A macroeconomic forecasting model for Bulgaria

Presented by Catherine Keppel and Anna Orthofer

Our forecasting exercise

- Forecasting model for GDP, imports and exports
- We consider only consumption, investment, import and exports equations in the macroeconomic model (BG is in a currency board arrangement since June 1997, thus has no room for independent monetary policy...)

- **Consumption:**
  $C = c + \beta_{C,1} Y + \beta_{C,2} R_{cpi}$
- **Investment:**
  $I = c + \beta_{I,1} Y + \beta_{I,2} R_{ppi}$
- **Exports:**
  $X = c + \beta_{X,1} Y + \beta_{X,2} Y_{EU27} + \beta_{X,3} X_{EU27} + \beta_{X,4} Q_{ppi}$
- **Imports:**
  $M = c + \beta_{M,1} Y + \beta_{M,2} Q_{ppi}$
- and the Identity:
  $Y = C + I + G + X - M + SC$

We transformed E to Q with PPI rather than CPI, since both Bulgaria's M and X are mainly commodities ($> 80\%$) and not manufactured goods.

The Data

- The data stem from Eurostat, the BNB and the wiiw monthly Database
- Our sample covers data from Q1/1998 (End of Hyperinflation) - Q1/2009
- The data were seasonally adjusted

The order of integration

Time series are I(1)

- Dickey Fuller tests for the 15 variables: We cannot reject the null hypothesis of a unit root for any variable on5% confidence levels
- We conclude that our time series are all at least trend-stationary in first differences

Cointegration

C, I, M and X equations are cointegration relations

- Engle and Granger: A number of I(1) series are cointegrated if there exists an I(0) linear combination of them (e.g. the error term)
- Engle and Granger 2-step Test on Cointegration: 2-step procedure
  - 1^{st} step: Estimate the cointegration equation, store residuals
  - 2^{nd} step: Dickey-Fuller tests on a unit root in the fitted residual series: We can reject the null hypothesis of a unit root on 5% confidence levels
- We conclude that our macroeconomic equations are cointegration relations

The Error Correction Model

- Let $\mathbf{x}_t$ and y_t denote cointegrated variables. Then they have an error correction representation of the form

$$\Delta y_t = \mathbf{a}_1' \Delta \mathbf{x_{t-1}} + b_1 \Delta y_{t-1} - \underbrace{\lambda(y_{t-1} - \mathbf{a}_0' \mathbf{x_{t-1}})}_{\text{EC-Term}} + \epsilon_t$$

- There exists a long-run equilibrium between y and x
- Deviations from long-run equilibrium: corrected at speed λ.
- Interpretation: Error correction models allow the long-run components of variables to obey equilibrium constraints (modeled through the error correction part) while short-run components have a flexible dynamic specification

Eventually, our SUR system looks like this:

$$C = C(1) + C(2)Y + C(3)R_{cpi}$$

$$I = C(4) + C(5)Y + C(6)R_{ppi}$$

$$X = C(7) + C(8)Y + C(9)Y_{EU} + C(10)X_{EU} + C(11)Q_{ppi}$$

$$M = C(13) + C(14)Y + C(15)Q_{ppi}$$

+ endogenized explanatory variables as AR(1) / AR(2) processes

(Effectively, each equation will enter in EC form

$$\Delta y_t = \mathbf{a}_1' \Delta \mathbf{x_{t-1}} + b_1 \Delta y_{t-1} - \underbrace{\lambda(y_{t-1} - \mathbf{a}_0' \mathbf{x_{t-1}})}_{\text{EC-Term}} + \epsilon_t)$$

Endogenized explanatory variables as AR(1) / AR(2) models:

- for BG: nominal and real interest rate i, R_{CPI}, R_{PPI}, CPI, PPI, government consumption G and stock changes SC
- for the Eurozone: PPI, the real exchange rate Q_{PPI}, output and export levels Y, X
- The nominal exchange rate against the Euro, E, is fixed within the Bulgarian Currency Board arrangement and is expected to remain at 1.9558 in the future.

Model = System + Identity Equations

- In order to use the system of equations for forecasting, we transform it into a model, which further includes the
- necessary identity equations - to solve the set of equations for time periods, where the variables are unknown
- Identity equations for: GDP, consumer and producer price inflation π, the real interest rates R_{CPI}, R_{PPI} and the real exchange rate Q_{PPI}.

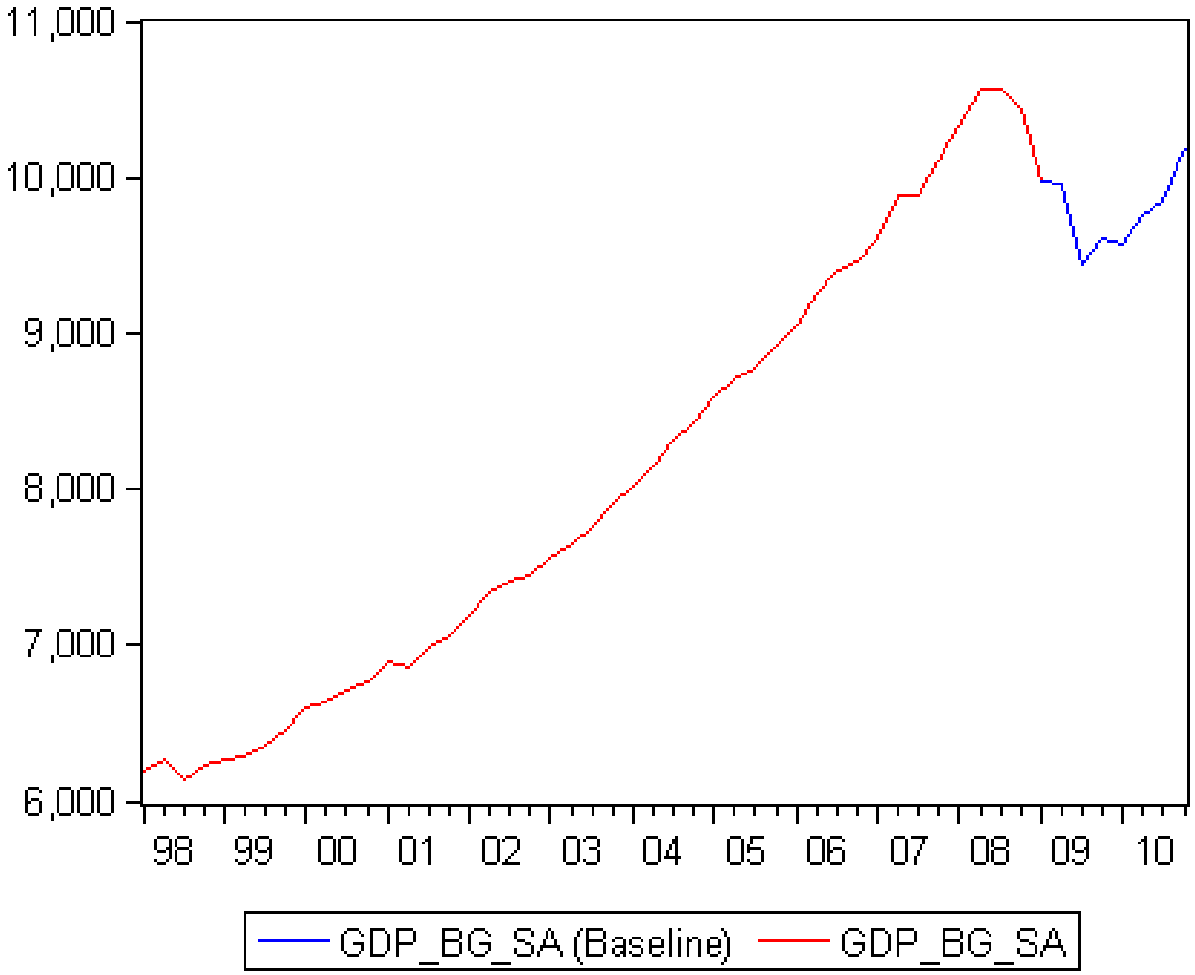
Estimation and Forecasting Window

- Starting with Q1/2002, we cut out a hole of 8 quarters - the forecasting window.
- The rest of the sample is used for estimating the model.
- We perform 1 to 8 step ahead forecasts on the (wandering) forecasting window. The forecasts obtained are stored for later evaluation.

