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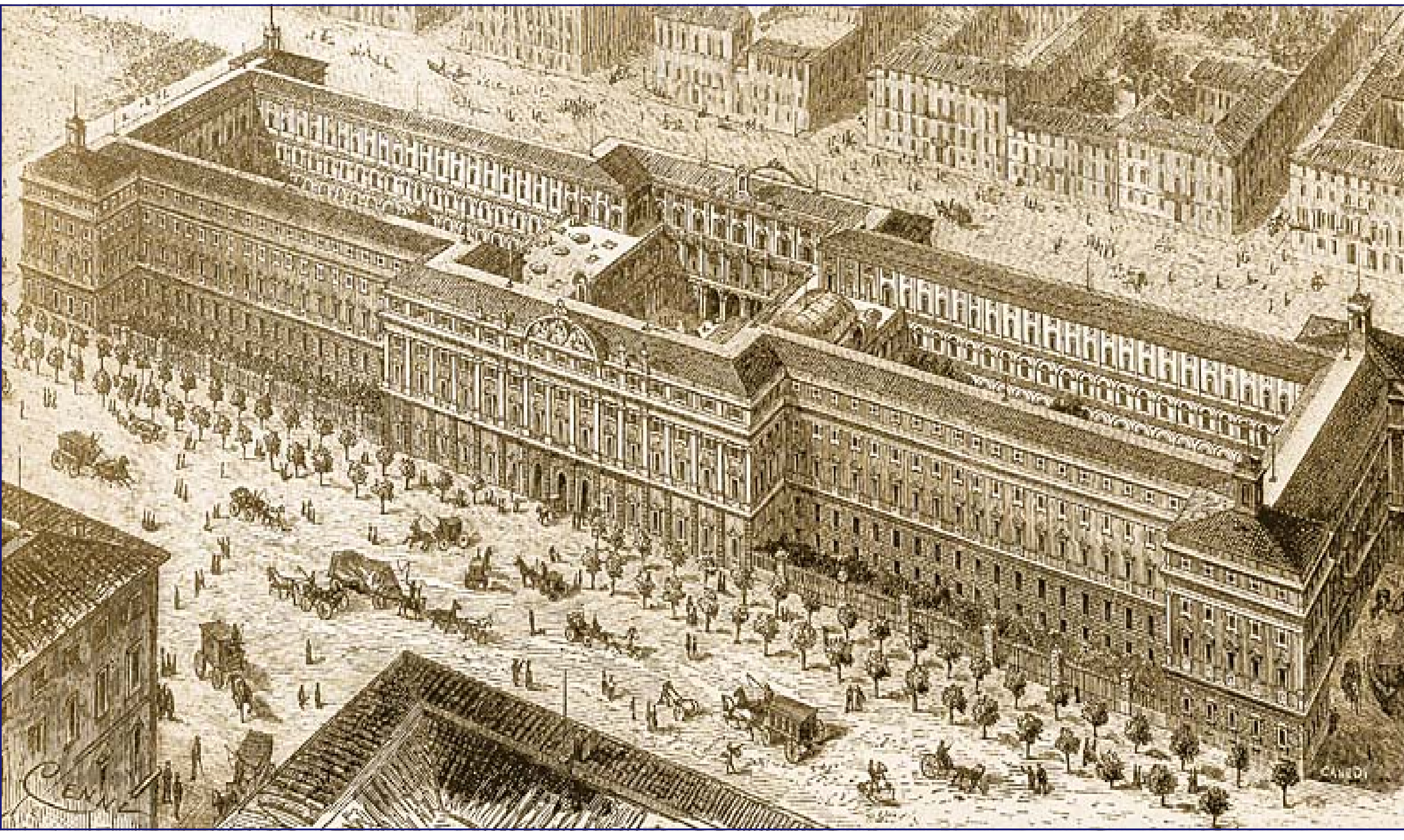

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The Italian Treasury Econometric Model (ITEM)[1]

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Ottavio Ricchi (***) and Cristian Tegami (*)

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. The model has a quarterly frequency and includes 371 variables. Out of these, 124 are exogenous and 247 endogenous. The model structure features 36 behavioral equations and 211 identities.

One of the key features of the model is the joint representation of the economic environment on both the demand and the supply side. 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 side. 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) variation of variables that affect the tax wedge in the labor market and the user cost of capital; b) labor supply change; c) variation in the trend component of TFP (technical progress). By contrast, variables that exert their effects on the demand side have only temporary effects on output.

We also perform in-sample dynamic simulation of the model. This allows us to derive simulated values of all the endogenous variables which can be compared with the corresponding actual values. This allows us to appraise, for each aggregate, whether the simulated values track the observed data.

JEL Classification: C51, C52 and E60
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CONTENTS

1. INTRODUCTION

The project

A macro-econometric model is a technical tool typically designed for both economic policy evaluation and forecasting exercises. In addition to assessing what the response of the economy is to shocks, an econometric model allows to analyze the entire propagation mechanism of each policy change. As a matter of facts, by conducting simulations, one is able to shed light on all channels through which a policy impulse transmits its effects to the whole economy. With the aim of acquiring these capabilities, at the beginning of the nineties the Department of Treasury of the Italian Ministry of the Economy and Finance launched a project for building a medium size model of the Italian economy.

The actual development of the project at the Italian Treasury started in 1994 when a team of economists, under the guidance of Carlo Favero (Bocconi University) and Riccardo Fiorito (University of Siena), started to design and build the model structure and estimate the equations. In the initial part of the project, a consulting firm specialized in forecasting and simulation models was also involved and gave its contribution in the construction of the database and the estimation of some equations. In 1998, a version of the model was officially presented at the Department of Treasury and the name of I.T.E.M., 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 the continuous work of testing and simulating it with updated datasets allowed users to identify a number of shortcomings. This work paved the way for a significant revision that was aimed at improving the simulation properties of the model and achieving, also in the long run, responses to shocks consistent with the predictions of economic theory. Most of the revised version of the model has been constructed since the beginning of 2002 and, among people in the original team, only two of them (the authors of this report: Francesco Nucci from the University of Rome “La Sapienza” and Ottavio Ricchi from the Department of Treasury) have been involved in the extension of the project and are, therefore, responsible for the work done. An important technical support has been continuously provided by the “forecasting models” unit of Consip s.p.a.. Claudio Cicinelli, Andrea Cossio and Cristian Tegami are the persons of this unit involved in the I.T.E.M. project.

The model coverage

The aim of this report is to provide a thorough and updated description of the Italian Treasury Econometric Model (henceforth, I.T.E.M.). In doing so, we illustrate its general structure and show the model properties, especially with regard to the economy’s response to changes in policy and in other dimensions of the economic environment (e.g., world economy, technical progress, demographics).

The model ITEM has a quarterly frequency and includes 371 variables. Out of these, 124 are exogenous and 247 endogenous. The model structure features 36 behavioral equations and 211 identities. The latter, as usual, refer 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. The major endogenous variables considered in the model are, to quote only a few, gross domestic product, and its components on both the demand and supply side (consumption and investment expenditure, value added), employment, wages and prices, household incomes and the aggregates of the trade block. Since ITEM is a model 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, in its most recent version, a complete modeling of financial assets and liabilities of the institutional sectors, with the economy being divided into four sectors: Household, Business, Government, and Foreign sector. 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; c) other domestic exogenous variables, such as those related to demographics and, most importantly, total factor productivity (*TFP*).

The model structure and its philosophy

With regard to the general structure of ITEM, it belongs to the class of macroeconomic models that assign a prominent role to the supply side of the economy. Indeed, one of the key features of our model is the joint representation of the economic environment on both the demand and the supply side. The demand side is formulated in a quite standard fashion. Behavioral equations for private consumption, investment, export and import are included in the model structure. Private consumption depends, *inter alia*, upon households labor disposable incomes as well as financial wealth. Expenditure for capital goods is determined by the user cost of capital and the level of output and a proxy for companies' cash flow contributes to explain investment in the short run. Export is determined by the real exchange rate and foreign demand, whilst import flows depends on the relative price of imported goods and services as well as on absorption.

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 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).[2]

The equations of demand for factors of production are estimated by imposing a long-run relationship coherent with the optimal conditions of a firm's profit maximization problem. 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 innovation, and a cyclical component. The latter reflects measurement problems in the available labor statistics, which fall short of properly capturing 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 aggregate demand changes and the ratio of supply and demand.

Inventory changes are calculated in the model structure 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 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 we do not explicitly model real or nominal frictions of any type, possibly characterizing one or more markets. For example, we do not provide any theoretical foundation

[2] Ideally, a supply side based model should provide a finer disaggregation of the value added, so as to include, for example, the breakdown between industry and service sectors. Such a feature would be particularly advisable in light of the different level and trend productivity of the two sectors, which are historically related to the uneven exposure to international competition. The present version of ITEM focuses mostly on assuring full consistency of the demand and supply sides and on achieving "well behaved" model properties. Future work could, however, envisage an extension of the model along this dimension.

for price or wage stickiness, like the state-dependent Calvo Price staggering. However, we do allow our model specification to accommodate the effects of frictions. In particular, as we will see below, the dynamic specification of the equations features a disequilibrium correction mechanism where the speed of adjustment varies from variable to variable and it is precisely this modeling tool that, to some extent, 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 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.

The approach underlying ITEM is not that of dynamic stochastic general equilibrium models (DSGE) which has become increasingly popular. In other words, the relationship between variables and the propagation mechanisms of any impulse that characterize our theoretical framework are not obtained within a forward-looking model, fully based on agents' intertemporal optimization. Admittedly, 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, in ITEM we are able to consider a breakdown of fiscal variables into a large number of components and this allows us to investigate a variety of fiscal policy issues in great detail. Somewhat similarly, in ITEM we explicitly consider the borrowing and lending activities (assets and liabilities) of all the institutional sectors in the Italian economy and this enables us to enrich the transmission channels of any impulse, 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 and, arguably, a DSGE-type of model would fall short of providing a satisfactory degree of forecasting accuracy.

Main features of equations estimation

In the present report, we document estimation results over the sample 1982:1 - 2006:4. We estimate all the behavioral equations of ITEM after selecting a specification for each of them that is satisfactory in terms of economic plausibility of the empirical findings, goodness of fit and validity according to the outcomes of a battery of diagnostic tests.

In order to account for both the short-run and long-run dynamics of variables, we employ single equation specifications using the error correction model (ECM) methodology (see Hendry, 1987 and 1995). Thus, our dynamic specifications involve long-run equilibrium relations among variables in level as well as lagged differences in the dependent variable and in regressors. The error correction mechanism allows to correct for deviations from equilibrium (see, e.g. Favero, 2001). Indeed, by using a short-run adjustment parameter reflecting the speed of such adjustment, the model allows to relate deviations from equilibrium to changes in the dependent variable. Whilst lagged changes of variables in the right-hand side of each equation capture the short-run dynamics of the dependent variable, the equilibrium relation in level contributes to characterize the long-run properties of the model. Equations are estimated using the OLS technique, as it is customary for large-, medium-sized econometric models. Importantly, we pay a great deal of attention to ensure adequacy of the statistical model implicit

[3] Notable examples of estimated DSGE models include Smets F. and R. Wouters. (2003) and Forni, L., Monteforte, L. and L. Sessa, (2007).

in the estimated structure. In particular, we allow for a rich dynamic structure in the specification of each equation and systematically verify - through the appropriate tests - that residuals do not exhibit autocorrelation, eteroschedasticity and deviation from normality.[4]

All the estimation results together with a number of diagnostic tests and all the outcome of a variety of simulation exercises can be found in a separate Appendix which is readily available from the Treasury Deparment's website.

