MATERIAŁY I STUDIA

Paper No. 36

# ECMOD
# Model of the Polish Economy

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Warsaw, October 2005

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Design:

Oliwka s.c.

Layout and print:

NBP Printshop

Published by:

National Bank of Poland
Department of Information and Public Relations
00-919 Warszawa, 11/21 Świętokrzyska Street
phone: (22) 653 23 35, fax (22) 653 13 21



http://www.nbp.pl

## Acknowledgements

The authors would like to thank the following persons for their suggestions and remarks concerning both the current and previous versions of the model:

*Piotr Boguszewski, Wojciech Charemza, Adam Czyżewski, Ryszard Kokoszczyński, Krzysztof Marczewski, Witold Orłowski, Krzysztof Rybiński, Krystyna Strzała, Piotr Szpunar, Aleksander Welfe, Leszek Zienkowski,* and the heads of the divisions involved in work on the model – *Jakub Borowski, Małgorzata Golik, Grażyna Mierzejewska, Ewa Rzeszutek, Zbigniew Żółkiewski* and *Roman Sawiński*.

In particular, the authors would like to thank *Michał Gradzewicz* who co-developed the previous version of the model. The model would not have the present form were it not for Michał's contribution.

The authors would also like to express their thanks to Tomasz Kuciński for his help in the preparation of this paper.

The authors bear full responsibility for any errors.

# Contents

# NON-TECHNICAL SUMMARY

This paper describes the multi-equation macroeconomic model of the Polish economy (ECMOD) developed for the purpose of conducting monetary policy in Poland.

Under the direct inflation targeting strategy, the assessment of inflation prospects, including projection of inflation, is an important factor in the decision-making process. The significance of forecasting in contemporary monetary policy is reflected in the words of Alan Greenspan, Federal Reserve Chairman:

*„Implicit in any monetary policy action or inaction is an expectation of how the future will unfold, that is, a forecast”* [Greenspan, 2002].

Macroeconomic models systematise the way of thinking about complex economic reality and enable economists to identify factors relevant to the explanation of the mechanisms governing the economy in the future.

The ECMOD model has been developed to generate forecasts for all key macroeconomic categories, mainly inflation, as well as GDP and its components and many other variables relevant to monetary policy. Another objective of the ECMOD model is to conduct simulations that enable quantification of the effects of economic policy and exogenous shocks to the main macroeconomic variables.

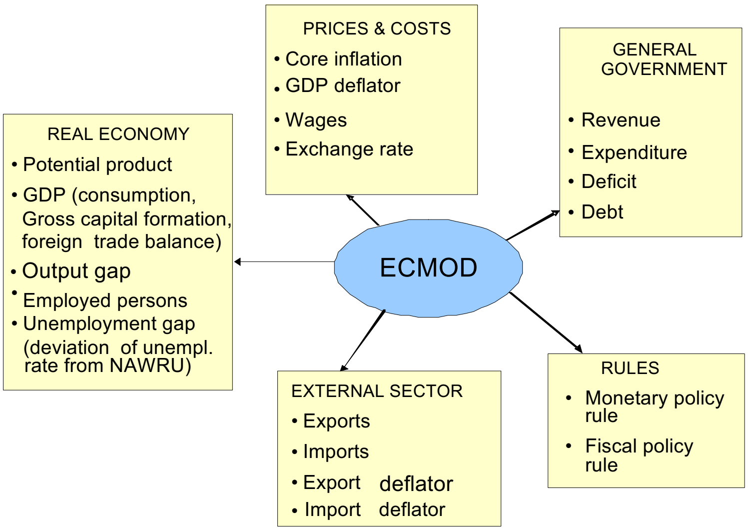
The ECMOD model reflect the macroeconomic processes observed in Poland during the sample period. At the same time, in describing the functioning of the economy, it refers to the contemporary macroeconomic achievements. Consequently, the ECMOD model combines the information coming from the empirical data with theoretical relationships, and thus it belongs to the class of hybrid models.

Like most models used in central banks to pursue monetary policy, the ECMOD model's theoretical fundamentals include both classical and keynesian elements. In the short-term, economic growth is mainly determined by demand factors, while, in the-long term, it is shaped by factors related to the supply-side of the economy.

The model describes the economy in a way that resembles the manner of reporting macro-processes in the national accounts. The ECMOD model differentiates among six types of entities: households, enterprises, financial intermediaries, monetary authorities, fiscal authorities, and foreign countries.

The figure Fig. 1 presents the structure of the ECMOD model broken down into modules.

**Fig. 1** Modules of the ECMOD model




Source: National Bank of Poland.

The ECMOD is based on a quarterly data and consists of more than 100 equations. In most cases, behavioural equation parameters are estimated, sometimes, however, they are calibrated. The ECMOD model encompasses data from Q1 1995 to Q4 2004.

Given the simplified, by definition, mapping of the reality in models, the assessments of experts are of great importance during the projection process. Therefore, establishing a framework to ensure cohesion of forecasts obtained both within and outside of the model was one of the criteria for the model's development. Consequently, a fully integrated forecast is achieved as a result of combining information from the model and experts.

This paper describes the methodology used in constructing the macro-model, generating forecasts and conducting simulations. It reviews the model's key equations and the results of simulating the economy's response to three standard impulses: the interest rate impulse, the exchange rate impulse and the fiscal impulse.

# 1

# GENERAL DESCRIPTION OF THE ECMOD MODEL

The class, form and degree of detail used in the models developed for the purposes of monetary policy are conditional upon their application. ECMOD, the multi-equation macroeconomic model of the Polish economy has been developed to generate forecasts and conduct simulation analyses. Forecasting is conditioned on the starting point assessment of future developments in the economy. Given the fact that the transmission mechanism is spread over time, the course of future economic growth is both determined by and determines current decisions related to macroeconomic policy. Conducting a simulation enables economists to quantify the effects of various economic policies and exogenous shocks on macroeconomic variables.

The model has been shaped by three criteria. First, it should provide a comprehensive image of the mechanisms functioning in the economy; i.e. it should not focus on a single variable, a section of the economy or partial equilibrium but rather on a set of variables that provide a comprehensive description of economic reality. Second, the model should enable the preparation of an internally and externally cohesive description of economic processes. The model's internal cohesion is construed as a mutual complementation of its interdependencies, whereas its external cohesion is supposed to guarantee that the model-based view of the economy reflects the actual course of macroprocesses in the Polish economy. Third, given the simplified, by definition, representation of reality, the model should enable economists to take into account information from outside of the model (experts´ adjustments) in a manner that guarantees cohesion of future paths for all variables.

ECMOD is a quarterly model, which structure comprises all of the main macrocategories of the economy —inflation, GDP and its components, wages, employment, the exchange rate, fiscal categories, etc. A proactive monetary policy, i.e. a policy reacting to developments in the economy, is an integral element of the model[1].

The ECMOD model is of medium size — it comprises approximately 100 equations, including approximately 15 behavioural equations[2]. Therefore, the model is

[1] Taylor's Rule is a nominal mechanism that stabilises the model's performance in the long-term. In the short and medium terms, the interest rate path may be determined according to Taylor's Rule (it refers, *inter alia*, to simulations that analyse less probable or even unrealistic scenarios) or on the basis of market expectations (it refers, *inter alia*, to forecasts depicting the most probable course of events). (Cf.: 3.1).

[2] According to standard categories in literature, the ECMOD model could be classified as a big macroeconometric model; however, compared with the models used by other institutions (for instance, FRB US – 300 equations), it may be assumed to be a medium-sized model.

detailed enough to generate forecasts and analyse essential macroeconomic categories while remaining transparent, which ensures the simplicity of its operation and facilitates reporting of results[3].



The form and distinctive features of the model are conditional upon analytical and research requirements in the pursuit of monetary policy under the direct inflation targeting strategy. The quarterly macroeconomic projections[4] are optional forecast for the economy under different interest rate scenarios, assuming the realisation of the expected exogenous variables. In principle, at least two projection scenarios are developed — using interest rates expected by the market and using fixed interest rates. The scenario of interest rates expected by the market is considered equivalent to the most probable economic growth scenario, whereas the scenario of fixed interest rates is of an informative nature only - "how would the economy develop, should interest rates remain unchanged." The simulation analyses, on the other hand, are conducted to determine the significance of individual transmission channels in the economy, and the response of the economy to selected impulses (a detailed analysis covers the exchange rate channel, the interest rate channel or the response of the economy to various fiscal policies). The model is also a tool used to carry out more complex analyses (concerning the adequacy of monetary and fiscal policies, scenarios of threats of exceeding safe debt-to-GDP thresholds, etc.).

The concept behind the construction of the ECMOD model is based on the attempt to reflect the macroeconomic processes observed in Poland during the sample period, so that their mutual relationships are properly explained and their future developments predicted. Adjustment to data is an empirical test of an adopted economic theory in the case of Poland, and may, in consequence, determine the quality of forecasting properties of the model. Embedding the model in the theory of the economy, on the other hand, is aimed at explaining the mechanisms governing the economy, according to which forecast and simulation results are interpreted. Consequently, in line with Pagan's classification (2001)[5], the ECMOD model belongs to the class of hybrid models that combine theory with information in the sample. In principle, Pagan differentiates between a few classes of models of different degrees of theoretical and empirical cohesion — in extreme cases, the form of the model is wholly derived from

[3] The importance of transparency of the models used for the purposes of monetary policy is also mentioned by C. Walsh in *Transparency in Monetary Policy*, Federal Reserve Bank of San Francisco Economic Letter 2001-66 (2001).
[4] The forecasts are made in iteration with experts. Section 1.1 presents more details concerning the forecasting methodology.
[5] Cf.: A. Pagan, *Report on modelling and forecasting at the Bank of England*, BoE, mimeo, 2003. Cf. also: the discussion in R. Kokoszczyński, B. Kłos, *Modelowanie i prognozowanie w nowej kadencji RPP — problemy i propozycje ich rozstrzygnięcia*, the NBP, mimeo, 2003. Pagan distinguishes between two types of hybrid models — type I and II hybrid models.

1

the existing economic theory or the model is of a statistical nature. Hybrid models fall in between the purely theoretical and the purely empirical models. Most of the models used by central banks to pursue monetary policy are hybrid models[6], where the steady state is based on the theory of economy, whereas short-term adjustments depend on specific features of particular economies.

The construction of the ECMOD model resembles that of the models used by the banks comprising the European System of Central Banks (the ESCB)[7]. Tab. 1 describes the basic characteristics of the models used for forecasting inflation by ESCB banks.

**Tab. 1** Comparative analysis — basic characteristics of the ECMOD model as compared to ESCB models

| | **ECMOD** | **ESCB models (prevailing approach)** |
|---|---|---|
| **Model structure** | | |
| Supply/demand model | Short term – demand factors<br>Long term – supply factors | Short term – demand factors<br>Long term – supply factors |
| • Supply side<br>- production function<br>- number of goods<br>- production factors | <br>Cobb-Douglas<br>1<br>Capital, labour | <br>Cobb-Douglas, CES<br>1<br>Capital, labour |
| • Demand side | disclosed according to the national accounts; i.e. the following are modelled: consumption, capital formation, foreign trade balance | disclosed according to the national accounts |
| • Inflation | A few price indices are modelled: CPI, GDP deflator, export and import deflators. Inflation is modelled on the basis of the cost-push theory. | The modelling usually involves GDP deflators and deflators of GDP components. The cost-push theory of inflation prevails. |
| **Monetary policy — transmission channels**<br>• Interest rate<br>- cost of credit<br>- cost of capital<br>• Exchange rate<br>• Asset<br>• Cash-flow | <br>Yes<br>Yes<br>Yes<br>Yes<br>Yes<br>No | <br>Yes<br>Yes<br>Yes<br>Yes<br>Yes<br>Yes |
| **Fiscal policy – categories**<br>• Number of expenditure categories | 9<br>The factors that are taken into account include transfers to the population, current expenditure, investment expenditure (Cf.: Section 2.4) *Data from Reports on the execution of the Budget Act* | 3 - 22<br>The degree of detail depends on available data. |
| • Number of revenue categories | 14<br>The following can be singled out: direct taxes, indirect taxes (Cf: Section 2.4) *Data from Reports on the execution of the Budget Act* | 4 – 26<br>The degree of detail depends on available data. |

[6] The type I and II hybrid models are used e.g. by: the EBC, the FRB US, the Bank of England, Bundesbank.
[7] For more details on the models used by the European System of Central Banks for inflation forecasting, cf.: B. Kłos, R. Kokoszczyński, T. Łyziak, J. Przystupa, E. Wróbel, *Modele strukturalne w prognozowaniu inflacji w Narodowym Banku Polskim*, Materials and Studies 180, the NBP, 2004.

| | | |
|---|---|---|
| **Macroeconomic policy rules**<br><br>▪ **Monetary policy** | | |
| Interest rate | Endogenous interest rate — Taylor's Rule is included to conduct a simulation analysis. | In most cases — exogenous interest rate (in the euro area, monetary policy is exogenous in relation to national banks). |
| | Exogenous interest rate — in the initial option, interest rate forecasts are compliant with market expectations. | Taylor's Rule conjugated with euro area aggregates is included to conduct an analysis of the models' properties. |
| ▪ **Fiscal policy** | The rule is based on the deficit. | The rule is based on the deficit. |
| | The rule is applied via effective PIT rate and social contributions. | The rule is applied via direct taxes. |

Given the changes observed in the economy and the development of the theory of the economy and the methods of macromodelling, work on the model should be of continuous character; i.e. the changes observed in the economy and the development of the methods of macromodelling should be accompanied by constant updates of the model, which means that no version of the model should be considered final.

This paper is composed of four sections. Section I explains the construction methodology, the forecasting methods and simulations and the theoretical basis of the ECMOD model. Section II presents a review of the model's equations — individual equations have been presented on a modular basis, the modules comprising the real economy, costs and prices, the external sector and the general government. Section III covers simulation analyses — it contains the results of simulation of the economy's response to three standard impulses: the interest rate impulse, the exchange rate impulse, and the fiscal impulse. Section IV is a summary of the findings.

## 1.1 ECMOD CONSTRUCTION METHODOLOGY, FORECASTING AND SIMULATION METHODOLOGY

The ECMOD model uses quarterly data seasonally adjusted with the TRAMO/SEATS method. The sample covers the period from Q1 1995 to Q4 2004[8]. The model is based on a co-integration analysis approach, commonly used in macroeconometric modelling. This approach enables differentiation between short- and long-term performance of the analysed macrocategories. Co-integrating relations correspond to long-term relations, whereas short-term dynamic is explained by current and lagged values of first differences of variables included in the co-integrating relation,

[8] The model has been re-estimated/re-specified on two occasions since work on the model started (i.e. since February 2003).

and other exogenous variables. A brief description of the co-integration analysis is included in Annex 4.

Individual equations are estimated separately, which results from the great degree of detail in the model and the limited length of the time series in Poland. Long-term relations have been estimated using the least-squares method, the modified least-squares method and the Johansen method.

In most cases, equation parameters are estimated, but they can also be calibrated. Three criteria have been used for the estimation and calibration of the equations: their simulation properties, forecasting properties, and the quality of its fitting to historical data.

Medium-term macroeconomic forecasts (covering eight to eleven quarters, depending on the quarter in which the forecast is made) are generated using the model. Experts' judgment play a significant role when generating forecasts based on the model.

Experts set the paths of exogenous variables and their uncertainty, and produce judgments concerning the selected endogenous variables (mainly the basic categories of national accounts) in the forecasting period. The model is solved and, subsequently, the obtained solution is compared with the experts' judgments, using the model-experts iteration method. It means that the forecast derived from the model undergoes evaluation by experts. The experts' adjustments are then included in the model, and the procedure is repeated until convergence is reached. A more detailed description of the model-experts iteration method is presentedin Annex 2. The CPI inflation forecast is generated by compiling core inflation, obtained on the basis of the model and the experts' forecasts of food and fuel prices. In order to eliminate the effects of food price shocks, the weight of this component is reduced to zero in the projection horizon (for more details, see Section 2.2.1 on inflation).

For the purposes of monetary policy, the majority of simulations are run during the forecasting period and are out-of-sample rather than in-sample simulations. The starting point for a simulation is a forecast; i.e. the most probable future development of selected macroeconomic categories, derived in the manner specified above[9]. Next, the path of a variable (or variables) is determined, conditioned on which the simulation is performed. The reaction of macroeconomic variables under analysis is determined by solving the model, and experts' interference with the endogenous variables is not repeated. In particular, after the forecast has been made using the most probable path of short-term interest rates, the experts' judgment no longer have any impact on the

[9] The experts' judgments refer to the most probable scenario of future events rather than to a scenario conditioned on fixed interest rates (projection).

projection; i.e. on the model solving under the assumption of fixed interest rates. Thus, the difference between a forecast and a projection is a reflection of the model's multipliers.



Potential interdependencies between the model's exogenous variables give rise to considerable restrictions on the simulations. In particular, given a strong disturbance to some exogenous variables, it should not be assumed that the developments in other exogenous variables remain unchanged (e.g. a strong adjustment of the expected economic growth rate in the case of Poland's major trading partners should be accompanied by a change in external prices). The ability to make such simulations depends on experts' ability to jointly and coherently affect a few exogenous variables.

## 1.2 ECMOD — THEORETICAL ASPECTS

ECMOD is a supply-demand model. In the short-term, the economic growth path is determined mainly by demand factors, taking into account inertia and rigidity. The longer the analytical horizon, the greater the role of the factors associated with the supply-side of the economy.

The model describes the economy in a way that resembles the manner of disclosing macroprocesses in the national accounts. The ECMOD model consists of six types of entities: households, enterprises, financial intermediaries, monetary authorities, fiscal authorities and foreign countries.

***Households*** receive income in the form of remuneration for work performed for enterprises, social benefits from the government and transfers from foreign countries. On the income they receive, households pay personal income tax as well as health and pension insurance contributions, and using the remaining part of their income (disposable income), they purchase goods manufactured at home or imported from abroad. In their decisions concerning the level of consumption, households take into account intertemporal substitution.

***Enterprises*** produce goods that are sold on the domestic market and to foreign countries. In the production process, they use two production factors — capital and labour. When setting production levels (and investment expenditure), enterprises follow the rule of profit maximisation, according to which the marginal product of capital is compared with the real user cost of capital. On their income earned for the sale of goods, enterprises pay corporate income taxes to the general government.

***Fiscal authorities*** obtain revenues from taxes, which they subsequently redistribute for retirement and disability pensions, social benefits for the unemployed, subsidies for enterprises, etc. The revenues are also spent by the government on purchases of consumer goods and for financing investments. To cover possible deficits, the state assumes debt on which interest is paid.

***Monetary authorities*** control the level of nominal interest rates so that the inflation target is met.

***Financial intermediaries*** conduct currency sale and purchase transactions, based on their evaluation of the attractiveness of the Polish economy when compared with Poland's major trading partners and expectations concerning its future growth (including, in particular, the possibility of receiving EU funds). Financial intermediaries also constitute an element of the transmission channel of the central bank's policy concerning interest rates on loans.

***Foreign countries*** provide goods purchased by domestic entities and are, at the same time, potential purchasers of goods manufactured at home.

In the model the conditions that optimise the decisions made by entities, given the predefined restrictions, are not directly derived. The relationships between the above mentioned entities shape the macroeconomic processes observed in the economy. Both the supply and demand sides are modelled explicitly.

In the long-term, the ***potential product*** is determined by the production function; i.e. it is obtained as a result of the combination of labour and capital outlays at an exogenously predefined level of technology (total factor productivity). The form of the production function determines the form of the demand for individual production factors. The demand for labour is modelled via a reversal of the production function, which is additionally influenced by demographic factors and labour costs. The desirable capital stock is determined by the profit maximisation condition, in line with the adopted production function. The actual capital stock gradually moves to the desirable level through fixed capital formation, and both the adjustment and the process of transforming capital formation into production assets occur over time. Consequently, it becomes possible to take into account the cost of capital adjustment, on the one hand, and delays between the outlay and building the effective capital stock (time-to-build), on the other.

Due to the nominal rigidity, i.e. the delay in adjustment processes, the GDP level in the short-term is determined by ***aggregate demand***: consumption (individual and collective), gross capital formation (fixed capital formation and changes in inventories) and the foreign trade balance (exports adjusted for imports).

***Individual consumption*** is determined by the disposable income of households and the amount of wealth. Disposable income is mainly composed of wages, income earned by self-employed individuals, income from property and net flows from the general government and foreign countries. Wealth comprises three main stock variables of the model: capital, public debt and net foreign assets. In the short-term, households follow intertemporal substitution, making the current consumption level conditional upon the interest rate level.

***Fixed capital formation*** is determined by the required capital level, set by the current demand and the real user cost of capital. Moreover, the financial accelerator effect, i.e. the interdependence between the ability of enterprises to form capital and their financial standing, and cost factors (oil prices), have been taken into account. Changes in inventories, on the other hand, depend on the level of economic activity.

