NOTA
DI LAVORO

2018-03

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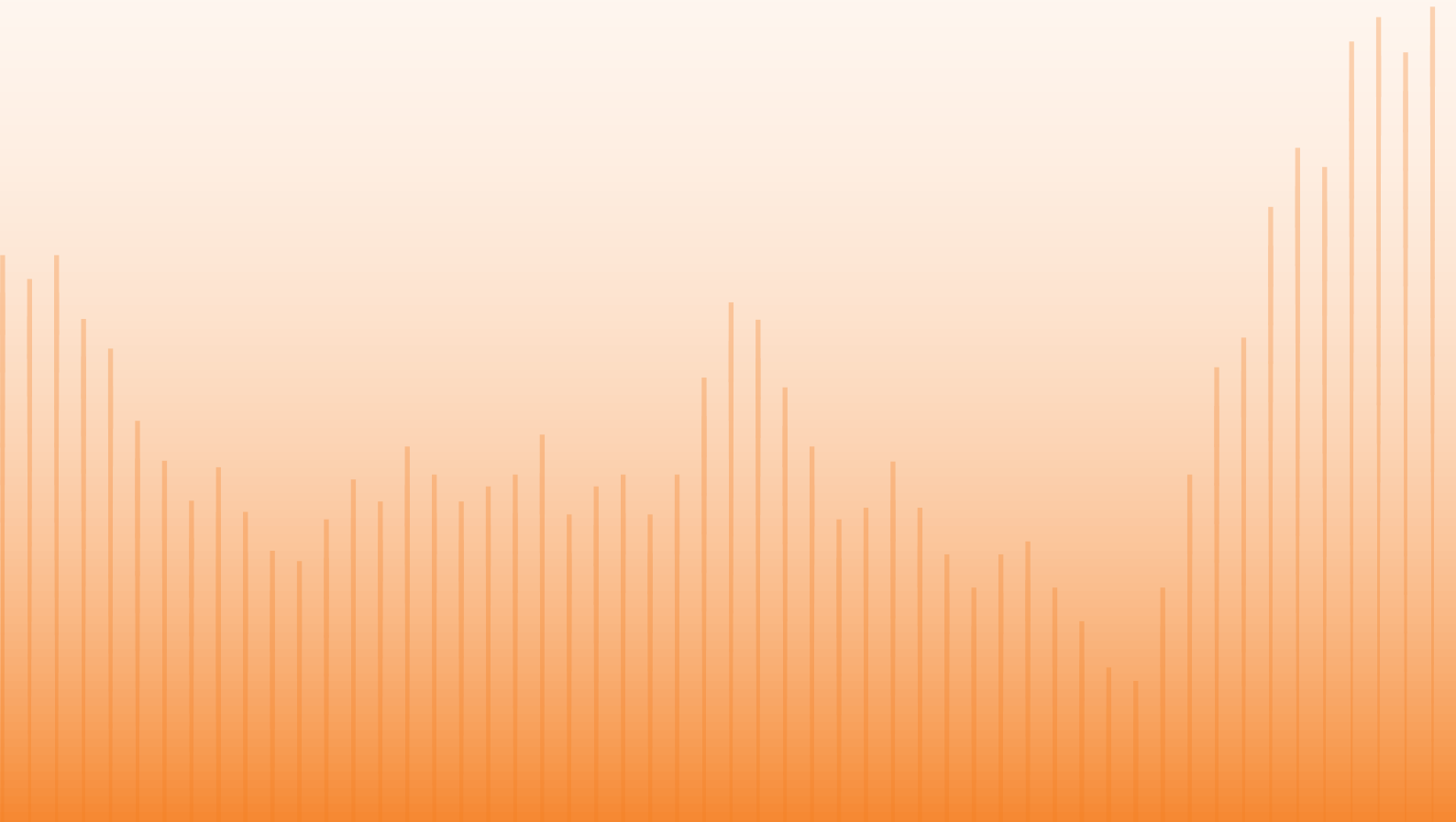
THE PROMETEIA ITALIAN QUARTERLY MODEL: PAST, PRESENT AND FUTURE

DECEMBER 2018



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The Prometeia Italian quarterly model: past, present and future

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Preliminary version, December 2018

Abstract

For more than 40 years, Prometeia has built and used large-scale econometric models. This paper presents the latest vintage in this long tradition and highlights how changing economic conditions, regulatory requirements and model uses have shaped its features. The role of financial markets and the mechanisms for the transmission of economic policies are treated with care. The paper presents the models general theoretical and econometric characteristics, describes the main features of the estimations, assesses the models dynamic properties through a set of simulations, and summarizes its estimation and forecasting properties and performance.

JEL classification: C30, E10, E17

Keywords: Macro-econometric models, fiscal and policy simulations

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†We wish to thank Lorenzo Forni for useful comments and suggestions.

1 Introduction

Prometeia was founded in 1974 to participate in the LINK project[1] by developing a quarterly model for the Italys economy to contribute to the building of a common, worldwide econometric model.

Since then, for more than 40 years, Prometeia has been building and using econometric models for numerous purposes. Over the years, we have learnt that no one model fits all and that different models are needed for different purposes. These purposes shape the model characteristics including theoretical foundation, size, disaggregation, data, specification and testing strategy. Prometeia currently has several models, built for different uses and based on different methodological approaches.

Now-casting and bridge models (see Bonucchi and Tomasini [2011]) are used for short-term forecasting. The forecasting model, used to predict the monthly industrial production index, which is still the best predictor of Gross Domestic Product (GDP), is based on principal component analysis applied to a large number of qualitative indicators (business and household confidence, purchasing manager index, etc.). We use bridge models to predict GDP and its main components (consumption, investment, export, import) for the current and immediate next quarter. These types of models create a link between available and expected data using qualitative leading indicators and monthly predictors of industrial production. The capacity of bridge models to capture the turning points in the variables of interest has proven to be greater than that of the structural macroeconomic models used for medium term forecasting.

For policy and structural analysis, and long-term analysis and forecasting we built dynamic stochastic general equilibrium (DSGE) and overlapping generations (OLG) models respectively. The DSGE model (see Catalano [2014]) is a computational and stochastic general equilibrium model with rational expectations. It is based on a neo-classical growth model, optimizing households and firms, and long-run growth induced by technological change and population increases. Among this class of models, it is relatively large (around 70 equations) and very detailed: the financial sector is modelled to account explicitly for Basel III capital requirements, financial fragility and credit rationing. The fiscal block is very detailed, allowing analysis of the effects of fiscal policies and different tax mixes. This model is sufficiently rich to be suitable for evaluating the macroeconomic impact of structural reforms.

The Prometeia multi-country model OLG (see Catalano and Pezzolla [2016]) and endogenous growth provides quantitative long-run projections (up to 2065) in a macroeconomic scenario driven by imbalances among countries characterized by diverging technology drivers, demographic trends and consequent life-cycle saving behaviours. The model investigates the interrelations between population ageing, open capital markets and endogenous growth in advanced economies including the USA, Germany, France and Italy, emerging countries such as China and India, and potential long-term developing areas such as the whole of Africa. The ongoing demographic ageing process in advanced economies influences interest rates and, thus, potential growth paths as well as demographic trends, and human capital endowments - both numbers

[1]The project, which is still running, was led initially by Nobel Prize winner Laurence Klein https://www.un.org/development/desa/dpad/project-link.html.

of educated people and type of education - provide for different rates of long-run growth and financial sustainability in partially integrated economic areas. The gradual and increasing degree of openness in capital markets allows assessment of the interrelations between the population ageing process and interest rates.

In relation to short and medium-term forecasting for the main international economies, the annual global model (PRIAMO) covers all EMU countries, the USA, Japan, the UK, Canada, China, India and eight developing country areas. PRIAMO is a large econometric model used for international forecasting and policy analysis. It is used, also, to determine international variables relevant to the Italian scenario.

In this context, the Quarterly Italian Prometeia Model (QuIProM) serves several purposes, but primarily the provision of the short and medium-term forecasts published in the Prometeia Quarterly Economic Outlook (Rapporto di Previsione). However, in recent years, the QuIProM has been used increasingly to evaluate the short-term macroeconomic impact of policies - both those implemented and alternative scenarios.

In light of the increased regulatory attention to controlling potential sources of risk, with the aim of limiting the effects of adverse shocks (stress tests), accounting for the uncertainty around forecasting has gained prominence. New regulatory frameworks and accounting principles requiring scenario analysis with associated probabilities for calculating expected credit losses (e.g., IFRS9), have been developed. Prometeia has made huge efforts to ensure it has the appropriate tools to address these requirements and, particularly, stochastic simulations to model the range of uncertainty around central forecasts. The Prometeia model provides both short and medium-term deterministic forecasts (i.e., simulations that do not consider the variance associated to estimation errors) and stochastic simulations to assign a probability distribution to alternative scenarios. Thus, the model can be used to perform stress test analyses and evaluate how macroeconomic uncertainty might affect variables such as bank capital adequacy, credit quality and default probabilities.

