DSGE MODEL FOR NATIONAL BANK OF POLAND

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BNP PARIBAS

CONTENT

I. INTRODUCTION

- NECMOD: The main forecasting model of the National Bank of Poland (NBP) from 2008 till now. ECMOD: the first origins of NECMOD that was employed to prepare regular inflation projections at the NBP from 2005 to the begining of 2008, and then they developed ECMOD to be NECMOD.
- NECMOD is a structural macroeconometric model designed to describes the Polish economy to publisded the inflation and GDP projection.
- Many banks and institutions used NECMOD to forecast and draft state budget for 2022, such as Santander Bank Polska, Union of Entrepreneurs and Employers (ZPP),…

II. MODEL DEVELOPMENT PROCESS

YEAR	CONTENT	COMMENTS
2005	Estimation of ECMOD model	This is the orginal model of NECMOD model
2008	Developed ECMOD to be NECMOD	The first version of the NECMOD which is developed from ECMOD model
2009	Re-estimation of NECMOD model, and NBP have been using this model till now	Changes to the foreign trade block
2010	Re-estimation of NECMOD model	Chages to prices block, new corporate investment equation
2011	Re-estimation of NECMOD model	Chages to prices block, including the hysteresis
2012	Re-estimation of NECMOD model	Respecification of labour participation block

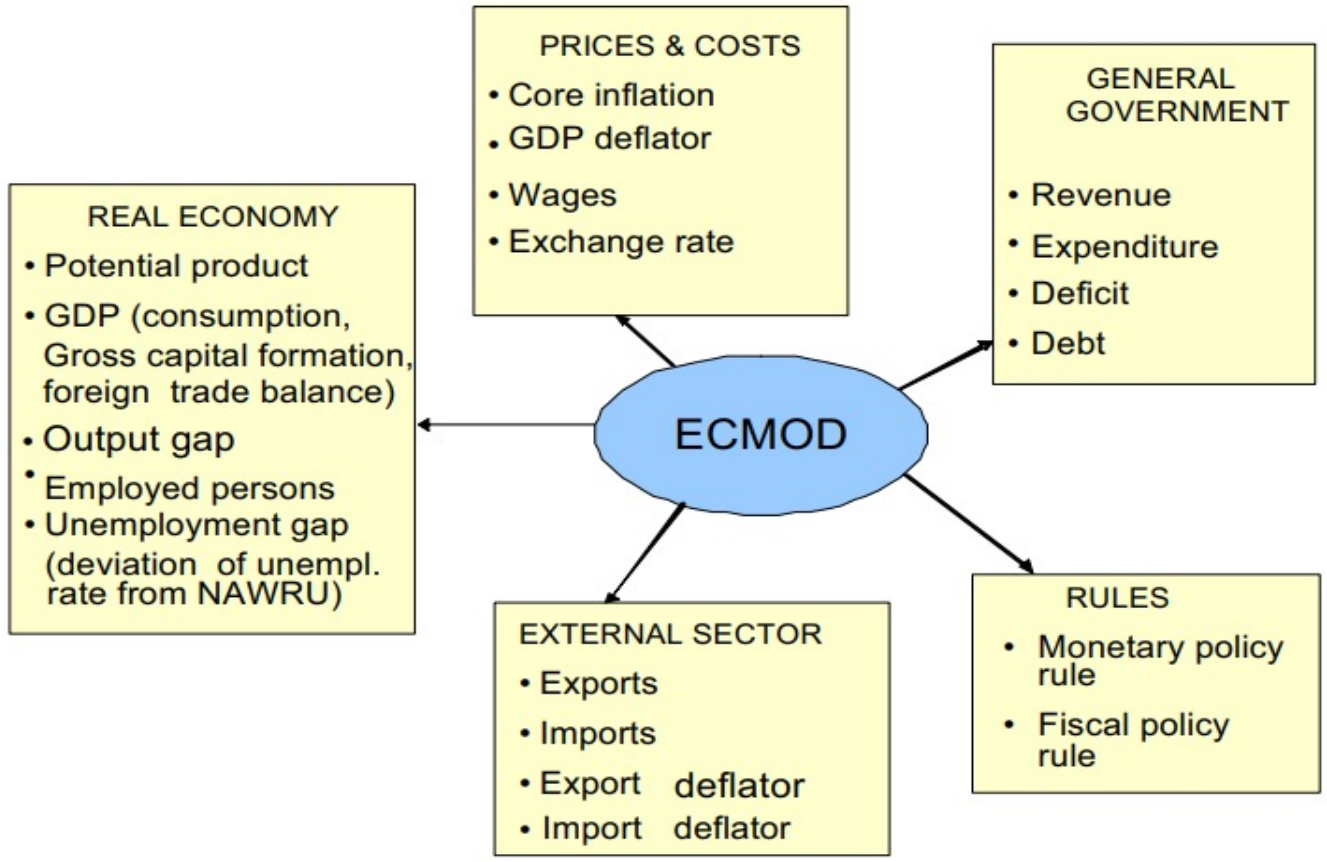
III. THE STRUCTURE OF NECMOD MODEL

3.1. THE STRUCTURE OF ORGINAL MODEL (ECMOD)

3.2. THE STRUCTURE OF NECMOD MODEL

3.1. THE STRUCTURE OF ORGINAL MODEL (ECMOD)

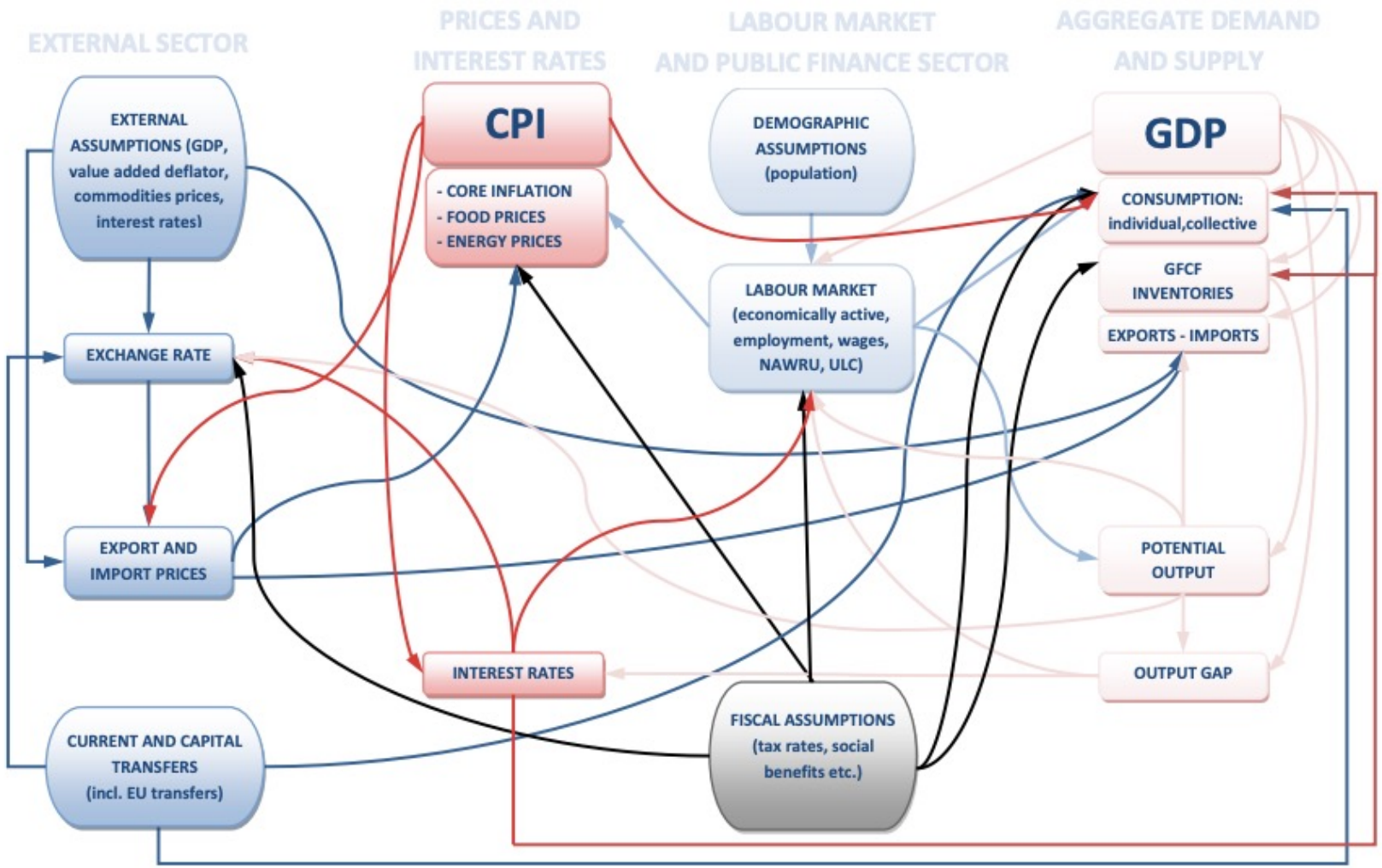
Fig. 1 Modules of the ECMOD model



ECMOD model has over 100 equations

3.2. THE STRUCTURE OF NECMOD MODEL

Figure 2: The NECMOD model structure



NECMOD model has 276 equations and 369 variables

IV. NECMOD MODEL

4.1. NECMOD MODEL _ 2008

4.2. NECMOD MODEL _ 2009

4.3. NECMOD MODEL _ 2010

4.4. NECMOD MODEL _ 2011

4.5. NECMOD MODEL _ 2012

4.1. NECMOD MODEL _ 2008

4.1.1 Overview

4.1.2. Characteristics of NECMOD model

4.1.3 Main blocks of NECMOD model

4.1.4. Equations

4.1.5 Model’s impulse response functions

4.1.6 Summary

4.1. NECMOD MODEL _ 2008

4.1.1 Overview

BNP bank changed ECMOD model to NECMOD model, because changing in economy in 2004, and there are some main arears changed:

- Labour market: high volatility of unemployee rate and migration flows
- Housing market: significant increasing prices of houses
- Oil shock and food price rise
- Fiscal reforms and change in regulations: changes in tax; energy market deregulation

Data:

- Main source: national accounts
- Information about labour market (LFS data), prices of consumer goods (CPI basket), financial data from BNP
- The times series for the period of 1995 - 2007

4.1. NECMOD MODEL _ 2008

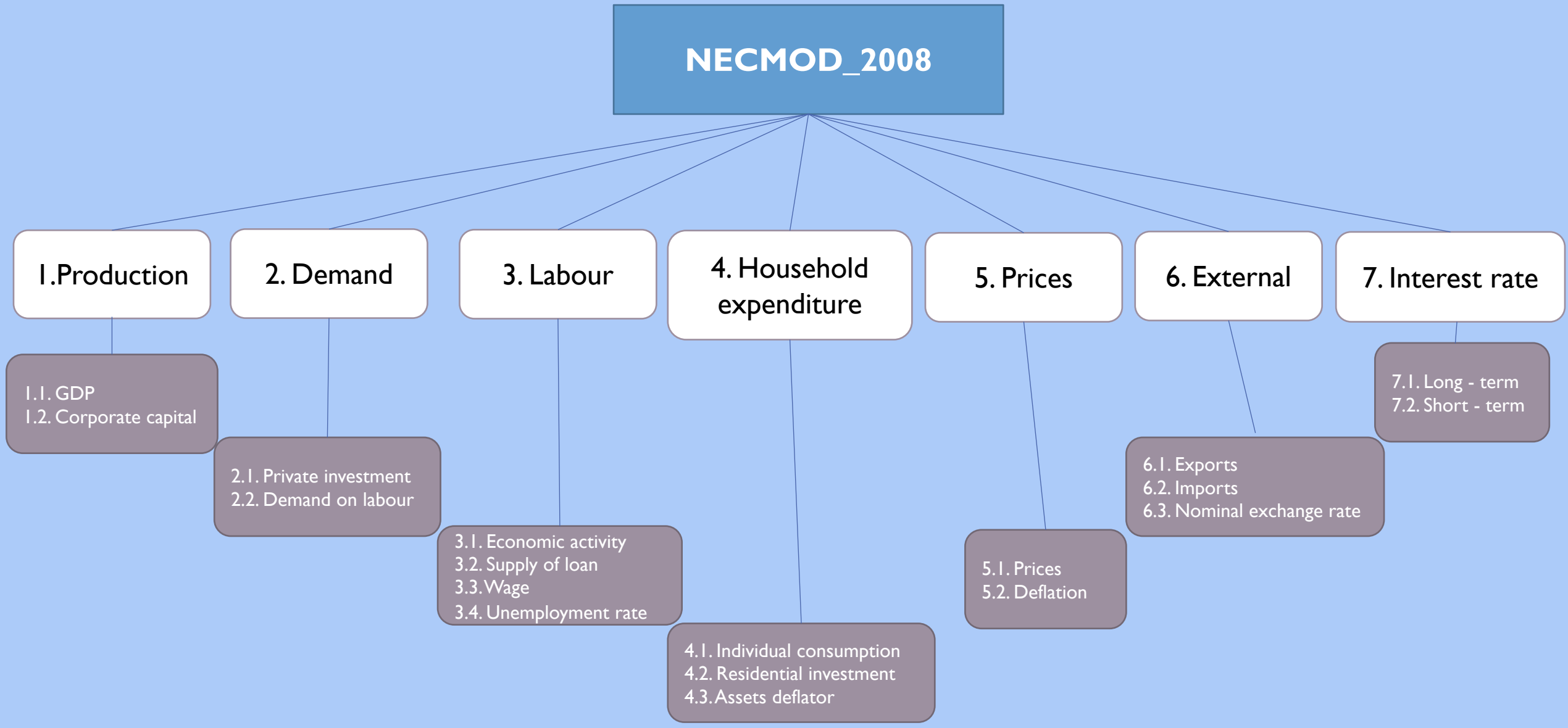
4.1.2. Characteristics of NECMOD model

- NECMOD 2008 reflects the evolution of the economy over the past few years
- The richer forecasting experience
- NECMOD is hybrid 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, equilibirum rate of economic activity, equilibrium exchange rate)
- Potential simulation posibilities can provide answers to many question:

• Impact of fiscal changes
• Structural fund
• Emigration

4.1. NECMOD MODEL _ 2008

4.1.3. Main blocks of NECMOD model



4.1.4. NECMOD MODEL _ 2008

Sectors	Equations	Variables
1.Production 1, Core: production function 2, Productive capital includes private and public productive capital 3, GDP determined by production fuction	$gdp_t = tfp\_trend_t + 0.67 \cdot emp_t + \cdot(1-0.67) \cdot kn_t$ (*) *(*) – small letters denote logarithms of variables*	• gdp: GDP • tfp_trend: total factor productivity • emp: employment • kn: productive capital
	$KN_t = \left(0.7^3 \cdot (KN\_P_t)^{-2} + 0.3^3 \cdot (KN\_G_t)^{-2}\right)^{-\frac{1}{2}}$	• KN_P: net corporate productive capital • KN_G: net public productive capital
	$gdppot_t = tfp\_trend_t + 0.67 \cdot log[(1-NAWRU_t) \cdot LF_t] + \cdot(1-0.67) \cdot kn_t$	• gdppot: potential capital • LF: labour force • NAWRU: equilibirium unemployment rate

Sectors	Equations	Variables
II. Demand for production **1, Two types of productive investment:** **Private investment** determined by the equality of marginal productivity of private capital and its real user cost; **Public investment** for general government **2, Demand on labour** depends on active labour market policy, labour costs, and effective labour supply	Condition for private investment: $$0.7^3 \cdot (1-0.67) \cdot \frac{GDP_t}{KN_t} \cdot \left(\frac{KN_t}{KP\_N_t} \right)^3 = RUCC_t$$	• RUCC: real user cost of capital • KP_N: corporate productive capital
	Private investment $$\Delta gfcfp_t = \underset{0.46}{0.31} \cdot (MPC_{t-1} - RUCC_{t-1}) + \underset{0.17}{0.11} \cdot \Delta gfcfp_{t-1} + \underset{0.17}{0.12} \cdot \Delta gfcfp_{t-2} + (1 - \underset{0.17}{0.11} - \underset{0.17}{0.12}) \cdot \Delta gdp_{t-1} - \underset{0.02}{0.006} \cdot \Delta_4 (p\_oil_t + s\_usd\_pln_t - pva_t) + \underset{0.35}{0.02} \cdot \Delta_4 (FINACC_t)$$	• gfcfp: investment in corporate productive capital • MPC: marginal product of private capital • p_oil: oil price • s_usd_pln: USD/PLN exchange rate • pva: value added deflator • FINACC: contribution of enterprises' disposable income to total national income
	Demand on labour $$emp_t = \underset{0.03}{0.09} \cdot (gdp_{t-1} - 0.67 \cdot emp_{t-1} - (1-0.67) \cdot k_{t-1} - tfp\_trend_{t-1}) + \underset{0.09}{0.74} \cdot \Delta emp_{t-1} + (1 - \underset{0.09}{0.74}) \cdot \Delta \log(LF_t \cdot (1 - NAWRU_t)) - \underset{0.04}{0.02} \cdot (\Delta \log(WAGE\_N_t \cdot (1 + GR\_CORP\_TR_t)/PVA_t) - \Delta tfp\_trend_t/0.67) + \underset{1.26}{2.05} \cdot \Delta \left(\frac{ALMP\_N_t}{GDPN_t} \right)$$	• WAGE_N: average wage in the economy • GR_CORP_TR: effective tax rate of social contribution paid by emloyer • PVA: gross value added deflator • ALMP_N: active labour market policy expenditures • GDPN: nominal GDP

Sector	Equations	Variables
III. Labour market **1, Model divided in 3 groups of population:** (15;24); (25;44); and over 45 **2, Economic activity has:** - Negative impact of unemployment - Negative impact of taxes - Negative impact of alternative sources of income	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 • UNRATE: unemployment rate • D99q1: the impact of changes in healthcare system • D97q1: 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 heath insurance • INTAX: effective rate of indirect taxes • MINW: minimal to average wage ratio • RR_REM: ratio of remittance to wage fund • STUDENT: share of fulltime students in population aged 15-24
Supply of labour force aged 15-24 $\Delta lf\_y_t = \underset{0.16}{-0.44} \cdot \left(\frac{LF\_Y_{t-1}}{POP\_Y_{t-1}} - \frac{LF\_Y_{t-1}}{POP\_Y_{t-1}}^{*}\right) + \underset{0.08}{0.43} \cdot \Delta lf\_y_{t-1} + \underset{0.08}{0.43^2} \cdot \Delta lf\_y_{t-2} + +\left(1 - \underset{0.08}{0.43} - \underset{0.08}{0.43^2}\right) \cdot \Delta pop\_y_t + \underset{0.12}{0.13} \cdot \left(\Delta(wage\_n_t - cpi_t) - \frac{\Delta tfp_t}{0.67}\right) -0.4 \cdot \Delta STUDENT_t$	• WAGE_N: average nominal wage in the economy • tfp: total factor productivity
Economic activity in group aged 25-44 $\frac{LF\_M_t}{POP\_M_t}^{*} = 0.89 + 0.04 \cdot \left(\frac{1}{4} \cdot \sum_{i=0}^{3} UNRATE_{t-i}\right) - 0.004 \cdot (1 - D99q1) + 0.002 \cdot (1 - D97q1) + -0.1 \cdot (GR\_EMP\_TR_t + GR\_PIT\_TR_t + GR\_HC\_TR_t) - 0.1 \cdot INTAX_t + -0.01 \cdot rr\_nlf\_m$	Economic activity in group aged 45+ $\frac{LF\_O_t}{POP\_O_t}^{*} = 0.59 - 0.30 \cdot \left(\frac{1}{4} \cdot \sum_{i=0}^{3} UNRATE_{t-i}\right) - 0.2 \cdot rr\_nlf\_o_t - 0.02 \cdot D07q1 + 0.006 \cdot (1 - D97q1) - 0.3 \cdot (GR\_EMP\_TR_t + GR\_PIT\_TR_t + GR\_HC\_TR_t) - 0.3 \cdot INTAX_t - 0.27 \cdot (1 - WORK\_AGE_t) - 0.04 \cdot rr\_relief\_kind_t$
Supply of labour force aged 25-44 $\Delta lf\_m_t = \underset{0.10}{-0.28} \cdot \left(\frac{LF\_M_{t-1}}{POP\_M_{t-1}} - \frac{LF\_M_{t-1}}{POP\_M_{t-1}}^{*}\right) + \underset{0.09}{0.23} \cdot \Delta lf\_m_{t-1} + \underset{0.09}{0.23^2} \cdot \Delta lf\_m_{t-2} + \left(1 - \underset{0.09}{0.23} - \underset{0.09}{0.23^2}\right) \cdot \Delta pop\_m_t$	$\Delta lf\_o_t = \underset{0.12}{-0.14} \cdot \left(\frac{LF\_O_{t-1}}{POP\_O_{t-1}} - \frac{LF\_O_{t-1}}{POP\_O_{t-1}}^{*}\right) + \underset{0.13}{0.15} \cdot \Delta lf\_o_{t-1} + \underset{0.13}{0.15^2} \cdot \Delta lf\_o_{t-2} + + \left(1 - \underset{0.13}{0.15} - \underset{0.13}{0.15^2}\right) \cdot \Delta pop\_o_t - \underset{0.00}{0.01} \cdot (I99q1 + I99q2 + I99q3) - \underset{0.03}{0.05} \cdot \Delta rr\_nlf\_o_t$

