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The Italian Treasury Econometric Model (ITEM)☆

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ABSTRACT

In this paper, we provide a description of the Italian Treasury Econometric Model (ITEM). We illustrate its general structure and model properties, especially with regard to the economy's response to changes in policy and in other dimensions of the economic environment.
One of the key features of the model is the joint representation of the economy on both the demand and the supply sides. Since it is designed for the needs of a Treasury Department, its public finance section is developed in great detail, both on the expenditure and revenue sides. It also features a complete modeling of financial assets and liabilities of each institutional sector. After documenting the model structure and the estimation results, we turn to the outcomes of model simulation and ascertain the model properties. In ITEM the shocks that generate permanent effects on output are associated with: a) variables that affect the tax wedge in the labor market and the user cost of capital; b) labor supply change; and c) variation in the trend component of TFP (technical progress). By contrast, demand shocks have only temporary effects on output.

1. Introduction

The aim of this paper is to provide a description of the Italian Treasury Econometric Model (henceforth, ITEM.)[1]. In doing so, we illustrate its general structure and properties, especially with regard to the economy's response to changes in policy and in other dimensions of the economic environment.

The model ITEM has a quarterly frequency and includes 371 variables (247 of which being endogenous). The model structure features 36 behavioral equations and 211 identities, referring to accounting definitions and institutional relationships among variables. Being a medium-size econometric model, ITEM is suitable to track and explain the behavior of a considerable number of macroeconomic aggregates of the Italian economy.

Exogenous variables are grouped in three categories: a) those dealing with the international economic environment. These are essentially world demand, exchange rate, oil and commodity prices, and — in forecasting exercises — short-term interest rates; b) fiscal policy variables: i.e. a variety of tax and contribution rates, as well as several public expenditure aggregates; and c) other domestic exogenous variables, such as those related to demographics and, most importantly, the non cyclical component of total factor productivity (TFP).

With regard to the general structure, ITEM belongs to the class of macroeconomic models that assign a prominent role to the supply side of the economy. Indeed, one of its key features is the joint and explicit representation of the economic environment on both the demand and the supply sides. Behavioral equations for private consumption, investment, export and import included in the model structure are rather conventional. The equation for private consumption features a long-run relationship between household expenditure at constant prices, real labor disposable income, real household net financial assets and the real interest rate on short-term borrowing. With regard to the demand for capital goods, a long-run relationship between investment, employment, the unit labor cost and the user cost of capital is imposed with a unit elasticity of investment with respect to both output and the user costs, consistently with the optimal conditions of a profit-maximizing firm facing Cobb–Douglas technology. The ECM specification for exports features a long-run relationship between export, world demand and real effective exchange rate. Real non-oil imports depend upon absorption and the relative price of non-oil

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[1] The actual development of the project at the Italian Treasury started in 1994 and a team of economists was involved, under the guidance of Carlo Favero and Riccardo Fiorito. In 1998, a version of the model was officially presented at the Department of Treasury and the name of ITEM, Italian Treasury Econometric Model, was assigned to it. A report with an overview of the first version of the model was also prepared (Favero et al., 2000). Since then the model has come under a growing scrutiny and a significant revision process has been undertaken which has led to the current version of the model.

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imports whilst imports of oil and energy have a simpler structure featuring a long-run relationship between oil and energy imports and the volume of economic activity.

A notable feature of ITEM is that gross domestic product is computed, via an accounting identity, on the supply side. In particular, total GDP is the sum of value added of market and non market sectors and net indirect taxes and, importantly, the value added of the market sector is obtained through a production function of the Cobb–Douglas type with constant returns to scale, where value added depends on labor, capital stock and total factor productivity (TFP).

The demand equation for labor input is estimated by imposing a long-run relationship coherent with the optimal conditions of the firm's profit maximization as it is done for the demand for capital goods. A specific characteristic of ITEM is that the TFP variable is modeled as a combination of two components: an exogenous trend component, that reflects long-run growth determinants, such as technical progress and organizational innovation, and a cyclical component. The latter reflects measurement problems in the available input statistics, which fall short of properly capturing cyclical variation in the degree of intensity of factor utilization. This cyclical component of TFP is thus modeled through a statistical equation that links it to demand conditions.

The model GDP accounting identities are closed by computing inventory changes as the difference between GDP and total demand. The fact that they are treated as a residual buffer, rather than a variable determined by a behavioral equation, represents a novel feature of our model dating back to its initial version (see Favero et al., 2000 and Fiorito, 2003).

Price and wage behavior is modeled similarly to most existing econometric models. Value added prices respond with a unit elasticity to unit labor costs and to the cyclical component of TFP. This channel provides a feedback from the supply side of the economy to the demand side. Indeed, price changes induced by tensions on capacity utilization and the demand side impinge on firms' external competitiveness thereby affecting aggregate demand. This brings back the observed TFP level toward its trend value. As far as the labor market is concerned, a bargaining model underlies the wage equation. The real wage is linked, in the long run, to labor productivity, the unemployment rate and the tax wedge on labor.

In ITEM real or nominal frictions usually characterizing several markets do not explicitly rest on microeconomic foundations. For example, we do not introduce price or wage stickiness by relying explicitly on theoretical underpinnings, like the state-dependent Calvo price staggering. However, we do allow our model specification to accommodate the effects of frictions. In particular the dynamic specification of the equations features a disequilibrium correction mechanism where the speed of adjustment varies from variable to variable. This modeling tool contributes to mimic, on empirical ground, the relevant effects of frictions.

To wrap up, output in ITEM — albeit computed directly on the supply side from an accounting identity — is determined in the short run by demand conditions. Indeed, the inclusion of TFP in the production function and the statistical equation to account for its observed cyclical variation are the technical devises to make demand conditions predominant in the short run. Output level is determined on the supply side as to what pertains the long run. In ITEM the shocks that generate permanent effects on output are associated with: a) variation of variables affecting the tax wedge in the labor market and the user cost of capital; b) labor supply change; and c) variation in the trend component of TFP (technical progress). By contrast, impulses on the demand side have only temporary effects on output and, in general, on the economy.