QuIProM, combined with other Prometeia models, provides a framework to organize and coordinate economic analyses and stress test procedures among different Prometeia branches: it defines the macroeconomic scenarios that frame the detailed industry sector and regional analysis (Sectoral and Territorial Departments), banking sector analysis (Financial Markets and the Banking Department), and the impact of macroeconomic uncertainty and its risk for banks, financial institutions and firms (Economic Scenario Service).

The paper proceeds as follows. Section 2 describes the models general features in terms of its theoretical and econometric characteristics, with a focus on how the global financial crisis influenced the model design; Section 3 outlines the main characteristics of the estimations; Section 4 assesses the dynamic properties of the model through a set of simulations; and Section 5 summarizes the models estimation and forecasting performance.

2 General features of the model

The QuIProM described in this paper is the most up-to-date version of a string models, starting from the original one that was developed in the mid-1970s (see D'Adda et al. [1976]). The original model has evolved to take account of new economic and econometric theories, new data sources (now ESA 2010), and changing institutional frameworks and policy rules.

The updated model involves some 1,200 equations, 150 of which are stochastic equations and the remainder identities, quasi-identities and policy rules. The large size of this econometric model means that most of the macroeconomic variables are determined within the model and all accounting schemes are generated in full. These latter include national accounts and the major components of their use and distribution, flow of funds through institutional sectors, and balance of payments. All institutional sectors are considered: households, non-financial firms, financial firms, public sector and foreign sector, and most assets and liabilities of these sectors are modelled with a particular focus on the Italian banking system and households asset allocations. The interest rate structure is very detailed as each financial instrument is associated to its interest rate.

GDP and all of its components are considered: private consumption (split into 5 categories), public consumption, investment in machinery, transport equipment and other products, residential construction investment, other construction investment, inventory changes, and exports and imports (goods and services). Variables such as value added, wages and employment are included for the five main sectors (agriculture, industry, construction, services, public administration). Producer and consumer prices (pre- and post-indirect tax) and deflators (for both the most important production sectors and GDP components) are modelled in depth.

The model pays special attention to the public sector and, over time, has been adjusted to keep track of all the institutional changes that have been introduced. Almost all types of expenditure and revenue are considered in the model to represent the public sector accounting schemes.

2.1 Design and principal linkages

Like its predecessors and most currently available macro econometric models, QuIProM can be described as a structural model, characterized mainly by neo-Keynesian features, with the level of economic activity determined primarily by aggregate demand. Multiplier and accelerator mechanisms in consumption and investment demand play a crucial role although there are several supply side factors that are also taken into account.

In fact, the model features several neo-classical characteristics: agents intra- and inter-temporal optimization process and the amounts of labour and capital depend also on the user cost of capital to labour ratio. The user cost of capital (see Hall and Jorgenson [1967]), which is influenced by interest rates and taxes, is at the heart of the transmission of monetary and fiscal policies to investment demand. A detailed measurement of the historical evolution of the user cost of capital and of the unit labour cost is performed on the basis of scrupulous analysis of the numerous changes to the tax system (see Bonucchi et al. [2015]).

An output trend with a constant elasticity of substitution production function is estimated, and the output gap is used to proxy for the aggregate rate of capacity utilization. Due to the models demand-side focus, the technical progress is treated as exogenous.

Prices are modelled as mark-up over production costs, mostly labour, with demand pressures, measured by the output-gap, less relevant.

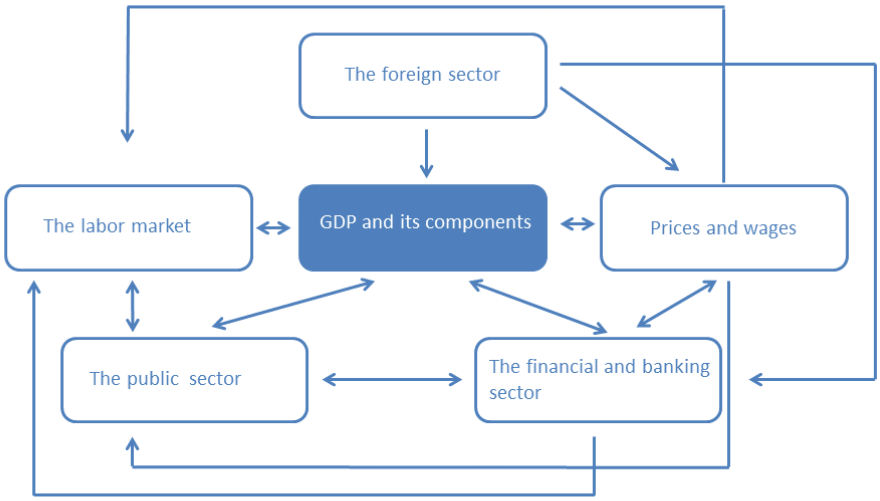
Stock-flow adjustments are accounted for by including, for example, a wealth term in private consumption, although disposable income is its most important driver. In the consumption relationship, we consider the Ricardian equivalence of decision-making; when planning their consumption, households take account of public-sector solvency conditions, so that the flow of interest on public debt and the stock of public debt held by households, are considered to be only partly included in their disposable income and total wealth.

Since GDP is calculated on the demand side, value added is modelled separately for the public and private sectors and, in the latter case, distinguishes among agriculture, industry, construction and services.

The QuIProM describes Italy as a small open economy in the European Economic and Monetary Union (EMU). Thus, it takes no account of the repercussions of Italys economic activity on the rest of the world, and the variables describing world economic conditions, including European economic policy, are set as exogenous and derived from our international macro model. Specifically, the income of Italys trading partners, the Italian real exchange rate, short and long-term interest rates, and world prices for tradable goods and services are treated as exogenous. The financial relations with the EU budget on both sides (own resources and transfers from the EU) are modelled also as exogenous variables.

The basic structure of the model is shown in Chart 1. It can be represented by six blocks: the foreign sector, GDP and its components, prices and wages, the labour market, the public sector, and the financial and banking sector. With the exception of the foreign sector, which has fewer interactions because most of the variables included (world trade, exchange rate, interest rates, international prices) are exogenous in the context of Italys economy, the blocks are strongly interconnected, both directly and indirectly. Economic activity and capital and labour prices affect employment, which, in turn, influences household consumption through disposable income. Also important, is the connection between the public sector and the other blocks in the model, that is, the public sector exerts an influence on disposable income in the private sector through taxes, transfers and interest payments. Via the user cost of capital, the public sector influences private investment while via public sector investment and intermediate consumption it contributes directly to determining GDP. In addition, the reverse direction of causality is considered, that is, the impact of economic activity on public budget items. Another interconnection whose importance was highlighted in the recent crisis and which is described in detail in the next section, is that between financial institutions and the real sector.

Chart 1: The structure of the QuIProM



2.2 The QuIProM and the Great Recession

The financial crisis and the sovereign debt crisis deeply affected the Italian economy and has made specification of single equations and the overall structure of the model, difficult. This has had an influence on the most recent version of the QuIProM.

The importance of uncertainty for households and firms decisions increased during the crisis and resulted in a bigger gap between the data and the predictions of the equations. Although the advantages of incorporating demand expectations and uncertainty in economic models are well understood in theory, in practice, they are difficult to quantify. The best measures[2] are extracted from surveys by professional forecasters and the financial markets (e.g., sovereign debt spreads and term *premia*). In the case of QuIProM, indicators of subjective expectations and *ex ante* uncertainty are derived from the Survey of Professional Forecasters[3] and enter the investments and household consumption equations.

In addition, the crisis highlighted the importance of the linkages between financial and macroeconomic developments. Although, traditionally, QuIProM pays attention to financing conditions and the role of banks, the importance of financial conditions has increased dramatically over the last decade. In fact, while the effect of the macroeconomic conditions on financial conditions are understood and have been modelled properly in the QuIProM since the 1980s, the opposite direction of causality - apart from the traditional interest rate channel - tends to be neglected. Modelling of the financial sector by QuIProM was already very detailed, from the flow of funds

[2] In the case that rational expectations are appropriated, we use our DSGE model (as for structural economic policy analysis).

[3] We follow the methodologies proposed by Zarnowitz and Lambros [1987], Giordani and Söderlind [2003], and Tsenova [2015].

from activities among institutional sectors to the banking sector accounts, but its influence on the macroeconomy was limited and, except for the interest rate channel, was restricted to the effects on consumption of households asset allocations, and interest flows in disposable income and of the value of households financial wealth. The financial crisis has taught us that financial intermediaries and, especially, the banking sector given its decisive role in financing the Italian economy, are subject to numerous frictions that can affect macroeconomic developments via different transmission channels. Attention has been drawn to the interest rate channel, in particular, and how it is affected by financial market distress, and the bank balance sheet channel.[4] This latter channel refers to lending rates, but also the supply of credit, and depends on the banks business model, more or less focused on lending to households or to firms, and on household saving allocations. Several factors (monetary policy, market expectations, financial and banking regulations, etc.) can affect bank liabilities and, thus, bank assets. In particular, in QuIProM, the bank balance sheet channel is implemented considering such variables as banking leverage, stock of non-performing loans, bank funding costs (approximated by the spread between BTP 10year yield and the corresponding Bund) as determinants of lending rates, the supply of credit and the investment decisions of firms and of households.

