

NECMOD

Presentation of the new forecasting model

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Presentation plan

- Rationale for changing the forecasting model
- Structure of the NECMOD model
- Main blocks of NECMOD
- Model's impulse response functions
- Summary

Rationale for changing the forecasting model

Changes in the economy after 2004

Institutional changes

- Accession to the European Union and acceleration of the integration process with the European economy
- Globalisation and the strengthening impact of global shocks on the domestic economy
- Experience with the direct inflation targeting strategy

Main areas of changes in the economy (1)

- Labour market:
 - High volatility of the unemployment rate and the economic activity rate amid moderate changes of wage pressure
 - Migration flows
- Housing market:
 - Soaring prices of houses and growing significance of the wealth channel in shaping the behaviour of economic agents
- Production sector and infrastructure:
 - EU structural funds
- Exchange rate:
 - Appreciation trend which was not accompanied by any significant slump in trade competitiveness

Main areas of changes in the economy (2)

- Oil shock and food price rise:
 - Strong hike in prices of oil and commodities (including agricultural products) on the world markets
- Fiscal reforms and changes in regulations:
 - Changes in tax and social security systems (both implemented and expected)
 - Energy market deregulation
- Expectations of economic subjects
- New methodological challenges
 - ESA 95 (transition from cash basis to accrual basis in the general government sector)
 - Data biases

Forecasting experience

Short history of expert adjustments (1)

- National accounts:
 - Consumption growth rate (problems with disposable income estimates)
 - Investment growth rate (the way of including structural funds)
 - Collective consumption
- Labour market:
 - NAWRU rate, business-cycle and institutional changes
 - Economic activity rate, business-cycle and institutional changes
 - Wage growth rate
 - The role of migration
 - Adjustments due to data bias

Short history of expert adjustments (2)

- Potential product:
 - Problems with TFP measurement
 - Substitution between private and public capital
 - Low contribution of housing assets to potential GDP growth
- Changes in fiscal and regulatory policy
 - Impact of tax changes and transfers on labour market and investment activity
 - Impact on prices

Structure of the NECMOD model

Data

- Official sources
 - Main source: national accounts
 - Labour market: LFS data (adjusted for data bias)
 - General government: in line with ESA methodology (consistent with national accounts)
 - Prices of consumer goods: in line with CPI basket
 - Financial data: NBP
- Own estimates
 - E.g. residential investment, series of capital

Main areas of changes (1)

- Extended supply side:
 - Endogenous rates of unemployment and economic activity
 - Disaggregation of fixed capital formation: productive investment (corporate and public) and residential investment
 - Limited elasticity of substitution between private productive and public capital
- Households:
 - Private consumption and residential investment derived from coherent assumptions; the housing market is modelled from the demand and supply sides
 - Remittances explicitly included in the households' income

Main areas of changes (2)

- Distorting influence of fiscal expenditure and revenues:
 - Impact on labour market (economic activity, employment, wages, NAWRU)
 - Impact on prices (cost channel, indirect taxes)
- Influence of structural funds:
 - Impact on private and public investment
 - Impact on labour market
- Equilibrium exchange rate adjustments consistent with the model's structure

Main areas of changes (3)

- Modification of the block of prices:
 - New definition of core inflation
 - Food and energy prices dependent on external factors
 - Value added deflator as the main producer price index
- Introduction of expectations:
 - Equation of core inflation and value added deflator – backward and forward-looking expectations
 - Real rates deflated with future (anticipated) inflation
 - Long-term rates are the composition of expected short-term rates (adjusted for the risk premium)
- Estimated monetary policy reaction function

Main blocks of NECMOD

Production sector (1)

- Core: production function
 - Labour supply: adjusted LFS employment (accounting for temporary migrations not fully covered in LFS data)
 - Productive capital: composition of private and public productive capital in line with CES technology
 - TFP: deterministic trend
- Potential GDP
 - Determined by production function
 - Effective labour supply instead of actual labour supply
 - The long-run rate of growth of the total factor productivity (TFP) instead of its short-run dynamics.

Production sector (2)

$$gdp_t = tfp_trend_t + 0.67 \cdot emp_t + \cdot(1 - 0.67) \cdot kn_t (*)$$

$$KN_t = \left(0.7^3 \cdot (KN_P_t)^{-2} + 0.3^3 \cdot (KN_G_t)^{-2} \right)^{-\frac{1}{2}}$$

$$gdppot_t = tfp_trend_t + 0.67 \cdot \log[(1 - NAWRU_t) \cdot LF_t] + \cdot(1 - 0.67) \cdot kn_t$$

GDP – GDP, **TFP_TREND** – total factor productivity, **EMP**– employment, **KN** – net productive capital, **KN_P** – net corporate productive capital, **KN_G** – net public productive capital, **GDPPOT** – potential GDP, **LF** – labour force, **NAWRU** – equilibrium unemployment rate

(*) – small letters denote logarithms of variables

Demand for production factors (1)

- Investment
 - Two types of productive investment:
 - Private investment: determined by the equality of marginal productivity of private capital and its real user cost
 - Public investment: investment expenditure of general government; in the long run from the condition of equality of marginal productivity of private and public capital
 - New way of modelling the impact of structural funds:
 - Funds flowing to the private sector: decreasing the cost of private capital utilisation
 - Funds flowing to the general government sector: direct transmission into public investment

Demand for production factors (2)

- First order condition for private investment:

$$0.7^3 \cdot (1 - 0.67) \cdot \frac{GDP_t}{KN_t} \cdot \left(\frac{KN_t}{KP_N_t} \right)^3 = RUCC_t$$

GDP – GDP, ***KN*** – net productive capital, ***KN_P*** – corporate productive capital, ***RUCC*** – real user cost of capital

Demand for production factors (3)

- Private investment

$$\begin{aligned} \Delta gfcfp_t = & \underset{0.46}{0.31} \cdot (MPC_{t-1} - RUCC_{t-1}) + \underset{0.17}{0.11} \cdot \Delta gfcfp_{t-1} + \underset{0.17}{0.12} \cdot \Delta gfcfp_{t-2} \\ & + (1 - \underset{0.17}{0.11} - \underset{0.17}{0.12}) \cdot \Delta gdp_{t-1} - \underset{0.02}{0.006} \cdot \Delta_4 (p_oil_t + s_usd_pln_t - pva_t) \\ & + \underset{0.35}{0.02} \cdot \Delta_4 (FINACC_t) \end{aligned}$$

$$Adj.R^2 = 0.03$$

GFCFP – investment in corporate productive capital, **MPC** – marginal product of private capital, **RUCC** - real user cost of capital, **GDP** – GDP, **P_OIL** – oil price, **S_USD_PLN** – USD/PLN exchange rate, adjusted for nominal-convergence effect, **PVA** – value added deflator, **FINACC** – contribution of enterprises' disposable income to total national income

