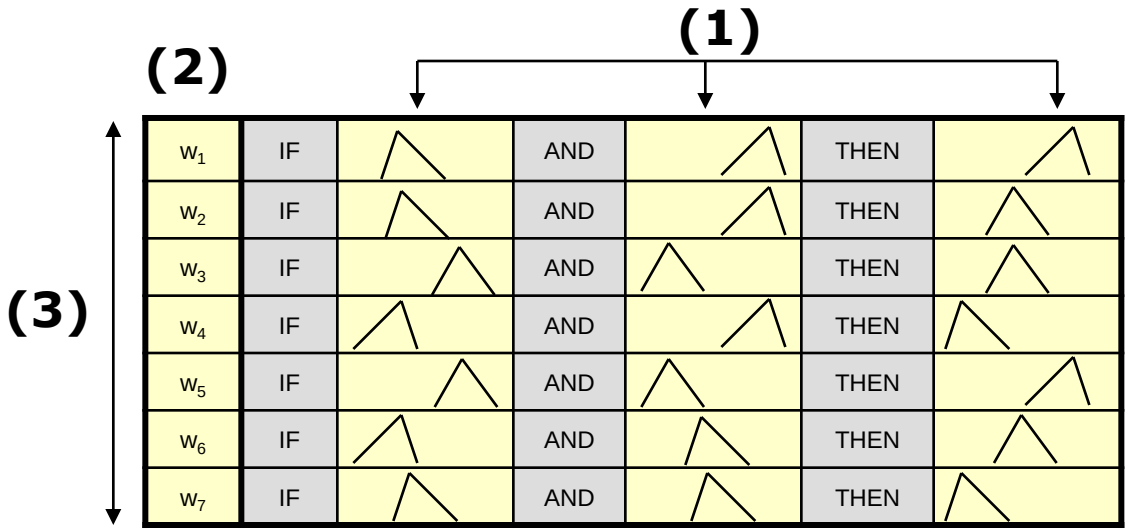


Fuzzy Rule-Base Parameter

(1) fuzzy set parameter

(2) rule weights

(3) number/network of rules



Forecasting with GENEFER

- forecasting process
  - identify relevant inputs
  - fuzzify identified inputs
  - create rules
  - tune rules
  - forecast (with/without training)
- learning technologies
  - Fuzzy Curves/Surfaces
  - Neuronal Networks
    (competitive learning, Backprop)
  - Genetic Algorithms