3 Main characteristics of the equations

3.1 Estimation method

All QuIProM behavioural equations are estimated over the largest sample made available by the data, using the Vector Error Correction Model (VECM), that is, a Vector Auto Regression (VAR) containing non-stationary variables. This model allows the identification of long-run equilibrium relationships among a set of non-stationary variables in order to exclude spurious regressions. If a stationary linear combination of these variables exists, these variables are said to be cointegrated (see Engle and Granger [1987]) and their linear combination can be thought of as a long-run equilibrium path. The VECM links changes in the variables, the short-term dynamic, with the deviation from long-run equilibrium (the cointegration term). The endogenous variables react to the disequilibrium in order to return to their long run path.

For the vector $Y$of the variables of interest the formulation of a VECM is the following::

$$\Delta Y_t = \alpha\beta Y_{t-1} + \Sigma_{i=1}^{p-1}\Gamma_i \Delta Y_{t-1} + BX_t + \epsilon_{Y,t} \tag{1}$$

β are the coefficients of the long-run equilibrium and α are the coefficients that measure the reaction at time t of each variable to the disequilibrium in the period $t-1$.

We estimate the VECM using Johansen [1995]'s method[5] with full-information techniques applied to each behavioural equation. Starting from the VECM specification, we estimate the short-term part of the equation of interest using Ordinary Least Squares (OLS), dropping lagged

[4] Over the last 10 years, in Prometeia, Rapporto di Previsione, numerous Approfondimenti have been published on this issue including Tomasini and Zicchino [2011], Tomasini [2013] and Antonecchia and Tomasini [2014].

[5] The EViews package is used.

endogenous variables with non-significant parameters: this preserves the statistical properties of estimators and, at the same time, provides some flexibility to the short term dynamics of the equations.

3.2 Household consumption

In QuIProM, the most important driver of household consumption is disposable income (YD), but net wealth - both financial (WF) and housing (WH) also plays a role.[6] The long-run equation includes the real interest rate (r), with a negative effect on demand. This can be interpreted as a substitution effect between consumption and saving, or an expression of financial constraints. The general structure of the equation (in logarithmic form) for consumption is:

$$C_t = \alpha^{YD} YD_t + \alpha^{WF} WF_t + \alpha^{WH} WH_t + \alpha^r r_t + \epsilon_{C,t} \tag{2}$$

where each explanatory nominal variable is deflated using the consumption deflator.

We introduce Ricardian household behaviour: they anticipate a tax increase or a government spending cut by reducing both the weight of interest on public bonds in disposable income, and the weight of public bonds in total wealth. In particular, disposable income and financial assets are corrected, as suggested by Onofri [1987], as follows:

$$YD = YD^1 e^{-\beta D/Y} + YD^2 \tag{3}$$

$$WF = WF^1 e^{-\beta D/Y} + WF^2 \tag{4}$$

where YD is split between interest on public bonds, YD^1, and the remaining disposable income, YD^2; WF is bond wealth, split between public, WF^1, and private, WF^2, assets. In these definitions, the weights associated to YD^1 and WF^1 fall as public debt increases as a share of GDP (D/Y). The exponential form guarantees that the zero value of YD^1 (or WF^1), when public debt tends to infinity, is achieved asymptotically in the case of ultra-rational consumer behaviour.

QuIProM distinguishes between consumption of durable goods and other expenditure (food, services, other goods). The decision process involves two steps: in the first step, households determine the amounts to be allocated to these two categories and in the second step, they choose how much consumption is allocated respectively to food, services and other goods based on their relative prices. Equations of durables goods and other expenditures are modelled in line with life cycle theory; the functional forms are similar, but the values of the coefficients differ.

3.3 Investment and employment

The long-run investment (excluding construction) and employment equations are derived by solving the optimizing problem of a representative firm given the technology constraints. The economy is assumed to produce a single good and the technology is described by a constant

[6] Housing wealth is net of mortgages.

elasticity production function with two input factors, capital (K) and labour (L). Technological progress is given exogenously at a constant rate (γ), and enters in the usual labour-augmenting or Harrod-neutral manner.

As a result, the real user cost of capital (U^k) is:

$$U_t^k = \frac{q_t(r_t - \pi_t + \delta_t)(1 - \tau_t F_t)}{p_t(1 - \tau_t)} \tag{5}$$

where τ is the statutory corporate tax rate; p and q denote output and investment prices respectively; π is the producers inflation rate; r is the interest rate; F is the present discounted value of fiscal depreciation allowances; and δ is the economic depreciation rate of capital.

The marginal labour cost U^l also is derived from the first order conditions of the cost-minimization problem facing a representative firm. It represents the relationship between real wages augmented by social contributions, and the output price. In the case of labour costs being completely deductible from the tax base, the definition is:

$$U_t^l = \frac{w_t(1 + s_t)}{p_t} \tag{6}$$

where w is the per-capita gross wage before personal income tax, and s is the social contribution rate.

The structure of the above formula has changed over time to allow incorporation of the specifics of various tax policies (Bonucchi et al. [2015]).

The long-term equilibrium relationship links investment (I) to aggregate demand (D) and to the relative user cost of capital to labour ($U^{k/l}$). This relation is accompanied by a slight downward deterministic trend, which could be considered a measure of exogenous technological progress giving rise to increased efficiency of investment per unit of output. The equation in logarithmic terms is:

$$I_t = \alpha^D D_t + \alpha^U U_t^{k/l} + \alpha_t^T + \epsilon_{I,t} \tag{7}$$

Investment depends positively on aggregate demand (both domestic and foreign) and negatively on the ratio of the user cost of capital relative to labour.

The short-run equation contains a full set of other factors such as expectations, uncertainty and constraints in credit supply due to the worsening financial conditions of Italian banks after the global financial crisis. In order to consider this last effect, we used the ratio between bad loans and total loans.

The model also includes two stochastic equations for construction investment: residential and non-residential private construction. Residential construction investment depends on household disposable income, real interest rates and the demographic structure. Supply factors are proxied by construction prices. Non-residential construction is broken down into private and public construction: private construction is linked to investment in machinery and equipment, while public construction is determined exogenously by policy makers.

Similar to the investment (excluding construction) equations, the labour demand equations are

derived from the optimizing. In the long-run, employment is explained by real value added and relative labour and capital factor prices.

Labour supply equations derive from the efficient allocation (in terms of maximization of a utility function) between consumer goods (i.e., goods that can be bought using wages), and leisure, thus, consumption and leisure depend on their relative prices. Since the overall effect is based on two opposite effects - a positive substitution effect and a negative income effect - a priori, it is impossible to say which of the two will prevail since they depend on factors such as gender and social, cultural and economic conditions. Structural factors relevant to the Italian context, include evolutions in the family institution and the consequent process of female emancipation, increased education, demographic trends related to the baby-boomer generation, and changes to the retirement age which was reducing in the past, but recently has increased. Among economic factors, in addition to the relative price of labour, the tax burden is particularly important.

For all these reasons, QuIProM estimates male and female labour supply separately and the estimated coefficients show that, in the case of males, the income effect prevails while in the case of females, the substitution effect dominates.

Taken together, labour supply and labour demand determine the unemployment rate.

3.4 Prices and wages

Producer and consumer prices (disaggregated by type of good and service, i.e., food, manufactured good, energy, services, and disaggregated by purpose. (i.e., tariffs) are pivotal in the prices block, while the deflators of the aggregate demand components and sectoral value added are driven by the corresponding price indices.

Prices are set as a mark-up on marginal costs, which are related mainly to labour. Depending on the price type (producer or consumer), the mark-up is related to the import prices (for producer prices) or prices set at the previous level in the production chain (for consumer prices). Both depend, in the short-run, on business cycle conditions.

Nominal wages per employee are set for the five sectors, with industry playing an essential role since wages in the other sectors vary mainly in line with industry wages and only marginally according to their relative productivity growth. In this situation, real wages are set above the frictionless equilibrium level, so that involuntary unemployment exists. Nominal wages are indexed partly to prices, but depend also on union bargaining power, which, in turn, depends on the unemployment rate. This is modelled by the following Adjusted-Phillips curve-type equation:

$$\dot{W}_t = \alpha + \alpha^P \dot{P}_t + \alpha^Y (\dot{Y}_t - \dot{L}_t) - \alpha^U U_t \tag{8}$$

where α is a constant, α^U indicates the sensitivity of nominal wage growth, W, to the unemployment rate U (i.e. union bargaining power), P is the expected consumer inflation, and $(\dot{Y} - \dot{L})$ is labour productivity growth. This Phillips curve-type equation accounts for two kinds

of rigidities. First, if inflation expectations are not perfect, nominal wages are not fully indexed on prices, meaning that there is nominal wage rigidity in the economy. Second, although (or even if) nominal wages are flexible, real wages may not adjust perfectly to marginal labour productivity unless $\alpha^Y = 1$ and $\alpha^U = 0$. If $\alpha^Y < 1 \alpha^U > 0$, labor productivity is only partly accounted for in the bargaining process and wage developments depend also on the unemployment rate. Indirect taxes, social contributions and terms of trade affect wages not directly, but through their impact on consumer prices.

