The PBO's macroeconomic forecasting tools

This note describes the forecasting tools used by the Parliamentary Budget Office (PBO) to construct its macroeconomic scenario. The medium-term forecast (3-5 years) is based on the annual Istat model (MeMo-It), modified in part to adapt it to the specific needs of the PBO. In addition, in the initial steps of the forecasting process, the assessments of developments in some macroeconomic aggregates incorporate the results of a set of short-term forecasting models (bridge models), which support the PBO estimation of the macroeconomic scenario. A description of the main features of the MeMo-It model and the extensions of the model by the PBO is given in section *A* of this note. The main references to the tools used for nowcasting purposes are given in section *B*. The other tools used to complete the macroeconomic forecast are indicated in section *C*.

A. The Istat-PBO forecasting model

Istat's MeMo-It model represents the main tool used by the PBO to construct the medium-term macroeconomic forecast. The PBO uses that model under the terms of a framework agreement signed with the National Statistical Institute (Istat). Currently, the characteristics of the macroeconomic model used by the PBO differ from the original Istat specification. Some changes, performed independently of Istat, are part of a work programme still under way. They refer to both individual behavioural equations and to the structure of the links between specific blocks of equations, so to adapt the MeMo-It model to the specific requirements of the PBO. On the one hand, one extension has involved the institutional sector accounts, with the specification of a block for the business sector (financial and non-financial corporations). The specification of this block has permitted a more detailed definition of the main aggregates specific to the firm sector (value added and gross operating surplus) in order to obtain a more accurate simulation of the effects of economic policy measures specific to that sector. The model is characterised by a complete and consistent structure of sector accounts, with additivity constraints, for certain nominal variables, linking their value for the economy as a whole to that resulting from the institutional sector accounts. On the other hand, as

a further extension, the supply-side block is supplemented with equations and identities to form a short-term supply-side block, in addition to the long-term specification, already present in the MeMo-It model (potential output). In the following, we introduce the main characteristics of the theoretical approach adopted in the construction of the model, as well as of the functional form used in the specification of the individual equations.

The MeMo-It model is developed following a New-Keynesian approach. In the short term, the economy is driven by demand conditions, while in the long run output is determined by the supply side, and the economic system is expected to converge towards an equilibrium output level (potential output). In the short term, aggregate demand and aggregate supply are mainly balanced through the model's nominal variables (prices, wages) which react in response to differences between actual and potential output (output gap). As an example, in the case actual output exceeds potential output, price pressures are generated, with a consequent loss of competitiveness. The change in prices is followed by an adjustment of the domestic demand components (the higher inflation reduces household purchasing power or the stock of household financial wealth) and/or net foreign demand, with the result that in the medium- to long-term actual output returns close to the equilibrium level.

The theoretical foundations of the MeMo-It model are discussed in Bacchini et al. (2013).[1] Here, it is important to note that the model is constructed as a system of simultaneous equations. In the specification of the model, the so-called Cowles Commission approach[2] is extended to recent developments in the econometric literature concerning the assessment of integration and cointegration properties of time series,[3] the dynamic representation of the equations in error-correction form[4], the model reduction methods and the assessment of weak exogeneity for sets of variables (all these approaches are summarised in a coherent manner, for example, in Fair, 2004)[5]. In the modified version used by the PBO, the model consists of more than 70 stochastic equations and 120 identities. Each equation is preliminary estimated using two-stage least squares (to account for the potential endogeneity of the regressors). Subsequently, all MeMo-It parameters are simultaneously estimated applying the

[1] Bacchini et al. (2013), "Building the core of the Istat system of models for forecasting the Italian economy: MeMo-It", Rivista di Statistica Ufficiale, Vol. 15 No. 1.

[2] Klein, L. R. (1950), "Economic Fluctuations in the United States, 1921-1941", Cowles Commission Monograph, N. 11, John Wiley and Sons.

[3] Dickey, D. A. and Fuller, W. A. (1979), "Distribution of the Estimators for Autoregressive Time Series with a Unit Root", Journal of the American Statistical Association, Vol. 74 No. 366. Sims C. A. (1980), "Macroeconomics and Reality", Econometrica, Vol. 48 No. 1. Johansen S. (1995), *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*, Oxford University Press.

[4] Hendry, D. F., Pagan, A. R. and Sargan, J. D. (1984), "Dynamic Specification", in Z. Griliches and Intriligator M. D. (eds.), *Handbook of Econometrics*, Vol. II, North Holland.