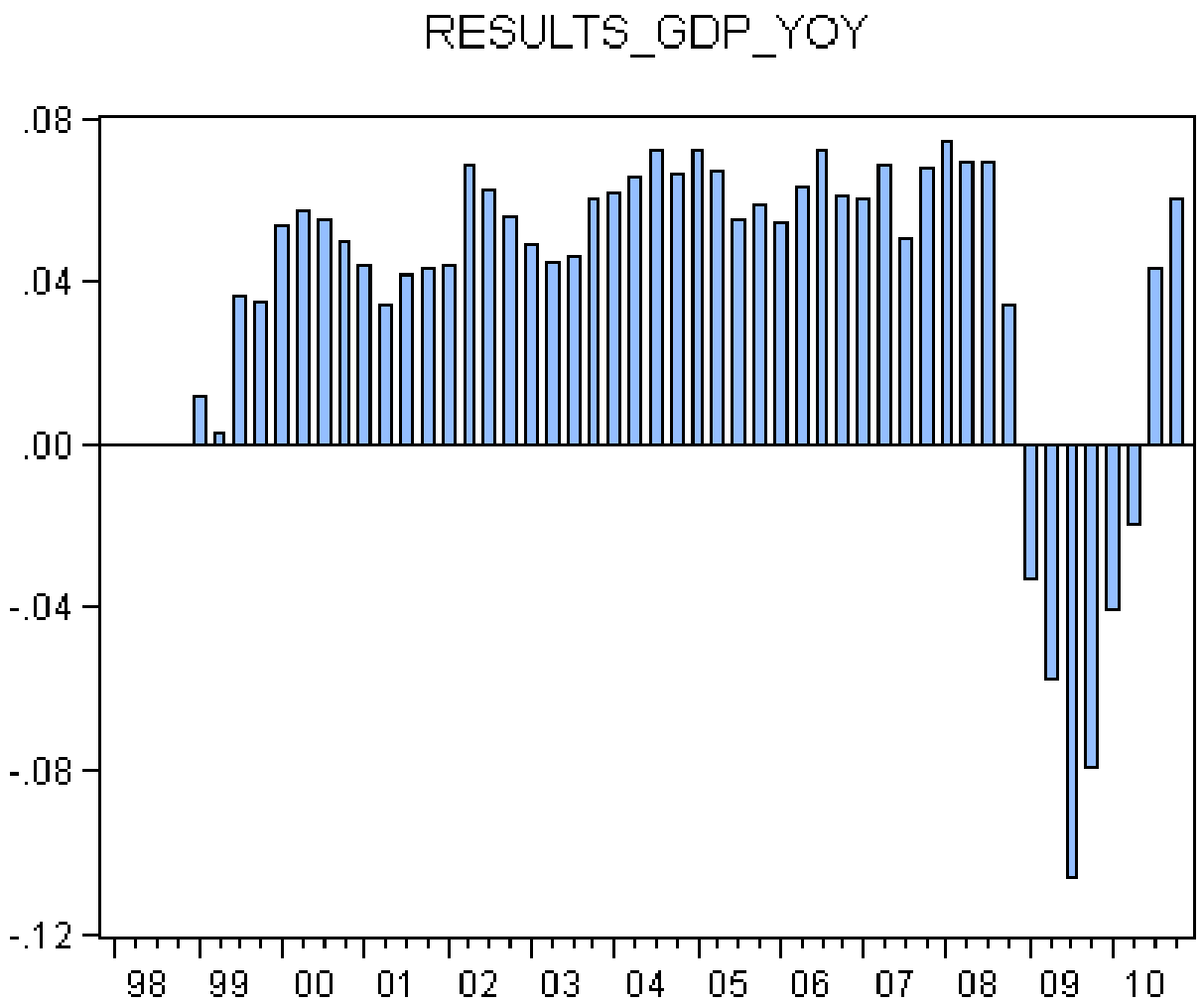
Szenarios

- Baseline Model: We use
  - True realizations of data until Q4/2008 for Euro Area and BG.
  - Without any assumptions on Euro Area: How would our model see the future of BG?
- Szenario 1: Eurozone enters recession
  - True realizations of data until Q4/2008 for the Euro Area and BG + exogenous assumptions on the Euro Area.
  - To which degree does the BG economy depend on Euro Area, which role do the channels suggested by the van Aarle model play?