Demand for production factors (4)

- Demand on labour
 - In the long-run determined by reversed production function
 - Sources of short-term fluctuations:
 - Active labour market policy
 - Labour costs
 - Effective labour supply

Demand for production factors (5)

- Demand on labour

$$\begin{aligned}
 emp_t = & \underset{0.03}{0.09} \cdot (gdp_{t-1} - 0.67 \cdot emp_{t-1} - (1 - 0.67) \cdot k_{t-1} - tfp_trend_{t-1}) \\
 & + \underset{0.09}{0.74} \cdot \Delta emp_{t-1} + (1 - \underset{0.09}{0.74}) \cdot \Delta \log(LF_t \cdot (1 - NAWRU_t)) \\
 & - \underset{0.04}{0.02} \cdot (\Delta \log(WAGE_N_t \cdot (1 + GR_CORP_TR_t) / PVA_t) - \Delta tfp_trend_t / 0.67) \\
 & + \underset{1.26}{2.05} \cdot \Delta \left(\frac{ALMP_N_t}{GDPN_t} \right)
 \end{aligned}$$

$$Adj.R^2 = 0.62$$

EMP – employment, **GDP** – GDP, **KN** – net productive capital, **TFP** – total factor productivity, **LF** – labour force, **NAWRU** – equilibrium unemployment rate, **WAGE_N** – average wage in the economy, **GR_CORP_TR** – effective tax rate of social contribution paid by employer, **PVA** – gross value added deflator, **ALMP_N** – active labour market policy expenditures (both public and private from EU funds related to human capital development), **GDPN** – nominal GDP

Labour market (1)

- Economic activity
 - Modelled in three age groups of population: people aged 15-24, 25-44 and over 45
 - To a large extent determined by changes in the age structure of the population
 - Negative impact of unemployment rate on economic activity ("discouragement effect")
 - Changes in social benefits systems in 1997 and 1999 were taken into account
 - Negative impact of taxes (particularly those imposed on labour and consumption)
 - Negative impact of alternative sources of income (benefits, social welfare, remittances from abroad)

Labour market (2)

- Economic activity in group aged 15-24

$$\frac{LF_Y_t}{POP_Y_t}^* = 0.74 - 0.33 \cdot \left(\frac{1}{4} \cdot \sum_{i=0}^3 UNRATE_{t-i} \right) - 0.02 \cdot (1 - D99q1) + 0.02 \cdot (1 - D97q1) +$$

$$- 0.3 \cdot (GR_EMP_TR_t + GR_PIT_TR_t + GR_HC_TR_t) - 0.3 \cdot INTAX_t +$$

$$+ 0.14 \cdot minw_t - 0.4 \cdot STUDENT - 0.04 \cdot rr_rem$$

LF_Y – labour force aged 15-24, **POP_Y** – population aged 15-24 lat, **UNRATE** – unemployment rate, **D99q1** - variable controlling for the impact of changes in healthcare system, **D97q1** - variable controlling for the impact of changes in unemployment benefit system, **GR_EMP_TR** – effective tax rate of social contribution paid by employees, **GR_PIT_TR** – effective rate of PIT, **GR_HC_TR** - effective rate of health insurance, **INTAX** - effective rate of indirect taxes, **MINW** – minimal to average wage ratio, **RR_REM** –ratio of remittances to wage fund, **STUDENT** – share of full-time students in population aged 15-24

Labour market (3)

- Economic activity in group aged 15-24

$$\begin{aligned} \Delta lf_y_t = & -\frac{0.44}{0.16} \cdot \left(\frac{LF_Y_{t-1}}{POP_Y_{t-1}} - \frac{LF_Y_{t-1}^*}{POP_Y_{t-1}} \right) + \frac{0.43}{0.08} \cdot \Delta lf_y_{t-1} + \frac{0.43^2}{0.08} \cdot \Delta lf_y_{t-2} + \\ & + \left(1 - \frac{0.43}{0.08} - \frac{0.43^2}{0.08} \right) \cdot \Delta pop_y_t + \frac{0.13}{0.12} \cdot \left(\Delta(wage_n_t - cpi_t) - \frac{\Delta tfp_t}{0.67} \right) \\ & - 0.4 \cdot \Delta STUDENT_t \end{aligned}$$

$$Adj.R^2 = 0.58$$

LF_Y – labour force aged 15-24, **POP_Y** – population aged 15-24, **WAGE_N** – average nominal wage in the economy, **CPI** – consumer price index, **TFP** – total factor productivity, **STUDENT** – share of full-time students in population aged 15-24

Labour market (4)

- Economic activity in group aged 25-44

$$\frac{LF_M_t}{POP_M_t}^* = 0.89 + 0.04 \cdot \left(\frac{1}{4} \sum_{i=0}^3 UNRATE_{t-i} \right) - 0.004 \cdot (1 - D99q1) + 0.002 \cdot (1 - D97q1) +$$

$$- 0.1 \cdot (GR_EMP_TR_t + GR_PIT_TR_t + GR_HC_TR_t) - 0.1 \cdot INTAX_t +$$

$$- 0.01 \cdot rr_nlf_m$$

LF_M – labour force aged 25-44, **POP_M** – population aged 25-44 lat, **UNRATE** – unemployment rate, **D99q1** - variable controlling for the impact of changes in healthcare system in 1999, **D99q7** - variable controlling for the impact of changes in unemployment benefit system in 1997, **GR_EMP_TR** – effective tax rate of social contribution paid by employees, **GR_PIT_TR** – effective rate of PIT, **GR_HC_TR** - effective rate of health insurance, **INTAX** - effective rate of indirect taxes, **RR_NFL_M** – expected replacement rate of basic social benefits for inactive population aged 25 – 44

Labour market (5)

- Supply of labour force aged 25-44

$$\Delta lf_m_t = -0.28 \cdot \left(\frac{LF_M_{t-1}}{POP_M_{t-1}} - \frac{LF_M_{t-1}^*}{POP_M_{t-1}} \right) + 0.23 \cdot \Delta lf_m_{t-1} + \frac{0.23^2}{0.09} \cdot \Delta lf_m_{t-2} + (1 - \frac{0.23}{0.09} - \frac{0.23^2}{0.09}) \cdot \Delta pop_m_t$$

Adj.R² = 0.75

LF_M – labour force aged 25-44, POP_M – population aged 25-44

Labour market (6)

- Economic activity in group aged 45+

$$\frac{LF_O_t}{POP_O_t} = 0.59 - 0.30 \cdot \left(\frac{1}{4} \cdot \sum_{i=0}^3 UNRATE_{t-i} \right) - 0.2 \cdot rr_nlf_o_t - 0.02 \cdot D07q1$$

$$+ 0.006 \cdot (1 - D97q1) - 0.3 \cdot (GR_EMP_TR_t + GR_PIT_TR_t + GR_HC_TR_t)$$

$$- 0.3 \cdot INTAX_t - 0.27 \cdot (1 - WORK_AGE_t) - 0.04 \cdot rr_relief_kind_t$$