Model validation and model properties

After documenting the model structure and the estimation results, we turn to the outcomes of model simulation. Indeed, the main purpose of ITEM is that of scenario or policy analysis. The key questions that our model seeks to answer deal with the response of macro variables to changes in a policy instrument or in another exogenous variable. To ascertain the insight provided by our model, we take the usual approach of assessing the model properties. 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 and conduct a battery of additional simulations (which are conventionally called "disturbed"). Comparing the pattern of the main endogenous variables under the baseline and under each disturbed simulation provides the simulated response to the policy impulse or to some other change. The characteristics of this response contribute to shed light on the model properties. The length of the simulation horizon is long (150 quarters), allowing to disentangle both short- and long-run effects.

In ITEM, as we will show, the shocks that generate permanent effects on output are associated with: a) variation of variables that affect the tax wedge in the labor market and the user cost of capital; b) labor supply change; c) variation in the trend component of TFP (technical progress). By contrast, variables that exert their effects on the demand side have only temporary effects on output and, in general, on the economy. These variables include, among others, world demand, exchange rate and public consumption.

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 derive simulated values of all the endogenous variables which can be compared with the corresponding actual values of the variables. Through this comparison it is possible to appraise, for each aggregate, whether the simulated values track the observed data.

The paper is organized as follows. The second chapter deals with the structure of the model and its equations. It analyses in detail the supply and demand side, the closing of the model as well as prices and labor market, public finance and monetary and financial sectors. The third chapter presents the model properties, with a focus on both model validation and the simulation properties.

[4] 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 the one characterizing our model.

2. THE STRUCTURE OF THE MODEL

2.1 The supply side

As outlined before, the structure of ITEM is characterized by an explicit joint representation of both the demand and the supply side of the economy. We begin our description of the model structure by examining the supply side, which plays a prominent role in the architecture of ITEM[5]. In particular, we first show the way in which *GDP* is derived by relying on a production function. Then, we investigate the role of total factor productivity (*TFP*); the latter enters the production function, but, in fact, its actual measure reflects both technical progress and cyclical conditions; as we show below, we will explicitly tackle this feature in the model. Subsequently, we analyze the demand for productive factors (capital and labor) and illustrate how equilibrium in labor market is achieved. We conclude the section by examining how prices and wages are determined in the model.

2.1.a Deriving GDP from a production function

Real *GDP* is determined on the supply side through an accounting identity[6]. The latter dictates that *GDP* is obtained by adding up market and non market value added (*VAM* and *VANM*, respectively) and net indirect taxes (*TXNT*):

(1) $$GDP = VAM + VANM + TXNT.$$

Thus we do not follow the customary approach to close the model using the demand side. Considering that we model all demand side variables with the exception of the inventory changes (*INVCH*) , the latter can be obtained as follows:

(2) $$INVCH = GDP + M - C - G - I - EX.$$

Output of the private sector corresponds to market real value added and is computed through the following identity which represents a standard constant return to scale Cobb-Douglas production function

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

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. In writing (3) we assume constant returns to scale because the output elasticities with respect to each input sum up to unity.

[5] The entire structure of the model is presented in a separate document, which is available on request.

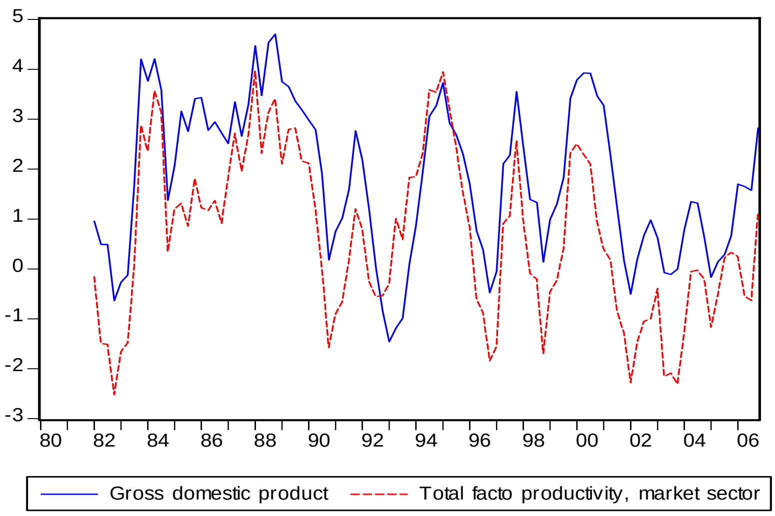
[6] Under the methodology currently used for deriving national accounts, real variables are computed through chain-weighted methods. The latter imply that the level of real GDP is not equal to the sum of its components, except for the reference year and the year following. We tackled this issue by considering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

Moreover, we assume that the output elasticity with respect to TFP is equal to one. 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 (3) to derive 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 (3) is an identity when we focus on observed data in the sample. When we solve the entire model, the value 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 next sub-section, we explain in detail the approach that has been followed.

2.1.b Total factor productivity

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).

Fig. 1 The cyclical behavior of total factor productivity (Italy; 1980 – 2006)



Source: Italian National Statistical Institute (ISTAT).

Several explanations have been proposed in the literature to account for this pattern. The explanation that has gained a widespread consensus owes to unobserved variation in the degree of intensity of factor utilization. These unobserved variation 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 induce 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[7]. This causes measured total factor productivity to be highly pro-cyclical. The fact that reported measures of labor and capital inputs do not properly consider movements in effective input services, inducing a cyclical mis-measurement in the standard Solow residual, has been largely analyzed in the literature. Among the early contributions which addressed this issue the most relevant are Oi (1962) and Solow (1964). Other recent contributions include 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:

(4) $$dtfp_t = dy_t - \alpha dl_t - (1-\alpha)dk_t$$

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*):

(5) $$dtfp\_tp_t = dy_t - \alpha(dl_t + difu_t) - (1-\alpha)(dk_t + difu_t)$$

where we have assumed for simplicity that variation in the intensity of factor use is the same across productive inputs ($difu_t$). This simplifying hypothesis combined with that of constant returns to scale are such that the following expression holds true:

(6) $$dtfp_t - dtfp\_tp_t = difu_t$$

Therefore, our production function in (2) can be re-formulated as:

(7) $$VAM_t = TFP\_tp_t \cdot (L \cdot IFU)_t^{\alpha} \cdot (K \cdot IFU)_t^{1-\alpha}$$

Consistently with the above framework, in ITEM we explicitly consider the two components of measured *TFP*, the one referring to 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 ones in (3) and (7), is the following:

(8) $$VAM_t = TFP\_tp_t \cdot IFU_t \cdot L_t^{\alpha} \cdot K_t^{1-\alpha}$$

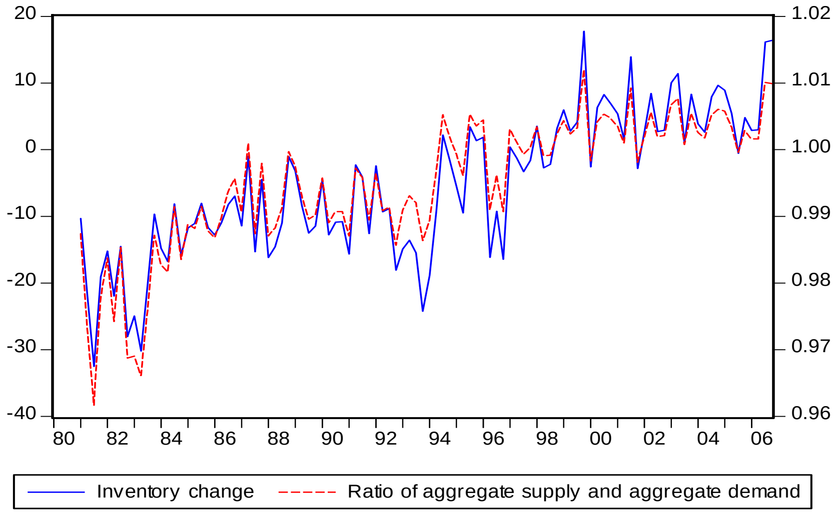
In our simulation analyses, we treat the “structural” component of TFP change ($dtfp\_tp_t$) as exogenous. On the contrary, we treat the other component, $difu_t$, as endogenous and relate its movements to the evolution of cyclical indicators, such as aggregate demand and the discrepancy between aggregate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

(9) $$dtfp_t - dtfp\_tp_t = difu_t = \beta + \gamma \cdot ddem_t - \varepsilon \cdot ASAD_{t-1},$$

[7] A similar concept is used in Turner, Richardson and Rauffet (1996).

where aggregate demand (*DEM*) is the sum of the demand components of *GDP* and *ASAD* is the ratio between aggregate supply and demand at current prices. The pattern of the latter variable mirrors the one of inventory changes. Hence, an increase of ASAD, for example, corresponds to an inventories depletion[8].

Fig. 2 Inventory change and the ratio of aggregate supply and aggregate demand (ASAD) (Italy; 1980 – 2006)



Source: Italian National Statistical Institute (ISTAT).

The interaction between the production function (3) and equation (9) 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 run down of inventories, as approximated by the discrepancy (the ratio) between supply and demand[9]. In the following period, the above mismatch will however increase the observed (pro-cyclical) *TFP*. This yields, through the production function (3), a parallel increase of output, that restores 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[10]. The way we address the issue of productivity cyclicality, by emphasizing the role of unobserved

[8] In the previous version of the model both, inventory changes and the ratio of aggregate supply to aggregate demand were considered referring to constant price levels. However, as a result of the introduction of chain linked prices in Italian national accounts, the above variables are no long stationary (they are now characterized by an upward trend). In the current version of the model we use instead the ratio of current values of supply and demand. Similarly, also the ratio between inventory changes and GDP deflator is a stationary variable.

[9] 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 per cent).

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

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 an demand. We turn next our attention to the demand for productive factors.

2.1.c Productive factor demand

The demand for employment and for 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 portion 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 the firms' profit maximization problem.

In particular, if we focus on the long-run relationships embedded in the two equations, these are the following:

$$(10)\qquad l = vam - (w - p)$$

$$(11)\qquad k = l - UC / ULC$$

where lower case letters denote the logarithm of a variable; in equation (10), *l* denotes employment and depends on output (*vam*) and the real wage (*w-p*); in equation (11), (the log of) capital, *k*, depends on employment and on the ratio between the user cost of capital (*UC*) and unit labor cost (*ULC*).

To be more specific, in the demand function for labor, we separately estimate two equations: one refers to employees in the market sector and the other one to self-employment. In the equation for employment of the market sector, in addition to the long-run relationship captured in (10), the short-run features output changes and lags of the dependant variable, plus the intensity of factor utilization, whose coefficient is found to have a positive sign. Concerning the equation for self-employment, in the long-run, we impose a unit elasticity between the number of self-employed and that of employees, whilst the short run behavior is related to the dynamics of output and of past self-employment.