Sector	Equations	Variables
III. Labour market **3, Wage equation:** The wage curve presents the relationship between the desired real wage of employees and their actual remuneration from work.	Wage equation $wage\_n_t^* = 5.42 + \left(\frac{1}{0.67}\right)\cdot tfp\_trend_t + cpi_t - 0.5\cdot INTAX_t - 1.05\cdot UNRATE_t$ $+0.11\cdot rr\_unemp_t + 0.5\cdot(GR\_PIT\_TR_t + GR\_HC\_TR_t + GR\_EMP\_TR_t) -$ $-0.5\cdot GR\_CORP\_TR_t - 0.18\cdot rr\_rem + 0.52\cdot\left(\frac{POP\_Y_t}{POP_t}\right)\cdot minw_t$	• cpi: consumer price index • 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
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
$\Delta wage\_n_t = -\underset{0.02}{0.044}\cdot(wage\_n_{t-1} - wage\_n_{t-1}^*) - \underset{0.03}{0.047}\cdot(pva_{t-1} - pva_{t-1}^*)$ $+\underset{0.11}{0.67}\cdot\Delta wage\_n_{t-1} + (1-\underset{0.11}{0.67})\cdot\Delta cpi_{t-1} + (1-\underset{0.11}{0.67})\cdot\Delta(gdp_t - empna_t)$ $-\underset{0.20}{0.46}\cdot\Delta(UNRATE_t) - \underset{0.01}{0.046}\cdot(I99q1 - I99q2)$	
• NAWRU $NAWRU_t = (1-0.67+1.05)^{-1}\cdot((cpi_t - pva_t + (0.11/0.67)\cdot D04Q2 - 0.5\cdot INTAX_t) +$ $+0.5\cdot(GR\_PIT\_TR_t + GT\_HC\_TR_t + GR\_EMP\_TR_t + GR\_CORP\_TR_t) +$ $+0.11\cdot rr\_unemp_t + 0.52\cdot\left(\frac{POP\_Y_t}{POP_t}\right)\cdot minw_t +$ $+\frac{1-0.67}{0.67}\cdot(pimp_t + GR\_TAR\_TR_t - pva_t) - \frac{EMP\_A_t}{LF_t} + (1-0.67)(lf_t - k_t)$ $+(1/0.67-1)\cdot tfp\_trend_t - (3.33/0.67) + 5.38 - 0.18\cdot rr\_rem_t)$	• NAWRU: unemployment equilibrium rate

Sector	Equations	Variables
IV. Household expenditure **1, Modelling of households'** spending derived from life cycle theory and permanent income theory **2, Wealth** = Private productive capital + Residential capital + Public debt + Net foreign assets **3, 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	Individual consumption of households: $conp_t^* = -0.28 + 0.90 \cdot yd_t + (1-0.90) \cdot wealth_t - 0.31 \cdot I\_3MR\_CPI_t$ $\Delta conp_t = -\underset{0.00}{0.01} - \underset{0.04}{0.10} \cdot (conp_{t-1} - conp_{t-1}^*) + \underset{0.04}{0.13} \cdot \Delta yd_t - \underset{0.09}{0.13} \cdot \Delta(I\_3MR\_CPI)$	• conp: individual consumption of households • yd: real disposable income of households • I_3MR_CPI: real 3-months interest rate • wealth: wealth of households
	Residential investment modelled from the supply side: $gfcf\_h_t^* - gdp\_pot_t = -3.36 + 0.27 \cdot (pgfcf\_h_t - pva_t)$ $\Delta gfcf\_h_t = \underset{0.20}{0.62} \cdot \Delta gdp\_pot_t + \underset{0.13}{0.22} \cdot \Delta gfcf\_h_{t-1} + (1 - \underset{0.20}{0.62} - \underset{0.13}{0.22}) \cdot \Delta gfcf\_h_{t-2} +$ $- \underset{0.08}{0.26} \cdot (gfcf\_h_{t-1} - gfcf\_h_{t-1}^*) + \underset{0.04}{0.13} \cdot I02Q2 - \underset{0.05}{0.23} \cdot I02Q3 - \underset{0.05}{0.16} \cdot I03Q4$	• gfcf_h: gross residential investment • gdp_pot: potential GDP • pgfcf: price of housing assets • pva: value added deflator
	Housing assets deflator modelled from demand side (equating marginal utility of owning a dwelling with real cost of its utilisation) $k\_h_t^* = 0.56 + conp_t - 0.31(rucc\_h)$ $\Delta pgfcf\_h_t = \underset{0.07}{0.80} \cdot \Delta pgfcf\_h_{t-1} + (1 - \underset{0.07}{0.80}) \cdot \Delta cpi_{t-1} - \underset{0.04}{0.12} \cdot (k\_h_{t-1} - k\_h_{t-1}^*) + \underset{0.11}{0.26}\, GAP_t +$ $- \underset{0.05}{0.13} \cdot D\left[4 \cdot DISC\_H_t + I\_H_t - \left(\frac{PGFCF\_H_{t-1}}{PGFCF\_H_{t-5}} - 1\right)\right]$ $Adj.R^2 = 0.81$	• 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

Sector	Equations	Variables
V. Prices **1, Prices of consumer goods** depends on CPI net of food and energy prices. **2, Producer prices** depends on value added deflator (it is main index of producer prices)	Core prices: $corecpi_t^* = -4.11 + 0.66 \cdot ulcna_t + (1-0.66) \cdot (pimp\_core_t + GR\_TAR\_TR_t) + BS\_TREND_t + GR\_VAT\_TR_t + GR\_GAM\_TR_t + GR\_EXT\_REST\_TR_t$	• 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 • 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
$\Delta corecpi_t = \left(1 - \underset{0.05}{0.54} - \underset{0..08}{0.36} - \underset{0.01}{0.043}\right)\left(\left(1 + \frac{1}{4} \cdot \sum_{i=-2}^{1} INF\_TARGET_{t-i}\right)^{\frac{1}{4}} - 1\right) + \underset{0.01}{-0.024} \cdot (corecpi_{t-1} - corecpi_{t-1}^*) + \underset{0.05}{0.54} \cdot \Delta corecpi_{t-1} + \underset{0.08}{0.36} \cdot \Delta corecpi_{t+1} + (1-0.66) \cdot \underset{0.01}{0.043} \cdot \Delta(pimp\_core_t + GR\_TAR\_TR_t) + 0.66 \cdot 0.043 \cdot \Delta ulcna_t$	• INF_TARGET: inflation target
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 • GR_TAR_TR: effective rate of import duties
Value added deflator: – GDP deflator = value added deflator adjusted for net indirect taxes $\Delta pva_\tau = \left(1 - \underset{0.02}{0.26} - \underset{0.04}{0.33} - \underset{0.02}{0.25}\right)\left(\left(1 + \frac{1}{4} \cdot \sum_{t=-2}^{1} INF\_TARGET_{t-i}\right)^{\frac{1}{4}} - 1\right) - \underset{0.01}{0.023} \cdot (pva_{t-1} - pva_{t-1}^*) + \underset{0.02}{0.26} \cdot \Delta pva_{t-1} + \underset{0.04}{0.33} \cdot \Delta pva_{t+1}$	• INF_TARGET: inflation target

Sector	Equations	Variables
V. Prices **3, Food and energy products prices** are adjusted by experts in the projection horizon	Food prices $foodcpi_t^* = -2.08 + 0.49 \cdot (p\_food_t + s\_usd\_pln_t) + (1-0.49) \cdot corecpi_t + 0.49 \cdot GR\_VAT\_TR_t$	• foodcpi: food price index • p_food: world price index of raw agriculture commodities • s_usd_pln: usd/pln exchange rate adjusted for norminal convergence effect • GR_VAT_TR: effective VAT rate
	$\Delta foodcpi_t = \underset{0.13}{0.54} \cdot \Delta foodcpi_{t-1} + \underset{0.14}{0.41} \cdot \Delta corecpi_{t-1} - \underset{0.04}{0.084} \cdot (foodcpi_{t-1} - foodcpi_{t-1}^*) + (1 - \underset{0.13}{0.54} - \underset{0.14}{0.41}) \cdot \Delta \log(p\_food_{t-1} + s\_usd\_pln_{t-1})$	• 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 norminal convergence effect
	Prices of energy products $enercpi_t^* = -2.1 + 0.45 \cdot (p\_ener_t + s\_usd\_pln_t + GR\_VAT\_TR_t) + (1-0.45) \cdot (corecpi_t - GR\_EXT\_REST\_TR_t) + GR\_EXT\_ENER\_TR_t$	• enercpi: enerdy product price index • p_ener: world raw energy commodities price index • GR_EXT_REST_TR: effective exercise tax rate-other goods • GR_EXT_ENER_TR: effective excise tax rate – energy products
	Prices of energy products: $\Delta enercpi_t = \underset{0.12}{0.45} \cdot \Delta enercpi_{t-1} + (1 - \underset{0.12}{0.45} - \underset{0.02}{0.063}) \cdot \Delta(corecpi_t - GR\_EXT\_REST\_TR_t) - \underset{0.03}{0.071} \cdot (enercpi_{t-1} - enercpi_{t-1}^*) + \underset{0.02}{0.062} \Delta(p\_ener_t + s\_usd\_pln_t)$	

Sector	Equations	Variables
VI. External **1, Volume of exports** builded from the supply side in the long run and the demand side in the short run **2, Volume of imports** modelled from the supply side	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
Volume of exports $\Delta(gdp\_exp_t - gdp\_pot_t) = -\underset{0.07}{0.24} \cdot ((gdp\_exp_{t-1} - gdp\_pot_{t-1}) + -(gdp\_exp_{t-1} - gdp\_pot_{t-1})^*) + + \underset{0.88}{1.91} \cdot (\Delta gdp\_ext_t - 0.005) + \underset{0.02}{0.03} \cdot I05q2 + 0.01$	• gdp_exp: external product	
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 • pimp_core: prices of imported products excluding oil and gas prices • GR_TAR_TR: effective rate of duties	
• Volume of imports $\Delta(gdp\_imp_t - gdp_t) = 0.01 - \underset{0.04}{0.07} \cdot ((gdp\_imp_{t-1} - gdp_{t-1}) + -(gdp\_imp_{t-1} - gdp_{t-1})^*) + + \underset{0.21}{1.15} \cdot \Delta\log\left(\frac{0.4\ GFCF_t + 0.2\ CONP_t + 0.4\ GDP\_EXP_t}{TFP\_TREND_t^{1/0.67}}\right) + -\underset{0.12}{0.19}\ \Delta\log(PIMP\_CORE_t \cdot (1 + GR\_TAR\_TR)_t/PVA_t)$	• GFCF: total gross fixed capital formation • CONP: individual consumption • TFP_TREND: total factor productivity	
Export and import prices: according to the notion of price maker – price taker $pexp_t^* = 0.35(pva\_ext_t + s\_neer_t) + (1 - 0.35)pva_t - 3.20$ $\Delta pexp_t = -\underset{0.09}{0.21}(pexp_{t-1} - pexp_{t-1}^*) + \underset{0.07}{0.31} \cdot \Delta(pva\_ext_t + s\_neer_t) + (1 - \underset{0.07}{0.31}) \cdot \Delta pva_t$	• pva_ext: external value added deflator • s_neer: nominal effective exchange rate adjusted for nominal convergence effect	

Sector	Equations	Variables
VI. External **3, Export function** is function of relative export prices, potential GDP and external demand **4, Imports** as function of relative import prices, GDP, domestic demand	Export and import prices: according to the notion of price maker – price taker $pimp\_core_t^* = 0.54 \cdot (pva\_ext_t + s\_neer_t) + (1-0.54) \cdot p\_va_t - 5.28$ $\Delta pimp\_core_t = \underset{0.10}{-0.22}(pimp\_core_{t-1} - pimp\_core_{t-1}^*)$ $+\underset{0.09}{0.36}\,\Delta(pva\_ext_t + s\_neer_t) + (1-\underset{0.09}{0.36}) \cdot \Delta pva_t$	• pimp_core: prices of imported products excluding oil and gas prices • pva_ext: external value added deflator • s_neer: nominal effective exchange rate adjusted for nominal convergence effect • Pva: value added domestic deflator • Gdp_pot: potential GDP
	Nominal exchange rate: $s\_neer_t^* = pva_t - pva\_ext_t - 0.6 \cdot (gdp\_pot_t - gdp\_ext\_pot_t) +$ $-0.25 \cdot NFA\_GDP_{t-1} - 1.28 \cdot (I\_3MR\_PVA_{t-1} - I\_3MR\_EXT_{t-1}) +$ $+9.11 - 0.06 \cdot D04q2 - 0.06 \cdot D06q3$	• gdp_ext_pot: external potential GDP • I_3MR_PVA: real 3months interest rate • I_3MR_EXT: external real interest rate • NFA_GDP: net foreign assets in relation to GDP
	Nominal exchange rate: $\Delta s\_neer_t = \underset{0.06}{-0.27} \cdot (s\_neer_{t-1} - s\_neer_{t-1}^*) + \underset{0.51}{0.51} \cdot \Delta(pva_t - pva\_ext_t) +$ $-\underset{1.12}{0.37} \cdot \Delta(gdp\_pot_t - gdp\_ext\_pot_t) +$ $-\underset{0.97}{0.64} \cdot \Delta(I\_3MR\_PVA_t - I\_3MR\_EXT_t)$	
	Equilibrium exchange rate (*s_reer**): $\exp\{0.35 \cdot (1+0.57) \cdot s\_reer^* - 1.50 + 0.01 \cdot t + 0.07 \cdot D05q2 - 3.20 \cdot (1+0.57) + 0.6 \cdot 0.35 \cdot (1+0.57) \cdot (gdp\_pot - gdp\_ext\_pot)\} =$ $= \exp\{0.54 \cdot (1-0.33) \cdot s\_reer^* - 1.55 + 0.01 \cdot t - 5.27 \cdot (1-0.33) + 0.6 \cdot 0.54 \cdot (1-0.33) \cdot (gdp\_pot - gdp\_ext\_pot) - 0.33 \cdot gr\_tar\_tr\}$ $(PIMP\_OILGAS\_R^*)^{0.062+0.026} - CAB\_INC\_GDP^* - CAB\_TRANS\_GDP^* + CAB\_GDP^*$	• GR_TAR_TR: effective rate of 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

Sector	Equations	Variables
VII. Interest rates: **1, All real interest rates deflated with future inflation** **2, Long-term interest rates** adjustment for risk premium (based on public finance sector, inflation expectations) **3, Short-term interest rates:** estimated Taylor's Rule	Long-term interest rates: $I\_5Y_t = 0.06 \cdot I\_3M_t + (1-0.06) \cdot I\_5Y_{t+1} - \underset{0.00}{0.01} - \underset{0.05}{0.15} \cdot G\_BALANCE\_GDP_t$	• I_5Y: 5-year interest rate • I_3M: 3-months interest rate • G_BALANCE_GDP: general government balance in relation to GDP
	Short-term interest rates: $I\_3M_t = \underset{0.00}{0.88} \cdot I\_3M_{t-1} + (1-0.88) \cdot (I\_3MR\_EQ + INF_{t+1} + \underset{0.07}{0.99} \cdot (INF_{t+1} - \frac{1}{4}\sum_{i=-3}^{0} INF\_TARGET_{t-i}) + \underset{0.05}{0.59} \cdot GAP_t)$	• I_3M_EQ: real interest rate in long-term equilibrium • INF: CPI inflation • INF_TARGET: inflation target • GAP: output gap

4.1. NECMOD MODEL _ 2008

4.1.4. Model's impulse response functions

(1) Monetary impulse

(2) Exchange rate impulse

4.1. NECMOD MODEL _ 2008

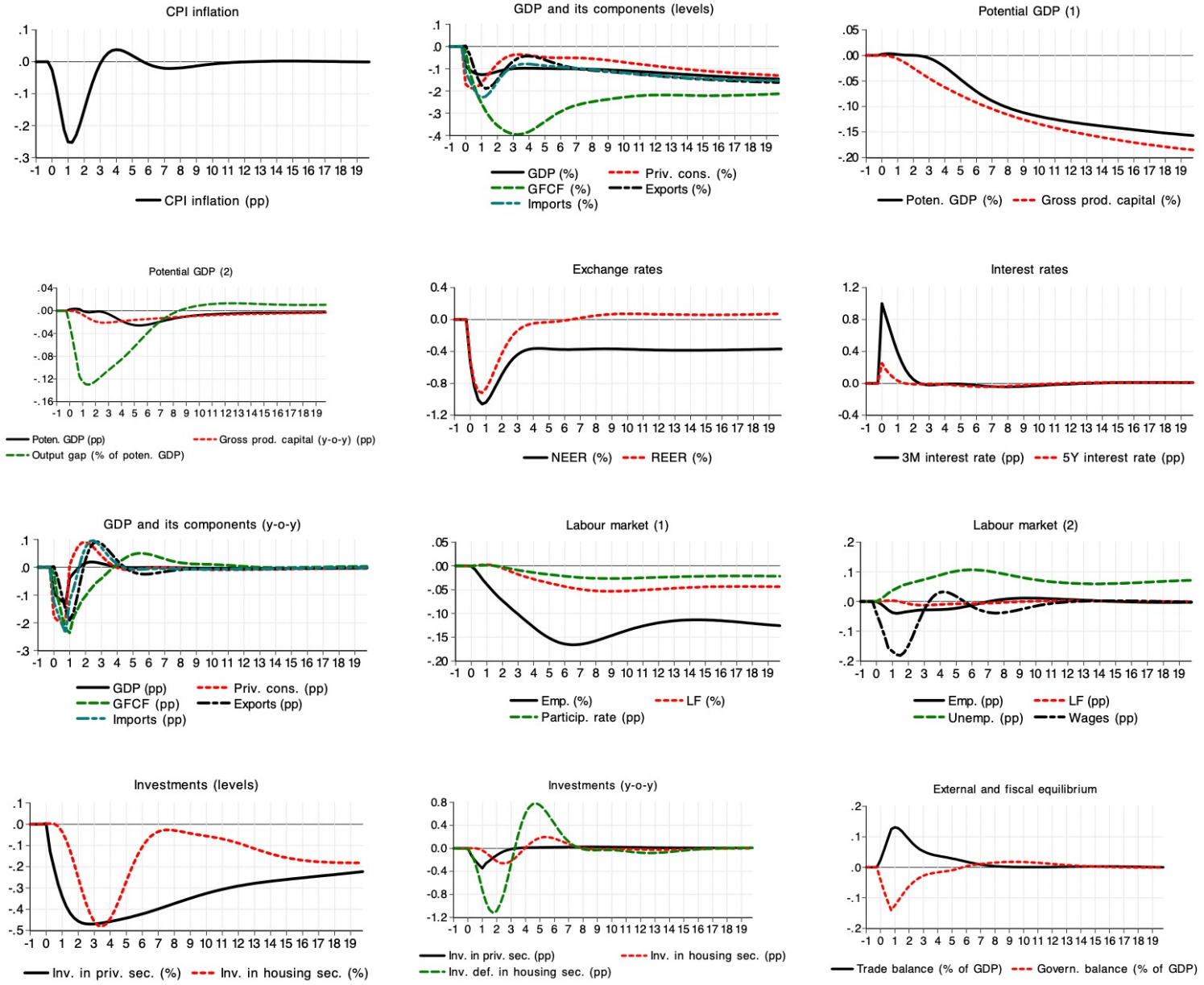
4.1.4. Model's impulse response functions

(1) Monetary impulse

- The interest rate shock in fluences the economy through 5 major channels:
  - The exchange rate channel
  - The substitution-effect channel
  - The cost of capital channel
  - The income and cash-flow channel
  - Wealth channel