***Exports,*** in the long-term, depend on the potential product level and the ratio of export prices to domestic production prices. In the short-term, external demand is an important determinant of exports. The ***import*** function corresponds to the export function: in the long-term, the level of imports depends on the potential product level and the ratio of import prices to domestic production prices; in the short-term, imports depend on the current level of economic activity.

Potential ***labour input*** is determined by demographic and structural factors, i.e. the number of professionally active persons adjusted by the NAWRU unemployment rate (*Non-Accelerating Wage Rate of Unemployment*), which is considered equivalent to structural unemployment. In the short-term, a gap may occur between the actual rate of unemployment and the NAWRU rate and a corresponding output gap, defined as the difference between the actual product and the potential product (consistent with the production function and potential labour input) may also exist. Both gaps have an impact on the level of prices and wages.

In the long-term, nominal ***wages*** are adjusted for labour productivity and price changes, taking into account restrictions in the form of production material costs. Apart from the real and nominal rigidities, one of the factors which makes the level of wages differ from the labour productivity level is the unemployment gap. In a situation where the actual rate of unemployment is higher than the NAWRU indicator, employees' power to negotiate wage increases is relatively weak and the pressure to increase wages is consequently lower. A corresponding situation can be observed where the actual rate of unemployment is lower than the NAWRU indicator — in such a case, the pressure to increase wages is greater than expected as the result of changes in labour productivity.

1

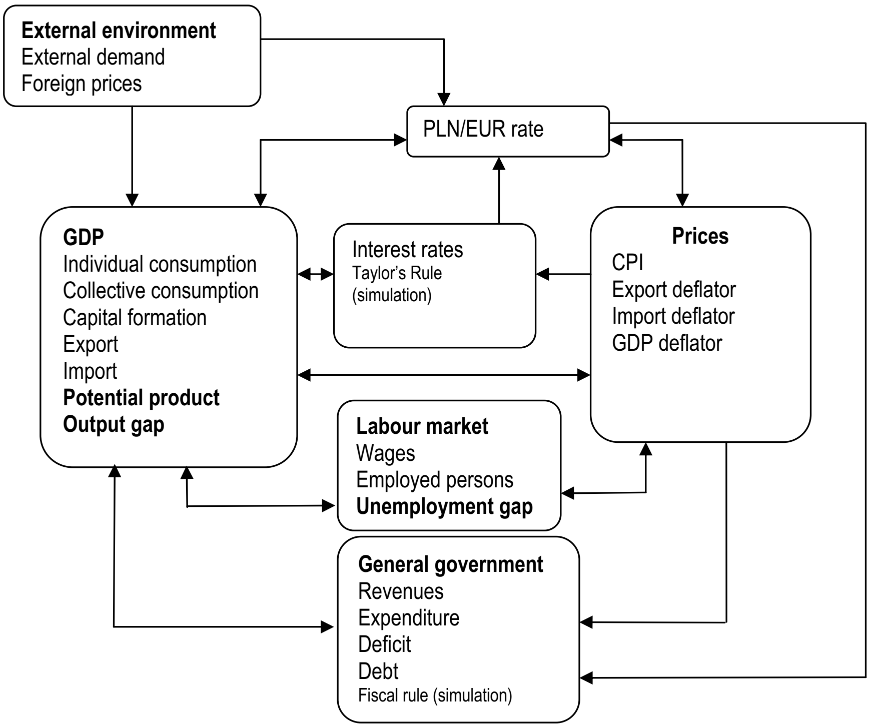
The level of ***prices*** in the long-term is determined by production costs, represented by unit labour costs and import prices. In the short-term, inflation is influenced by the current level of economic activity measured by the output gap and the supply shocks represented by exogenous changes in food and fuel prices.

The long-term path of the ***exchange rate*** is consistent with the theory of purchasing power parity. The exchange rate's deviation from the long-term path depends on the real interest rate disparity at home and abroad and the level of net foreign assets, as well as the risk premium.

***The general government*** has an impact, via its spending policy (collective consumption, transfers and subsidies) and income policy (tax rates), on both the real and nominal sectors of the economy.

Fig. 2[10] presents a simplified diagram of the interdependencies in the ECMOD model.

**Fig. 2** Simplified diagram of interdependencies between variables in the ECMOD model




Source: NBP.

[10] To ensure the diagram's transparency, , arrows are used to mark only the most important linkages. The equations set forth in section II of this paper contain a detailed description of interdependencies within the model.

# 2
# Modules of the Economic Model

The table below defines the main equations and identities, broken down into blocks, found in the model. Small letters were used to mark the logarithms of the variables. A description of the variables is included in Annex 5.

**I. Supply side**

(1) Production function:

$$GDP_t = EMP_t^{0,68} K_t^{0,32} TFP$$

(2) Capital stock:

$$K_t = (1 - DEPR)K_{t-1} + 0,38FINV_t + 0,22FINV_{t-1} + 0,12FINV_{t-2} + 0,09FINV_{t-3} + 0,08FINV_{t-4} + 0,06FINV_{t-5} + 0,05FINV_{t-6}$$

(3) Employed persons:

$$\Delta emp_t = \underset{2,8}{0,16}(gdp_{t-1} - 0,68\,emp_{t-1} - 0,32\,k_{t-1} - tfp_{t-1})/0,68 + \underset{6,4}{0,70}\,\Delta lf_t + 0,30\,\Delta emp_{t-1} + \underset{1,8}{0,23}(\Delta gdp_t - \Delta tfp_t/0,68) - 0,1(\Delta \ln(WAGE_{t-1}/PGDP_{t-1}) - \Delta tfp_{t-1}/0,68)$$

(4) Potential product:

$$GDP\_POT_t = (LF_t(1 - NAWRU_t))^{0,68} K_t^{0,32} TFP$$

(5) Output gap:

$$GAP_t = \frac{GDP_t}{GDP\_POT_t} - 1$$

**II. Demand side**

(6) GDP

GDP = CONP + CONGOV + INV + (GDP_EXP-GDP_IMP)

(7) Individual consumption:

$$\Delta conp_t = \underset{3.1}{0.01} - \underset{2.2}{0.12}(conp_{t-1} - 0,94\,yd_{t-1} - (1-0,94)wealth_{t-2} - 0.25) + \underset{1.6}{0,27}(\Delta conp_{t-1} + \Delta conp_{t-2} + \Delta conp_{t-3} + \Delta conp_{t-4})/4 + \underset{1.4}{0,09}\,\Delta yd_t - \underset{0,78}{0,0006}\,i\_w3mr\_cpi_t + DUMMIES$$

(8) Disposable income:

$$YD\_N_t = WAGEFUND\_N_t + YD\_NO_t + YD\_WL_t + GTR\_N_t + TR\_WPR\_CON_t + YD\_POZOSTALE_t - GPIT\_N_t - GLT\_EMP\_N_t - GLT\_HC\_N_t - GLT\_SB\_N_t$$

(9) Fixed capital formation:

$$\Delta finv_t = \underset{1,9}{0,27}\left(0,32\frac{GDP_{t-1}}{K_{t-1}} - RUCC_{t-1}\right) + \underset{5,5}{0,46}\,\Delta finv_{t-1} + \underset{3,6}{0,27}\,\Delta finv_{t-2} + \underset{1,8}{0,17}\,\Delta FINACC_t$$

**III. Prices and costs**

(10) Core inflation:

$$\Delta netcpi_t = \underset{(2,78)}{1,33}\Delta dl_t - \underset{(-1,7)}{0,15}(netcpi_{t-1} - (0,61 + 0,83ulc_{t-1} + 0,17p\_imp^*_{t-1} + 0,7dl_{t-1})) + \underset{(2,16)}{0,33}\Delta netcpi_{t-1} + \underset{(2,34)}{0,22}\Delta ulc_t + \underset{(1,25)}{0,1}\,GAP_t + \underset{(0,65)}{0,02}\Delta p\_imp^*_t$$

(11) CPI inflation:

$$\Delta cpi = waga\_net * \Delta netcpi + waga\_food * \Delta foodcpi + waga\_fuel * \Delta fuelcpi$$

where: *waga_net + waga_fuel + waga_food* = 1

(12) GDP deflator:

$$\Delta pgdp_t = -\underset{3,5}{0,18}(pgdp_{t-1} - 0,8\,ulc_{t-1} - 0,20\,p\_imp_{t-1} + 4,0) + \underset{4,1}{0,32}\,\Delta pgdp_{t-1} + \underset{2,2}{0,16}\,\Delta pgdp_{t-2}$$

(13) Wages:

$$\Delta wage_t = \underset{4,2}{0,43}\Delta wage_{t-1} + 0,57\,\Delta cpi_{t-1} + 0,57(\Delta gdp_t - \Delta emp_t) - \underset{3,4}{0,23}(UNEMP_{t-1} - NAWRU_{t-1})) - \underset{3,9}{0,18}(wage_{t-1} - gdp_{t-1} + emp_{t-1} - 1,25\,pgdp_{t-1} + 0,25\,p\_imp_{t-1} - 5,02)$$

(14) Real effective zloty exchange rate:

$$\Delta s\_reer_t = -0,75\Delta(gdp\_pot - gdp\_ext\_pot)_t - \underset{(0,39)}{0,28}\,\Delta(i\_w3mr\_pgdp - i3mr\_ext - s\_risk\_pr)_{t-1} - \underset{(0,09)}{0,26}(s\_reer - 10,55 + 0,75(gdp\_pot - gdp\_ext\_pot) + 0,25(\frac{NFA}{4*GDP\_N}) + 1,31(i\_w3mr\_pgdp - i3mr\_ext - s\_risk\_pr))_{t-1} + DUMMIES$$

(15) Interest rates on loans to enterprises:

$$I\_RENTP_t = -\underset{(-2,76)}{0,27} - \underset{(-4,56)}{0,44}(I\_RENTP_{t-1} - 2,16 - I\_W3M_{t-1}) + \underset{(11,02)}{0,64}\,\Delta I\_W3M_t + I\_RENTP_{t-1}$$

**IV. External sector**

(16) Balance of payments:

$$CAB_t = CAB\_NT_t + CAB\_INC_t + CAB\_TRANS_t$$

(17) Exports:

$$\Delta gdp\_\exp_t = \underset{(2,96)}{0,02} - \underset{(3,92)}{0,35}(gdp\_\exp + 1,44 - \underset{(10,1)}{0,01}\,trend - gdp\_pot - \underset{(1,96)}{0,74}(p\_\exp - pgdp))_{t-1} + \underset{(0,81)}{1,01}\Delta gdp\_ext_t + DUMMIES$$

(18) Imports:

$$\Delta gdp\_imp_t = \underset{(0,91)}{0,01} - \underset{(1,75)}{0,12}(gdp\_imp + 1,44 - \underset{(10,1)}{0,01}\,trend - gdp\_pot + \underset{(1,3)}{0,70}(p\_imp\_noil + gtar\_tr - pgdp))_{t-1} + \underset{(2,26)}{1,59}\,\Delta gdp_t + DUMMIES$$

(19) Export deflator:

$$\Delta p\_\exp_t = \Delta pgdp_t - \underset{(4,92)}{0,61}((p\_\exp - pgdp) + 6,12 - \underset{(6,31)}{0,58}(s\_reer + 0,75(gdp\_pot - gdp\_pot\_ext)))_{t-1} + \underset{(4,72)}{0,45}\,\Delta(s\_reer)_t + DUMMIES$$

(20) Import deflator adjusted by oil price movements according to the national accounts:

$$\Delta p\_imp\_noil_t = \Delta pgdp_t - \underset{(2,54)}{0,21}((p\_imp\_noil - pgdp) + 6,88 - \underset{(4,32)}{0,61}(s\_reer + 0,75(gdp\_pot - gdp\_ext\_pot)))_{t-1} + \underset{(4,32)}{0,63}\Delta(s\_reer)_t + DUMMIES$$

(21) Import deflator:

$$p\_imp_t = 0,92\,p\_imp\_noil_t + 0,08(oil + s\_usd\_p\ln)_t$$

**V. General government (GG)**

(22) General Government (GG) revenues:

GINC_N = GIDT_N + GPIT_N + GCIT_N + GLT_N + GTAR_N + GCT_N + CGNBP_N + GINC_UE_N + GRT_N

| | | |
|---|---|---|
| (23) | GG expenditure: | GEXP_N = GCE_N + GTR_N + GINV_N + GTR_CORP_N + GDS_N + GEXP_UE_N + GRE_N |
| (24) | GG balance: | GDEF_N = GINC_N - GEXP_N |
| (25) | Public debt: | GDEBT_N = GDEBT_N(-1) * [(GDEBT_EUR * S_EUR_PLN + + (1-GDEBT_EUR) * S_USD_PLN) / (GDEBT_EUR * * S_EUR_PLN(-1) + (1-GDEBT_EUR) * S_USD_PLN(-1)) * * (1 - GDEBT_PL) + GDEBT_PL] - GDEF_N - GPRIV_N + + adjustment for the balance of pre-financing of EU projects + + adjustment for funds in government accounts + + adjustment for hospital debt |
| **VI. Rules governing monetary and fiscal policies** | | |
| (26) | Monetary policy (Taylor's Rule): | $i\_w3m_t = (1-\alpha)*[\phi + \inf_t + \beta GAP_t + \gamma(\inf_t - \inf\_cel)] + \alpha * i\_w3m_{t-1}$ |
| (27) | Fiscal policy: | $\Delta e_t = \theta \times (d_{t-1} - d^*)$ |

2

## 2.1 REAL ECONOMY

### 2.1.1 Supply side

The two-factor Cobb-Douglas production function is the core element of the supply side of the model. The parameters have been calibrated, on the basis of the share of remuneration of both production factors in gross value added, less the balance of taxes and subventions from producers[11], according to the assumption of perfect competition on the product market in the long-term.

The so-called Solow residuals, which, having been HP filtered, constitute an approximation of the trend in the total factor productivity, have been calculated on the basis of the estimated product elasticity against production factor inputs. As a result, the production function is expressed in the following equation:

$$GDP_t = EMP_t^{0,68} K_t^{0,32} TFP \qquad \textbf{E. 1}$$

where:

GDP – gross domestic product,

EMP – employed persons according to BAEL (equation E. 4),

[11] The problem concerning calculation of remuneration of production factors on the basis of data from the national accounts is the household-related category of mixed income, which combines remuneration of both the labour and capital factors (cf.: A. Czyżewski (2002)). Upon distribution of the mixed income

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K – capital stock at the end of the period (equation E. 3),

TFP – total factor productivity.

The factors of production — capital and labour inputs – are determined in the following manner. The capital stock in the base year corresponds to the value of fixed assets according to the Central Statistical Office's national accounts. Gross capital formation, on the other hand, is calculated using the perpetual inventories method, with regard to the lags´distribution describing the relationship between the completed fixed assets and the outlays incurred on them (cf.: M. Gradzewicz, M. Kolasa, 2004)[12]:

$$KEP_t = (1 - depr)KEP_{t-1} + 0{,}38FINV_t + 0{,}22FINV_{t-1} + 0{,}12FINV_{t-2} + 0{,}09FINV_{t-3} + 0{,}08FINV_{t-4} + 0{,}06FINV_{t-5} + 0{,}05FINV_{t-6} \qquad \textbf{E. 2}$$

where:

KEP – capital stock at the end of the period

FINV – investment input (equation E. 11)

$$K_t = (KEP_t + KEP_{t-1})/2 \qquad \textbf{E. 3}$$

where:

K- average stock of capital KEP in the period.

Labour input in the long-term are determined via a reversal of the production function. The demand for labour in the short-term is also influenced by GDP growth and by the real cost of labour incurred by the employer, with both categories adjusted for the long-term growth rate in labour productivity[13]. Moreover, short-term growth has been supplemented by the autoregressive part, taking account of the dynamic homogeneity.

$$\begin{aligned}\Delta emp_t = &\underset{2,8}{0{,}16}(gdp_{t-1} - 0{,}68\, emp_{t-1} - 0{,}32\, k_{t-1} - tfp_{t-1})/0{,}68 + \underset{6,4}{0{,}70}\,\Delta lf_t \\ &+ 0{,}30\,\Delta emp_{t-1} + \underset{1,8}{0{,}23}(\Delta gdp_t - \Delta tfp_t / 0{,}68) \\ &- 0{,}1(\Delta \ln(WAGE_{t-1}/PGDP_{t-1}) - \Delta tfp_{t-1}/0{,}68)\end{aligned} \qquad \textbf{E. 4}$$

where:

EMP –employed persons according to BAEL,

between both factors, it has been assumed that the share of the remuneration thereof in the household sector is the same as in the whole economy.

[12] The annual data on fixed assets obtained from investment activity and their structure by type, published by the Central Statistical Office, has been used. The split into quarters has been based on the data on gross fixed capital formation from the national accounts. In the case of discrepancy between the sum of quarterly gross fixed capital formation from the national accounts and the annual data published by the Central Statistical Office (which follows from taking into account in the quarterly data in the national accounts the outlays on renovation, intangible assets and outlays incurred in the grey economy) the pro-rata adjustment thereof has been made.

[13] Upon the growth of real wages, the parameter has been set at -0.1.

GDP – gross domestic product (equation E. 1),

TFP– total factor productivity,

LF – labour force, in thousands, according to BAEL,

WAGE – gross wages (equation E. 16),

PGDP – GDP deflator (equation E. 15).

Adjusted $R^2$: 61.0%
Autocorrelation of the random component $\chi^2$ (1)=1.97 (p=0.16)
Autocorrelation of the random component: $\chi^2$ (4)=4.05 (p=0.40)
Normality of distribution of the random component: JB=0.93 (p=0.63)
Sample: 1996 Q1 – 2004 Q4



The estimated production function (E. 1) is also used to determine the potential product in which the potential labour input is determined by the labour force, adjusted by the NAWRU indicator (non-accelerating wage rate of unemployment). Both the number of professionally active persons and the NAWRU[14] indicator are set exogenously.

$$GDP\_POT_t = (LF_t(1 - NAWRU_t))^{0,68} K_t^{0,32} TFP \qquad \textbf{E. 5}$$

The output gap is defined as the relative difference between actual and potential GDP:

$$GAP_t = \frac{GDP_t}{GDP\_POT_t} - 1 \qquad \textbf{E. 6}$$

### 2.1.2 Demand side

The demand-side of the economy (the market for goods and services) is modelled explicitly. This means that equations are estimated for individual GDP components. GDP is calculated as the sum of all its components.

#### *2.1.2.1 Individual consumption (by households)*

Households provide entrepreneurs with labour and receive remuneration in return. They also receive transfers from both the government (social benefits) and

[14] In the sample period, the NAWRU indicator is estimated using the modified Elmeskov method (1993), according to which the change in wage growth rate is proportional to the difference between the actual rate of unemployment and the NAWRU indicator; i.e.: $\Delta^2 \log W = -\alpha(U - NAWRU)$, $\alpha$ >0, where W — wage level, U — rate of unemployment or its lags´distribution . Under the assumption of a constant NAWRU indicator for two subsequent quarters, the $\alpha$ parameter is estimated for the following periods, and on its basis a NAWRU series is calculated; a smoothed series is used in the model.

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foreign countries (at the moment, these are mainly benefits received as part of the Common Agricultural Policy). In order to smoothen consumption, households, as holders of all assets; i.e. government securities (the amount of which is reflected in the amount of public debt), net foreign assets and the value of capital, control the amount of their savings/debt.

Consequently, the long-term level of consumption is determined by the amount of disposable income (cf: E. 8) and the value of wealth. The value of wealth is construed as a sum of public debt, net foreign assets and the amount of capital. In the short-term, consumption growth is also influenced by the interest rate (according to the hypothesis of intertemporal consumption substitution, higher interest rates encourage postponement of current consumption). Consequently, the individual consumption function is as follows:

$$\Delta conp_t = \underset{3.1}{0.01} - \underset{2.2}{0.12}(conp_{t-1} - 0{,}94\, yd_{t-1} - (1-0{,}94)wealth_{t-2} - 0.25) + \underset{1.6}{0{,}27}(\Delta conp_{t-1} + \Delta conp_{t-2} + \Delta conp_{t-3} + \Delta conp_{t-4})/4 + \underset{1.4}{0{,}09}\Delta yd_t - \underset{0{,}78}{0{,}0006}\, i\_w3mr\_cpi_t - 0.009 * i00q3 - 0.008 * i02q2 \qquad \textbf{E. 7}$$

where:

CONP – individual consumption,

YD – disposable income (equation E. 8),

WEALTH – wealth,

I_W3MR_CPI – real interest rate (WIBOR 3M deflated by CPI inflation).