With regard to the demand for capital goods, as most of the behavioral equations, it is estimated with an error correction specification. In the long-run, a relationship between investment[11], 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 cost. This is consistent with the optimal conditions of a profit-maximizing firm facing a Cobb-Douglas production function[12].

The short-run side of equation (11) features lagged difference terms of value added and the contemporaneous first difference of a net profit variable deemed to represent a proxy of companies' cash flow.

The capital stock is then computed using the standard capital accumulation equation:

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[11] The equation is estimated with investment as the dependent variable. However, it can be shown that in steady state the specification is equivalent to one in which the capital stock appears on the right-hand side.

[12] The user cost of capital is computed according to the standard, well-known Hall and Jorgenson's (1967) approach. Thus, the user cost of capital, *UC*, is expressed as follows:

$$UC = p_I \cdot \frac{\delta + (i - \pi)}{1 - \tau},$$

where p_I is the price of investment goods, $(i - \pi)$ is the ex-post real interest rate and τ is an effective tax rate that summarizes all tax-related components of the user cost.

$$K_t = (1 - \delta_t) K_{t-1} + I_{t-1}$$

where δ_t is the capital depreciation rate.

2.1.d Labor market equilibrium

Equilibrium in the labor market is achieved through the interaction of the demand for and the supply of labor. The latter is modeled by estimating a participation equation with the ratio of labor force (*LF*) over working age population (the one between 15 and 64 years of age: *N1564*) as dependent variable. In the short run, the participation rate (*PART*) depends on employment changes, representing an indicator of cyclical conditions. The variables that enter the specification in levels are the real product wage variable – implying that labor supply responds to wage increases – and the rate of unemployment (*UR*). Secular movements of the participation rate are explained by social factors that we try to capture by means of a simple deterministic trend. Thus, in the long run, labor force depends upon the hypotheses made on the evolution of the working age population and the participation rate. More precisely:

$$LF = N1564 \cdot PART\,(\Delta L, Trend, UR, real\ product\ wage). \quad (12)$$

Finally, we combine the information on employment and the labor force and derive the unemployment rate. In order to do so, we need to undertake a simple empirical procedure that controls for discrepancies between employment data drawn from the national accounts, which are the ones used in modeling the supply side, and those stemming from labor force surveys.

2.1.e Prices and wages

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*.

To show this, we recall the first order condition of cost minimization with respect to labor, allowing for the presence of market power and focusing on the production function as the technological constraint of the firm's problem:

$$W = \lambda \cdot F_L; \quad (13)$$

W is nominal wage, F_L is marginal productivity of labor and λ is the Lagrange multiplier of the problem, which has the intuitive interpretation of marginal cost (*MC*). Indeed, it measures how the value of firm's objective function (total cost) varies when we relax the technology constraint at the margin (i.e. when we increase output, *Y*, by a unit[13]).

Manipulating the above expression and invoking the definition of mark-up, $\mu = \frac{P}{MC}$, we rewrite (13) as follows

[13] We denote output as *Y* , because it is the acronym which is generally used. Of course, *Y* corresponds exactly to real value added of the market sector, which we have labeled before as *VAM*.

(14) $$W \cdot \frac{L}{Y} = \frac{P}{\mu} \cdot F_L \cdot \frac{L}{Y}.$$

Recalling that the labor elasticity of output is $\alpha = \frac{F_L L}{Y}$ and that unit labor cost (*ULC*) is defined as *ULC = W / (Y/L)*, we obtain

(15) $$P = \frac{\mu}{\alpha} \cdot ULC$$

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. Thus, our equation has the following baseline structure:

(16) $$p = ulc + \gamma \cdot (IFU)$$

where, again, lower-case letters denote logarithms of variables. This formulation of the equation accommodates the presence of a mark-up that fluctuates throughout the business cycle. Indeed, if we consider the ratio of prices to unit labor costs as an approximation of the mark-up, it can be seen from equation (16) that such approximation of the mark-up would be pro-cyclical.

In the empirical implementation of the price equation, we insert the variable unit labor costs using as its definition the ratio of wage over trend labor productivity. More specifically, we derive the latter starting from the following definition (in logs):

(17) $$(y - l) = tfp + (1 - \alpha) \cdot (k - l).$$

The above equation states that labor productivity growth reflects *TFP* growth as well as capital deepening. Since we are dealing with a long-run relationship, we define the right-hand side of the above expression as follows: a) we use the trend component of total factor productivity (*tfp_trend*); b) we take the time average of the capital share ($1 - \alpha$); c) we express labor, *l*, as the product of working age population times the trend component of the participation rate times one minus the unemployment rate; d) we express capital, *k*, as the actual capital stock. Time changes of the unit labor costs are also included in the equation and capture prices' short run dynamics.

The wage equation is designed consistently with a theoretical model of wage bargaining (see, e.g. Layard, Nickell, 1986). In this equation, the real wage is linked, in the long run, to labor productivity, the unemployment rate (*UR*) and the tax wedge on labor (*WEDGE*). The long-run relationship of the wage equation is, therefore, the following:

(18) $$w - p = \beta + (y - l) + \delta \cdot wedge - \zeta \cdot ur$$

It is important to note that labor productivity is inserted in the wage equation in the same way as it was previously shown for the price equation. The short-run dynamic of wages per employee is modeled through the inclusion in the equation of lagged changes of consumer and producer prices as well as of labor productivity. Moreover, the rate of change of the fiscal component of labor cost is also included in the short-run section of the equation. The tax wedge on labor is calculated as follows. It is an effective tax rate, whose numerator is obtained as the sum of the following items: a) the tax revenues from labor incomes (excluding pensions), b) the social security contributions, c) the revenues from indirect taxes whose burden is on workers but not on individuals retired, d) the portion of tax entries from *IRAP* (an Italian tax on productive activities) that is associated to labor costs. This amount of tax revenues is divided by the amount of net labor incomes.

2.2 The demand side

In explaining the behavior of aggregate demand components, we first recall that the specification of private investment (*I*) decisions is illustrated in the section where the supply side of the model is documented. This choice was made because the capital stock is an input in the production process. Thus, in this section we focus only on private demand for consumer goods as well as on foreign demand for domestic products (export) and on domestic demand for foreign products (import).

2.2.a Private consumption and the household sector

The equation for private consumption (*C*) features a long-run relationship between household expenditure at constant prices, real labor disposable income, (*YLD*), real household net financial assets (*HNFA*) and the real interest rate on short-term borrowing *(r)*;

$$c = \alpha \cdot yld + (1-\alpha) \cdot hnfa - \gamma \cdot r. \quad (19)$$

The short-run behavior of consumption is also modeled in the equation through the inclusion of lagged rates of change of the dependent variables and of real disposable labor income. The real interest rate inserted in the equation is the short-term bank prime rate, net of the ex-post rate of change of producer prices. The consumption deflator is used to deflate nominal disposable income as well as net financial assets. As it is documented in other sections of this paper, in the model structure we consider financial assets and liabilities of the institutional sectors. In particular, we explicitly reconstruct and model the flow of funds of the economy. As far as households are concerned, there is an accumulation equation for household financial assets in nominal terms (*HFA*). This accumulation equation has the following form:

$$HFA = (1 + app) \cdot HFA_{-1} + ACC \quad (20)$$

The rate of appreciation/depreciation of financial assets (*app*) is projected as a function of the U.S stock exchange price index (the Dow Jones), the structural component of *TFP* growth and a measure of foreign inflation. The coefficient related to structural TFP growth is imposed and equal to one; on the contrary, the coefficient for the remaining variables are estimated[14]. Each quarter, the value of household financial assets is adjusted by means of its appreciation or depreciation as well as through the flows of household savings (net of investments) augmented with capital transfers (*ACC*). By contrast, household financial liabilities (*HFL*) are assumed to evolve over time in accordance with the dynamics of the structural component of real *GDP* evaluated at domestic prices. The difference between household financial assets and liabilities is household net financial assets (*HNFL*), which is the variable entering the consumption function.

[14] Despite the fact that this equation is actually estimated, it should not be perceived as a proper and fully specified behavioral equation. Rather, it is a projection rule capturing a few key drivers of the asset revaluation. The rationale behind the link of the rate of appreciation of financial assets to total factor productivity is that, in the long run, the Italian stock market value should be expected to move in line with productivity. The foreign price variable captures nominal revaluation and foreign stock market behavior is introduced because not all assets owned by Italian households are issued domestically.

Whilst equation (10) refers to the value added deflator, we also consider in the model the evolution of consumer prices. In particular, we first estimate a behavioral equation for the private consumption deflator net of indirect taxes. This equation features a short- and a long-run component and links the consumer prices to producer prices as well as to import prices. Subsequently, we derive the standard measure of consumer prices by adding the impact of indirect taxes.

2.2.b The trade block and the foreign sector

Three behavioral equations represent the trade block. One for real exports of goods (*X*) and services and two for real imports (*M*), one of which refers to all goods but oil and energy and the other one refers to oil and energy only. The ECM specification for exports features a long run relationship between export, world demand (*WD*) and real effective exchange rate (*REER*). The bulk of the export equation is therefore the following:

$$(21) \qquad x = \alpha \cdot wd + \beta \cdot reer$$

Of course, both the trade weighted world demand index and a depreciation of the real exchange rate have a positive effect on exports. A rise in our measure of real exchange rate represents a real depreciation; in particular, we compute such variable as the ratio of the foreign producer prices expressed in Euro to export prices (the export deflator).

The rate of change of world demand and of real exchange rate as well as lags of the dependent variable enter the part of the equation that seeks to account for the short-run dynamics of export.

Real imports (net of oil and energy), M^1, depend upon absorption (*AB*) and the relative price of non-oil imports (P_M/P). The long-run relationship is the following:

$$(22) \qquad m^1 = ab + \gamma \cdot (pM - p)$$

The relative price of imports is measured as the ratio of import deflator and value added deflator. Whilst the long-run elasticity of imports to absorption is restricted to be unity, the relative price elasticity of import demand is not restricted. The lagged dependent variable and changes in other demand indicator enter the short-run side of the equation. Absorption is computed as a weighted average of the aggregate demand components of the national income accounts identity. The weights are derived from the most recent input-output table of the Italian economy. The equation for real imports of oil and energy has a simpler structure. A long run relationship is postulated between oil and energy imports and the volume of economic activity as measured by real *GDP*. Whilst the unit elasticity is imposed for *GDP*, the relative price of oil and energy imports enters the equation without any restriction on its impact on import volumes of such goods.

In ITEM, we also model export and import prices. In particular, for export prices (the deflator of exports) we employ an ECM specification where a long run equilibrium is established between export prices and both domestic value added deflators and foreign producer prices expressed in the Italian currency. We impose the linear (long-run) restriction that the elasticities of import prices with respect to the domestic and the foreign prices sum to unity. To account for the short-run evolution, the rate of change of these variables are inserted in the specification. As far as import prices are concerned, we treat prices of imports net of oil and energy as an endogenous variable and model their behavior through a specific stochastic equation. In particular, the long run relationship links import prices to both domestic prices (value added deflator) and foreign producer prices (expressed in the Italian currency). In both cases, of course, the elasticity is positive and, again, the sum of the two elasticities is restricted to be equal to one. On the contrary, prices of imported oil and energy are assumed to be exogenous.

