# Assessing policy reforms for Italy using ITEM and QUESTIII

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## Abstract

In this paper we assess the implications of policy reforms for the Italian economy by jointly using the Italian Treasury Econometric Model (ITEM) and QUEST III, the endogenous growth dynamic general equilibrium (DGE) model of the European Commission (DG ECFIN) in the version calibrated for Italy. We point out some of the key differences between the two models, highlighting some policy insights that DGE models can provide compared to those of traditional macro-econometric models. Their structural characteristics and the results of simulations are analyzed by using an array of shocks commonly examined in the evaluation of possible reforms. We show that two elements incorporated into the QUEST model play a key role in explaining the qualitative and quantitative differences among the two models in the dynamic responses to structural shifts, namely: the role of expectations in the transmission of reforms and the endogenous growth mechanism. We conclude that the joint consideration of the two models can improve our understanding of how the assessment of policy interventions is likely to be affected by the uncertainty surrounding model-based evaluation.

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# 1. Introduction

Since the seminal paper by Kydland and Prescott (1982) the field of macroeconomics has witnessed a significant evolution in the development of new models, recording deep changes in both methodological and theoretical aspects. In this regard, the most renowned advance is the dynamic general equilibrium (DGE) class of models, among which the Dynamic New Keynesian (DNK) models occupy a prominent role. The latter integrates typical Keynesian features, such as imperfect competition and nominal frictions, into a general equilibrium framework (see e.g. Woodford 2003, Christiano *et al.* 2005, Smets and Wouters 2003, 2007, Goodfriend 2007).

Unquestionably, this approach to macroeconomic modelling presents a number of advantages over alternative methods. First, DGE models are built from first principles, as the equilibrium path of the economic variables is derived from the optimal conditions of intertemporal maximisation problems of households and firms, combined with the market clearing conditions. In addition, this approach allows to establish a direct relationship between the structural parameters, describing preferences and technology, and the parameters in reduced form governing the equilibrium dynamic of the economic variables. In DGE models the calibrated (or estimated) deep structural parameters are independent from both expectations and the conduct of monetary and fiscal policy; they are therefore not subject to the Lucas critique (see Lucas 1976) that seriously challenges the macro models in the so called Cowles Commission tradition. Moreover, the DGE modelling approach has become rather flexible and, owing to significant developments in computational techniques, basic models of this type can now be extended along several dimensions by introducing additional frictions, propagation mechanisms and shocks. For these reasons, in recent years a number of central banks, government treasury departments and international institutions have developed their own medium- to large-scale DGE models for policy analysis.[1]

On the other hand, in spite of the increasing reliance on these models, some economists highlight a number of challenges in them. These include a trade-off between their theoretical coherence and the ability of providing a good statistical fit of the data (see Schorfeide 2011). For example, DGE models are not fully able to account for the degree of persistence observed in actual data of inflation, without relying on arbitrary *ad hoc* assumptions and departing from the coherence of the microfoundations. Parallel to this, concerns over the dominance of the DGE approach in macro modelling has been raised in the literature, especially since the 2007 financial crisis (see, for example, Pesaran and Smith 2011; Caballero 2010 and De Grauwe 2010).

[1] Examples of the main Central Banks that have developed their DGE models include: the European Central Bank (Christoffel *et al.* 2008), the Federal Reserve Board (Erceg *et al.* 2006), the Bank of Canada (Murchison and Rennison 2006), the Bank of England (Harrison *et al.* 2005), the Bank of Norway (Brubakk *et al.* 2006), the Bank of Spain (Andrés *et al.* 2006 ), and the Bank of Sweden (Adolfson *et al.* 2007a,b). Also the IMF has developed its own DGE model, GEM, (see e.g. Bayoumi 2004, Laxton 2008 and Pesenti 2008). The European Commission has developed different versions of its own DGE model and QUEST III is the one that is used in this paper.

Having said that, an intensive reform agenda requires economic policy institutions to quantify the possible effects of single policy interventions as well as of complex reform scenarios. Since no single model can account for all the issues that are relevant for policy makers, in most cases economic institutions have to rely on a plurality of models. From this point of view, a more in depth understanding and comparison of the available models and a careful selection of the tools, that more closely fit the case study, are of the utmost importance.