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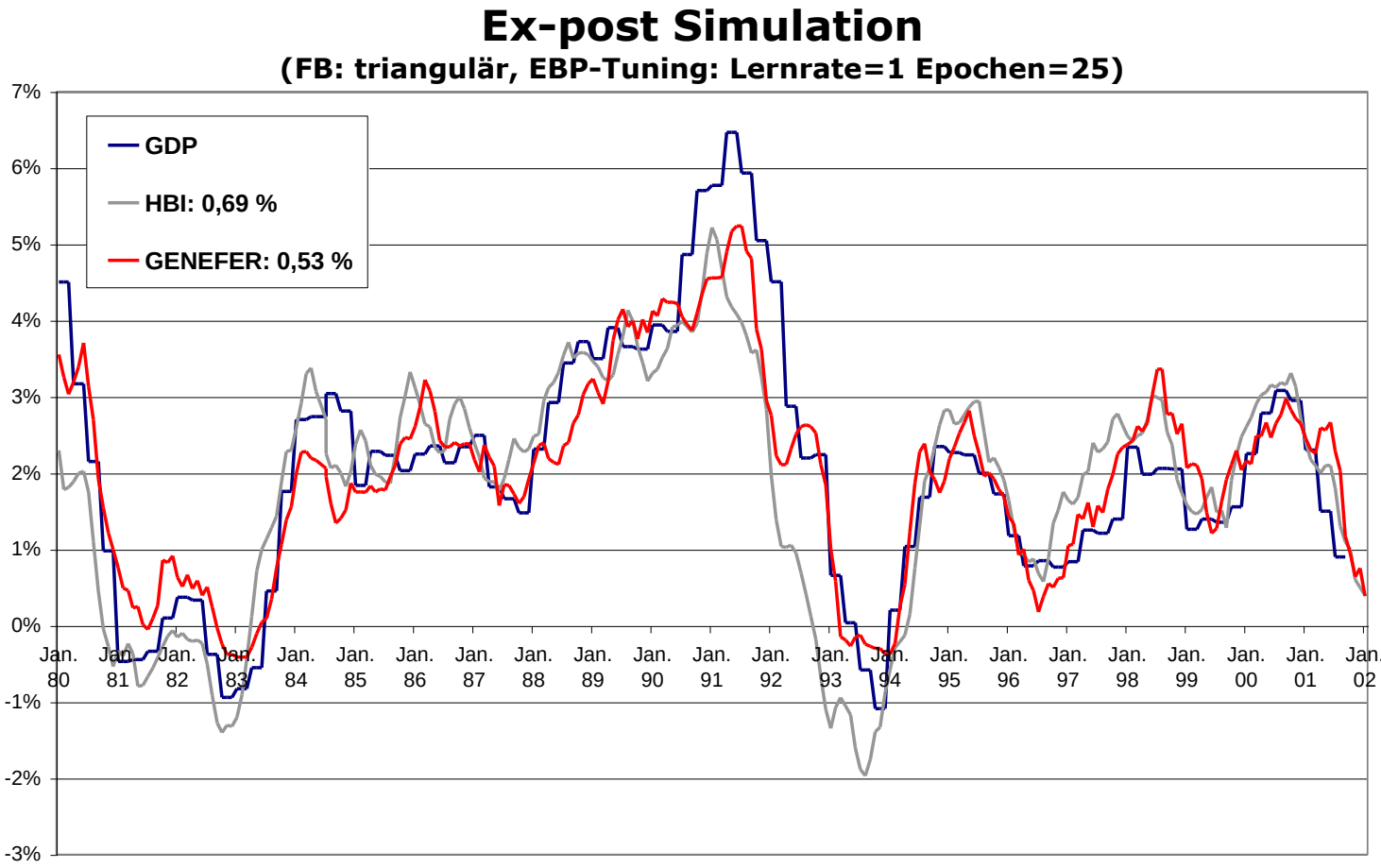
adaptive fuzzy rule-based approach