The difference between exports and imports represents the trade balance, which is one of the key component of the current account balance (*CA*). The latter is composed of the trade balance, the balance of inflows from abroad and outflows of incomes, the balance of current transfer and, finally, the balance of capital transfer. In the structure of ITEM, in addition to export and import flows, we explicitly model capital income inflows stemming from assets issued by non residents as well as capital income outflows related to domestic assets owned by non residents. The current account (plus some other minor adjustment entities) is the flow that contributes to increase/decrease the financial liabilities held by non residents (*NRFL*). In particular, we insert in the model structure the following accumulation equation for this aggregate:

$$NRFL = (1 + rev) \cdot NRFL_{-1} + CA \tag{23}$$

The rate *rev* captures the revaluation/devaluation of financial liabilities held by non residents. It is modeled in ITEM through a simple statistical equation that links it to the evolution of foreign prices converted in the domestic currency (euro). With regard to financial assets held by non residents (*NRFA*), they are expressed as a weighted average of financial liabilities held by each institutional sector in Italy with weights given by the exposure (in terms of liabilities) of each sector towards foreign residents. Net financial assets of foreign residents (*NRNFA*) is obtained as the difference between assets and liabilities held by non-residents.

2.3 Public finance

The public finance is reproduced with a fine disaggregation. Spending and revenue items are modeled almost with the same level of break-down provided by the national statistical institute (ISTAT) in the general government appropriation accounts. Such a feature enables us to analyze the impact on the economy of several fiscal policy shocks.

2.3.a Public expenditure

On the expenditure side the most relevant distinction to be made is between public consumption – in turn decomposed in its labor and non-labor (purchase of intermediate goods) components –, subsidies and public investment. Albeit official sources provide virtually all public finance aggregates only in nominal terms, we assume that fiscal authorities choose primary spending in real terms. As a matter of fact, patterns of nominal variables are partly shaped by inflation dynamics, which government is not responsible for controlling. Hence, when determining fiscal multipliers we give an impulse to real variable defined as the ratio between the official nominal budgetary item and the most appropriate price deflator. All the above primary expenditures summed to interest payments – which are estimated as a function of the debt stock and interest rates pattern – add up to total government expenditures.

Government outlays have an impact on GDP, although generally a temporary one. They affect demand either directly, through the purchase of intermediate consumption goods, or indirectly, with subsidies to households and firms income.

2.3.b Taxation

Concerning revenues, all main components are separately included: direct taxes on labor (IRPEF) and on profits (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 (for instance, in the case of the VAT tax, the latter is represented by total nominal consumption; see Mendoza, Razin and Tesar, 1994). In addition, ITEM includes also taxation on income from financial capital, on capital gains and on local duty on real estate (ICI).

Revenues affect the demand side of the economy by reducing income of households and business sector profits. In general, tax rates are distortionary as they either enter into the fiscal wedge between real disposable salary and the wage cost or contribute to determine the value of the user cost of capital. In both ways taxation ends up affecting permanently the level of GDP and, possibly, its composition on the demand side.

2.3.c Closing the model: financial assets of the business sector and income flows

In the previous section, we have documented how financial assets and liabilities of the institutional sectors are accumulated and the way in which their evolution influences the agents' choice. In particular, we have reconstructed the flow of funds for three institutional sectors: a) the household sector, b) the non residents sector and c) the sector pertaining to public administration. The remaining institutional sector is the business sector featuring both non financial firms as well as financial intermediaries. To ensure consistency in the flow of funds of all sectors, we derive net financial assets of the business sector (*BNFA*) as a residual, namely as the negative of the sum of net financial assets of the other three sectors:

$$BNFA = -\,(HNFA + NRNFAL + PANFA) \tag{24}$$

Deriving net financial assets of the business sector according to the above expression allows us to close the model as to what pertains net funds raised by different sectors in the economy. Given that the financial liabilities of the business sector are assumed to reflect variation in the structural component of total factor productivity evaluated at foreign prices (expressed in national currencies), financial assets held by this institutional sector are obtained adding the values of liabilities to the value of net assets.

In the model structure, net financial assets (as a ratio to GDP) enters in the long run of the equation for distributed profits, while in the short-run side of the equation, the latter variable is assumed to be related to gross operating profits net of net indirect taxes on production. All three variables are considered as a ratio to GDP. It is important to note that we have also modeled in a complete and coherent fashion all flows of capital income. Indeed, every sector of the economy has a stock of financial liabilities on which it pays interests. Those interest payments are channeled as capital incomes to the other sectors of the economy. The distribution of these payments is made according to the relative exposure of each sector to the others in terms of assets held. For example, households capital incomes are obtained by adding portions of payments made by the other sectors to serve their debt. Those portions are derived using the share of each sector liabilities towards household on its total liabilities.

Importantly, the explicit consideration in the model of the entire set of stocks (in this case, the financial assets and liabilities held by each sector) and their feedbacks on agents' economic decisions contribute to obtain a stable long run evolution of the stocks themselves (as a percentage of GDP).

2.4 Model simulations: exogenous variables projections and assumptions on policy rules

2.4.a Exogenous variables and their projection rules

The main international exogenous variable, as in most small-country models, are: trade weighted foreign demand of Italian goods and producer price of foreign competitors, oil price, the international stock exchange (as proxied by the Down Jones index), the euro-dollar exchange rate and international interest rates. The ITEM base scenario embodies a projection for these variable consistent with the most recent forecast produced by international organizations (the OECD mediut term scenario is the most commonly used). Simulation analysis contemplates changing the assumed pattern of these variables. Such alternative scenarios provide the estimated impact, in terms of changes with respect to the base simulation, on the Italian economy.

Productivity and demographic variables are also projected exogenously. The trend level of Total Factor Productivity is extrapolated from the recent pattern of the economy (or is made consistent with the view of its likely behaviour in the medium term). Population forecasts are drawn from ISTAT (the Italian national statistical institute). The trend component of participation rate is again extrapolated from past behaviour (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 (unless fiscal forthcoming policy measures contemplate a change for them). 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 (this is typically the case for public consumption)[15], with pension expenditure being also tight to demographic projections. Public employment is set on a smoothly declining pattern. Unemployment benefits is the only variable properly responding to the cycle. Public sector deflators are, on the contary, endogenous and always 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. The stock level is tracked using the traditional accumulation equation.

2.4.b Fiscal policy feedback rules

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 budget deficit (surplus) to GDP ratio moves back to the base value or, at least stabilizes at a new value, after a shock to the base 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 not to alter the model responses (i.e. multiplier values) in the medium term.

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 equation (25).

$$(25)\qquad TPnd_t = TPnd_{t-1} + \psi\,(GOVNFA_{\,t-1}/GDP_{\,t-1} - \{GOVNFA_{t-1}/GDP_{t-1}\}^{base})$$

where, *TPnd* is a non distortionary component of the taxes paid by households, *GBAL/GDP* is the budget deficit to GDP ratio, ψ is the speed of adjustment parameter[16].

The current version of ITEM does not contemplate forward-looking solutions; therefore the

[15] Simulation results presented in the model properties section are achieved complying with the projection rules just described. This kind of setting is what we deemed as the most appropriate, especially for investigating medium term properties of the model. However, as a matter of fact, model properties interplay with public expenditure projection rules. For instance, on a long term horizon it could be more appropriate to project many expenditure variables as a constant proportion of GDP, rather than constant in real terms. A few experiments that were carried out showed that, introducing this projection rules delays the model adjustment to the steady state and increases volatility.

[16] To smooth out simulation results the adjustment parameter is multiplied by an additional variable that, starting from zero, move gradually toward one following an arc tangent function.

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 tem 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.

2.4.c The policy interest rate and other rates

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[17].

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 accommodating. It would also be possible to calibrate a Taylor rule just for the Italian economy (see Clarida, Gali and Gertler, 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[18]. This assumption is generally maintained in the present paper, although in a dedicated section we show model responses under different monetary policy response assumptions.

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

[17] We therefore assume that Italian economic conditions are factored into the interest rates projections that we adopt. Of course, there is no guarantee that these conditions coincide with the outcome of our base simulations; however there is no obvious way out of this problem. Furthermore, we think that unless the divergence is very big the magnitude of the problem is not relevant.
[18] A large number of model simulations is reported in the separated document mentioned in footnote 1.

to the changes of short term interest rates[19]. 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[20].

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.

[19] A more rigorous modeling of the long-term rate is achieved by projecting this variable by forward convolution of short-term interest rate changes. This feature has been coded into the model and it is used when deemed important.

[20] When running in sample historical simulations for the pre-EMU area we use the spread on fixed interest rate swaps denominated in German and Italian currencies to disentangle expectations of exchange rate devaluations from fluctuations in the credit risk premia. Such spread is kept at zero for all simulations in the EMU period.

3. THE MODEL PROPERTIES

3.1 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[21]. 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 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 a value of 1% of GDP[22].

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)[23].

Demand shocks

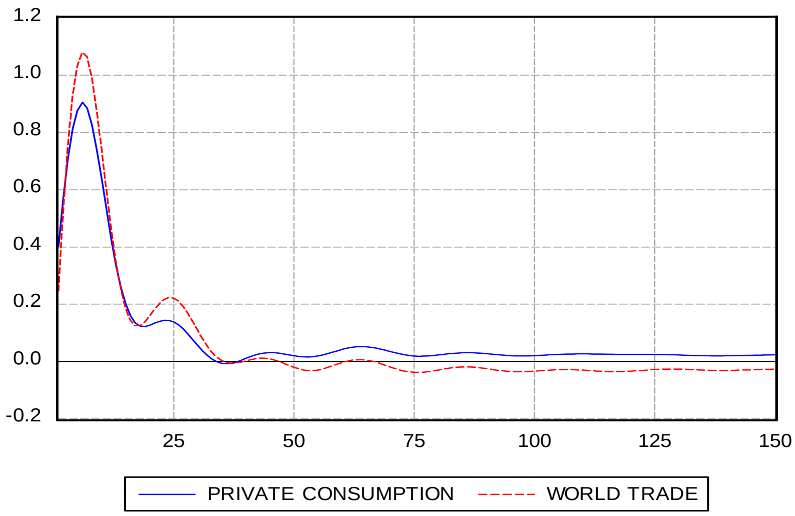
We first consider a positive shock to world trade and to private consumption (figure 1).

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

[22] 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.