Moreover, since ITEM is designed for the needs of a Treasury Department, its public finance section is developed in great detail. Spending and revenue items are modeled almost with the same level of breakdown provided by the national statistical institute (ISTAT) in the general government appropriation accounts. On the expenditure side the most relevant distinction is between public consumption — decomposed in its labor and non-labor (purchase of intermediate goods) components, subsidies and public investment. These primary expenditure items summed to interest payments — estimated as a function of the debt stock and interest rates pattern — add up to total government expenditures. Shocks to government outlays have an impact on GDP, although generally a temporary one. Concerning revenues, all main components are separately included: direct taxes on labor (IRE, formerly called IRPEF) and on profits (IRES, formerly called IRPEG), indirect taxes — divided into value added tax (IVA), excises on fuel production and regional tax on productive activities (IRAP) — and social security contributions. For the latter we keep the official distinction between employers, self-employed and employees' contributions. Each revenue variable included in the above list is obtained by multiplying an implicit average tax rate to the corresponding tax base (see Mendoza et al., 1994). In addition, ITEM includes taxation on income from financial capital, on capital gains and on local duty on real estate (ICI). In general, tax rates are distortionary and they either enter into the fiscal wedge between real disposable wage and salary and the labor cost or contribute to determine the value of the user cost of capital. In both ways taxation ends up affecting the level of GDP permanently.

A relevant characteristic of ITEM is the explicit modeling of the accumulation process of financial assets and liabilities of the institutional sectors as well as of their feedbacks on agents' decisions. In particular, we have reconstructed the flow of funds for: a) the household sector, b) the non residents sector, c) the sector pertaining to public administration and d) the business sector featuring both financial and non financial firms. It is important to note that we also model in a comprehensive and coherent fashion all flows of capital income.[2]

The approach underlying ITEM is not that of dynamic stochastic general equilibrium models (DSGE) which has become increasingly popular (see, e.g., Smets and Wouters, 2003 and Forni et al., 2007). In other words, the relationship between variables and the propagation mechanisms of any impulse that characterize our theoretical framework is not obtained within a forward-looking model, fully based on agents' intertemporal optimization. In some respect such a carefully micro-founded theoretical model would have proved more appropriate than our own approach, as in that framework, for example, the parameters describing tastes and technology are readily identified (see Favero, 2007). On the other hand, however, a parsimoniously parameterized model of the DSGE type has some limitations with respect to a less theory dependent, but more data-driven, dynamic model like our own. For example, as we emphasized before, in ITEM we allow for a breakdown of fiscal variables into a large number of components and also explicitly consider the borrowing and lending activities of all the institutional sectors in the Italian economy thus making our model more informative. Whilst the recent DSGE models estimated in a Bayesian framework allow one to increase the number of parameters with respect to previous approaches, it is clear that DSGE models do not allow for a variable coverage as large as the one featured in ITEM.[3] Moreover, an institutional scope assigned to the Treasury model is that of forecasting macroeconomic aggregates

[2] The entire structure of the model is analyzed in greater detail in a separate Attachment to the online version of the paper (see Attachment I).

[3] As eloquently exposited in Favero (2001), Spanos (1990) introduces the distinction between structural and statistical identification in econometric modeling, positing that structural identification refers to the uniqueness of the structural parameters, as defined by the re-parameterization of the model's reduced form, whilst statistical identification deals with the selection of a well-defined model as reduced form. Whilst DSGE models pursue structural identification, models in the so called LSE tradition (where LSE stands for London School of Economics) pay a greater attention to statistical identification. Therefore, it is this latter feature that characterizes our model.

and, arguably, a DSGE type of model would fall short of providing a satisfactory degree of forecasting accuracy.

The behavioral equations of ITEM are estimated over the sample 1982:1 2006:4. In order to account for both the short- and long-run dynamics of variables, we employ single equation specifications using the error correction model (ECM) methodology (see Hendry, 1987, 1995). Thus, our dynamic specifications involve long-run equilibrium relations among variables in (log) level as well as lagged (log) differences in the dependent variable and in regressors. The error correction mechanism allows to correct for deviations from the equilibrium (see, e.g. Favero, 2001). We pay a great deal of attention to ensure adequacy of the statistical model implicit in the estimated structure. In particular, we allow for a rich dynamic structure in the specification of each equation and systematically verify — through appropriate tests — that residuals do not exhibit autocorrelation, eteroschedasticity and deviation from normality.[4]

After documenting the main features of the model supply side, we assess the model properties as follows. We first conduct an out-of-sample baseline simulation, which is conditional on a set of projected values for the exogenous variables. Then, we impart a number of single shocks changing in turn the values of policy variables or of other exogenous variables. Comparing the pattern of the main endogenous variables under the baseline scenario and under each disturbed simulation provides the dynamic responses to the policy impulse or to some other shocks. The length of the simulation horizon is long (150 quarters), allowing to disentangle both short- and long-run effects. In addition to assessing the model properties in terms of the economy's response to shocks, we also perform in-sample dynamic simulation of the model using the estimated coefficients of the behavioral equations. This allows us to appraise, for each aggregate, whether the simulated values track the observed data.

The paper is organized as follows. Section 2 deals with the characterization of the supply side of the model. Section 3 presents the model properties. Section 4 draws some conclusions.

2. The characterization of the supply side

In this section we provide a characterization of the supply side which plays a prominent role in the model architecture and, differently from the demand side, has specific features usually not found in existing macro models.

In “closing” the model, we do not follow the customary approach of using the demand side. To be more specific, we model all demand side variables with the exception of the inventory changes and obtain the latter variable as a residual after determining real GDP on the supply side through an accounting identity.[5] The latter dictates that GDP is obtained by adding up market and non-market values added and net indirect taxes. Output of the private sector corresponds to the market real value added and is computed through the following identity which represents a standard constant return to scale Cobb–Douglas production function

$$VAM_{\mathrm{t}} = TFP_t \cdot L_t^{\alpha} \cdot K_t^{1-\alpha} \tag{1}$$

where L and K denote labor and capital, respectively, and TFP is total factor productivity. The parameter α is the output elasticity with respect to labor and in writing Eq. (1) we assume constant returns to scale. In the model, we do not estimate the parameters of the production function. Rather, we rely on the fact that, under the standard hypotheses of perfect competition in the product and factor markets and constant returns to scale, output elasticities are equal to the factor shares, i.e. to the shares of each factor's remuneration over value added in nominal terms. Since these shares are observed with available data, in order to approximate α and $(1-\alpha)$, we simply take the time average of labor share and its complement to one. In the sample used, the average value of labor share for the Italian economy is .65. The calculation in Eq. (1) to derive the output is fully consistent with the procedure to measure *TFP*, which is based on the standard approach developed by Solow (1957). This implies, of course, that expression (1) is an identity when we focus on observed data in the sample. When we solve the entire model, the values of labor and capital are obtained by estimating separate demand equations for labor and capital goods.