In our model, the estimated coefficients imply a sluggish rate of adjustment of wages to inflation and to labour productivity.

3.5 Trade equations

The most important elements in this sector are export and import volumes of goods. We also include other balance of payment variables such as travel, transportation, other services and primary and secondary incomes. However, not all of these are determined stochastically.

In the long run, exports of goods exhibit a positive link to foreign demand for Italian goods, and to price competitiveness. In order to consider all types of external shocks, both variables are built taking into account Italys trade with foreign countries: foreign demand is determined by foreign countries' imports weighted by the share of Italian exports in these countries, and competitiveness is measured by the ratio between the weighted average of competitors prices in euros and Italian export prices.

Goods imports depend on total demand (including exports) and price competitiveness. Each demand component exerts a different influence on imports, and, overall, demand elasticity is greater than 1.

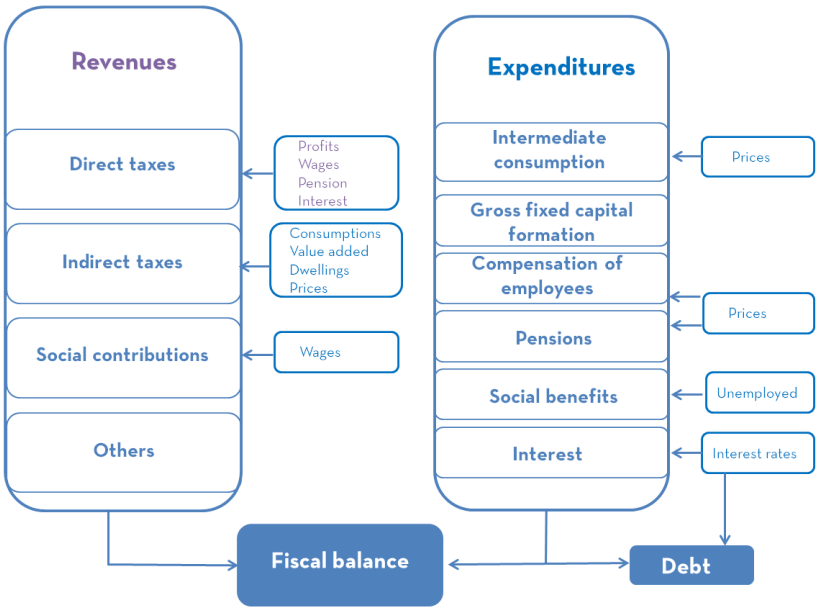
3.6 Public sector

The public sector is very detailed in order to provide forecasts of the general government budget balance and debt, and to evaluate the impact on the Italian economy of fiscal policy or, conversely, to assess the effects of the macroeconomic scenario on public finances. Thus, in the model, general government sector accounts reproduce most of the revenue and expenditure items presented in the government statistics and define the numerous relationships with other parts of the model (Chart 2).

Since the architecture of these relationships is determined mainly by legislation, the model equations try to match, as closely as possible, the legal framework shaping government sector behaviour, particularly in the calculation of fiscal receipts. For each tax, we define its base according to current legislation, using disaggregated income, consumption and output variables from the others blocks of the model, and making appropriate adjustments to bring national accounts values in line with the respective legislative framework. The proceeds from each tax are calculated by multiplying its statutory tax rate by the corresponding tax base and applying, where they exist, deductions, detractions and exemptions. This takes account of any legislative changes to both the definition of the tax base and the structure of the tax rates and tax

allowances.

Chart 2: The public sector



In the forecasting of public expenditure, government programmes are important and, therefore, in QuIProM, spending items have a higher degree of exogeneity compared to revenue equations. Exceptions are interest expenditure estimations, which are modelled at a quite detailed level, and expenditure on unemployment benefits, which represents the main cyclical component in government expenditure. In the case of other items, endogenous impulses come mainly from the impact of inflation.

The link between financial and real flows is complex and operates in both directions to determinate public accounts and influence economic private agents incomes and choices. The tax system and social security schemes affect investment, consumption, demand and labour supply as well as economic activity, and flows of financial activities and their corresponding yields are inputs for the public revenue and expenditure equations (Chart 3).

The model does not include a policy rule. Thus, government deficit, B, and public debt, D, are derived using a bottom up approach:

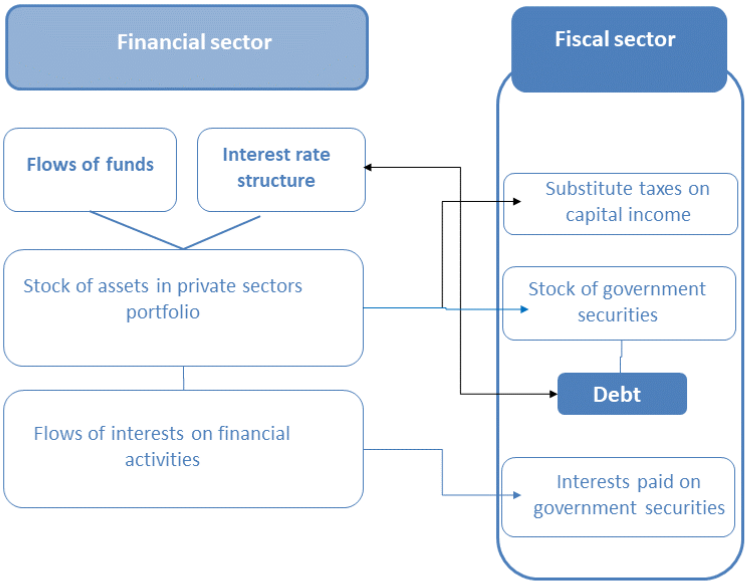
$$B_t = T_t - rD_{t-1} - G_t \tag{9}$$

$$D_t = D_{t-1} + B_t + SFA_t \tag{10}$$

where T are total revenues, r is an implicit rate of interest on the public debt rate, G are primary expenditures, and SFA are stock flow adjustments.

On the revenue side, the most significant items, because of their quantitative dimension and their larger degree of interdependence with other parts of the model, are the three main broad

Chart 3: The public sector: overview of relations with the financial sector



current fiscal proceeds clusters: direct taxes, indirect taxes and social security contributions. While tax rates are considered policy variables and, thus, are treated as exogenous, tax bases are strongly connected to both the real and the financial sides of the model. In addition, to ensuring that all of these interdependencies are captured, each revenue is represented in detail.

Direct taxes are broken down into a) taxes on individual income, that is, personal income tax, and taxes on income from financial asset; and b) taxes on corporate income.

For personal income tax, which represents 74 per cent of Italian direct tax revenue, the model is very detailed in order to capture all the main legislative mechanisms and the impact of alternative tax policies. Progressive tax rates are applied to the corresponding five tax brackets of income, determined using an estimated income distribution curve. Starting from the two relative distributions of total and dependent income provided by the tax register, we can derive two continuous functions, which allow income and taxpayers to be distributed according to the legal brackets, and broken down into employees and pensioners, and other recipients of income. Then, the gross tax is calculated applying the respective share of deductions. Finally, the attribution of the estimated detractions for each bracket provides the net receipts.

The breakdown of taxes on income from financial assets includes household income from deposits, private bonds, government bonds and other financial assets. Stocks of financial assets and the reference interest rates are determined in the models financial block and provide the estimated income flows, to which the tax rate is applied to calculate the tax revenue.

Indirect taxes are divided into value added tax (VAT), excise on fuel production, a regional tax on productive activities (IRAP), real estate taxes and other indirect taxes.

To determine VAT revenue, the tax base used is household consumption disaggregated into

food, manufactured goods, services and energy. The respective VAT rates are obtained for each item, as the weighted average of the rates of the basic products that fall into the group. This structure allows us to estimate the VAT revenue according to both the legal rate and the level and structure of consumption. The revenue obtained from taxing household consumption is reduced to take account of an estimated share of evasion and avoidance (which considers the VAT gap, defined as the difference between the amount of VAT collected and the theoretical tax liability according to the tax law, 27.1 per cent in 2010-2015). In the estimates of IRAP revenue, the model equations consider a sectoral breakdown, determined by the different tax rate levels and, in the case of the public sector, also by different calculation of the tax base.[7]

For social contributions, QuIProM retains a distinction between employee, self-employed and employer contributions; in the last case, the equation refers to the implicit average rather than to the statutory rate, and is split into contributions paid in the five main sectors of agriculture, industry, construction, services and public administration.

Other revenues, that is, capital taxes and current and capital transfers, are exogenous.

Government expenditure consists of government consumption (disaggregated into the wage bill and purchases of goods and services), interest, social transfers (pensions, unemployment benefits, and other social transfers), investment and other current and capital transfers.