[5] Fair, R. C. (1984), *Specification, Estimation and Analysis of Macroeconometric Models*, Harvard University Press.

three-stage least squares method.[6] The following describes the main blocks of the forecasting model.

A.1 Supply

The supply-side block is essential to determining the features of the model. In the PBO specification, the model distinguishes between long- and short-run production functions. In the long term, the supply-side block includes a set of equations and identities to estimate a production function for goods and services that is consistent with price stability (potential output). The specification follows the approach adopted by the European Commission,[7] in which potential output is represented through a Cobb-Douglas production function with constant returns to scale. The input factors, capital and labour, are expressed in terms of their long-term components (i.e. net of the cyclical component). Potential labour input (expressed in terms of hours worked) is a function of the trend component of per capita hours worked, labour supply, working age population and the structural unemployment rate (NAWRU). The latter is modelled as a function of the difference between actual and potential output (output gap) and of the unemployment rate. The potential capital stock is equal to the actual capital stock of the market sector, therefore assuming full utilisation of this production factor. The specification includes the long-term component of total factor productivity (technical progress) obtained from a representation of potential output as a Cobb-Douglas production function with constant returns to scale.

In the short term, the total supply of goods and services in the economy is modelled as the sum of real value added in the market sector and the value added of the public sector. Like the long-term specification, the supply of goods and services in the market sector is specified within a Cobb-Douglas framework and is obtained from the contributions of labour, capital stock (both considered at their observed levels) and total factor productivity. Value added for the public-sector is provided by the general government accounts and is expressed in real terms using the corresponding deflator. Gross domestic product is obtained by adding net indirect taxes (taxes less subsidies on products) to the sum of value added considered above. The gap between short-term supply-side output and final aggregate demand is explained by changes in nominal variables (prices, wages), adjustments in the demand for factors of production and change in inventories.

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[6] Hsiao, C. (1997), "Cointegration and Dynamic Simultaneous Equations Model", Econometrica, Vol. 65 No. 3.

[7] Havik, K., Mc Morrow, K., Orlandi, F., Planas, C., Raciborski R., Roeger, W., Rossi A., Thum-Thysen, A. and Vandermeulen, V. (2014), "The Production Function Methodology for Calculating Potential Growth Rates & Output Gaps", European Economy. Economic Papers, No. 535.

A.1.1 Prices and wages

With regard to nominal variables, the output price formation process (value added deflator at factor cost) follows the theoretical formulation in Gordon (1981, 1988)[8], assuming backward-looking expectations, which leads to a specification of inflation equation analogous to a New-Keynesian Phillips curve.[9] In addition to the lagged output price inflation, which captures persistence, the variation in value added deflator depends on demand shocks, attributable to differences between actual and structural unemployment and between actual and potential output, as well as on the cyclical component of total factor productivity (which is specified in the model as a function of the utilisation rates of production factors). External supply-side shocks impact the dynamics of output deflator through import prices, while internal productivity shocks are measured through unit labour costs. The other price variables in the model (implicit deflators of the components of demand) are expressed as a function of the value added deflator, import prices and average effective indirect tax rates. Finally, the per capita wage in the business sector is modelled using the approach set out in Golinelli (1998)[10] and is expressed as a function of price dynamics, private sector labour productivity and the unemployment rate.

A.1.2 Demand for factors

As regards the demand for the factors of production, investment spending is modelled taking account of the heterogeneity of capital assets, whose short- and long-term determinants, especially with regard to the role of financial constraints and uncertainty, differ significantly across assets. The model follows the approach described in Bacchini et al. (2017)[11] for three types of capital goods in the business sector: machinery and equipment, non-residential buildings (both representing non-ICT assets), and information and communication technologies (ICT assets). The empirical results indicate that the neoclassical stock adjustment mechanism (the accelerator model)[12] explains the long-term dynamics of non-ICT capital accumulation, which essentially depends on the level of output and the cost of capital. In this context, uncertainty and liquidity

[8] Gordon, R. J. (1981), "Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment", in Baily, M. N. (Ed.), *Workers, Jobs, and Inflation*, Brookings Institution. Gordon, R. J. (1988), "U.S. Inflation, Labor's Share and the Natural Rate of Unemployment", NBER Working Paper, No. 2585.