Importantly, as far as *TFP* is concerned, we explicitly consider two distinct components of it: a first one which refers to technical progress and a second one which is pro-cyclical and reflect measurement problems in the available statistics of labor and capital. Indeed, these statistics fail to properly account for labor and capital hoarding and for the ensuing cyclical variation in the degree of factor utilization. We tackle this issue explicitly by estimating a statistical equation for the cyclical component of *TFP* linking it to cyclical indicators. In the following, we explain in detail the approach that has been followed.

According to standard textbook treatment of the production function, the inclusion of *TFP* in it seeks to capture the role of technical progress and organizational innovation in shifting the amount of production for a given level of inputs. In fact, available measures of *TFP* variation and, in particular, the standard Solow residual are characterized by a substantial degree of pro-cyclicality. In other words, the observed rate of *TFP* growth varies remarkably at cyclical frequencies and its pattern tracks considerably that of demand conditions and cyclical indicators (see Fig. 1).

Several explanations have been proposed in the literature to account for this pattern. The explanation that has gained a widespread consensus owes to the unobserved variations in the degree of intensity of factor utilization. These unobserved variations in input use are due to adjustment costs in hiring and firing and in undertaking investments. This induces firms to rely on some form of factor hoarding, which typically induces serious problems of input measurement. Indeed, whilst factor utilization contributes to output, the available statistics on labor and capital do not capture their variation induced by changes in the degree of intensity of factor use[6]. This causes measured total factor productivity to be highly pro-cyclical. Among the early contributions which addressed this issue the most relevant are Oi (1962) and Solow (1964). Other recent contributions include, among others, Bernanke and Parkinson (1991), Basu (1996) and Sbordone (1996).

To account for this phenomenon in our framework, we first define the standard measure of *TFP* growth rate:

$$dtfp_{\mathrm{t}} = dy_t - \alpha dl_t - (1-\alpha) dk_t \tag{2}$$

where lower case letters denote logarithms. We also define a measure of *TFP* variation that explicitly allows for variation in the intensity of factor utilization (*IFU*) and therefore provides a better measure of technical progress (we call this *TFP_TP*):

$$dtfp\_tp_{\mathrm{t}} = dy_t - \alpha(dl_t + difu_t) - (1-\alpha)(dk_t + difu_t) \tag{3}$$

where we have assumed for simplicity that variation in the intensity of factor use is the same across productive inputs ($difu_t$). This

[4] All the estimation results together with a number of diagnostic tests and the outcome of a variety of simulation and model validation exercises can be found in two separate Attachments to the online version of the paper (see Attachments II–III).

[5] Under the methodology currently used for deriving national accounts, real variables are computed through chain-weighted methods. The latter imply that the level of real GDP is not equal to the sum of its components, except for the reference year and the year following. We tackled this issue by considering a residual variable that restores additivity in the national accounts' identity.

[6] See the discussion on similar issues in Turner et al. (1996).

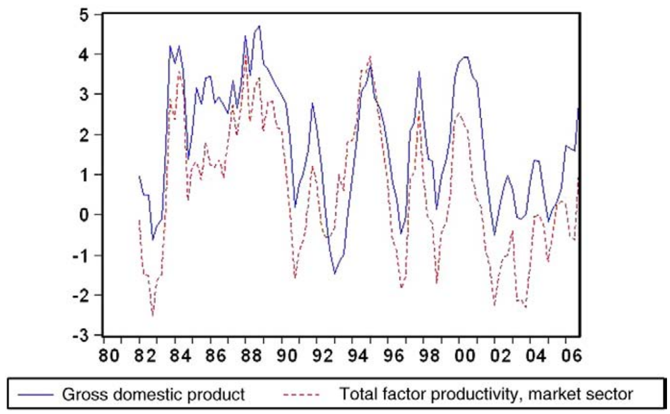

Fig. 1. The cyclical behavior of total factor productivity (Italy; 1980–2006).
Source: Italian National Statistical Institute (ISTAT).

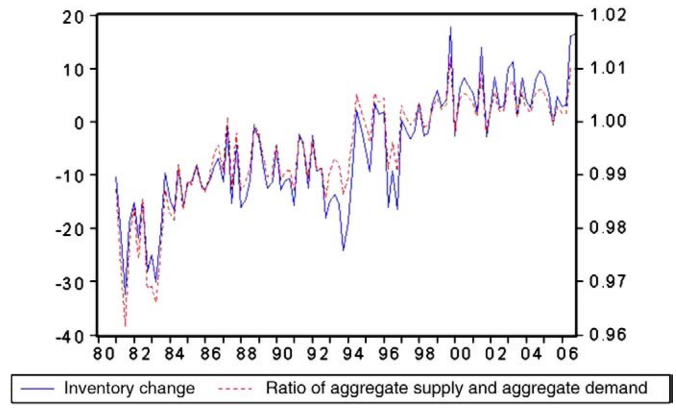

Fig. 2. Inventory change and the ratio of aggregate supply and aggregate demand (*ASAD*) (Italy; 1980–2006).
Source: Italian National Statistical Institute (ISTAT).

simplifying hypothesis combined with that of constant returns to scale is such that the following expression holds true:

$$dtfp_t - dtfp\_tp_t = difu_t \tag{4}$$

Therefore, our production function in Eq. (1) can be re-formulated as:

$$VAM_t = TFP\_TP_t \cdot (L \cdot IFU)_t^{\alpha} \cdot (K \cdot IFU)_t^{1-\alpha} \tag{5}$$

Consistently with the above framework, in ITEM we explicitly consider the two components of measured *TFP*, the one referring to the technical and organizational innovation (TFP_TP_t) and the one referring to changes in factor use (IFU_t). The two components are identified by applying the HP filter to the available data on *TFP*, so that condition (7) is ensured.