The aim of this paper is indeed to provide a comparative assessment of the predictions of a DGE model with focus on the Italian economy and a medium-scale econometric model used for policy analysis at the Italian Treasury department.[2] In particular, we compare simulation results from the Italian Treasury Econometric Model (ITEM) with those obtained through the latest version of the European Commission's DGE model, QUEST III, calibrated for the Italian economy (see Cicinelli *et al.* 2008, 2010; Roeger *et al.* 2008; D'Auria *et al.* 2009). There are several contributions in the literature that focus on comparing the implications of different macroeconomic models (see e.g. Wieland *et al.* 2012, Wallis 2004, Church *et al.* 2000 and Mitchell *et al.* 1998). Some of them, in particular, present a comparative analysis of the implications of a DGE model and of a macroeconometric model. Similarly to what highlighted in these studies (see e.g. Wieland *et al.* 2012), the primary difference across the models examined in this paper deals with the different relative weights on theoretical foundations and data of the two models. While ITEM does not feature optimising agents with rational expectations, it is however a data-oriented econometric model, which significantly departs from the models built in the Cowles Commission tradition (see Favero 2001 for details). In particular, a great deal of attention is paid to the statistical model implicit in the estimated structure; in ITEM a rich dynamic structure is allowed for and the adequacy of the model specification is assessed through a number of tests on residuals such as, for example, those for homoscedasticity and absence of serial correlation.

For the comparison among the two models, we carry out some simulation exercises analysing the dynamic response of the main macrovariables to an array of shocks often examined in policy analysis. These include productivity improvements, pro-competitive policy in the product markets, an increase in public consumption and a shift in the tax burden from labour to consumption. The simulations are conducted by adopting hypotheses on the shocks themselves which are standardised as much as possible, although in some cases, admittedly, the differences across models do not allow to design identical policy impulses. In comparing the implications of the policy shifts, we try to emphasize the main transmission channels in each of them.

For both models, our simulation results turn out to be consistent with economic theory and show the beneficial effect on growth and employment of reforms, like those for enhancing competition in the final goods market or those dealing with the tax system. On the other hand, our comparative

[2] It should be noted that a more in depth comparison should require the use of sensitivity analysis (see Saltelli *et al.* 2004) which is beyond the scope of this paper. Our comparative exercise seeks to highlight some of the key differences between the two models, pointing to the insights that these different models provide.

assessment reveals some noticeable differences between the two models as to what pertains the dynamic responses to shocks. However, despite the methodological differences, the two models provide pieces of information that are somehow complementary and that can be considered as reflecting different views on how the economic system works.

The remainder of the paper is organized as follows. Section 2 is devoted to a brief description of QUEST III and ITEM. Section 3 compares the results of long-horizon simulations carried out with both models, in order to appraise differences in the macroeconomic effects of a number of permanent shocks. Section 5 concludes.

## 2. A summary on the structure of QUEST and ITEM

In this Section we provide a brief summary of the two models describing their main characteristics and illustrating the main channels through which shocks propagate. Differences between the two models along these dimensions provide a rationale to account for possible discrepancies in the results.

### 2.1 The QUEST model

QUEST III is a large-scale model in the class of dynamic general equilibrium models. In these models, households are utility maximising, forward-looking agents who decide how much to consume and invest and who supply (possibly) differentiated types of labour. Firms are profit maximising entities, employing labour services and capital, and setting prices as monopolistic suppliers of differentiated goods.[3] By incorporating imperfect competition in goods and labour market, nominal and real rigidities, and allowing for the existence of a variety of shocks, DNK models provide a realistic representation of the economic system in a fully micro-founded, optimisation-based environment.

The new QUEST III model we use in this paper is an extension of the original DGE model for quantitative policy analysis developed at the Directorate general for Economic and Financial Affairs at the European Commission (see Ratto *et al.* 2009), augmented with endogenous growth (see Roeger *et al.* 2008). The latter is modelled consistently with the framework proposed by Jones (1995, 2005) to adapt the Romer's (1990) model with endogenous development of the R&D sector. In particular, in our simulation exercise we will use the version of the model calibrated for Italy, already employed in several multi-country analyses of structural reforms (e.g. D'Auria *et al.* 2009) and in a paper evaluating different structural reform scenarios for the Italian economy (see Annicchiarico *et al.* 2013). The endogenous growth version of QUEST is particularly well-suited to analyse the impact of structural economic reforms enhancing growth. By including several nominal and real frictions and by modelling markets as imperfectly competitive, the model can be used to study the effects of competition-enhancing policy. On the other hand, the explicit consideration of an endogenous mechanism of

[3]For a description of the baseline DGE models, see, for example, Walsh (2003) and Galí (2008) and the references therein.

growth allows to study policies and reforms aimed at increasing the rate of knowledge creation, while the distinction of labour services in three skill categories (low, medium, high) allows to analyse the effects of policy measures such as those a) increasing the social benefits for low-skilled workers, b) changing the skill composition of the labour force, c) promoting high skilled immigration policies or d) subsiding employment of the high-skilled workers in the R&D sector.