[9] Galì, J. and Gertler, M. (1999), "Inflation dynamics: A structural econometric analysis", Journal of Monetary Economics, Vol. 44 No. 2. The MeMo-It model can incorporate alternative mechanisms for the formation of expectations, such as model-consistent forward expectations or the rational inattentiveness model. See Coibion, O. and Gorodnichenko, Y. (2015), "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts", American Economic Review, Vol. 105 No. 8.

[10] Golinelli, R. (1998), "Fatti stilizzati e metodi econometrici "moderni": una rivisitazione della curva di Phillips per l'Italia (1951-1996)", Politica Economica, No. 3.

[11] Bacchini, F., Bontempi, M. E., Golinelli, R. and Jona-Lasinio, C. (2018), "Short-and long-run heterogeneous investment dynamics", Empirical Economics, Vol. 54 No. 2.

[12] Koyck, L. M. (1954), *Distributed lags and investment analysis*, Contributions to Economic Analysis, IV. Amsterdam, North Holland.

constraints only have temporary effects. Conversely, in the long run, liquidity conditions and uncertainty have permanent effects on ICT assets, which are modelled with reference to the corresponding flow variables. This formulation reflects the assumption that technology assets incur flow adjustment costs (in particular, R&D investment) rather than stock adjustment costs. The specific nature of adjustments for the stock of intangible capital compared with physical capital is therefore at the basis of the different response of those assets to macroeconomic shocks, as well as the high persistence and lower responsiveness to cyclical conditions in a situation of high uncertainty compared with other types of capital goods.[13]

The formulation of the demand for labour is obtained from the optimality conditions in profit maximisation in a manner consistent with the Cobb-Douglas production function. Private sector labour demand (both employees and self-employed, expressed in terms of standard labour units) depends on the level of gross output and the real wage. Overall, labour demand is obtained by summing the employment demand in the public sector, which is assumed to be exogenous, with the input of labour in the private sector.

A.1.3 Labour market

Changes in employment, measured in terms of Labour Force Survey, are modelled as a function of standard labour units (full-time equivalent workers). The labour supply is specified in terms of the participation rate, which is broken down by gender to take account of the divergent behaviour of that variable in the long-term (declining for men, rising for women). In both specifications, the participation rate is a function of real per capita earnings and the employment rate by gender, which represents an indicator of cyclical conditions in the labour market.[14] Additional explanatory variables in the equation for the female labour supply are the stock of household non-financial wealth and the male participation rate.[15] The total labour supply is obtained from the estimates of the labour force by gender. The unemployment rate is specified as an identity and is computed in terms of the persons employed and the active labour force.

A.2 Demand

The demand blocks in the MeMo-It model aim to describe the behaviour of economic agents and, therefore, the development of the related variables contributing to the formation of gross domestic product on the demand side: households' consumption

[13] Bloom, N. (2007), "Uncertainty and the Dynamics of R&D", American Economic Review, Vol. 97 No.2.
[14] Bodo G. and Visco, I. (1987), "La disoccupazione in Italia: un'analisi con il modello econometrico della Banca d'Italia", Temi di Discussione, Banca d'Italia, No. 91.
[15] Fair, R. C. (2004), *op. cit.* Lundberg, S. (1988), "Labor Supply of Husbands and Wives: A Simultaneous Equations Approach", The Review of Economics and Statistics, Vol. 70 No. 2.

decisions, firms' investment choices, the role of the public sector that directly affects the final demand through consumption and investment plans, the transactions in goods and services of resident institutional units with the rest of the world. These behaviours are also the result of decisions concerning other variables specific to each sector (for example, savings decisions) which are assessed in the context of the institutional sector accounts. Therefore, in addition to specifying the main demand functions (consumption, investment, exports, imports), the model includes a complete and consistent structure of sector accounts. For each resident institutional sector, the model provides an assessments of value added, compensation of employees, gross operating surplus, disposable income, gross saving and net lending/net borrowing.

A.2.1 Households

The household block consists of equations and identities that are aimed to model the development of private consumption as well as of disposable income and its components (which refer to the household sector accounts). Private consumption expenditure is modelled in accordance with the permanent income hypothesis,[16] and is specified as a function of real disposable income, the medium-term interest rate and the stock of households' financial and non-financial wealth.[17] Disposable income is an endogenous variable in the model. Using an accounting identity, it is defined as the balance of primary income (compensation of employees, mixed income, net property income) and the redistribution of income in cash (social security benefits and other transfers received, social contributions paid, current taxes on income and wealth paid), which are incorporated in the model through a set of stochastic relationships. Developments in the stock of financial wealth reflect household savings, capital gains/losses accrued in the previous period and average returns in financial markets. An approach consistent with the perpetual inventory method is used to specify the stock of non-financial assets, which is a function of households' residential investment (expressed in terms of household disposable income) and the real interest rate. Household consumption and disposable income in real terms are obtained by deflating the corresponding nominal variables with the private consumption deflator. The latter variable is expressed as a function of the output price, the import deflator and the average rate of indirect taxes.