The production function that we use in ITEM, which is actually identical to the one in Eqs. (1) and (5), is the following:

$$VAM_t = TFP\_TP_t \cdot IFU_t \cdot L_t^{\alpha} \cdot K_t^{1-\alpha} \tag{6}$$

In our simulation analyses, we treat the "structural" component of TFP change ($dtfp\_tp_t$) as exogenous. On the contrary, we treat the other component, $difu_t$, as endogenous and relate its movements to the evolution of cyclical indicators, such as aggregate demand and the discrepancy between aggregate demand and supply. The statistical equation that we estimate is the following

$$dtfp_t - dtfp\_tp_t = difu_t = \beta + \gamma \cdot ddem_t - \epsilon \cdot ASAD_{t-1} \tag{7}$$

where aggregate demand (*DEM*) is the sum of the demand components of GDP and *ASAD* is the ratio between aggregate supply and demand. The pattern of the latter variable mirrors the one of inventory changes. Hence, an increase of *ASAD*, for example, corresponds to an inventories build up (Fig. 2).

The interaction between the production function (1) and Eq. (7) contributes to explain the mechanism through which, in the short run, the balance between supply and demand is re-established after demand impulses. Let us consider, for instance, a positive demand shock arising at time *t*. Such increase affects directly the intensity of factors utilization (and thus the measured level of total factor productivity). The increase of demand will not be immediately matched by an equivalent increase of production; thus it will be accompanied by a rundown of inventories, as approximated by the discrepancy (the ratio) between supply and demand.[7] In the following period, the above mismatch will however increase the pro-cyclical component of *TFP*. This yields, through the production function (1), a parallel increase of output, that restores the equilibrium between supply and demand and let inventories revert towards their "normal", pre-shock levels. To sum up, through the described mechanism the supply side of the economy temporarily accommodates demand shocks. Moreover, in the aftermath of this shock, the expansion of actual *TFP* increases the gap between *TFP* and its trend (structural) value[8]. The way we address the issue of productivity cyclicality, by emphasizing the role of unobserved variation in input use, allows us to interpret the gap between actual and trend *TFP* as a measure, albeit indirect, of the degree of capacity utilization. Later in this section we will show how we take advantage of the informative content of this variable in other equations of the model (such as, for example, the price equation) and by doing so we introduce additional channels of interaction between supply and demand.

With regards to the firm's demand for productive factors, the demand for employment and capital services are modeled in ITEM through behavioral equations that seek to explain both the short and long-run dynamics of labor and capital inputs. Importantly, the long-run side of each of these equations, i.e. the long-run relationship in level between the dependent variable (labor and capital) and its explanatory variables, directly stems from the optimal conditions of firms' profit maximization.

In ITEM, we model producer prices using value added deflators. The long-run portion of the price equation features a structural positive relationship between the price level and unit labor costs (*ULC*). Consistently with theoretical predictions, we impose a unit price elasticity to *ULC*. Moreover, the structure of the price equation includes the gap between actual and trend *TFP* in order to allow for the impact of the degree of intensity of factor utilization. Our formulation of the equation accommodates the presence of a mark-up that fluctuates throughout the business cycle. The wage equation is designed consistently with a theoretical model of wage bargaining (see, e.g. Layard and Nickell, 1986). In this equation, the real wage is linked, in the long run, to labor productivity, the unemployment rate and the tax wedge on labor.

3. The model properties

3.1. Model simulations: exogenous variables projections and policy rules

The main international exogenous variable are: trade weighted foreign demand of Italian goods, producer price of foreign competitors, oil price, the international stock exchange (as proxied by the

[7] In addition to that, the overall demand stimulus will be initially contained due to the fact that the short term import elasticity to aggregate demand is high (close to 2%).

[8] The trend value of *TFP* is projected exogenously (as a function of a time trend and of lagged terms) in out-of sample projections.

Down Jones index), the euro-dollar exchange rate and international interest rates. The ITEM base scenario embodies a projection for these variables consistent with the most recent forecast produced by international organizations (the OECD medium term scenario is the most commonly used). Productivity and demographic variables are also projected exogenously. The trend level of total factor productivity is extrapolated from the recent pattern of the economy. Population forecasts are drawn from ISTAT (the Italian National Statistical Institute). The trend component of participation rate is again extrapolated from past behavior (this variable is partially endogenous).

Finally, public sector variables, are extrapolated according to different rules. Implicit tax rates are kept constant at their most recent historical value. Whilst most of the revenue variables are anchored to a specific tax base (e.g. VAT taxes respond to nominal consumption), a few items grow simply in line with nominal GDP. Expenditure projection rules are slightly more articulated. In general, public expenditures are exogenous and held constant in real terms, with pension expenditure being also tight to demographic projections. Public employment is set on a smoothly declining pattern. The amount of unemployment benefits is the only variable properly responding to the cycle. Public sector deflators, on the contrary, move in line with private sectors deflators. Finally, interest rate expenditure on public debt is a function of a moving average of past (short-term and long-term) interest rates, of duration of the debt (proxied by the percentage of outstanding public debt with a maturity respectively shorter and longer than one year) and of the stock of the debt.

When looking at the model long-run properties, we can switch on a fiscal policy feedback rule, which ensures that in the long term the public debt to GDP ratio moves back to the base value or, at least stabilizes at a new value, after a shock to the baseline scenario is imparted. The feedback rule is not activated immediately but it kicks in after 20 periods (five years) of simulation. This choice was made in order to prevent alteration in the medium term of the model responses.

By sticking to the usual assumption that personal income bears the brunt of the adjustment, the feedback operates on the non distortionary component of personal income taxation (in terms of model response, the same effect would be achieved by cutting transfers to households). The rule is described by the equation

$$TPnd_t = TPnd_{t-1} + \psi[(GDEBTABI_{t-1} / GDP_{t-1}) - (GDEBTABI_{t-1} / GDP_{t-1})^{base}] \quad (8)$$

where, TPnd is a non distortionary component of the taxes paid by households, GDEBTABI/GDP is the General Government financial debt to GDP ratio, ψ is the speed of adjustment parameter.