Baseline NWH-Forecast



Baseline


RESULTS_GDP_YOY
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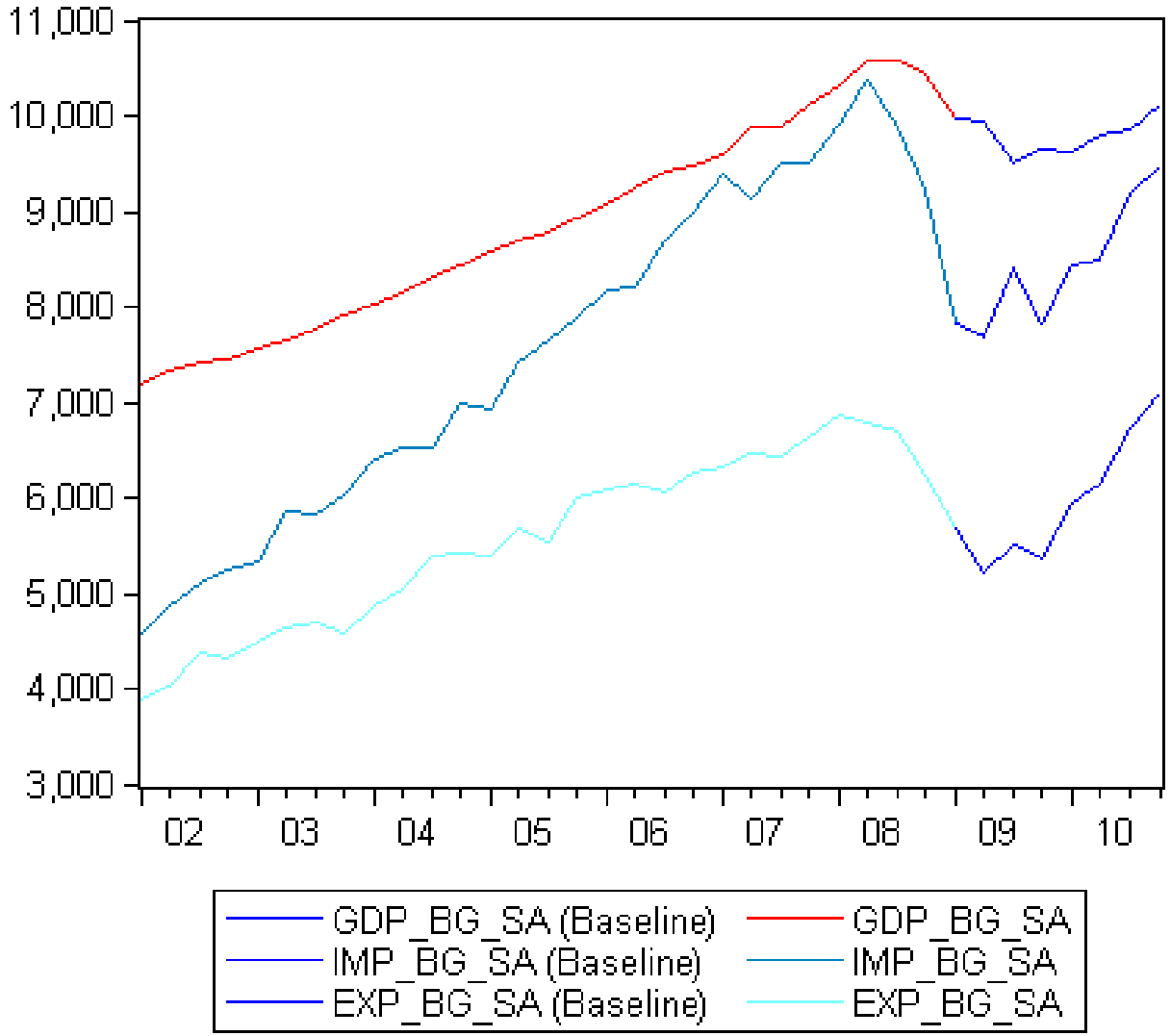
Baseline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GDP_BG_SA (Baseline)
IMP_BG_SA (Baseline)
EXP_BG_SA (Baseline)
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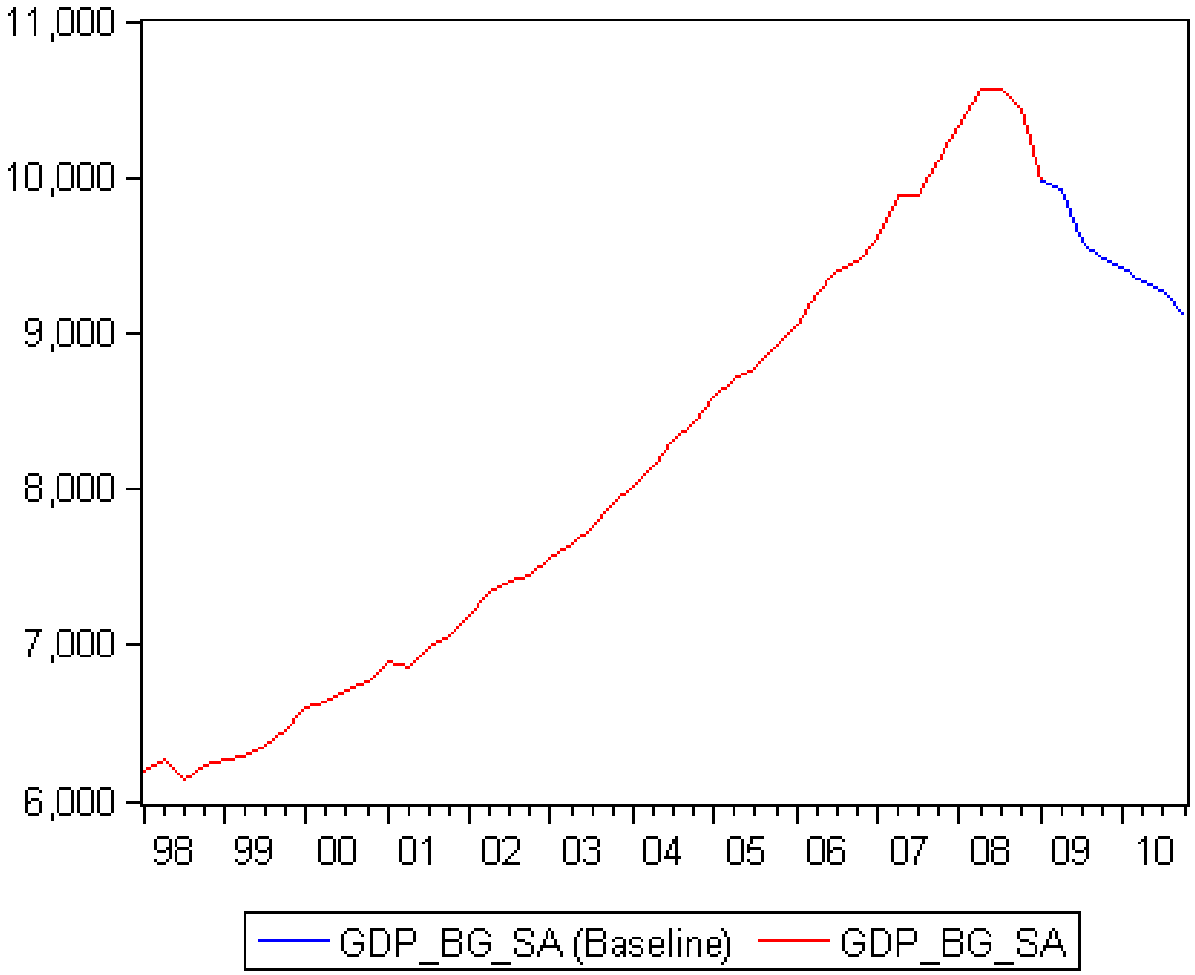
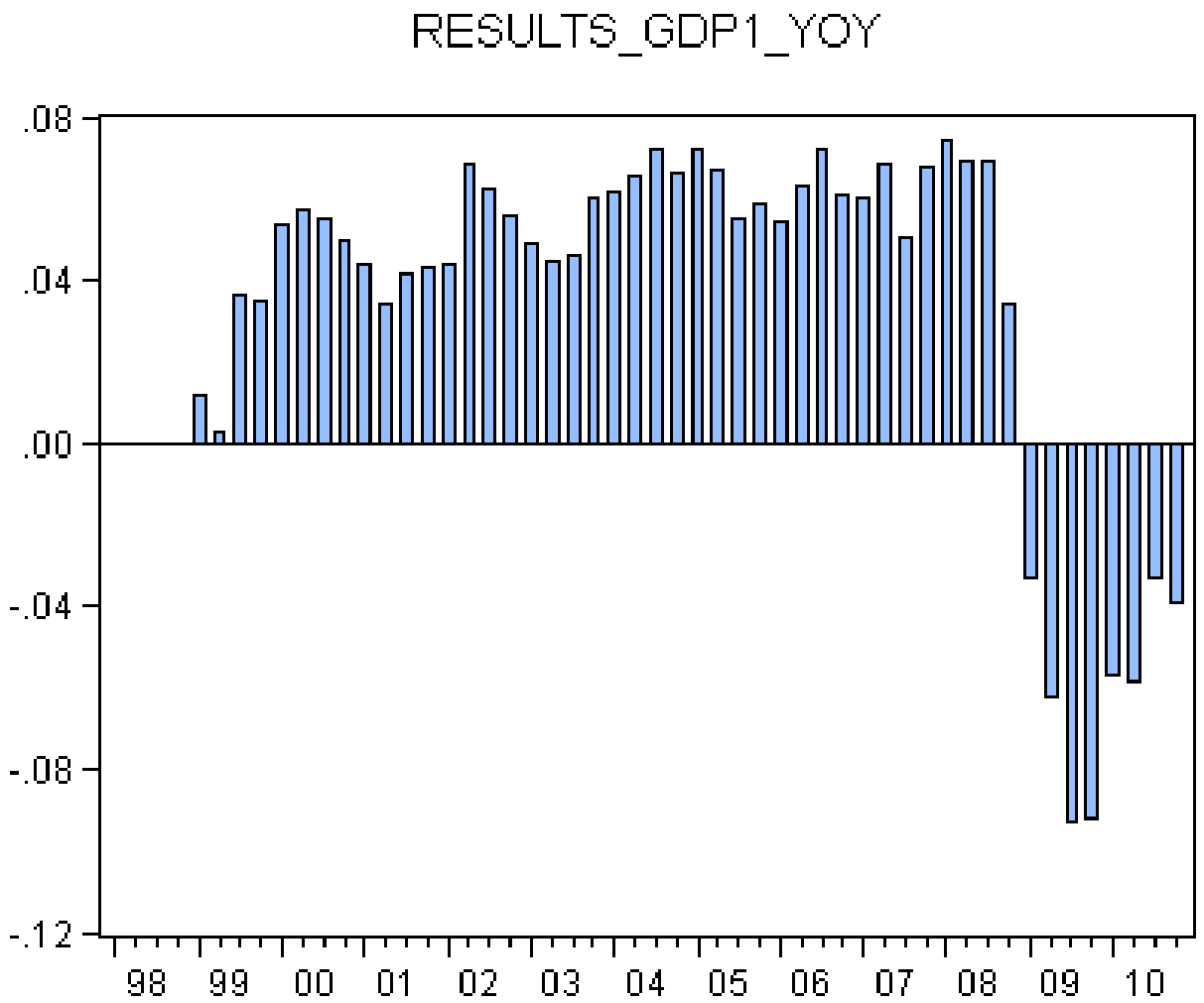
EXP_BG_SA