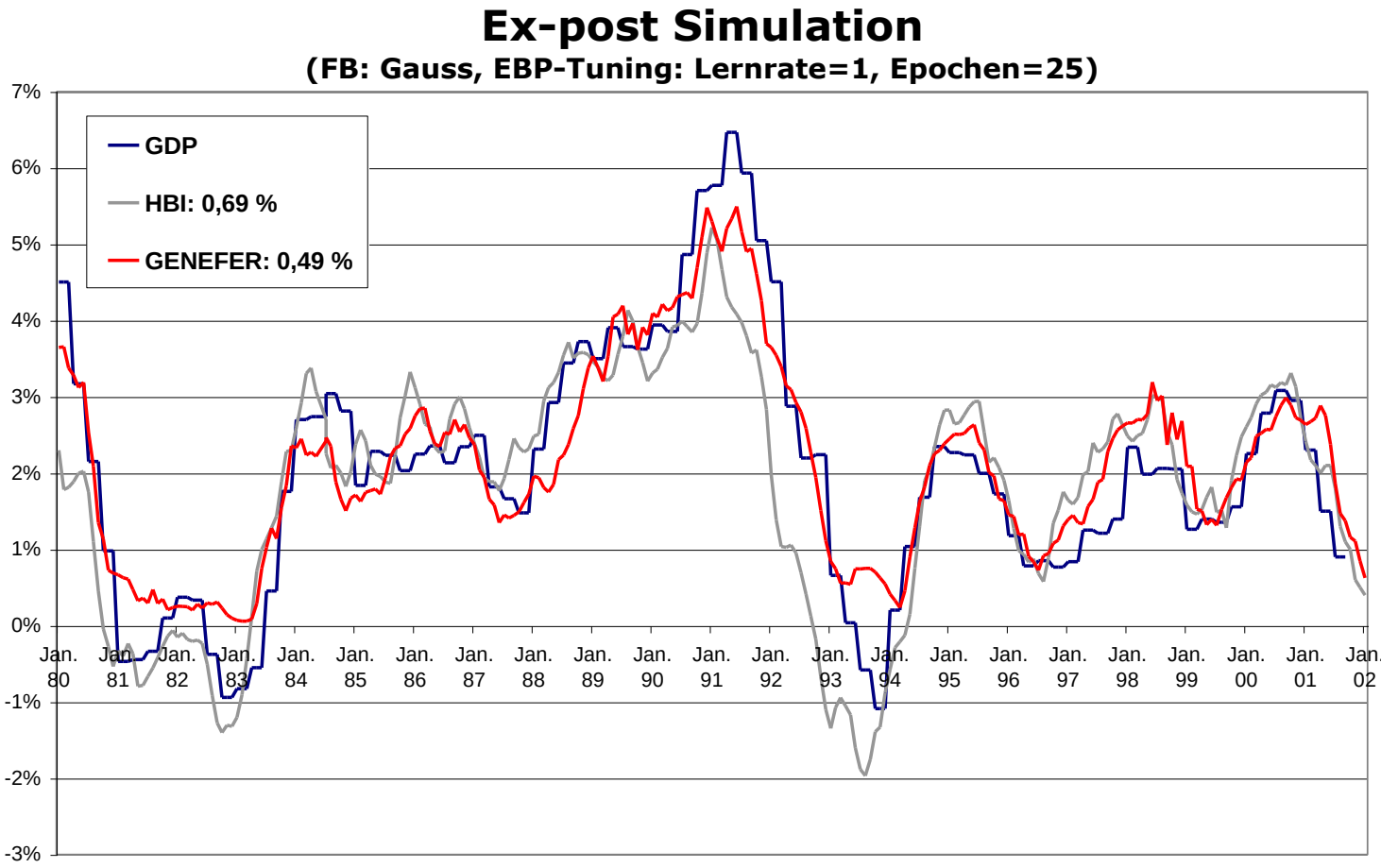
Example: Handelsblatt BC-Indicator

- **Output: GDP annual growth rate (quarterly)**
- **Inputs (monthly):**
  - order inflow (manufactoring)
  - order inflow (construction)
  - retail sales
  - ifo-business climate (manufacturing)
  - interest structure (iL – Fibor)
- **period**
  - Jan. 1980 to Okt. 2001 (265 observations)
  - GDP-growth until Q3 2001
  - 3-months-ahead forecast