LF_O – labour force in group aged 25-44, **POP_O** – population aged 25-44, **UNRATE** – unemployment rate, **D97Q1** - variable controlling for the impact of changes in unemployment benefit system in 1997, **GR_EMP_TR** – effective tax rate of social contribution paid by employees, **GR_PIT_TR** – effective rate of PIT, **GR_HC_TR** - effective rate of health insurance, **INTAX** - effective rate of indirect taxes on goods, **RR_NFL_O** – expected replacement ratio of basic social benefits for inactive population aged 45+, **RR_RELIEF_KIND** – replacement ratio of public benefits in kind, **WORK_AGE** –labour force aged 45-65 to those aged 45+ ratio, showing the ageing effect in this demographic group

Labour market (7)

- Economic activity in group aged 45+

$$\begin{aligned} \Delta lf_o_t = & -0.14 \cdot \left(\frac{LF_O_{t-1}}{POP_O_{t-1}} - \frac{LF_O_{t-1}^*}{POP_O_{t-1}} \right) + 0.15 \cdot \Delta lf_o_{t-1} + 0.15^2 \cdot \Delta lf_o_{t-2} + \\ & + (1 - 0.15 - 0.15^2) \cdot \Delta pop_o_t - 0.01 \cdot (I99q1 + I99q2 + I99q3) \\ & - 0.05 \cdot \Delta rr_nlf_o_t \end{aligned}$$

$$Adj.R^2 = 0.55$$

LF_O – labour force in group aged 45, **POP_O** – population aged 45+, **RR_NLF_O** – expected replacement rate of basic social benefits for inactive population aged 45+

Labour market (8)

- Wage equation
 - Cointegration relationships derived from the wage bargaining model,
 - The first order conditions for employee's utility maximisation from remuneration from work and profit of the enterprise, presented by two separate cointegration relationships interpreted as wage curve and price curve
 - The price curve represents enterprises' decisions on prices, wages and employment
 - The wage curve presents the relationship between the desired real wage of employees and their actual remuneration from work
- NAWRU (unemployment equilibrium rate)
 - Unemployment rate for which both cointegration relationships are fulfilled, i.e. both maximisation conditions are met

Labour market (9)

- Wage equation

$$\begin{aligned}
 wage_n_t^* = & 5.42 + \left(\frac{1}{0.67} \right) \cdot tfp_trend_t + cpi_t - 0.5 \cdot INTAX_t - 1.05 \cdot UNRATE_t \\
 & + 0.11 \cdot rr_unemp_t + 0.5 \cdot (GR_PIT_TR_t + GR_HC_TR_t + GR_EMP_TR_t) - \\
 & - 0.5 \cdot GR_CORP_TR_t - 0.18 \cdot rr_rem + 0.52 \cdot \left(\frac{POP_Y_t}{POP_t} \right) \cdot minw_t
 \end{aligned}$$

WAGE_N – average nominal gross wage in the economy, **TFP** – total factor productivity, **CPI** – Consumer Price Index, **GR_EMP_TR** – effective tax rate of social contributions paid by employees, **GR_PIT_TR** – effective rate of PIT, **GR_HC_TR** – effective rate of health insurance, **GR_CORP_TR** – effective tax rate of social contributions paid by employers, **INTAX** – effective rate of indirect taxes, **UNRATE** – unemployment rate, **RR_UNEMP** – replacement ratio of unemployment benefits, **RR_REM** – ratio of remittances to wage fund, **POP_Y** – population aged 15-24, **POP** – total population, **MINW** – minimum to average wage ratio

Labour market (10)

- Price equation:

$$pva_t^* = -3.33 + 0.67 \cdot ulcna_t + (1 - 0.67) \cdot (pimp_t + GR_TAR_TR_t) + 0.11 \cdot D04Q2$$

***PVA** – value added deflator, **ULCNA** – non- farm unit labour cost, **PIMP** – prices of imported goods, **GR_TAR_TR** – effective rate of import duties*

Labour market (11)

- Wage equation

$$\begin{aligned} \Delta wage_n_t = & -\underset{0.02}{0.044} \cdot (wage_n_{t-1} - wage_n_{t-1}^*) - \underset{0.03}{0.047} \cdot (pva_{t-1} - pva_{t-1}^*) \\ & + \underset{0.11}{0.67} \cdot \Delta wage_n_{t-1} + (1 - \underset{0.11}{0.67}) \cdot \Delta cpi_{t-1} + (1 - \underset{0.11}{0.67}) \cdot \Delta (gdp_t - empna_t) \\ & - \underset{0.20}{0.46} \cdot \Delta (UNRATE_t) - \underset{0.01}{0.046} \cdot (I99q1 - I99q2) \end{aligned}$$

$$Adj.R^2 = 0.81$$

WAGE_N – average nominal gross wage in the economy, **PVA** – value added deflator,
CPI – Consumer Price Index, **GDP** – GDP, **EMPNA** – non- farm employment,
UNRATE – unemployment rate

Labour market (12)

- NAWRU

$$\begin{aligned}
 NAWRU_t = & (1 - 0.67 + 1.05)^{-1} \cdot ((cpi_t - pva_t + (0.11/0.67) \cdot D04Q2 - 0.5 \cdot INTAX_t) + \\
 & + 0.5 \cdot (GR_PIT_TR_t + GT_HC_TR_t + GR_EMP_TR_t + GR_CORP_TR_t) + \\
 & + 0.11 \cdot rr_unemp_t + 0.52 \cdot \left(\frac{POP_Y_t}{POP_t} \right) \cdot minw_t + \\
 & + \frac{1 - 0.67}{0.67} \cdot (pimp_t + GR_TAR_TR_t - pva_t) - \frac{EMP_A_t}{LF_t} + (1 - 0.67)(lf_t - k_t) \\
 & + (1/0.67 - 1) \cdot tfp_trend_t - (3.33/0.67) + 5.38 - 0.18 \cdot rr_rem_t)
 \end{aligned}$$

Household expenditure (1)

- Remittances (source: NBP) explicitly included in disposable income (own estimates)
- Expenditure on private consumption and residential investment
- Modelling of households' spending derived from life cycle theory and permanent income theory
- Permanent income proxied by weighted average of disposable income and wealth
- $\text{Wealth} = \text{Private productive capital} + \text{Residential capital} + \text{Public debt} + \text{Net foreign assets}$
- Residential investment modelled from the supply side whereas housing assets deflator modelled from the demand side - it ensures that in response to demand shock, the reaction of prices outpaces the reaction of investment

Household expenditure (2)