Scenario1 NHW-Forecast



Scenario 1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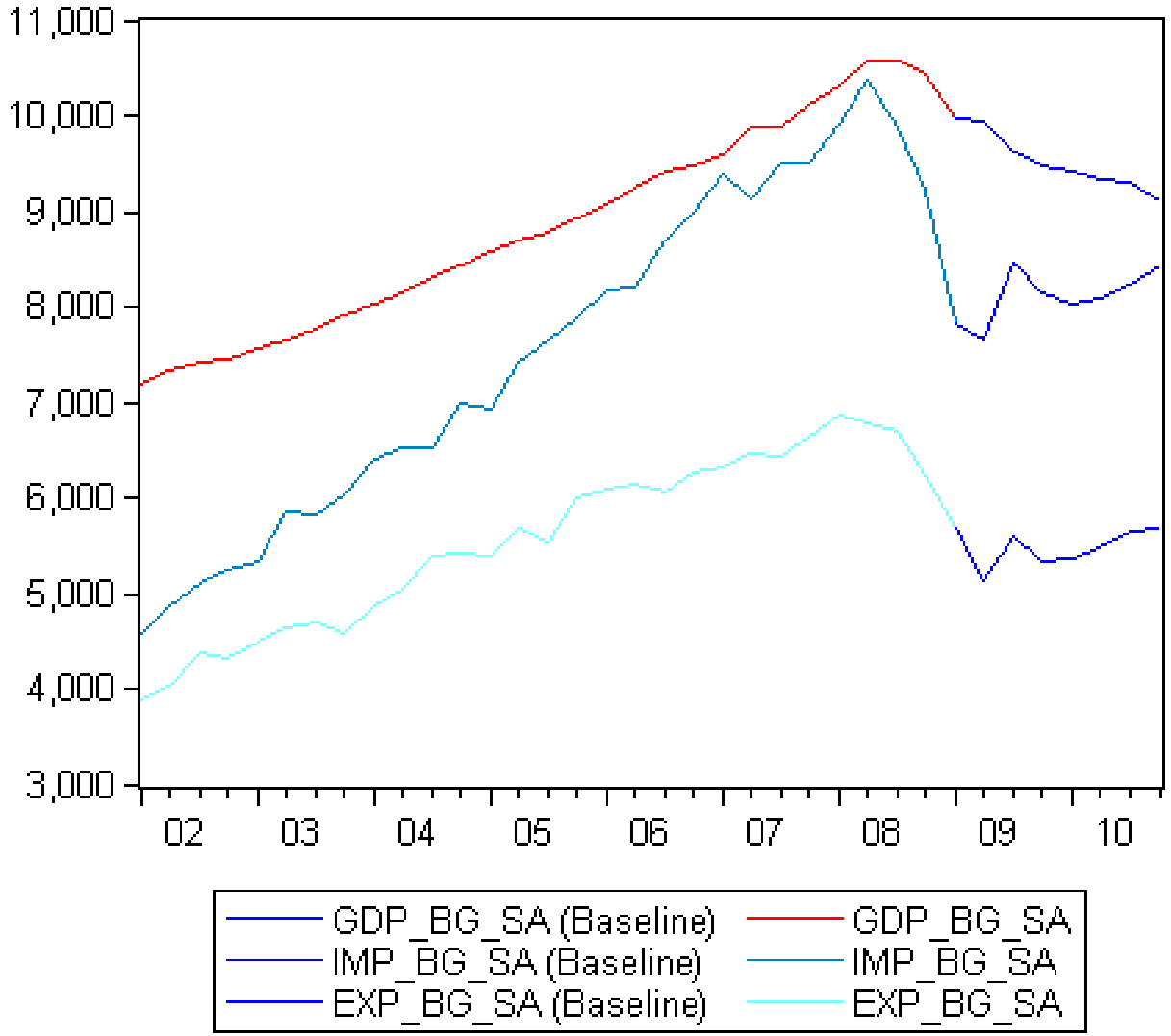
Scenario 1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GDP_BG_SA (Baseline)
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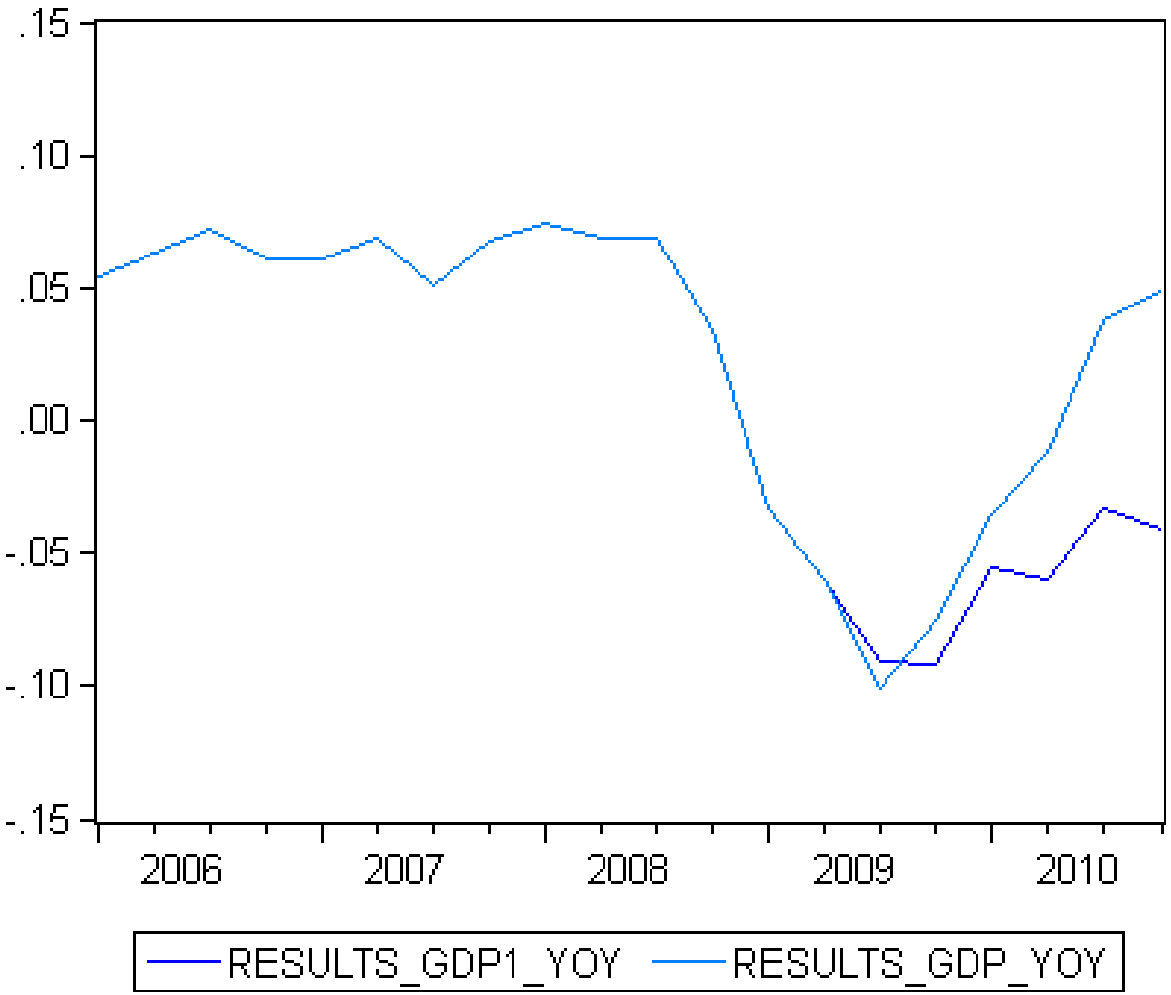
EXP_BG_SA

Comparison: Light Blue - Baseline, Dark Blue - Scenario1



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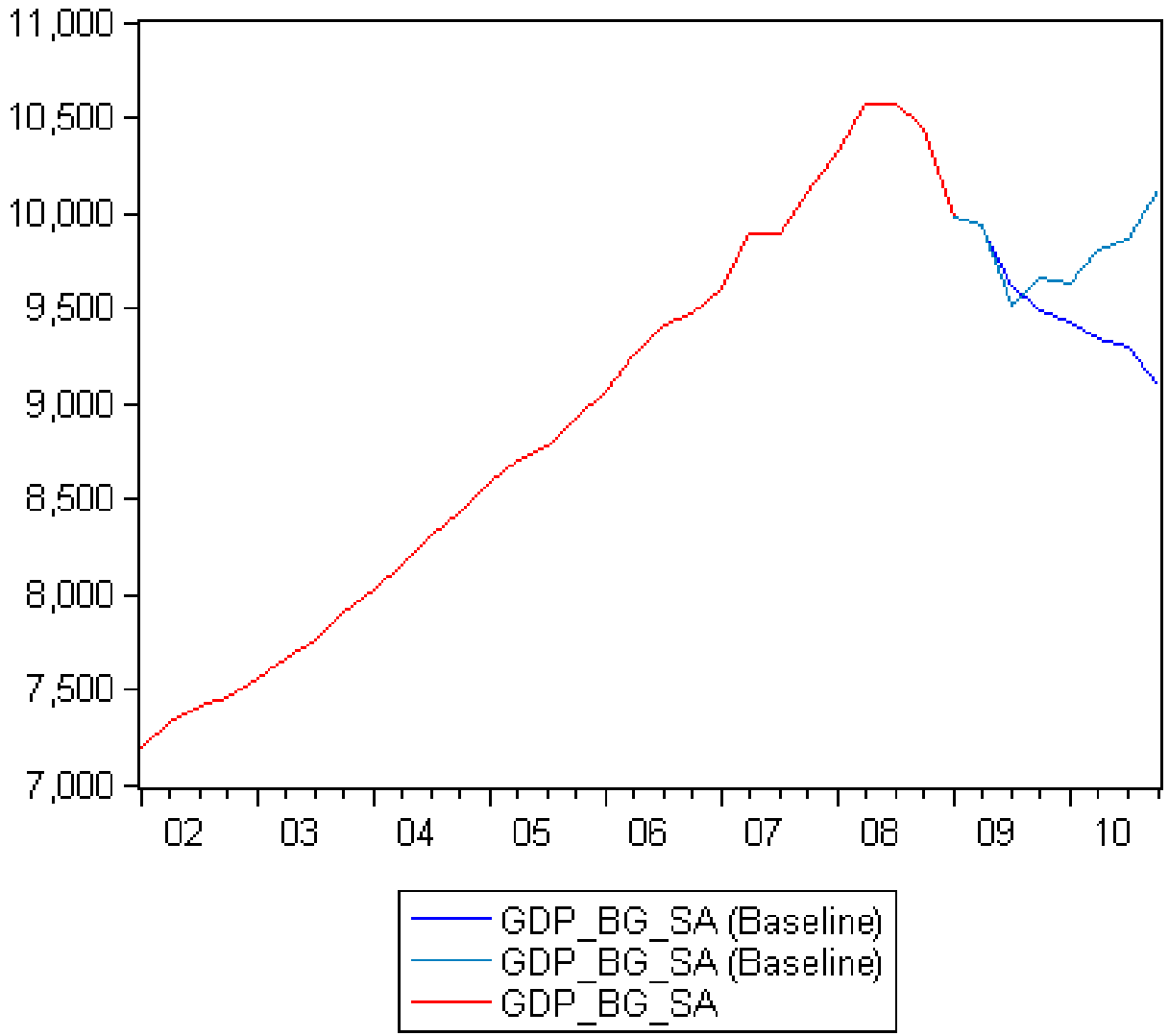
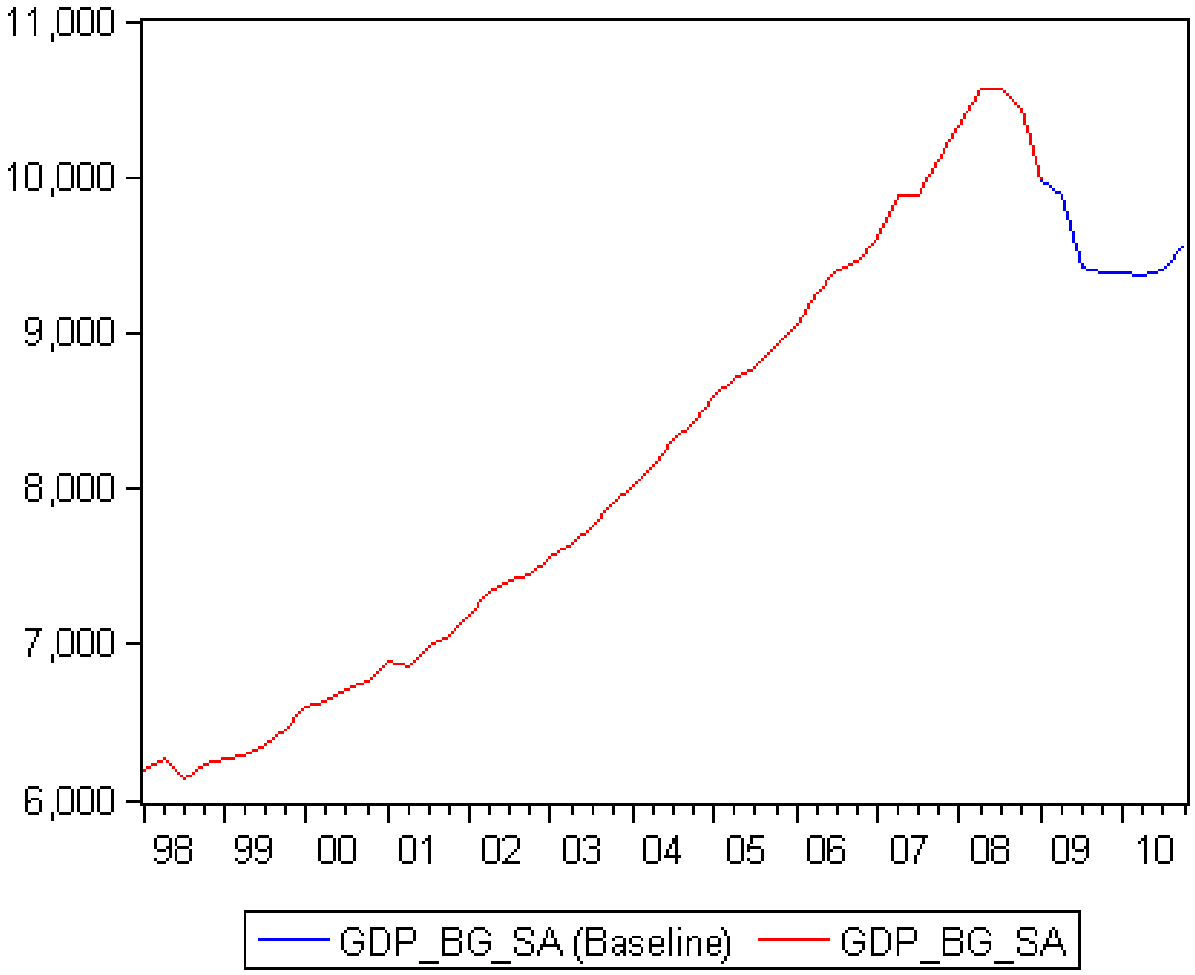