- Impulse reaction functions of key macrocategories are given in Table 1

Table 1: Monetary impulse



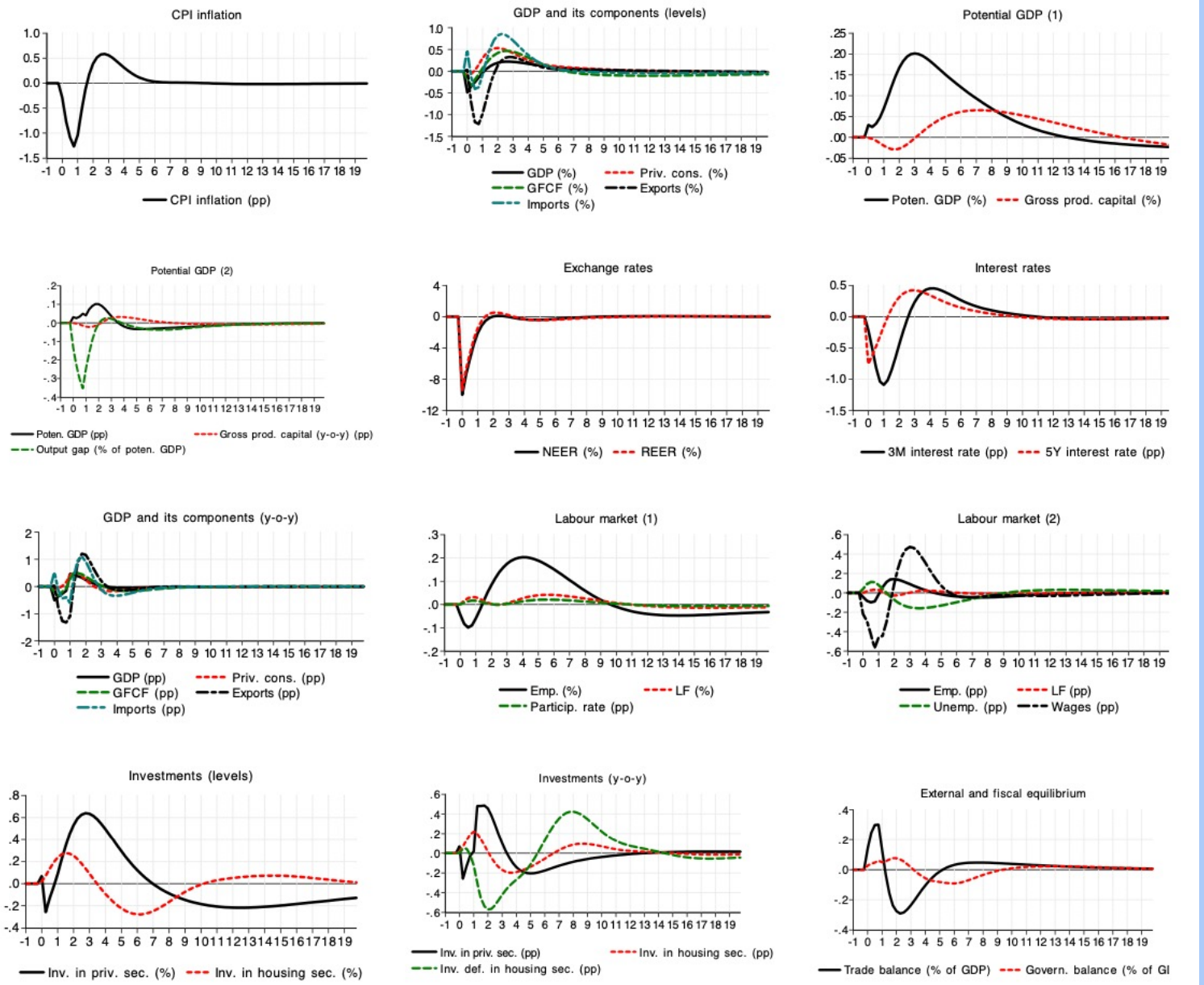
4.1. NECMOD MODEL _ 2008

4.1.4. Model's impulse response functions

(2) Exchange rate impulse

- An appreciation of the exchange rate reduces import and export prices → decreases production cost, such as the stronger zloty passes through into lower food and energy prices
- Higher import price and lower profit, net export and the current account balance deteriorate
- After the current account balance worsening, moderation of the appreciation trend in the exchange rate already sets in.

Table 2: Exchange rate impulse



4.1. NECMOD MODEL _ 2008

4.1.6 Summary

(I) The BNP’s method in 2008

(II) Advantages and disadvantages

4.1. NECMOD MODEL _ 2008

4.1.6 Summary

(I) The BNP's method in 2008

- In this method, the width of the fan chart is consistnet with the past errors of the ECMOD model, at the same time depending on the current uncertainty assessment of exogenous variables
- The procedure of constructing the fan charts consist of the following steps:

• Step 1: Determining the distributions of historical forecast errors
• Step 2: Simulation of paths of exogenous variables
• Step 3: Simulations from the NECMOD model
• Step 4: Determining the current uncertainty concerning GDP and inflation

4.1. NECMOD MODEL _ 2008

4.1.6 Summary

(II) Advantages and disadvantages:

- **Advantages:**

• With of the fan charts is consistent with the expert-adjusted, historical forecast errors from the ECMOD model

• Reflecting 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 is flexible and can be modified/extended easily

- **Disadvantages:**

• Changes in endogenous uncertainty are not accounted for

• Consequences of improvement of the model and expert adjustments are not accounted for

4.2. NECMOD MODEL _ 2009

4.2.1 Overview

4.2.2. Characteristics of NECMOD model

4.2.3 Main blocks of NECMOD model

4.2.4. Equations

4.2.5 Model’s impulse response functions

4.2.6 Summary

4.2. NECMOD MODEL _ 2009

4.2.1 Overview

An update of the structural macro econometric model of the Polish economy NECMOD. The present version of NECMOD was estimated on the data covering a period from 1995 to 2008. There are some main changes:

- Re-estimation on the data sample from 1995 to 2008
- The block of external sector with exchange rate determination derived from the taste-for-variety theory.
- More precise definition of household wealth,
- Higher level of fiscal sector sophistication,
- Refurbished specification of dynamics of inventories

Data:

- Main source: national accounts
- Information about labour market (adjusted for data bias of LFS), General government (ESA methodology), prices of consumer goods (CPI basket), financial data from BNP.

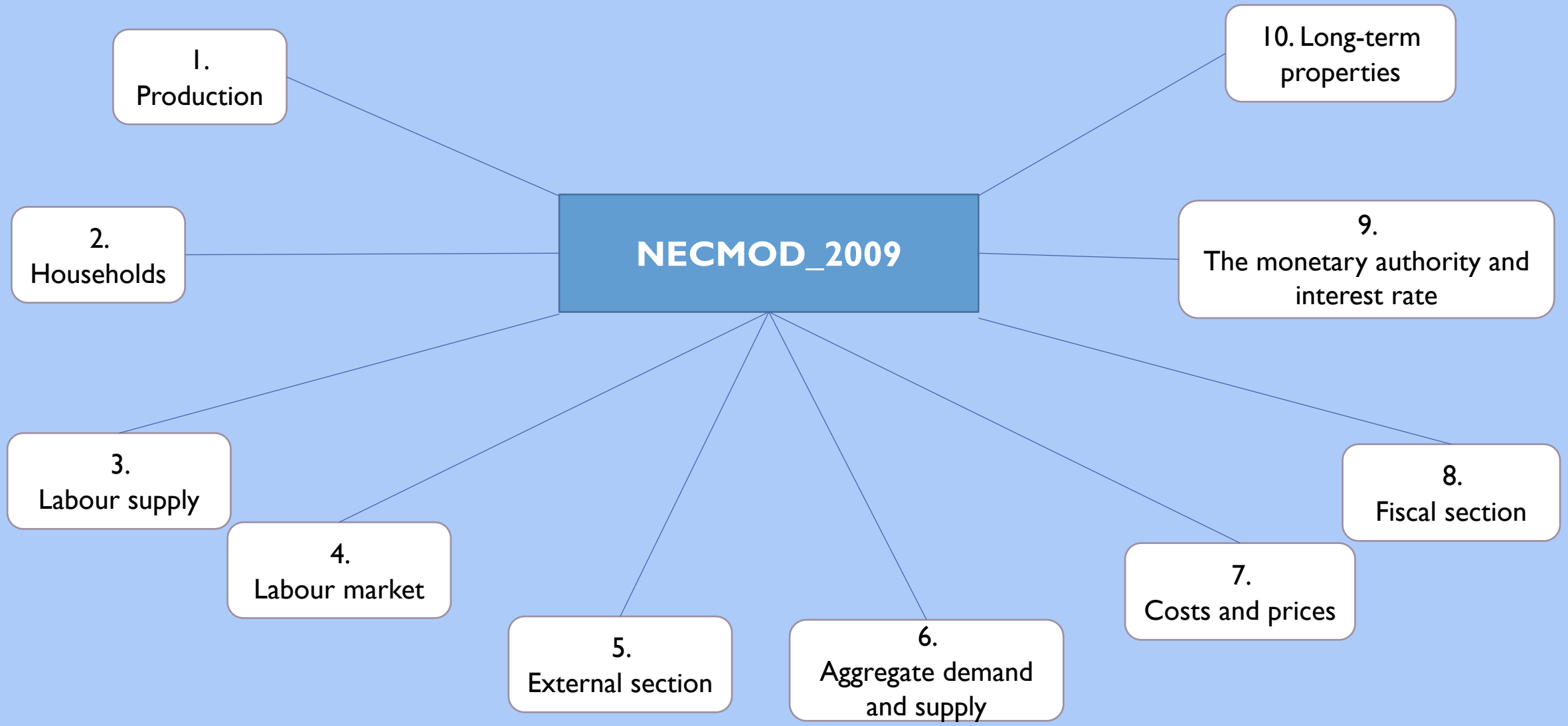
4.2. NECMOD MODEL _ 2009

4.2.2. Characteristics of NECMOD model

- The characteristics of the model has not changed significantly since 2008

4.2. NECMOD MODEL _ 2009

4.2.3. Main blocks of NECMOD model



4.2.4. NECMOD MODEL _ 2009

Sectors	Equations	Variables
1.Production	$GDP_t = TFP_t \cdot EMP_t^{0.67} \cdot KN_t^{1-0.67}$	• GDP: gross domestic product • TFP: total factor productivity • EMP: employment • KN: net productive capital
	$KN_t = \left(0.70^3 \cdot KN\_P_t^{-2} + (1-0.70)^3 \cdot KN\_G_t^{-2}\right)^{-\frac{1}{2}}$	• KN_P: net corporate capital • KN_G: net public capital
	$FINACC_t = (OPSURP\_N_t + 0.51 \cdot KN\_P_t \cdot PGDP_t \cdot DISC\_P_t - GR\_FARM\_N_t - GR\_CIT\_N_t + GE\_SUB\_NOFARM\_N_t + GE\_CAP\_TRANS\_N_t - YD\_NOS\_N_t - YD\_PRO\_NOGINT_t + G\_REF_t \cdot OFE\_N_t + GE\_INT\_NRES\_N_t + CAB\_INC\_EUR\_NOREM_t \cdot S\_EUR\_PLN_t)/GDP\_N_t$	• *FINACC* - corporate disposable income share in GDP • *GR_FRAM_N* - GG revenues from social security contributions paid by farmers, • *GR_CIT_N* - taxes on income or profits of firms including holding gains, • *YD_NOS_N* - nominal income of households from the operating surplus, • ….

4.2.4. NECMOD MODEL _ 2009

Sectors	Equations	Variables
1.Production	$\Delta stock_t = \underset{(0.07)}{0.83} \cdot \Delta stock_{t-1} + (1 - \underset{(0.07)}{0.83}) \cdot sales_t - \underset{(0.02)}{0.05} \cdot (STOCK_{t-1} - STOCK^*_{t-1}) / GDP\_POT_{t-1}$	• Adjusted R^2 = 0.69 • S.E. of equation = 0.006 • LM test (p-value) = 0.13 • Estimation period: 1996q1 - 2008q4

Sectors	Equations	Variables
II. Households' sector	$$conp_t^* = 0.86 \cdot yd_t + (1 - 0.86) \cdot wealth_t - 0.35 - 0.16 \cdot I\_3MR\_CPI_t + 0.24 \cdot HH\_NET\_WEALTH\_RATIO_t$$	• CONP - individual consumption. • YD - real disposable income, WEALTH - wealth, • I_3MR_CPI - real 3-month interest rate (deflated with CPI). • HH_NET_WEALTH_RATIO - ratio of a difference between financial assets and liabilities of households to the nominal value of wealth,
	$$YD_t = (YD\_WF\_N_t + GE\_UNEMP\_N_t \cdot (1 - GR\_CORP\_TR_t) + GE\_PENSIONS\_N_t + GE\_FAMILY\_N_t \cdot (1 - 0.16 \cdot GR\_CORP\_TR_t) + GE\_PRERETIRE\_N_t + GE\_SOCSECURITY\_N_t + GE\_RELIEF\_REST\_N_t + GE\_RELIEF\_KIND\_N_t + TRANS\_CAP\_N_t + GE\_SUB\_FARM\_N_t - GR\_EMP\_N_t - GR\_FARM\_N_t - GR\_HC\_N_t - GR\_PIT\_N_t - GR\_PIT\_CIT\_N_t - GR\_OTAX\_HH\_N_t + REM\_BALANCE_t \cdot S\_EUR\_PLN_t + YD\_NOS\_N_t + YD\_PRO\_NOGIT\_N_t + GE\_INT\_RES\_N_t)/CPI_t$$	• *YD_N* - total nominal disposable income of households, • *YD_NOS_N* - nominal income of households from the operating surplus, *YD_PRO_N* - nominal income of households from property, • *YD_WF_N* - nominal wage bill, *GE_UNEMP_N* - general government (GG) expenditures on unemployment benefits • ….

Sectors	Equations	Variables
II. Households' sector	$$\Delta conp_t = \underset{(0.04)}{0.86} \cdot (\Delta tfp\_trend_t/0.67) + (1 - \underset{(0.04)}{0.86}) \cdot \Delta yd_t - \underset{(0.06)}{0.21} \cdot (conp_{t-1} - conp^*_{t-1}) - \underset{(0.07)}{0.06} \cdot \Delta(I\_3MR\_CPI_t)$$	• Adjusted R^2 = 0.08 • S.E. of equation = 0.005 • LM test (p-value) = 0.1082 • Estimation period: 1997q2 - 2008q4 • TFP_TREND - trend total factor productivity,
	$$\Delta gfcf\_h_t = \Delta gdp\_pot_t - \underset{(0.09)}{0.24} \cdot (gfcf\_h_{t-1} - gfcf\_h^*_{t-1}) - \underset{(0.04)}{0.18} \cdot (I02Q2_t - I02Q3_t) + \underset{(0.18)}{0.32} \cdot \Delta(pgfcf\_h_{t-1} - 0.32 \cdot GR\_VAT\_TR_t - pva_{t-1})$$	• Adjusted R^2 = 0.43 • S.E. of equation = 0.054 • LM test (p-value) = 0.29 • Estimation period: 1996q1 - 2008q4
	$$\Delta pgfcf\_h_t = \underset{(0.04)}{0.34} \cdot \Delta cpi_t + (1 - \underset{(0.04)}{0.34}) \cdot \Delta pgfcf\_h_{t-1} - \underset{(0.08)}{0.09} \cdot (k\_h_{t-1} - k\_h^*_{t-1}) - \underset{(0.03)}{0.08}\Delta(0.08 + I\_H_t - \Delta_4 pgfcf\_h_{t-1}) + \underset{(0.07)}{0.16} \cdot GAP_t + \underset{(0.001)}{0.04} \cdot (I03Q1_t - I03Q2_t) + \underset{(0.01)}{0.05} \cdot (I06Q1_t + I06Q2_t + I06Q3_t + I06Q4_t)$$	• Adjusted R^2 = 0.93 • S.E. of equation = 0.009 • LM test (p-value) = 0.084 • Estimation period: 1996q3 - 2008q4

Sector	Equations	Variables
III. Labour supply	$$\left(\frac{LF_t}{POP_t}\right)^* = \left(\frac{POP\_Y_t}{POP_t}\right)\left(\frac{LF\_Y}{POP\_Y}\right)^* + \left(\frac{POP\_M_t}{POP_t}\right)\left(\frac{LF\_M_t}{POP\_M_t}\right)^* + \left(\frac{POP\_O_t}{POP_t}\right)\left(\frac{LF\_O_t}{POP\_O_t}\right)^*$$	• LF - labour force, • POP - total population, • LF_Y - force 15-24 years, • POP_Y - population 15-24 years, • LF_M - labour force 25-44 years, • POP_M - population 25-44 years, • LF_O - labour force 45+ years, • POP_O - population 45+ years,
	Labour force from 15-24 $$\begin{aligned}\Delta lf\_y_t = & \underset{(0.15)}{-0.30} \cdot \left(\frac{LF\_Y_{t-1}}{POP\_Y_{t-1}} - \left(\frac{LF\_Y_{t-1}}{POP\_Y_{t-1}}\right)^*\right) \\ & + \Delta pop\_y_t + \underset{(0.18)}{0.42} \cdot \left(\Delta(wage\_n_{t-1} - cpi_{t-1}) \right. \\ & \left. - \Delta tfp\_trend_{t-1}/0.67\right) + \underset{(0.03)}{0.05} \cdot \Delta minw_t\end{aligned}$$	• Adjusted R^2 = 0.35 • S.E. of equation = 0.01 • LM test (p-value) = 0.11 • Estimation period: 1996q1 - 2008q4 • WAGE_N - nominal gross average wage, • CPI - consumer price index, • TFP_TREND - trend total factor productivity

Sector	Equations	Variables
III. Labour supply	Labour force from 25-44 $$\Delta lf\_m_t = \underset{(0.13)}{-0.40} \cdot \left(\frac{LF\_M_{t-1}}{POP\_M_{t-1}} - \left(\frac{LF\_M_{t-1}}{POP\_M_{t-1}}\right)^*\right) + \underset{(0.09)}{0.15} \cdot \Delta lf\_m_{t-1} + \underset{(0.10)}{(0.14)^2} \cdot \Delta lf\_m_{t-2} + \Delta pop\_m_t - \underset{(0.01)}{0.01} \cdot \Delta rr\_nfl\_m_t$$	• *Adjusted* R^2 *= 0.69* • *S.E. of equation = 0.002* • *LM test (p-value) = 0.013* • *Estimation period: 1996q1 - 2008q4*
	Labour force from 45+ $$\Delta lf\_o_t = \underset{(0.05)}{-0.14} \cdot \left(\frac{LF\_O_{t-1}}{POP\_O_{t-1}} - \left(\frac{LF\_O_{t-1}}{POP\_O_{t-1}}\right)^*\right) + \Delta pop\_o_t - \underset{(0.03)}{0.08} \cdot \Delta rr\_nfl\_o_t - \underset{(0.03)}{0.08} \cdot 0.5 \cdot \Delta rr\_relief\_kind_t + \Delta WORKAGE_t + \underset{(0.10)}{0.08}(\Delta wage\_n_{t-1} - \Delta cpi_{t-1} - \Delta tfp\_trend_{t-1}/0.67)$$	• *Adjusted* R^2 *= 0.32* • *S.E. of equation = 0.007* • *LM test (p-value) = 0.014* • *Estimation period: 1996q1 - 2008q4*

Sector	Equations	Variables
IV. Labour market	$$\begin{aligned} wage\_n_t^* = {} & 5.51 + (1/0.67) \cdot tfp\_trend_t + cpi_t - 0.5 \cdot (GR\_VAT\_TR_t \\ & + (W\_ENER_t + W\_CORE_t) \cdot GR\_EXT\_TR_t \\ & + W\_CORE_t \cdot GR\_GAM\_TR_t) \\ & - 0.88 \cdot UNRATE_t + 0.06 \cdot rr\_unemp_t + 0.5 \cdot (GR\_PIT\_TR_t \\ & + GR\_HC\_TR_t + GR\_EMP\_TR_t) - 0.5 \cdot GR\_CORP\_TR_t \\ & - 0.11 \cdot rr\_rem_t + 5.51 \cdot \Delta pop\_y_t \\ & + 0.47 \cdot \frac{POP\_Y_t}{POP_t} \cdot minw_t \end{aligned}$$	• WAGE_N - gross nominal average wage in the economy, • TFP_TREND - trend total factor productivity, • CPI - consumer price index, • GR_VAT_TR - effective rate of VAT, • W_ENER - weight of energy prices in CPI basket, • W_CORE - weight of core inflation in CPI basket, • GR_EXT_TR - effective rate of excise duties, • GR_GAM_TR - effective rate of gambling taxes, • UNRATE - unemployment rate, • RR_UNRATE - replacement rate for unemployed (including unemployment benefits), • GR_PIT_TR - effective rate of personal income tax, • GR_HC_TR - effective rate of compulsory health care contribution, • GR_EMP_TR - effective rate of social security contributions paid by employees, • GR_CORP_TR - effective rate of social security contributions paid by employers, • RR_REM - replacement rate for remittances, • POP_Y - population 15-24, POP - total population, • MINW - relation of minimum wage to the average gross nominal wage in the economy,