Adjusted $R^2$: 42%

Autocorrelation of the random component: $\chi^2(4)=2.21$ (p=0.09)

Normality of distribution of the random component: JB=1.65 (p=0.44)

Sample: 1996Q2 – 2004Q4

#### *2.1.2.2 Disposable income*

Gross disposable income is calculated as the sum of income earned from employment (wages), the operating surplus of the household sector, income from property, social benefits from the public sector, other disposable income and, since 2004, transfers from the European Union granted as part of the Common Agricultural Policy. Personal income taxes and health and pension insurance contributions are paid on the above-mentioned income:

$$YD\_N_t = WAGEFUND\_N_t + YD\_NO_t + YD\_WL_t + GTR\_N_t + TR\_WPR\_CON_t + YD\_POZOSTALE_t - GPIT\_N_t - GLT\_EMP\_N_t - GLT\_HC\_N_t - GLT\_SB\_N_t \quad \textbf{E. 8}$$

where:

YD_N – gross nominal disposable income,

YD_NO – nominal operating surplus of the household sector (equation E. 9),

YD_WL – nominal property income in households´ sector (equation E. 10),

WAGEFUND_N – quarterly wage fund,

GTR_N – transfers to the population (social benefits, unemployment benefits, pensions) (equation E. 53),

TR_WPR_CON – revenue obtained as part of the Common Agricultural Policy allocated to consumption,

YD_POZOSTALE – other disposable income,

GPIT_N – personal income tax (equation E. 41),

GLT_EMP_N – social contributions paid by employees (equation E. 44),

GLT_HC_N – health insurance contributions (equation E. 47),

GLT_SB_N – social contributions paid by business owners and freelance professionals (equation E. 46).

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The gross operating surplus of households constitutes more than 1/3 of gross disposable income. This is the gross value-added created by domestic units comprising the household sector (mainly employers[15] and self-employed individuals, excluding the agricultural sector) less the costs of employment and production-related taxes and increased by subsidies to producers.

The gross operating surplus of households is conditional upon aggregate demand in the economy (in the long-term, the elasticity with unitary restriction):

$$\Delta yd\_no_t = -\underset{(-1,51)}{0{,}10}(yd\_no_{t-1} - gdp\_n_{t-1} + 1{,}36) + \underset{(2,69)}{0{,}31}\Delta yd\_no_{t-1} + \underset{(5,67)}{0{,}60}\Delta gdp\_n_t \quad \textbf{E. 9}$$

where:

YD_NO – operating surplus of the household sector,

GDP_N – nominal gross domestic product.

Adjusted R2: 55.1%

Autocorrelation of the random component: $\chi 2(2)=4.15$ (p=0.13)

Normality of distribution of the random component: $\chi 2\ (2)=12.5$ (p=0.00)

Sample: 1995Q1 – 2004Q4

[15] The households sector includes self-employed individuals employing up to 9 workers.

Real property income from households´sector (CPI-deflated) is a function of the product of the real interest rate and wealth. Part of the property income is directly dependent on the interest rate level. It refers to investment in certain financial instruments, including bank deposits, loans and bonds:

$$YD\_WL = \underset{(-1,51)}{-46{,}1} + \underset{(2,69)}{5{,}88 * 10^{-7}}\, I\_W3M * WEALTH \qquad \textbf{E. 10}$$

where:

YD_WL – property income in the households´ sector,
I_W3M – average quarterly value of WIBOR3M (equation E. 66),
WEALTH – wealth.

Adjusted R2: 28.5%
Autocorrelation of the random component: $\chi2(2)$=8.84 (p=0.01)
Normality of distribution of the random component: $\chi2$ (2)=0.8 (p=0.66)
Sample: 1995Q1 – 2004Q4

#### 2.1.2.3 Fixed capital formation

In the case of the investment equation (fixed capital formation), a decision has been made to substitute estimation of the co-integrating relation with a theoretical relation describing fixed assets (capital) in a steady-state of the neoclassical model[16].

The long-term relationship is linked to the rule of profit maximisation by business entities, according to which the marginal capital product is equal to a real user cost of capital (RUCC). Assuming the production function is expressed as a Cobb-Douglas production function (equation E. 1), the required (optimum) capital level is expressed in the following equation:

$$K_t = \alpha \frac{Y_t}{RUCC_t}$$

where:

$\alpha$- product elasticity against capital,
K – capital,
GDP – gross domestic product,
RUCC – real user cost of capital.

[16] It is extremely difficult to estimate the investment equation. In the investment equation, long-term relationships have been accepted on the basis of the theory of economy, consistent with the disclosure in the supply-side of the model (the condition of maximisation of profits earned by enterprises, under the Cobb-Douglas production function).

Deviation of the actual capital stock from its optimum level causes adjustment in fixed capital formation.

Short-term growth in fixed capital formation is explained using the error correction model. Given the inertia of investment processes, the autoregressive part was added to the equation. Moreover, the short-term equation takes into account the financial accelerator , according to which in the condition of information asymmetry the improvement of the financial standing of enterprises increase their capital formation ability[17].

$$\Delta finv_t = \underset{1,9}{0,27}(0,32\frac{GDP_{t-1}}{K_{t-1}} - RUCC_{t-1}) + \underset{5,5}{0,46}\Delta finv_{t-1} + \underset{3,6}{0,27}\Delta finv_{t-2} + \underset{1,8}{0,17}\Delta FINACC_t \qquad \textbf{E. 11}$$

where:

FINV – investment input,

K – capital (equation E. 3),

GDP – gross domestic product (equation E. 1),

RUCC – real user cost of capital (interest rates on enterprises´loans deflated with the GDP deflator, adjusted by capital depreciation and the corporate income tax),

FINACC – share of disposable income of enterprises[18] in national disposable income.

Adjusted $R^2$: 88.5%

Autocorrelation of the random component: F(1)=0.44 (p=0.51)

Autocorrelation of the random component: F(4)=0.49 (p=0.74)

Normality of distribution of the random component: JB=1.34 (p=0.51)

Sample: 1996 Q1 – 2004 Q4

## 2.2 PRICES AND COSTS

### 2.2.1 CPI index

In the ECMOD model, inflation is represented by the core inflation index. The inflation equation is based on the concept of cost-push inflation, according to which prices depend on the costs of production factors, i.e. unit labour costs and import prices. The price level is also influenced by demand factors, quantified using the output gap. Where demand is higher than supply, sellers are able to demand higher margins, which results in price growth. Otherwise, the low demand barrier necessitates a reduction in

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[17] For the purpose of cost-push shock, the negative logarithm of oil prices and the domestic goods price ratio is added to the equation – to reflect changes in relative price levels. The cost-push shock results in price increases, but (contrary to the demand shock) the demand for a product decreases.

margins. Inflation is additionally affected by inflation expectations. Research on the mechanism of formation of inflation expectations in the Polish household sector has confirmed its adaptation properties (see: Łyziak (2003)). For this reason, they are represented in the model by the lagged inflation.

The following is the core inflation equation:

$$\Delta netcpi_t = \underset{(2.78)}{1.33}\Delta dl_t - \underset{(-1.7)}{0.15}(netcpi_{t-1} - (0.61 + 0.83 ulc_{t-1} + 0.17 p\_imp^*_{t-1} + 0.7 dl_{t-1})) + \underset{(2.16)}{0.33}\Delta netcpi_{t-1} + \underset{(2.34)}{0.22}\Delta ulc_t + \underset{(1.25)}{0.1} GAP_t + \underset{(0.65)}{0.02}\Delta p\_imp^*_t \quad \textbf{E. 12}$$

where:

NETCPI – net core inflation price index – excluding food and fuel prices,

ULC – unit labour costs, $ulc = emp + wage - gdp$

P_IMP$^*$ – import prices adjusted by customs duties and import taxes (applicable in the mid-90s),

GAP – output gap (equation E. 6),

dl – an artificial variable used to quantify the growth of net core inflation faster than the cost determinant of inflation in the sample.

Adjusted $R^2$: 85.0%

Autocorrelation of the random component: $\chi^2(4)=0.96$ (p=0.62)

Normality of distribution of the random component: $\chi^2$ (4)=3.62 (p=0.16)

Sample: 1995Q1 – 2004Q4

The homogeneity of the impact of unit labour costs and import prices on net inflation has been achieved through the imposition of relevant restrictions. The *dl* variable has been added to the equation as a result of a number of factors occurring in the sample in favour of a higher level of net inflation rather than a higher rate of growth in the cost factors found in E. 12. These factors include price deregulation, a higher share of services and a smaller share of industrial goods in the NETCPI index structure than in the structure of GDP.

In the model, core inflation is quantified using the net inflation index, which is derived by removing food and fuel prices from the complete CPI index. In order to compute the CPI index in simulations and forecasts, it is necessary to add food and fuel prices to net inflation derived from the E. 12 equation. Thus, CPI inflation is calculated according to the following equation:

---

[18] Enterprises consist of two institutional sectors specified in the national accounts: the business sector and the sector of financial institutions.

$$\Delta cpi = waga\_net * \Delta netcpi + waga\_food * \Delta foodcpi + waga\_fuel * \Delta fuelcpi \qquad \textbf{E. 13}$$

where:

$$waga\_net + waga\_fuel + waga\_food = 1 \qquad \textbf{E. 14}$$

In the forecasting process, inflation series for food and fuel prices are forecasted outside of the model by experts. Experience shows that independent forecasting of food price inflation is justifiable only on a time horizon of approximately one year; in the case of long-horizon forecasting, forecasts of food price inflation are consistent with forecasts concerning inflation in general. Thus, it has been assumed in the model that over the forecast horizon, the weight of food prices (*waga_food*) in CPI inflation decreases, and after one year it equals zero. At the same time, *waga_net* is increased, so that the condition contained in E. 14 is maintained. In the case of fuel prices, the most important determinant is the change in crude oil prices on international markets. For this reason, no analogous mechanism of reducing to zero has been applied in the the *waga_fuel* series. This corresponds to the assumption concerning the external environment and the fact that crude oil prices have been taken into account in other segments of the model.

### 2.2.2 GDP deflator

As in the case of the core inflation equation (cf. E. 12) the GDP deflator, in the long-term, is determined by unit labour costs and import prices, with the requirement of homogeneity being met. The co-integrating relationship corresponds to the co-integrating relationship in the wage equation (cf. E. 16).

$$\Delta pgdp_t = -\underset{3,5}{0{,}18}(pgdp_{t-1} - 0{,}8\,ulc_{t-1} - 0{,}20\,p\_imp_{t-1} + 4{,}0) + \underset{4,1}{0{,}32}\,\Delta pgdp_{t-1} + \underset{2,2}{0{,}16}\,\Delta pgdp_{t-2} \qquad \textbf{E. 15}$$

where:

PGDP – GDP deflator,

ULC – unit labour costs, $ulc = emp + wage - gdp$,

P_IMP – import prices adjusted by customs duties and import taxes (applicable in the mid-90s.) (equation E. 35).

Adjusted $R^2$: 83.9%

Autocorrelation of the random component: $\chi^2$ (1)=3.52 (p=0.07)

Autocorrelation of the random component: $\chi^2$(4)=5.81 (p=0.21)

Normality of distribution of the random component: $\chi^2$ (2)=5.43 (p=0.07)

Sample: 1995Q4 – 2004Q3

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### 2.2.3 Wages

The concept of the function of real wages has been based on the productivity mechanism of determining average wages in the economy consistent with the adopted Cobb-Douglas production function. In the short-term, growth in nominal wages is determined by the autoregressive factor on the one hand, and movements in consumer goods prices and short-term changes in labour productivity (the requirement of dynamic homogeneity has been imposed in both cases) on the other. The impact of the cost of living, measured using the CPI index, on nominal wages is spread over time and reflects the existence of nominal rigidities. Moreover, it has been assumed that, in the long-term, changes in prices of goods fully translate into changes in wages, which is one of the conditions necessary to ensure equilibrium on the goods and labour markets.

Wages react to deviations from two types of equilibria, which may occur in the short-term. The first disequilibrium is the difference between actual and natural unemployment (measured using the NAWRU indicator). It reflects the situation on the labour market and, in the case of a high unemployment rate, leads to a reduction in the supply pressure to increase labour prices. The other disequilibrium, related to the specification of the production function, is the difference between productivity and real wages. Here, both the price index of goods manufactured in the domestic economy and the import price index[19] have been used as deflators of nominal wages in the long-term, with the imposed requirement of homogeneity. Excessive growth in the productivity of employed persons above the real marginal labour cost defined in this way results in upward pressure on wages, and offsets the initial disequilibrium.

$$\begin{aligned}\Delta wage_t &= \underset{4,2}{0{,}43}\,\Delta wage_{t-1} + 0{,}57\,\Delta cpi_{t-1} + 0{,}57(\Delta gdp_t - \Delta emp_t)\\ &- \underset{3,4}{0{,}23}(UNEMP_{t-1} - NAWRU_{t-1}))\\ &- \underset{3,9}{0{,}18}(wage_{t-1} - gdp_{t-1} + emp_{t-1} - 1{,}25\,pgdp_{t-1} + 0{,}25\,p\_imp_{t-1} - 5{,}02)\end{aligned} \qquad \textbf{E. 16}$$

where:

WAGE – nominal wages,

CPI – consumer price index,

PGDP – GDP deflator (equation E. 15),

GDP – gross domestic product (equation E. 1),

EMP – number of employed persons according to BAEL (equation E. 4),

UNEMP – rate of unemployment,

NAWRU – Non-Accelerating Wage Rate of Unemployment, P_IMP – import prices adjusted by customs duties and import taxes (applicable in the mid-90s) (equation E. 35).

Adjusted $R^2$: 81.1%

Autocorrelation of the random component $\chi^2$ (1)=0.52 (p=0.47)

Autocorrelation of the random component $\chi^2$ (4)=2.79 (p=0.59)

Normality of distribution of the random component $\chi^2$(2)=4.37 (p=0.11)

Sample: 1995Q1-2004Q4



### 2.2.4 Exchange rate

In 2002, GDP per capita in Poland, adjusted for the difference in prices, was 40.5% of the average GDP per capita of Poland's major trading partners (the weights are shown in Tab. 2). In the same period, the price level in Poland represented 51.0% of the price level of Poland's major trading partners[20]. The basis for this long-term exchange rate equation lies in the hypothesis that real convergence is accompanied by nominal convergence; namely[21]:

$$s\_reer_t^{LR} = \underset{(0,022)}{10{,}55} - 0{,}75(gdp\_pot_t - gdp\_ext\_pot_t) \qquad \textbf{E. 17}$$

where:

*S_REER*$^{LR}$ – long-term level of real effective zloty exchange rate (weights Tab. 2),

*GDP_POT* – potential GDP (equation E. 5),

*GDP_EXT_POT* – weighted (weights in Tab. 2) potential GDP abroad.

Elasticity of exchange rate with respect to the difference in potential GDPs has been calibrated at -0.75, so that equalisation of GDP levels at home and abroad is accompanied by the equalisation in the level of prices. If the growth rate of GDP in Poland equals growth rates abroad, the long-term level of the real exchange rate remains steady. In this context, it may be assumed that the long-term exchange rate path is consistent with the relative version of the purchasing power parity theory.

**Tab. 2** Share in Poland's foreign trade and the weights adopted (%)

| | 1995 | 2002 | 1995-2002 | Weights adopted[a)] |
|---|---|---|---|---|
| Germany | 32.5 | 28.3 | 30.0 | 46.9 |
| Italy | 6.7 | 6.9 | 7.4 | 11.5 |
| Russia [b)] | 6.2 | 5.6 | 5.9 | - |
| France | 4.2 | 6.5 | 5.5 | 8.6 |
| Great Britain | 4.6 | 4.5 | 4.5 | 7.1 |

[19] The import price index is an approximate measure of material production costs, whose growth above producer prices limits the ability to finance wage increases.
[20] Calculated on the basis of OECD data, International Comparison Program.
[21] A growth in variables used to determine the exchange rate denotes depreciation of the zloty.

2

| | | | | |
|---|---|---|---|---|
| The Netherlands | 5.1 | 4.0 | 4.4 | 6.8 |
| Czech Republic | 3.1 | 3.6 | 3.4 | 5.4 |
| The United States | 3.3 | 3.0 | 3.3 | 5.1 |
| Sweden | 2.8 | 2.9 | 2.7 | 4.3 |
| Belgium | 2.5 | 3.0 | 2.7 | 4.2 |

[a)] The adopted weights are directly proportional to a given country's share in Poland's exports in 1995-2002.

[b)] Given the difficulties in accessing comparable historical data and a small number of published forecasts of economic values, a decision was made not to take Russia into account.

Source: OECD.

Deviations of the real exchange rate from its long-term path depend on two factors: the level of net foreign assets and the real interest rate disparity. An increase in net foreign assets results in exchange rate appreciation. Such a mechanism prevents excessive accumulation of receivables and liabilities with respect to foreign entities. The other factor, which leads to deviation of the exchange rate from its long-term path, is the real interest rate disparity — its increase results in appreciation of the zloty exchange rate. Consequently, the exchange rate equation is as follows:

$$
\begin{aligned}
\Delta s\_reer_t &= -0{,}75\Delta(gdp\_pot - gdp\_ext\_pot)_t - \\
&- \underset{(0,39)}{0{,}28}\,\Delta(i\_w3mr\_pgdp - i3mr\_ext - s\_risk\_pr)_{t-1} - \\
&- \underset{(0,09)}{0{,}26}(s\_reer - 10{,}55 + 0{,}75(gdp\_pot - gdp\_ext\_pot) + 0{,}25(\frac{NFA}{4*GDP\_N}) + \\
&+ 1{,}31(i\_w3mr\_pgdp - i3mr\_ext - s\_risk\_pr))_{t-1} + dummies
\end{aligned}
\qquad \textbf{E. 18}
$$

where:

*S_REER* – real effective zloty exchange rate,

*i_w3mr_pgdp* – real WIBOR 3M rate deflated using the GDP deflator,

*i3mr_ext* – real foreign WIBOR 3M rate deflated using the GDP deflator (equation E. 19),

*s_risk_pr* – risk premium valuation[22],

*GDP_POT* – potential GDP (equation E. 5),

*GDP_EXT_POT* – weighted (weights Tab. 2) potential GDP abroad,

*NFA* – net foreign assets (equation E. 29),

*GDP_N* – GDP nominal level.

Adjusted $R^2$: 50.8%

Autocorrelation of the random component: $\chi^2(4)=2.6$ (p=0.63)

Normality of distribution of the random component: $\chi^2(2)=1.6$ (p=0.45)

Sample: 1997Q3-2004Q4

[22] In the case of simulations, it is assumed that the risk premium (*s_risk_pr*) is fixed. For forecasting purposes, on the other hand, it is assumed that the risk premium is conditional upon public debt and increases a quarter before parliamentary elections. Consequently, the variable is determined based on the following equation:

The real foreign interest rate is defined by the following formula:

$$i3mr\_ext_t = i3m\_ext_t - \left( \frac{PGDP\_EXT_t}{PGDP\_EXT_{t-4}} - 1 \right) \qquad \textbf{E. 19}$$

where:

*i3m_ext* – weighted (weights Tab. 2) nominal 3M rate abroad,

*PGDP_EXT* – weighted (weights Tab. 2) GDP deflator abroad.



With a defined path of the real effective zloty exchange rate, the nominal effective zloty exchange rate is calculated using the following identity:

$$S\_NEER_t = \frac{S\_REER_t * PGDP_t}{PGDP\_EXT_t} \qquad \textbf{E. 20}$$

where:

*S_NEER* – nominal effective zloty exchange rate – an increase corresponds to depreciation of the zloty,

*S_REER* – real effective zloty exchange rate (equation E. 18),

*PGDP* – GDP deflator (equation E. 15),

*PGDP_EXT* – weighted (weights Tab. 2) GDP deflator abroad.

The zloty exchange rate against the US dollar is subsequently calculated using the following equation:

$$s\_usd\_pln_t = s\_neer_t - 0{,}782 s\_usd\_eur_t - 0{,}071 s\_usd\_gbp_t - \\ - 0{,}053 s\_usd\_czk_t - 0{,}04 s\_usd\_sek_t \qquad \textbf{E. 21}$$

where:

*S_USD_PLN* – nominal zloty exchange rate against the US dollar,

*S_NEER* – nominal effective zloty exchange rate,

*S_USD_EUR* – nominal euro exchange rate against the US dollar,

*S_USD_GBP* – nominal exchange rate of the pound sterling against the US dollar,

*S_USD_CZK* – nominal exchange rate of the Czech crown against the US dollar,

*S_USD_SEK* – nominal exchange rate of the Swedish crown against the US dollar.

The exchange rate against the euro (as in the case of other currencies) is calculated using the following equation:

---

$s\_risk\_pr_t$=-0,05+0,49$s_risk_pr_{t-1}$ + 0,09(0,25*GDEBT_N*/*GDP_N*) + 0,05(i97q2+i01q2+i05q2).

$$S\_EUR\_PLN_t = \frac{S\_USD\_PLN_t}{S\_USD\_EUR_t} \qquad \textbf{E. 22}$$

where:

*S_EUR_PLN* – nominal zloty exchange rate against the euro – an increase corresponds to depreciation of the zloty,

*S_USD_PLN* – nominal zloty exchange rate against the US dollar (equation E. 21),

*S_USD_EUR* – nominal euro exchange rate against the dollar.