Baseline NWH-Forecast

- AR(2)-Endogenization for the variables where the AIC suggest that they are higher-order processes than AR(1) may improve forecasting quality!
- Try AR(2) for all processes except the interest rate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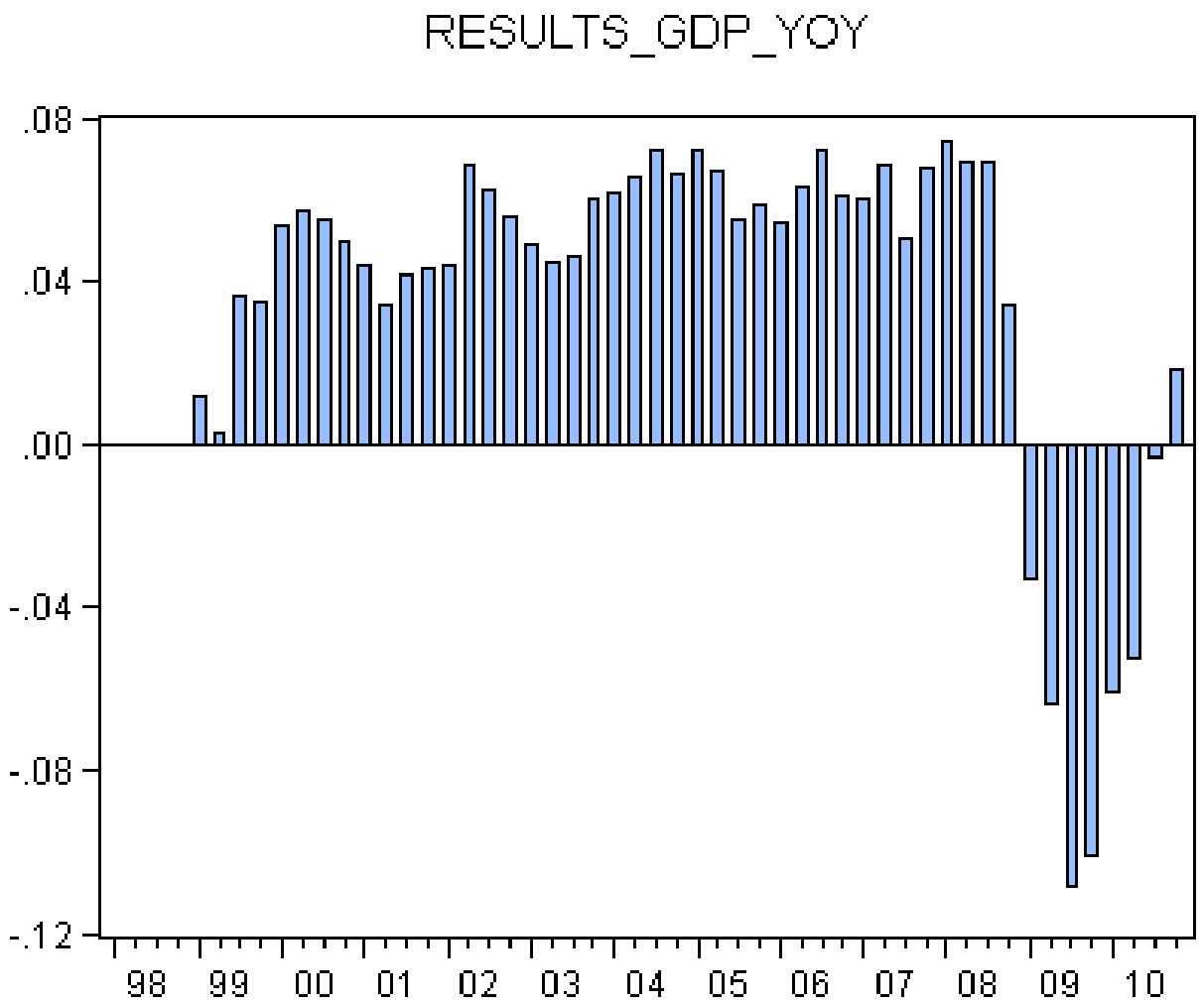
GDP_BG_SA (Baseline)
GDP_BG_SA

