THE ISTAT MACROECONOMETRIC MODEL

METHODOLOGICAL NOTE

Introduction

This note describes the main features of the economic forecasting model developed by Istat: the Macro Econometric Model for Italy (MEMo-It) [1]. The model includes 66 stochastic equations and 94 accounting identities with annual frequency, representing the Italian economic system by specifying behavioural equations for the economic agents (Households, Businesses, Public Administrations, and the Rest of the World). The time series of variables used in the model cover the period from 1970 to 2023. Where data were unavailable, ad hoc reconstructions of the missing data were carried out.

The theoretical approach used in constructing the model is neo-Keynesian. In the model, short-term economic growth dynamics are driven by demand factors, while in the long term, the economy tends towards equilibrium conditions represented by potential output. The interaction between aggregate demand and supply occurs through the price system, which reacts to deviations of the actual unemployment rate from the natural unemployment rate (NAIRU) and imbalances between actual and potential output (output gap). The model is structured into blocks, where the direction of causality in behavioural equations and the framework of accounting identities have been predetermined.[2]

The specification and estimation of the model follow three successive steps: (a) analysis of the integration and cointegration properties of variables for individual equations or blocks of equations and assessment of weak exogeneity for blocks of relevant variables; (b) two-stage single-equation estimation of the model's variables to account for endogeneity and measurement errors in the explanatory variables; (c) combining the individual equations and blocks of the model with three-stage estimation of their parameters to take into account the covariance between error terms belonging to different stochastic equations.

The dynamic properties of the model are evaluated through a predefined sequence of shock exercises on certain exogenous variables relative to the baseline solution. These exercises are performed using deterministic and stochastic simulation techniques. The standard errors obtained during the three-stage estimation of the complete model generate the stochastic solution, allowing for the quantification of forecast uncertainty.

In its current version, the model offers an aggregate description of the economic system. Future research directions for the model's development will focus on explicitly representing the behaviour of different economic sectors and extending to intra-annual economic movements.

The rest of this note is organised as follows: the second paragraph describes the characteristics of the supply block, while the third and fourth paragraphs describe the price system and the labour market. The fifth paragraph illustrates the demand block broken down by individual agents. Finally, the sixth paragraph is dedicated to describing the model's database.

[1] The forecasting model was developed by a research group at Istat under the scientific coordination of Professor Roberto Golinelli, full professor of econometrics at the University of Bologna, Department of Economic Sciences.

[2] The methodological foundations of the model follow the traditional approach of the Cowles Commission for Research in Economics (Klein, 1950; Fair, 2004), integrated with the fundamental works of Dickey and Fuller (1979), Engle and Granger (1987), Sims, Stock, and Watson (1990), and Johansen (1995) on estimation and inference with time series potentially generated by integrated and cointegrated stochastic processes; of Hsiao (1997a and 1997b) on the properties of estimators with instrumental variables in the context of non-stationary stochastic processes; and of Hendry, Pagan, and Sargan (1984), and Pesaran et al. (2001) on the importance of the dynamic specification of the model's equations.

Supply

The supply side is integrated into the model by referring to the "Solow model," according to which the stocks of productive resources (capital and labour) and technological progress are the main determinants of economic growth. This forms the basis for estimating the level of potential output, which is defined as the sustainable output level without generating an increase in inflation. In the long run, the economic system converges towards the potential growth path determined exclusively by supply forces. In contrast, in the short run it fluctuates around this path due to shocks generated by demand forces. These fluctuations are captured by the deviations of actual output (Y_{EFF}) from its potential level (Y_{POT}), which can be summarised through the output gap, defined by the following expression:

$$GAP = Y_{EFF} / Y_{POT} - 1$$

The gap between actual and potential output is inversely correlated with the gap between actual unemployment (*UR*) and structural unemployment (*NAIRU*), according to the following relationship (Okun, 1962):

$$GAP = -b\ (UR - NAIRU)$$

Imbalances between actual and structural unemployment and between actual and potential output generate price changes that help to rebalance the system.

In the model, potential output is measured following the production function approach, similar to the method suggested by the European Commission (see D'Auria *et al*., 2010) [3]. The central assumption is that the potential supply of the economy can be represented by a Cobb-Douglas production function. Formally, this is expressed as:

$$Y_{POT} = f_{POT}\ (K, LP, HTFP)$$

where *LP* represents potential labour input, K is capital stock, and HTFP is trend component[4] of total factor productivity (Solow residual). Potential labour input is obtained by filtering out the cyclical component from actual employment. The potential capital stock, *K*, is estimated using the perpetual inventory method (Goldsmith, 1951). The central assumption is that the potential capital stock coincides with the actual stock, assuming it represents the full employment utilisation of capital goods.