2

### 2.2.5 Interest rates

The interest rates that affect consumption in the ECMOD model are interest rates on commercial bank loans. The central bank monitors the level of short-term interest rates on the interbank market, and those, in turn, have an impact on interest rates on loans. In the model, WIBOR3M is the variable directly controlled by the central bank. WIBOR3M values are transmitted via the banking system for the purpose of determining interest rates on loans to the non-banking sector.

**Transmission mechanism for interest rates on loans granted by commercial banks**

Interest rates on loans in commercial banks differ, depending on the sector to which the loans are granted. In the ECMOD model, the capital formation equation uses the average weighted interest on loans to enterprises[23] (see equation E. 11).

The equation of transmission from WIBOR3M is as follows:

$$I\_RENTP_t = \underset{(-2,76)}{-0,27} - \underset{(-4,56)}{0,44}(I\_RENTP_{t-1} - 2,16 - I\_W3M_{t-1}) + \underset{(11,02)}{0,64}\Delta I\_W3M_t + + I\_RENTP_{t-1} \qquad \textbf{E. 23}$$

where:

I_RENTP –average quarterly value of average weighted interest rates on loans to enterprises by commercial banks,

I_W3M – average quarterly value of WIBOR3M.

Adjusted $R^2$: 79.4%

Autocorrelation of the random component: $\chi^2(2)=0.91$ (p=0.64)

Normality of distribution of the random component: $\chi^2$ (2)=1.94 (p=0.38)

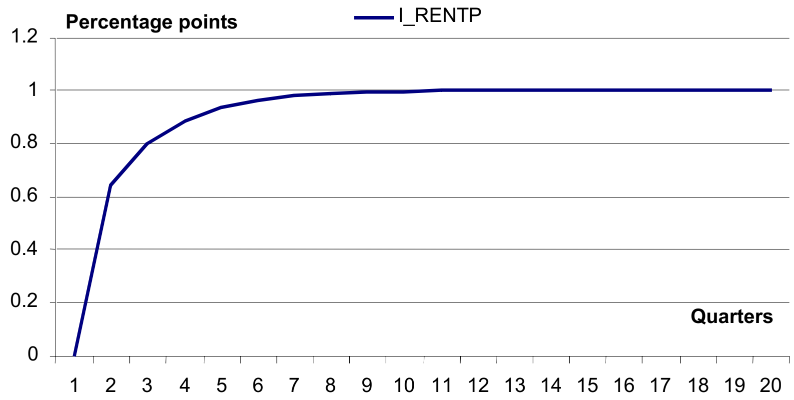
Sample: 1995Q1 – 2004Q4

[23] Average weighted interest rate on loans used in the model: quarterly average from the data published by the Statistical Department of the NBP, adjusted for the effects of changes in methodology in January 2004 and March 2002.

Equation E. 23 is consistent with the prevailing literature (e.g. Weth (2002), Winker (1999), Chmielewski (2004)). The parameters of equation E. 23 have been estimated without restrictions. The unit flexibility of the average interest rate on loans against the exchange rate on the interbank market has been tested using an independent long-term equation and has not been rejected. The result shows that changes in interest rates on the interbank market fully flow into changes in interest rates on corporate loans (see Fig. 3).



**Fig. 3**
Transfer of changes in interest rates on the interbank market to interest rates on corporate loans– the diagram shows the reaction of the I_RENTP interest rate to the increase in I_W3M by one percentage point




Source: NBP estimates.

## 2.3 External sector

This part of the paper provides a description of the impact of the external environment on Poland's economy. In the ECMOD model, the external environment influences the domestic economy through three channels. First, such variables as the disparity in real interest rates, the relation between domestic and foreign prices, the relation between potential GDP in Poland and abroad as well as net foreign assets all determine the evolutionary path of the real effective exchange rate (equation **E. 18**). Second, the nominal exchange rate and external prices have an impact on export and import deflators, which in turn influence domestic prices. Third, the level of the real exchange rate, external demand and domestic demand influence net exports and the current account balance.

2

### 2.3.1 Balance of payments[24]

The current account balance (*CAB*) is described with the following identities:

$$CAB_t = CAB\_NT_t + CAB\_INC_t + CAB\_TRANS_t$$ **E. 24**

$$CAB\_NT_t = GDP\_EXP\_N_t - GDP\_IMP\_N_t$$ **E. 25**

$$GDP\_EXP\_N_t = GDP\_EXP_t * P\_EXP_t$$ **E. 26**

$$GDP\_IMP\_N_t = GDP\_IMP_t * P\_IMP_t$$ **E. 27**

where:

*CAB* – current account balance in zloty (equation E. 24),

*CAB_NT* – balance of goods and services (equation E. 25),

*CAB_INC* – income balance,

*CAB_TRANS* – current transfers balance,

*GDP_EXP_N* – nominal value of exports of goods and services according to the national accounts (equation E. 26),

*GDP_IMP_N* – nominal value of imports of goods and services according to the national accounts (equation E. 27),

*GDP_EXP* – exports of goods and services in constant prices according to the national accounts (equation E. 31),

*GDP_IMP* – imports of goods and services in constant prices according to the national accounts (equation E. 32),

*P_EXP* – export deflator according to the national accounts (equation E. 33),

*P_IMP* – import deflator according to the national accounts (equation E. 35).

Section 2.3.2 presents estimates of the imperfect substitute model on the basis of which the balance of goods and services is determined. When making forecasts, balances of income and transfers are exogenous variables. For the sake of the simulation, it is assumed that the income balance is proportional to net foreign assets, i.e.

$$CAB\_INC_t \sim \underset{8,3}{0{,}013}\, NFA_{t-1}$$ **E. 28**

where:

$NFA_t$ – value of net foreign assets at the end of period *t* (equation E. 29).

Adjusted $R^2$: 71.5%

Autocorrelation of the random component: $\chi^2(4)=11.7$ (p=0.02)

Normality of distribution of the random component: $\chi^2$ (2)=0.32 (p=0.85)

Sample: 1995Q1-2004Q3

[24] Transaction-based balance of payments is discussed.

The above estimates imply that revenues on net foreign assets amount to about 1.3% quarterly, i.e. slightly above 5.0% annually. The value of net foreign assets is measured as cumulated balances in current accounts (cf.: Lane and Milesi-Ferretti, 1999):

$$NFA_t = NFA_{t-1}(1+\delta_t^{NFA}) + CAB_t \qquad \textbf{E. 29}$$

The value of the net investment position as at the end of 2003 has been assumed to be the initial value of net foreign assets. Due to the impact of exchange rate movements on the value of net foreign assets, the following adjustment has been introduced:



$$\delta_t^{NFA} = \frac{S\_USD\_PLN_t^{\,0,4} * S\_EUR\_PLN_t^{\,0,6}}{S\_USD\_PLN_{t-1}^{\,0,4} * S\_EUR\_PLN_{t-1}^{\,0,6}} - 1 \qquad \textbf{E. 30}$$

where:

$S\_USD\_PLN_t$ – zloty exchange rate per US dollar (equation **E. 21**),

$S\_EUR\_PLN_t$ – zloty exchange rate per euro (equation **E. 22**).

### 2.3.2 Foreign trade

The set of equations describing factors impacting foreign trade growth is based on the theory of imperfect substitutes (cf. Goldstein M., Khan M., 1985), according to which there is no perfect substitution of imported (exported) goods for goods present in the domestic market. This is an assumption confirmed by reality, in particular in countries with a diverse structure of imports and exports.

#### *2.3.2.1 Exports of goods and services*

It has been assumed that, in the long-term, real volumes of Polish exports are influenced by supply factors. An equation has been adopted, based on a transformation function, according to which the share of exports in potential GDP is a function of the relation between export prices and domestic producer prices. For the short-term, it has been assumed that exports are largely influenced by domestic demand. A combination of trend and long-term dynamics is aimed at allowing for phenomena described by Mroczek and Rubaszek (2003 and 2004), such as integration with the European Union, trade liberalisation or inflow of foreign direct investments. The following results were obtained:

$$\Delta gdp\_\exp_t = \underset{(2,96)}{0,02} - \underset{(3,92)}{0,35}(gdp\_\exp + 1,44$$
$$- \underset{(10,1)}{0,01} trend - gdp\_pot - \underset{(1,96)}{0,74}(p\_\exp - pgdp))_{t-1} + \underset{(0,81)}{1,01}\Delta gdp\_ext_t + dummies \qquad \textbf{E. 31}$$

where:

*GDP_EXP* – exports of goods and services in constant prices according to the national accounts,

*GDP_POT* – level of potential GDP (equation E. 5),

*GDP_EXT* – weighted GDP for Poland's major trading partners (weights Tab. 2),

*P_EXP* – export deflator according to the national accounts (equation E. 33),

*PGDP* – GDP deflator (equation **E. 15**).

Adjusted $R^2$: 56.0%

Autocorrelation of the random component: $\chi^2(4)=6.0$ (p=0.20)

Normality of distribution of the random component: $\chi^2$ (2)=0.2 (p=0.90)

Sample: 1995Q2-2004Q3

#### 2.3.2.2 Imports of goods and services

In the case of import volume, an assumption has been made that supply is unlimited. For the long-term, a function specification with constant elasticity of substitution has been adopted, according to which the share of imports in potential GDP depends on the domestic-import price ratio. The goal of adding the trend to the long-term growth rate is to take into account the same phenomena as in the export volume equation. Therefore, an equality requirement has been imposed on the trend parameters in the export and import equations. The following results were obtained:

$$\begin{aligned}\Delta gdp\_imp_t &= \underset{(0,91)}{0{,}01} - \underset{(1,75)}{0{,}12}(gdp\_imp + 1{,}44 \\ &- \underset{(10,1)}{0{,}01} trend - gdp\_pot + \underset{(1,3)}{0{,}70}(p\_imp\_noil + gtar\_tr - pgdp))_{t-1} + \underset{(2,26)}{1{,}59}\Delta gdp_t + \\ &+ dummies\end{aligned} \qquad \textbf{E. 32}$$

where:

*GDP_IMP* – import of goods and services in constant prices according to the national accounts,

*GDP_POT* – level of potential GDP (equation E. 5),

*GDP* – Gross Domestic Product (equation E. 1),

*P_IMP_NOIL* – import deflator according to the national accounts, adjusted for oil price fluctuations (equation E. 34),

*GTAR_TR* – rate of customs duties,

*PGDP* – GDP deflator (equation E. 15).

Adjusted $R^2$: 40.1%

Autocorrelation of the random component: $\chi^2(4)=5.5$ (p=0.24)

Normality of distribution of the random component: $\chi^2$ (2)=1.72 (p=0.42)

Sample: 1995Q2-2004Q3

#### 2.3.2.3 Export deflator

The export deflator is modelled on the concept “price maker — price taker”, adjusted for the convergence effect. It has been assumed that export profitability, influencing export volumes according to equation E. 31 , depends on the deviation of the real exchange rate from its long-term path (cf. E. 17). In other words, exchange rate appreciation resulting from long-term fundamentals does not change export profitability, whereas an appreciation of the zloty due to factors other than those mentioned in E. 17 does influence exporters’ decisions. The following results were obtained:



$$\begin{aligned}\Delta p\_\exp_t &= \Delta pgdp_t - \underset{(4,92)}{0{,}61}((p\_\exp - pgdp) + 6{,}12 - \underset{(6,31)}{0{,}58}(s\_reer + \\ &+ 0{,}75(gdp\_pot - gdp\_pot\_ext)))_{t-1} + \underset{(4,72)}{0{,}45}\Delta(s\_reer)_t + dummies\end{aligned} \qquad \textbf{E. 33}$$

where:

*P_EXP* – export deflator according to the national accounts,

*PGDP* – GDP deflator (cf. equation E. 15),

*S_REER* – real effective zloty exchange rate (equation E. 18),

*GDP_POT* – potential GDP (equation E. 5),

*GDP_EXT_POT* – weighted potential GDPs abroad (weights Tab. 2).

Adjusted $R^2$: 70.4%

Autocorrelation of the random component: $\chi^2(4)=4.8$ (p=0.30)

Normality of distribution of the random factor: $\chi^2$ (2)=2.1 (p=0.35)

Sample: 1995Q2-2004Q3

#### 2.3.2.4 Import deflator

The import deflator adjusted for oil prices movements is also modelled on the concept “price maker — price taker”, adjusted for the convergence effect. As in the export deflator equation, it has been assumed that the measure of price competitiveness influencing import volumes, as in E. 32, depends on the deviation of the real exchange rate from its long-term path (cf. E. 17). The following results were obtained:

$$\begin{aligned}\Delta p\_imp\_noil_t &= \Delta pgdp_t - \underset{(2,54)}{0{,}21}((p\_imp\_noil - pgdp) + 6{,}88 - \underset{(4,32)}{0{,}61}(s\_reer + \\ &+ 0{,}75(gdp\_pot - gdp\_ext\_pot)))_{t-1} + \underset{(4,32)}{0{,}63}\Delta(s\_reer)_t + dummies\end{aligned} \qquad \textbf{E. 34}$$

where:

*P_IMP_NOIL* – import deflator adjusted for oil price movements according to the national accounts,

*PGDP* – GDP deflator (cf. equation E. 15), *S_REER* – real effective zloty exchange rate (equation E. 18),

*GDP_POT* – potential GDP (equation E. 5),

*GDP_EXT_POT* – weighted potential GDPs abroad (weights Tab. 2).

Adjusted $R^2$: 57.0%

Autocorrelation of the random component: $\chi^2(4)=3.0$ (p=0.55)

Normality of distribution of the random component: $\chi^2$ (2)=0.2 (p=0.90)

Sample: 1995Q2-2004Q3

2

The import deflator is derived from the weighted sum of the import price deflator, adjusted for oil price movements and oil prices on global markets denominated in zloty:

$$p\_imp_t = 0{,}92\,p\_imp\_noil_t + 0{,}08(oil + s\_usd\_p\ln)_t \qquad \textbf{E. 35}$$

where:

*P_IMP* – import deflator according to the national accounts,

*P_IMP_NOIL* – import deflator adjusted for oil price movements according to the national accounts (cf. equation E. 34),

*OIL* – US dollar-denominated world oil prices,

*S_USD_PLN* – zloty exchange rate per US dollar (cf. equation E. 21).

## 2.4 General government

The fiscal module of the model is based on data covering general government (GG), which includes the central budget, local governments, special state funds, the National Health Fund, government agencies and extra-budgetary entities. Thus, problems related to modelling the effect of decentralisation of the public administration or transfers between entities of the general government, have been avoided. In this section, we model the volumes of GG revenues and expenditures and the resulting deficit and public debt. All equations presented below are identities. There are numerous interactions between specific categories of expenditures and revenues and the real economy, frequently resulting from legal regulations (e.g. determining a tax base for tax revenues).

The fiscal module has been constructed on the basis of nominal data, published in *Reports on the execution of the Budget Act* for the years 1995-2003. Annual data from that source have been converted into quarterly data, on the basis of other available information. For example, annual central budget data has been broken down into quarters on the basis of monthly information from *Operational reports on the execution* *of the central budget*; local government data — on the basis of quarterly *Reports on the execution of budgets of local governments*; and data concerning some agencies and funds has been broken down on the basis of quarterly information on their current financial standing as submitted to the NBP under the existing reporting system. A small percentage of data, which could not be broken down into quarters in this manner, has been divided into quarters on the basis of nominal GDP growth, nominal wage growth or the consumer price index, depending on the nature of the data.



### 2.4.1 GG revenues

GG revenues represent the sum of individual revenue categories, as presented in the following equation:

GINC_N = GIDT_N + GPIT_N + GCIT_N + GLT_N + GTAR_N + GCT_N + CGNBP_N + GINC_UE_N + GRT_N **E. 36**

where:
GINC_N – revenues of the general government (equation E. 36),
GIDT_N – indirect tax revenues (equation E. 37),
GPIT_N – personal income tax revenues (equation E. 41),
GCIT_N – corporate income tax revenues (equation E. 42),
GLT_N – health and social contributions (equation E. 43),
GTAR_N – customs revenues (equation E. 48),
GCT_N – real estate tax revenues (equation E. 49),
CGNBP_N – the NBP profit transfer (exogenous variable),
GINC_UE_N – special cash-flow facility from the EU budget (exogenous variable),
GRT_N – other revenues (equation E. 50).

In the accession treaty, Special EU funds were allocated to Poland to compensate for the negative effects of accession (known as a special cash-flow facility). These funds will continue to flow into the central budget in the years 2004-2006, in the amount specified in the treaty. For this reason, the GINC_UE_N is treated as an exogenous variable in the model. The other revenue categories (except for the NBP profit transfer) are endogenous variables.

In all tax categories, revenues from social contributions and customs duties are determined on the basis of effective tax rates and the tax base. The effective tax rate makes it possible to include a number of factors, such as the nominal rate, the system of tax deductions and exemptions or the share of grey economy, in a single variable. It is which data are available. For the forecast period, rates are adjusted for the effects of known systemic changes, e.g. freezing of PIT tax thresholds in 2005, growth of the health insurance contribution rate from 8.25% in 2004 to 8.50% in 2005, 8.75% in 2006 and 9.00% in 2007, additional personal income tax revenues in 2007 (the 2006 annual settlement) due to elimination of the home improvement tax deduction in 2006.

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#### *2.4.1.1 Indirect tax revenues*

Indirect tax revenues can be divided into value-added tax revenues, excise tax revenues and gaming tax revenues, i.e.:

GIDT_N = GVAT_N + GEXT_N + GGAM_N **E. 37**

where:

GVAT_N –value added tax revenues (equation E. 38),

GEXT_N – excise tax revenues (equation E. 39),

GGAM_N – gaming tax revenues (equation E. 40).

The tax base for VAT and the excise tax is calculated as the sum of private consumption, public purchases (which account for about 30% of current government expenditure) and public investment[25], which is illustrated with the following identities:

GVAT_N = GVAT_TR * (CONP_N + 0,3 * GCE_N + GINV_N) **E. 38**

GEXT_N = GEXT_TR * (CONP_N + 0,3 * GCE_N + GINV_N) **E. 39**

where:

GVAT_TR – effective VAT rate (exogenous variable),

GEXT_TR – effective excise tax rate (exogenous variable),

CONP_N – nominal individual consumption (equation **E. 7**),

GCE_N – current government expenditure, consisting of expenditure on purchases of non-investment goods (about 30% of total spending) and wages (about 70% of spending) (equation E. 52),

GINV_N – public investment (equation E. 61).

Gaming tax revenues are a product of the effective tax rate and private consumption.

GGAM_N = GGAM_TR * CONP_N **E. 40**

[25] Public entities may not deduct VAT paid on their own investment since they are not VAT payers.

where:
GGAM_TR – gaming tax effective rate (exogenous variable),
CONP_N – nominal individual consumption (equation **E. 7**).

### *2.4.1.2 PIT revenues*

The tax base for PIT revenues consists of the wage fund increased by retirement and disability pension transfers and unemployment benefits, and is illustrated by the following relation:

GPIT_N = GPIT_TR * (GTR_RETIRED_N + GTR_UNEMP_N + WAGEFUND_N) **E. 41**

where:
GPIT_TR – effective PIT rate (exogenous variable),
GTR_RETIRED_N – retirement and disability pension transfers (equation E. 58),
GTR_UNEMP_N – unemployment benefits (equation E. 54),
WAGEFUND_N – quarterly wage fund in the economy.

### *2.4.1.3 CIT revenues*

Corporate entities pay CIT on profit generated, i.e. on revenues less expenses. CIT revenues are forecast on the basis of the assumed constant ratio of CIT revenues to gross added value[26] across the whole country, net of labour costs and depreciation of fixed assets. Thus, the so-called tax base in the case of CIT revenues includes gross domestic product less indirect taxes[27], wage fund, non-wage labour costs, depreciation of fixed assets[28] and is increased by subsidies to enterprises[29].

GCIT_N = GCIT_TR * (GDP_N – GIDT_N + GTR_CORP_N – WAGEFUND_N – GLT_CORP_N – KEP * PGDP * DEPR) **E. 42**

where:
GCIT_TR – effective CIT rate (exogenous variable),
GDP_N – nominal GDP value,
GIDT_N – indirect tax revenues (equation E. 37),
GTR_CORP_N – subsidies to enterprises (equation E. 62),
WAGEFUND_N – quarterly wage fund in the economy,

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[26] Gross added value is constructed as GDP value decreased by taxes on products and increased by subsidies to products.
[27] Indirect taxes are a variable replacing taxes on products.
[28] Depreciation of fixed assets is a variable replacing amortisation of fixed assets.
[29] Subsidies to enterprises are a variable replacing subsidies to products.