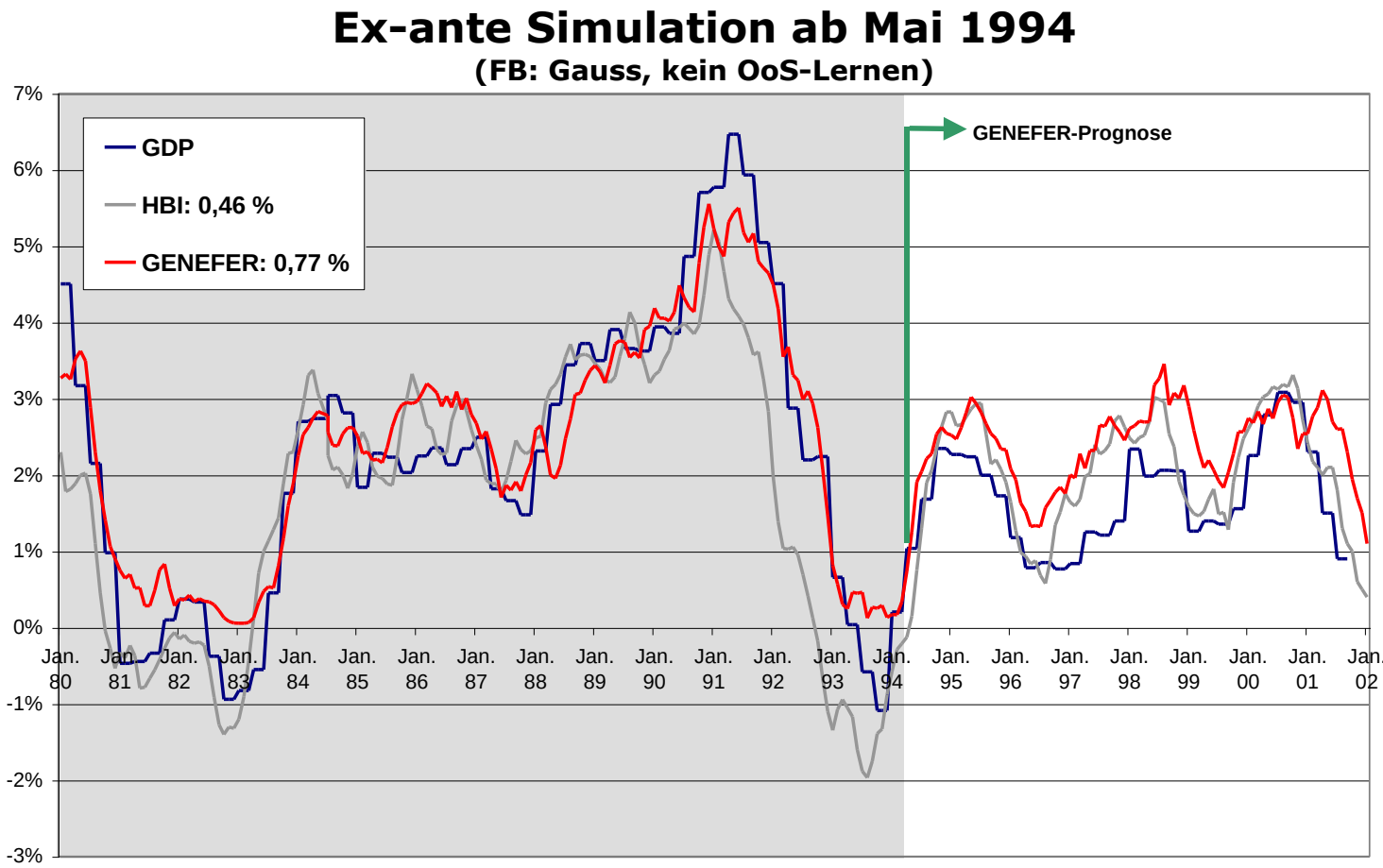
Comparison 1



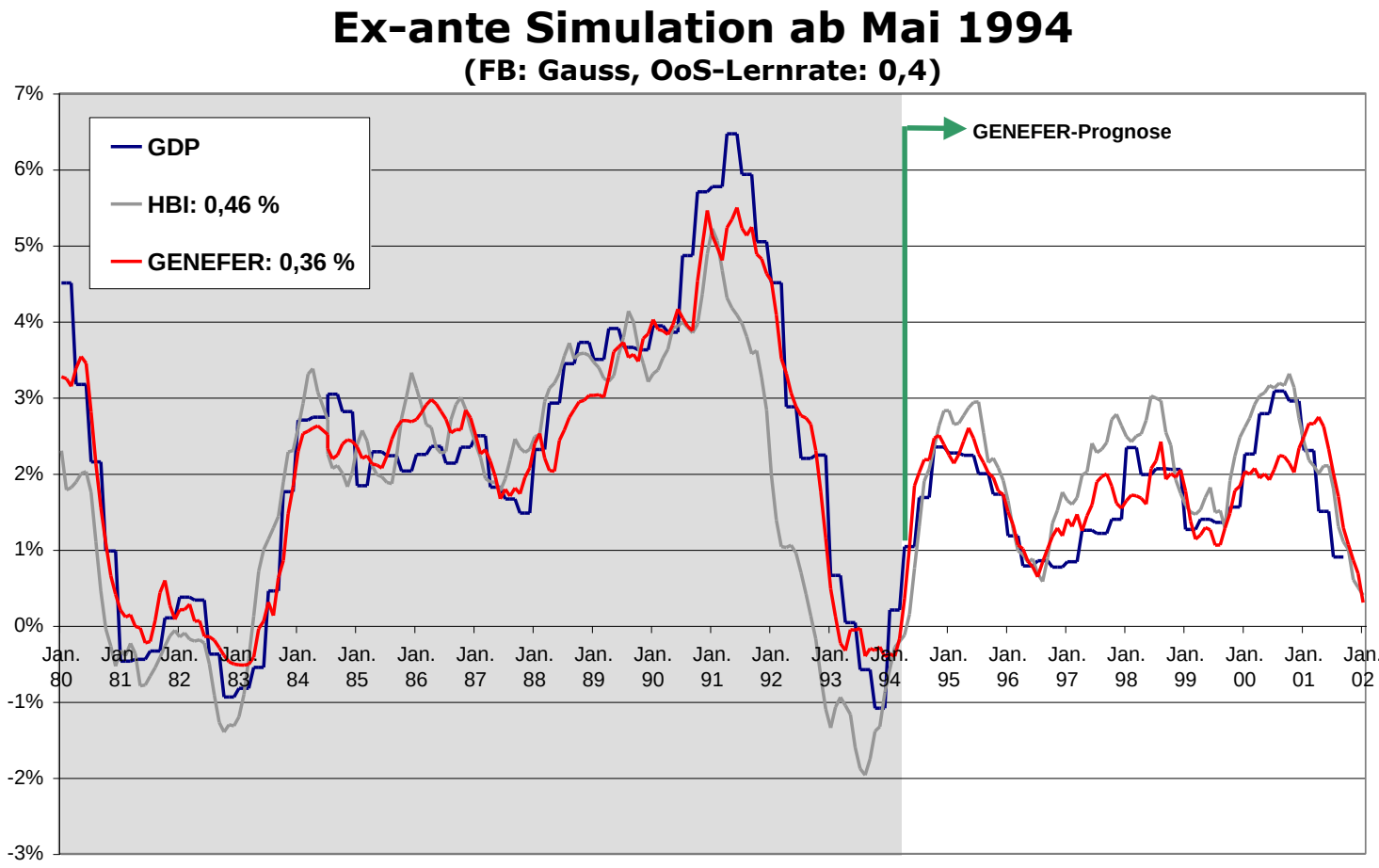