Prices and Wages

The mechanism for forming prices and wages drives actual demand for goods and services and employment to adjust respectively to the supply level (potential output) and potential employment, which in turn is defined by the interaction between *NAIRU* and a combination of labour force participation rate and demographic trends of the working-age population.

Using the "triangle" stylisation proposed by Gordon (1981, 1988), both the system's reference price variable (pivot) and per capita wages are affected by three main factors: (1) persistence, measured by their dynamics in previous years; (2) demand shocks, measured by the output gap and the excess of the actual unemployment rate over *NAIRU*; (3) other significant shocks, which in the Italian economic context include those arising from import prices, labour productivity shocks and labour market tensions during contract renewal phases.

The value-added deflator at factor cost (*PV*) is the model's *pivot* price:

$$dlogPV = f_{PV}\ (dlogPV_{-1}, GAP, WB/YU)$$

where $dlogPV_{-1}$ measures inertia, *GAP* measures demand shocks, and *WB/YU* (the real labour cost per unit of output, calculated as the ratio between employee income and GDP at current prices) measures productivity and labour cost shocks. The equation for *PV* can also be interpreted as a New Keynesian Phillips Curve (NKPC, Galì and Gertler, 1999), where expectations are assumed to be *backward-looking*. [5].

[3] See also De Masi (1997), Denis et al. (2006), and Giorno et al. (1995).

[4] The trend components of the variables used are obtained using the Hodrick and Prescott (1997) filter.

[5] For a comparison between the triangle model and the NKPC, see Gordon (2011).

Nominal wages growth is explained by the household consumption deflator from the previous year (which implies backward-looking inflation expectations), the unemployment rate, labor productivity, and a variable that measures labor market tensions during contract renewal phases. [6]

The import deflator is determined by the dollar price index of manufactured goods on international markets, Brent oil prices in dollars, and the nominal dollar-to-euro exchange rate[7]. Additionally, the inflation rate of the import deflator from the previous year measures a persistence component.

The deflators of demand components depend on these variables and on the average effective rates of indirect taxation, differentiated by value-added tax, other indirect taxes, and production contributions.

The Labor Market

The labour market block is represented by three equations defining labour demand, labour supply, and wages. The specification of labour demand derives directly from the production function (Hamermesh 1996 and 1999). Under the assumption of perfect competition, where the labour factor is remunerated based on the marginal product, the labour demand equation is obtained, which depends positively on output and negatively on the real wage. Consequently, private sector demand (*LDP*), expressed in terms of standard labour units (*ULA*), is defined by the following expression:

$$LDP = f_{LD}(Y, PY, \frac{WB}{LDD}, PV)$$

where *Y* is the value added at current prices, *PY* is the GDP deflator, *WB* represents the total amount of employee income at current prices before social security contributions, *LDD* defines the employee labour units expressed in terms of production capacity, and *PV* is the value-added deflator at factor cost.

The public sector labour input ($\overline{LDP}$) is exogenous. It follows that the total labour input (*LD*) used in the production process is composed of:

$$LD \equiv (LDP + \overline{LDP})$$

Labour market equilibrium is achieved through the interaction between supply and demand. The model considers demographic factors and the relationship between business cycle fluctuations and participation rates (Lucas and Rapping, 1969) by using the labour force variable in the definition of the supply function.

Labour supply is defined as participation rates disaggregated by gender (*i* = F, M). More precisely, the participation rate ($PART_i$) is specified as follows:

$$PART_i = f_{LS}(\overline{POP_i}, WIPC, EMPR_i, PCH)$$

where POP_i is the population aged 15 to 64, disaggregated by gender, *WIPC/PCH* represents real per capita wages (*PCH* is the private consumption deflator), and $EMPR_i$ is the employment rate, which provides a summary measure of labour market conditions (Bodo and Visco, 1987). The two measures used in the model—standard labour units and resident employment—are consistent through a bridging equation. The unemployment rate is derived as an identity by combining information on resident employment and the labour force (supply function).

[6] The wage equation is inspired by the work of Phillips (1958), with its specification modified here to account for the inflation rate; for a discussion, see Golinelli (1998)

[7] Before introducing the euro, the reference exchange rate was between US dollar and the Italian lira.