[16] Friedman, M. (1957), *A Theory of the Consumption Function*, Princeton University Press.
[17] Rossi, N. and Visco, I. (1995), "National saving and social security in Italy", Ricerche economiche, Vol. 49 N. 4. Bassanetti, A. and Zollino, F (2008), "The Effects of Housing and Financial Wealth on Personal Consumption: Aggregate Evidence for Italian Households", Bank of Italy Research Paper, No. A12.

A.2.2 Firms

The model includes a block for the enterprise sector (financial and non-financial corporations). It consists of behavioural equations for the main aggregates in that institutional sector and represents one of the PBO's developments of the macroeconometric model. Firms' behaviour is essentially described by the investment functions described earlier (section *A.1.2*), whose specifications (together with those of the corresponding deflators and the functions for the user cost of capital) also include variables drawn from the enterprise sector accounts (for example, gross operating surplus, the average effective corporate tax rate). In the corporation sector (financial and non-financial), value added in volume at basic prices is represented through a Cobb-Douglas production function with constant returns to scale. Similar to the short-term supply-side specifications, the factor demand functions are derived from the optimality conditions for profit maximisation. Firms' demand for labour (in terms of standard labour units) depends positively on output and negatively on unit labour costs. Investment spending is specified in accordance with the formalisation proposed by Christiano et al. (2005),[18] assuming the presence of adjustment costs that penalise the level of investment. Wages paid by firms are formulated within a traditional Phillips curve framework and are expressed as a function of the labour productivity specific to the sector and the difference between the unemployment rate and the NAWRU. Gross operating surplus is obtained by subtracting indirect taxes net of production subsidies and compensation of employees paid by firms from value added. Compensation of employees is obtained on the basis of labour demand and the employer social security contribution rates. Net property income is a function of the stocks of financial assets and liabilities specific to the institutional sector, the interest rate and the output gap. Corporate income tax (Ires) revenue is determined by multiplying gross operating income by the corresponding average effective tax rate (an exogenous variable like the other implicit average tax rates). Other current transfers are estimated as a function of social security benefits, the unemployment rate, firm demographics and net non-life insurance premiums. The disposable income is obtained from gross operating surplus, adding net property income, social contributions received and the balance of other net current transfers, and subtracting social security benefits paid and direct taxes. In the case of corporations, this balancing item is comparable to gross saving and represents an indicator of the sector self-financing capacity. Net lending/net borrowing is obtained by adding to gross saving the balance of capital transfers and subtracting investment expenditure.

[18] Christiano, L. J., Eichenbaum, M. and Evans, C. L. (2005), "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy", Journal of Political Economy, Vol. 113 No.1.

A.2.3 Public sector

The public sector block reproduces the government finance statistics provided by the general government accounts. The main variables on the revenue and expenditure sides are mainly defined using identities consistent with the national accounts definitions. A small number of aggregates is modelled using stochastic relationships. To assess the macroeconomic effects of fiscal policy and the impact of macroeconomic shocks on the public finances, the model allows the activation of fiscal policy "transmission channels" in the form of interactions among the economic policy instruments available to government and the behavioural functions of other economic agents. For example, government can contribute directly to the level of aggregate demand through discretionary spending on public consumption and investment. It can impact private consumption spending through changes in the compensation paid to public-sector employees and through measures that impact household disposable income (for example, through income taxes and social security benefits). It influences decisions concerning the labour supply and demand by adjusting tax and contribution rates; it affects the general price level through changes in indirect taxes.

Fiscal policy instruments, which correspond to exogenous variables in the model, are largely defined on the revenue side in the form of average effective (or implicit) rates. The corresponding level aggregates (revenues for both direct and indirect taxes) are represented in the model using identities, and are obtained as the product of the implicit rates and the specific reference tax base. On the expenditure side, the policy variables are represented by level variables (for example, intermediate consumption, gross fixed capital formation and social security benefits).