QUEST III features eight types of agents: households-workers, trade unions, final goods firms, intermediate goods firms, R&D sector, foreign sector, monetary and fiscal authorities.

The economy is populated by two types of households. The first type, the non-liquidity constrained households, supply medium and high skilled labour services, trade domestic and foreign assets, accumulate investment goods and physical capital which they rent out to the intermediate goods producers, buy the patents produced in the R&D sector and license them to the intermediate goods sector; they take decisions on how much to consume in an intertemporal optimisation context, making use of all the available information and taking into account technological, institutional and budgetary constraints.

One of the most relevant equilibrium condition, stemming from their optimizing behaviour, is the Euler's equation which describes the optimal time path of consumption of non-liquidity constraint households:

$$U_{C^i}\left(C_t^i, C_{t-1}\right) = \beta E_t \frac{1+i_t}{1+\pi_{t+1}} \frac{1+t_t^c}{1+t_{t+1}^c} U_{C^i}\left(C_{t+1}^i, C_t\right), \qquad (1)$$

where $U_{C^i}$ is the partial derivative of the utility function with respect to $C^i$, $\pi_{t+1}$ is inflation, $i_t$ denotes the nominal interest rate, $t_t^c$ is the tax rate on consumption and $C_{t-1}$ is the past level of the economy-wide consumption, as the model features a strong habit component. The Euler equation represents one of the key building blocks of the DGE methodology. It is an equilibrium relationship which establishes that, along the optimal path of consumption, a reallocation at the margin of one unit of consumption from today into the future is still compatible with households' intertemporal optimization as it does not alter the maximized level of utility. From eq. (1) it is clear that forward looking expectations play a fundamental role in shaping current consumption. When making their consumption plans, households take into account expectations about the future, standing ready to revise their plans in response to shocks, so that the economy returns to its equilibrium path (the so called "saddle path").

The other set of households, the liquidity constrained households, are hand-to-mouth consumers who do not have access to financial markets and consume their current disposable income, supplying low-skilled labour services (see Galí *et al.* 2007). As already mentioned, for liquidity constrained

households optimal consumption is simply equal to the net wage income plus transfers from the public sector and they only supply low-skilled labour services (for details see Roeger *et al.* 2008).[4]

This differentiation among consumers allows to introduce non-Ricardian consumption behaviour and yields Keynesian effects of fiscal policy. Indeed, without the existence of these liquidity constraints, fiscal policy would generate only non-Keynesian effects in these models, because the consumption choice of Ricardian households is based on intertemporal budget constraints and a higher public expenditure diminishes the present value of after-tax income, thus inducing a negative wealth effect and an ensuing decline of consumption (see e.g. Galí *et al.* 2007 and Forni *et al.* 2009).

For each skill group (high, medium and low) it is assumed that households supply differentiated labour services to unions which, in turn, set wages in monopolistically competitive labour markets. Nominal wage rigidity is given by the existence of adjustment costs for changing wages. Each category of workers represents a constant fraction of the population (see Roeger *et al.* 2008 for a more detailed description of QUEST model used in this paper).

Trade unions set wages charging a wage mark-up over the reservation wage. In particular, for each category of skills, *s*, a trade union maximizes a joint utility function for each type of labour. It follows that real wages are higher and employment is lower than in a standard Real Business Cycle model. The wage set by unions will crucially depend on preferences, on the tax rate on labour, on the level of unemployment subsidies and on the degree of market power of unions, which, in turn, depends on the elasticity of substitution between different types of labour services for each skill category of workers. These factors introduce a wedge between the real wage rate and the marginal rate of substitution between leisure, *1-L*, and consumption, *C* , ($MRS_{c,1-L}$), that is

$$\frac{W_t^s}{P_t^C} = \mathbf{MU}_{W^s} \frac{1+t^C}{1-t^{w,s}-b^s} MRS_{t,C,1-L}, \qquad (2)$$

where index $s = L, M, H$ denotes the skill level, $W_t^s$ the nominal wage, $P_t^C$ the consumption price index, $\mathbf{MU}_{W^s}$ denotes the gross wage markup, $t^C$ the consumption tax rate, the $t^{w,s}$ wage income tax rate and $b^s$ the unemployment benefit rate. The reforms intervening in the labour market aim at reducing this wedge to stimulate employment and enhance economic activity. In the simulations we will consider a tax shift from labour (by reducing $t^{w,s}$) to consumption (by increasing $t^C$).