Government consumption and public investment are included in the model, in both nominal and real terms. Although official sources provide public finance aggregates only in nominal terms, QuIProM assumes that the fiscal authorities choose primary spending in real terms. Therefore, real purchases of goods and services, and real investment, which is split into construction investment and other investment, are exogenous variables, while their nominal values are shaped by inflation dynamics. Similarly, in employee compensation, the average real wage and the number of employees are determined exogenously on the basis of government programmes. In the case of expenditure on social benefits, unemployment benefits depend on labour market conditions while pension payments are treated as endogenous only for the part depending on inflation.

Among the endogenous variables, QuIProM emphasizes the amount of interest payments in public debt, defined as the sum of the interest payments related to the various government securities, estimated in the model's financial block. The savings allocation choice splits demand among the different debt tools. Based on these choices, we can derive the shares representing these different instruments in total public sector liabilities, and the maturity of the public debt. Each debt instrument has an associated interest rate; interest flows are determined by multiplying the interest rate by the stock of the corresponding instrument.

The increase in the stock of public debt is the sum of public administration cash borrowing requirements and other relevant items, including revenue from privatization, contributions to support the euro area, and debt valuation effects. Since in the QuIProM, flows of financial activities result from the allocative choices of economic agents, the level of the public borrowing requirement and, thus, of public debt, derive both from the balance of general government

[7]The taxable base of IRAP (Regional tax on business activities) equals the value of production; for business and commercial companies the cost of labour is deductible for employees. Rates other than the ordinary tax rate are applied to companies operating in the following sectors: public administration, insurance and banks. Agricultural enterprises are exempt.

economic accounts and demand for government securities in the financial markets.

3.7 Monetary and financial sector

The QuIProM is characterized by a direct link between real and financial flows, in both directions. Economic agents choose between consumption and saving; in turn, saving is allocated between gross capital formation and financial investment. For each economic sector, the difference between saving and fixed investment changes the net financial position (net lending/net borrowing) towards the rest of the economy. Financial flow accounts (see Chart 4 for its structure) are an important analysis tool, because they allow evaluation of the composition of household financial saving/wealth, the funds raised by firms and the public administration, the balance sheet structure of the financial sector, and the financial position of the country vis--vis the rest of the world (in terms of both stocks and flows). Overall, flow-of-funds data record financial transitions and the positions of economic sectors. The value of this tool increased after the financial crisis because can be used to analyse sectoral imbalances and, hence, to detect possible causes of vulnerability.

The QuIProM adopts a portfolio choice approach to explain the flows of funds for six operators (non-financial firms, monetary and financial institutions, other financial firms, government, households, and rest of the world), and almost all financial instruments (cash, deposits, short and medium term private and public bonds, mutual funds, loans, derivatives and equities, insurance and pension funds, foreign assets). Chart 4 shows the structure of the flow of funds and variables considered in the model: E and X are respectively the endogenous (stochastic or deterministic) and exogenous variables.

Each financial asset or liability (ideally) has a corresponding interest rate. The interest rate structure reflects the monetary policy of the European Central Bank (ECB) and market expectations.

Households, firms and banks play a crucial role in shaping financial transactions, the former on the demand side and the latter on the supply side.

For the household sector, the model specifies demand for different assets, and the corresponding yields that produce equilibrium in the market. Households choose how to allocate their income among saving and consumption, then how to allocate total saving among real (mainly property) and financial assets.

A hierarchical scheme is assumed in the asset allocation of households financial saving. In the first stage, households choose among liquid assets (currency and deposits), bonds and assets under management. In the second stage, a more detailed asset allocation is set. The first stage is modelled employing stochastic equations and the second is modelled applying historical quotas.

Assuming the presence of adjustment costs, households' allocation choices may deviate temporarily from their equilibrium values. The first stage in the household allocation decision (optimal-long term equilibrium) is modelled as a process of dynamic adjustment towards a long-term equilibrium, in which each asset class on total financial assets depends positively on the corresponding yield compared to alternatives, to other variables according to the sign

Chart 4: The flow of funds (E: endogenous variables, X: exogenous variables)

Institutional sectors	Non-financial corporations		Financial corporations				General governement		Households and non-profit institutions serving households		Rest of the world	
			Monetary financial institutions		Other financial intermediaries							
Financial instruments	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
MONETARY												
Currency and transferable deposits	X			E	X		E		E		X	
Other deposits	X	X		E	X		X	X	E		X	
other deposits with rest of the world			E									E
Short term securities with general governmen	X		E		E			E	E		X	
BONDS, issued by												
MFIs	E		E	E	E				E			
central government, CCTs	E		E		E			E	E		X	
central government: other	E		E		E			E	E		X	
other resident	E	E	E		E	X			E			
rest of the world	X		E		E		X		X			E
LOANS												
short, medium and long term loans of MFIs		E	E			E				E		
other resident		X			E					E		E
rest of the world		X		E		X		X			E	
MUTUAL FUND SHARES issued by:												
resident				X		E			E			
rest of the world	X				X				E			E
Insurance, pension and standardised guarantee schemes	X	E		X		E			E	X		
SHARES AND OTHER EQUITY issued by:												
resident	X	E	X	X	X	X	X		E		E	
rest of the world	X		E		X		X		X			E
OTHER ACCOUNTS RECEIVABLE												
trade credits	E	X						X	X		X	E
other	X	X	X		X		X	E		X	X	

indicated. The allocative model, in which equities on total assets are determined on a residual basis, is:

$$QL_t = \alpha + \alpha^{RL}(RL_t - RB_t) + \alpha^{PC} PC_t^- + \alpha^Y Y_t^+ + \alpha^{risk} Risk_t^+ + \epsilon_{QL,t} \quad (11)$$

$$QB_t = \beta + \beta^{RB}(RB_t - RL_t) + \beta^{PC} PC_t^- + \beta^Y Y_t^+ + \beta^{risk} Risk_t^- + \epsilon_{QB,t} \quad (12)$$

$$QF_t = \gamma + \gamma^{RF}(RF_t - RB_t) + \gamma^{PC} PC_t^+ + \gamma^Y Y_t^+ + \gamma^{risk} Risk_t^- + \epsilon_{QF,t} \quad (13)$$

where QL, QB and QF stand respectively for the liquidity, bonds and assets under management to total financial assets ratio; RL, RB and RF are the yields from these assets, PC is inflation, Y is GDP, and $Risk$ is an indicator of asset riskiness (related to the BTP-Bund 10Y spread). Superscripts denote the expected signs of the coefficients associated to the corresponding variables.

In the case of the banking sector, traditionally, the literature proposes several options. The oligopolistic model explains the bank portfolio structure and size by maximizing revenues based on demand for banking products. In the deposit and loans markets, banks are price makers and quantity takers; in the securities market they are price takers and quantity makers. The structure and size of bank assets and liabilities can be explained, also, in terms of cost flows. A maximization problem is solved if the marginal revenue from loans equals the marginal cost of

deposits, under the assumption of perfect competition in both the deposit and loans markets. Finally, portfolio-type models are based on the assumption that banks are price takers in both the bonds and loans markets, so that their behaviour and, consequently, the structure of their portfolios, are explained by taking account of the risks and returns related to possible alternative assets. In this context, the bank maximizes its own utility function subject to budget constraints.

None of these approaches consider all aspects of banks ways of working and, more importantly, of their transformation in recent years. Thus, the QuIProM does not refer, *a priori*, to any of these theoretical models, but adopts a more eclectic approach, relying also on empirical results. In fact, increased market competition has significantly reduced banks abilities to set prices on the basis only of a mark-up on variable costs (as in an oligopolistic market). Banks are operating in more competitive revenue (loans) and costs (deposits) environments. Greater uncertainty about customers' and competitors behaviours has led to the abandonment of full cost theory and the need, especially in loans markets, for an interest rate to act as a benchmark (the policy interest rate or the market interest rate).

The 2008 financial crisis caused additional uncertainty and put pressure on the banking system. QuIProM tries to account for changes such as constraints to credit supply arising from the tightening of capital requirements, increased funding costs, and higher loan portfolio risks. Therefore, overall, the banking sector model is very detailed and explains the balance sheet and bank interest rate components.

On the assets side, the model determines loans to households and to non-financial firms (both broken down by duration), loans to central government and to other financial intermediaries, bad loans and bonds (private and public, short and medium-long term).

Loans to households and non-financial firms are estimated separately, but simultaneously, as part of the same VECM. *A priori*, it is impossible to say whether the equation is a demand or a supply equation, but the empirical results account for a demand-type equation, as though the bank is a quantity taker in the loan market. In fact, loans (L) depend positively on economic activity (Y) and negatively on the cost of loans (RL); supply factors are included through the riskiness of the counterpart (BL):

$$L_t = \alpha + \alpha^Y Y_t + \alpha^{RL} RL_t + \alpha^{BL} BL_t + \alpha^{PP} PP_t + \epsilon_{L,t} \tag{14}$$

In the case of non-financial corporations, loans are correlated to investment and exports and to the real interest rate paid by non-financial corporations, while loans to households depend on consumption of durable goods, on investment in residential constructions, and on the real interest rate paid by households. We include the quality of the loan portfolio, measured by bad loans as a share of total loans, which, in recent years, has worsened, with negative effects on credit supply and consequently on real activity. Finally, we consider the property price (PP) as indicating on of the expectations about on real estate market yield.