- Individual consumption of households:

$$comp_t^* = -0.28 + 0.90 \cdot yd_t + (1 - 0.90) \cdot wealth_t - 0.31 \cdot I_3MR_CPI_t$$

$$\Delta comp_t = \underset{0.00}{-0.01} - \underset{0.04}{0.10} \cdot (comp_{t-1} - comp_{t-1}^*) + \underset{0.04}{0.13} \cdot \Delta yd_t - \underset{0.09}{0.13} \cdot \Delta(I_3MR_CPI)$$

$$Adj.R^2 = 0.28 \quad J-stat = 0.04$$

CONP – individual consumption of households, **YD** – real disposable income of households, **I_3MR_CPI** – real 3-month interest rate (deflated with future CPI inflation), **WEALTH** – wealth of households

Household expenditure (3)

- Residential investment modelled from the supply side:

$$gfcf_h_t^* - gdp_pot_t = -3.36 + 0.27 \cdot (pgfcf_h_t - pva_t)$$

$$\begin{aligned} \Delta gfcf_h_t = & \underset{0.20}{0.62} \cdot \Delta gdp_pot_t + \underset{0.13}{0.22} \cdot \Delta gfcf_h_{t-1} + (1 - \underset{0.20}{0.62} - \underset{0.13}{0.22}) \cdot \Delta gfcf_h_{t-2} + \\ & - \underset{0.08}{0.26} \cdot (gfcf_h_{t-1} - gfcf_h_{t-1}^*) + \underset{0.04}{0.13} \cdot I02Q2 - \underset{0.05}{0.23} \cdot I02Q3 - \underset{0.05}{0.16} \cdot I03Q4 \end{aligned}$$

$$Adj.R^2 = 0.61$$

GFCF_H – gross residential investment, **GDP_POT** – potential GDP, **PGFCF_H** – prices of housing assets, **PVA** – value added deflator

Household expenditure (4)

- Housing assets deflator modelled from demand side (equating marginal utility of owning a dwelling with real cost of its utilisation)

$$k_h_t^* = 0.56 + \text{comp}_t - 0.31(\text{rucc_h})$$

$$\begin{aligned} \Delta \text{pgfcf_h}_t = & \frac{0.80}{0.07} \cdot \Delta \text{pgfcf_h}_{t-1} + (1 - \frac{0.80}{0.07}) \cdot \frac{\Delta \text{cpi}_{t-1}}{0.07} - \frac{0.12}{0.04} \cdot (k_h_{t-1} - k_h_{t-1}^*) + \frac{0.26}{0.11} \text{GAP}_t + \\ & - \frac{0.13}{0.05} \cdot D \left[4 \cdot \text{DISC_H}_t + \text{I_H}_t - \left(\frac{\text{PGFCF_H}_{t-1}}{\text{PGFCF_H}_{t-5}} - 1 \right) \right] \end{aligned} \quad \text{Adj.}R^2 = 0.81$$

PGFCF_H – prices of housing assets, **CPI** – Consumer Price Index, **K_H** – residential capital stock, **GAP** – output gap, **DISC_H** – depreciation rate of residential capital, **I_H** – interest rate on housing loans, **RUCC_H** – real user cost of residential capital

Prices (1)

- Prices of consumer goods:
 - New measure of core inflation (CPI net of food and energy prices)
 - Singled out and modelled separately
 - Food prices
 - Prices of energy products
- Producer prices:
 - Value added deflator - main index of producer prices, basis for determining relative prices
 - GDP deflator used for determining nominal GDP

Prices (2)

- Core prices:

$$\text{corecpi}_t^* = -4.11 + 0.66 \cdot \text{ulcna}_t + (1 - 0.66) \cdot (\text{pimp_core}_t + \text{GR_TAR_TR}_t) + \text{BS_TREND}_t + \text{GR_VAT_TR}_t + \text{GR_GAM_TR}_t + \text{GR_EXT_REST_TR}_t$$

CORECPI – Consumer Price Index net of prices of energy products and food, **ULCNA** – non- farm unit labour cost, **PIMP_CORE** – prices of imported goods excluding prices of oil and natural gas, **BS_TREND** – trend (constant since 2002q3), **GR_TAR_TR** – effective rate of import duties, **GR_VAT_TR** – effective VAT rate, **GR_GAM_TR** – effective gambling tax rate, **GR_EXT_REST_TR** - effective rate of other (non-energy) excise taxes

Prices (3)

- Core prices:

$$\begin{aligned} \Delta corecpi_t = & \left(1 - \frac{0.54}{0.05} - \frac{0.36}{0.08} - \frac{0.043}{0.01} \right) \left(\left(1 + \frac{1}{4} \cdot \sum_{i=-2}^1 INF_TARGET_{t-i} \right)^{\frac{1}{4}} - 1 \right) + \\ & - \frac{0.024}{0.01} \cdot (corecpi_{t-1} - corecpi_{t-1}^*) + \frac{0.54}{0.05} \cdot \Delta corecpi_{t-1} + \frac{0.36}{0.08} \cdot \Delta corecpi_{t+1} \\ & + (1 - 0.66) \cdot \frac{0.043}{0.01} \cdot \Delta (pimp_core_t + GR_TAR_TR_t) + 0.66 \cdot 0.043 \cdot \Delta ulcna_t \end{aligned}$$

$$Adj.R^2 = 0.98 \quad J-stat = 0.14$$

CORECPI – Consumer Price Index net of prices of energy products and food,
INF_TARGET – inflation target, **PIMP_CORE** – prices of imported goods net of oil and gas prices, **GR_TAR_TR** – effective rate of import duties, **ULCNA** – non- farm unit labour cost,

Prices (4)

- Value added deflator:
 - GDP deflator = value added deflator adjusted for net indirect taxes,

$$pva_t^* = -3.33 + 0.67 \cdot ulcna_t + (1 - 0.67) \cdot (pimp_t + GR_TAR_TR_t) + 0.11 \cdot D04Q2$$

***PVA** – value added deflator, **ULCNA** – non- farm unit labour cost, **PIMP** – prices of imported goods, **GR_TAR_TR** – effective rate of import duties*

Prices (5)

- Value added deflator:
 - GDP deflator = value added deflator adjusted for net indirect taxes

$$\begin{aligned} \Delta pva_t = & \left(1 - \frac{0.26}{0.02} - \frac{0.33}{0.04} - \frac{0.25}{0.02}\right) \left(1 + \frac{1}{4} \cdot \sum_{t=-2}^t INF_TARGET_{t-i}\right)^{\frac{1}{4}} - 1 - \frac{0.023}{0.01} (pva_{t-1} - pva_{t-1}^*) + \\ & + \frac{0.26}{0.02} \cdot \Delta pva_{t-1} + \frac{0.33}{0.04} \cdot \Delta pva_{t+1} \\ & + (1 - 0.67) \cdot \frac{0.25}{0.02} \cdot \Delta (pimp_t + GR_TAR_TR_t) + 0.67 \cdot 0.25 \cdot \Delta ulcna_t \end{aligned}$$

$$Adj.R^2 = 0.66 \quad J-stat = 0.16$$

PVA – value added deflator, **INF_TARGET** – inflation target, **PIMP** – prices of imported goods, **GR_TAR_TR** – effective rate of import duties, **ULCNA** – non-farm unit labour cost