The setup of the public sector block in the MeMo-It model reflects the results of multiple analyses, sensitivity checks and statistical assessments at the basis of the estimation of a more disaggregated structure of the general government sector accounts conducted by the Public Finance (PFD) and Sectoral Analysis (SAD) departments of the PBO. These departments carry out a more comprehensive and detailed forecasts of the individual revenue and expenditure components of the general government accounts, relying on historical trends, in-year monitoring of the variables of interest, an initial macroeconomic forecast and the quantification of the effects of budget adjustment measures. These assessments are used as a benchmark both for the endogenous and exogenous variables in the public sector block, and are subsequently incorporated in the model through the calibration of the fiscal policy instruments. This could involve revisions of the initial macroeconomic projection, which can lead to subsequent adjustments of the public finance scenario in order to ensure consistency between the macroeconomic scenario and the government sector accounts over the forecasting horizon.

As for the description of the model's public finance block, current expenditure items are represented by government consumption, social security benefits in cash, production

subsidies and interest expenditure. Capital expenditure is broken down into gross fixed capital formation and investment grants. A residual exogenous aggregate, which reflects the estimation of individual components by the PFD and SAD, closes the government accounting identity on the expenditure side.

More specifically, final consumption expenditure is broken down into nominal intermediate consumption and compensation of employees. The first component is exogenous to the model and represents a fiscal policy instrument. Compensation of employees is obtained by multiplying labour input in the public sector (exogenous variable expressed in terms of standard labour units) and the average per capital wage in the public sector, which is specified as a function of compensation per employee in the private sector. Government consumption in real terms contributes to the formation of gross output through the national accounts identity. It is obtained by deflating nominal consumption spending with the corresponding deflator, whose equation is specified as a function of the private consumption deflator and per capita compensation of public-sector employees. Social security benefits in cash represents another exogenous variable. Interest expenditure is defined on the basis of a relation between the average cost of the debt and the stock of government debt in the previous period. Changes in interest expenditure are constrained to the results obtained with the approach described in Gabbriellini and Pollastri (2017),[19] which provides a projection for interest spending based on assumptions on rollover of maturing securities, forward interest rates and the need to finance the state-sector borrowing requirement. With regard to capital expenditure, public investment in nominal terms is an exogenous variable, and the aggregate in real terms is obtained using the corresponding deflator. Production subsidies are expressed as a proportion of value added in nominal terms. Investment grants are treated analogously and are defined as a percentage of nominal private sector investment. These variables are exogenous and represent fiscal policy instruments.

Revenue items are divided into direct and indirect taxes and social contributions. Among direct taxes, revenue from personal income tax (Irpef) and corporate income tax (Ires) is obtained, respectively, from the product of the corresponding tax base (endogenous) and the average effective tax rate (policy instrument). Revenue from the tax on interest income and other property income is estimated as a function of interest rates (short- and long-term) and the change in the tax bases. Revenue from indirect taxes is broken down into revenue from value-added tax (VAT), the regional business tax (IRAP) and the mineral oils tax, each defined by the product of the corresponding tax bases and the specific average implicit tax rates. Social contribution revenue is obtained from the sum of contributions paid by employers (which are calculated by multiplying total wages by the corresponding contribution rate) and the social contributions paid by workers (employees and the self-employed), which are estimated by applying the specific contribution rate to a tax base that also includes mixed income in the household sector. Other less significant

[19] Gabbriellini, C. and Pollastri, C. (2017), "Il modello UPB di analisi e previsione della spesa per interessi", Nota di lavoro 3/2017, UPB.

direct and indirect taxes and other current and capital revenue are included in exogenous components that complete the accounting identity for the total revenue of government.

The general government net lending/net borrowing is the difference between total revenue and total expenditure. The stock of debt is estimated on the basis of an algebraic relationship between the stock of debt in the previous period (corrected for an exogenous component representing the stock-flow adjustment) and net lending/net borrowing in the current period.

A.2.4 Rest of the world

The rest of the world accounts record transactions between resident and non-resident institutional units. Real exports of goods and services are obtained using a behavioural equation establishing a relationship between exports in volume, world demand and real effective exchange rate. Imports are broken down into non-energy goods, energy goods and services. Each aggregate in volume is modelled as a function of final demand and the ratio between the corresponding import deflator and the domestic demand deflator. These price indices are estimated using specific equations in the price block of the model. The external balance of goods and services is obtained as the difference between the value of total exports and total imports and contributes to the balance of rest of the world accounts. The latter also includes the balance of primary and secondary incomes (covering compensation of employees, property and investment income and current transfers) and the capital account. The balancing item of rest of the world accounts represents the resources that the rest of the world provides to the Italian economy (if positive) or receives from that economy (if negative). That balance must be equal to the sum (with the opposite sign) of the net lending/net borrowing of resident institutional sectors.