Baseline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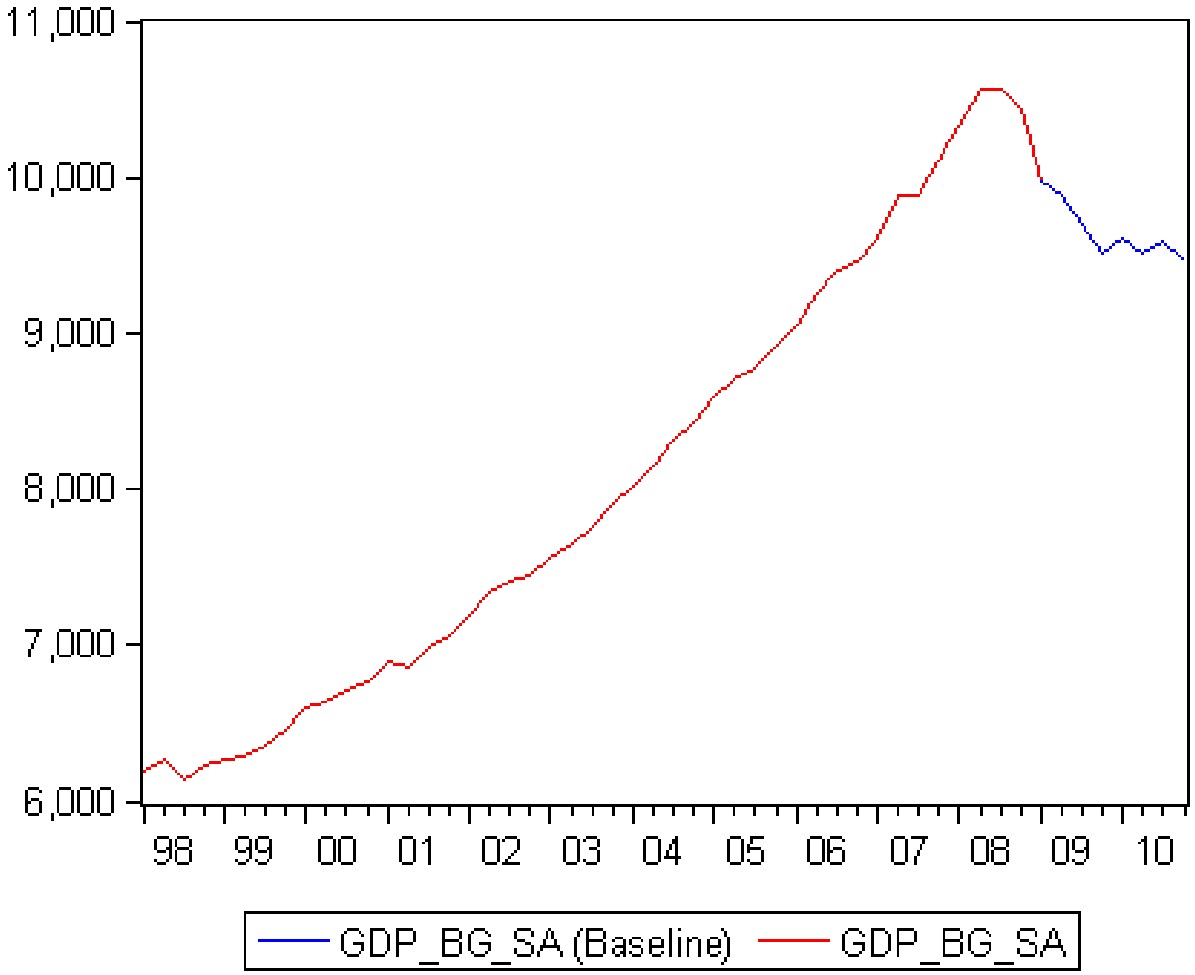
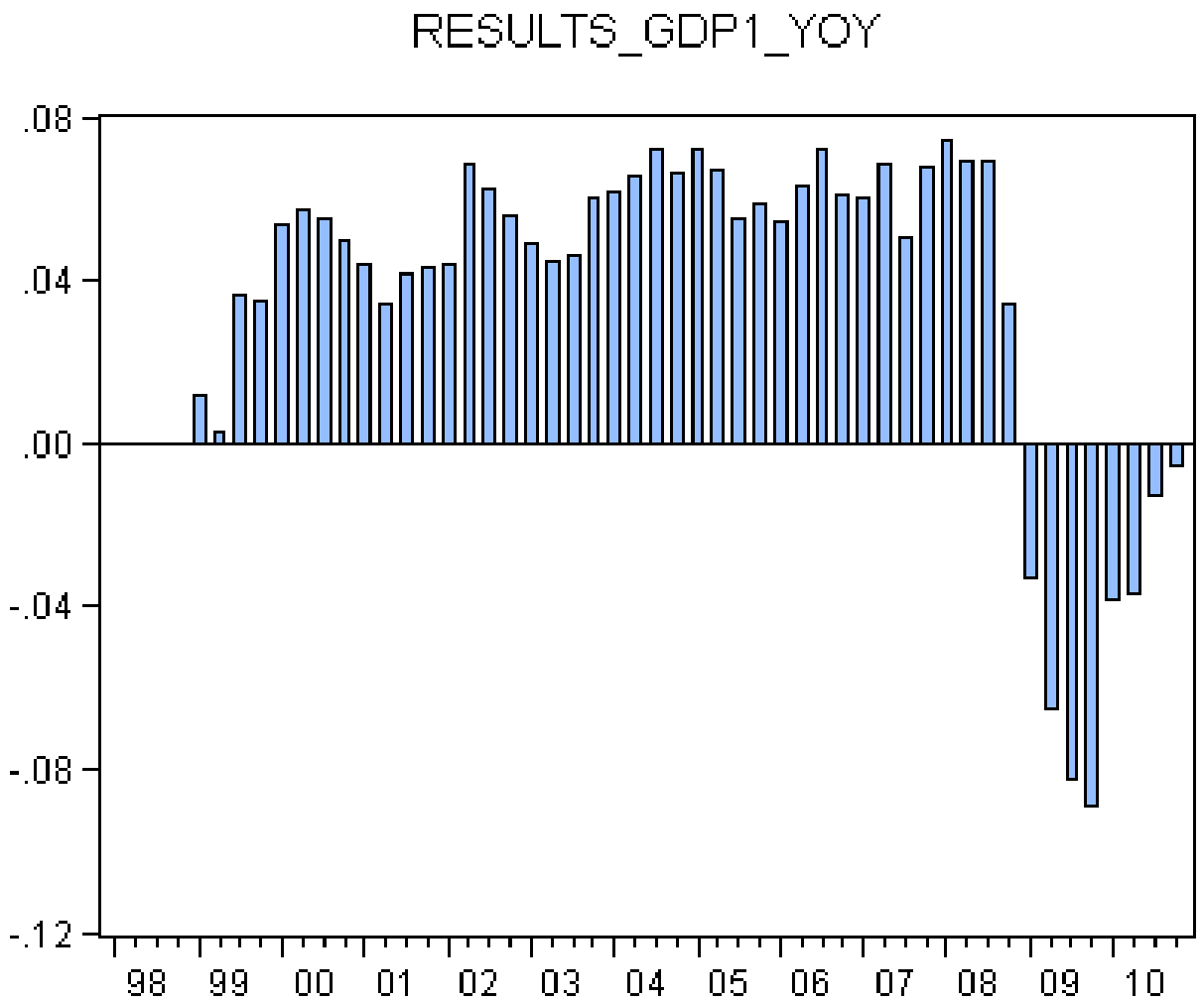
Scenario1 NHW-Forecast