The current version of ITEM does not contemplate forward-looking solutions; therefore the model would be solved even in the absence of the above rule and a feedback rule is not strictly required. However, there are good reasons for adopting the above framework. Namely, it is necessary to stabilize in the long-term net asset holdings of the institutional sectors. Additionally, running simulations without the provision of a stabilizing mechanism for public finance would induce users to draw incorrect conclusions on the long-term impact of fiscal policy. For instance, a deficit generated by a tax cut (i.e. not offset by an expenditure reduction) would have a permanent effect on GDP. The implications of switching on and off the feedback rule will be illustrated when commenting on simulation results.

In our model monetary policy is captured by movements in the policy interest rate. The relevant variable in our case is the three-month Euro rate. The long-term portion of the term structure is considered by modeling the yield to maturity of 10-year bonds. Being the ECB the institution in charge of determining the appropriate policy rates for the Euro area since the beginning of the European Monetary Union in 1999, the level of nominal short-term interest rates is largely exogenous for the Italian economy. This occurrence has created modeling problems when running single country models of the euro area. Namely, it has to be projected a level for the — common — policy rate and it has to be decided whether and to what extent the policy rate reacts to shocks occurring to the country in question.

With reference to the first issue, we decided to consider the policy rate as exogenous. When assembling our base forecast either we project this variable by using the sequence of one-month forward rates implicit in the term structure of the euro-area interest rates or we resort to commercial forecaster assumptions.

The second issue becomes prominent when running alternative scenarios. We have a number of options. One is to keep nominal interest rates unchanged with respect to the baseline simulation; this solution implies that monetary policy is assumed to be largely accommodative. It would also be possible to calibrate a Taylor rule just for the Italian economy (see Clarida et al., 1998). Such an approach would provide the most responsive policy rule out of the alternative options we resort to and it would be useful for delivering clear cut long-term model properties. However, it also would be the most distant from the policy setting of the euro area, which does not contemplate independent monetary authorities at country level. The most realistic solution is to introduce a reaction function for the ECB so that the feedback that Italian economy has on the policy rate is restricted to the weight that Italy has in the area GDP. When testing extensively model properties, as a compromise solution, we run the whole set of reported perturbed simulations assuming constant real interest rate.

For projecting long-term rates we resort, like in the case of short-term policy rates, either to private forecasters or to future contracts. When simulating alternative scenarios new long-term rate projections are computed assuming that changes with respect to the base value are equal to the changes of short-term interest rates. Taking the yield of ten-year German government bonds as the reference rate we model the credit risk premia of Italian government bonds as a function of the Italian government debt to GDP ratio.[9]

3.2. Multiplier analysis

Long-term properties of the model ITEM are determined by supply conditions, i.e. by production factors behavior. Therefore only policy changes that affect capital and/or labor equilibrium level will have permanent effect on simulation outcomes. On the contrary, changes in demand conditions give rise to temporary effects only; GDP long-term level remains broadly unaffected.[10] Examples of the former are fiscal measures designed to reduce the tax wedge on labor income or the user cost of capital. Examples of the latter are increases of public consumption, of world trade or nominal exchange rate movements.

These distinctive features can be highlighted by illustrating the model responses to several shocks. Output and other relevant variables changes with respect to the values of a base simulation can be commented upon and interconnections between different variables responses can be used to explain how the model settles to a new equilibrium.

Unless otherwise specified, lines shown in the following figures represent the percentage change of a variable in the perturbed

[9] ITEM includes also interest rates on bank lending, which are modelled via ECM specifications as mark-ups on the three-month euro rate. The interest rate on bank lending enters the aggregate demand block via the determination of the user cost of capital, which affects investment, and of the real interest rate, which enters the consumption equation. In ITEM money demand is determined by income and it is not related to interest rate behavior, nor it conveys information on monetary policy. The only variable of the monetary sector we model is bank account deposits, which we hold constant as a proportion of GDP. This variable has no other feedback on the model than determining the tax base for tax revenues on bank deposits.

[10] Changes in the demand mix can lead to very small permanent effects.

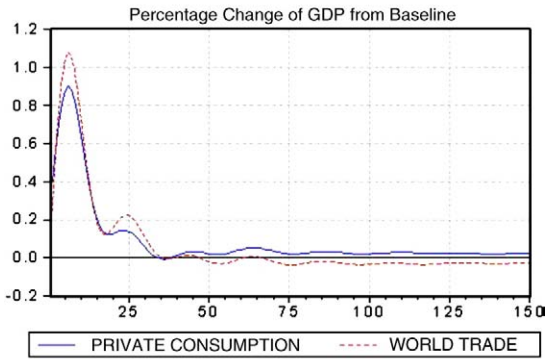

Fig. 3. Shocks on world trade and private consumption.

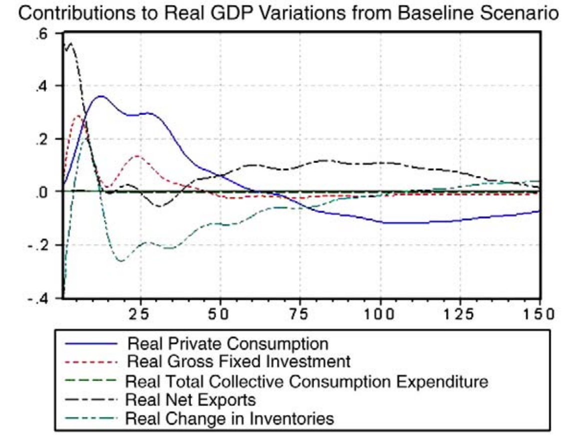

Fig. 4. Shock on world trade: effects on the demand side.

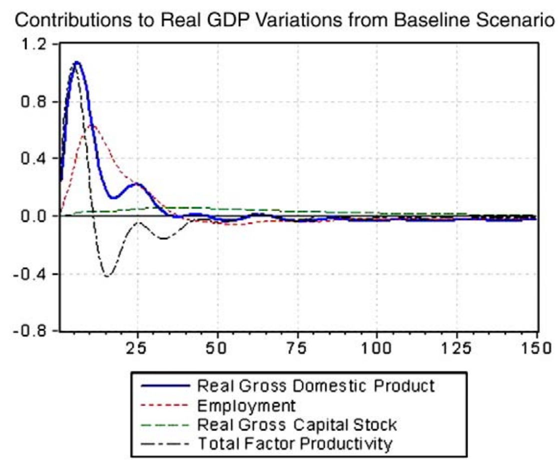

Fig. 5. Shock on world trade: effects on the supply side.