Prices (6)

- Food prices:

$$\begin{aligned} foodcpi_t^* = & -2.08 + 0.49 \cdot (p_food_t + s_usd_pln_t) + (1 - 0.49) \cdot corecpi_t \\ & + 0.49 \cdot GR_VAT_TR_t \end{aligned}$$

FOODCPI – food price index, **CORECPI** – Consumer Price Index net of prices of energy products and food, **P_FOOD** – world price index of raw agriculture commodities, **S_USD_PLN** – USD/PLN exchange rate adjusted for nominal convergence effect

Prices (7)

- **Food prices:**

$$\Delta foodcpi_t = \underset{0.13}{0.54} \cdot \Delta foodcpi_{t-1} + \underset{0.14}{0.41} \cdot \Delta corecpi_{t-1} - \underset{0.04}{0.084} \cdot (foodcpi_{t-1} - foodcpi_{t-1}^*) + \\ + (1 - \underset{0.13}{0.54} - \underset{0.14}{0.41}) \cdot \Delta \log(p_food_{t-1} + s_usd_pln_{t-1})$$

$$Adj.R^2 = 0.57$$

FOODCPI – food price index, **CORECPI** – Consumer Price Index net of prices of energy products and food, **P_FOOD** – world price index of raw agriculture commodities, **S_USD_PLN** – USD/PLN exchange rate adjusted for nominal convergence effect

Prices (8)

- **Prices of energy products**

$$\begin{aligned} \text{energcpi}_t^* = & -2.1 + 0.45 \cdot (p_ener_t + s_usd_pln_t + GR_VAT_TR_t) \\ & + (1 - 0.45) \cdot (\text{corecpi}_t - GR_EXT_REST_TR_t) + GR_EXT_ENER_TR_t \end{aligned}$$

ENERCPI – energy product price index, **CORECPI** – Consumer Prices Index net of prices of energy products and food, **P_ENER** – world raw energy commodities price index, **S_USD_PLN** – USD/PLN exchange rate adjusted for nominal convergence effect, **GR_EXT_REST_TR** – effective excise tax rate – other goods, **GR_EXT_ENER_TR** – effective excise tax rate – energy products

- Food and energy products prices are adjusted by experts in the projection horizon

Prices (9)

- Prices of energy products:

$$\begin{aligned} \Delta enercpi_t = & \underset{0.12}{0.45} \cdot \Delta enercpi_{t-1} + (1 - \underset{0.12}{0.45} - \underset{0.02}{0.063}) \cdot \Delta (corecpi_t - GR_EXT_REST_TR_t) \\ & - \underset{0.03}{0.071} \cdot (enercpi_{t-1} - enercpi_{t-1}^*) + \underset{0.02}{0.062} \Delta (p_ener_t + s_usd_pln_t) \\ & + (1 - \underset{0.12}{0.45}) \cdot \Delta GR_EXT_ENER_t + \underset{0.01}{0.037} \cdot I98q1 \end{aligned}$$

$$Adj.R^2 = 0.40$$

ENERCPI – energy product price index, **CORECPI** – Consumer Prices Index net of prices of energy products and food, **P_ENER** – world raw energy commodities price index, **S_USD_PLN** – USD/PLN exchange rate adjusted for nominal convergence effect, **GR_EXT_REST_TR** – effective excise tax rate – other goods, **GR_EXT_ENER_TR** – effective excise tax rate – energy products

External sector (1)

- Volume of exports – modelled from the supply side in the long run, from the demand side in the short run:
 - Exports as function of relative export prices, potential GDP and external demand
- Volume of imports – modelled from the supply side
 - Imports as function of relative import prices, GDP, domestic demand (weighted by import absorption)

External sector (2)

- Volume of exports

$$(gdp_exp_t - gdp_pot_t)^* = 0.57 \cdot (pexp_t - pva_t) + 0.01 \cdot t + \\ + 0.07 \cdot D05q2 - 1.50$$

GDP_EXP – volume of exports, **GDP_POT** – potential GDP, **PEXP** – deflator of exports, **PVA** – value added domestic deflator, **t** – trend connected with gradual integration of Polish economy

External sector (3)

- Volume of exports

$$\begin{aligned} \Delta(gdp_exp_t - gdp_pot_t) = & -\frac{0.24}{0.07} \cdot ((gdp_exp_{t-1} - gdp_pot_{t-1}) + \\ & - (gdp_exp_{t-1} - gdp_pot_{t-1})^*) + \\ & + \frac{1.91}{0.88} \cdot (\Delta gdp_ext_t - 0.005) + \frac{0.03}{0.02} \cdot I05q2 + 0.01 \end{aligned}$$

$$Adj.R^2 = 0.26$$

GDP_EXP – volume of exports, **GDP_POT** – potential GDP, **GDP_EXT** – external product,

External sector (4)

- Volume of imports

$$(gdp_imp_t - gdp_t)^* = -0.33 \cdot \log(PIMP_CORE_t \cdot (1 + GR_TAR_TR_t) / PVA_t) \\ + 0.01 \cdot t - 1.55$$

GDP_IMP – volume of imports, **GDP** – GDP, **PIMP_CORE** – prices of imported products excluding oil and gas prices, **GR_TAR_TR** – effective rate of duties, **PVA** – value added deflator, **t** – trend connected with gradual integration of Polish economy

External sector (5)

- Volume of imports

$$\begin{aligned} \Delta(\text{gdp_imp}_t - \text{gdp}_t) = & 0.01 - \frac{0.07}{0.04} \cdot ((\text{gdp_imp}_{t-1} - \text{gdp}_{t-1}) + \\ & - (\text{gdp_imp}_{t-1} - \text{gdp}_{t-1})^*) + \\ & + \frac{1.15}{0.21} \cdot \Delta \log \left(\frac{0.4 \text{GFCF}_t + 0.2 \text{CONP}_t + 0.4 \text{GDP_EXP}_t}{\text{TFP_TREND}_t^{1/0.67}} \right) + \\ & - \frac{0.19}{0.12} \Delta \log (\text{PIMP_CORE}_t \cdot (1 + \text{GR_TAR_TR})_t / \text{PVA}_t) \end{aligned}$$

*Adj.R*² = 0.47

GDP_IMP – volume of imports, **GDP** – GDP, **GFCF** – total gross fixed capital formation, **CONP** – individual consumption, **GDP_EXP** – volume of exports, **TFP_TREND** – total factor productivity, **PIMP_CORE** – prices of imported goods excluding prices of oil and natural gas, **GR_TAR_TR** – effective rate of import duties, **PVA** – value added deflator