Sector	Equations	Variables
IV. Labour market	$$\begin{aligned} NAWRU_t = {} & (1-0.67+0.88)^{-1} \cdot ((cpi_t - pva_t + (0.08/0.68) \cdot d04q3 \\ & -0.5 \cdot (GR\_VAT\_TR_t + (W\_ENER_t + W\_CORE_t) \cdot GR\_EXT\_TR_t \\ & + W\_CORE_t \cdot GR\_GAM\_TR_t)) + 0.5 \cdot (GR\_PIT\_TR_t \\ & + GR\_HC\_TR_t + GR\_EMP\_TR_t + GR\_CORP\_TR_t) \\ & + 0.06 \cdot rr\_unemp_t + 0.47 \cdot \left(\frac{POP\_Y_t}{POP_t}\right) \cdot minw_t \\ & + 0.47 \cdot (pimp_t + GR\_TAR\_TR_t - pva_t \\ & - \left(\frac{EMP\_A_t}{LF_t}\right) + (1-0.67) \cdot [lf_t - k\_n_t] \\ & + ((1/0.67) - 1) \cdot tfp\_trend_t + 0.5 - 0.11 \cdot rr\_rem_t) \end{aligned}$$	• NAWRU - non-accelerating wage inflation rate of unemployment, • PVA - value added deflator, • DxxQy - shift dummy variable where xx means year and y denotes quarter when the shift takes place, • PIMPc -imports prices corrected for the equilibrium exchange rate fluctuations, • GR_TAR_TR - effective rate of import duties, • EMP_A - employment in agriculture, • LF - labour force, • KN - net productive capital, • TFP_TREND - trend total factor productivity,
	$$\begin{aligned} \Delta wage\_n_t = {} & \underset{(0.02)}{0.05} \cdot (wage\_n_{t-1} - wage\_n^*_{t-1}) \\ & + \underset{(0.03)}{0.05}(pva_{t-1} - pva^*_{t-1}) \\ & + \underset{(0.12)}{0.73} \cdot \Delta wage\_n_{t-1} + (1 - \underset{(0.12)}{0.73}) \cdot \Delta cpi_{t-1} \\ & + (1 - \underset{(0.11)}{0.73}) \cdot (\Delta gdp_{t-1} - \Delta emp\_na_{t-1}) - \underset{(0.21)}{0.28} \Delta UNRATE_{t-1} \end{aligned}$$	• Adjusted R^2 = 0.74 • S.E. of equation = 0.007 • LM test (p-value) = 0.001 • Estimation period: 1996q1 - 2008q4 • ULCNA - unit labour costs in non-agriculture, • GDP - gross domestic product, • EMP_NA - non-agriculture employment

Sector	Equations	Variables
V. External sector	Specification of the external sector is the furthest reaching change in the NECMOD model as compared to its original version. It offers a number of advantages over the former set-up.	
	export activity is proportional to domestic potential product, $gdp\_exp = gdp\_ext_t - 19.78 + 1.51 \cdot gdp\_pot_t - 0.78 \cdot pexp_t - (pva\_ext_t + s\_neer_t) + 0.22 \cdot D04Q03$	• GDP_EXP – exports • GDP_EXT - foreign GDP (weighted average of GDP in the euro area, the UK, and the USA) • GDP - gross domestic product,
	• import intensity is proportional to potential product of the country's trade partners, $gdp\_imp = gdp_t - 12.2 + 1.51 \cdot gdp\_ext\_pot_t - 1.52 \cdot (pimp_t + GR\_TAR\_TR_t - pva_t) + 0.04 * D04Q3$	
	Export prices $pexp_t^* = pva\_ext_t + s\_neer_t - 3.02 - 0.52 \cdot s\_reer_t + 0.07 \cdot D04Q3$	• *PVA_EXT* - foreign value added deflator, • *S_NEER* - nominal effective exchange rate, • *S_REER* - real effective exchange rate, • *DxxQy* - shift dummy variable where xx means year and y denotes quarter when the shift takes place
	Import prices $pimp_t^* = pva_t - GR\_TAR\_TR_t - 4.08 + 0.66 \cdot s\_reer_t + 0.04 \cdot D04Q3$	• *PIMP* - deflator of imports, • *PVA* - deflator of value-added, • *GR_TAR_TR* - effective rate of import duties

Sector	Equations	Variables
V. External sector	Equilibrium exchange rate: $\Delta s\_reer\_eq_t = ((1-1.51)/(1+078\cdot 0.52 +1.51\cdot 0.66-0.52-0.66)\cdot(\Delta gdp\_pot_t -\Delta gdp\_ext\_pot_t)+(1/(1+0.78\cdot 0.52+1.52\cdot 0.66-0.52 -0.66))\cdot(\Delta TCAB_t-\Delta CAB\_TRANS\_INC\_GDP_t)/OPEN_t +(1/(1+0.78\cdot 0.52)+1.52\cdot 0.66-0.52 -0.66))\cdot\Delta GR\_TAR\_TR_t$	• *S_REER_EQ* - the equilibrium exchange rate, • *GDP_POT* - domestic potential output, • *GDP_EXT_POT* - foreign potential output (weighted average of the potential output in euro area, the UK, and the USA), • *TCAB* - the equilibrium current account to GDP ratio, • *CAB_TRANS_INC_GDP* - ratio of current account income and transfer balances to GDP, • *OPEN* - measure of openness - ratio of imports and exports to GDP, • *GR_VAT_TR* - effective rate of VAT,
	Net foreign assets in PLN: $NFA_t = NFA_{t-1}+NFA_{t-1}\cdot(\frac{S\_NEER_t}{S\_NEER_{t-1}}-1) +CAB\__t\cdot S\_EUR\_PLN_t$ $NFA_t\_GDP_t = NFA_t/GDP\_N_t$	• *NFA* - net foreign assets in PLN, • *CAB* - current account balance (including the capital account) in EUR, *S_EUR_PLN* - EUR/PLN exchange rate, • *NFA_GDP* - net foreign assets to GDP ratio

Sector	Equations	Variables
V. External sector	Export prices $\Delta pexp_t = \underset{(0.09)}{-0.42} \cdot (pexp_{t-1} - pexp^*_{t-1}) \underset{(0.18)}{+0.38} \cdot \Delta pva_{t-1} + \underset{(0.10)}{0.26} \Delta s\_reer_t$	• Adjusted R^2 = 0.24 • S.E. of equation = 0.030 • Q test (p-value) = 0.041
	Import prices $\Delta pimp_t = \underset{(0.08)}{-0.33} \cdot (pimp_{t-1} - pimp^*_{t-1}) \underset{(0.17)}{+0.41} \cdot \Delta pva_{t-1} + \underset{(0.09)}{0.34} \Delta s\_reer_t \underset{(0.02)}{+0.02} \Delta(0.7 \cdot (p\_oil_{t-1} + s\_usd\_p\ln_{t-1}) + 0.3 \cdot (p\_gas_{t-1} + s\_usd\_p\ln_{t-1}))$	• Adjusted R^2 = 0.27 • S.E. of equation = 0.028 • Q test (p-value) = 0.041
	Exchage rate $\Delta s\_reer_t = \underset{(0.12)}{-0.33} \cdot (s\_reer_{t-1} - s\_reer\_eq_{t-1} - \underset{(0.07)}{1.78}) \underset{(0.32)}{-0.69} \cdot (I\_3MR\_PVA_t - I\_3MR\_EXT_t) - \underset{(0.52)}{-1.67} \cdot GAP_{t-1} - \underset{(2.12)}{2.27} \cdot \Delta G\_BALANCE\_GDP_t \underset{(0.59)}{-1.18} \cdot \Delta CAB\_GDP_t \underset{(0.78)}{-0.67} \cdot (I\_5Y - INF\_TARGET_t - I\_5Y\_EUR_t - 0.02)$	• Adjusted R^2 = 0.31 • S.E. of equation = 0.041 • LM test (p-value) = 0.083

Sector	Equations	Variables
VI. Aggregate demand and supply	Real gross domestic product $GDP_t = CONP_t + CONGOV_t + GFCF_t + INV_t + GDP\_EXP_t - GDP\_IMP_t$	• GDP - gross domestic product, • CONP - individual consumption, • CONGOV - government consumption, • GFCF - gross fixed capital formation, • INV - change in inventories, • GDP_EXP - exports, • GDP_IMP - imports
	Nominal gross domestic product $GDP\_N_t = CONP\_N_t + CONGOV\_N_t + GFCF\_N_t + INV\_N_t + GDP\_EXP\_N_t - GDP\_IMP\_N_t$ $= CPI_t \cdot CONP_t + PCONGOV_t \cdot CONGOV_t + GFCF\_N_t + PVA_t \cdot INV_t + PEXP_t \cdot GDP\_EXP_t - PIMP_t \cdot GDP\_IMP_t$	• X_N - nominal value of variable X, • CPI - consumer price index, • PCONGOV - government consumption deflator, • PVA - value added deflator, • PEXP - export prices, PIMP - import prices,
	GDP deflator $PGDP_t = \frac{GDP\_N_t}{GDP_t}$	
	The potential output $GDP\_POT_t = (LF\_EQ_t \cdot POP_t \cdot (1 - NAWRU_t))^{0.67} \cdot (KN_t)^{(1-0.67)} \cdot TFP\_TREND_t$	• GDP_POT - domestic potential output, • LF_EQ - the equilibrium participation rate, • POP - total population, • NAWRU - non-accelerating wage inflation rate of unemployment, • KN - net productive capital, • TFP_TREND - trend total factor productivity

Sector	Equations	Variables
VII. Cost and prices	Value added deflator - short run solution $\Delta pva_t = ((1 + \overline{inf\_target}_{t+2})^{0.25} - 1) \cdot (1 - \underset{(0.05)}{0.10} - \underset{(0.05)}{0.20} - \underset{(0.06)}{0.31}) \cdot \Delta pva_{t-1} + \underset{(0.05)}{0.21} \cdot pva_{t+1} + 0.682 \cdot \underset{(0.06)}{0.31} \cdot \Delta ulcna_{t-1} + (1 - 0.682) \cdot \underset{(0.06)}{0.31} \cdot \Delta(pimp_{t-1} + GR\_TAR\_TR_{t-1}) - \underset{(0.009)}{0.05} \cdot (pva_{t-1} - pva^*_{t-1}) + \underset{(0.004)}{0.04} \cdot I04Q2_t$	• PVA - value added deflator, • ULCNA - unit labour costs in non-agriculture, • PIMP – imports prices corrected for the equilibrium exchange rate fluctuations, • GR_TAR_TR - effective rate of import duties, • INF_TARGET - 4-quarter moving average of inflation target, • IxxQy - one period dummy variable, where xx denotes year and y stands for quarter. • Adjusted R^2 = 0.45 • S.E. of equation = 0.007 • J statistic(p-value) = 0.1 • Estimation period: 1997q4 - 2008q4
	Core inflation $\Delta corecpi_t = ((1 + \overline{inf\_target}_{t+2})^{0.25} - 1) \cdot (1 - \underset{(2.01)}{3.35} \cdot \underset{(0.05)}{0.10} - \underset{(0.05)}{0.21} \cdot \underset{(0.65)}{2.49} - \underset{(0.04)}{0.11} \cdot \underset{(0.06)}{0.31}) + \underset{(2.01)}{3.35} \cdot \underset{(0.06)}{0.10} \cdot \Delta corecpi_{t-1} + \underset{(0.05)}{0.21} \cdot \underset{(0.65)}{2.49} \cdot corecpi_{t+1} + \underset{(0.03)}{0.11} \cdot 0.53 \cdot \underset{(0.06)}{0.31} \cdot \Delta ulcna_{t-1} + \underset{(0.03)}{0.11} \cdot \underset{(0.06)}{0.31} \cdot (1 - 0.53) \cdot \Delta(pimp\_core_{t-1} + GR\_TAR\_TR_{t-1}) + \underset{(0.14)}{0.36} \cdot \underset{(0.01)}{(-0.05)} \cdot (corecpi_{t-1} - corecpi^*_{t-1})$	• Adjusted R^2 = 0.92 • S.E. of equation = 0.003 • J statistic(p-value) = 0.1 • Estimation period: 1997q4 - 2008q4

Sector	Equations	Variables
VIII. Fiscal sector	General government revenues $GR\_N_t = GR\_PROD\_TAX\_N_t + GR\_INC\_TAX\_N_t + GR\_TCONTR\_N_t + GR\_PROP\_INC\_N_t + GR\_OTHER\_CURT\_N_t + GR\_OUTPUT\_N_t + GR\_CAP\_TRANS\_N_t$	• GR_N - total general government (GG) revenues, • GR_PROD_TAX_N - GG revenues from taxes on production and imports, • GR_INC_TAX_N - GG revenues from income and wealth taxes, • GR_TCONTR_N - total social contributions, • GR_PROP_INC_N - GG's property income, • GR_OTHER_CURT_N - GG revenues from other current transfers, • GR_OUTPUT_N - GG market output, output for own final use and payments for other non-market output, • GR_CAP_TRANS_N - GG revenues from capital transfers,
	General government expenditures $GE\_N_t = GE\_RELIEF\_KIND\_N_t + GE\_SOC\_CASH\_N_t + GE\_SUB\_FARM\_N_t + GE\_SUB\_NOFARM\_N_t + GE\_OTHER\_TRANS\_N_t + GE\_EU\_N_t + GE\_FIN\_N_t + GE\_WF\_N_t + GE\_CON\_N_t + GE\_GFCF\_N_t + GE\_CAP\_TRANS\_N_t$	• GE_N - total GG expenditures, • GE_RELIEF_KIND_N - GG expenditures on social transfers in kind, • GE_SOC_CASH_N – GG expenditures on social benefits other than social transfers in kind, • GE_SUB_FARM_N - GG subsidies to farmers, • GE_SUB_NOFARM_N GG subsidies excluding subsidies to farmers, • GE_OTHER_TRANS_N - other GG transfers without EU budget contribution, • GE_EU_N GG contribution to the EU budget, • GE_FIN_N - interest on the GG debt, • GE_WF_N - GG compensations for employees, • GE_CON_N GG intermediate consumption, • GE_GFCF_N - nominal GG investments, • GE_CAP_TRANS_N - GG capital transfers

Sector	Equations	Variables
VIII. Fiscal sector	General government balance: $G\_BALANCE\_N_t = GR\_N_t - GE\_N_t$	• GR_N - total general government (GG) revenues, • GE_N - total GG expenditures,
	General government debt: $G\_DEBT\_N = G\_DEBT\_DOM\_RES\_N + G\_DEBT\_DOM\_NRES\_N + G\_DEBT\_FOR\_RES\_N + G\_DEBT\_FOR\_NRES\_N$	• G_BALANCE_N - GG balance, • G_DEBT_N - GG debt, • G_DEBT_DOM_RES_N - GG debt in domestic currency held by residents, • G_DEBT_DOM_NRES_N - GG debt in domestic currency held by non-residents, • G_DEBT_FOR_RES_N - GG debt in foreign currencies held by residents, • G_DEBT_FOR_NRES_N - GG debt in foreign currencies held by non-residents,
	Total servicing cost of the GG debt: $GE\_FIN\_N_t = GE\_INT\_DOM\_RES\_N_t + GE\_INT\_DOM\_NRES\_N_t + GE\_INT\_FOR\_RES\_N_t + GE\_INT\_FOR\_NRES\_N_t$ Interest on the GG debt in domestic currency $\frac{GE\_INT\_DOM\_N_t}{G\_DEBT\_DOM\_N_t} \propto W\_SHORT\_DOM_t \cdot I\_3M_t + (1 - W\_SHORT\_DOM_t) \cdot \overline{I\_5Y_t}$	Interests on the GG debt in foreign currencies: $GE\_INT\_FOR\_N_t \propto \sum_{i=1}^{5} G\_DEBT\_FOR\_N_{t-4i} \cdot I\_5Y\_EUR_{t-4i} \cdot (GDEBT\_EXCHANGE_{t-4i}^{t} / GDEBT\_EUR_{t-4i}^{t-4i})$ Effective exchange rate relevant for GG debt denominated in foreign currencies: $GDEBT\_EXCHANGE_t^s = GDEBT\_EUR_s \cdot S\_EUR\_PLN_t + (1 - GDEBT\_EUR_s) \cdot S\_USD\_PLN_t$

Sector	Equations	Variables
IX. The monetary authority and interest rates	Money demand $m3_t^* = 1.25 \cdot (I\_3M_{t-1} - I\_5Y_{t-1}) - 1.47 \cdot gdp\_n_{t-1} + 5.25$ $\Delta m3_t = \underset{(0.09)}{-0.34} \cdot (m3_{t-1} - m3_{t-1}^*) \underset{(0.13)}{+0.44} \cdot \Delta m3_{t-1} + \underset{(0.22)}{0.75} \cdot \Delta gdp\_n_t \underset{(0.05)}{+0.15} \cdot \Delta s\_neer_{t-1})$	• M3 - M3+ monetary aggregate, • GDP_N - nominal gross domestic product, • S_NEER - nominal effective exchange rate
	Monetary policy rule: $I\_3M_t = \underset{(0.02)}{0.86} \cdot I\_3M_{t-1} + (1 - \underset{(0.02)}{0.86} \cdot (I\_3MR\_EQ_t + INF_{t+1})) + \underset{(0.36)}{1.04} \cdot INF_{t+1} - \overline{INF\_TARGET}_{t+3} + \underset{(0.15)}{0.29} \cdot GAP_t$	• Adjusted R^2 = 0.99 • S.E. of equation = 0.005 • J statistic(p-value) = 0.830 • Estimation period: 2000q3 - 2008q3
	Long term interest rate $I\_5Y_t = \frac{1}{17} \cdot I\_3M_t + (1 - \frac{1}{17}) \cdot I\_5Y_{t+1} + \underset{(0.002)}{0.001}$	• I_3M - WIBOR 3M, • I_3MR_EQ - the equilibrium interest rate, • INF - CPI inflation, • INF_TARGET - 4-quarter moving average of inflation target, • GAP - output gap, • I_5Y - yield on 5-year government bonds,

Sector	
X. Long-term properties	A few simplifying assumptions are imposed on the long-run dynamics of the key exogenous variables: • All foreign nominal variables (commodity price indexes, value-added deflators in Poland's trading partners) grow at a common and constant rate, • Growth rate of foreign actual and potential GDP, as wel as TFP growth, is whereas foreign output gap is assumed to be zero, • Nominal interest rates abroad are constant, • Population of Poland and its age structure are constant, • Minimum wage rate is fully indexed to the average wage rate

4.2. NECMOD MODEL _ 2009

4.2.5. Model's impulse response functions

(1) Monetary impulse

(2) Exchange rate impulse

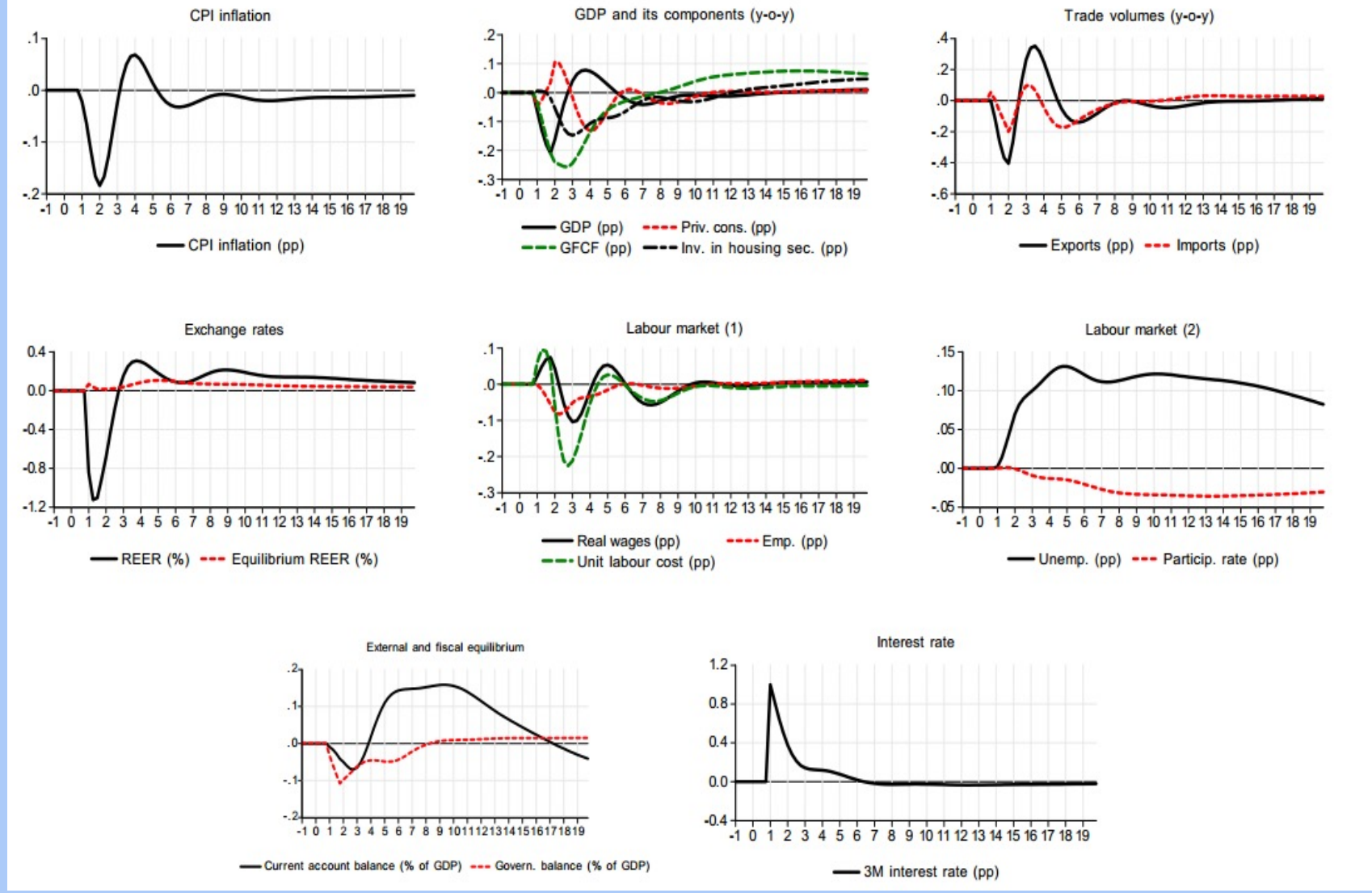
4.2. NECMOD MODEL _ 2009

4.2.5. Model's impulse response functions

(1) Monetary impulse

- The monetary impulse is defined as an unexpected one quarter increase in the short-term interest rate by 100 basis points
- The interest rate moves in line with the monetary feedback rule → The fiscal rule is switched on.
- GDP growth rate, value of households wealth and aggregate demand reduce.
- Inflation is further reduced.