GLT_CORP_N – quarterly non-wage labour costs (equation E. 45),

KEP – capital value equal to cumulated investment (equation E. 2),

PGDP – GDP deflator (equation **E. 15**),

DEPR – quarterly depreciation rate (exogenous variable).

#### *2.4.1.4 Revenues from health and social insurance contributions*

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Revenues from health and social contributions consist of the sum of social contributions (paid by employees, employers, business owners and freelance employees) and health insurance contributions (paid by employees, business owners, freelance employees and pensioners).

GLT_N = GLT_EMP_N + GLT_CORP_N + GLT_SB_N + GLT_HC_N **E. 43**

GLT_EMP_N = GLT_EMP_TR * WAGEFUND_N **E. 44**

GLT_CORP_N = GLT_CORP_TR * WAGEFUND_N **E. 45**

GLT_SB_N = GLT_SB_TR * WAGEFUND_N **E. 46**

GLT_HC_N = GLT_HC_TR * (WAGEFUND_N + GTR_RETIRED_N) **E. 47**

where:

GLT_EMP_N – social contributions paid by employees (equation E. 44),

GLT_CORP_N – social contributions paid by employers (equation E. 45),

GLT_SB_N – social contributions paid by business owners and freelance employees (equation E. 46),

GLT_HC_N – health insurance contributions (equation E. 47),

GLT_EMP_TR – effective rate of revenues from social contributions paid by employees (exogenous variable),

GLT_CORP_TR – effective rate of revenues from social contributions paid by employers (exogenous variable),

GLT_SB_TR – effective rate of revenues from social contributions paid by business owners and freelance employees (exogenous variable),

GLT_HC_TR – effective rate of revenues from health insurance contributions (exogenous variable).

#### *2.4.1.5 Customs revenues*

Customs revenues depend on the value of imported goods[30]. The following identity is used:

[30] Since Poland joined the European Union, i.e. the customs union, it has been receiving customs revenues from goods crossing the EU border in Poland, but not necessarily intended for Polish end users. Similarly, some products that are Polish imports cross the EU external border outside of Poland and thus

GTAR_N = GTAR_TR * GDP_IMP * P_IMP **E. 48**

where:

GTAR_TR – effective rate of customs duties (exogenous variable),

GDP_IMP – volume of imports of goods and services at constant prices, according to the national accounts (equation E. 32),

P_IMP – import deflator according the national accounts (equation E. 35).



#### *2.4.1.6 Real estate tax revenues*

In the case of real estate tax revenues, a simplified assumption is used that the value of real estate is proportional to GDP. The form of the assumed relation is as follows:

GCT_N = GCT_TR * GDP_N **E. 49**

where:

GCT_TR – real estate tax effective rate (exogenous variable).

#### *2.4.1.7 NBP profit transfer and other revenues*

The NBP profit transfer (comprising mostly profit on foreign reserves and open market operations), is forecast by the NBP's Accounting & Operations Department and used in the ECMOD.

Other revenues - comprising dividend revenues and contributions paid by local governments - depend on numerous factors, which are difficult to quantify. Due to the difficulties related to modelling, it has been assumed that other GG revenues grow at the same rate as nominal GDP.

GRT_N = GRT_N(-4) * GDP_N / GDP_N(-4) **E. 50**

where:

GRT_N – other GG revenues (equation E. 50),

GDP_N – nominal GDP.

### 2.4.2 GG expenditure

GG expenditure consists of individual expenditure categories: current expenditure, transfers to the population, investment spending, subsidies for economic

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the respective customs duties are not paid to the Polish budget. However, data on the flows mentioned above are not available, which prevents the construction of a better equation on customs revenues.

projects, debt service costs, contribution to the EU budget, and other expenditures. It is represented by the following equation:

GEXP_N = GCE_N + GTR_N + GINV_N + GTR_CORP_N + GDS_N + GEXP_UE_N + GRE_N **E. 51**

where:
GEXP_N – general government expenditure (equation E. 51),
GCE_N – current expenditure (equation E. 52),
GTR_N – transfers to the population (equation E. 53),
GINV_N – investment expenditure (equation E. 61),
GTR_CORP_N – subsidies to enterprises (equation E. 62),
GDS_N – costs of debt service (equation E. 60),
GEXP_UE_N – contribution to the European Union budget (exogenous variable),
GRE_N – other expenditure (equation E. 63).

The contribution made by member states to the EU budget is composed of four parts: customs revenues, revenues from agricultural fees, VAT revenues and the part of the contribution relative to the GNP volume of the member state in relation to the GNP of the whole EU. In the case of Poland, the last part accounts for about 70% of the total amount. In order to estimate its value for the coming years, a comparable GNP growth forecast for the 25 EU countries would have to be applied. However, the NBP does not have at its disposal such estimates and therefore the contribution has been assumed exogenously on the basis of separate expert research[31]. The other variables are endogenous, and their corresponding equations are presented below.

#### *2.4.2.1 Current expenditure*

Remuneration and related spending account for about 70% of current expenditure; the remaining 30% comprises rents and purchases of non-investment goods. This results in the following equation:

GCE_N = GCE_N(-4) * (70% * WAGE / WAGE(-4) + 30% * PGDP / PGDP(-4)) **E. 52**

where:
WAGE – average wage in the economy (equation **E. 16**),
PGDP – GDP deflator (equation **E. 15**).

[31] Report on "Benefits and costs of Poland's membership in the European Union" European Centre Natolin, Warsaw, 2003.

#### 2.4.2.2 *Transfers to the population*

Transfers to the population have been further disaggregated into unemployment benefits, retirement and disability pensions, and other social welfare transfers, i.e.:

GTR_N = GTR_UNEMP_N + GTR_RETIRED_N + GTR_RELIEF_N **E. 53**

where:

GTR_UNEMP_N – unemployment benefits (equation E. 54),

GTR_RETIRED_N – retirement and disability pensions and pre-pension benefits (equation E. 58),

GTR_RELIEF_N – transfers from social assistance (equation E. 56).



The amount of unemployment benefits and social welfare transfers is calculated as a product of the average benefit and the number of unemployed (i.e. the difference between the labour force and the number of employed persons), under the assumption that the number of persons requiring social welfare assistance is proportional to the number of unemployed. An assumption has been made that indexation of transfers (i.e. the growth of the average benefit) is based on inflation. This is illustrated by the following equations:

GTR_UNEMP_N = AVGBENEFIT_N * (LF – EMP) **E. 54**

AVGBENEFIT_N = AVGBENEFIT_N(-1) * CPI(-1) / CPI(-2) **E. 55**

GTR_RELIEF_N = AVGRELIEF_N * (LF – EMP) **E. 56**

AVGRELIEF_N = AVGRELIEF_N(-1) * CPI(-1) / CPI(-2) **E. 57**

where:

AVGBENEFIT_N – the average quarterly benefit from the Labour Fund per unemployed person (equation E. 55),

LF – labour force, according to BAEL (exogenous variable),

EMP – number of employees, according to BAEL (equation E. 4),

CPI – consumer price index (E. 13),

AVGRELIEF_N – the average quarterly social welfare benefit (equation E. 57).

Retirement and disability pension spending depends on the number of beneficiaries and the amount of the average pension, as illustrated by the equation below:

GTR_RETIRED_N = RETIRED * AVGPENSION_N **E. 58**

where:

RETIRED – number of pensioners (exogenous variable),

AVGPENSION_N – the average pension (equation E. 59).

The number of retirement and disability pensioners depends on the demographic structure of the population, as well as on administrative and legal regulations — therefore it is an exogenous variable in the model. The rate of pension indexation had been, until recently, determined partly on the basis of regulations, and partly negotiated by the Trilateral Commission. On March 1, 2004 indexation was performed using a 1.8% rate. According to the Act on retirement and disability pension benefits, starting in 2005, indexation will occur when accumulated inflation (since the previous indexation) exceeds 5%, but not less frequently than every three years. Inflation forecasts indicate that the next indexation will occur in 2006.

The equation for indexation of pensions is composed of two sections. The first section describes price indexation in 2006, to be introduced on March 1st, i.e. 33% of the indexation takes place in the first quarter of a given year and the remaining 66% in the second quarter. The other section of the equation (average_pension_correction) is an adjustment for flows to beneficiaries, which is determined by experts. Newly granted retirement and disability pensions are based on average salaries in the years preceding retirement[32]; thus, new beneficiaries of the system will receive a higher average benefit than those whose benefits are only inflation-indexed[33]. An assumption has been made that the average period of pension benefit pay-out is 15 years[34].

AVG_PENSION_N / AVG_PENSION_N(-1) = 1 + 59/60 * (I06Q1 * (CPI(-1) / CPI(-9) - 1) + 66% * I06Q2 * (CPI(-2) / CPI (-10) - 1)) + 1/60 * avg_pension_correction **E. 59**

where:
I06Q1 – dummy variable , equal to 1 in the first quarter of 2006, and equal to 0 in other periods,
I04Q2 – dummy variable , equal to 1 in the second quarter of 2004, and equal to 0 in other periods.

#### *2.4.2.3 Costs of debt service*

Costs of debt service depend on the debt volume and the effective debt interest rate. In the model, the effective rate has been assumed as exogenous due to problems

[32] In reality the system of pension calculation is more complex; however, it is fully based on wages.
[33] Where nominal wages grow at a higher rate than prices.
[34] Hence the quarterly index of 1/60.

with modelling this variable. Apart from a very short time series record[35], the basic problem is the fact that costs of debt service are accounted on a cash basis and not an accrual basis. Thus, the costs of debt service depend largely on the debt structure (both term-structure and structure by type of debt instrument). For example, in the case of the issuance of zero-coupon bonds, all costs of debt service are recorded (using the cash method) on the maturity date, which distorts the picture of the real effective interest rate of the debt.



In ECMOD, when preparing a fiscal forecast, the forecast for the effective interest rate applicable to public debt is made on the basis of data from the Ministry of Finance on the structure and maturity dates of Treasury bills and bonds.

In the model, public debt is divided into domestic and foreign debt, the value of which denominated in zloty depends on the current exchange rate. Therefore, changes in the exchange rate are reflected in the costs of debt service.

GDS_N = GDEBT_N * GDEBT_IR **E. 60**

where:

GDEBT_N – nominal value of public debt (equation E. 65),

GDEBT_PL – share of domestic debt in public debt (exogenous variable),

GDEBT_IR – effective interest rate applicable to public debt (exogenous variable).

### *2.4.2.4 Investment expenditure, subsidies to enterprises and other expenditure*

The following expenditure categories are determined on the basis of discretional decisions made by the government and the Parliament:

1) public investments,

2) subsidies to enterprises,

3) other spending of the general government, including pre-determined contributions to international organizations (apart from the EU).

Expenditure in the above categories in 2003 accounted for about 7.3% of total GG spending. The model assumes that the above categories change in line with growth in nominal GDP, i.e.:

GINV_N = GINV_N(-4) * GDP_N / GDP_N(-4) **E. 61**

GTR_CORP_N = GTR_CORP_N(-4) * GDP_N / GDP_N(-4) **E. 62**

[35] A variable indispensable to calculate the effective debt interest rate is the debt volume; estimates of which are available from the fourth quarter of 1999 on.

GRE_N = GRE_N(-4) * GDP_N / GDP_N(-4) **E. 63**

where:

GINV_N – investment expenditures (equation E. 61),

GDP_N – nominal GDP,

GTR_CORP_N – subsidies to enterprises (equation E. 62),

GRE_N – other expenditures (equation E. 63).



### 2.4.3 GG deficit and public debt

The balance of the general government is calculated in a standard manner, according to the following equation:

GDEF_N = GINC_N - GEXP_N **E. 64**

As for public debt, State Treasury debt is the dominant component and, to a lesser extent, the debt of local governments. Other general government entities, although generating debt, have a relatively low level of indebtedness, since their debt is usually assumed by the State Treasury.

Aggregate data on general government debt is available since 1999. Therefore, the volume of GG debt in the period from the fist quarter of 1995 – third quarter of 1999 was estimated using information on the State Treasury debt.

The growth of debt depends on a number of factors. First, the debt is increased by the GG deficit. Second, changes in exchange rates may have an impact on the value of external debt calculated in domestic currency. Third, the debt may be decreased by revenues from privatisation and increased by outflows from budget compensation. Fourth, the shortcomings of the Polish financial system mean that not all operations executed by the government are accounted for in the sector deficit. Fifth, the government may fund the deficit either by borrowing, or by using cash accumulated in accounts (so-called liquidity cushion)[36]. The fourth and the fifth reasons for changes in the level of debt have been accounted for in the equation in the form of adjustments to debt volume.

Having allowed for all the above comments, the equation looks as follows:

GDEBT_N = GDEBT_N(-1) * [(GDEBT_EUR * S_EUR_PLN + (1-GDEBT_EUR) * S_USD_PLN) / (GDEBT_EUR * S_EUR_PLN(-1) + (1-GDEBT_EUR) * S_USD_PLN(-1)) * (1 - GDEBT_PL) + GDEBT_PL] - GDEF_N - GPRIV_N + correction on pre-financing UE projects + cash **E. 65**

[36] In this way, the deficit may be financed only temporarily, since funds in government accounts perform the role of the so-called liquidity cushion and their level must not be too low.

accumulated correction + hospital debt correction

where:

GDEBT_EUR – share of euro-denominated debt in total debt[37] (exogenous variable),

GDEBT_PL – share of domestic debt in public debt (exogenous variable),

S_EUR_PLN – PLN/EUR exchange rate (equation E. 22),

S_USD_PLN – PLN/USD exchange rate (equation E. 21),

GDEF_N – GG balance (equation E. 64),

GPRIV_N – revenues from privatisation (adjusted for budget compensation) (exogenous variable).



[37] Debt denominated in currencies other than the euro and the US dollar has been attributed to the euro and the US dollar in proportion to their share in the basket. This translates into an assumption that the zloty exchange rate against other currencies changes in proportion to the euro and US dollar basket exchange rate.

# 3
# Simulation Analyses

This section of the paper deals with the simulated results of reactions of the Polish economy to three impulses:

- impulse of monetary policy;
- exchange rate impulse;
- impulse of fiscal policy.

All simulations have been conducted with a built-in interest rate rule[38] and fiscal policy rule[39]. During the simulations, it is necessary to allow in the model for the function of reactions of the central bank, endogenising the short-term interest rate. Otherwise, the results of the simulations would describe an improbable path of development of the economy, one in which the central bank does not react to changes in the economy. An assumption of no fiscal adjustments in the case of a shock which leads to a growing general government deficit (and thus the debt) would be equally unrealistic. Simulations are primarily aimed at analysing the function of reaction to an impulse; should the interest rate rule be not taken into account, the results would be distorted. In the process of preparation of ECMOD projections/forecasts, the interest rate rule is substituted with an exogenously pre-defined path of short-term interest rates. This allows for an analysis of “what if” scenarios, which are the basic reason behind projection preparation.

In all cases, the impulse is sustained for eight quarters. Transmission channels of individual impulses in the economy as well as the reactions of selected macro-economic categories are presented below. The results are presented in Tab. 5-Tab. 7 in the annexes, which show the differences between a scenario with an impulse and a baseline scenario (scenario of economic growth without disturbances).

[38] Taylor’s rule, *backward-looking*, cf. item 3.1. The monetary policy rule is included at the moment the impulse is ended in the case of simulation of the interest rate. In the other two simulations, the rule is included throughout the simulation period.
[39] Cf. item 3.2. The fiscal policy rule is included at the moment the impulse is ended in case of fiscal simulation. In the other two simulations, the rule is included with a delay, which — on the one hand — does not distort short- and medium-term reactions of key macrocategories, and on the other — assures that the deficit and the public debt return to their original values.

## 3.1 MONETARY POLICY RULE

In simulations, a monetary policy rule is applied, which specification is compliant with Taylor's Rule (cf. Taylor (1997 and 2000)). Weights used in the output gap, the inflationary gap and the parameter defining the smoothing of the interest rate path have been determined on the basis of values commonly used in literature. The value of the natural interest rate, determined at 4%, is compliant with NBP studies on its level and changes through time (cf. Brzoza-Brzezina 2003). The value of 4% is in the lower range of values received from independent estimates; a decision was made to use the lower-end value, due to the downward trend of the natural interest rate in Poland, based on the results of research. The form of Taylor's Rule used in the simulations is as follows:

$$i\_w3m_t = (1-\alpha)*[\phi + \inf_t + \beta GAP_t + \gamma(\inf_t - \inf\_cel)] + \alpha * i\_w3m_{t-1} \qquad \textbf{E. 66}$$

where,

$i\_w3m_t$ – nominal WIBOR3M, interest rate, quarterly average,

*inf* –CPI inflation (equation E. 13),

*GAP* – output gap (equation E. 6),

*inf_cel* – inflation target (i.e. 2.5%, exogenous variable),

$\phi$ – natural interest rate,

$\alpha$ – smoothing coefficient,

$\beta$, $\gamma$- weights for output gap and distance of inflation from inflation target, respectively.

## 3.2 FISCAL POLICY RULE

When conducting a simulation, a fiscal policy rule, which balances general government revenues and expenditures, is applied. PIT revenues and social contribution revenues change by adjusting their effective rates, so that the balance of GG remains at zero. The following equation is assumed:

$$\Delta e_t = \theta \times (d_{t-1} - d^*) \qquad \textbf{E. 67}$$

where:

$\Delta e_t$ – percentage growth of the effective rate,

d – balance level in relation to GDP,

$d^*$ – assumed balance level in relation to GDP (0% of GDP),

$\theta$ – coefficient describing the speed of the adjustment.

This guarantees that the balance returns to its assumed value, and through the costs of public debt service, gradually stabilises the debt level.

The general government balance is improving gradually, so that the relation of the balance to gross domestic product fully stabilises only in the long-term. The parameters of the rule have been set at such a level that they stabilise the long-term properties of the model, having little influence on the current economy. This is necessary due to the fact that balancing of public sector revenues and expenditures results in the weakening of automatic stabilisers in the model[40]. Assuming such a solution, stabilisation of the deficit and public debt is obtained in the long-run, without short-term shocks.

This rule is not an operational rule; it is only aimed at stabilising the balance of the sector (and thus the public debt) in simulations and as an exercise for examining long-term properties. The choice of categories of effective rates to be changed as well as delays has been of technical nature, driven by the intention to smooth the movement of fiscal variables (delay -1) and by the limited impact of the rule on inflation (omission of effective rates of indirect taxes[41]).

## 3.3 FORECAST PROPERTIES OF THE MODEL – SIMULATIONS IN- AND OUT-OF-SAMPLE

In order to evaluate the forecasting properties of the model, out of sample and in-sample simulations have been performed. An out-of-sample simulation begins with model re-estimation on a shortened sample (until moment *t*), maintaining the present specification of the equations[42], and then the forecast is prepared for $t+k$ quarters forward, where $k=1,2,\ldots,8$. An in-sample simulation consists in model re-estimation on the sample ending at the moment *t*, and then on "moving back in time" to the moment *t 8* and preparing forecasts for *t-p* quarters, where $p=7,6,5,\ldots,1,0$. In both these exercises, actual values of exogenous variables are adopted, and forecast errors are calculated. Such simulations enable the examination of forecasting properties of the

[40] In the case of a supply shock in the economy, automatic stabilisers are not able to assure permanent economic equilibrium. In such a situation, a fiscal adjustment is necessary, which is assured in the ECMOD model by the application of the fiscal policy rule. In case of a demand shock, the automatic stabilisers are able to assure a return to the equilibrium, and the fiscal policy rule weakens their impact on the economy. The coefficient describing the speed of adjustment has been selected in such a way as to provide a sufficiently strong impact of the rule in case a supply shock occurs and a sufficiently weak impact in case of a demand shock.

[41] It is precisely this tax category that the government can change easiest and fastest.

[42] In the case of each re-estimation, the same uniform set of variables and their delays is maintained.

entire model, which would be impossible only on the basis of analysing the quality of individual equations' fit to the data.

Out-of-sample simulations have been conducted under the assumption of gradual extension of the sample, i.e. by the *rolling-window out-of-sample forecast* method. No re-estimation of cointegrating relationships has been performed. In the first step, the moment to start the out-of-sample forecast was chosen — it was assumed that the shortest sample selected for model re-estimation ended in the fourth quarter of 2001. Then, the solution of the re-estimated model from the first quarter of 2002 to the third quarter of 2004 was examined, analysing the basic macroeconomic categories. In the next step, the sample was extended by one quarter, and the model was re-estimated again[43] and solved from the second quarter of 2002 to the third quarter of 2004, calculating forecast errors afterwards. This procedure was repeated until the model was re-estimated on a sample ending in the second quarter of 2004, thus obtaining a forecast for the third quarter of 2004.