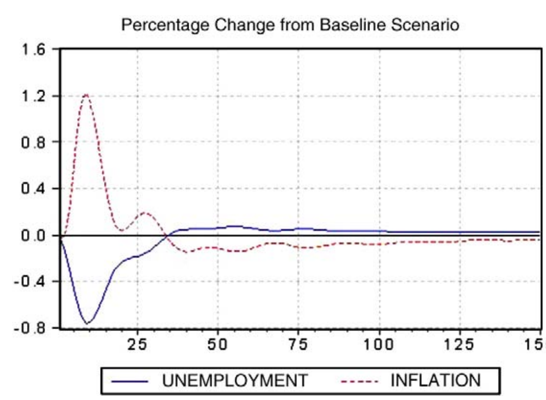

Fig. 6. Shock on world trade: effects on unemployment and inflation.

simulation with respect to the values obtained under the baseline scenario. All changes to exogenous variables are permanent and for the sake of comparison, when possible, they are calibrated so that the initial impulse amounts to a value equal to 1% of GDP[11].

Model responses to exogenous shocks are conditional on policy assumptions built into the simulations, which in most cases will affect the transition pattern of variables toward the new steady state. As mentioned above, unless otherwise specified, simulations are run under the hypothesis of unchanged real interest rates with respect to the baseline scenario and a fiscal policy feedback rule is activated.

The figures reported below represent the GDP multiplier under different shocks imparted to the baseline scenario (numbers along the horizontal axis represent quarters).[12]

We first consider a positive shock to world trade and to private consumption (Fig. 3). Both curves present the usual hump-shaped profile that is expected to characterize output response to demand shock, with total activity moving back to base in the medium term. The size of the multiplier varies slightly across the two shocks. In the short term this is related to the different import content of export and consumption.

Afterwards, the reduction of the household net financial assets — with respect to the base simulation — directly related to the exogenous increase of consumption becomes a relevant factor. In the medium term, it curbs down the output expansion whilst in the long term it causes a lower level of consumption. In the long-term output ends up below base because of net indirect taxes, that enter the GDP identity.

With reference to the world trade shock, the change of GDP can be decomposed into the change of its components from both the demand (Fig. 4) and the supply side (Fig. 5). Changes with respect to the base simulation in unemployment rate and inflation are presented in Fig. 6.

The positive shock to world trade provides an impulse which is propagated by means of the well known multiplier mechanisms. Through time the stimulus is transmitted to domestic demand components. On the contrary, net exports, which initially provide a positive contribution to growth, become a drag because of higher activity boosting imports. The maximum value of the multiplier is reached between the second and third year of simulation. In the medium term — after approximately 5–6 years of simulation — aggregate demand is gradually brought back to base. In the long term demand components behavior is influenced by adjustments of the financial assets of all the sectors.

Growing demand immediately drives upward the degree of input utilization and, thereby, the measured value of total factor productivity, which in the first year of the simulation is the prevailing driver of the value added increase. Afterwards, the output rise is sustained by the positive contribution of employment and — only to a minor extent — capital stock, which has been boosted by higher demand. Over the medium term all contributions are brought back to zero.

The initial TFP positive response is only cyclical, being associated with an increase in the extent of utilization of the existing productive factors. The ensuing positive mismatch between the actual level and

[11] For instance reductions of the implicit tax rates are calibrated so that they determine an ex-ante reduction of government revenues equal to 1% of GDP.

[12] It has to be pointed out that in this section we refer to a restricted number of shocks. A technical Appendix in Attachment III provides, however, detailed results for a very large number of simulations (more than 20), including shocks to interest rates, population and oil price.

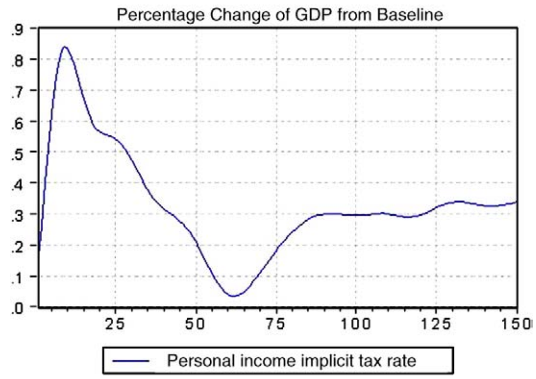

Fig. 7. Shock on personal income implicit tax rate: the effect on GDP.

the trend value of TFP feeds into the price equation, generating a rise of the rate of inflation. The same argument applies to the employment response to the upswing, which causes unemployment to move above its trend value. Therefore, upward pressure on the inflation rate comes also from the wage equation. Unemployment and inflation changes with respect to the base simulation have an opposite behavior, mirroring each other as represented in Fig. 6.

The reduced competitiveness worsens net external demand and, mostly by this channel[13], output is driven back to its base value by the seventh year of simulation.

We turn next to examine a reduction of the personal income implicit tax rate. In the model this kind of shock propagates through two channels: a demand side — which is related to the increase of disposable income experienced by households — and a supply side, arising because the cut affects the tax wedge on labor income.

There are two main differences with respect to the previously examined exercise: total output does not revert back to base in the long term and, furthermore — notwithstanding the permanent impact of the shock — there is a temporary downward rebound of output (Fig. 7).

The increase of disposable income boosts consumption, which in turn drives investments upward; the overall result is a higher level of domestic demand. Conversely, net export contribution to growth is immediately negative and it stays so over a long time span[14] (Fig. 8).

The demand component outcomes are reflected by the supply side of the simulation. Whilst total factor productivity moves back to base in the long term, it is, however, the main driver of the negative rebound in the central part of the simulation. Capital stock and employment levels end up above base in the long term, with employment accounting for most of the change with respect to the base projection. As a matter of fact, the rate of unemployment, contrary to the world trade simulation, ends up permanently below the baseline due to the wedge reduction (Fig. 9).