External sector (6)

- Export and import prices: according to the notion of price maker – price taker

$$pexp_t^* = 0.35(pva_ext_t + s_neer_t) + (1 - 0.35)pva_t - 3.20$$

$$\Delta pexp_t = -\frac{0.21}{0.09}(pexp_{t-1} - pexp_{t-1}^*) + \frac{0.31}{0.07} \cdot \Delta(pva_ext_t + s_neer_t) + (1 - \frac{0.31}{0.07}) \cdot \Delta pva_t$$

*Adj.R*² = 0.37

PEXP – exports prices, **GDP** – GDP, **PVA_EXT** – external value added deflator, **S_NEER** – nominal effective exchange rate adjusted for nominal convergence effect, **PVA** – domestic value added deflator, **GDP_POT** – potential GDP in Poland, **GDP_EXT_POT** – external potential GDP

External sector (7)

- Export and import prices: according to the notion of price maker – price taker

$$pimp_core_t^* = 0.54 \cdot (pva_ext_t + s_neer_t) + (1 - 0.54) \cdot p_va_t - 5.28$$

$$\begin{aligned} \Delta pimp_core_t = & -0.22_{0.10} (pimp_core_{t-1} - pimp_core_{t-1}^*) \\ & + 0.36_{0.09} \Delta(pva_ext_t + s_neer_t) + (1 - 0.36_{0.09}) \cdot \Delta pva_t \end{aligned}$$

$$Adj.R^2 = 0.34$$

PIMP_CORE – import prices excluding oil and gas prices, **PVA_EXT** – external value added deflator, **S_NEER** – nominal effective exchange rate adjusted for nominal convergence effect, **PVA** – domestic value added deflator, **GDP_POT** – potential GDP in Poland, **GDP_EXT_POT** – external potential GDP

External sector (8)

- Nominal exchange rate:

$$\begin{aligned}
 s_neer_t^* = & pva_t - pva_ext_t - 0.6 \cdot (gdp_pot_t - gdp_ext_pot_t) + \\
 & - 0.25 \cdot NFA_GDP_{t-1} - 1.28 \cdot (I_3MR_PVA_{t-1} - I_3MR_EXT_{t-1}) + \\
 & + 9.11 - 0.06 \cdot D04q2 - 0.06 \cdot D06q3
 \end{aligned}$$

S_NEER – nominal effective exchange rate, **PVA** – value added deflator, **PVA_EXT** – external gross value added deflator, **GDP_POT** – potential GDP, **GDP_EXT_POT** – external potential GDP, **I_3MR_PVA** – real 3-month interest rate (deflated with gross value added deflator), **I_3MR_EXT** – external real interest rate, **NFA_GDP** – net foreign assets in relation to GDP

External sector (9)

- Nominal exchange rate:

$$\begin{aligned} \Delta s_neer_t = & -\frac{0.27}{0.06} \cdot (s_neer_{t-1} - s_neer_{t-1}^*) + \frac{0.51}{0.51} \cdot \Delta(pva_t - pva_ext_t) + \\ & -\frac{0.37}{1.12} \cdot \Delta(gdp_pot_t - gdp_ext_pot_t) + \\ & -\frac{0.64}{0.97} \cdot \Delta(I_3MR_PVA_t - I_3MR_EXT_t) \end{aligned}$$

$$Adj.R^2 = 0.13 \quad J-stat = 0.01$$

S_NEER – nominal effective exchange rate, **PVA** – value added deflator, **PVA_EXT** – external gross value added deflator, **GDP_POT** – potential GDP, **GDP_EXT_POT** – external potential GDP, **I_3MR_PVA** – real 3-month interest rate (deflated with gross value added deflator), **I_3MR_EXT** – external real interest rate

External sector (10)

- Equilibrium exchange rate (s_reer^*):
 - Modelled explicitly in line with the theory of fundamental equilibrium exchange rate (FEER), cf. Rubaszek (2005)
 - Derived from long-run relationships of the external block for given long-run macroeconomic proportions (other variables marked with *)

$$\begin{aligned} & \exp\{0.35 \cdot (1+0.57) \cdot s_reer^* - 1.50 + 0.01 \cdot t + 0.07 \cdot D05q2 - 3.20 \cdot (1+0.57) + 0.6 \cdot 0.35 \cdot (1+0.57) \cdot (gdp_pot - gdp_ext_pot)\} = \\ & = \exp\{0.54 \cdot (1-0.33) \cdot s_reer^* - 1.55 + 0.01 \cdot t - 5.27 \cdot (1-0.33) + 0.6 \cdot 0.54 \cdot (1-0.33) \cdot (gdp_pot - gdp_ext_pot) - 0.33 \cdot gr_tar_tr\} \cdot \\ & (PIMP_OILGAS_R^*)^{0.062+0.026} - CAB_INC_GDP^* - CAB_TRANS_GDP^* + CAB_GDP^* \end{aligned}$$

- Objective:
 - Possibility to include adjustments of the mid-term exchange rate path in a way that is consistent with the model's structure
 - Enhancing simulation possibilities

S_REER – real effective exchange rate, **GDP_POT** – potential GDP in Poland, **GDP_EXT_POT** – external potential GDP, **GR_TAR_TR** – effective rate of import duties, **PIMP_OILGAS_R** – relative prices of imported commodities, **CAB_INC_GDP** – income account in relation to GDP, **CAB_TRANS_GDP** – balance on current transfers in relation to GDP, **CAB_GDP** – current account balance in relation to GDP, * stands for equilibrium levels

Interest rates (1)

- All real interest rates deflated with future inflation
- Long-term interest rates:
 - Composition of expected short-term interest rates
 - Adjustment for risk premium (situation of public finance sector, inflation expectations)

$$I_{5Y}_t = 0.06 \cdot I_{3M}_t + (1 - 0.06) \cdot I_{5Y}_{t+1} - \underset{0.00}{0.01} - \underset{0.05}{0.15} \cdot G_BALANCE_GDP_t$$

$$Adj.R^2 = 0.94 \quad J_stat = 0.23$$

I_5Y – 5-year interest rate, *I_3M* – 3-month interest rate, *G_BALANCE_GDP* – general government balance in relation to GDP

Interest rates (2)

- Short-term interest rates:
 - Estimated Taylor's Rule

$$I_{3M}_t = 0.88 \cdot I_{3M}_{t-1} + (1 - 0.88) \cdot (I_{3MR_EQ} + INF_{t+1} + 0.99 \cdot (INF_{t+1} - \frac{1}{4} \sum_{i=-3}^0 INF_TARGET_{t-i}) + 0.59 \cdot GAP_t)$$

