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Methodology and main features of the NEMPF model

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The New Econometric Model of Public Finance (NEMPF) is a hybrid model in which long-term properties are largely consistent with theoretical models, while short-term properties are identified using information derived from the time series data. The model incorporates several concepts from the European Central Bank's AWM model (Fagan et al., 2005), particularly in the specification of the macroeconomic equations block (see below for details).

Analysis of time series of the variables included in the NEMPF leads, in almost all cases, to the conclusion that the underlying data-generating processes are non-stationary. Therefore, the main econometric approach used there is the cointegration analysis, which enables the identification and quantification of long-run relationships toward which the variables converge after they have been displaced from the equilibrium by shocks. The selected approach to estimating causal equations in such a case takes the form of the error correction model (ECM) framework:

$$\Delta y_t = ECT_y(y_{t-1} - \delta_1 x_{1,t-1} - \cdots - \delta_L x_{L,t-1}) + \gamma_1 \Delta x_{1,t} + \cdots + \gamma_L \Delta x_{L,t} + \varepsilon_t$$

where ECT_y is the error-correction parameter, and γ_l denotes the short-run parameters; ε_t is the random component, with $\varepsilon_t \sim iid(0, \sigma^2)$. For simplicity, the above example of ECM model assumes only one lag, and other variables that may affect Δy_t in the short run are omitted. The bracketed term captures deviations from the long-run equilibrium defined by a cointegrating relationship that is stable over time:

$$y = \delta_1 x_1 + \cdots + \delta_L x_L$$

where $x_1, \ldots, x_L$ denote the determinants of the dependent variable y, while δ_l is the long-run parameter. Equilibrium equations are most often constructed under the assumption of long-run homogeneity (formally tested), which implies that the elasticities of the main explanatory variables sum to one.

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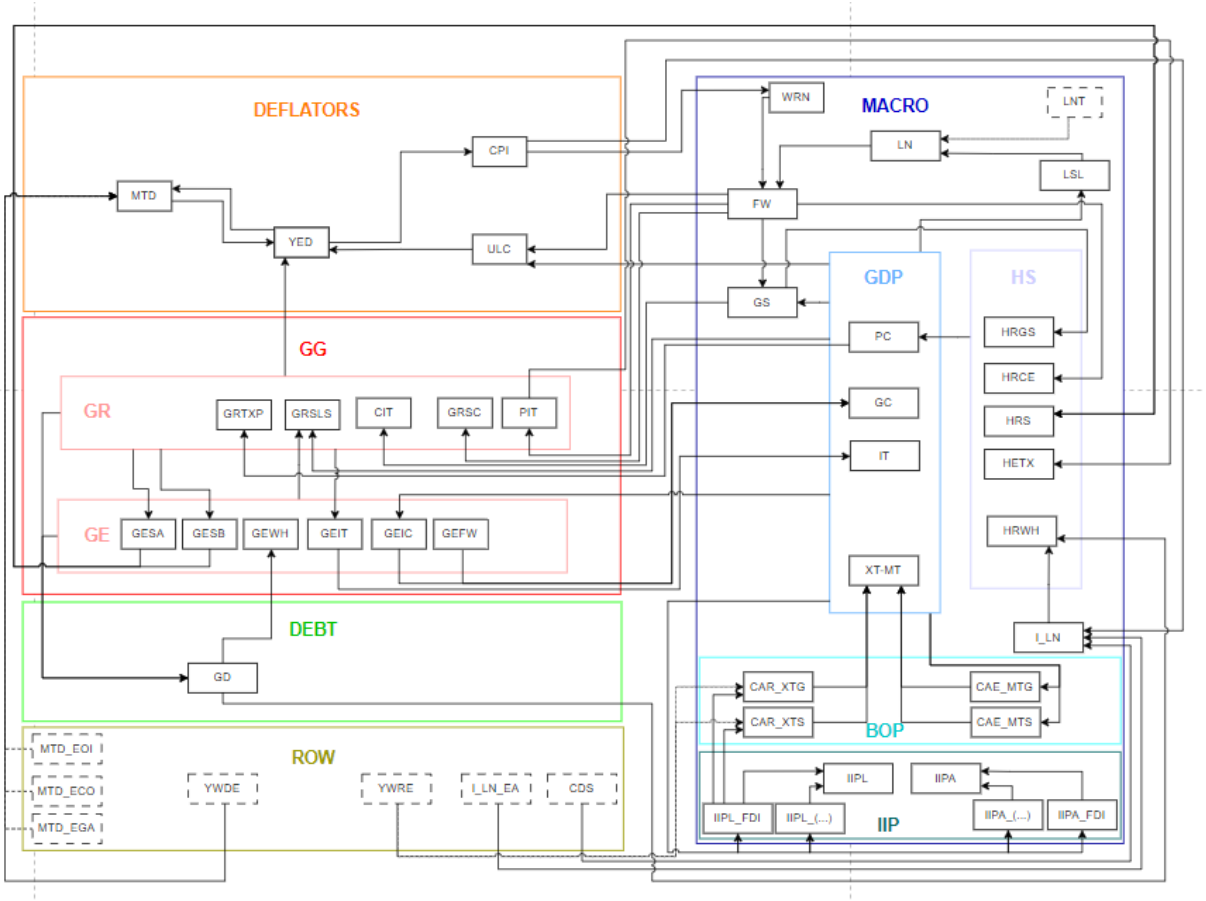
The solution to the problem of estimating the parameters $\delta_1, \ldots, \delta_L$ and $\gamma_1, \ldots, \gamma_1$ is based on Johansen's procedure (1988, 1995), followed by Juselius (2006) recommendation to integrate submodels into a complete system of equations. Therefore, the main approach to estimating behavioural equations is the vector error correction model (VECM).