It should be stressed that errors obtained in out-of-sample simulations are not identical to forecast errors, since the simulation does not account for experts' evaluations, which also have some impact on forecast results. Therefore, errors obtained in such simulations are usually higher than the actual forecast errors. It is additionally assumed that the relations incorporated in the present model version were also true for previous years — i.e. there is an automatic re-estimation of equation parameters without changing their specification, which may also influence the quality of forecasts obtained in the exercise. Fig. 4 presents errors of out-of-sample forecast for inflation in 8-quarter forecast horizon. The number of observations, on the basis of which the analysed errors were calculated, are shown in parentheses. A small number of observations indicate a necessity of a cautious interpretation of errors obtained in this simulation.

**Tab. 3** Out-of-sample inflation simulation errors

| Number of quarters for which the forecast is made | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Quarters<br>Errors in percentage points | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **MAE** | 0.23 | 0.51 | 0.69 | 0.89 | 0.99 | 1.30 | 1.56 | 2.25 |
| **MSE** | 0.001 | 0.005 | 0.010 | 0.015 | 0.021 | 0.033 | 0.038 | 0.068 |
| **RMSE** | 0.29 | 0.71 | 1.02 | 1.23 | 1.46 | 1.81 | 1.96 | 2.61 |

[43] At this stage, model re-estimation is made on the sample of 1995 Q1–2002 Q1.

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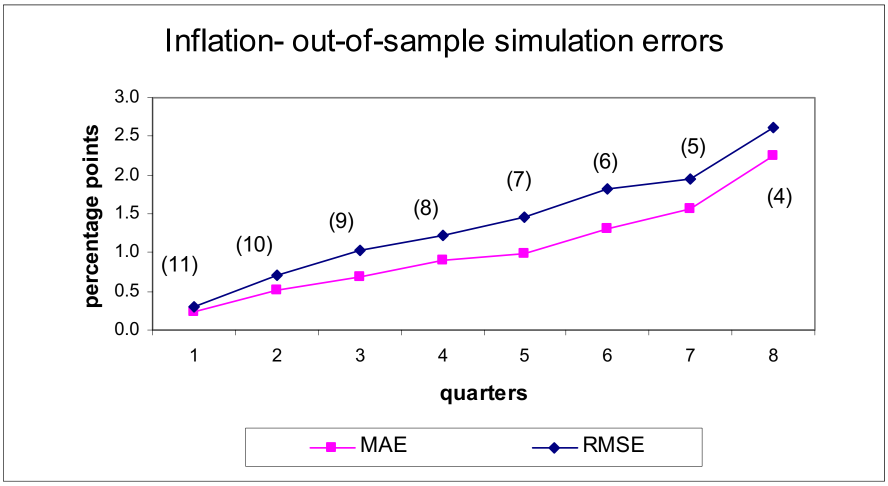
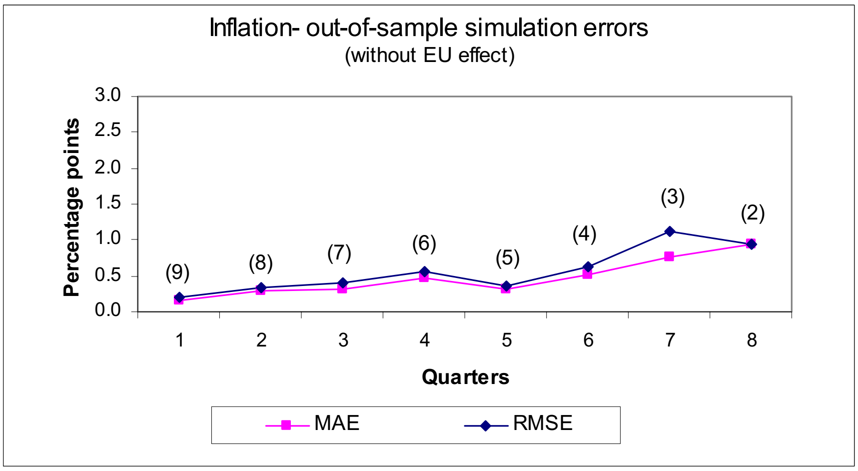
**Fig. 4** Out-of-sample inflation simulation errors




One of the main factors influencing the errors in an out-of-sample simulation — apart from the lack of experts' evaluations — is the assumption of unchanged specification of the equations. Making such an assumption we are not able to account for the changes that have occurred due to Poland's accession to the European Union. The so-called "EU effect" caused a growth in inflation, which was difficult to foresee in previous years. Since the results presented concern a *rolling-window out-of-sample forecast* simulation, the unexpectedly high inflation in the second quarter of 2004 had an impact on the increased forecast errors from the first quarter[44] up to 8 quarters forward. Fig. 5 presents out-of-sample forecast errors, without taking into account forecasts for the second and the third quarter of 2004. The number of observations used in calculating the analysed errors are in parentheses.

**Fig. 5** Out-of-sample inflation simulation errors, excluding forecasts for the second and the third quarter of 2004




[44] In a "raw" model solution, without accounting for experts' evaluations.

**Tab. 4** Out-of-sample Simulation errors for inflation, excluding forecasts for the second and the third quarter of 2004

| Number of quarters for which the forecast is made | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Quarters Errors in percentage points | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **MAE** | 0.16 | 0.28 | 0.31 | 0.47 | 0.31 | 0.52 | 0.77 | 0.93 |
| **MSE** | 0.000 | 0.001 | 0.002 | 0.003 | 0.001 | 0.004 | 0.012 | 0.009 |
| **RMSE** | 0.20 | 0.34 | 0.40 | 0.57 | 0.36 | 0.62 | 1.11 | 0.94 |

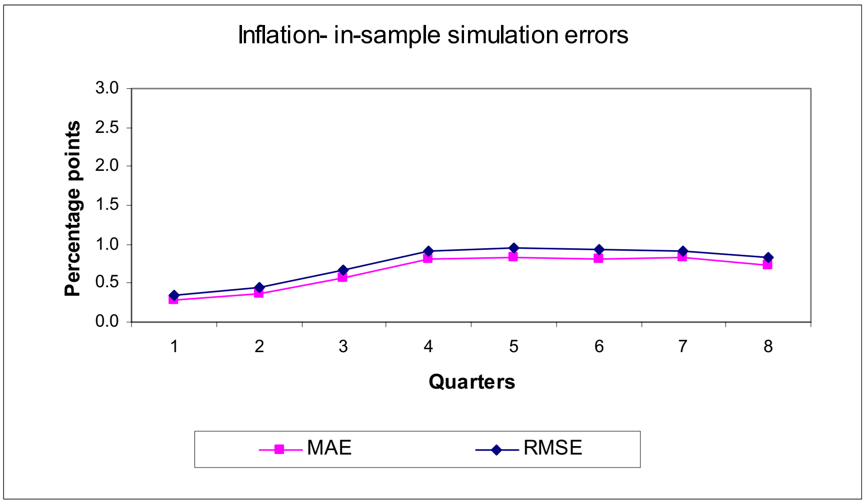
In the exercise excluding the EU effect, errors are much lower than in the exercise which include the second and the third quarter of 2004. The errors for the 7th and 8th quarters, however, should be interpreted with caution, due to a small number of observations.



An in-sample simulation consists of examining forecast errors obtained in the sample on which equations were re-estimated. Cointegrating relationships (similar to the out-of-sample simulation) remain unchanged. In the case of the in-sample simulation, the model is re-estimated 11 times, without changing the equations and preserving the actual paths of exogenous variables. The first re-estimation is performed on the sample ending in the fourth quarter of 2001. The model is solved from the fouth quarter of 1999 to the fourth quarter of 2001 (i.e. until the end of the sample on which the equations were re-estimated) and forecast errors are calculated. Then the model is solved from the first quarter of 2000 to the fourth quarter of 2001 (the end of the sample period on which the equations were re-estimated). The following forecasts are made from one quarter later until the fourth quarter of 2001, and the procedure is repeated until a forecast is made only for the fourth quarter of 2001. Then the entire model is re-estimated using the sample ending with the first quarter of 2002, i.e. extended by one quarter in relation to the previous re-estimation. The re-estimated model is solved, starting from the fourth quarter of 1999 until the end of the sample (i.e. until the first quarter of 2002). The subsequent solutions always begin one quarter later and end in the first quarter of 2002, i.e. at the end of the sample period on which the re-estimation was performed. Then the model is re-estimated again on the sample extended by one quarter in relation to the previous re-estimation, and the procedure of solving the model is repeated, always changing the starting point of the solution and leaving the last quarter included in a solution at the end of the sample, on which the re-estimation was made.

Thus a much larger number of observations are obtained. In-sample simulation errors are presented in figure Fig. 6.

**Fig. 6** In-sample forecast errors for inflation

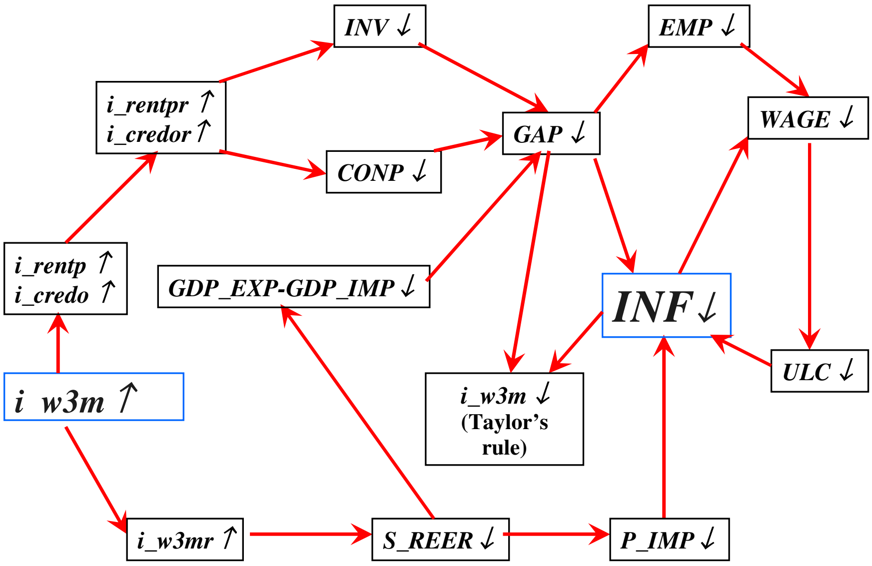



The forecast errors obtained concern a "raw" model solution, without experts' predictions. The lack of changes in the equations in the case of the forecast from the fourth quarter of 1999 does not provide for the structural changes that have occurred in Poland since that time. In the case of a large number of observations available in in-sample simulations, the impact of the "EU effect" is negligible, since it concerns only 23 observations out of 759 (3% of observations). However, the changes that took place in the first two years of the analysed period account for 64% of observations, and thus have a strong influence on the results. Considering the above, the errors obtained can be treated as quite low.

## 3.4 INTEREST RATE IMPULSE

Interest rates influence the economy in a number of ways. In the ECMOD model, the following transmission channels are distinguished: the interest rate channel (via the cost of credit and the cost of capital), the exchange rate channel and the asset channel. A simplified transmission mechanism is illustrated in Fig. 7.

**Fig. 7** Monetary transmission in the ECMOD model[45]




The monetary impulse has been defined as a rise in the short-term interest rate controlled by the central bank by 1 percentage point over its level in the baseline scenario and maintaining it at the increased level for eight quarters. A simulation has been conducted with an endogenous interest rate (with Taylor's Rule included). The results are presented in Tab. 5 and in Fig. 10.

In the short term, the growth of the interest rate results in decreased individual consumption due to higher interest rates on consumer loans and a decrease in investments due to the increased cost of capital. This entails a decrease in GDP, which induces a drop in employment. Additionally, wages decrease, which results in lower unit labour costs. Lower employment and lower growth lead to a higher general government deficit. Higher interest rates, through appreciation of the exchange rate, are also reflected in a decrease in exports, influencing the decline of GDP and import prices. Eventually, inflation declines in accordance with the above factors[46].

After the monetary impulse decays, due to lower inflation and lower demand, following the interest rate rule, the level of nominal and real interest rates drops below the baseline scenario. Eventually, this causes an upward movement in the growth rates of GDP components as well as wages and employment, to the level above the baseline

[45] Due to a large number of relations in the ECMOD model, the presented diagram of monetary transmission is simplified.
[46] Food and fuel price paths are the same in both scenarios, thus they have no impact on the results of their comparison.

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scenario, as well as a temporary growth in y/y inflation and its subsequent return to the baseline level.

## 3.5 EXCHANGE RATE IMPULSE

In the ECMOD model, the direct influence of the exchange rate on the economy is exerted in two ways. First, currency deprecation makes import prices grow and thus leads to higher CPI inflation. Second, the weakening of the zloty, through changes in relative prices, causes an improvement in the trade balance. The indirect impact on the economy has been presented in figure Fig. 8.

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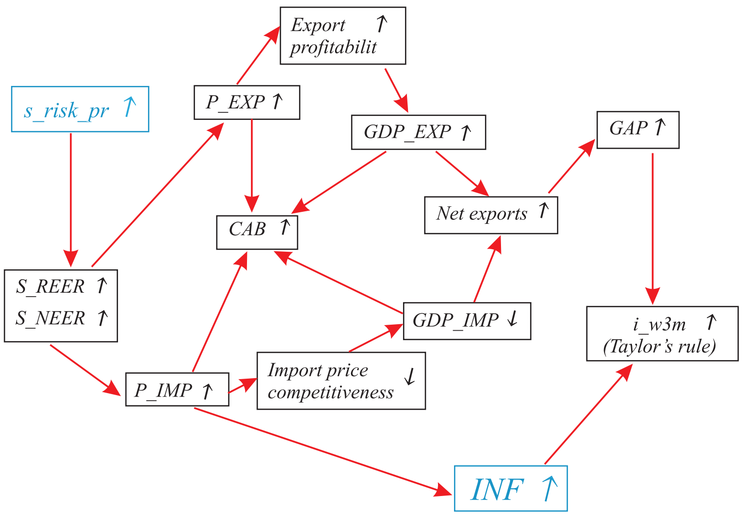
**Fig. 8** Exchange rate impulse in the ECMOD model[47]




The exchange rate impulse has been introduced into the ECMOD model in the following way - the model has been solved with the interest rate rule included. For the first eight quarters, the valuation of the FX risk premium in the second scenario has been increased by 1 percentage point in relation to the baseline scenario. For the remaining quarters, the risk premium has been determined at a similar level. The results, presented in Tab. 6 and in Fig. 11, are as follows.

In the short-term, after introducing the impulse, depreciation of the currency through an increase in exports and slightly lower imports both results in improved net exports and an improved current account balance. Moreover, due to higher import prices, growth of CPI inflation is in place. Higher demand and intensified inflation processes lead to increased interest rates, according to the interest rate rule.

[47] Due to a high number of interdependencies in the ECMOD model, the presented diagram of exchange rate transmission is simplified.

In subsequent quarters, higher interest rates cause a reduction in investment demand. After eight quarters, the return of the risk premium to its baseline level results in the return of the real exchange rate to its previous level. In the medium-term, the main macroeconomic variables, i.e. GDP and the CPI inflation, return to their baseline levels. The economy returns to its previous long-term development path, from which it was temporarily pushed off.

## 3.6 FISCAL IMPULSE

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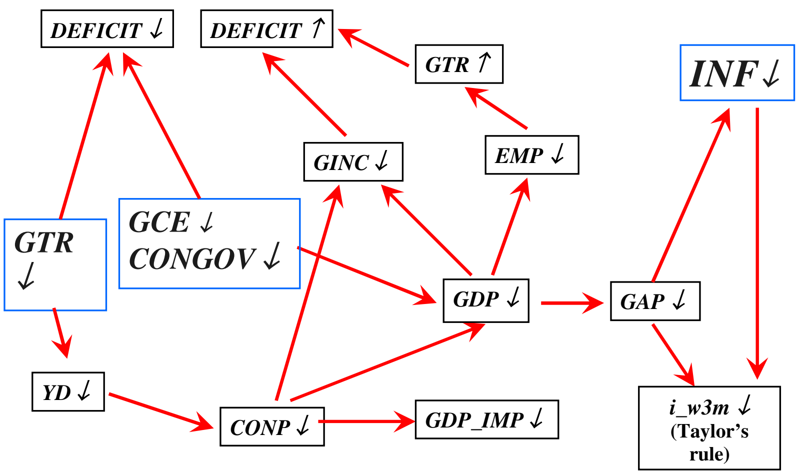
The fiscal impulse is defined as a decrease in specific categories of public expenditure — current expenditure, pension expenditure, unemployment benefits and other social expenditure, so that their total decrease equals 1% of GDP.

A decrease in current expenditure, which is reflected in a drop in collective consumption, has a direct impact on GDP, whereas a decrease in transfers influences the real economy through the channel of disposable income. The mechanisms of transmission are presented in the following figure.

**Fig. 9** Fiscal impulse in the ECMOD model[48]




It should be noted that a decrease in public expenditure by 1% of GDP does not necessarily mean an equivalent decrease in the general government deficit. This is due to the feedback mechanism between the fiscal sector and the real economy (Fig. 9). Results are presented in Tab. 7 and in Fig. 12.

Initially, a drop in government demand results in a GDP decrease. As a result of decreased transfers, individual consumption shrinks, which implies a further GDP

[48] Due to a high number of relations in the ECMOD model, the presented diagram of fiscal transmission has been simplified.

decrease and thus a reduction in the output gap. This results in lower inflation. Lower demand leads to decreased imports and, thus, an improved current account balance. Declining inflation, along with a negative output gap, according to the interest rate rule, leads to lower interest rates. As a result, there is a rebound in demand — both for investments and from consumers.

# 4
# Concluding Remarks

This paper presents a quarterly macroeconometric ECMOD model, constructed in order to forecast the main macroeconomic indicators and to perform simulation analyses for the Polish economy. ECMOD is a structural model in which short-term dynamics are conditioned upon demand; in the long-run, however, an important role is played by elements of the supply side of the economy.

This paper reviews the key equations of the macromodel by modules, and so it discusses the real sector, prices and costs, the external sector and the fiscal sector. Simulated reactions of the economy to standard impulses (the interest rate impulse, the exchange rate impulse and the fiscal impulse) are presented.

# 5
# Selected References

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5

**Tab. 5** Reaction of the economy to the interest rate impulse (deviation in % from the baseline scenario; in the case of y/y inflation and y/y GDP, deviation in percentage points)

| | Quarters | | | | | | | | | | | | Years | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 11 | 21 |
| CPI | -0.00 | -0.01 | -0.04 | -0.07 | -0.12 | -0.18 | -0.26 | -0.35 | -0.47 | -0.59 | -0.72 | -0.85 | -0.03 | -0.22 | -0.65 | -1.16 | -1.60 | -1.59 | -1.80 |
| Inflation y/y (CPI) | -0.00 | -0.01 | -0.04 | -0.07 | -0.12 | -0.16 | -0.22 | -0.28 | -0.35 | -0.41 | -0.46 | -0.50 | -0.03 | -0.19 | -0.43 | -0.51 | -0.44 | 0.17 | 0.03 |
| GDP | -0.03 | -0.06 | -0.13 | -0.20 | -0.28 | -0.36 | -0.45 | -0.55 | -0.61 | -0.65 | -0.65 | -0.63 | -0.11 | -0.41 | -0.64 | -0.48 | -0.25 | -0.01 | 0.05 |
| GDP growth rate y/y | -0.03 | -0.06 | -0.14 | -0.21 | -0.26 | -0.32 | -0.34 | -0.37 | -0.34 | -0.30 | -0.21 | -0.09 | -0.11 | -0.32 | -0.24 | 0.16 | 0.24 | -0.07 | 0.01 |
| Individual consumption | -0.05 | -0.10 | -0.14 | -0.19 | -0.25 | -0.31 | -0.36 | -0.43 | -0.44 | -0.44 | -0.42 | -0.40 | -0.12 | -0.34 | -0.43 | -0.30 | -0.16 | -0.01 | -0.04 |
| Investments | -0.02 | -0.07 | -0.16 | -0.28 | -0.43 | -0.60 | -0.79 | -1.00 | -1.20 | -1.37 | -1.48 | -1.54 | -0.13 | -0.71 | -1.40 | -1.44 | -0.95 | 0.14 | 0.28 |
| Exports | 0.00 | 0.00 | -0.07 | -0.16 | -0.24 | -0.31 | -0.37 | -0.43 | -0.48 | -0.53 | -0.49 | -0.40 | -0.06 | -0.34 | -0.48 | -0.08 | 0.25 | -0.20 | -0.02 |
| Imports | -0.05 | -0.09 | -0.16 | -0.21 | -0.27 | -0.31 | -0.35 | -0.40 | -0.39 | -0.34 | -0.27 | -0.19 | -0.13 | -0.33 | -0.30 | -0.01 | 0.09 | -0.09 | 0.04 |
| NEER | 0.00 | -0.64 | -0.83 | -1.00 | -1.14 | -1.27 | -1.40 | -1.51 | -1.63 | -1.09 | -0.64 | -0.29 | -0.62 | -1.33 | -0.91 | 0.11 | -0.22 | -2.06 | -2.01 |
| Export deflator | 0.00 | -0.29 | -0.43 | -0.55 | -0.65 | -0.75 | -0.84 | -0.93 | -1.03 | -0.84 | -0.64 | -0.48 | -0.32 | -0.79 | -0.75 | -0.36 | -0.77 | -1.95 | -1.97 |
| Import deflator | 0.00 | -0.42 | -0.55 | -0.67 | -0.77 | -0.86 | -0.96 | -1.05 | -1.15 | -0.81 | -0.55 | -0.35 | -0.41 | -0.91 | -0.71 | -0.21 | -0.66 | -1.98 | -1.98 |
| Nominal wages | -0.01 | -0.03 | -0.06 | -0.08 | -0.12 | -0.18 | -0.25 | -0.34 | -0.45 | -0.56 | -0.69 | -0.84 | -0.05 | -0.22 | -0.63 | -1.25 | -1.87 | -1.67 | -1.88 |
| Employed persons (BAEL) | -0.01 | -0.02 | -0.05 | -0.10 | -0.16 | -0.24 | -0.33 | -0.43 | -0.52 | -0.62 | -0.69 | -0.74 | -0.05 | -0.29 | -0.64 | -0.72 | -0.47 | 0.16 | 0.07 |
| Unit labour costs | 0.01 | 0.01 | 0.02 | 0.02 | -0.00 | -0.05 | -0.12 | -0.22 | -0.36 | -0.52 | -0.73 | -0.95 | 0.01 | -0.10 | -0.64 | -1.48 | -2.09 | -1.50 | -1.86 |
| Unemployment | 0.01 | 0.02 | 0.04 | 0.08 | 0.13 | 0.19 | 0.26 | 0.34 | 0.42 | 0.49 | 0.55 | 0.59 | 0.04 | 0.23 | 0.51 | 0.58 | 0.38 | -0.13 | -0.06 |
| General government deficit (% of GDP) | -0.01 | -0.02 | -0.04 | -0.07 | -0.10 | -0.14 | -0.18 | -0.23 | -0.26 | -0.29 | -0.33 | -0.37 | -0.04 | -0.17 | -0.31 | -0.39 | -0.28 | -0.02 | 0.01 |
| Public debt (% of GDP) | 0.08 | -0.22 | -0.10 | 0.08 | 0.37 | 0.71 | 1.08 | 1.64 | 2.14 | 3.18 | 3.97 | 4.85 | -0.04 | 0.95 | 3.54 | 6.40 | 8.27 | 5.97 | 3.38 |

Source: NBP calculations.