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

Fig. 1 Shocks on world trade and private consumption
(percentage change of GDP from baseline scenario)



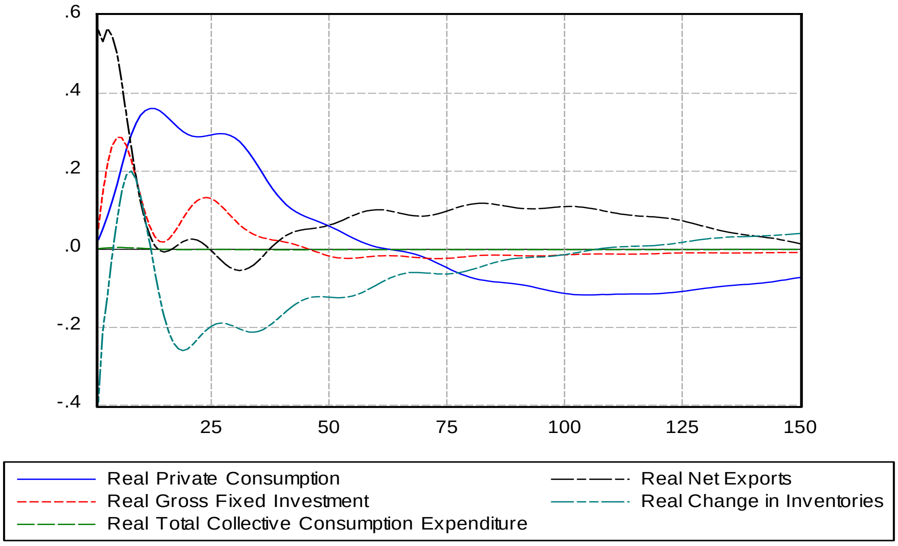
Both curves present the usual hump-shaped profile that is expected to characterize output response to demand shock, with total activity moving back to base in the medium term. The size of the multiplier varies slightly across the two shocks. In the short term this is related to the different import content 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 net indirect taxes, that enter the GDP indentity,

With reference to the world trade shock, the change of GDP can be decomposed into the change of its components from both the demand (figure 2) and the supply side (figure 3). Changes with respect to the base simulation in unemployment rate and inflation are presented in figure 4.

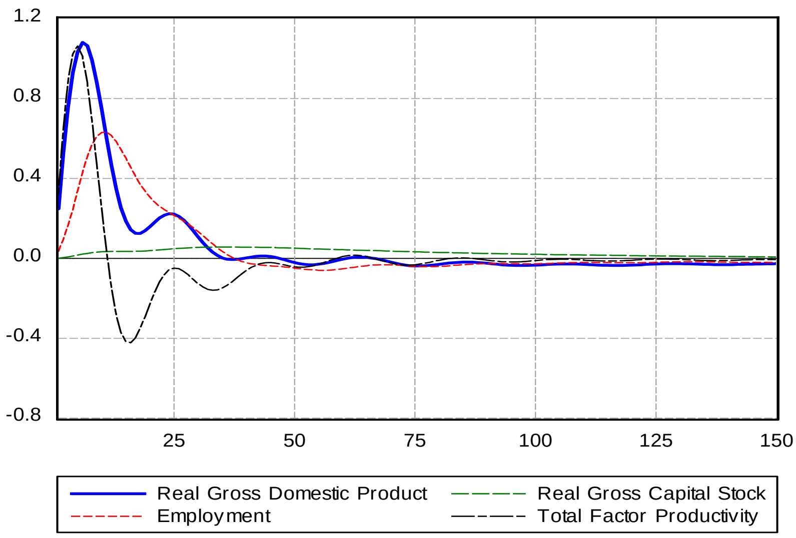
The positive shock to world trade provides an impulse which is propagated by means of the well known multiplier mechanisms. Through time the stimulus is transmitted to domestic demand components; on the contrary, net exports, which initially provide a positive contribution to growth, become a drag because 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 afterwards aggregated 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.

Fig 2 Shock on world trade
(contributions to real GDP variations from baseline scenario)



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 have been boosted themselves by higher demand. Over the medium term all contributions are brought back to zero.

Fig. 3 Shock on world trade
(contributions to real GDP variations from baseline scenario)



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 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 figure 4.

Fig. 4 Shock on world trade
(percentage change from baseline scenario)

The reduced competitiveness worsens net external demand and, mostly by this channel[24], output is driven back to its base value by the seventh year of simulation.

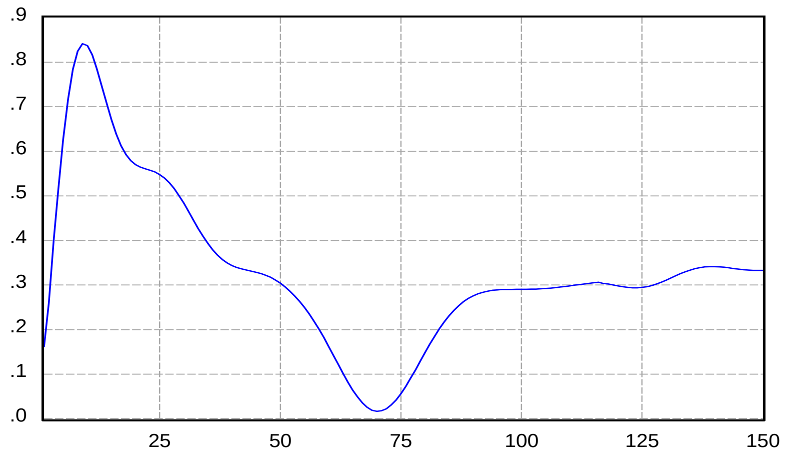
Supply shocks

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.

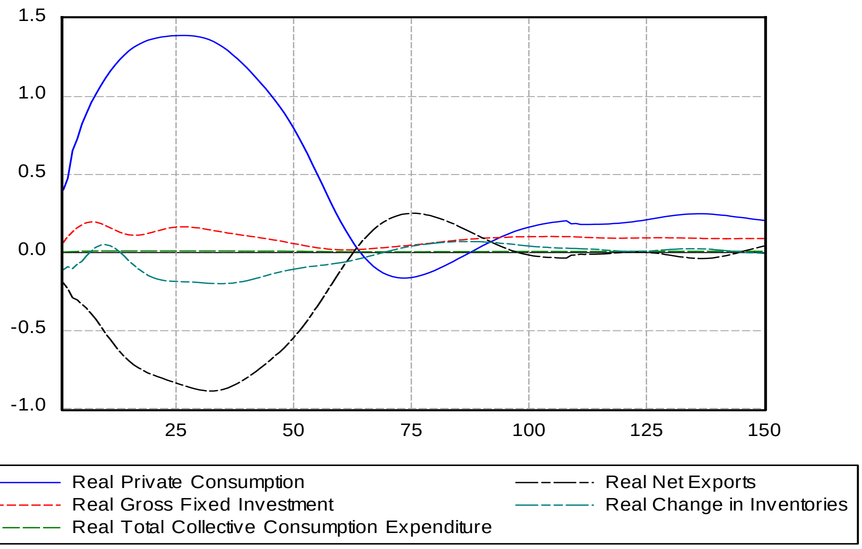
[24] Also internal demand is driven down as increased inflation reduces real financial wealth of households.

Fig. 5 Shock on personal income implicit tax rate
(percentage change of GDP from baseline scenario)



The increase of disposable income boosts consumption, which in turn drives upwards investments; 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[25].

Fig. 6 Shock on personal income implicit tax rate
(contributions to real GDP variations from baseline scenario)

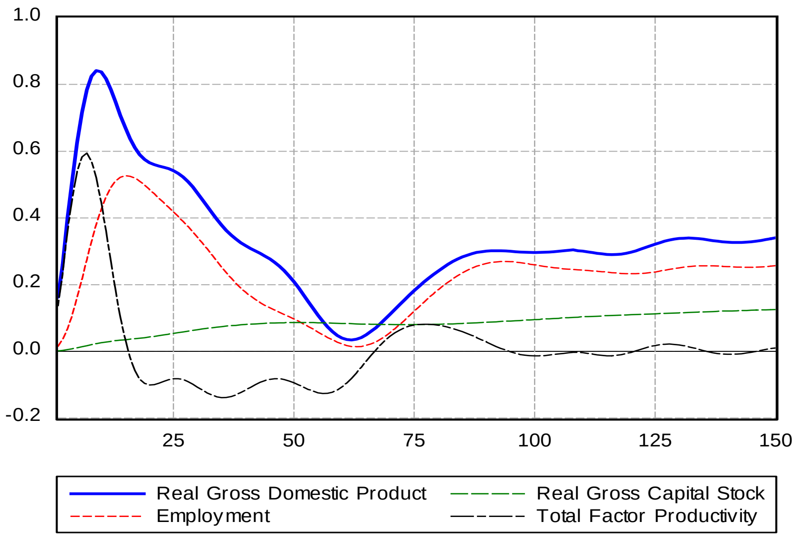


The demand components outcomes are reflected by the supply side of the simulation. Whilst total factor productivity moves back to base in the long term, it is, however, the main driver of the negative rebound in the central part of the simulation. Capital stock and employment level end up above base 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,

25 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.

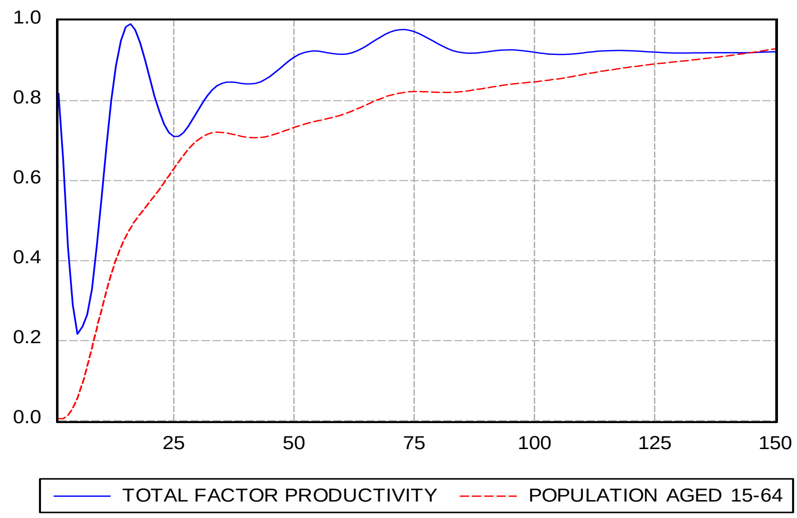
contrary to the world trade simulation, ends up permanently below baseline due to the wedge reduction.

Fig. 7 Shock on personal income implicit tax rate
(contributions to real GDP variations from baseline scenario)



The following pictures shows the impact of a 1% increase of working age population and of a 1% increase of the trend level of total factor productivity (figure 8). In both cases GDP increases in the long term by approximately 1%.

Fig. 8 Shocks on TFP and population
(percentage change of GDP from baseline scenario)



The behavior of the supply side components is illustrated in figure 9 and figure 10. 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 time. Second, when simulating the model within sample, investment behavior matches quite well its historical pattern.