Table 2: Monetary impulse



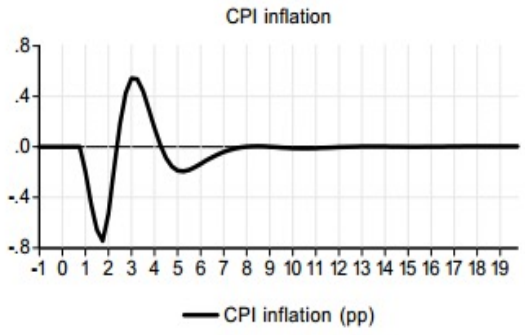
4.2. NECMOD MODEL _ 2009

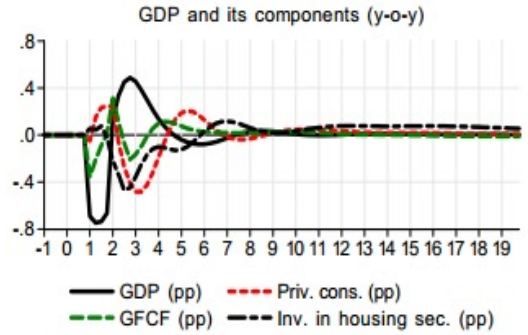
4.2.5. Model's impulse response functions

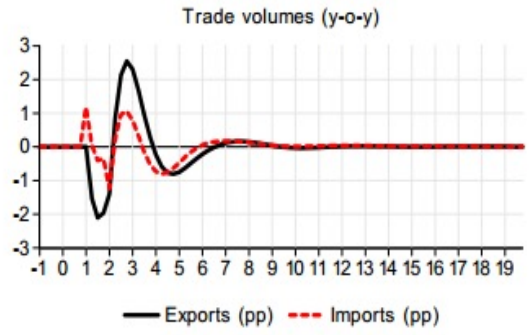
(2) Exchange rate impulse

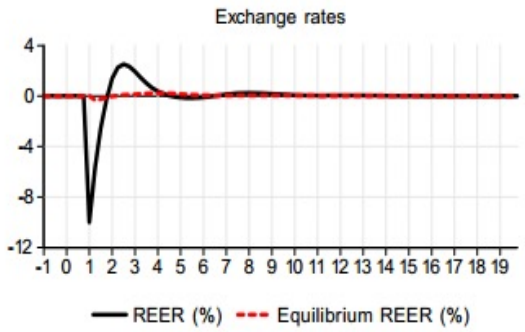
- Is an unexpected one-quarter appreciation of the real (and nominal) effective exchange rate of 10%.
- Exchange rate appreciation leads to a reduction in import prices and, consequently, to a fall in the core inflation rate.
- Food and energy inflation also decrease.

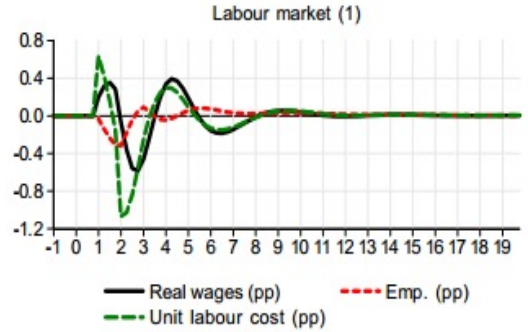
Table 3: Exchange rate impulse

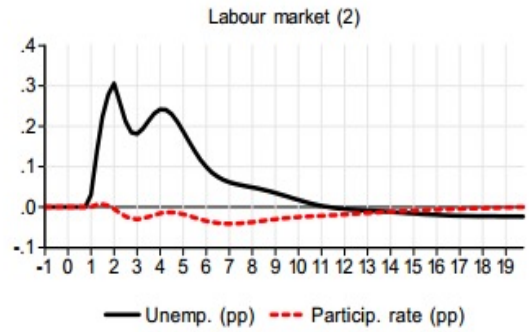


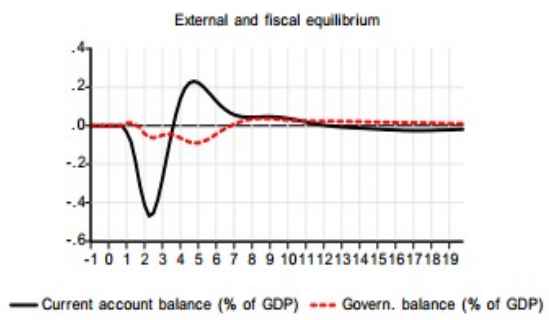


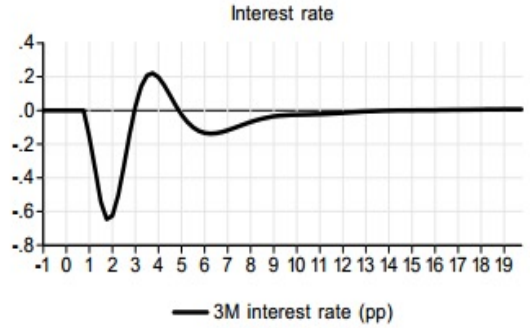












4.2. NECMOD MODEL _ 2009

4.2.6 Summary

(I)The BNP’s method in 2009

(II) Advantages and disadvantages

4.2. NECMOD MODEL _ 2009

4.2.6 Summary

(I) The BNP's method in 2009

- It is a more detailed and coherent approach to the modelling of the external sector block.
- Secular changes in the exchange rate and foreign trade dynamics are explained- jointly with reference to the taste-for-variety theory.
- Reflects better interdependencies between domestic and external sector
- Improvement of seasonal adjustment algorithms

4.2. NECMOD MODEL _ 2009

4.2.6 Summary

(II) Advantages and disadvantages:

- **Advantages:**
  - Major challenges tackled in the current version of the model.
  - Closer look was given to coherency of specification of the trade block jointly with the equilibrium exchange rate.
  - Its explicit treatment of policies (i.e. inflow of structural funds) and phenomena (i.e. stronger inflow of remittances) connected with Polish participation in the European Union.
  - Offers more promising framework for forecasting in conditions of strong fluctuations of global demand and high medium-run volatility of the exchange rate.
- **Disadvantage:**
  - The model has been re-estimated in more detail, however it has not yet assessed all the influencing factors.

4.III. NECMOD MODEL _ 2010

4.III.1 Overview

4.III.2. Changes in the NECMOD model

4.III.3 Main blocks of NECMOD model

4.III.4. Equations

4.III.5 Model's impulse response functions

4.III.6 Summary

4.II. NECMOD MODEL _ 2010

4.III.1 Overview

- In 2008, the most important changes included: the extension of the labour market component, the introduction of forward-looking expectations to the model, the disaggregation of investments and accounting for the impact of world market prices on domestic prices
- In 2009, the most important modification implemented was the change in the specification of the foreign trade block.
- In 2010, the scale of changes was relatively smaller and focused on modifications in the price equations

Data:

- Changes, as compared to the previous version of the model, result from the extension of the re-estimation sample (including the year 2009), as well as from the modifications introduced to certain blocks of the model.

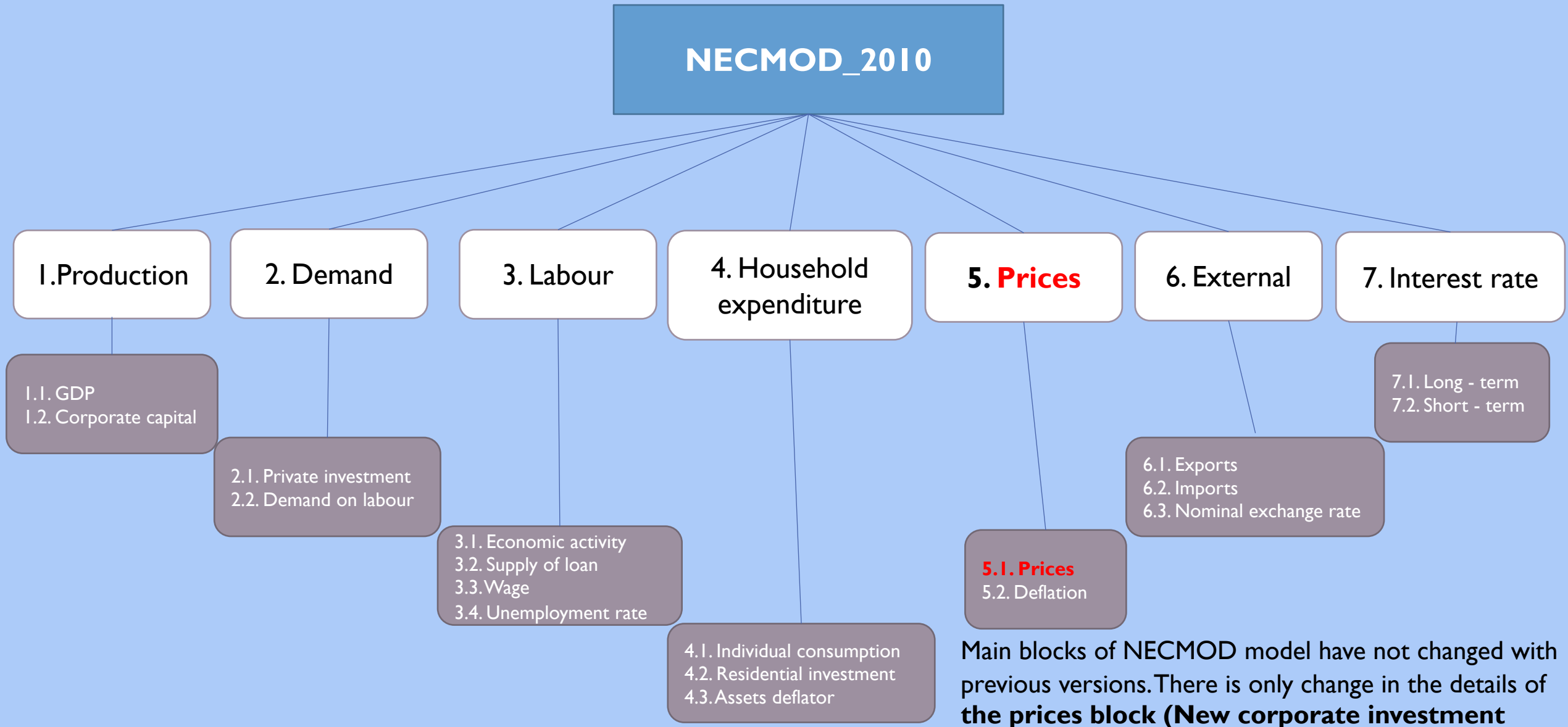
4.III. NECMOD MODEL _ 2010

4.III.2. Changes in the NECMOD model

- **Deflators of gross value added and core inflation**: In this version of the model, the block of prices is based on the concept used in the model of Banco de Espana (Estrada et al. 2004; Ortego et al. 2007).
- **Equation of corporate gross fixed capital formation**: the definition of the marginal product of capital was changed. Now, it is determined on the basis of current rather than potential GDP. Whereas, the marginal product of labour is determined accounting for the adjustment of the total employment to the current level of production
- **Equations of energy and food prices:** In the new version, the gross value added deflator is used as a measure of domestic prices, instead of core inflation, which is a narrower category.
- **Changed definition of capital:** the new specification of the model displays a lower inertia of productive capital (and potential output) in the cycle.
- **Disaggregation of consumption:** each type of consumption is modeled separately, not in the same equation as before.

4.III. NECMOD MODEL _ 2010

4.III.3. Main blocks of NECMOD model



Main blocks of NECMOD model have not changed with previous versions. There is only change in the details of **the prices block (New corporate investment equation.**

4.III. NECMOD MODEL _ 2010
4.III.4. Equations

Sector	Equations	Variables and Changes in the model
V. Prices **1,Producer prices** depends on value added deflator (it is main index of producer prices).	2009 $pva_t^* = -3.33 + 0.67 \cdot ulcna_t + (1-0.67) \cdot (pimp_t + GR\_TAR\_TR_t) + +0.11 \cdot D04Q2$ 2010 $pva_t^* = \alpha_1' + \alpha_2' \cdot (wage\_n_t - \frac{1}{0.67} tfp\_trend_t + (\frac{1}{0.67} - 1)(gdp_t - k_t)) + (1-\alpha_2') \cdot (pimp_t^c + \log(1 + GR\_TAR\_TR_t))$	• GR_TAR_TR: effective rate of import duties • PVA: value added deflator • TREND: trend • PIMP – prices of imported goods • The block of prices is based on the concept used in the model of Banco de Espana. • Current unit labour costs have been changed for unit labour costs determined for the level of employment adjusted to the current output leve • Both approaches, produce the same long-term solution. However, the short-run behaviour of prices is different in these two equations.
2, Equation of corporate gross fixed capital formation:	2009 $MPC_t = RUCC_t$ where: $MPC_t = \frac{\delta GDP\_POT_t}{\delta KP_t} = 0.33 \cdot \frac{GDP\_POT_t}{K_t} \cdot 0.7^3 \cdot \left(\frac{K_t}{KP_t}\right)^3.$ 2010 $\frac{MPC_t'}{MPL_t} = \frac{RUCC_t}{RUCL_t}$ where: $MPC_t' = \frac{\delta GDP_t}{\delta KP_t^*} = 0.33 \cdot \frac{GDP_t}{K_t} \cdot 0.7^3 \cdot \left(\frac{K_t}{KP_t^*}\right)^3,$ $MPL_t = \frac{\delta GDP_t}{\delta EMP_t^*} = 0.67 \cdot GDP_t^{(-0.33/0.67)} \cdot TFP\_TREND_t^{(1/0.67)} \cdot K_t^{(0.33/0.67)}.$	• MPC –marginal product of private capital, • RUCC - real user cost of capital • MPL –marginal product of labour. • RUCL - real user cost of labour. • In the new version, the corporate investment demand increases if the ratio of the marginal product of capital to the marginal product of labour is higher than the corresponding relation of their real costs

Sector	Equations	Variables and Changes in the model
V. Prices **3, Food and energy products prices** are adjusted by experts in the projection horizon	2009 **Prices of energy products** $enercpi_t^* = -2.1 + 0.45 \cdot (p\_ener_t + s\_usd\_pln_t + GR\_VAT\_TR_t) + (1-0.45) \cdot (corecpi_t - GR\_EXT\_REST\_TR_t) + GR\_EXT\_ENER\_TR_t$	• enercpi: enerdy product price index • p_ener: world raw energy commodities price index • GR_EXT_REST_TR: effective exercise tax rate-other goods • GR_EXT_ENER_TR: effective excise tax rate – energy products
	2010 $enercpi_t^* = \beta_1' + \beta_2' \cdot (p\_ener_t + s\_usd\_pln_t^c) + (1-\beta_2') \cdot pva_t + \log(1 + GR\_ENER\_TR_t)$	• The gross value added deflator is used as a measure of domestic prices, instead of core inflation, which is a narrower category. • Because, after the accession to the EU, the energy prices were rising faster than it was expected from analyzing cost determinant
4, Disaggregation of consumption	2009 $conp_t^* = \gamma_1 + \gamma_2 \cdot yd_t + (1-\gamma_2) \cdot wealth_t + \gamma_3 \cdot I\_3MR\_CPI_t + \gamma_4 \cdot HH\_NET\_WEALTH\_RATIO_t$	
	2010 $conp\_dur_t^* = \gamma_1' + \gamma_2' \cdot yd_t + (1-\gamma_2') \cdot wealth_t + \gamma_3' \cdot I\_3MR\_CPI_t.$	• each type of consumption is modeled separately from before there was only one model.
	$conp\_resid_t^* = conp_t - \gamma_1'' + \gamma_2'' \cdot UNRATE_t + \gamma_3'' \cdot (pgfcf\_h_t - cpi_t + rucc\_h_t),$	
	$conp\_ndur_t^* = \gamma_1''' + \gamma_2''' \cdot yd_t + (1-\gamma_2''') \cdot wealth_t + \gamma_3''' \cdot HH\_NET\_WEALTH\_RATIO_t.$	

4.III. NECMOD MODEL _ 2010

4.III.5. Model's impulse response functions

(1) Analysis of the effects of changes in external prices

(2) Analysis of the effects of EU funds inflow

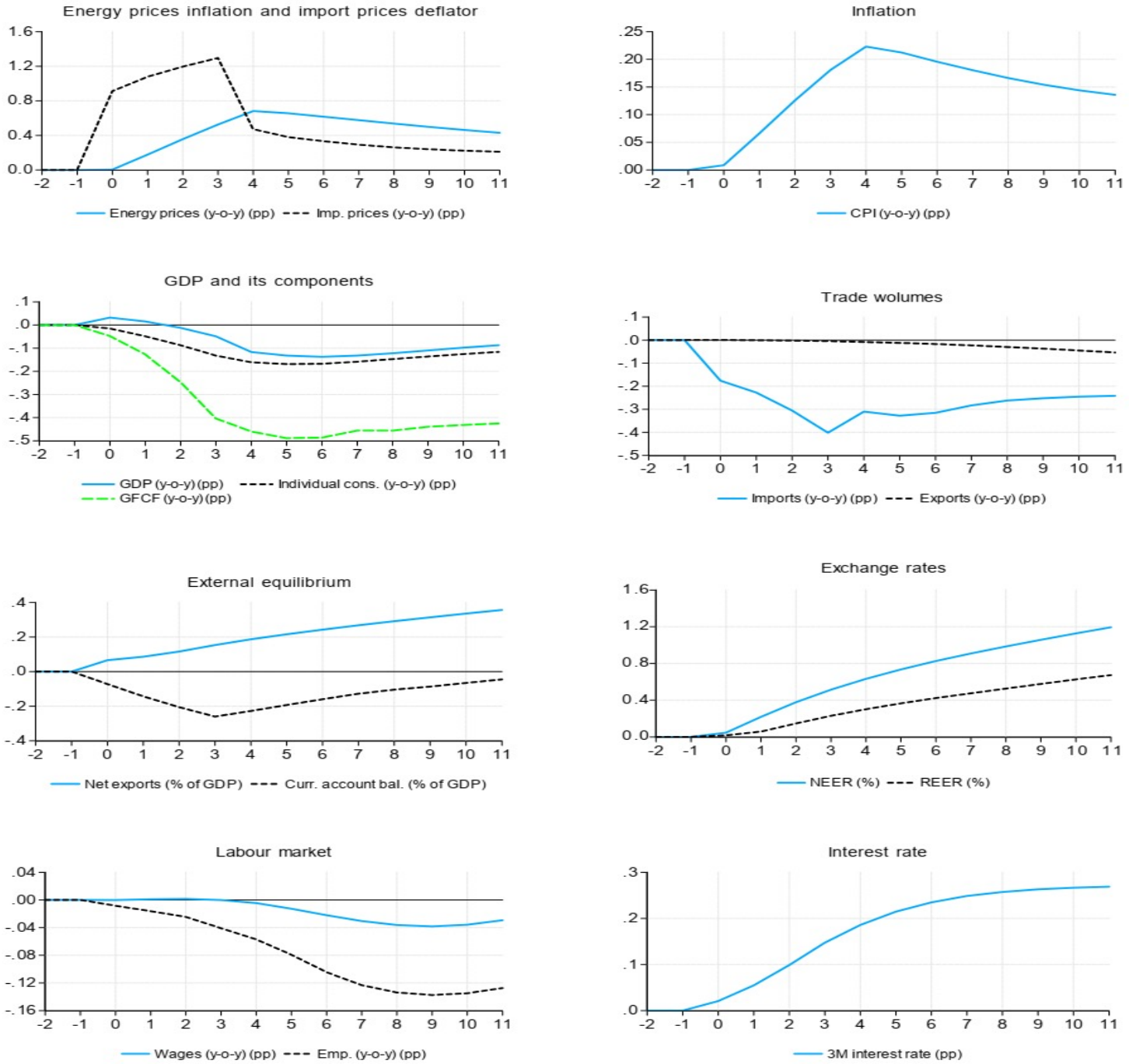
4.III. NECMOD MODEL _ 2010

4.III.5. Model's impulse response functions

(1) Analysis of the effects of changes in external prices

- The increase in energy commodity prices leads directly to a higher growth rate of import prices and energy prices in the domestic market. The trade balance deterioration, caused by less favourable terms of trade, translates into weakening of the equilibrium exchange rate and, consequently, lower current exchange rate.
- Enterprises incur additional costs associated with rising energy prices and higher credit costs, which curbs their investments, and translates, with some delay, into decline of productive capital. This leads to a reduction in the level of potential output and wealth. Wealth is further reduced by the depreciation of the exchange rate, which affects the level of net foreign assets