Comparison 2



Comparison 3



Comparison 4



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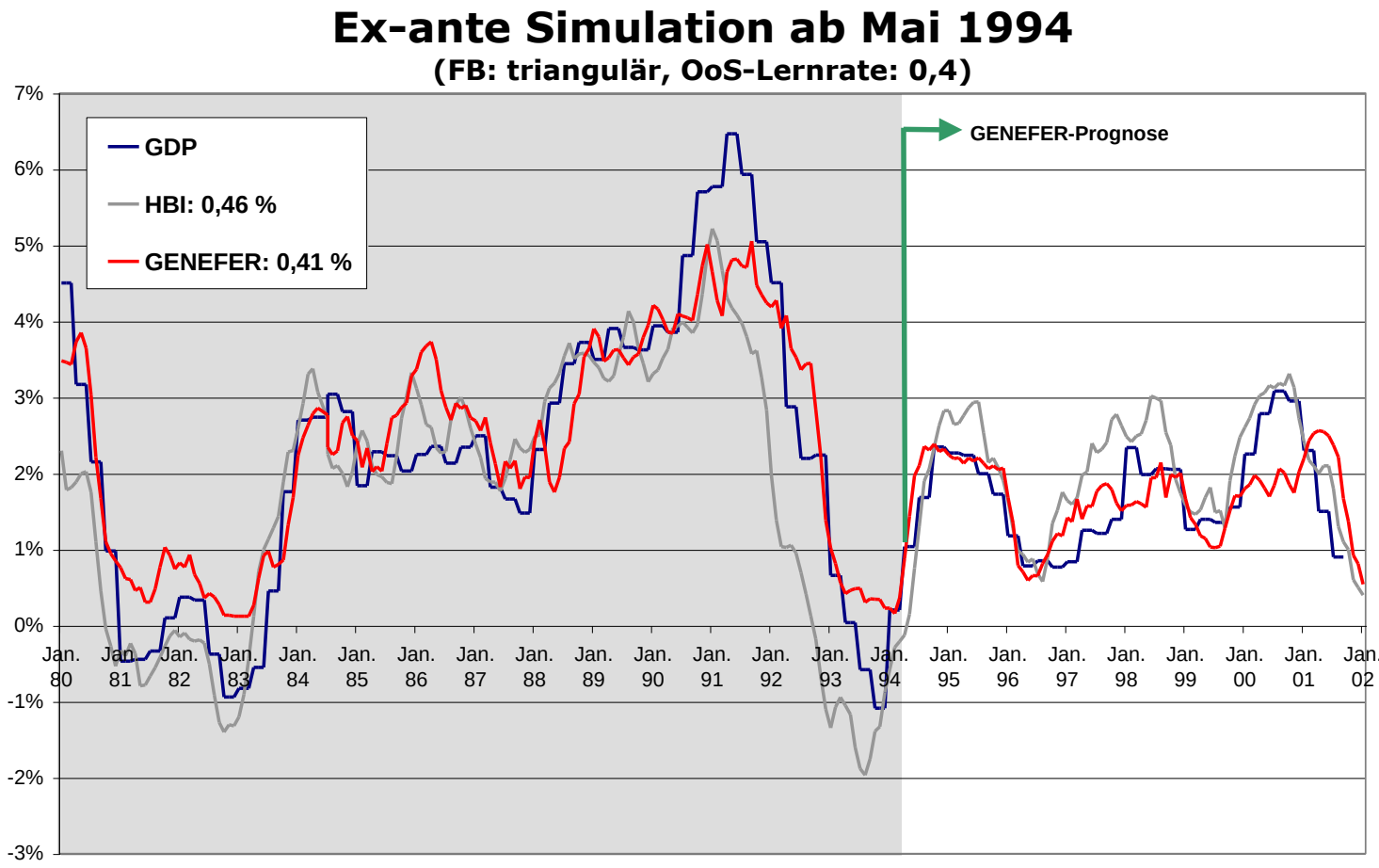
Comparison 5