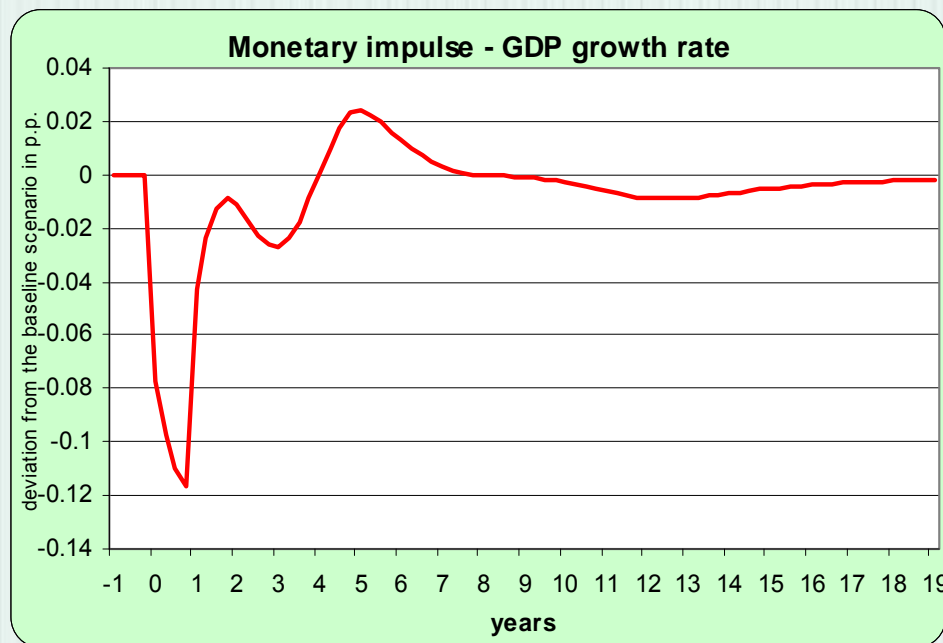
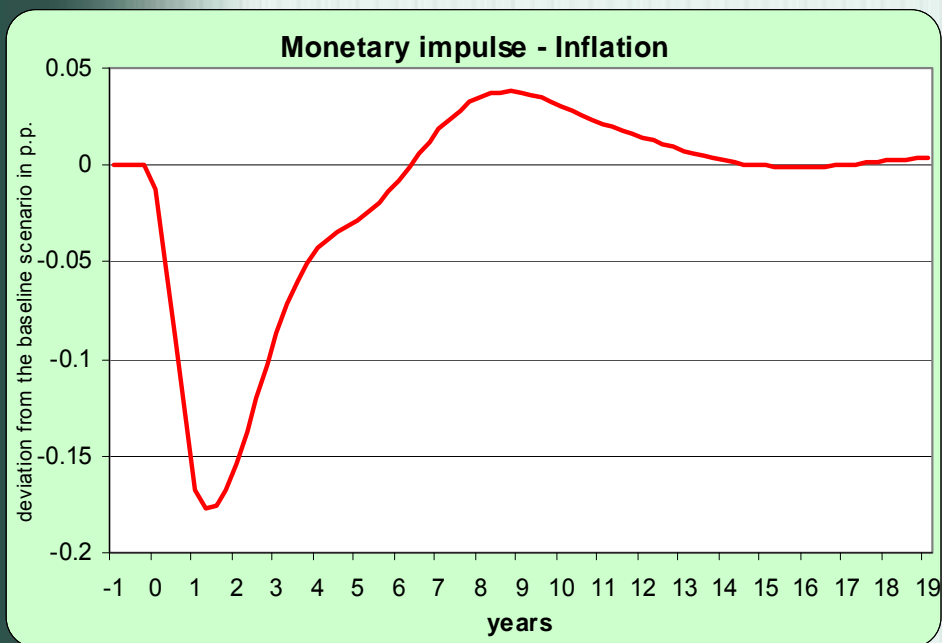
$$Adj.R^2 = 0.98 \quad J_{stat} = 0.33$$

I_3M – 3-month interest rate, *I_3M_EQ* – real interest rate in long-term equilibrium,
INF – CPI inflation, *INF_TARGET* – inflation target, *GAP* – output gap

Model's impulse response functions

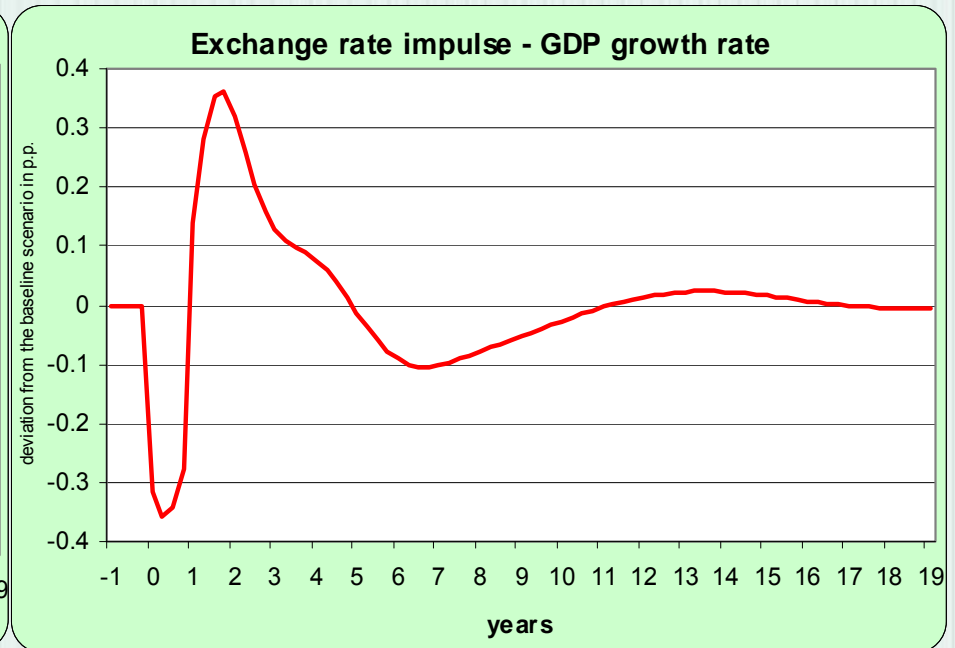
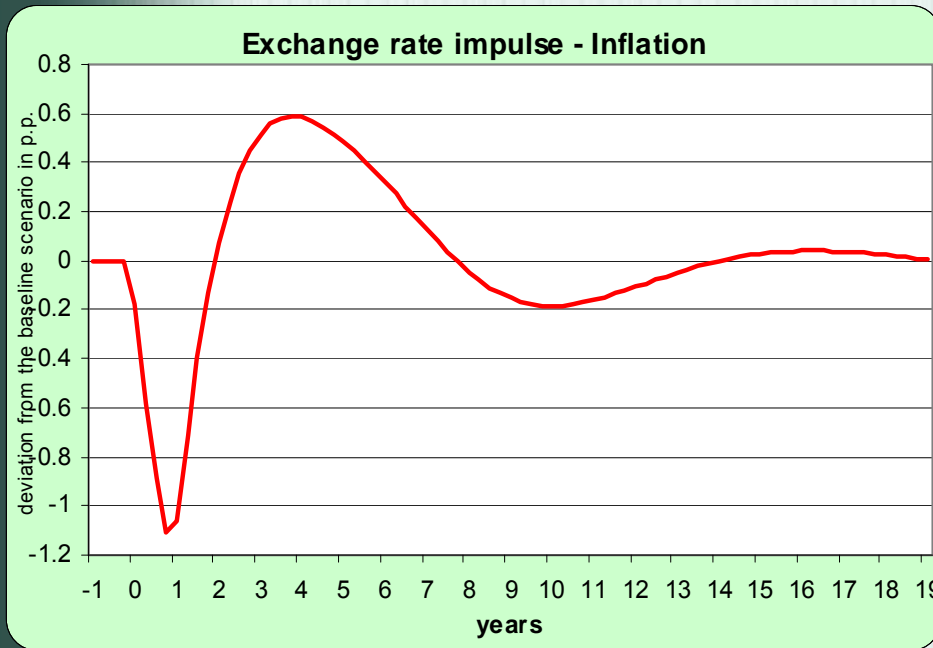
Monetary impulse