Figure 2. Analysis of the effects of changes in external prices



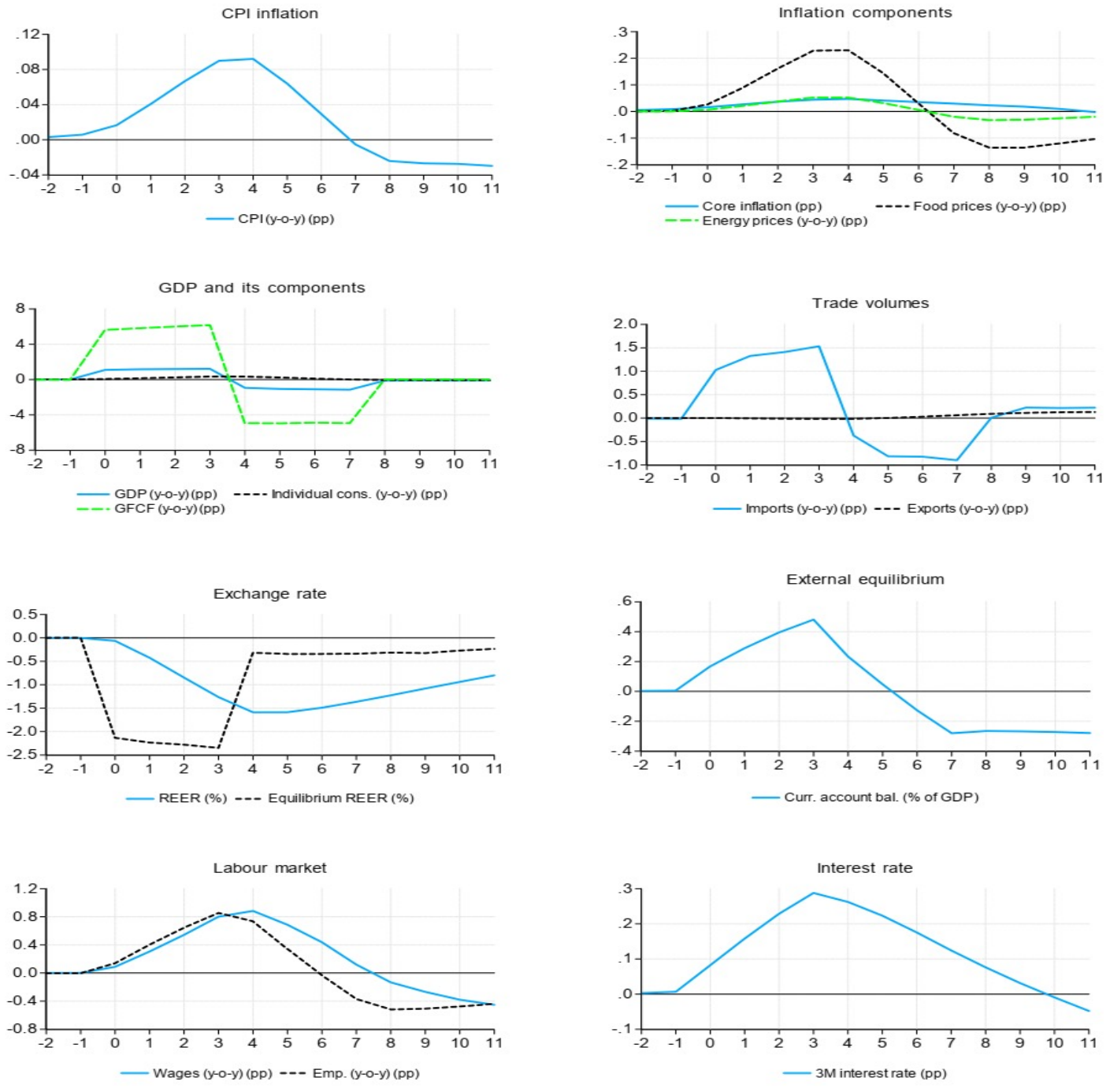
4.III. NECMOD MODEL _ 2010

4.III.5. Model's impulse response functions

(2) Analysis of the effects of EU funds inflow

- Higher public investment, due to its low import intensity, significantly increase the demand for domestic goods, which translates into faster GDP growth. On the other hand, the inflow of EU funds improves the current account balance, which leads to the strengthening of the zloty exchange rate. The stronger zloty reduces exports and increases imports, adversely affecting GDP growth.
- In the short term, the inflow of EU funds raises demand in the economy, pushing CPI inflation up. The opposite influence is exerted by the appreciation of the exchange rate leading to a decline in import prices, including food prices expressed in domestic currency, which leads to the reduction in core inflation and food price inflation.

Figure 5. Analysis of the effects of EU funds inflow



4.III. NECMOD MODEL _ 2010

4.III.6 Summary

- NECMOD Model_2010 mainly presents the **changes in the price equation, new corporate investment equation** and capital definition used in the model compared with the previous models.
- In the current version of the model the definition of capital has been changed from gross capital to net capital, what is consistent with national accounts.
- Net capital assumes lower values than gross capital, and therefore, investments more strongly affect the relative change in net capital than that in gross capital. Consequently, the new specification of the model displays a lower inertia of productive capital (and potential output) in the cycle.

4.IV. NECMOD MODEL _ 2011

4.IV.1 Overview

4.IV.2. Changes in the NECMOD model

4.IV.3 Main blocks of NECMOD model

4.IV.4 Model's impulse response functions

4.IV.5 Summary

4.IV. NECMOD MODEL _ 2011

4.IV.1 Overview

- In 2008, the most important changes included: the extension of the labour market component, the introduction of forward-looking expectations to the model, the disaggregation of investments and accounting for the impact of world market prices on domestic prices
- In 2009, the most important modification implemented was the change in the specification of the foreign trade block.
- In 2010 and 2011, the scale of changes focused on modifications in the price equations (New corporate investment equation in 2010 and including the hysteresis in 2011).

Data:

- Changes, as compared to the previous version of the model, result from the extension of the re-estimation sample (including the year 2010), as well as from the modifications introduced to certain blocks of the model.

4.IV. NECMOD MODEL _ 2011

4.IV.2. Changes in the NECMOD model

- **Domestic energy prices**: domestic energy prices are dependent, apart from other variables, on global index of energy commodity prices, which is a weighted average of hard coal, crude oil and natural gas prices. The equation was modified to diversify the speed of the impact, that changes of certain commodities prices have on domestic energy prices.
- **Re-estimation of the short-term exchange rate equation:** Sarno and Valente (2009) claim that information derived from the fundamentals may provide an explanation for a large part of changes in the exchange rate, yet it is not possible to choose a model ex ante. The reason is the behavior of the exchange rate which, in the short-term, is close to the random walk process; moreover, factors influencing exchange rate developments change over time
- **Impact of indirect taxes on prices:** In short-term equations of core inflation, energy prices and food prices, parameters were calibrated, given effective rates of indirect taxes, on the basis of an estimated pass-through of changes in VAT rates into consumer prices after January 1, 2011.
- **Accounting for hysteresis effects:** An OECD study (2009) shows that a 1% rise in unemployment rates feeds through, in the longer term, into a 0.7% increase in the equilibrium unemployment rate. This phenomenon has not been so far fully incorporated into the NECMOD model

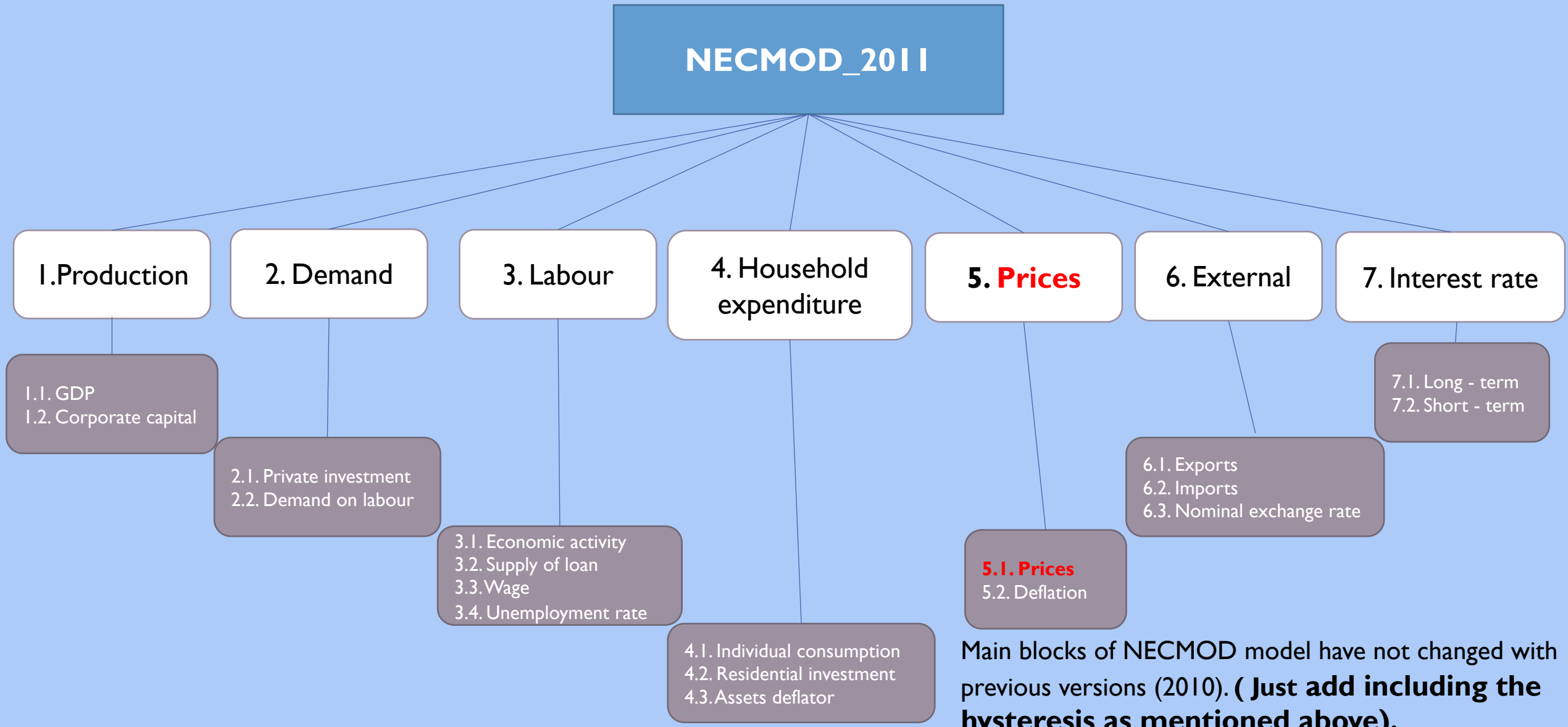
4.IV. NECMOD MODEL _ 2011

4.IV.2. Changes in the NECMOD model

- **Change in the external sector weights:** The pace of recovery of the German economy (Poland's main trading partner) largely exceeds the one observed in France or Spain. During the model re-estimation, the euro area was divided into Germany and other euro area countries. Thus, Germany's weight in the external sector of the model increased.
- **Change in the breakdown of the economically active population:** . In the present version of the NECMOD model, the participation rate is modeled in four age groups. In the new version of the model, as compared to the previous version, population aged 45 years and older was divided into two age groups: 45-59/64 years and 60/65 years and more
- **Revision of the TFP estimate:** During the model re-estimation, TFP level was re-estimated using the guidelines of the European Commission under which HP filter used to smooth TFP series is extended by information contained in additional variables (i.e. production capacity utilization) (European Commission, 2008, 2009)

4.IV. NECMOD MODEL _ 2011

4.IV.3. Main blocks of NECMOD model



Main blocks of NECMOD model have not changed with previous versions (2010). **(Just add including the hysteresis as mentioned above).**

4.IV. NECMOD MODEL _ 2011

4.IV.4. Model's impulse response functions

(1) Impulse of changes in agricultural commodity prices

(2) Analysis of the effects of higher VAT rate

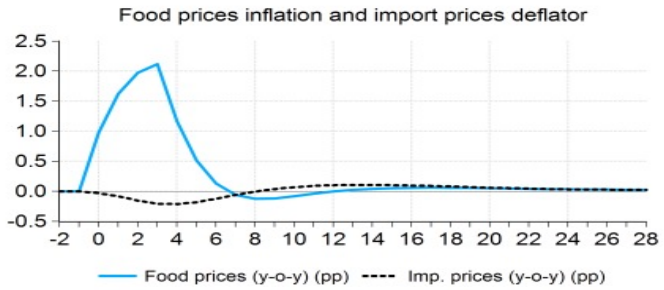
4.IV. NECMOD MODEL _ 2011

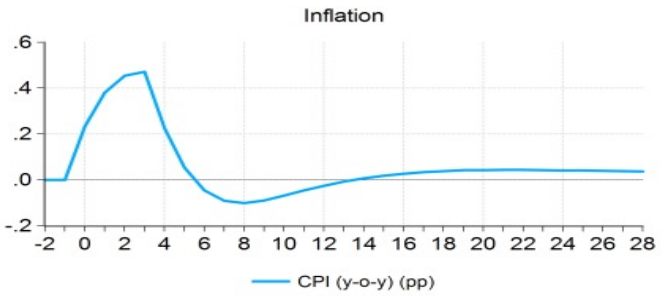
4.IV.4. Model's impulse response functions

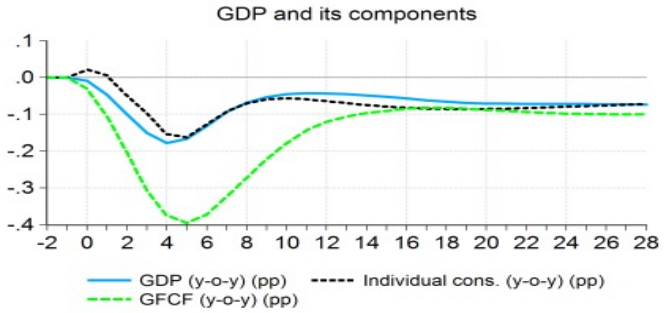
(1) Impulse of changes in agricultural commodity prices

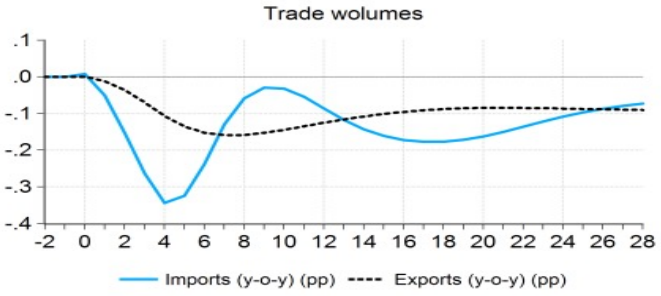
- The rise in agricultural commodity prices abroad translates into higher domestic prices of these commodities. This leads to growing domestic food prices (CPI component) - in the third quarter after the impulse by slightly over 2 percent, which means a rise in CPI inflation by approx. 0.5 percentage points
- The rise in agricultural commodity prices has also resulted in a decline in GDP growth. Higher interest rates affect the decisions of households and enterprises by curbing consumption, investment and inventories. Higher interest rates are also a factor behind exchange rate appreciation which results in lower exports and higher imports.

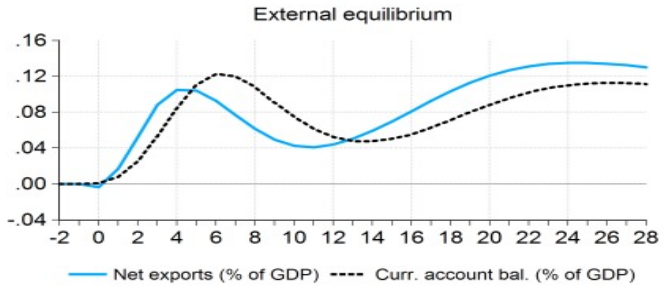
Figure 6: Analysis of changes in agricultural commodity prices