Demand

The model's demand side refers to economic agents' behaviour: Households, Businesses, Public Administrations, and the Rest of the World. Households spend on consumption and residential investments, accumulating real and financial wealth. Businesses purchase all other investment goods (machinery, equipment, and others). Public Administration spending directly influences final demand through public consumption and investments. The Rest of the World determines the external component of demand, represented by net exports, i.e., exports minus imports.

Households

The permanent income hypothesis is the theoretical approach to determining household consumption (Friedman, 1957). A similar approach for Italy has been adopted by Rossi and Visco (1995) and, more recently, by Bassanetti and Zollino (2008). Actual consumption (CHO) is therefore modelled as a function of disposable income, wealth (both real and financial), and the interest rate:

$$CHO = f_{CHO}(YDH, HWFA, HWDW, PCH, IRN)$$

where YDH is the disposable income at current prices; $HWFA$ and $HWDW$ are financial and real wealth, respectively, also at current prices; PCH is the consumption deflator and IRN is the nominal long-term interest rate.

The portion of disposable income not consumed contributes to real wealth accumulation. Additionally, the share of disposable income not allocated to consumption or residential investment (IRO) contributes to the growth of financial wealth. The two wealth stocks, valued at market prices, are modelled using a framework consistent with the permanent inventory approach (Goldsmith, 1951). The equations for residential investments, real wealth, and financial wealth are as follows:

$$IRO = f_{IRO}(YDH, PIR, IRN)$$

$$HWDW = f_{HWDW}(YDH, IRO, PIR, IRN)$$

$$HWFA = f_{HWFA}(YDH, CHO, IRO, IRN, COMIT)$$

where PIR is the deflator for residential investments; $COMIT$ is the stock market index, linking the dynamics of financial wealth not only to saved income not invested in real assets but also to capital gains/losses on securities.

Disposable income is defined as an identity, as the sum of various components related to the institutional household sector:

$$YDH = GOSH + WBH + IDH + SBH + OCTH - (SSH + DTH)$$

$GOSH$ is the gross operating surplus, WBH is the total wages and salaries net of those from the rest of the world, IDH represents income from interest and dividends, SBH refers to net social benefits, $OCTH$ stands for other transfers, SSH denotes net social contributions, and finally, DTH represents direct taxes paid.

Businesses

Businesses contribute to the model's stylised economic framework by investing in machinery, equipment, and other productive assets. These investments, expressed as a share of potential output, are influenced by factors such as persistence, the cost of capital, gross operating income (considered as a summary measure of profits and self-financing), and the degree of uncertainty (measured by the conditional volatility of business cycle disturbances).

The cost of capital represents the price of productive services a capital asset generates. It is assumed to depend on the financing cost (or the opportunity cost of preceding an alternative investment in the case of self-financing), the economic depreciation of the capital asset during its period of use and the capital gains or losses arising from asset purchase price changes.

Public Administrations

The description of the public sector within the MEMo-It model follows an institutional approach. This is characterised by algebraic identities and relationships that stylise the accounting rules (SEC95) and the regulations governing the primary aggregates of the consolidated economic account of Public Administrations (PA).

The direct relationships between PAs and the rest of the economy manifest through their effects on total demand, driven by final consumption spending, public investments, and income from the public sector. PAs also influence prices through net indirect tax rates, unit labour costs via social contribution rates, and disposable income obtained through direct taxation and transfers.

Total PA expenditures are disaggregated into final consumption spending, production subsidies, interest payments, gross fixed capital formation, investment grants, and a residual exogenous variable capturing other expenditure items. The aggregate for final consumption spending consists of two components: direct spending and wage-related expenditures. The latter is derived from the per capita average wage in the public sector (estimated in the labour market block) and the number of public employees.

Both direct spending in volume and employee numbers are considered exogenous and serve as fiscal policy instruments. Public investments are also exogenous in real terms, with their deflator derived in the price formation block. Nominal social benefits are linked to the population's age structure and a price indicator. Production subsidies and investment grants are linked to the private sector's value-added investments through coefficients expressing the percentage contribution to the private sector.

Total revenues are disaggregated into social contributions, indirect taxes, direct taxes, and residual exogenous items. Social contributions are calculated as the sum of those paid by employers, employees, and self-employed workers, using specific effective average rates as the basis.