**Tab. 6** Reaction of the economy to the exchange rate impulse (deviation in % from the baseline scenario; in case of y/y inflation and y/y GDP, deviation in percentage points)

| | Quarters | | | | | | | | | | | | Years | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 11 | 21 |
| CPI | 0.06 | 0.09 | 0.12 | 0.15 | 0.19 | 0.24 | 0.29 | 0.34 | 0.39 | 0.44 | 0.49 | 0.53 | 0.10 | 0.26 | 0.46 | 0.61 | 0.67 | -0.02 | 0.15 |
| Inflation y/y (CPI) | 0.06 | 0.08 | 0.09 | 0.11 | 0.13 | 0.15 | 0.17 | 0.19 | 0.20 | 0.20 | 0.20 | 0.19 | 0.09 | 0.16 | 0.20 | 0.14 | 0.06 | -0.11 | -0.00 |
| GDP | 0.10 | 0.13 | 0.15 | 0.17 | 0.20 | 0.20 | 0.21 | 0.21 | 0.22 | 0.19 | 0.15 | 0.10 | 0.14 | 0.21 | 0.17 | -0.01 | -0.15 | -0.16 | 0.02 |
| GDP growth rate y/y | 0.10 | 0.12 | 0.11 | 0.11 | 0.10 | 0.08 | 0.07 | 0.04 | 0.02 | -0.01 | -0.07 | -0.11 | 0.11 | 0.07 | -0.04 | -0.18 | -0.15 | 0.05 | 0.00 |
| Individual consumption | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 | 0.00 | 0.00 | 0.00 | -0.00 | -0.00 | 0.00 | -0.02 | -0.06 | -0.16 | 0.03 |
| Investments | 0.01 | 0.01 | -0.00 | -0.02 | -0.04 | -0.08 | -0.12 | -0.18 | -0.24 | -0.32 | -0.40 | -0.49 | -0.00 | -0.11 | -0.37 | -0.71 | -0.96 | -0.10 | 0.16 |
| Exports | 0.23 | 0.30 | 0.35 | 0.39 | 0.42 | 0.43 | 0.44 | 0.44 | 0.43 | 0.41 | 0.32 | 0.22 | 0.32 | 0.43 | 0.34 | 0.01 | -0.15 | -0.12 | 0.00 |
| Imports | 0.03 | 0.01 | -0.00 | -0.03 | -0.04 | -0.08 | -0.11 | -0.15 | -0.17 | -0.23 | -0.28 | -0.32 | 0.00 | -0.09 | -0.25 | -0.37 | -0.37 | -0.10 | 0.10 |
| NEER | 1.09 | 1.17 | 1.21 | 1.23 | 1.24 | 1.22 | 1.21 | 1.20 | 1.19 | 0.55 | 0.37 | 0.25 | 1.18 | 1.22 | 0.59 | 0.19 | 0.42 | 0.16 | 0.10 |
| Export deflator | 0.63 | 0.69 | 0.73 | 0.76 | 0.77 | 0.78 | 0.79 | 0.80 | 0.82 | 0.55 | 0.43 | 0.36 | 0.70 | 0.79 | 0.54 | 0.34 | 0.52 | 0.02 | 0.15 |
| Import deflator | 0.73 | 0.79 | 0.82 | 0.84 | 0.85 | 0.85 | 0.85 | 0.85 | 0.87 | 0.46 | 0.36 | 0.30 | 0.80 | 0.85 | 0.49 | 0.30 | 0.51 | 0.03 | 0.15 |
| Nominal wages | 0.01 | 0.01 | 0.03 | 0.05 | 0.09 | 0.13 | 0.18 | 0.23 | 0.29 | 0.34 | 0.40 | 0.46 | 0.03 | 0.16 | 0.37 | 0.59 | 0.68 | -0.22 | 0.22 |
| Employed persons (BAEL) | 0.05 | 0.08 | 0.11 | 0.15 | 0.18 | 0.21 | 0.23 | 0.25 | 0.27 | 0.28 | 0.28 | 0.26 | 0.10 | 0.22 | 0.27 | 0.16 | -0.01 | -0.06 | -0.03 |
| Unit labour costs | -0.04 | -0.03 | -0.01 | 0.03 | 0.07 | 0.13 | 0.20 | 0.27 | 0.34 | 0.42 | 0.52 | 0.61 | -0.01 | 0.17 | 0.47 | 0.76 | 0.82 | -0.11 | 0.18 |
| Unemployment | -0.04 | -0.07 | -0.09 | -0.11 | -0.14 | -0.16 | -0.18 | -0.20 | -0.21 | -0.22 | -0.22 | -0.20 | -0.08 | -0.17 | -0.22 | -0.13 | 0.01 | 0.05 | 0.02 |
| General government deficit (% of GDP) | 0.01 | 0.02 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.10 | 0.09 | 0.08 | 0.09 | 0.10 | 0.03 | 0.08 | 0.09 | 0.08 | 0.01 | 0.02 | -0.00 |
| Public debt (%of GDP) | 0.23 | 0.14 | 0.04 | -0.10 | -0.30 | -0.46 | -0.63 | -0.84 | -1.07 | -1.68 | -1.84 | -2.01 | 0.08 | -0.56 | -1.65 | -2.20 | -2.13 | 1.27 | -0.13 |

Source: NBP calculations.

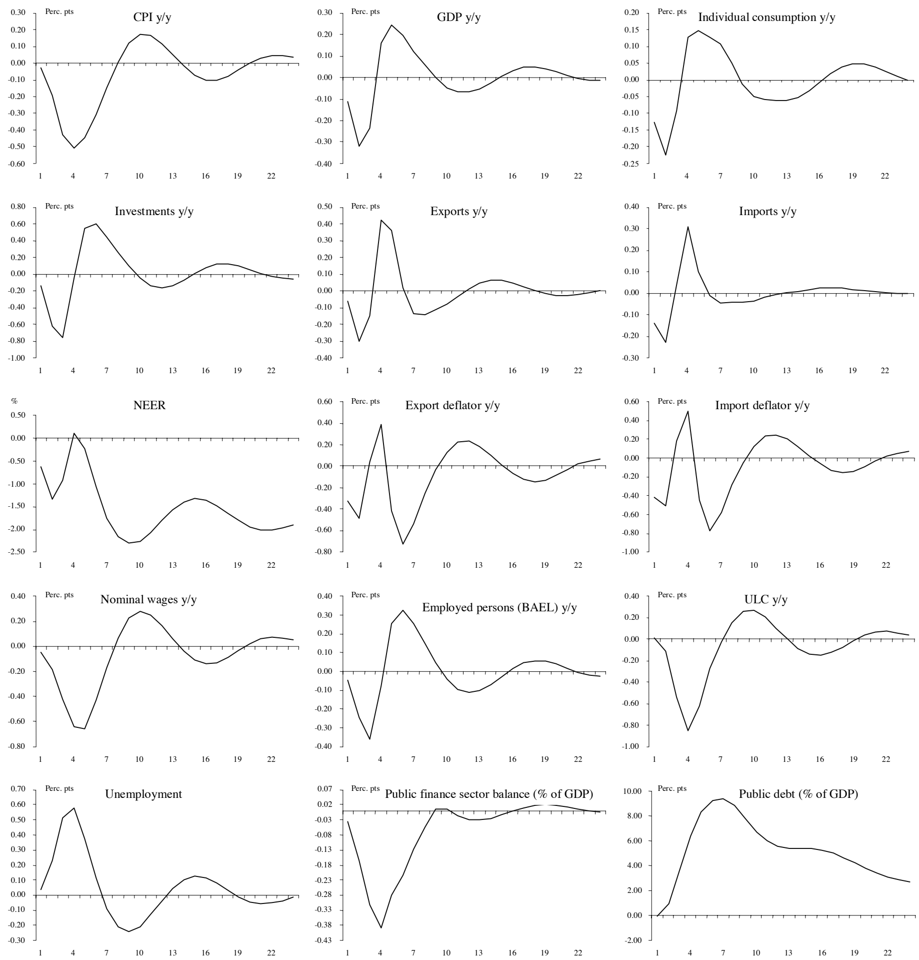
6

**Tab. 7** Reaction of the economy to the fiscal impulse (deviation in % from the baseline scenario; in the case of y/y inflation and y/y GDP, deviation in percentage points)

| | Quarters | | | | | | | | | | | | Years | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 11 | 21 |
| CPI | -0.01 | -0.05 | -0.09 | -0.15 | -0.21 | -0.31 | -0.42 | -0.53 | -0.64 | -0.76 | -0.88 | -0.98 | -0.07 | -0.37 | -0.82 | -1.22 | -1.47 | -0.56 | -0.91 |
| Inflation y/y (CPI) | -0.01 | -0.05 | -0.09 | -0.15 | -0.20 | -0.26 | -0.33 | -0.38 | -0.44 | -0.46 | -0.47 | -0.46 | -0.07 | -0.29 | -0.45 | -0.40 | -0.26 | 0.22 | 0.03 |
| GDP | -0.30 | -0.24 | -0.30 | -0.29 | -0.60 | -0.51 | -0.55 | -0.50 | -0.51 | -0.43 | -0.35 | -0.24 | -0.28 | -0.54 | -0.38 | -0.06 | 0.22 | 0.42 | 0.35 |
| GDP growth rate y/y | -0.32 | -0.25 | -0.31 | -0.31 | -0.31 | -0.29 | -0.27 | -0.22 | 0.10 | 0.09 | 0.21 | 0.28 | -0.30 | -0.27 | 0.17 | 0.34 | 0.29 | -0.10 | -0.02 |
| Individual consumption | -0.05 | -0.11 | -0.17 | -0.23 | -0.30 | -0.36 | -0.41 | -0.46 | -0.44 | -0.38 | -0.29 | -0.19 | -0.14 | -0.38 | -0.33 | 0.09 | 0.53 | 1.50 | 1.39 |
| Investments | -0.01 | 0.00 | 0.01 | 0.04 | 0.07 | 0.14 | 0.22 | 0.32 | 0.45 | 0.61 | 0.78 | 0.95 | 0.01 | 0.19 | 0.70 | 1.38 | 1.93 | 1.25 | 0.95 |
| Exports | 0.00 | 0.00 | 0.01 | 0.02 | 0.04 | 0.07 | 0.11 | 0.16 | 0.22 | 0.27 | 0.33 | 0.37 | 0.01 | 0.10 | 0.30 | 0.43 | 0.39 | 0.11 | 0.32 |
| Imports | -0.48 | -0.32 | -0.38 | -0.34 | -0.80 | -0.58 | -0.60 | -0.49 | -0.48 | -0.33 | -0.23 | -0.07 | -0.38 | -0.62 | -0.28 | 0.11 | 0.35 | 0.54 | 0.27 |
| NEER | 0.00 | 0.07 | 0.14 | 0.22 | 0.30 | 0.45 | 0.54 | 0.61 | 0.64 | 0.64 | 0.56 | 0.42 | 0.11 | 0.48 | 0.57 | -0.14 | -1.16 | -1.60 | -1.28 |
| Export deflator | 0.00 | 0.04 | 0.07 | 0.11 | 0.14 | 0.21 | 0.24 | 0.25 | 0.23 | 0.19 | 0.10 | -0.03 | 0.06 | 0.21 | 0.12 | -0.48 | -1.25 | -1.01 | -1.02 |
| Import deflator | 0.00 | 0.05 | 0.10 | 0.15 | 0.19 | 0.28 | 0.32 | 0.34 | 0.33 | 0.29 | 0.19 | 0.05 | 0.07 | 0.28 | 0.21 | -0.44 | -1.27 | -1.08 | -1.05 |
| Nominal wages | -0.13 | -0.15 | -0.20 | -0.23 | -0.40 | -0.46 | -0.56 | -0.64 | -0.75 | -0.84 | -0.94 | -1.03 | -0.18 | -0.52 | -0.89 | -1.27 | -1.52 | -0.00 | -0.65 |
| Employed persons (BAEL) | -0.07 | -0.13 | -0.19 | -0.25 | -0.36 | -0.46 | -0.54 | -0.60 | -0.64 | -0.65 | -0.64 | -0.59 | -0.16 | -0.49 | -0.63 | -0.43 | -0.10 | 0.11 | 0.07 |
| Unit labour costs | 0.10 | -0.05 | -0.09 | -0.19 | -0.17 | -0.41 | -0.54 | -0.73 | -0.88 | -1.06 | -1.22 | -1.38 | -0.06 | -0.46 | -1.14 | -1.64 | -1.84 | -0.31 | -0.93 |
| Unemployment | 0.06 | 0.10 | 0.16 | 0.20 | 0.29 | 0.36 | 0.43 | 0.48 | 0.51 | 0.52 | 0.51 | 0.47 | 0.13 | 0.39 | 0.50 | 0.34 | 0.08 | -0.09 | -0.06 |
| General government deficit (% of GDP) | 0.63 | 0.62 | 0.59 | 0.57 | 0.87 | 0.85 | 0.81 | 0.79 | 0.30 | 0.17 | 0.07 | 0.02 | 0.60 | 0.83 | 0.14 | 0.04 | 0.09 | -0.03 | 0.00 |
| Public debt (% of GDP) | 0.50 | -0.38 | -0.52 | -1.16 | -0.60 | -1.57 | -1.72 | -2.58 | -2.35 | -2.41 | -2.29 | -2.39 | -0.39 | -1.62 | -2.36 | -2.22 | -2.55 | -5.60 | -2.35 |

Source: NBP calculations.

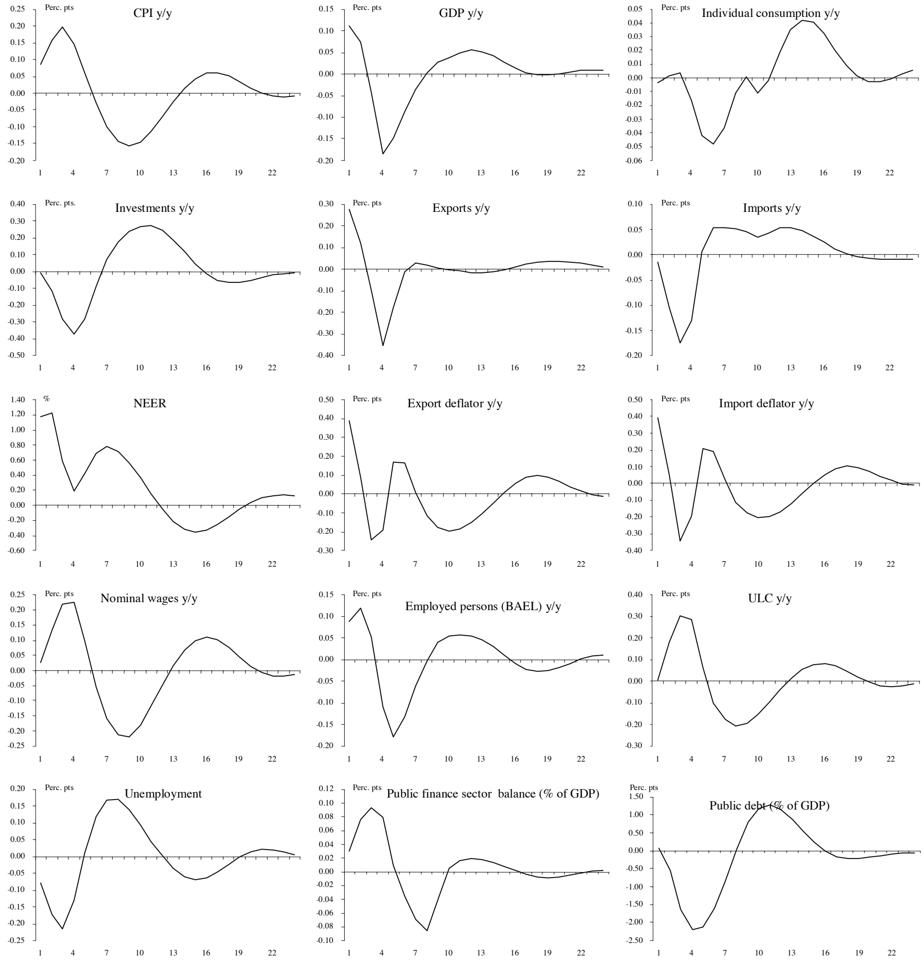
**Fig. 10**. Reaction of the economy to the interest rate impulse




Source: NBP calculations.

Description: The monetary impulse is defined as a rise in the short-term interest rate by 1 percentage point for a period of 8 quarters. The simulation has been conducted with an endogenous interest rate (with Taylor’s Rule included) and with the fiscal policy rule included.

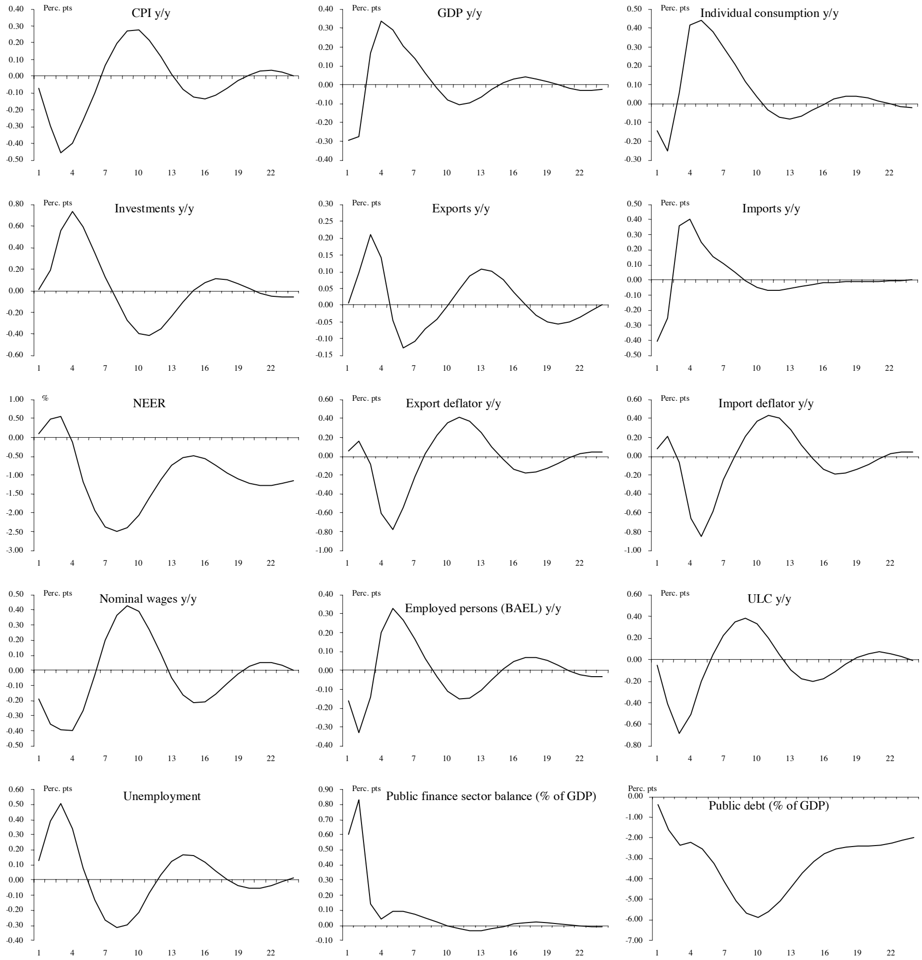
**Fig. 11.** Reaction of the economy to the exchange rate impulse




Source: NBP model.