According to the assumptions and purpose, the NEMPF is a model in which – unlike the vast majority of traditional macromodels – the fiscal block describing the general government (GG) sector's revenues and expenditures, as well as the sector's linkages with other spheres of the economy, is separated and expanded with a high degree of detail. The complexity of linkages between the GG sector and other sectors of the economy makes the fiscal multiplier in the NEMPF as important as the consumption multiplier and accelerator, which are typically included. A diagram illustrating the linkages between the key macroeconomic and fiscal variables in the model is presented in Figure 1.

Figure 1. The blocks of the NEMPF model, main variables and linkages between them.



**Framing the variable name with a dashed line distinguishes exogenous variables.*

Legend: MTD – import deflator, YED – GDP deflator, CPI – consumer price index, ULC – unit labour cost, GR – government revenues, GRTXP – taxes on production and imports, GRSLS - market output and output for own final use of the GG sector, CIT – corporate income tax, GRSC – social security contribution, PIT – personal income tax, GESA – social assistance, GESB – social benefits, GEWH - debt servicing cost, GEIT – public investment, GEIC – intermediate consumption in the GG sector, GEFW – compensation of employees in the GG sector, GD – public debt, MTD_EOI – global oil prices, ROW – rest of the world,

MTD_ECO –global coal prices, EGA – global gas prices, YWDE – deflator in the EA, YWRE – GDP in the EA, I_LN_EA – long-term interest rate in the EA, CDS – credit default swaps, WRN – compensation of employees (total economy), LNT – labor supply, LSL – labor demand, LN – number of employees, FW – wage fund in the total economy, GS – gross operating surplus, PC – private consumption, GC – government consumption, IT – total investment, XT – exports, MT – imports, HS – households, HRGS – gross operating surplus (received by the HS), HRCE – compensation of employees, HRS – social assistance & benefits, HETX – income taxes paid by the HS, HRWH – property income, I_LN – long-term interest rate, BOP – balance of payments, CAR – current account (revenues), CAE – current account (expenditure), XTG/S – exports of goods/services, MTG/S – import of goods/services, IIP – international investment position.

In particular, accurate accounting for GG sector revenues required the model to include separate blocks of equations describing the formation of household budgets (e.g. income and property taxes and social security contributions), corporate profits (subject to corporate income tax – CIT), and aggregate demand as well as its structure, which affect revenues from value-added tax (VAT) and excise duties.

Similarly, a precise accounting of GG sector expenditures required not only distinguishing the volume of public consumption (which depends mainly on public sector labor costs and intermediate consumption), but also taking into account social benefits and social assistance received by households, the mechanisms determining GG investment expenditures (EU and domestically funded), and debt servicing costs, including those related to the foreign debt.

Full representation of the causal feedbacks described above, and in particular the adequately detailed heterogeneous fiscal multiplier mechanism, determined the relatively large size of the model. The NEMPF consists of 267 equations forming blocks: prerecursive (57 equations), simultaneous (98 equations) and postrecursive (112 equations). This version of the model was estimated using quarterly data covering the period from Q1 1995 to Q4 2022.

In the block of simultaneous equations, 6 feedback (key endogenous) variables can be identified:

- taxes on production and imports (GRTXP),
- GG sector investment (GEIT),
- aggregate effective tax rate (R_TXP),
- value added deflator (YFD, i.e. a tax-adjusted GDP deflator),
- number of employees in the economy (LN),
- real gross domestic product (YER).

The number of feedback variables reflects the complexity of the system, and their features confirm the interaction of the consumption multiplier, the accelerator, the fiscal multiplier and the wage-price spiral. From an economic perspective, the NEMPF can be distinguished by blocks of equations describing:

- aggregate supply, capital formation mechanism and labor market,

- demand, broken down into its main components,
- household budgets,
- prices and wages,
- exchange rates and interest rates,
- the balance of payments and net foreign assets,
- GG sector revenues,
- GG sector expenditures,
- GG sector balance and debt.

The exogenous variables (external assumptions) in the NEMPF are mainly relate to:

- demographics (population, labor supply),
- foreign markets (GDP and prices developments in the euro area and the US, foreign interest rates, and financial instruments such as CDS),
- commodity prices (oil, natural gas, coal) and imported food prices,
- minor fiscal components (e.g. small revenues with short time-series).

These assumptions mainly affect variables linked to prices, the labor market and the components of the balance of payments. A detailed discussion of the specification and estimation results of the parameters of all equations that make up the highlighted blocks is presented in the documentation of the model available on the website of the Polish Ministry of Finance (Chmura et al., 2024).

The properties and validity of the NEMPF were evaluated using standard procedures: an *ex-post* dynamic forecast (analysis period: Q1 2015-Q4 2022, i.e. 32 quarters) and simulation of external shocks applied to exogenous and selected endogenous variables. The results of these analyses are also included in the documentation of the model (pp. 89-106). Conclusions from the evaluation, the accuracy of the ex-post forecast and the shape of IRFs to external shocks, confirmed the acceptable properties of the NEMPF.

References

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