Scenario 1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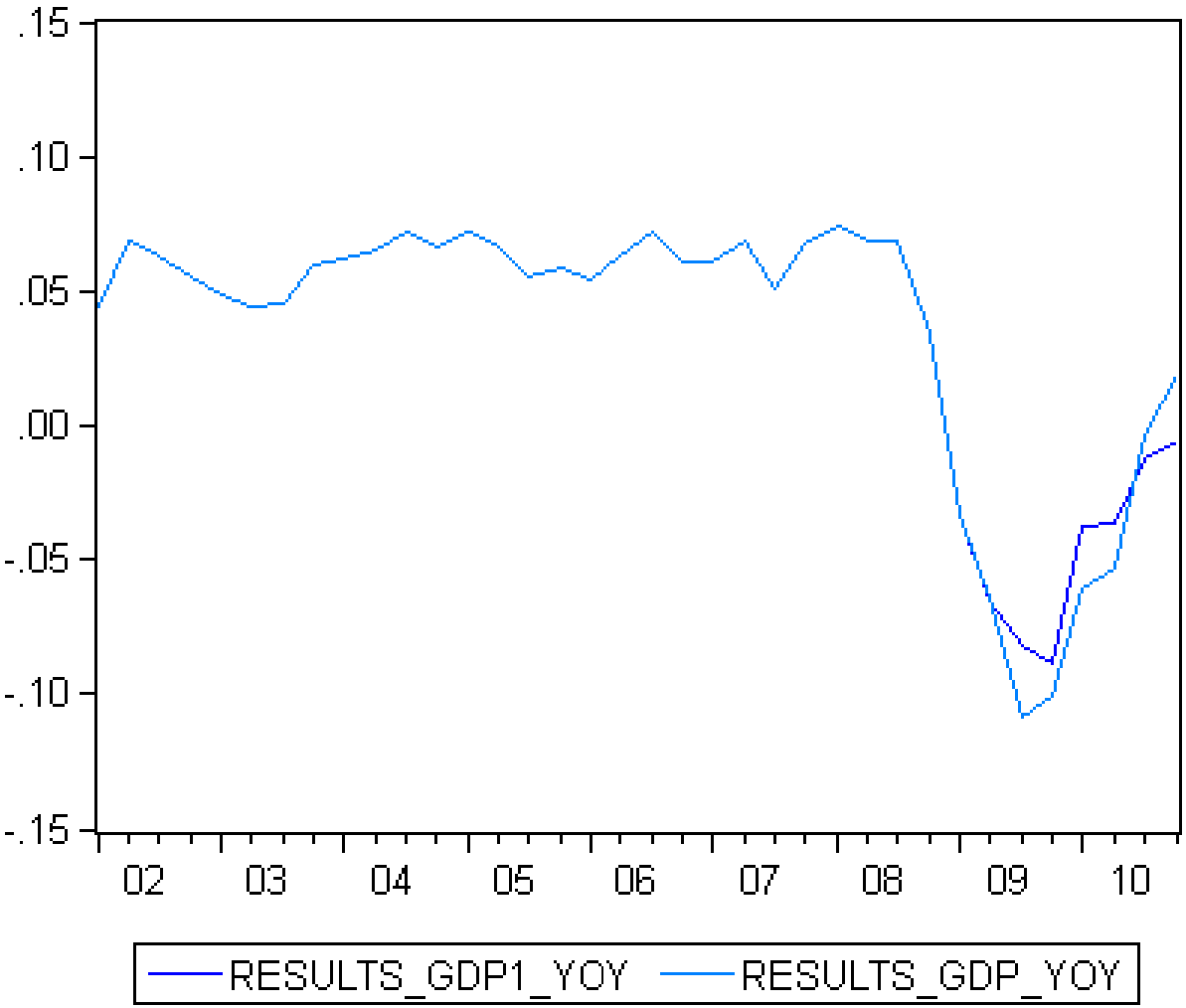
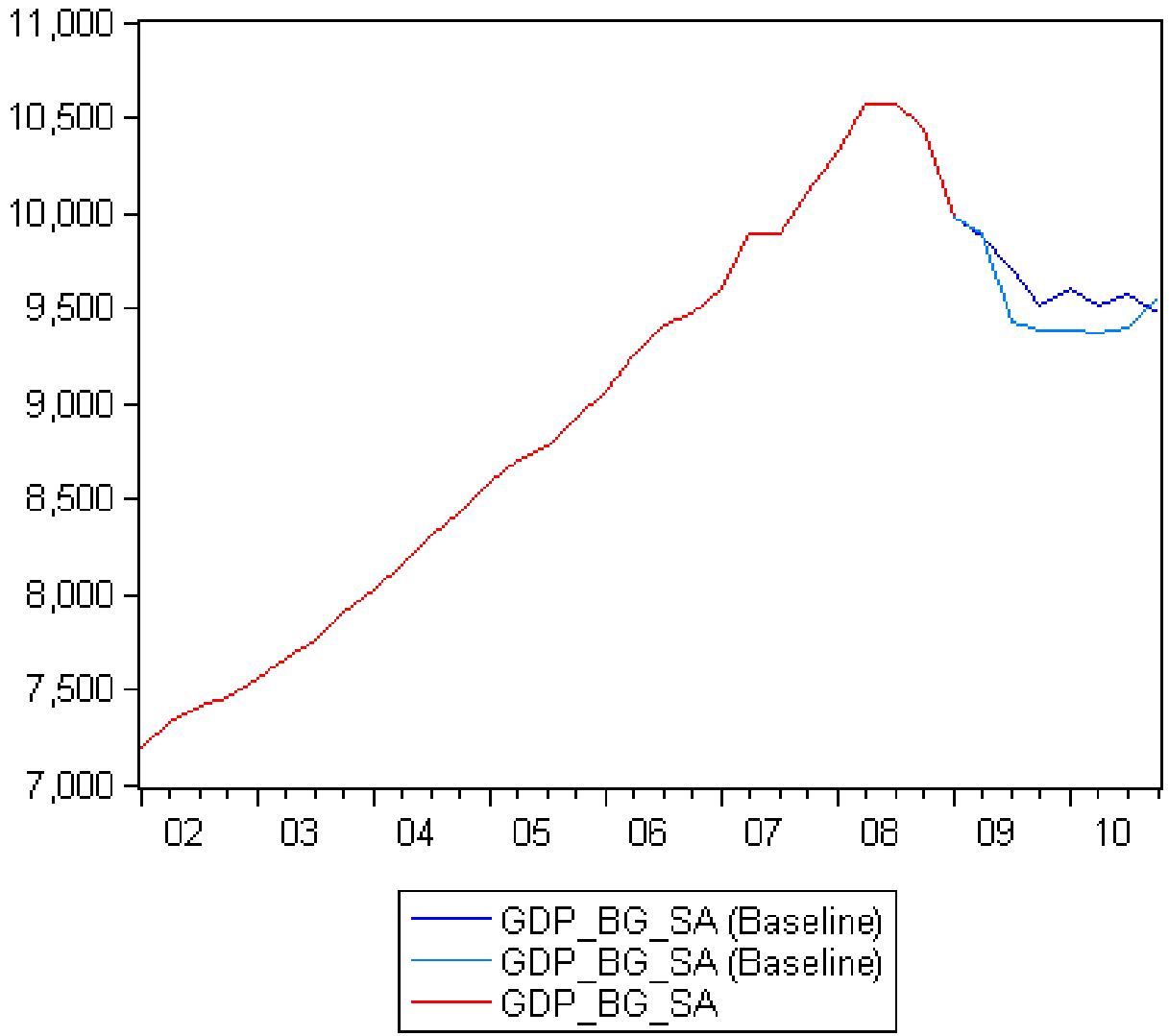
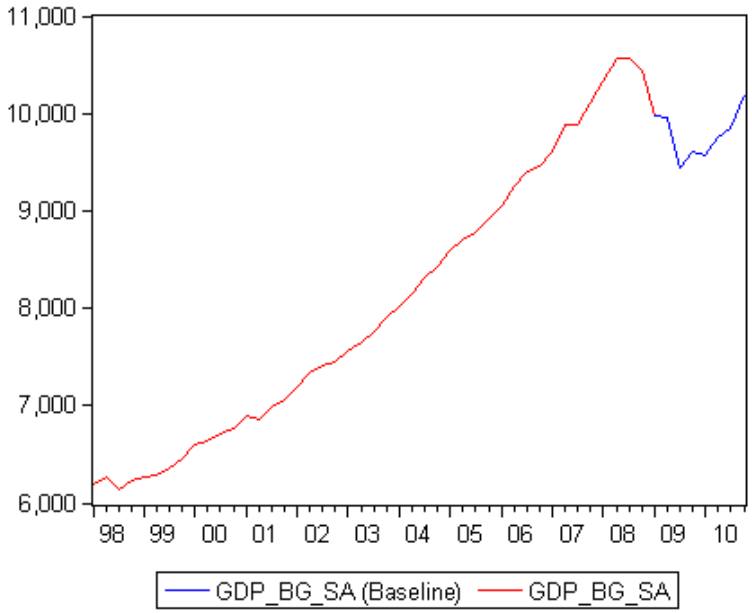
Comparison: Light Blue - Baseline, Dark Blue - Scenario1

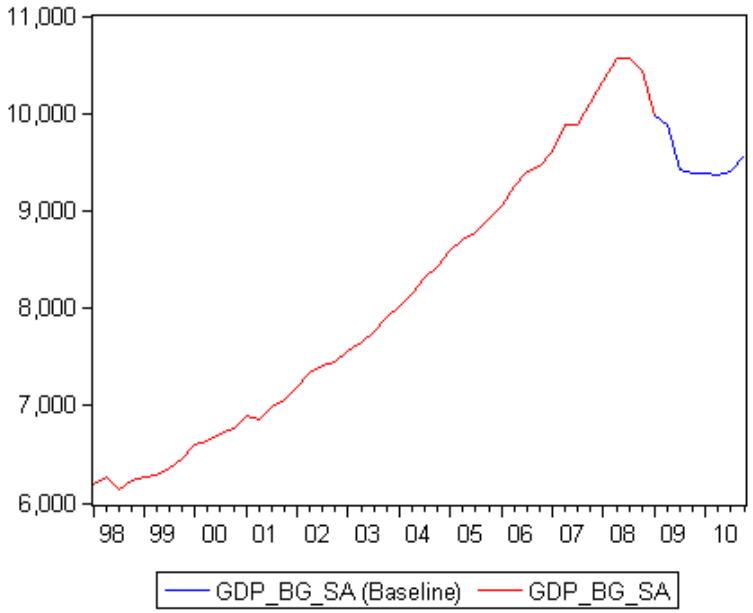


Comparison: Light Blue - Baseline, Dark Blue - Scenario1

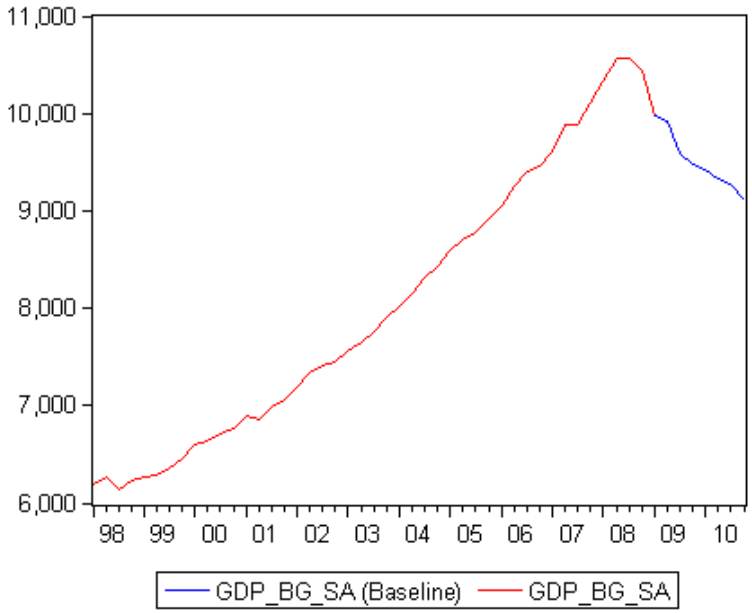


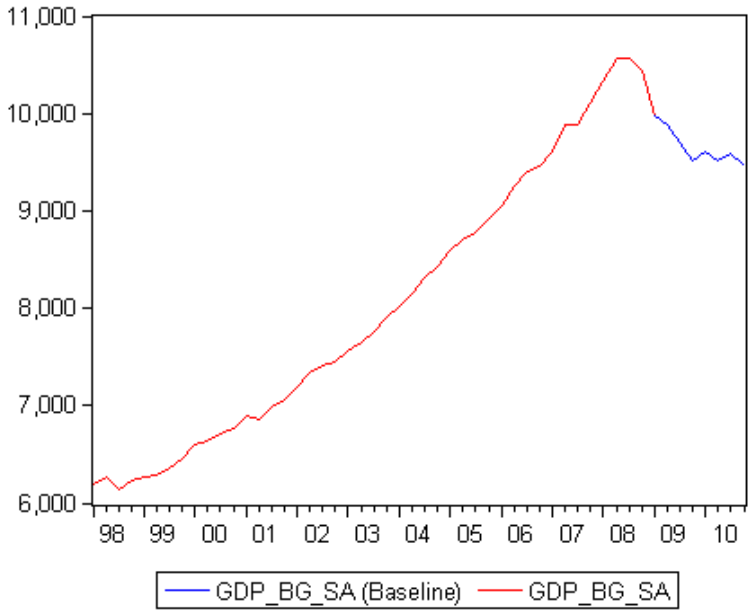
Comparison: AR(1) vs. AR(2) Endogenization, Baseline