Bad loans to households and non-financial corporations are positively correlated to the level of past loans and to the real bank lending interest rate, and negatively correlated to economic activity. The equation shows a long lag between the worsening economic situation and the

increase in bad loans.

Bank reserves depend on both deposits and reserve requirements, while asset allocations are driven by the relative convenience based on the interest rate structure.

On the liability side, as expected, banks can be considered to be mainly quantity takers: households make their own decisions about the allocation of their financial savings providing funds for different types of deposits and for bank bonds, as described above.

The non-financial firm sector is shaped on the liabilities side by the estimated demand for bank loans. Given the financial balance, this determines the amount of bonds and shares issued.

The QuIProM provides a detailed interest rates structure in terms of financial instruments, institutional sector and maturity. It is estimated against two benchmarks: the ECB policy rate (repo), as the short term pivot, and the 10Y Bund rate as the medium-long term rates pivot. The expected inflation and the relative risk of the issuing institution also play a role.

The increased competition in the Italian banking system has weakened the ability of the oligopoly model (according to which banks are price makers in the loans market) to fit the data. Thus, the explanatory variables in the loans interest rate equation include the level of bad loans, a macroeconomic expression of risk, and the costs associated to the increased capital requirements specified in European banking legislation. In particular, interest rates on loans, RL, depend positively on the short-term market rate, R^*,the mark-up applied by the banks depending on the funding cost, MU, and the banks' capitalization, COR. In order to consider risk factors, the spread, $SPREAD$, between interest rates on Italian and German 10Y bonds, is introduced to account for country risk, and the bad loans ratio (BL) is included to account for banking sector risk. The specification of the equation is the following:

$$RL_t = \alpha + \alpha^{R^*} R_t^* + \alpha^{MU} MU_t + \alpha^{COR} COR_t + \alpha^{SPEAD} SPREAD_t + \alpha^{BL} BL_t + \epsilon_{RL,t}. \quad (15)$$

It is worth noting that the estimation of loan interest rates shows some asymmetric reaction (different elasticities and speeds of adjustment) to a reduction or an increase in the ECB interest rate.

In the case of deposit interest rates, those applied to more liquid deposits depend on the short-term market rate, while those applied to deposits with longer maturities depend also on the differential between the 10Y rate of Italian and German sovereign bonds. Finally, the banks bond interest rate is estimated using the yields on government bonds for both short and medium-long term maturities which already include the country risk factor.

The model accounts also for the term structure of Italian government bonds, which depends on the level of the short term interbank rate (3 months), and the benchmark ten-year government bond, with different elasticities depending on the maturity. The spread between Italian and German 10Y bonds is determined endogenously and its fair value is linked negatively to economic activity growth, and positively to inflation and to the government debt to GDP ratio:

$$SPREAD_t = \alpha^D \frac{D}{Y}_t + \alpha^P \dot{P}_y + \alpha^Y \dot{Y}_t + \epsilon_{SPREAD,t}. \quad (16)$$

4 Dynamic properties of the model

In order to depict the characteristics and the dynamic properties of the QuIProM, we present some sensitivity exercises. We evaluate international shocks and policy shocks - both monetary and fiscal. External shocks are generated by the international model in order to take account of the effects of other external variables that might affect the Italian scenario. The results of these shocks, assumed to last three years, are presented as differences from a baseline scenario. In general, the model reactions to different shocks are approximately linear.

4.1 Oil price

The shock consists of a 10 per cent permanent increase in the oil price. In addition, employing our international model, we can estimate the changes to the external variables induced by the oil price change (foreign demand for Italian goods, prices in dollars of imports and of the goods produced by competitors), assuming that monetary policy does not respond. Table 1 shows the results of the exercise, configured as a supply shock.

Table 1: Macroeconomic effects of a 10% increased oil price
(percentage deviations from the baseline scenario)

	1Y	2Y	3Y
GDP	-0.08	-0.13	-0.17
Import (goods and services)	-0.11	-0.51	-0.62
Household consumption	-0.13	-0.25	-0.36
Public consumption	0.00	0.00	0.00
Total fixed investment	-0.07	-0.19	-0.44
Export (goods and services)	-0.08	-0.31	-0.23
Employment	-0.02	-0.08	-0.13
Consumer prices	0.43	0.52	0.48

A reduction in household purchasing power is the first impact on economic activity of a higher oil price. Its initial effect increases over time as other components of aggregate demand are affected, in particular, investment in machinery and equipment.

The intensity of the effect depends on several factors, including how much of the oil price change is transferred to final prices. The effect can be broken down into direct and indirect effects, and second-round effects. Direct effects are sudden and are caused by the fact that energy products are considered in the basket of production and consumer price indices. Indirect effects are more gradual and are related to modifications to intermediate goods prices, mainly those with higher energy inputs. Speed and intensity of the pass-through are determined by firms' market conditions and, therefore, by their ability/power to set prices. The second round effect is the reaction of wages to changes in consumer prices. While the direct effect modifies the consumer

price level, second-round effect can affect inflation. This occurs when oil price movements modify wage settlements and households and firms expectations.

As expected, the overall effect on GDP is negative (about 0.2 per cent after 3 years); consumption shows an immediate reduction due to higher prices, and investment reacts negatively because of reduced output. The export reduction depends mainly on the fall in foreign demand, especially from countries hit by higher oil prices, and reduced competitiveness.

4.2 Euro exchange rate

In this section, we discuss the impact of an effective euro exchange rate appreciation of 10 per cent (Table 2). To obtain an accurate evaluation, we simulate all changes in the external variables (such as international prices in foreign currency and foreign demand) due to the new exchange rate, using the PRIAMO model. We assume that monetary policy does not change with respect to the baseline scenario.

Exchange rate movements have important consequences for the economy. In the case of an appreciation in the exchange rate, the deterioration in price competitiveness reduces exports and favours imports with a negative effect on GDP. Since investments are strictly linked to exports, they also decrease, adding to the negative impact on GDP.

In the case of domestic demand, consumption benefits from higher disposable income in real terms due to lower consumption prices because of the reduced import prices. This reduction in import prices does not translate fully into export prices in the period considered. Euro appreciation also affects relative tradable-non tradable goods prices and corresponding consumption. Tradable prices react to the reduction in import prices while non-tradable prices react only marginally and this modification favours the consumption of tradable compared to non-tradable goods.

Table 2: Macroeconomic effects of nominal euro exchange rate
(appreciation of 10% in effective terms, percentage deviations from the baseline scenario)

	1Y	2Y	3Y
GDP	-0.43	-0.78	-0.96
Import (goods and services)	-1.09	-1.03	-1.12
Household consumption	0.25	0.51	0.64
Public consumption	0.00	0.00	0.00
Total fixed investment	-0.58	-1.30	-1.38
Export (goods and services)	-2.49	-3.50	-4.23
Employment	-0.14	-0.40	-0.63
Consumer prices	-0.83	-1.48	-1.45

4.3 Fiscal policy

Since the public sector is very detailed in the model, the effects on the macroeconomic scenario of fiscal impulses using numerous different instruments can be assessed. We describe three exercises involving an ex-ante increase in the fiscal deficit of 1 per cent of GDP with respect to the baseline scenario using different tools: (i) an increase in public consumption (which is a component of GDP and, thus, modifies it directly); (ii) an increase in transfers (or a reduction in personal income taxes), which enters household disposable income; and (iii) a reduction in the social contributions paid by employers, which affects GDP through household and firm decisions.

Table 3 presents the responses to an increase in intermediate and final public goods and services on the main economic variables.

Table 3: Macroeconomic effects of increased public consumption
(1% of GDP, percentage deviations from the baseline scenario)

	1Y	2Y	3Y
GDP	1.03	1.02	1.03
Import (goods and services)	0.66	1.99	2.67
Household consumption	0.07	0.31	0.54
Public consumption	5.11	5.15	5.20
Total fixed investment	1.02	2.72	3.46
Export (goods and services)	-0.06	-0.13	-0.20
Employment	0.41	1.00	1.43
Consumer prices	0.09	0.14	0.21

A change in public consumption has a direct impact on GDP. This expansion in economic activity acts positively on investment (mainly machinery and equipment), which increases by 5 per cent after three years, through the accelerator effect, and, to a lesser extent, on consumer spending (+0.5 per cent after 3 years), through the expansion in disposable income. The rise in household consumption is limited, in part, by the Ricardian mechanism; in fact, household consumption demand takes into account a probable future increase in taxation to compensate for the negative effect on the public accounts due to the higher public spending.

The rise in output boosts domestic prices, which has a negative effect on competitiveness and, hence, exports. The reduction in exports is modest at 0.2 per cent in the third year.

Imports react positively to higher aggregate demand, reducing the increase in GDP. However, the value of the Keynesian multiplier is greater than 1, although only slightly.