B. Short-term forecasting tools

The PBO's forecasting process is supplemented with a set of econometric models which use both monthly and quarterly information. The information set include both hard data (quantitative indicators from Istat, Eurostat, etc.) and soft indicators (qualitative indicators from business and household surveys). The short-term models are mainly used to support the estimates on the macro-economic development for the current year (nowcast), as they allow to close the information gap concerning the availability of some economic indicators, which are published with a delay compared to the requirements of the macroeconomic projection.

The PBO uses five short-term forecasting models for GDP and its components (both on the demand side and for the sectors of economic activity). All of them are constrained

on the basis of the national accounts identities (ensuring the chain-linking of real variables), so that the GDP projection is consistent with that for the individual components.[20] These models fall within the class of so-called bridge models and mixed-frequency models, also using the MIDAS approach.[21]

The forecasting of short-term developments in GDP also relies on the results of a model for forecasting Italian industrial production, which is based on a broad set of hard and soft monthly indicators, and follows the methodology proposed in Bańbura et al. (2016) and Costantini and Pappalardo (2010).[22]

Furthermore, a quarterly factor model, inspired by the work of Stock and Watson (2002) and Forni et al. (2005),[23] is also used. It includes information from a substantial number of real and nominal economic indicators and provides forecast over a longer time horizon for GDP and its components and headline inflation. The projections generated by the short-term models are incorporated in the framework of the annual model and represent a benchmark in the initial steps of the forecasting process (namely, for the current year and, considering the carry-over obtained from the short-term forecast, partially for the subsequent year).

C. Other forecasting tools

Another tool used by the PBO in forecasting the macroeconomic scenario is an international multi-country model.[24] The model is mainly used to construct a consistent framework of assumptions for the main exogenous international variables underlying the projection exercise (international prices, exchange rates, interest rates, world trade) which are fed into the PBO forecast for Italy using the Istat model. The multi-country model is also used to simulate the impacts of international shocks.

[20] Five different models are currently used, two for direct estimation of GDP and three for indirect estimations, obtained by aggregating the components of demand (consumption, investment, imports and exports) or the value added for sectors of economic activity (agriculture, industry excluding construction, construction, services). The short-term forecast of GDP is usually obtained as the average of the five forecasts, or using the median in the case of unlikely extreme values.

[21] Frale, C., Marcellino, M., Mazzi, G. and Proietti, T. (2011), "EUROMIND: a monthly indicator of the euro area economic conditions", Journal of the Royal Statistical Society, Series A, Vol. 174. Frale, C. and Monteforte, L. (2011), "FaMIDAS: A Mixed Frequency Factor Model with MIDAS Structure", Temi di discussione, Banca d'Italia, No. 788 .

[22] Bańbura, M., Giannone, D. and Lenza, M. (2015), "Conditional forecasts and scenario analysis with vector autoregressions for large cross-sections", International Journal of Forecasting, Vol. 31 N. 3. Costantini, M. e Pappalardo, C. (2010), "A hierarchical procedure for the combination of forecasts", International Journal of Forecasting, Vol. 26 No. 4.

[23] For more details, see Stock, J. H. and Watson, M. W. (2002), "Forecasting Using Principal Components from a Large Number of Predictors", Journal of the American Statistical Association, Vol. 97 No. 460 and Forni, M., Hallin, M., Lippi, M., and Reichlin, L. (2005), "The Generalised Dynamic Factor Model: One-Sided Estimation and Forecasting", Journal of the American Statistical Association, Vol. 100 No. 471.

[24] For more information on the model, see: www.oxfordeconomics.com.

Finally, the PBO estimates for potential GDP and the output gap (needed to calculate the structural budget balances) are also provided by the MeMo-It model. A further assessment on those indicators, based on the macroeconomic projections by the PBO, is obtained by implementing the European Commission methodology for output gap estimation (agreed within the Output Gap Working Group).[25] Nevertheless, alternative methods are used on an experimental basis to assess the uncertainty associated with the estimation of those variables.

[25] Havik, K., Mc Morrow, K., Orlandi, F., Planas, C., Raciborski, R., Roeger, W., Rossi, A., Thum-Thysen, A. and Vandermeulen, V. (2014), *op. cit.*