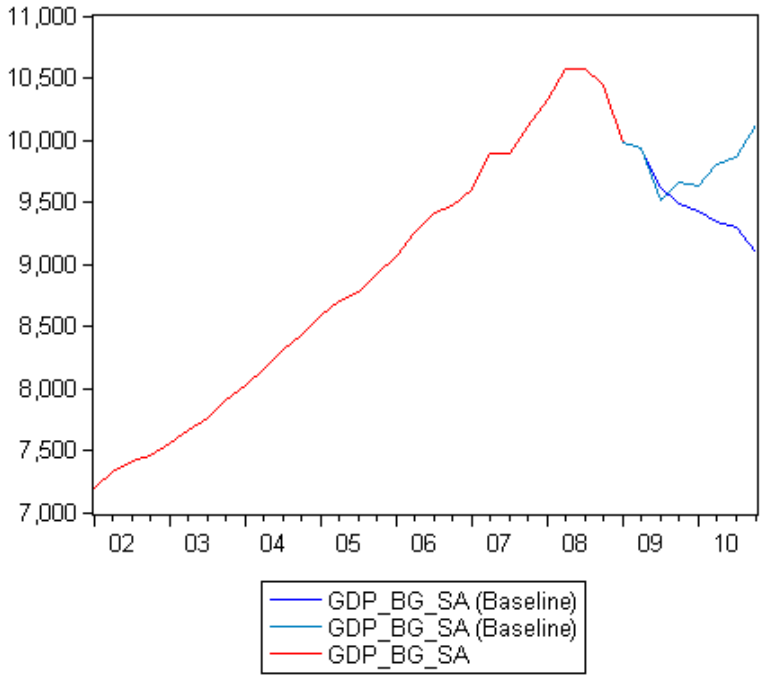


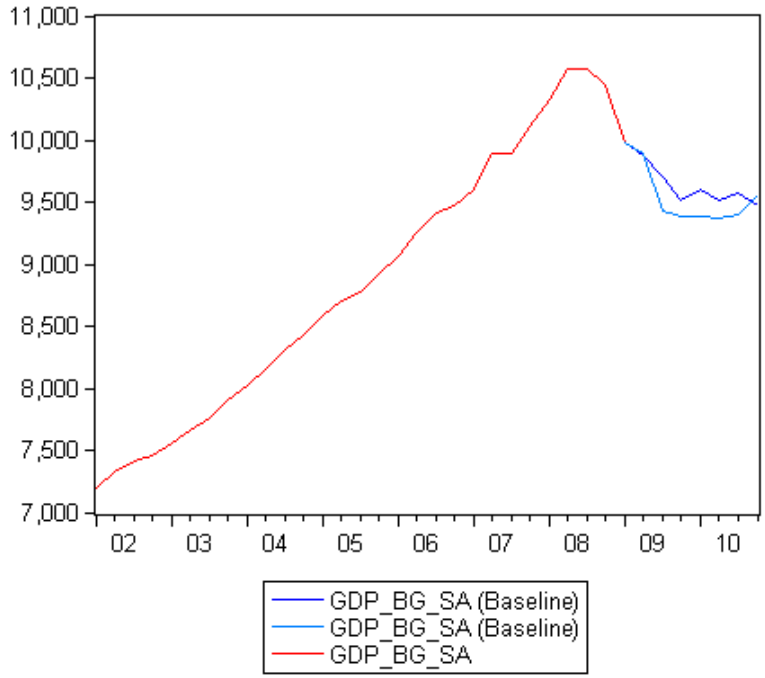
Comparison: AR(1) vs. AR(2) Endogenization, Scenario1





Comparison: AR(1) vs. AR(2)





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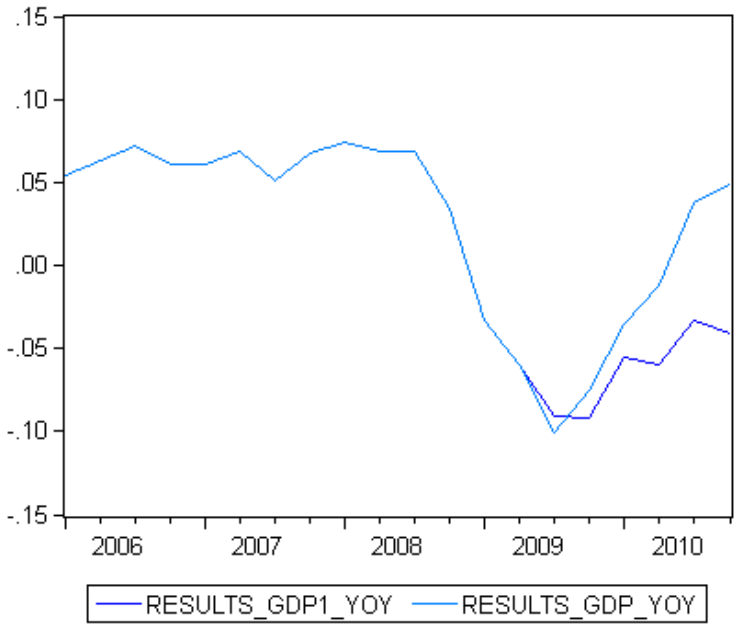

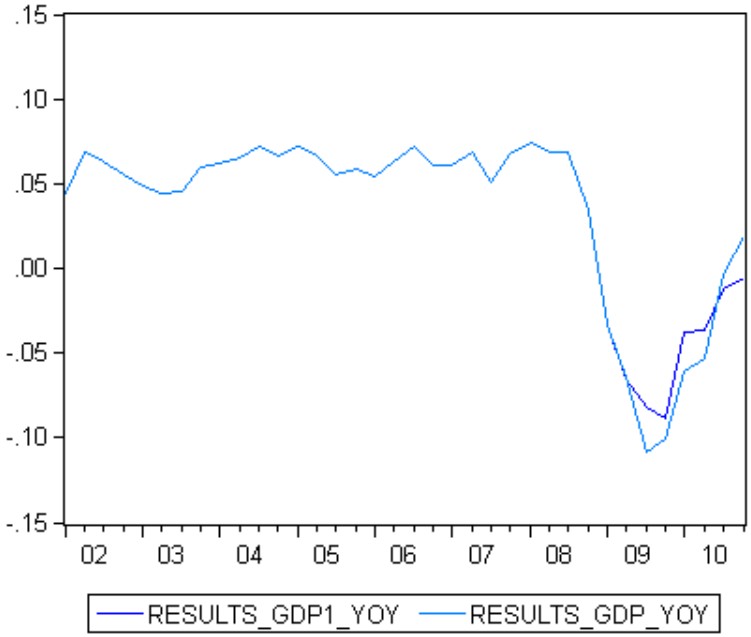

Comparison of Results: 2009/2010

	Baseline	Scenario 1
AR(1) End.	-6.9% / $+1.1\%$	-7.0% / -4.7%
AR(2) End.	-7.7% / -2.4%	-6.7% / -2.3%

Comparison of Results: Baseline versus Scenario (AR(1))

yoy	Baseline AR(1)	Scenario1 AR(1)
2009q1	−3.3%	−3.3%
2009q2	−5.8%	−6.2%
2009q3	−10.6%	−9.3%
2009q4	−8.0%	−9.2%
2010q1	−4.1%	−5.7%
2010q2	−2.0%	−5.8%
2010q3	+4.3%	−3.3%
2010q4	+6.03%	−3.9%

Comparison of Results: Baseline versus Scenario (AR(2))

yoy	Baseline AR(2)	Scenario1 AR(2)
2009q1	−3.3%	−3.3%
2009q2	−6.4%	−6.5%
2009q3	−10.8%	−8.2%
2009q4	−10.1%	−8.9%
2010q1	−6.1%	−3.8%
2010q2	−5.3%	−3.7%
2010q3	−0.3%	−1.3%
2010q4	+1.9%	−0.6%

Remarks on our Model and Open Questions

- We had to introduce the Bulgarian GDP to the Export equation (as the group did) in order to avoid a Multicollinearity Problem. How can one justify the presence of GDP in the Export equation?
- AR(2) seems to provide a smoother path than AR(1)
- ....