In Table 4 presents the macroeconomic effects of increased household disposable income through public transfers or income taxes. These measures support an increase in GDP of 0.3 per cent

after one year, mostly through consumption which reacts only gradually to income.[8]

After three years, the average propensity to consume is 0.6 percentage points lower than in the baseline scenario, and consumption increases by 1.2 per cent. There is also an indirect positive impulse on total fixed investment which contributes around 0.4 percentage points to the overall increase in GDP after three years. The increased GDP boosts employment by 0.8 per cent after three years.

Table 4: Macroeconomic effects of increased household disposable income due to public transfers or cuts in income taxes
(1% of GDP, percentage deviations from the baseline scenario)

	1Y	2Y	3Y
GDP	0.27	0.53	0.71
Import (goods and services)	0.12	0.51	0.77
Household consumption	0.43	0.86	1.16
Public consumption	0.00	0.00	0.00
Total fixed investment	0.30	1.08	1.70
Export (goods and services)	-0.01	-0.07	-0.14
Employment	0.11	0.43	0.79
Consumer prices	0.02	0.09	0.19

The third exercise involves a cut in employers social contributions (Table 5). This fiscal measure increases GDP by 1.1 per cent after three years through the channel of reduced labour costs and the consequent reduction in prices on one hand, and increased employment on the other. This produces a positive effect on households purchasing power and on competitiveness, boosting consumption and exports. The effect on employment is significant at 1.7 per cent higher than in baseline scenario and an elasticity to GDP greater than 1 after the third year. The increased output exerts a positive effect on investment in machinery and equipment, which is cushioned, only partially, by the negative impulse of a higher user cost of capital to labour cost.

The results of these fiscal policy exercises show that, in the first two years, increasing intermediate and final public spending would be more beneficial than both increasing household transfers (or cutting taxes) and decreasing employers social contributions. However, after the third year the results reverse and cutting social contributions boosts output more than the other two fiscal measures, thanks to improved price competitiveness which strengthens exports.

[8] In fact, even though, in the long run equation, the elasticity of total consumption to disposable income is about 0.8 (0.1 on total wealth), this value is reached only after 4-5years because of the very slow adjustment of non-durable consumption.

Table 5: Macroeconomic effects of reduction in employers' social contributions (1% of GDP, percentage deviations from the baseline scenario)

	1Y	2Y	3Y
GDP	0.37	0.85	1.07
Import (goods and services)	0.09	0.56	0.75
Household consumption	0.46	1.09	1.44
Public consumption	0.00	0.00	0.00
Total fixed investment	0.37	0.75	1.15
Export (goods and services)	0.17	0.69	0.68
Employment	0.33	1.01	1.71
Consumer prices	-1.07	-1.33	-0.89

4.4 Monetary policy

In this section, we simulate a shock consisting of a permanent 100 basis points increase in the ECB policy rate, that is, the repo rate.

As expected, monetary policy tightening has a negative influence on GDP (-0.1 per cent after 3 years, 6) due mainly to reduced investments caused by higher user cost of capital. Household consumption is affected by two opposite effects that almost offset each other. A negative impulse is transmitted through the standard substitution effect between saving and consumption (an increase in interest rates makes it more advantageous for households to save and to postpone consumption). However, because Italian households are net lenders in the economy, a positive impulse acts through an increase in net interest flows in disposable income (income channel).

Table 6: Macroeconomic effects of increase of the ECB policy interest rate (100 bases points, percentage deviations from the baseline scenario)

	1Y	2Y	3Y
GDP	-0.02	-0.03	-0.09
Import (goods and services)	-0.06	-0.14	-0.26
Household consumption	0.03	0.07	-0.02
Public consumption	0.00	0.00	0.00
Total fixed investment	-0.24	-0.45	-0.63
Export (goods and services)	-0.03	-0.09	-0.15
Employment	0.00	0.00	-0.04
Consumer prices	0.00	-0.01	-0.01

After three years, total fixed investment is lower by 0.6 per cent. Also, other EMU countries output is hit negatively by the increase in the ECB policy interest rate and, consequently, their

demand of Italian goods is lower than in the baseline scenario and exports reduce by 0.1 per cent in the third year.

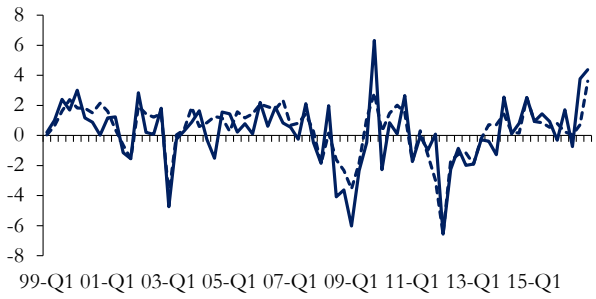
5 Model estimation and forecasting performance

For brevity, we do not present details of the estimation characteristics of each individual equation,[9] although Table 7 includes some of them by way of examples.

Table 7: (1) - Estimates characteristics of some main equations
(% change q-on-q)

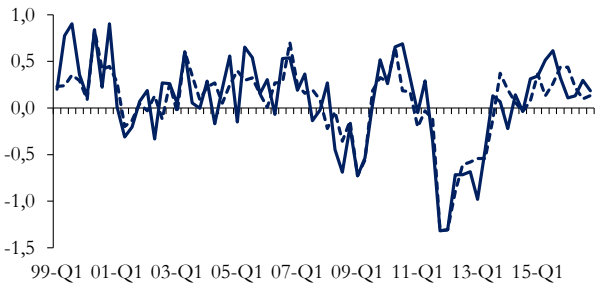
solid line: actual, dashed line: fitted

Investments in plant. machinery and means of transport



R^2	0.663
Adjusted R^2	0.58
Standard deviation dependend variable	0.021
Standard error. of regression	0.014
Serial Correlation	Prob. F(4.53) 0.378
LM Test	
Heteroskedasticity Test	Prob. F(15.56) 0.941

Households consumption (Non-durable)



R^2	0.7
Adjusted R^2	0.638
Standard deviation dependend variable	0.005
Standard error of regression	0.003
Serial Correlation	Prob. F(4.53) 0.166
LM Test	
Heteroskedasticity Test	Prob. F(13.57) 0.277

In general, much attention has been paid to the statistical accuracy of the estimates and, as a result, estimation errors are very low on average. As a double check, we provide fun charts for some of the variables (Table 8), obtained by running stochastic simulations of the entire model using the estimation errors. Hence, the estimation range presented in the fan charts can be considered as due to the uncertainty of the entire model and not the individual equations.

5.1 Forecasting errors

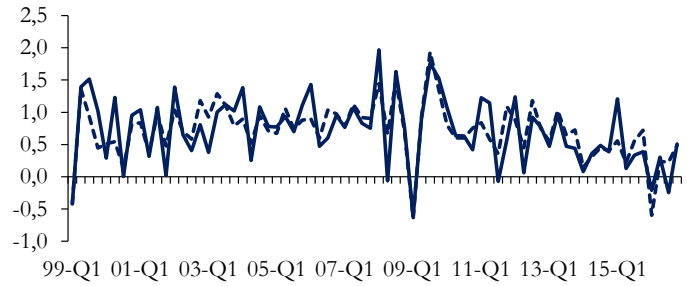
We regularly assess the accuracy of our forecast, calculating the absolute mean errors for the main variables. The magnitude of past errors differs for different macroeconomic variables, indicating that some are easier to predict than others, and reflecting the intrinsic volatility of the

[9] Detailed information on the equation estimates are available from the authors on request.

Table 7: (2) - Estimates characteristics of some main equations
(% change q-on-q)

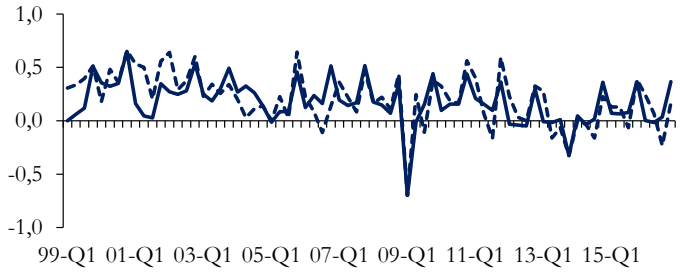
solid line: actual,dashed line: fitted

Wages (industrial sector)



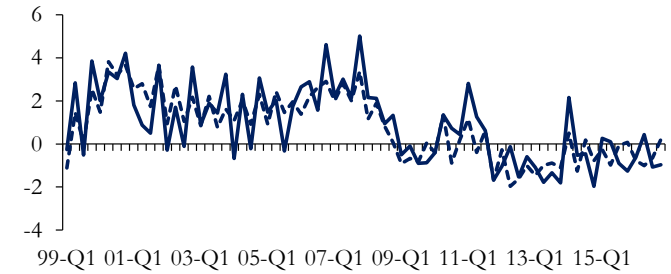
R^2	0.588
Adjusted R^2	0.477
Standard deviation dependend variable	0.005
Standard error of regression	0.004
Serial Correlation LM Test	Prob. F(4.52) 0.148
Heteroskedasticity Test	Prob. F(15.56) 0.881