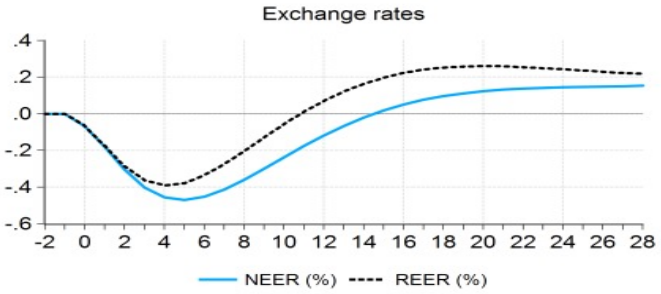


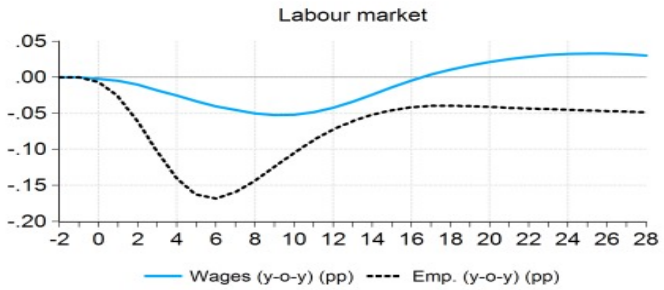


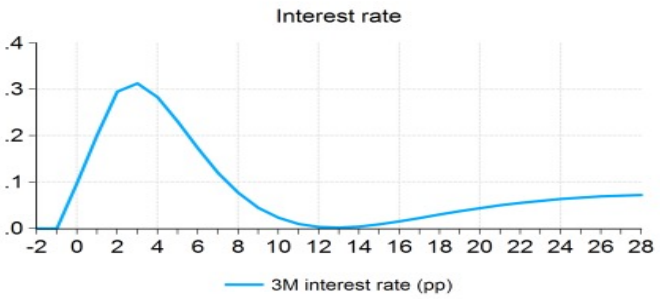












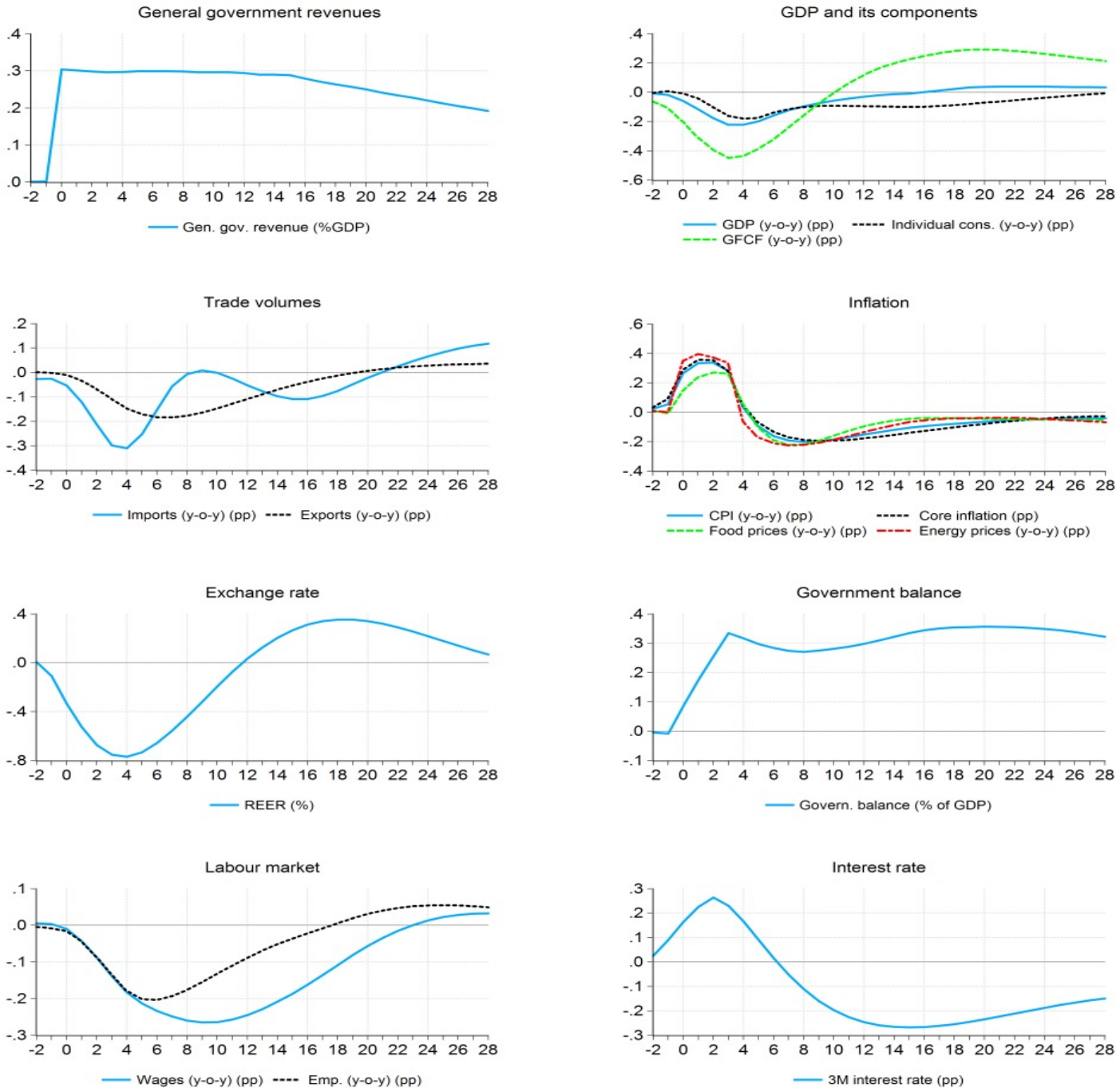
4.IV. NECMOD MODEL _ 2011

4.IV.4. Model's impulse response functions

(2) Analysis of the effects of higher VAT rate

- Increased VAT income in the short term will improve the public sector balance by approx. 0.3 percent of GDP, at the same time, boosting inflation and curbing GDP growth. Rising tax burden translates partly into higher consumer prices (inflation growth in the first year of 0.3 percentage points), and partly is taken over by producers, which is conducive, in turn, to diminishing households income from operating surplus.
- In the longer term horizon, lower economic growth translates into a deterioration in the labour market and further decline in real wage fund and private consumption. Unfavourable situation in the labour market and limited demand brings inflation in the medium term below the base scenario

Figure 7: Analysis of the effects of higher VAT rate



4.IV.NECMOD MODEL _ 2011

4.IV.5 Summary

- NECMOD Model_2011 mainly presents the changes to price block (**Including the hysteresis).** The main blocks of NECMOD model_2011 are similar to 2010 as described above.
- More specifically, the model includes some changes related to domestic energy prices, short-term exchange rate, impact of indirect taxes, external sector weights, breakdown of the economic prices active population and TFP estimate

4.5. NECMOD MODEL _ 2012

4.1.1. Overview

4.1.2. Changes in the model

4.1.3. The NECMOD model

4.1.4. Main blocks of NECMOD model

4.1.5. Equations

4.1.6. Model’s impulse response functions

4.1.7. Summary

4.1. NECMOD MODEL _ 2012

4.1.1 Overview

- During re-estimation rounds in 2010 and 2011 changes focused on modifications in price equations.
- In 2012, the economic activity block was re-specified to ensure stronger impact of legal changes limiting the number of persons eligible for retirement pay on the number of economically active persons.
- The model distinguishes three types of investment, modeled separately: residential, corporate and public investment.

Data:

- Main source: national accounts
- Information about labour market (LFS data), prices of consumer goods (CPI basket), financial data from BNP

4.1. NECMOD MODEL _ 2012

4.1.2. Changes in the model

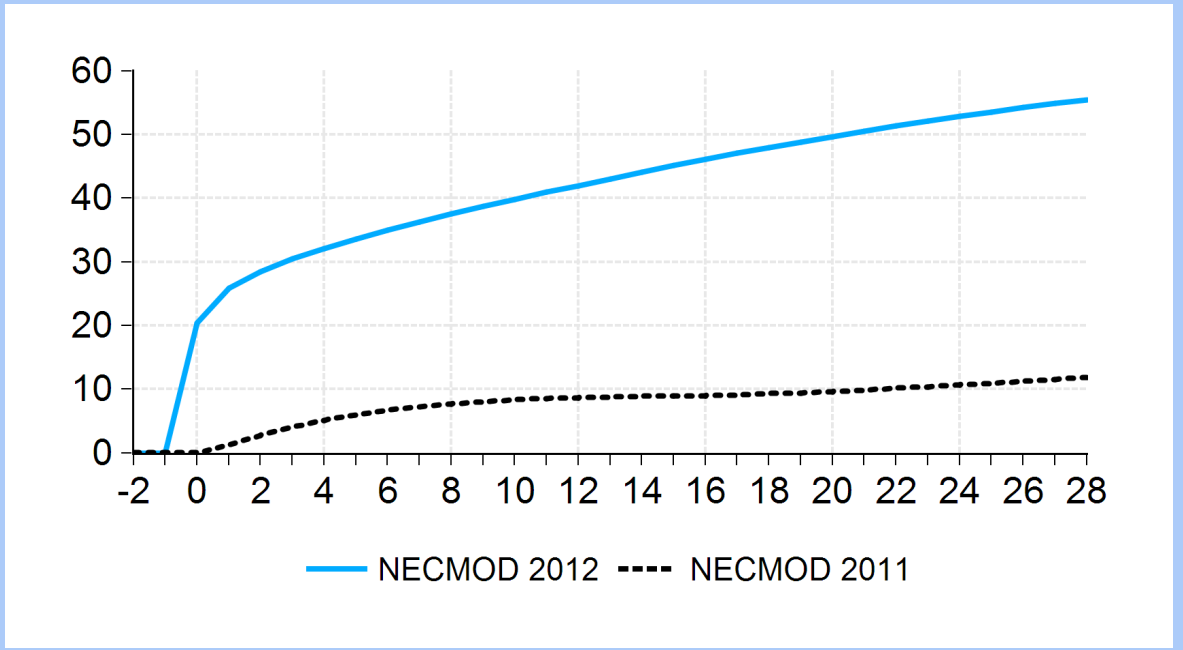
As compared to the previous re-estimation rounds, the extent of modifications introduced to the model was minor – in fact, it was limited to two modifications referred to below.

a. Re-specification of the economic activity block

- to ensure stronger, translation of legal changes limiting the number of persons eligible for retirement pay into the number of the economically active persons.

b. Stronger translation of the situation abroad into domestic economy

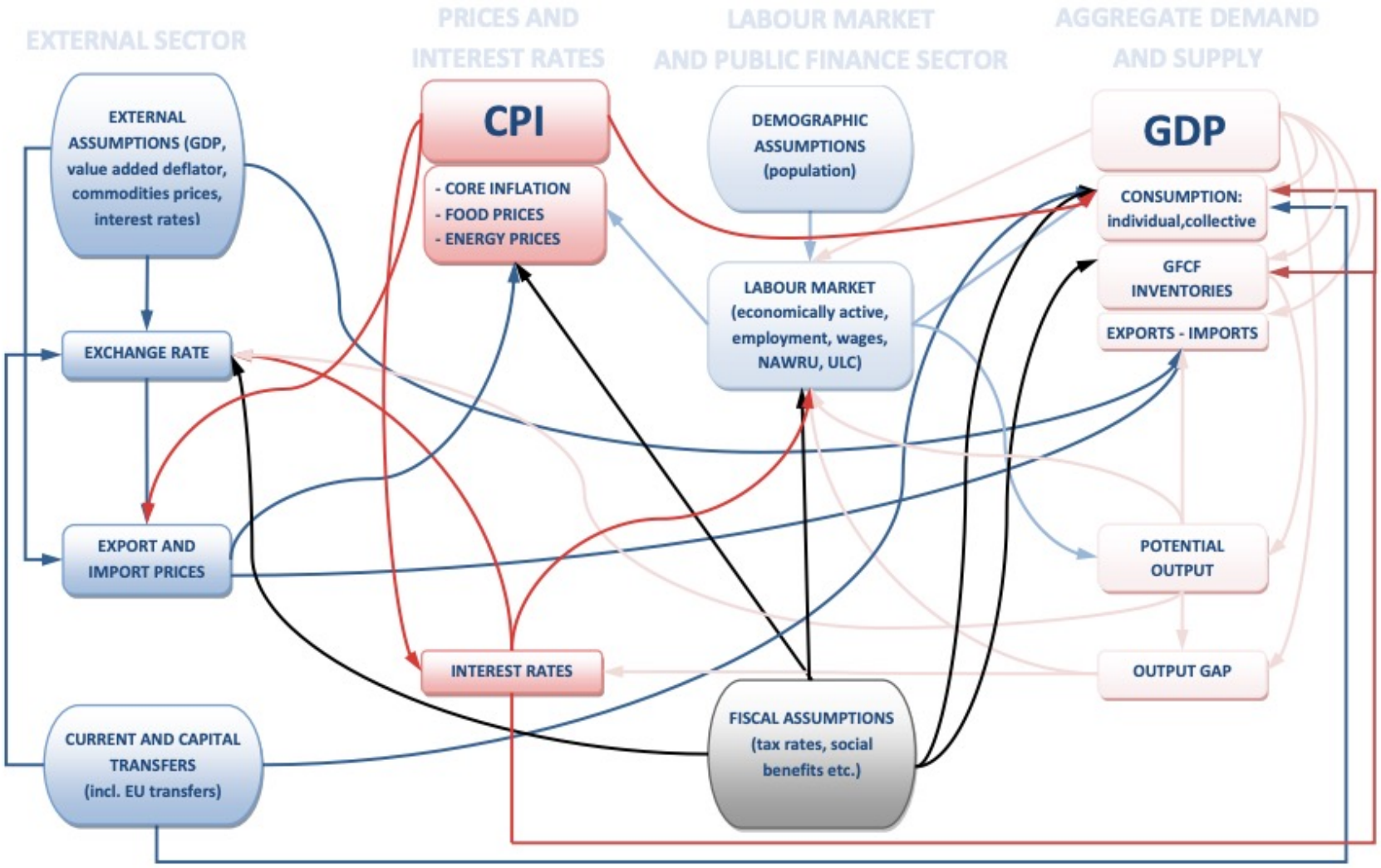
- external economic activity affects domestic economic activity have been added
- adding variables reflecting business conditions abroad



4.1. NECMOD MODEL _ 2012

4.1.3. The NECMOD model

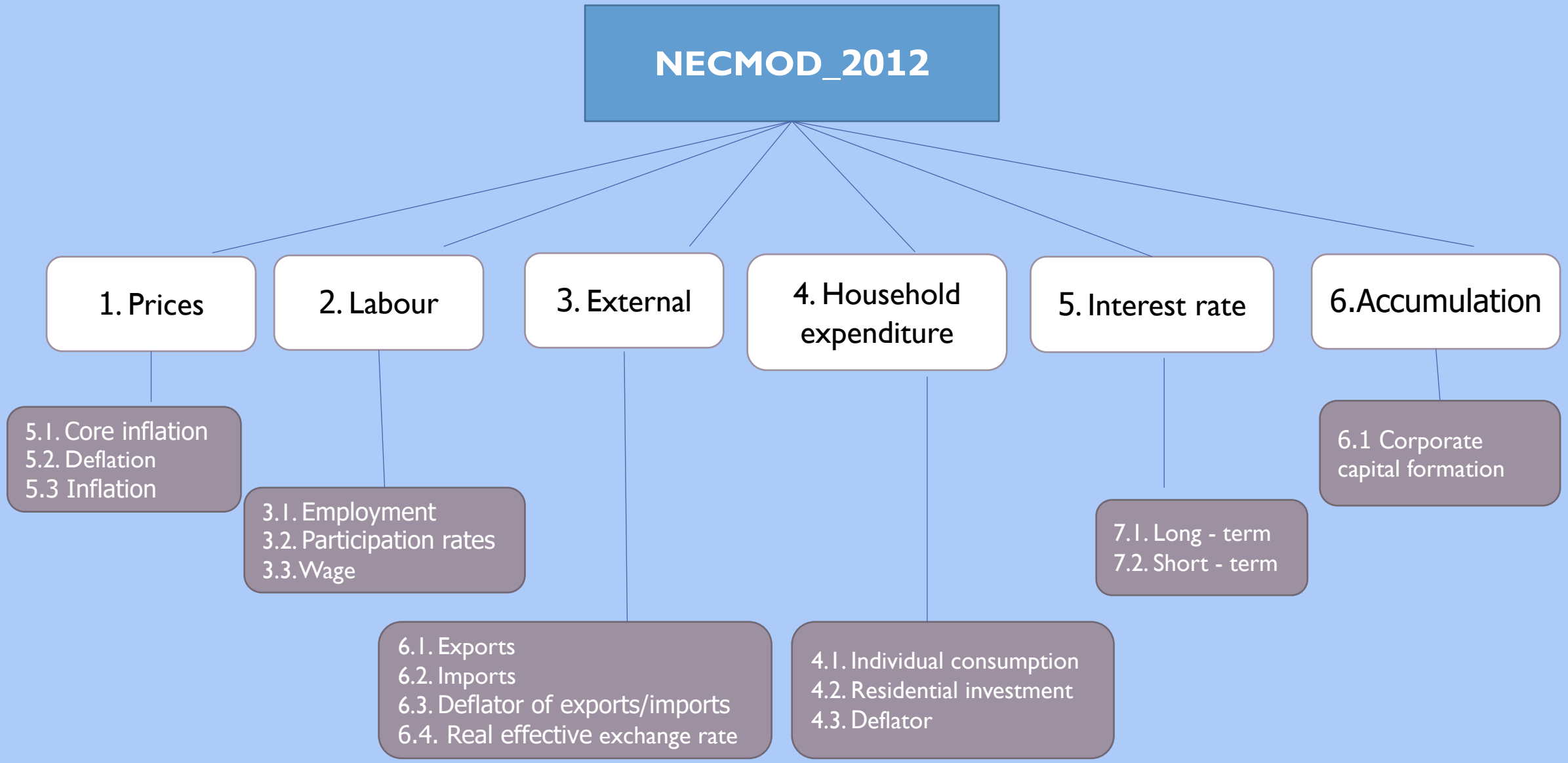
Figure 2: The NECMOD model structure



NECMOD model has 276 equations and 369 variables

4.1. NECMOD MODEL _ 2012

4.1.3. Main blocks of NECMOD model



4.1.4. NECMOD MODEL _ 2012

Sectors	Equations	Variables
1.Prices	Core inflation $$corecpi_t^* = C\_CORE_t + 0.69 \cdot (wage\_n_t + (1 + GR\_CORP\_TR_t)) + 0.69 \cdot (1/0.67 - 1) \cdot (gdp_t - k_t) - 0.69 \cdot 1/0.67 \cdot tfp\_trend_t + (1 - 0.69) \cdot (pimp\_core_t^c + \log(1 + GR\_TAR\_TR_t)) + GR\_CORE\_TR_t + GR\_CO2\_CORE\_TR_t$$	• C_CORE (EX) – time-varying constant in core inflation equation • GR CORE TR (EN) – effective rate of taxes imposed on prices of goods and services which are in the core inflation basket
	Deflator of value-added $$pva_t^* = C\_PVA_t + GR\_CO_2\_PVA\_TR_t + 0.67 \cdot wage\_n_t + 0.67 \cdot GR\_CORP\_TR_t + 0.67 \cdot (1/0.67 - 1) \cdot (gdp_t - k_t) - 0.67 \cdot 1/0.67 \cdot tfp\_trend_t + (1 - 0.67) \cdot pimp_t^c$$	• C PVA (EX) – time-varying constant in value added equation • GR CORP TR (EN) – effective rate of social security contributions paid by employers
	Inflation of energy prices $$enercpi_t^* = -0.12 + 0.37 \cdot p\_ener\_pl_t + (1 - 0.37) \cdot pva_t + GR\_ENER\_TR_t + GR\_CO2\_ENER\_TR_t + dummies$$	• GR ENER TR (EN) – effective rate of taxes imposed on energy prices • GR CO2 ENER TR (EN) – effective rate of charges imposed on energy prices connected with costs of purchasing CO2 emission rights
	Inflation of food prices $$foodcpi_t^* = C\_FOOD_t + 0.08 \cdot (p\_food_t + s\_usd\_pln_t^c) + (1 - 0.08) \cdot pva_t + GR\_VAT\_TR_t$$	• C_FOOD (EX) – time-varying constant in food prices inflation equation • GR VAT TR (EN) – effective rate of VAT

Sectors	Equations	
II. Labour market	Employment: $$emp_t^* = (1/0.67) \cdot gdp_t - (1/0.67) \cdot tfp\_trend_t - (0.33/0.67) \cdot k_t$$	• Estimation period: 1997q1 - 2011q4
	Participation rate net of persons eligible for pension benefits and persons pursuing full-time studies aged 15-24 $$LF\_MOD_t = \frac{LF_t - LF\_RET_t - 0.05 \cdot POP\_EDU_t}{POP_t - POP\_EDU_t - (RETIRED_t - (RETIRED\_Y_t - LF\_Y\_RET_t))}$$ $$\begin{aligned} LF\_MOD_t^* = & LF\_DEMOG + 0.01 \\ & - 0.09 \cdot (LF\_TAX\_WEDGE_t + LF\_INTAX_t) \\ & - 0.16 \cdot RR\_NLF_t + 0.35 \cdot \frac{ALMP_t}{GDP\_N_t} \\ & + 0.37 \cdot \frac{EMP\_A_t}{EMP_t} + dummies \end{aligned} \quad (11)$$	• Participation rate for population aged 15-24 net of persons eligible for pension benefits and persons pursuing full-time studies $$\begin{aligned} & \Delta\left(\frac{LF\_Y_t - 0.05 \cdot POP\_EDU_t - LF\_Y\_RET_t}{POP\_Y_t - POP\_EDU_t - LF\_Y\_RET_t}\right) = \\ & - 0.01 \cdot (LF\_MOD_t - LF\_MOD_t^*) \\ & - \underset{(0.12)}{0.15} \cdot \Delta\left(\frac{LF\_Y_{t-1} - 0.05 \cdot POP\_EDU_{t-1} - LF\_Y\_RET_{t-1}}{POP\_Y_{t-1} - POP\_EDU_{t-1} - LF\_Y\_RET_{t-1}}\right) \end{aligned}$$
	Participation rate for population aged 25-44 net of persons eligible for pension benefits $$\begin{aligned} \Delta\left(\frac{LF\_M_t - LF\_M\_RET_t}{POP\_M_t - RETIRED\_M_t}\right) = & \quad (13) \\ & - \underset{(0.12)}{0.02} \cdot (LF\_MOD_t - LF\_MOD_t^*) \\ & - \underset{(0.1)}{0.005} \cdot \Delta emp_t + \underset{(1.17)}{1.33} \cdot \Delta\left(\frac{ALMP\_N_t}{GDP\_N_t}\right) \end{aligned}$$	• Participation rate for population aged 45-59/64 net of persons eligible for pension benefits $$\begin{aligned} \Delta\left(\frac{LF\_O_t}{POP\_O_t}\right) = & - \underset{(0.10)}{0.07} \cdot (LF\_MOD_t - LF\_MOD_t^*) \\ & + \underset{(0.03)}{0.02} \cdot \Delta_4 emp_t + \underset{(0.14)}{0.17} \cdot \Delta\left(\frac{LF\_O_{t-1}}{POP\_O_{t-1}}\right) \\ & - \underset{(0.13)}{0.20} \cdot \Delta\left(\frac{RETIRED\_O_t}{POP\_O_t}\right) \end{aligned}$$