1 percentage point interest rate increase in the 1st quarter. In subsequent periods interest rate consistent with estimated Taylor's Rule.



Exchange rate impulse

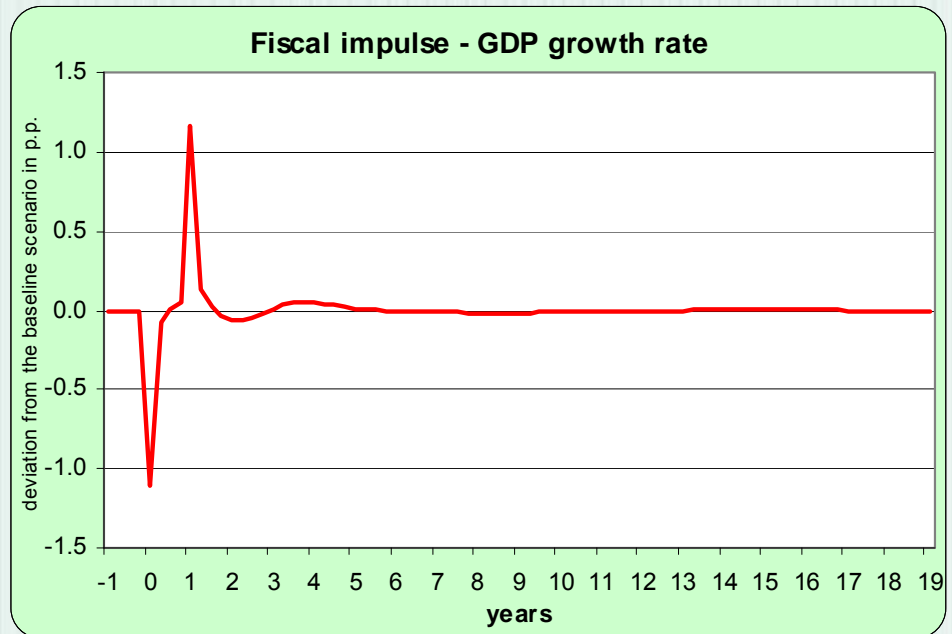
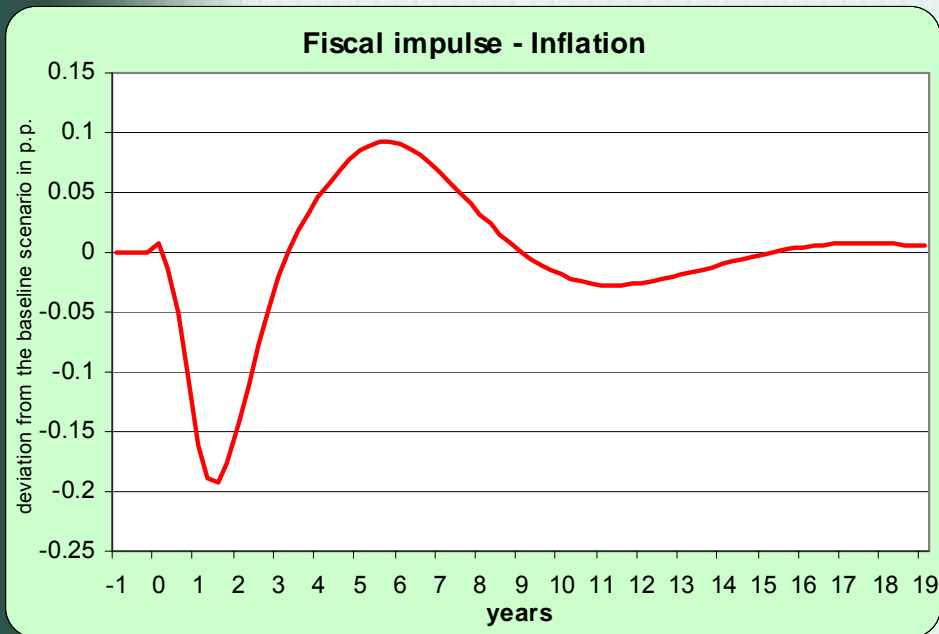
10-percent appreciation in the 1st quarter. In subsequent periods exchange rate consistent with the equation. Taylor's Rule activated.



Fiscal impulse

Reduction in current expenditure of general government (in purchase of goods and services section) of 1% of GDP in the 1st quarter. Starting from the next period, expenditure return to the "old path" (increase of 1% of GDP) and then continue consistently with model equation.

Taylor's Rule activated.



Summary

General characteristics of the NECMOD model

- It reflects the evolution of the economy over the past few years (and, as is our intention, also in the years to come) as well as the richer forecasting experience of the team
- It refers to a number of model-related analyses and studies
- Hybrid-like character of the model and its long-term stability have been preserved
- The supply side of the economy has been extended and elaborated in greater detail (potential product, equilibrium unemployment rate, equilibrium rate of economic activity, equilibrium exchange rate)
- Expectations are modelled explicitly
- Potential simulation possibilities can provide answers to many topical questions (impact of fiscal changes, structural funds, emigration)

Forecasting features of the NECMOD model

- Possibility of constructing a more coherent and comprehensive story for forecasting scenarios
- Less invasive and more coherent expert adjustments
- Forecasting process can be streamlined
- Greater flexibility of the model in terms of forecasting and simulation exercises
- "Embedding" of some expert adjustments of the past few years and/or extension of critical blocks
- Updating the equations with 2007 data