Fig. 9 Shock on TFP
(contributions to real GDP variations from baseline scenario)

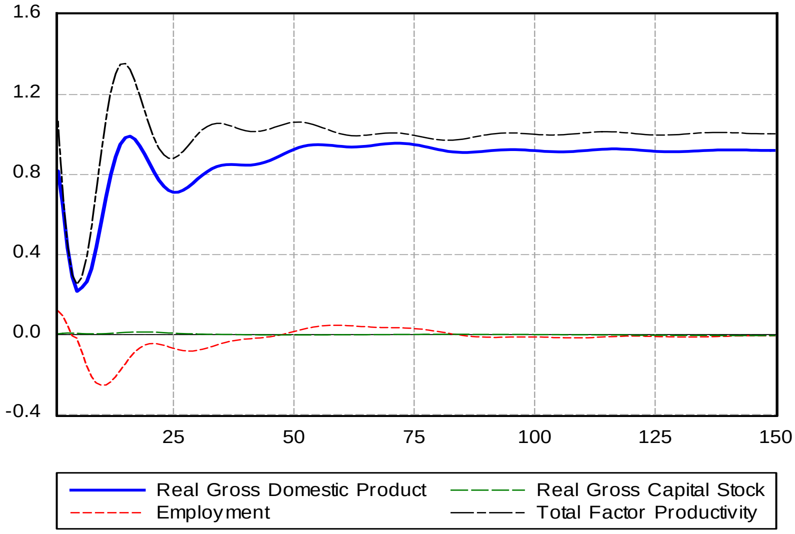
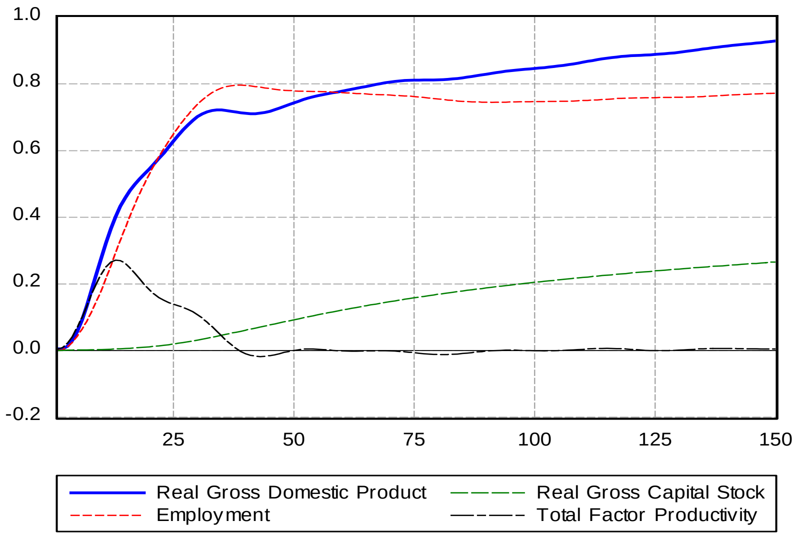


Fig. 10 Shock on population
(contributions to real GDP variations from baseline scenario)



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 by the fiscal rule. Therefore the introduction of the latter provides the equivalent to a negative income shock that acts so as to offset to 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 equal amount 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 of 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.

Fig. 11 Three different shocks of fiscal policy
(percentage change of GDP from baseline scenario)

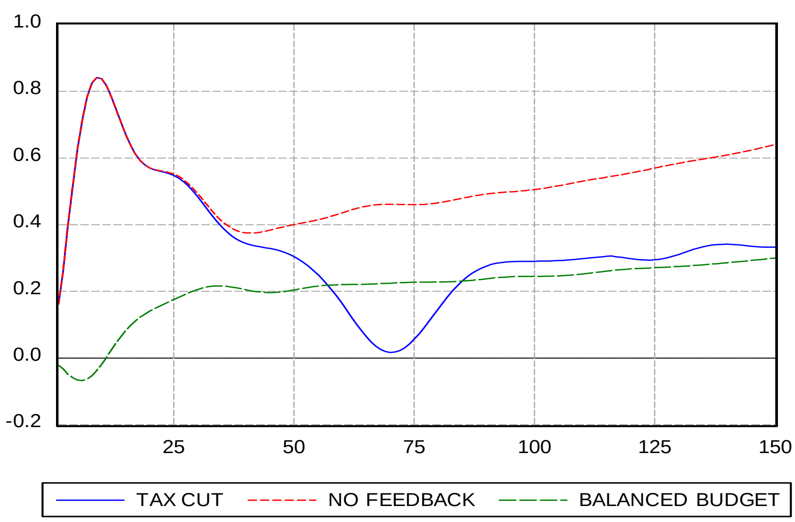
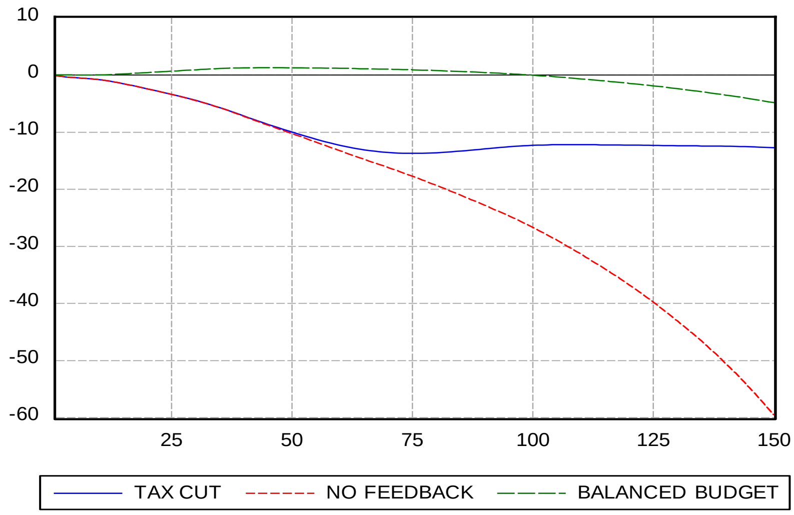
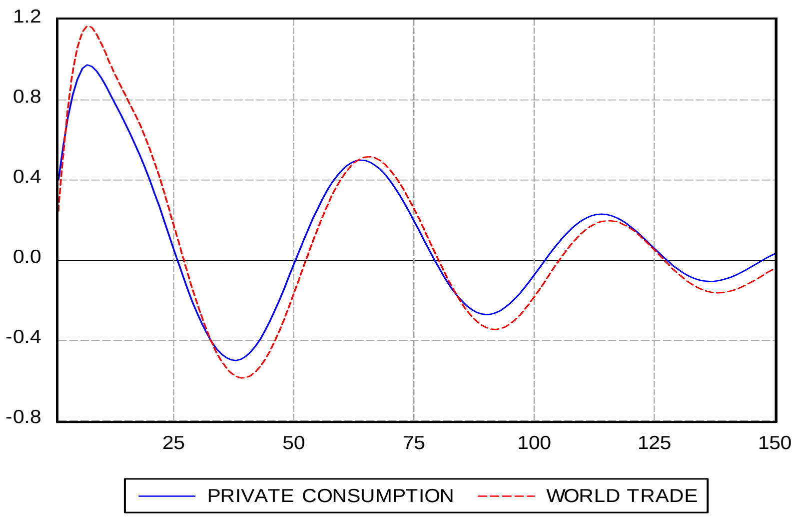


Fig. 12 Response of public debt to three different shocks of fiscal policy
(variation from baseline scenario as percentage of GDP)



One final issue concerns the impact of different monetary poliy rules on simulation properties. The figure below shows how a constant interest rate rule – with respect to base – affects the model response to demand shocks (foreign trade and private consumption). The GDP multiplier is compared to the one achieved with the usually adopted constant real interest rates. As it could be expected, constant nominal rate provide the following impact: a) the short term GDP response is slightly higher, b) there is a increased cyclical pattern, c) long term impact is unaffected (i.e. same as in the constant real interest rate rule).

Fig. 13 Shocks on world trade and private consumption (constant nominal rate)
(percentage change of GDP from baseline scenario)



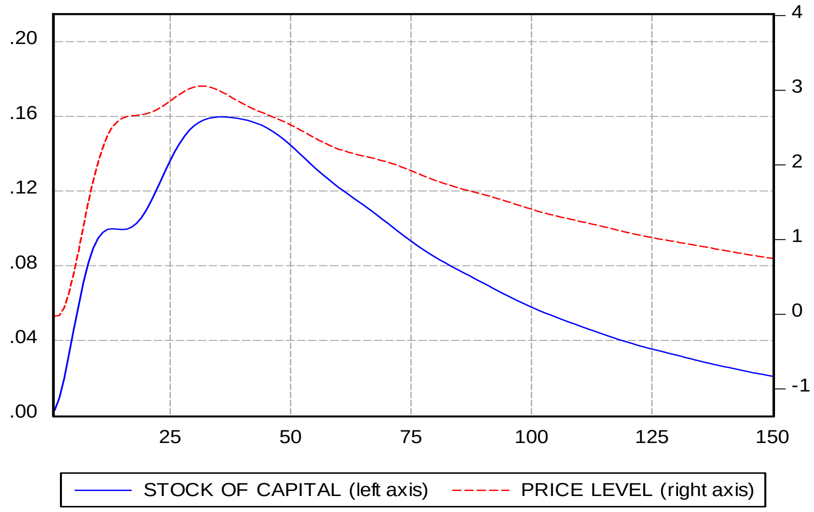
Impact of stocks and flow adjustments

The model delivers stable responses to exogenous shocks over the medium term.

Generally the output level stabilize 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.

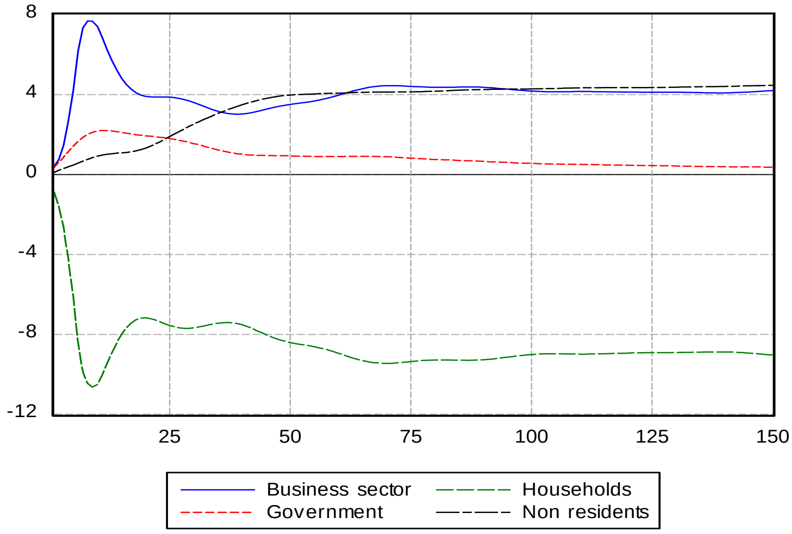
The capital stock slow reaction to shocks generates some inertia also on price behaviour. The price level does not stabilize to a new value until the capital stock does the same. Figure 14 shows for instance the pattern for this two variables in the case of the foreign demand shock. This is due to the 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 figure 14, the impact on the rate of inflation is virtually negligible.

Fig. 14 Shock on world trade
(percentage change 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. Figure 15 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.

Fig. 15 Shock on private consumption
(percentage change of net financial assets from baseline scenario)



3.2 Model validation

After documenting the model properties as to what pertains the economy's response to shocks, in this section we provide further evidence in order to validate the model. In addition to reporting tests of specification validity, measures of goodness of fit and regression diagnostics of individual equations[26], we simulate the entire model. In particular, we illustrate the results obtained when the model is dynamically simulated since 1996:1 through 2006:4. All the foreign exogenous variables are set at their historical values. The same happens for policy variables, interest rates and exchange rates. Public finance variables are set equal to the actual values in real terms (price deflator of fiscal items are anchored to the corresponding endogenous variable of the private sector, that is the market sector value added deflator).

The purpose of the exercise is not to find out how policy rules influence model properties but to check the model fit and forecasting accuracy. Dynamic simulations provide true multi-step forecasts. Figures 16 through 25 show the pattern of actual time series for a number of relevant endogenous variables compared to the one of the corresponding simulated series. Despite the sizeable length (about 10 years) of the simulation horizon, visual inspection of the figures indicates a good tracking of the actual patterns.