Description: The exchange rate impulse is defined as a rise in the FX risk premium by 1 percentage point for a period of 8 quarters. The simulation has been conducted with an endogenous interest rate (with Taylor's Rule included) and with the fiscal policy rule included.

**Fig. 12**. Reaction of the economy to the fiscal impulse




Source: NBP models.

Description: The fiscal impulse is defined as a fall, for a period of 8 quarters, in a few categories of public spending — current expenditures, pension spending, unemployment benefits and other social expenditures - so that their total drop equals 1% of GDP. The simulation has been conducted with an endogenous interest rate (with Taylor's Rule included) and with the fiscal policy rule included.

## Annex 2. "Model-experts" iteration method

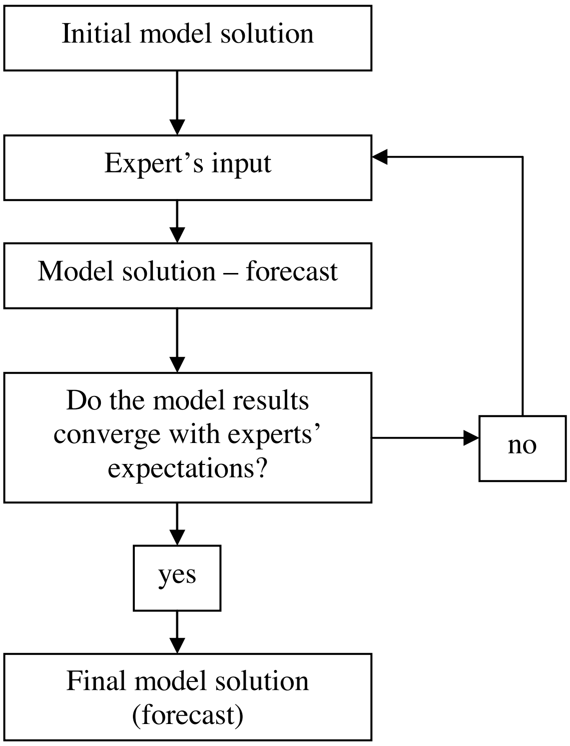
In forecasting, there are two methods of compiling information from the model and information from experts' judgements: the iteration method and the weighted method. In the process of forecast preparation, the method of model-experts iteration is used. This refers to the variables in the case of which there are difficulties in estimating a fully satisfying equation - a special case here is the investment equation.

An expert, having studied forecast results, may propose a correction of the investment path. His or her information is used to make relevant changes to the constant in the investment equation. The model is solved again, with the changed equation. The results are presented to the expert and the correction procedure is repeated, until obtaining the convergence of the expert's judgement with the results generated by the model[49].

Thus the final forecast is a result of co-operation of the authors of the ECMOD model and experts. The co-operation principles guarantee that the mechanism of interdependencies within the model remain intact, and at the same time external information is taken into account (the expert adjusts the constant values in the model equations), the forecast retains its internal cohesion (the model is thus prevented from a loss of cohesion between the model-generated and the expert-corrected variables), and the comparability of various forecasts or simulations is preserved (constant values that represent corrections of experts are used to determine all forecast variants).



[49] In contrast to the iteration method, the weighted method forecast is generated by combining two independent forecasts (model forecast and expert forecast) with appropriate weights.


Initial model solution
Expert's input
Model solution – forecast
Do the model results converge with experts' expectations?
no
yes
Final model solution (forecast)

## Annex 3. Long-term equilibrium

The approach of the cointegration analysis used in the ECMOD model enables us to distinguish between the short-term and the long-term behaviour of macrocategories. In order to examine strictly long-term properties of the model, the model has been analysed without considering in behavioural equations the part responsible for the short-term dynamics.

The analysis should take into account the monetary policy rule and the fiscal policy rule[50], which help to achieve stabilisation in inflation, the output gap and the general government balance in relation to GDP. These variables influence both the nominal sector and the real sector of the economy. It is assumed that, in the long-term, Poland's economy will achieve complete convergence with the euro area economies. It implies the assumption of equal dynamics of potential product in Poland and abroad as well as the equal growth rate of the GDP deflator in Poland and abroad.

Let us analyse the nominal variables in the model. The assumed equal dynamics of the GDP deflator in Poland and abroad, while domestic interest rates remain stable (interest rates stabilise when the economy achieves long-run equilibrium), contribute to the stabilisation of the disparity between Polish and foreign interest rates. A constant disparity in interest rates, combined with the assumed equal dynamics of potential products and GDP deflators in Poland and abroad, leads to the stabilisation of the real exchange rate. The nominal exchange rate grows at a steady rate, determined by GDP deflators. Exchange rate stability, combined with stable growth of the GDP deflator in Poland, leads to a stable growth rate of import and export prices equal to the GDP deflator growth rate. Due to changes in interest rates, triggered by the reaction of the monetary policy rule, inflation stabilises. This is additionally supported by the equilibrium (described below) achieved in the real economy. Stable growth of nominal wages results from the stable growth of labour productivity and stable inflation growth. Thus, long-term equilibrium in the nominal sector of the economy is achieved.

In the real economy, gross domestic product is the most important variable. The long-run growth path of the gross domestic product in line with the adopted production function results from the assumed dynamics of the total factor productivity (exogenous variable). In the long-term, an assumption has been made with regard to the equalisation of the marginal product of capital with the real cost of capital to the user[51] (the relation is included in the investment equation). We additionally assume that the supply of

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[50] The rules are described in sections 3.1 and 3.2.
[51] The relation complies with the theory describing fixed asset formation in the neoclassical model.

labour is determined by the labour force[52] adjusted for the NAWRU. Thus, the potential product's growth is determined and GDP growth adopts itself to the potential products dynamics.

The steady state is achieved partly due to the monetary policy rule, which — through adjustments in the output gap — leads to changes in the levels of consumption and investments, until reaching a constant growth rate. In the general government module automatic stabilisers exert an anti-cyclical influence, thus helping to achieve steady growth. At the same time, the fiscal rule ensures the stabilisation of the relation of the general government balance to GDP and — by changes in the costs of debt service —the stability of public debt.

Stable growth of import and export prices as well as assumptions concerning the GDP deflator and the determined growth of the potential product determine a constant growth rate for exports and imports that is equal to the growth of the potential and thus the growth of the Gross Domestic Product. This entails stabilisation of the share of net exports in GDP (one of the components of the domestic product). As a result, the growth of the current account equals GDP growth. This, in turn, leads to stable growth of net foreign assets.

Equilibrium of the general government (presented above) results in the same growth of both public revenues and expenditures as GDP growth (by maintaining a stable balance to GDP ratio). This has a direct impact on determining the growth of collective consumption at the level of public expenditure growth, i.e. at the level of growth in Gross Domestic Product. This means a constant share of collective consumption (another GDP component) in GDP.

Stabilisation of capital growth (at the GDP growth rate), public debt (at the GDP growth rate) and the balance of foreign assets (at the GDP growth rate) leads to a constant wealth growth rate (i.e., a constant share of wealth in GDP). Stable growth in disposable income (equal to the GDP growth rate, since it is determined by growth in public revenues and expenditures and growth in real wages), combined with stable growth in wealth, leads to steady increases in individual consumption, equal to the GDP growth rate. Thus, we have shown that the dynamics of all GDP components, i.e. net exports, collective consumption, individual consumption and investments (through the capital relationship described above) stabilise at the level of GDP dynamics. This also entails the stability of individual components in gross domestic product.

[52] We assume that the labour force remains stable in the long-term.

**Annex 4. Cointegration analysis**

Equations in the paper are presented in the form of error correction models (small letters indicate variables in logarithms). Every equation enables us to read both long-term relations and short-term dynamics:

(i) long-term relation corresponds to the relation in parentheses concerning of variable levels,

(ii) short-term dynamics are illustrated with other variables (these are usually variables in first differences, since the variables are non-stationary in most cases).

This annex presents analysis of cointegration and the essence of the error correction models. The discussion is based on R. Engle and C. Granger (1987), Cointegration and Error Correction: Representation, Estimation, and Testing, *Econometrica*, vol. 55, pp. 251-276.

Process $\{x_t\}$ is wide-sense stationary if three conditions are met:

$$E(x_t) = \mu \text{ for } t=1,2,... \qquad \text{(V.1a)}$$

$$Var(x_t) = \sigma^2 \text{ for } t=1,2,... \qquad \text{(V.1b)}$$

$$Cov(x_t, x_{t-k}) = \sigma_k \text{ for } t=1,2,... \text{ and } k=1,2,... \qquad \text{(V.1c)}$$

The first two conditions mean that the expected value and the variance of the process $\{x_t\}$ are constant over time. Condition (1c) indicates that the co-variance between two variables $x_t$ and $x_{t-k}$ is determined only by the distance $k$, and not by the choice of the time $t$. The stationary process is said to be integrated of order 0, noted $x_t \sim I(0)$. In the event that processs $\{x_t\}$ does not meet the conditions (V.1a)-(V.1c), and the series in the first differences $\{\Delta x_t\}$, where $\Delta x_t = \Delta^{(1)} x_t = x_t - x_{t-1}$, is stationary, process $\{x_t\}$ is said to be non-stationary, integrated of order 1, which is recorded as $x_t \sim I(1)$.

<u>Definition of cointegration</u>

Two one-dimensional processes $x_t$ and $y_t$ are cointegrated of order $d$, $b$, which is recorded as $(x_t, y_t) \sim CI(d,b)$, if two conditions are met. First, each process is integrated of order d, i.e. $x_t \sim I(d)$ and $y_t \sim I(d)$. Second, there exists a cointegrating vector $[\alpha_1 \quad \alpha_2]^T \neq [0 \quad 0]^T$ so that the process $\{u_t\}$, where

$$u_t = \alpha_1 x_t + \alpha_2 y_t \qquad \text{(V.2)}$$

is integrated of order *d-b*, i.e. $u_t \sim I(d-b)$, $b>0$. Since a large part of economic time series is integrated of order 1, the econometric model for $b=d=1$ is particularly interesting. In this case, the existence of a cointegrating relation implies that, for the system of the analysed variables, there is a precisely specified long-term equilibrium, derived from the cointegrating relation (i.e. when $u_t = 0$). When there is a disturbance leading to deviation from the equilibrium (i.e. when $u_t \neq 0$), the system automatically returns to the level determined by the cointegrating relation (hence, the cointegrating relation is also called a long-term relationship).

The above mentioned automatic return of the system to the level determined by the long-term relationship was recorded in mathematical form by Engle and Granger (1987), who proposed the following model[53]:

$$\begin{bmatrix} \Delta y_t \\ \Delta x_t \end{bmatrix} = \sum_{k=1}^{K} \mathbf{A}_k \begin{bmatrix} \Delta y_{t-k} \\ \Delta x_{t-k} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \end{bmatrix} \begin{bmatrix} \alpha_1 & \alpha_2 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}, \tag{V.3}$$

where $[\varepsilon_{1t} \quad \varepsilon_{2t}]^T$ is a two-dimensional random component with variance $\mathbf{\Sigma}$, and the moduli of eigenvalues of matrix $\mathbf{A} = \sum_{k=1}^{K} \mathbf{A}_k$ are less than one. In accordance with the (V.3) specification, the dynamics of the *i*- variable (*i*=1,2) of vector $[\, x_t \quad y_t \,]^T$ depend on past vector changes $[x_t \quad y_t]^T$ and on the product of the adjustment parameter $\delta_i$ and system deviation from the level given in the long-term (cointegrating) relationship in time *t*-1. For $\boldsymbol{\delta} = [\delta_1 \quad \delta_2]^T \neq \mathbf{0}$ the deviation is adjusted through the impact on current changes in the vector $[\, x_t \quad y_t \,]^T$. This phenomenon has been named in the econometric literature as the error correction mechanism. The relation given in equation (V.3) describes current dynamics of the vector $[\, x_t \quad y_t \,]^T$, and therefore it is frequently called a short-term relationship.

**Annex 5. Definitions of variables**

**Endogenous variables**

AVGBENEFIT_N — average quarterly amount of benefit from the Labour Fund per unemployed person (equation E. 55),

AVGPENSION_N — average amount of retirement and disabled pension benefits (equation E. 59),

[53] A case of two variables.

6

AVGRELIEF_N — average quarterly amount of social benefits (equation E. 57),

CAB — current account balance in zloty (equation E. 24),

CAB_INC — balance of revenues (equation E. 28),

CAB_NT — balance of goods and services (equation E. 25),

CAB_TRANS — balance of transfers,

CONP — individual consumption (equation **E. 7**),

CONP_N — nominal individual consumption,

CPI — consumer price level in period $t$ (**E. 13**),

$CPI^e$ — expected inflation,

EMP — number of employees in thousands, by BAEL (equation **E. 4**),

FINACC — share of enterprises' disposable income[54] in national disposable income,

FINV — gross fixed capital formation (equation E. 11)

GAP — output gap (equation E. 6)

GCE_N — current government spending, comprising purchases of non-investment goods (about 30% of total expenditure) and wagefund (about 70% of total expenditure) (equation E. 52),

6

GCIT_N — corporate income tax revenues (equation E. 42),

GCT_N — real estate tax revenues (equation E. 49),

GDEBT_N — nominal volume of public debt (equation E. 65),

GDEF_N — general government balance (equation E. 64),

GDP — Gross Domestic Product (equation E. 1),

GDP_EXP — exports of goods and services in constant prices, according to the national accounts (equation E. 31),

GDP_EXP_N — nominal value of exports of goods and services, according to the national accounts (equation E. 26),

GDP_IMP — volume of imports of goods and services, according to the national accounts (equation E. 32),

GDP_IMP_N — nominal value of imports of goods and services, according to the national accounts (equation E. 27),

GDP_N — nominal GDP value,

GDP_POT — potential GDP (equation E. 5)

[54] By the term "enterprises" we understand two institutional sectors, distinguished in the national accounts: the enterprise sector and the sector of financial institutions .

GDS_N — costs of debt service (equation E. 60),

GEXP_N — general government expenditures (equation E. 51),

GEXT_N — excise tax revenues (equation E. 39),

GGAM_N — gaming tax revenues (equation E. 40),

GIDT_N — indirect tax revenues (equation E. 37),

GINC_N — general government revenues (equation E. 36),

GINV_N — public investment (equation E. 61),

GLT_N — revenues from health and social insurance contributions (equation E. 43),

GLT_CORP_N — social insurance contributions paid by employers (equation E. 45),

GLT_EMP_N — social insurance contributions paid by employees (equation E. 44),

GLT_HC_N — health insurance contributions (equation E. 47),

GLT_SB_N — social insurance contributions paid by business owners and freelance professionals (equation E. 46),

GPIT_N — personal income tax revenues (equation E. 41),

GRE_N — other expenditures (equation E. 63),

GRT_N — other revenues (equation E. 50),

GTAR_N — customs revenues (equation E. 48),

GTR_CORP_N — subsidies to enterprises (equation E. 62),

GTR_N — transfers to the population (social benefits, unemployment benefits, pensions) (equation E. 53),

GTR_RELIEF_N — transfers from social welfare (equation E. 56),

GTR_RETIRED_N — pension transfers (equation E. 58),

GTR_UNEMP_N — unemployment benefits (equation E. 54),

GVAT_N — value-added tax revenues (equation E. 38),

I_RENTP — average quarterly value of the average weighted interest rate on loans to enterprises from commercial banks (E. 23),

I_W3M — quarterly nominal average value of WIBOR3M (equation E. 66),

I_W3MR_CPI — quarterly real average value of WIBOR3M deflated by the CPI,

I_W3MR_PGDP — GDP-deflated real WIBOR 3M,

I3MR_EXT — GDP-deflated real foreign 3M rate (equation E. 19),

INF — CPI inflation (equation E. 13),

INV — gross capital formation

K — average capital KEP in the period (equation E. 3),

KEP — capital stock at the end of the period, equel to cumulated investment value (equation E. 2),

NETCPI — index of the core inflation price level, net of food and fuel prices (E. 12

NFA — net foreign assets (equation E. 29),

P_EXP — export deflator according to the national accounts (equation E. 33),

P_IMP — import deflator according to the national accounts (equation E. 35),

$P\_IMP^*$ — import prices adjusted for customs duties and import taxes (in effect until the mid-90s): $P\_IMP^*$=P_IMP*(1+podatek imp.*cło),

P_IMP_NOIL — import deflator according to the national accounts, adjusted for oil price movements (equation E. 34),

PGDP — GDP deflator (equation E. 15),

RUCC — real cost of capital (interest rates on loans to enterprises, GDP-deflated, adjusted for capital depreciation and corporate income taxes),

S_EUR_PLN — nominal PLN/EUR exchange rate — growth denotes zloty depreciation (equation E. 22),

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S_NEER — nominal effective PLN exchange rate — growth denotes zloty depreciation (equation E. 20),

S_REER — real effective PLN exchange rate (weights Tab. 2) — growth denotes zloty depreciation (equation E. 18),

S_USD_PLN — nominal PLN/USD exchange rate (equation E. 21),

ULC — unit labour costs,

UNEMP — BAEL unemployment rate,

WAGE — average monthly wage in nominal terms (adjusted for the transition to gross wages in 1999 — equation E. 16),

WAGEFUND_N — nominal quarterly wage fund in the economy,

WEALTH — wealth,

YD — disposable income,

YD_N — nominal gross disposable income (equation E. 8),

YD_NO — nominal operational surplus of the households' sector (equation E. 9),

YD_WL — nominal property income in households' sector (equation E. 10),

YD_POZOSTALE — other disposable income.

**Exogenous variables**

CGNBP_N — NBP profit transfer,

CONGOV — collective consumption,

DEPR — quarterly depreciation rate,

dl — dummy variable, quantifying the impact of the growth rate of the "net" core inflation price index higher than the GDP deflator price index,

FOOD_CPI — food and alcohol price level,

FUEL_CPI — fuel prices for private means of transport,

GCIT_TR — effective CIT rate,

GCT_TR — effective real estate tax rate,

GDEBT_EUR — share of euro-denominated debt in total debt,

GDEBT_IR — effective interest rate of public debt,

GDEBT_PL — share of domestic debt in public debt,

GDP_EXT — weighted GDP level for Poland's major trading partners (weights Tab. 2),

GDP_EXT_POT — weighted potential GDP abroad (weights Tab. 2),

GEXP_UE_N — contribution to the EU budget,

GEXT_TR — effective excise tax rate,

GGAM_TR — effective gaming tax rate,

GINC_UE_N — special cash-flow facility from the EU budget,

GLT_CORP_TR — effective rate of revenues from social contributions paid by employers,

GLT_EMP_TR — effective rate of revenues from social contributions paid by employees,

GLT_HC_TR — effective rate of revenues from health insurance contributions,

GLT_SB_TR — effective rate of revenues from social contributions paid by business owners and freelance professionals,

GPIT_TR — effective PIT rate,

GPRIV_N — revenues from privatisation (adjusted for compensation from the budget),

GTAR_TR — customs duty effective rate,

GVAT_TR — VAT effective rate,

I3M_EXT — weighted nominal M interest rate abroad (weights in Tab. 2), INF_CEL — inflation target (i.e. 2,5%),

LF — labour force in thousands, according to BAEL,

NAWRU — Non-Accelerating Wage Rate of Unemployment

OIL — world oil prices in US dollars,

PGDP_EXT — weighted (weights in Tab. 2) GDP deflator abroad,

RETIRED — number of pensioners,

S_RISK_PR — valuation of risk premium,

S_USD_CZK — nominal CZK/USD exchange rate,

S_USD_EUR — nominal EUR/USD exchange rate — growth denotes depreciation of the euro,

S_USD_GBP — nominal GBP/USD exchange rate,

S_USD_SEK — nominal SEK/USD exchange rate,

TFP — total factor productivity,

TR_WPR_CON — revenues obtained within the Common Agricultural Policy, allocated for consumption.