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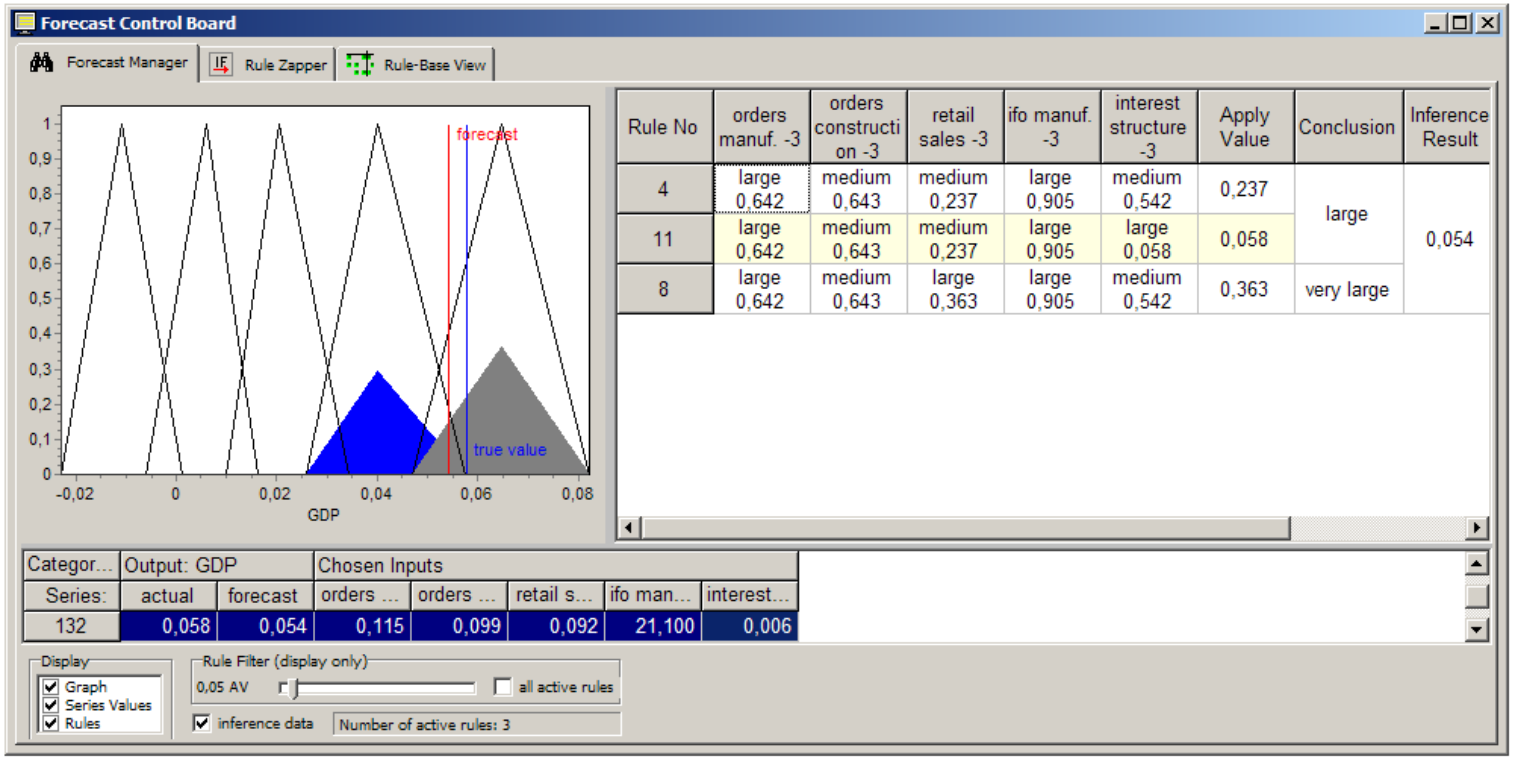
Inference Monitoring (Jan. 1991)



Discussion

future extensions

- heterogeneous rule dimensions (general and specific rules)
- endogeneous learning