The following pictures show the impact of a 1% increase of working age population and of a 1% increase of the trend level of total factor productivity (Fig. 10). In both cases GDP increases in the long term by approximately 1%.

The behavior of the supply side components is illustrated in Figs. 11 and 12. Both figures illustrate that adjustments of the capital are very low to occur. Although the length of the period might seem excessive, this is not a worrisome feature. First of all, at any rate, the majority of the adjustment takes place in a relatively short span of

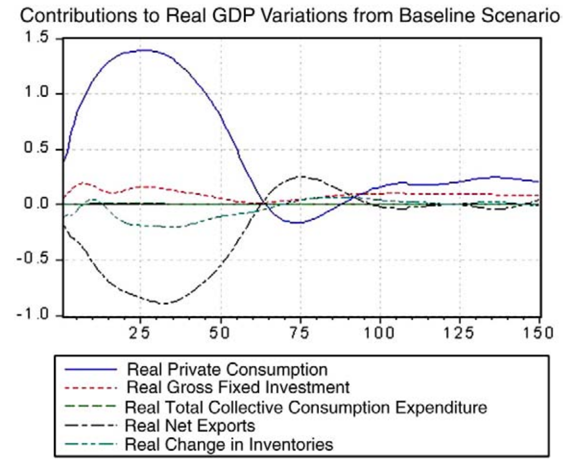

Fig. 8. Shock on personal income implicit tax rate: effects on the demand side.

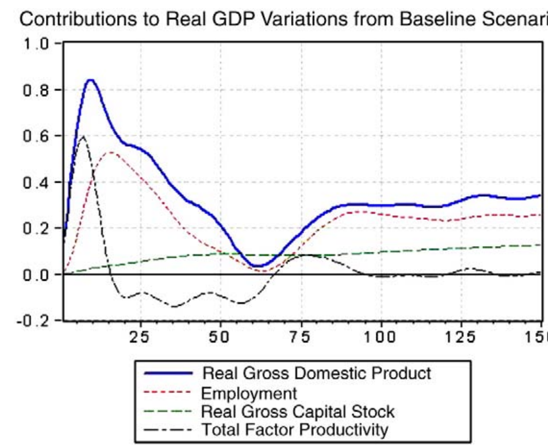

Fig. 9. Shock on personal income implicit tax rate: effects on the supply side.

time. Second, when simulating the model within sample, investment behavior matches quite well its historical pattern.

3.2.1. Policy rules

The fiscal policy feedback rule affects model properties. The cyclical GDP rebound in tax cut or public spending simulations is induced by the kicking in of the rule beyond the medium term of the simulation (after 5 years). The public debt to GDP stabilization is matched by a dampening household disposable income, which is hit

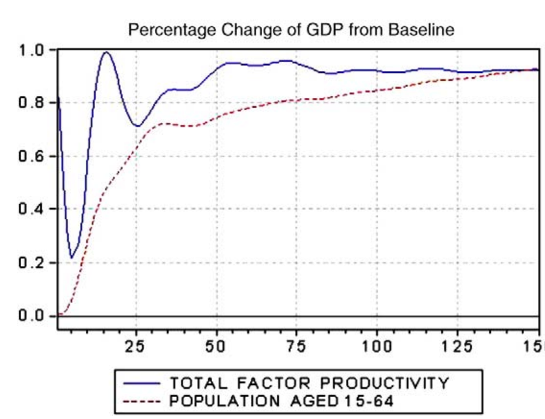

Fig. 10. Shocks on TFP and population.

[13] Also internal demand is driven down as increased inflation reduces real financial wealth of households.

[14] Eventually the contribution is reverted. This simulation generates a price level lower than base, due to the wedge reduction, which causes export level to increase. Domestic demand, and therefore imports, is held down by the need to stabilize public finance in the long term, which is achieved by reducing consumers' disposable income.

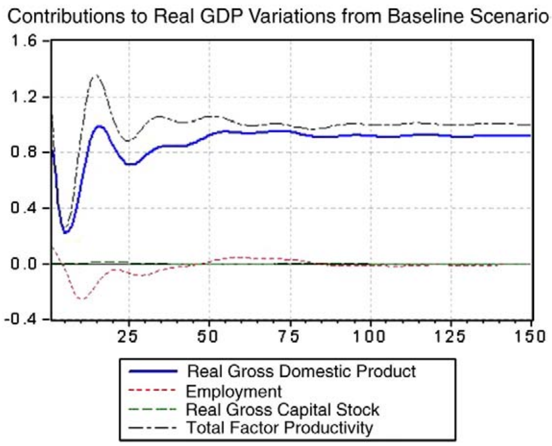

Fig. 11. Shock on TFP.

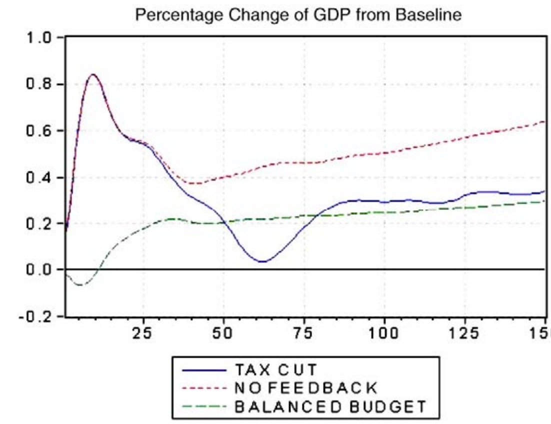

Fig. 13. Three different shocks of fiscal policy.

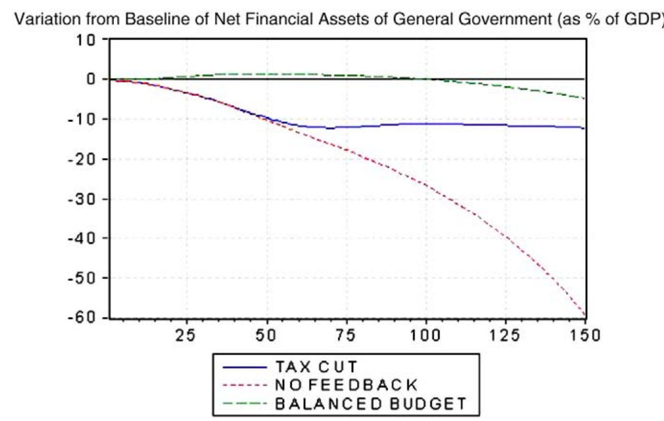

Fig. 14. Response of public debt to three different shocks of fiscal policy.

by the fiscal rule. Therefore the introduction of the latter provides the equivalent to a negative income shock that acts so as to offset the expansionary impact of fiscal expansions. In tax cut simulations, the supply side positive effect related to the reduction of the tax wedge on labor eventually prevails. In public spending simulations the GDP level ends up below base due to a reduced level of consumption (like in the shown case of the exogenous private consumption increase).