Consumer price (Manufacturing goods)



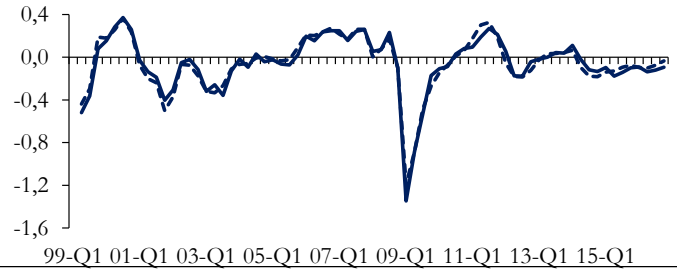
R^2	0.494
Adjusted R^2	0.402
Standard deviation dependend variable	0.003
Standard error of regression	0.002
Serial Correlation LM Test	Prob. F(4.56) 0.094
Heteroskedasticity Test	Prob. F(15.56) 0.568

Loans to non-financial corporations



R^2	0.686
Adjusted R^2	0.609
Standard deviation dependend variable	0.018
Standard error of regression	0.011
Serial Correlation LM Test	Prob. F(4.54) 0.114
Heteroskedasticity Test	Prob. F(15.56) 0.373

Bank interest rate on loans



R^2	0.959
Adjusted R^2	0.955
Standard deviation dependend variable	0.266
Standard error of regression	0.056
Serial Correlation LM Test	Prob. F(4.60) 0.086
Heteroskedasticity Test	Prob. F(15.56) 0.521

phenomenon being measured: for example, the average error in the prediction of consumption expenditure is lower than the average error related to predictions of investments which are characterized by considerably higher standard deviation. In addition, the forecasting error for GDP growth is usually lower than the error related to its components since the components errors tend to offset each other. It should be noted, also, that, for some variables, such as inflation, the scale has changed significantly over the past 30 years: in 1980, inflation reached 21.2 per cent, while now it is well below 2 per cent, which affects the size of the forecast error.

Based on the absolute mean error in, for instance, the Autumn Economic Outlook forecasting[10] (Rapporto di Previsione) for 1980 to 2016, Table 9 shows that the confidence intervals are around the deterministic predictions. Assuming that the errors are normally distributed (broadly confirmed by the tests), the projection range can be calculated as approximately twice the standard deviation of the mean absolute error, for the 95 per cent confidence interval, and about two-and-a-half times the standard deviation of the mean absolute error for the 99 per cent confidence interval.

Comparing the forecast errors in GDP growth and consumer price inflation, between Prometeia and other institutes for the years 1999-2015 (Table 10), it can be seen that Prometeia errors are smaller than those in Consensus predictions of GDP and of a similar magnitude for inflation.

5.2 Out-of-sample forecasting

To evaluate the models forecasting performance, we simulated it out-of-sample four quarters ahead for each year in the period 2004-2016. Table 11 compares the results of these simulations to actual GDP growth and consumer price inflation values.

Mean absolute errors are almost the same for GDP growth and inflation, and quite low (0.6pp) and the mean errors are approximately nil in both cases, with a slight negative bias for inflation. In the case of GDP, the models largest forecasting errors occurred in 2010 and 2012, meaning that QuIProM predicted the GDP drop in 2009, but not the strong rebound in 2010 or the large fall in 2012. The error in 2012 might be due to the fact that, during the sovereign crisis, increased uncertainty and the credit crunch had a strong negative impact on investment and consumption: although these transmission channels are incorporated in QuIProM, they are difficult to quantify. QuIProM predicted the turning point in 2014, when recovery started, but not its strengthening in 2015. This might be due to difficulty related to detecting the strong increase in the propensity to consume that occurred in 2015 (1.3pp), likely related to the fiscal measures to support of low income employees with higher propensity to consume.

[10] Forecast errors differ according to the timing of the forecast since the information sets differ. Therefore, we provide tables of quarterly forecast errors (Spring, Summer, Autumn and Winter).

Table 8: Stochastic simulations of the model

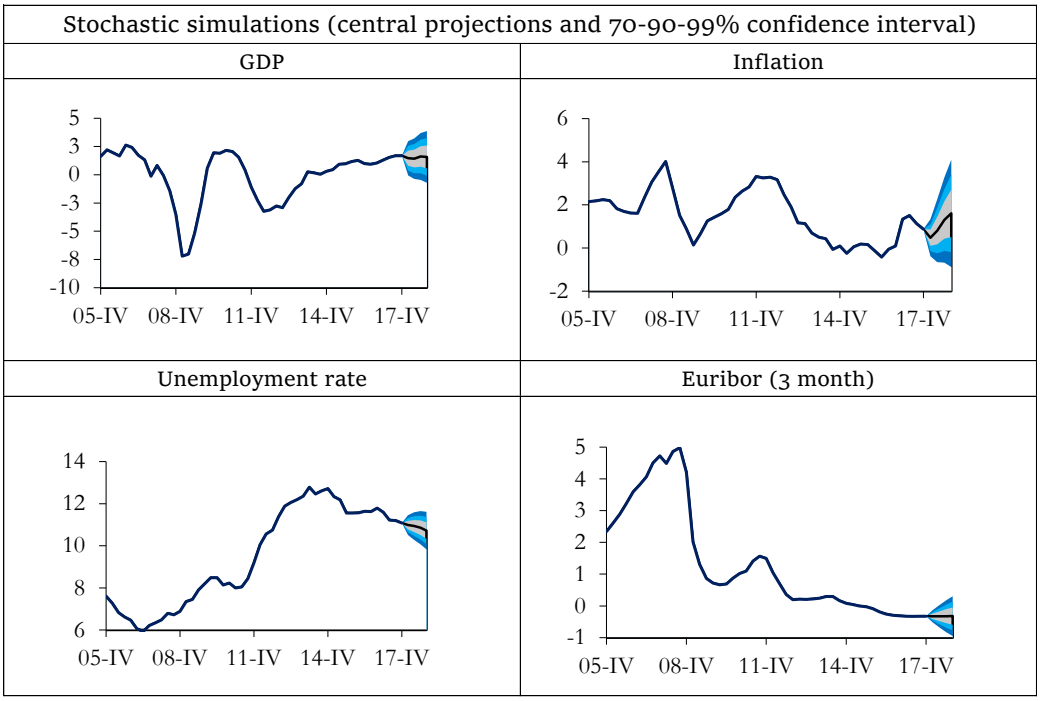


Table 9: Mean errors of Prometeia forecasts made in September-October (1980-2017, % change)

	Current year forecast				Next year forecast			Historical values	Standard deviation
	Mean error	Mean absolute error	Error range min	Error range max	Mean absolute error	Error range min	Error range max		
Gross domestic product	0.0	0.2	0.0	0.8	1.1	0.1	4.7	1.0	1.8
Household consumption	0.0	0.4	0.0	1.0	1.0	0.1	4.1	1.1	1.8
Investment	-0.6	1.9	0.1	6.4	4.2	0.1	13.9	1.5	7.2
Consumer prices	0.0	0.1	0.0	0.7	0.8	0.0	3.0	5.0	5.1
General government balance (% GDP)	0.0	0.4	0.0	3.6	0.9	0.0	2.9	6.5	4.1

Table 10: Forecast error (current year)

	GDP growth	Consumer inflation
Prometeia	0.31	0.12
Bank of Italy	0.30	0.11
European Commission	0.42	0.16
IMF	0.39	0.29
OECD	0.35	0.17
Consensus	0.40	0.12

Table 11: Simulated out-of-sample forecasts four quarters ahead of the QuIProM

	GDP growth				Consumer inflation			
	observed	simulated	error	absolute error	observed	simulated	error	absolute error
2004	1.4	1.0	-0.4	0.4	2.2	1.7	-0.5	0.5
2005	1.2	1.8	0.7	0.7	2.0	1.9	-0.1	0.1
2006	2.1	2.0	-0.1	0.1	2.1	2.3	0.2	0.2
2007	1.3	1.0	-0.3	0.3	1.8	1.8	0.0	0.0
2008	-1.1	-0.9	0.1	0.1	3.3	4.0	0.7	0.7
2009	-5.5	-5.0	0.5	0.5	0.8	0.0	-0.8	0.8
2010	1.6	0.0	-1.7	1.7	1.5	2.6	1.1	1.1
2011	0.7	0.8	0.0	0.0	2.8	3.6	0.9	0.9
2012	-2.9	-0.8	2.0	2.0	3.0	3.0	0.0	0.0
2013	-1.7	-0.9	0.8	0.8	1.2	1.1	-0.2	0.2
2014	0.2	0.2	0.0	0.0	0.2	0.0	-0.3	0.3
2015	0.7	-0.2	-0.8	0.8	0.0	-1.9	-1.9	1.9
2016	1.0	1.0	0.0	0.0	-0.1	-0.9	-0.8	0.8
	mean absolute error		0.58		mean absolute error		0.56	
	mean error		0.08		mean error		-0.14	

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