In Table 1, for a subset of the endogenous variables, we compare the cyclical component of simulated and actual series. Preliminary to this, we apply the Baxter-King filter to both the actual and simulated series of the economic aggregates in order to derive the cyclical component of the time series[27]. In particular, we report the ratio between the standard deviation of the simulated series and the standard deviations of the actual series (column 1). We also report the

[26] These results are included in the additional model documentation.

[27] According to the methodology devised by Baxter and King (1999) for de-trending, the cyclical components are derived by band pass filtering the time series in order to eliminate those frequencies of the data that are lower or higher than cyclical frequencies. Our choice for the upper bound of the length of a business cycle is 40 quarters, whilst that for the lower bound is 6 quarters. Moreover, the truncation of the band pass filter is done with 8 leads and lags. The methodology was applied over the time horizon 1994:1-2008:4. Of course, for 2007 and 2008 only the simulated series are considered.

ratio of the standard deviation of each series over the one of GDP. This is done for both the simulated and actual series (column 2).

Finally, in column 3 we report the cross correlation (lag, contemporaneous and lead) of each variable with respect to contemporaneous GDP (see Agresti and Mojon, 2003). The comparison of standard deviations, reported in the first two columns, is a relevant evaluation criterion because it sheds light on the business cycle amplitude, i.e. the volatility characterizing each economic time series. The track seems to be generally satisfactory. Importantly, ITEM is not affected by the problems of predicting too low an employment volatility and too high a wage volatility, which, on the contrary, characterize a number of existing econometric models.

Relevant information is also provided by cross correlations. The overall model performance is satisfactory on this respect and most of the evidence mimics quite closely the main features of the actual Italian business cycle. The contemporaneous and lag/lead correlations with GDP of the simulated variables of the supply side are remarkably in line with the actual values. In particular, for example, simulated total factor productivity (or, better to say, its cyclical component) is the one exhibiting the highest correlation with GDP at time t (approximately +0.9). Moreover, the degree of correlation declines as the number of lags/leads increases and this pattern closely resembles the one characterizing historical data. Moreover, the simulated pattern of employment, which features a contemporaneous correlation with GDP of approximately 0.5, and of capital accumulation (i.e. investment) are very close to the actual behavior. A note of caution is in order for some patterns on the demand side.

In particular, private consumption seems to be slightly more correlated to GDP than what is observed on actual data. Arguably, this indicates that, in the consumption function, the estimated weight to labor related disposable income (which is more correlated to GDP than financial wealth) is relatively too high. Admittedly, foreign trade variables provide a rather weak performing track in terms of correlations with GDP. This contrasts with the other evidence that their standard deviations on simulated series are quite close to the corresponding figures obtained on the historical values. This is possibly related to the model ability to track the patterns of variables in nominal terms. Simulated price deflators and per capita wages exhibit a slightly different pattern with respect to those of actual variables (see fig. 17).

Most likely, this causes the cyclical components of price competitiveness (and, thereby, of trade variables) to be less aligned with the corresponding pattern of the historical values. Again, however, the extent of volatility of the simulated variables is quite close to the one of the actual time series. Moreover, if considered in real terms, per capita wages from the model's simulation exhibit a correlation with GDP that closely resembles the one observed on actual data.

Table 1: Comparing the first and second moments of cyclical components of the actual and simulated series

Variables	Std. Deviation (simulated /actuals)		St. Dev relative to GDP	Cross Correlation with GDP(t+k)						
			k	-4	-2	-1	0	1	2	4
TOTAL REAL VALUE ADDED	0.84	actual	0.97	-0.10	0.57	0.87	0.98	0.82	0.49	-0.20
		simulated	0.95	-0.19	0.51	0.84	0.99	0.87	0.54	-0.18
REAL VALUE ADDED , MARKET SECTOR	0.83	actual	1.12	-0.16	0.52	0.85	0.98	0.82	0.49	-0.21
		simulated	1.08	-0.27	0.43	0.79	0.97	0.86	0.55	-0.20
REAL NET INDIRECT TAXES ON PRODUCTS	0.76	actual	2.09	-0.43	0.15	0.47	0.66	0.64	0.45	-0.05
		simulated	1.86	-0.07	0.53	0.75	0.80	0.65	0.40	-0.09
REAL PRIVATE CONSUMPTION EXPENDITURE	1.08	actual	0.88	-0.11	0.25	0.41	0.48	0.45	0.33	0.05
		simulated	1.11	-0.13	0.23	0.48	0.67	0.76	0.70	0.29
REAL GROSS FIXED INVESTMENT, TOTAL	1.06	actual	1.89	-0.23	0.23	0.49	0.60	0.45	0.20	-0.12
		simulated	2.34	0.10	0.41	0.54	0.54	0.31	0.00	-0.38
REAL EXPORTS OF GOODS AND SERVICES	0.81	actual	4.20	-0.30	0.45	0.77	0.90	0.78	0.47	-0.28
		simulated	3.99	-0.53	0.01	0.39	0.69	0.80	0.68	0.01
REAL IMPORTS OF GOODS AND SERVICES	0.86	actual	3.50	-0.33	0.27	0.55	0.68	0.60	0.34	-0.20
		simulated	3.51	-0.06	-0.65	-0.66	-0.44	-0.11	0.20	0.49
TOTAL EMPLOYMENT	0.93	actual	0.59	0.21	0.51	0.55	0.48	0.30	0.04	-0.39
		simulated	0.64	0.11	0.33	0.46	0.50	0.36	0.11	-0.35
TOTAL EMPLOYMENT, MARKET SECTOR	0.96	actual	0.67	0.17	0.49	0.54	0.48	0.29	0.03	-0.41
		simulated	0.75	0.06	0.30	0.43	0.48	0.35	0.10	-0.36
EMPLOYEES - MARKET SECTOR	0.79	actual	0.83	0.22	0.26	0.28	0.28	0.23	0.11	-0.20
		simulated	0.77	0.01	0.17	0.30	0.38	0.33	0.18	-0.18
TOTAL SELF EMPLOYMENT	0.81	actual	1.42	-0.02	0.38	0.42	0.34	0.15	-0.07	-0.34
		simulated	1.34	0.09	0.30	0.38	0.36	0.20	-0.03	-0.39
PARTICIPATION RATE (15-64)	0.84	actual	0.46	0.03	0.03	-0.06	-0.12	-0.10	-0.03	0.15
		simulated	0.45	0.01	0.13	0.22	0.28	0.29	0.20	-0.07
UNEMPLOYMENT RATE, LABOR FORCE SURVEY	1.14	actual	4.48	-0.03	-0.23	-0.34	-0.39	-0.32	-0.17	0.14
		simulated	5.94	0.00	0.06	0.06	0.07	0.13	0.16	0.03
PER CAPITA WAGE, MARKET SECTOR	1.28	actual	0.56	0.10	-0.20	-0.38	-0.45	-0.33	-0.06	0.43
		simulated	0.83	-0.05	-0.31	-0.29	-0.16	0.05	0.24	0.41
PER CAPITA REAL WAGE, MARKET SECTOR	0.88	actual	0.98	-0.24	-0.30	-0.18	0.05	0.38	0.63	0.67
		simulated	1.00	-0.28	-0.39	-0.25	0.02	0.41	0.72	0.82
PER CAPITA LABOR COST	1.12	actual	1.51	-0.25	-0.45	-0.34	-0.11	0.14	0.31	0.16
		simulated	1.97	-0.16	-0.54	-0.52	-0.34	-0.06	0.21	0.39
TOTAL FACTOR PRODUCTIVITY, MARKET SECTOR	0.89	actual	0.99	-0.26	0.38	0.72	0.90	0.81	0.55	-0.04
		simulated	1.03	-0.38	0.25	0.61	0.85	0.87	0.67	0.01
LABOR PRODUCTIVITY, TOTAL	0.82	actual	0.88	-0.26	0.29	0.60	0.77	0.72	0.52	0.04
		simulated	0.84	-0.30	0.32	0.60	0.74	0.70	0.53	0.06
TOTAL REAL GROSS OPERATING SURPLUS	0.94	actual	1.82	-0.07	0.68	0.90	0.88	0.56	0.15	-0.38
		simulated	1.99	-0.12	0.60	0.84	0.86	0.60	0.20	-0.46
REAL PERSONAL DISPOSABLE INCOME	1.12	actual	0.94	0.28	0.11	-0.05	-0.17	-0.20	-0.12	0.05
		simulated	1.23	0.43	0.39	0.21	-0.02	-0.25	-0.38	-0.37
IMPLICIT PRICE DEFLATOR, GROSS DOMESTIC PRODUCT	0.99	actual	0.72	0.12	-0.08	-0.25	-0.42	-0.59	-0.63	-0.40
		simulated	0.84	-0.04	-0.38	-0.43	-0.38	-0.34	-0.29	-0.21
IMPLICIT PRICE DEFLATOR, TOTAL VALUE ADDED	0.91	actual	0.93	0.17	0.07	-0.08	-0.26	-0.45	-0.53	-0.41
		simulated	0.98	0.10	-0.06	-0.15	-0.22	-0.31	-0.37	-0.35
IMPLICIT PRICE DEFLATOR, HOUSEHOLD CONSUMPTION	0.93	actual	0.68	-0.29	0.11	0.29	0.36	0.20	0.01	-0.27
		simulated	0.74	-0.34	-0.51	-0.39	-0.18	-0.04	0.05	0.04

Fig. 16 Real gross domestic product

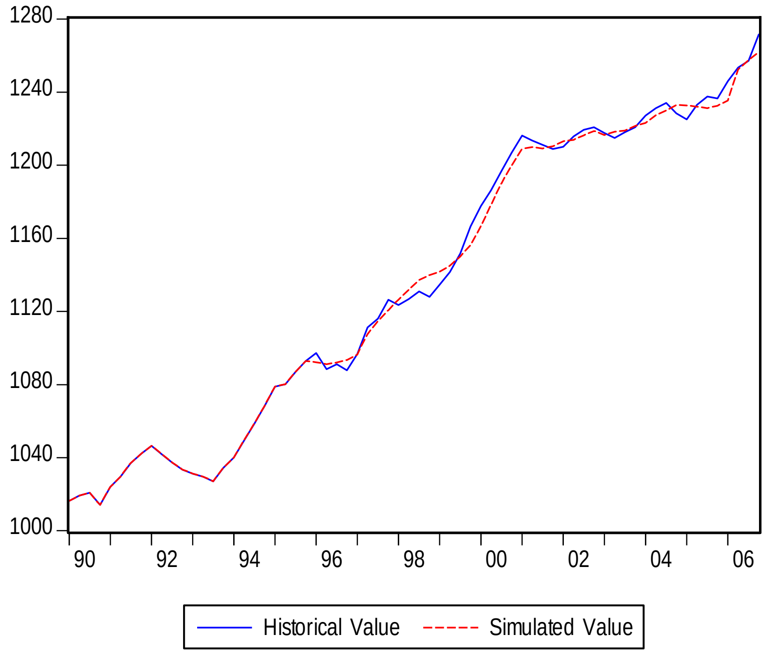


Fig. 17 Implicit price deflator of value added at basic prices (market sector)