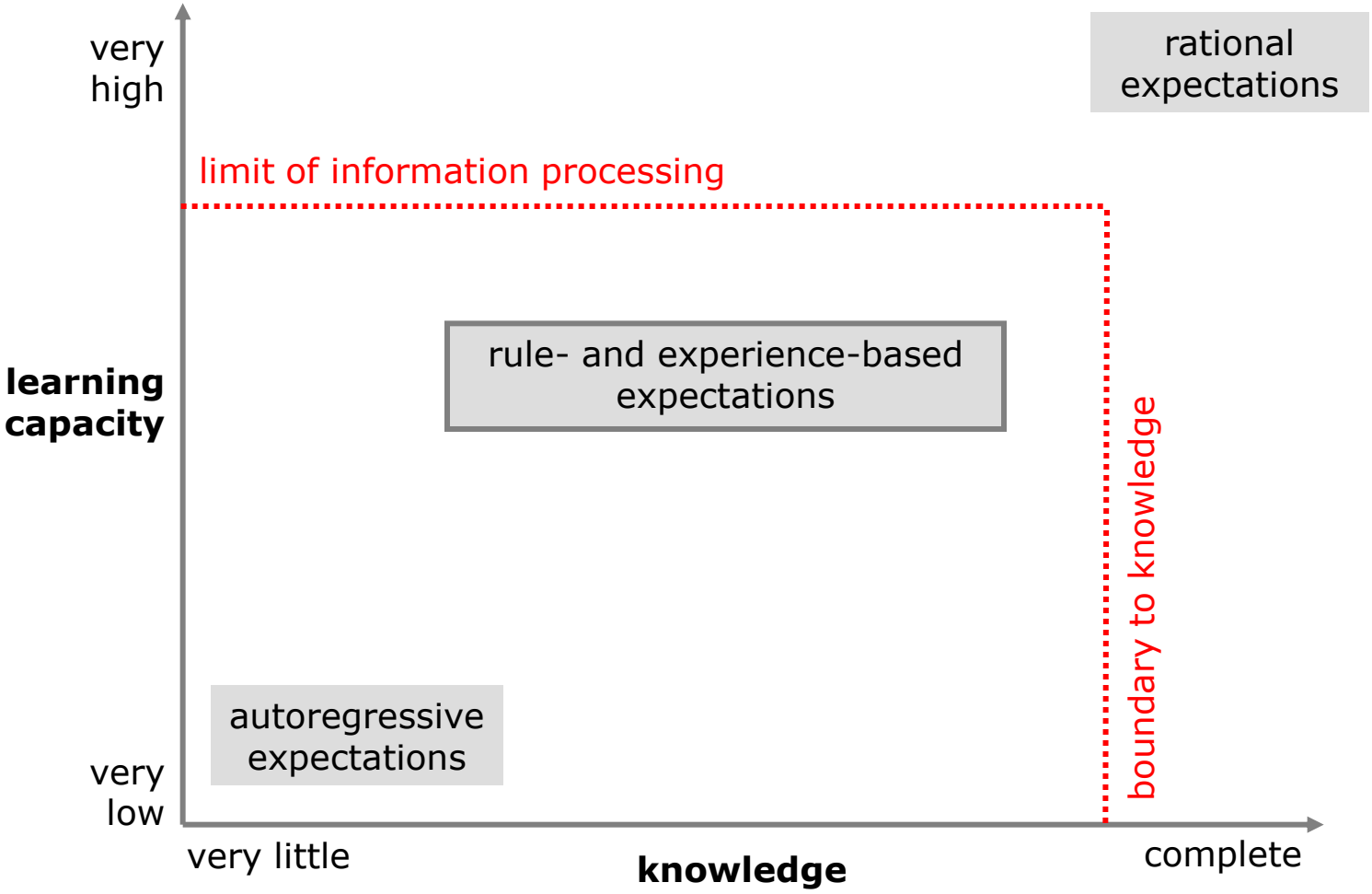
problems

- degrees of freedom at system design

use

- stand-alone
- combined with econometric methods (data pre-processing)

Starting Point: Expectation Formation



Adaptive Fuzzy Rule-Based Approach

In a world …

- of high complexity
- and a high degree of uncertainty
- where humans form mental models

we need a modelling approach that …

- explicitly represents knowledge (interpretability)
- accounts for the vagueness of perceived information (bounded rationality)
- allows for new experience (learning)

⇨ adaptive fuzzy rule-based approach

Design and Application

- rule- and experience-based expectations
  ⇩
  empirical data

- forecasting software GENEFER
  - core technology: Fuzzy Logic
  - hybridized with Neural Networks and Genetic Algorithms

- example: Handelsblatt BC-Indicator
  - performance check
  - rule base vs. black box