Sector	Equations	Variables
II. Labour market	Participation rate for population aged 60/65+ net of persons eligible for pension benefits $$\Delta\left(\frac{LF\_PW_t - LF\_PW\_RET_t}{POP\_PW_t - RETIRED\_PW_t}\right) = -0.01 \cdot (LF\_MOD_t - LF\_MOD_t^*) - \underset{(0.12)}{0.33} \cdot \left(\frac{LF\_PW_{t-1} - LF\_PW\_RET_{t-1}}{POP\_PW_{t-1} - RETIRED\_PW_{t-1}}\right) + \underset{(0.61)}{0.47} \cdot \Delta emp_t + 0.90 \cdot \Delta\left(\frac{EMP\_A_t}{EMP_t}\right)$$	• LF PW (EN) – post-production labour force (60/65+ years) • LF PW RET (EN) – number of the economically active persons aged 60/65+, eligible, at the same time, for pension benefits • LF PW (EN) – post-production labour force (60/65+ years) • LF PW RET (EN) – number of the economically active persons aged 60/65+, eligible, at the same time, for pension benefits
	Wages $$wage\_n_t^* = 1.78 + tfp\_trend_t + (1 - 0.67) \cdot k_t + cpi_t - 0.85 \cdot (UNRATE_t - UNRATE\_AVER_t) + 0.2 \cdot RR\_UNEMP_t - 0.5 \cdot GR\_INDIR\_TR_t + (1 - 0.5) \cdot GR\_DIR\_TR_t - 0.5 \cdot GR\_CORP\_TR_t + 1.38 \cdot RUCC_t + 0.1 \cdot minw_t + dummies$$	• UNRATE (EN) – unemployment rate • UNRATE AVER (EN) – long-lasting unemployment rate – geometrical average of unemployment rate multiplied by 0.74 • RR UNEMP (EN) – replacement rate for unemployed (including unemployment benefits and social relief)

Sector	Equations	
III. Foreign trade	• Exports volume $gdp\_exp_t^* = gdp\_ext_t - 23.45 + 1.69 \cdot gdp\_pot_t - 1.10 \cdot (pexp_t - (pva\_ext_t + s\_neer_t)) + 2.80 \cdot (gdp\_ext_t - gdp\_ext\_pot_t) + dummies$	• Deflator of exports $(pexp_t - pva\_ext_t - s\_neer_t)^* = -3.56 - 0.53 \cdot s\_reer_t + 0.10 \cdot (gdp\_pot_t - gdp\_ext\_pot_t) + dummies$
	• Imports volume $gdp\_imp_t^* = gdp_t - 12.18 + 1.69 \cdot gdp\_ext\_pot_t - 1.02 \cdot (pimp\_core_t + \log(1 + GR\_TAR\_TR_t) - pva_t) + 1.00 \cdot \log((CONP_t + INV_t + GFCF\_P_t)/DD_t)$	• Deflator of imports $(pimp_t - pva_t)^* = -2.79 + 0.44 \cdot s\_reer_t + 0.06 \cdot (p\_oil_t + s\_usd\_pln_t - pva_t) + 0.03 \cdot (p\_gas_t + s\_usd\_pln_t - pva_t)$

Sector	Equations	Variables
III. Foreign trade	Real effective exchange rate	• TCAB (EN) – the equilibrium current account to GDP ratio • CAB TRANS INC GDP (EN) – ratio of current account income and transfer balances to GDP • CONP (EN) – individual consumption • GFCF P (EN) – gross fixed corporate capital formation • DD (EN) – domestic demand • INV (EN) – change in inventories

$$
\begin{aligned}
s\_reer_t^* = & \frac{1}{(1-1.09)\cdot(-0.53)-(1-1.02/0.91)\cdot 0.44+0.91}\cdot \\
& \Bigg(\frac{TCAB_t - CAB\_TRANS\_INC\_GDP_t}{OPEN_t} \\
& - \Big(-23.45+12.18-\log\Big(\frac{CONP_t+INV_t+GFCF\_P_t}{DD_t}\Big) \\
& + (-1.09+1)\cdot(-3.56+0.1\cdot(gdp\_pot_t - gdp\_ext\_pot_t)) \\
& - (-1.02/0.91+1)\cdot(-2.79) \\
& + (1.69-1)\cdot(gdp\_pot_t - gdp\_ext\_pot_t) \\
& + 1.02\cdot\log(1+GR\_TAR\_TR_t) \\
& - 0.06\cdot(p\_oil_t + s\_usd\_pln_t - pva\_ext_t - s\_neer_t) \\
& - 0.03\cdot(p\_gas_t + s\_usd\_pln_t - pva\_ext_t - s\_neer_t) \\
& + dummies\Big)\Bigg)
\end{aligned}
$$

Sector	Equations	
IV. Household's' sector	Individual consumption of durable goods $$conp\_dur_t^* = -3.18 + 0.44 \cdot yd_t + 0.32 \cdot M3_t/CPI_t + (1 - 0.44 - 0.32) \cdot gdp\_pot_t - 0.5 \cdot I\_3MR\_CPI_t + dummies$$	• Individual consumption of non-durable goods and services $$conp\_ndur_t^* = -0.47 + 0.49 \cdot yd_t + (1 - 0.49) \cdot gdp\_pot_t + 0.24 \cdot HH\_NET\_WEALTH\_RATIO_t - 0.4 \cdot I\_3MR\_CPI_t$$
Gross fixed residential capital formation $$(gfcf\_h_t - gdp\_pot_t)^* = 0.25 \cdot (pgfcf\_h_t - pva_t + \log(1 - 0.32 \cdot GR\_VAT\_TR_t)) - 3.56$$	• M3 (EN) – money supply, M3 monetary aggregate • HH NET WEALTH RATIO (EN) – variable reflecting changes in households' assets and liabilities as compared to their wealth • I 3MR CPI (EN) – real 3-month interest rate (deflated with CPI) • GR VAT TR (EN) – effective rate of VAT • INF TARGET (EX) – inflation target	
Deflator of gross fixed residential capital formation $$\Delta pgfcf\_h_t = \underset{(0.06)}{0.15} \cdot \log(1 + INF\_TARGET_t)/4 + (1 - \underset{(0.06)}{0.15} + \underset{(0.12)}{0.33}) \cdot \Delta pgfcf\_h_{t-1} - \underset{(0.12)}{0.33} \cdot \Delta pgfcf\_h_{t-2} - \underset{(0.02)}{0.02} \cdot (conp\_resid_{t-1} - conp\_resid_{t-1}^*) - \underset{(0.92)}{0.30} \cdot \Delta RUCC\_H_t - \underset{(0.38)}{0.55} \cdot \Delta UNRATE_t$$	• RUCC H (EN) – real user cost of residential capital • UNRATE (EN) – unemployment rate • INF TARGET (EX) – inflation target	

Sector	Equations	Variables
V. Interest rates	WIBOR 3M quarterly average $$I\_3M_t = \underset{(0.01)}{0.88} \cdot I\_3M_{t-1} + (1 - \underset{(0.01)}{0.88}) \cdot (I\_3MR\_EQ_t + INF_{t+1} + \underset{(0.24)}{0.77} \cdot (INF_{t+1} - \overline{INF\_TARGET}_{t+3}) + \underset{(0.09)}{0.40} \cdot GAP_t)$$	• I 3M (EN) – WIBOR 3M quarterly average • I 3MR EQ (EX) – equilibrium real interest rate • INF TARGET (EX) – smoothed inflation target (four-quarter moving average)
	Yield on 5-year government bonds $$I\_5Y_t = \underset{(0.05)}{0.37} \cdot I\_5Y_{t-1} + (1 - \underset{(0.05)}{0.37}) \cdot (\frac{1}{17} \cdot I\_3M_t + (1 - \frac{1}{17}) \cdot I\_5Y_{t+1} - \underset{(0.01)}{0.004} \cdot G\_BALANCE\_GDP_t)$$	• I_5Y (EN) – yield on 5-year government bonds • G BALANCE GDP (EN) – General Government balance to GDP ratio

	Equations	Variables
VI. Accumulation	Gross fixed corporate capital formation $KP^{*}\ meets\ condition: \frac{MPC_t}{MPL_t} = \frac{RUCC_t}{RUCL_t}$	• MPC (EN) - marginal product of corporate capital 29 • MPL (EN) - marginal product of labour after adjusting for current GDP • RUCC (EN) – real user cost of capital • RUCL (EN) - real cost of labour

$$\Delta gfcf\_p_t = -\underset{(0.14)}{0.16} \cdot (kp_{t-1} + 0.10 - kp^{*}_{t-1}) \quad (39)$$

$$- \underset{(0.14)}{0.04} \cdot \Delta gfcf\_p_{t-1} + \underset{(0.11)}{0.27} \cdot \Delta gfcf\_p_{t-2} + \underset{(0.11)}{0.20} \cdot \Delta gfcf\_p_{t-3}$$

$$+ (1 + \underset{(0.14)}{0.04} - \underset{(0.11)}{0.27} - \underset{(0.11)}{0.20} + \underset{(0.78)}{0.13}) \cdot \Delta gdp_{t+1} - 0.002 \cdot \Delta_4 (p\_ener\_pl_t - pva_t)$$

$$+ \underset{(0.17)}{0.51} \cdot \Delta_3 (gdp\_ext_t - gdp\_ext\_pot_t) - \underset{(0.78)}{0.13} \cdot \Delta tfp\_trend_t / 0.66 + 0.4 \cdot$$

$$\Delta \left(\frac{(TRANS\_GFCF\_P\_EUR_t \cdot S\_EUR\_PLN_t) / (PVA_t \cdot (1 + GR\_VAT\_TR_t))}{GFCF\_P_{t-1}} \right)$$

$$+ dummies$$

4.1. NECMOD MODEL _ 2012

4.1.4. Model's impulse response functions

(1) Monetary impulse

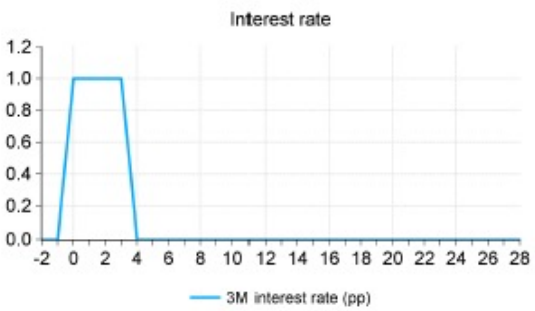
(2) Exchange rate impulse

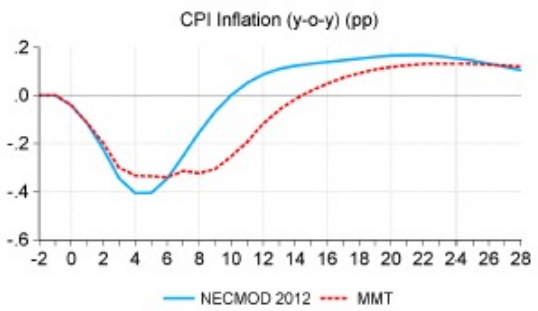
4.1. NECMOD MODEL _ 2012

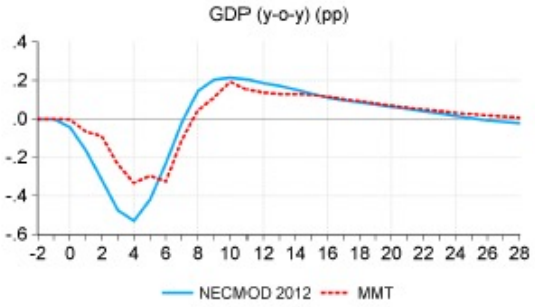
4.1.4. Model's impulse response functions

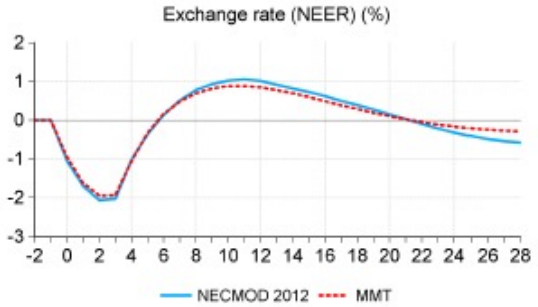
(1) Monetary impulse

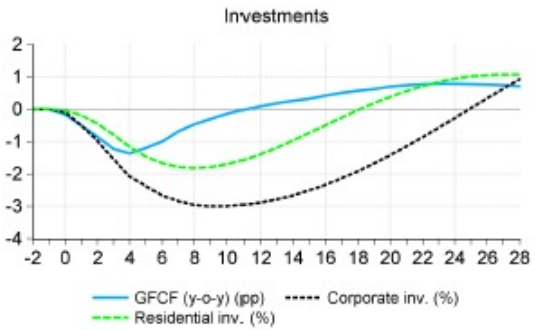
- increase in the short-term interest rates
- increase in costs of raising capital
- reduces both corporate and household investment
- a drop in housing prices, the decline in household assets reducing consumer demand
- GDP growth falls by about 0.53 percentage points
- Consequently, CPI inflation falls by about 0.41 percentage points 4 quarters after the increase in interest rate.

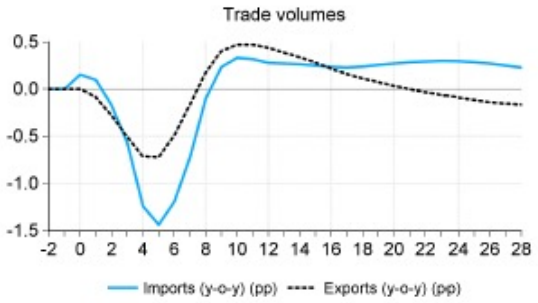


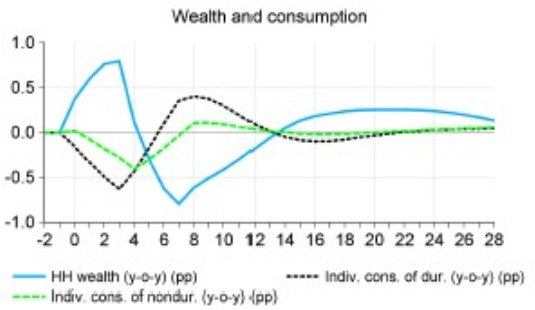


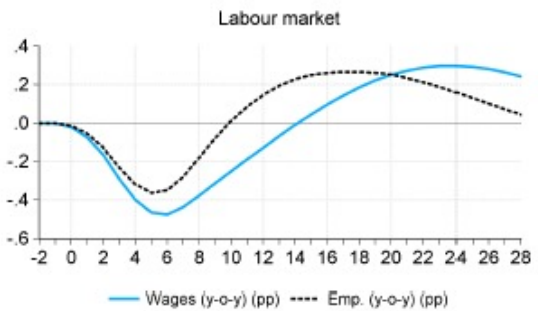












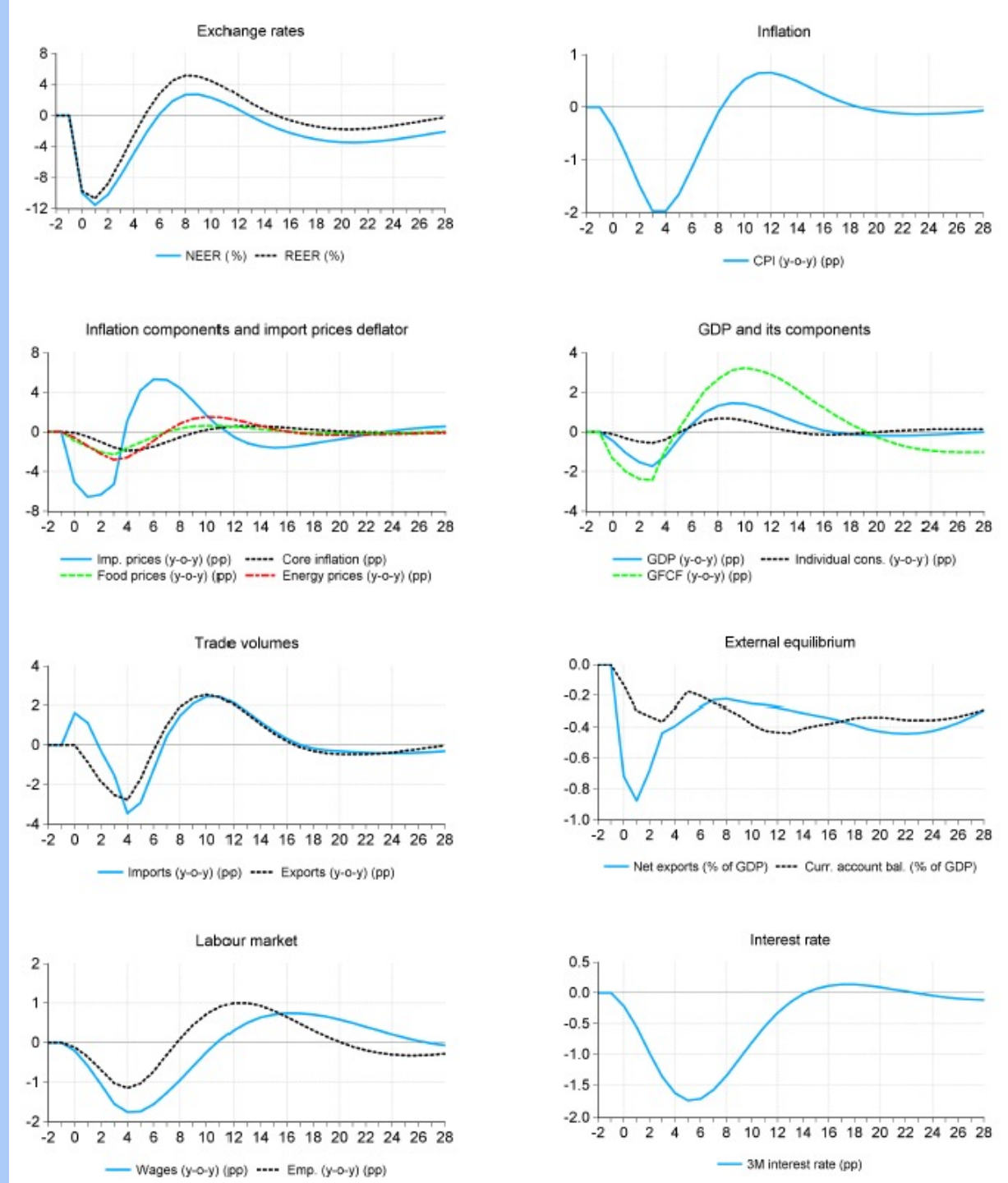
4.1. NECMOD MODEL _ 2012

4.1.4. Model's impulse response functions

(2) Exchange rate impulse

- decline in import prices and in all the components of CPI inflation
- Domestic products become less competitive abroad
- In total, interest rate fluctuations lead to deterioration in net exports' contribution to GDP
- a deterioration in the labour market situation
- a reduction of disposable income of households and a consumption decline

In response to falling prices and lower economic growth, monetary policy is being relaxed, supporting the economy in its return to the equilibrium state.



4.1. NECMOD MODEL 2012

4.1.6 Summary

- As compared to the previous re-estimation rounds, the extent of modifications introduced to the model was minor – in fact, it was limited to two modifications.
- During re-estimation rounds in 2010 and 2011 changes focused on modifications in price equations
- In 2012, the economic activity block was re-specified to ensure stronger impact of legal changes limiting the number of persons eligible for retirement pay on the number of economically active persons.

V. Conclusion

- NECMOD, which was developed foremost to facilitate implementation of the monetary policy in Poland through a regular delivery of inflation and GDP projections.
- The model encompasses all major channels of the monetary policy transmission mechanism and is able to deliver a comprehensive account of factors underlying the main economic developments
- NECMOD is able to describe propagation of a range of macroeconomic shocks
- reflect the dynamic nature of a converging economy
- The re-estimation of the NECMOD model is carried out once a year, before the July projection round – the last one took place in May 2019.
- Last update in 2012

THANK YOU FOR YOUR ATTENTION !!!

DSGE MODEL for National Bank of Poland

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UNIWERSYTET EKONOMICZNY W POZNANIU

REFERENCE:
https://www.nbp.pl/homen.aspx?f=/en/publikacje/raport_inflacja/necmod.html

BNP PARIBAS


THANK YOU :)