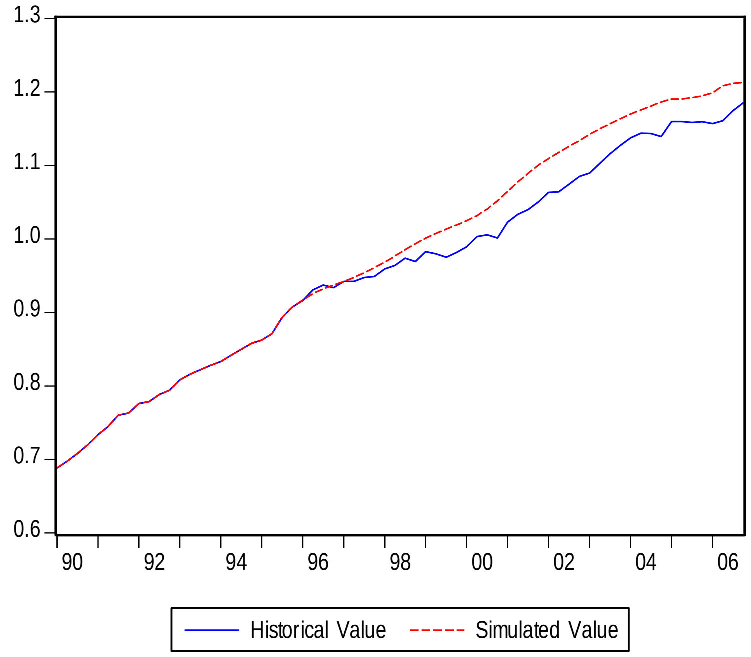


Fig. 18
Real value added at basic prices – market sector

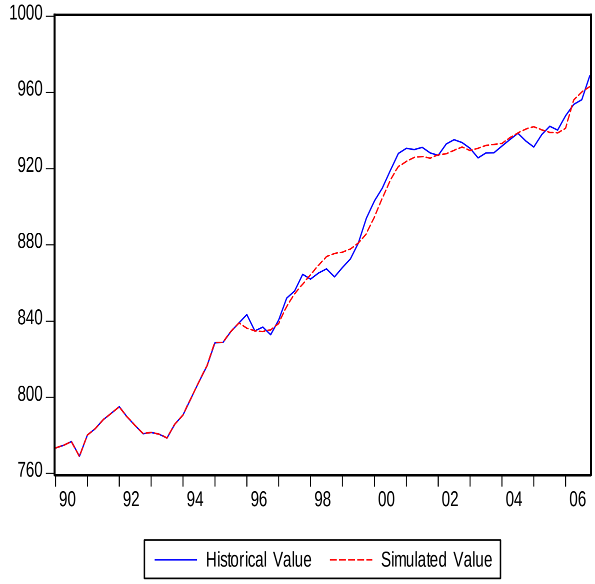


Fig. 19
Real private consumption expenditure

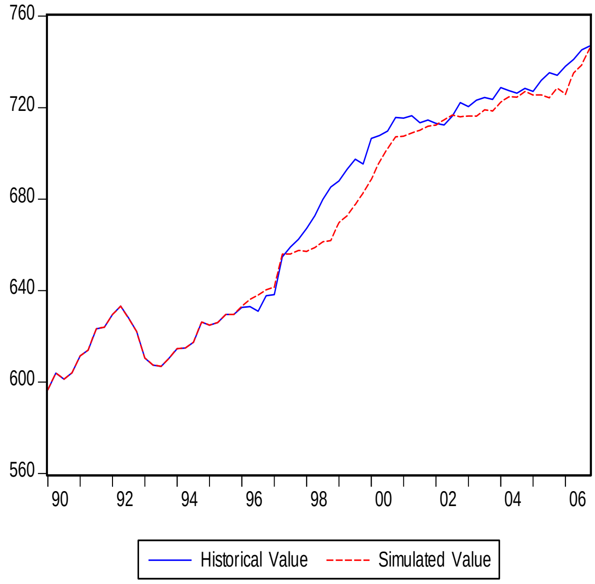


Fig. 20
Real gross fixed investment – market sector

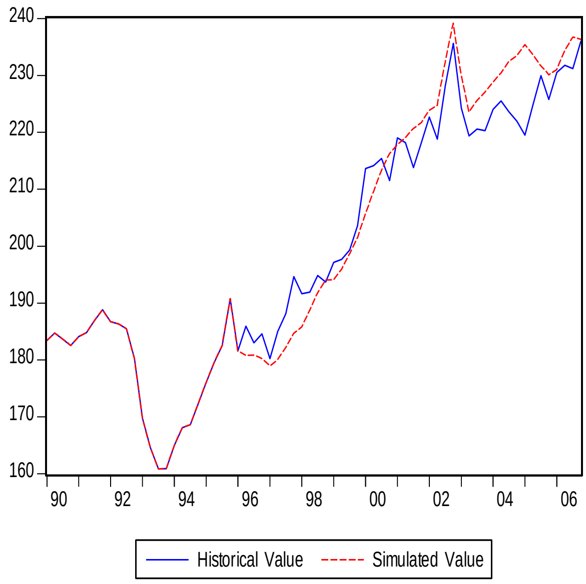


Fig. 21
Trade balance (% of GDP)

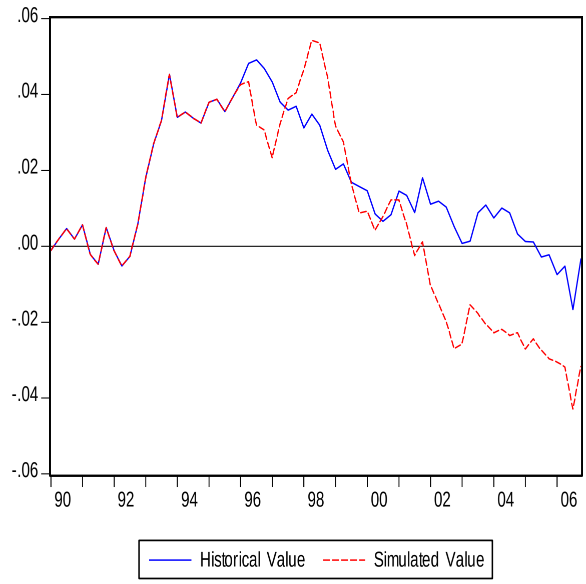


Fig. 22
Total employment – market sector

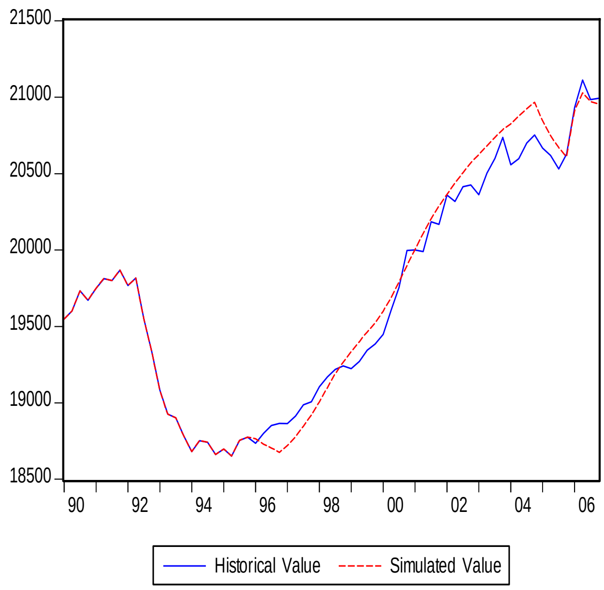


Fig. 23
Unemployment rate – labor force survey

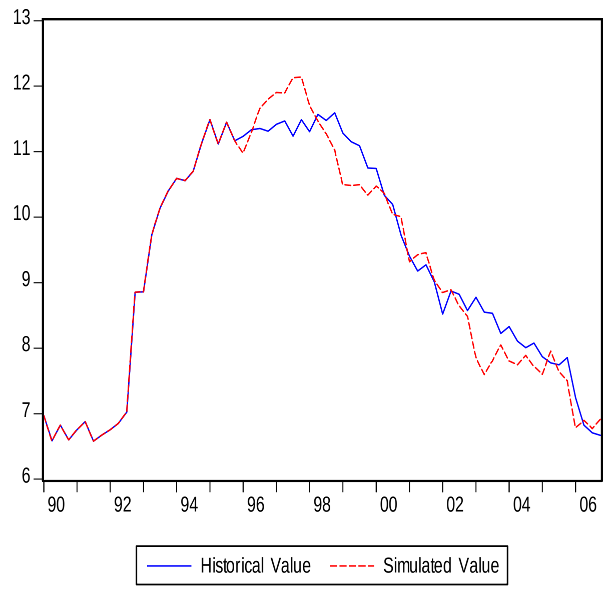


Fig. 24
Real personal disposable income

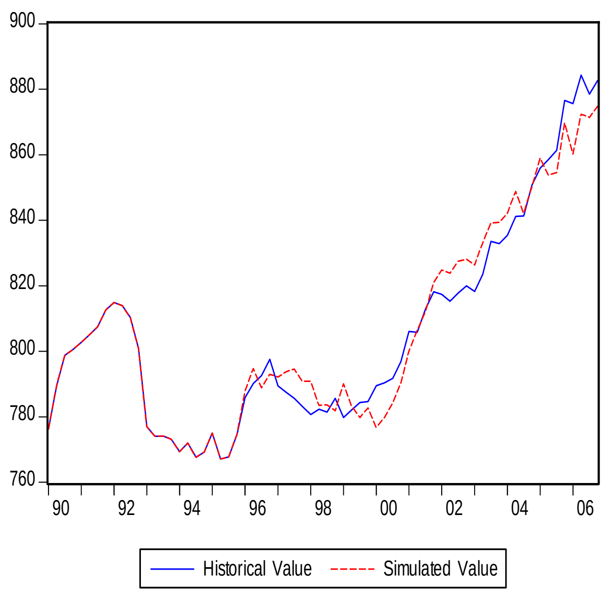
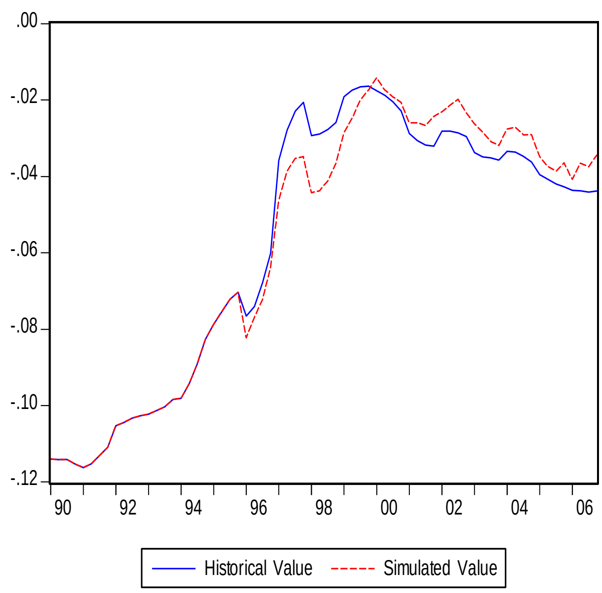


Fig. 25
General government balance (% of GDP)



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