Indirect taxes include revenues from Value Added Tax (VAT), the Regional Tax on Productive Activities (IRAP), excise duties on mineral oils and derivatives, and a residual exogenous component. The model calculates indirect taxes using appropriate, effective average rates, considered exogenous. Revenues from excise duties on mineral oils and derivatives are computed using two equations: estimating the energy intensity of GDP (based on persistence and oil price in euros per barrel) and multiplying an exogenous effective average rate by energy consumption.

Direct taxes are the sum of revenues from personal income tax, corporate income tax, substitutive tax on interest, other capital income, and a residual exogenous component. The substitutive tax on interest and capital income is estimated based on the previous year's revenue, GDP, interest rate changes, and new financial activities approximated by household savings.

The fiscal balance of PAs is calculated as the difference between total revenues and expenditures. Public debt stock is determined by subtracting the previous year's budgetary balance from the debt stock, adding an exogenous adjustment variable to account for factors affecting debt independently of the fiscal balance (e.g., financial transactions, changes in financial instrument values, privatisations). Interest payments are calculated by multiplying the average cost by the debt stock. The average cost of public debt is estimated based on short- and long-term interest rates.

Rest of the World

The specification of the external sector block is based on the accounting identity that defines the balance of transactions with the rest of the world:

$$ROWSALDO = (XO \times PX - MO \times PM) + (WB - WBH) + (APETIND - APUCP - TINDN) + ROWDT + ROWID + ROWSB + ROWOTH$$

where ($XO \times PX - MO \times PM$) represents the trade balance in value (XO and MO are export and import volumes respectively, PX and PM are their respective prices); ($WB - WBH$) are the net labour income from abroad, ($APETIND - APUCP - TINDN$) are the net indirect taxes, $ROWID$ is the net capital income from abroad, $ROWDT$ are the current taxes on income and wealth, $ROWSB$ are the social benefits, and $ROWOTH$ are the other transfers. [8]

The theoretical approach for determining the balance with the rest of the world in the model is grounded in literature (Lane and Milesi-Ferretti, 2011; Obstfeld and Rogoff, 2010). The volume of goods and services imports is specified by an equation reflecting the interaction between domestic demand and international factors.

$$MO = f_{MO}(DDO, PM, GAP)$$

where DDO is real domestic demand, PM is the imports deflator, and GAP measures the effects of short-term cyclical fluctuations.

The equation for export volumes is expressed as follows:

$$XO = f_{XO}(WDXXTR, ITXRXER)$$

where *WDXXTR* represents the value of global exports, and *ITXRXER* is the real effective exchange rate. Net capital income (which primarily includes profits and dividends) is derived through the following function:

$$ROWID = f_{ROWID}(APSALDO)$$

where $APSALDO$ represents the balance of the Public Administration account. The inclusion of this variable is justified by the expectation that an improvement in the PA balance will reduce the risk premium (Lane and Milesi-Ferretti, 2011; Caporale and Williams, 2002), thereby enhancing the balance of capital income, primarily through a reduction in the interest component.

Finally, the equation for other transfers (encompassing the balance of public and private transfers, both current and capital account) is given by:

$$ROWOTH = f_{ROWOTH}(ITALIA)$$

where $ITALIA$ approximates the share of Italian exports, which is assumed to have an inverse relationship with incoming transfers.

The time series used for model estimation and the treatment of exogenous variables

The model was developed using 139 basic annual time series covering 1970 to 2022 as input. The model estimation process generates 222 variables, of which 157 are endogenous (66 stochastic and 91 identities), and 65 are exogenous (including 9 scenario variables).

A significant portion of the input variables are from national accounting sources which, in September 2024, published the estimates relating to the general revision of the National Economic Accounts, with reference year 2021, agreed at European level, which introduces innovations and improvements in methods and sources.

To estimate the model's relationships, a reconstruction covering the period from 1970 to 2023 was carried out. This task was facilitated by the model's compact size, which does not include sectoral disaggregation in its current version. The reconstruction was conducted by leveraging information in a time series based on the previous classification of economic activities, with particular attention given to rebuilding chain-linked values for the variables in the macroeconomic framework. This effort extended the new national accounting aggregates used in the model for specification and estimation purposes back to 1970.

[8] The reference for compiling the Rest of the World accounts by Istat is the Balance of Payments prepared by the Bank of Italy, based on the concepts and definitions outlined in the 5th Manual of the International Monetary Fund. See Istat (2005), Part Two, Chapter 3 for more details.

The forecasts were produced using demographic scenarios available on **demo.istat.it** for demographic variables and the assumptions outlined in the State Budget Forecast for 2024 for public finance variables.

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