In order to better understand the results just examined, we designed two additional simulations also characterized by a permanent cut of the personal income tax rate. One was run without switching on the fiscal feedback rule — named "No Feedback" — and the other was a balanced budget exercise — named "Balance Budget" —, featuring also a cut of the transfers to households of an amount equal to the revenue loss on an ex-ante basis. We call "tax cut" the initial simulation.

The following figures compare the deviation from baseline of GDP and of the net debt to GDP ratio under the three different simulations. In the case of "No Feedback" overall output response behavior is even more "favorable" than in the "Tax cut" case; however, the government debt evolution is clearly unsustainable. The output pattern of the "Balanced Budget" scenario is much smoother and equivalent in the long term to the "Tax cut" scenario. In fact, the Balance Budget scenario contemplates only the supply side effects of a tax reduction (Figs. 13 and 14).

3.2.2. Impact of stocks and flow adjustments

The model delivers stable responses to exogenous shocks over the medium term. Generally the output level stabilizes around a new value (or moves back to base in case of demand shocks) within 5 to 10 years of the shock. However, two important qualifications are in order on this regard: fiscal policy reaction and capital stock movements can give rise to prolonged adjustment process. In this section we provide some additional insight on the impact of stock (physical capital and financial assets) adjustments on model properties.

The capital stock's slow reaction to shocks generates some inertia also on price behavior. The price level does not stabilize to a new value until the capital stock does the same. Fig. 15 shows for instance the pattern for these two variables in the case of the foreign demand shock. This is due to the fact that unit labor cost, the driving variable of prices, will keep moving alongside labor productivity (which is influenced by the stock of capital per capita). As shown in Fig. 15, the impact on the rate of inflation is virtually negligible.

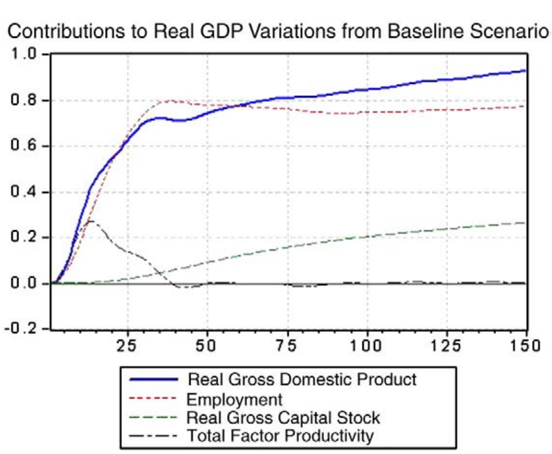

Fig. 12. Shock on population.

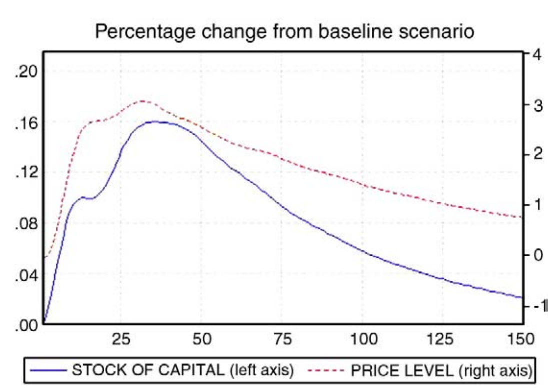

Fig. 15. Shock on world trade.

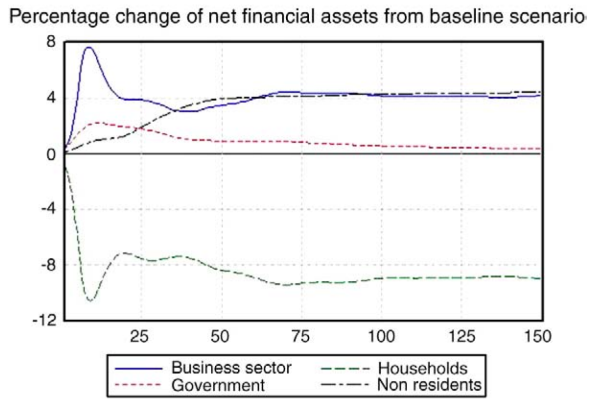

Fig. 16. Shock on private consumption. (Percentage change of net financial assets from baseline scenario).

An additional important feature is that exogenous shocks to the model can induce the financial assets of sectors to stabilize to a new level as a percentage of GDP. Fig. 16 shows the impact of a private consumption shock on financial assets. The outcome is a permanently lower level of net financial assets of households that, as mentioned above, induces a lower long-term level of private consumption.

4. Conclusions

We provided an account of the main features and properties of the Italian Treasury Econometric Model (ITEM). The model provides a consistent joint specification of the demand and supply side of the economy, accounting for the rich interaction between their components.

In the long run, output level is determined based on supply side conditions. In particular, technical progress and the behavior of factors of production are responsible for its pattern. In turn, labor supply conditions determine, in the long run, the level of employment. Growth is also influenced by demographics and trend participation rate, i.e. labor supply.

GDP is computed, via an accounting identity, on the supply side and, in particular, value added of the market sector is explicitly modeled as a Cobb–Douglas production function. A distinctive feature of ITEM is that TFP is modeled as a combination of a structural and a cyclical component. The latter component of TFP is modeled through a statistical equation that links it to demand conditions.

The model response to a number of shocks provides insights on its properties and main features. According to a number of validation procedures and, in particular, based on the economy's response over time to impulses, the model displays quite standard properties that make it appropriate and useful as a quantitative policy tool.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version at doi:10.1016/j.econmod.2009.08.001.

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