The final good sector is modelled *à la* Dixit and Stiglitz (1977). Firms produce differentiated final goods which are imperfect substitutes to each others. Each firm acts as a monopolistic competitor facing a demand function with a constant price elasticity, which in turn is equal to the elasticity of substitution among different varieties of the final good. The representative firm *j* produces output

[4]For a version of QUEST extended to include also credit constrained households, see Roeger and in 't Veld (2009).

using a production technology characterized by the following inputs: $A_t$ different varieties of intermediate goods, $x^j$, a combination of labour services, $L_{y,t}^j$, and public capital, $KG_t$:

$$Y_t{}^j = \left[A^{exog}(L_{y,t}^j - FC_L)\right]^{\alpha} \left[\sum_{i=1}^{A_t}(x_{i,t}^j)^{\theta}\right]^{\frac{1-\alpha}{\theta}} KG_t{}^{1-\alpha_G} - FC_y, \quad (3)$$

where $A^{exog}$ denotes labour productivity subject to shocks; $\alpha$ and $\alpha_G \epsilon$ (0,1) measure, respectively, the contribution of labour inputs and of public capital to production, $\theta$ is the elasticity of substitution between different varieties of the intermediate goods $x$, $FC_y$ denotes fixed costs and $FC_L$ overhead labour. The number of available intermediate goods, $A_t$, in turn, depends on the creation of new ideas (patents) in the R&D sector, where the production of new designs depends on the number of skilled workers employed and on the existing stock of ideas.

The labour input $L_{y,t}^j$is defined by the following CES aggregator:

$$L_{y,t}^j = \left\{ s_L^{\frac{1}{\sigma_L}} (ef_L L_t^L)^{\frac{\sigma_L - 1}{\sigma_L}} + s_M^{\frac{1}{\sigma_L}} (ef_M L_t^M)^{\frac{\sigma_L - 1}{\sigma_L}} + s_{H,Y}^{\frac{1}{\sigma_L}} (ef_H L_t^{HY})^{\frac{\sigma_L - 1}{\sigma_L}} \right\}^{\frac{\sigma_L - 1}{\sigma_L}}, \quad (4)$$

where $s_L$ $s_M$ and $s_{HY}$ denote the population shares of labour force for each category of skills, low, medium and high, respectively, while $ef_L$, $ef_M$ and $ef_H$ denote the corresponding efficiency level. Finally, the parameter $\sigma_L$ is the elasticity of substitution between the three categories of skills (for further details see Roeger *et al.* 2008). The above production function incorporates the product variety framework proposed by Dixit and Stiglitz (1977) applied to the literature of R&D diffusion (Grossman and Helpman 1991; Aghion and Howitt 1998).

Each firm of the final good sector sets the optimal price and makes choices about labour inputs and intermediate goods in order to maximise profits. Firms are subject to adjustment costs on price resetting (nominal frictions). In addition, hiring or firing of workers involves a convex adjustment cost (real frictions). Imperfect competition in the final goods market impinges on prices which are equal to a markup, denoted as $\mathbf{MU}_p$ over marginal costs. As we will see in detail, policies aimed at increasing competition in the model will be introduced by decreasing this markup .

Finally, the foreign sector is exogenous (small open economy hypothesis). In particular, it is assumed that economies trade both final and intermediate goods, given constant elasticities of substitution between bundles of domestic and foreign goods. In both sectors exporters act as monopolistic competitors in their respective exports market and charge a mark-up over their respective domestic prices.

The conduct of monetary policy is described by a Taylor-type rule (see Taylor 1993 and Clarida *et al.* 1999), allowing for a certain degree of inertia of the interest rate response to inflation and output gap (see Roeger *et al.* 2008 for details).

Finally, the behaviour of the fiscal authority is described by a set of equations according to which both expenditures and receipts are responsive to economic fluctuations.

### 2.2 The ITEM model

The Italian Treasury Econometric Model (ITEM) is a quarterly medium-size macroeconometric model which has been developed at the Department of Italian Treasury and is used for policy analysis and forecasting (for more details see Cicinelli *et al.* 2008; 2010 and Favero *et al.* 2000).

Differently from the DGE approach, which achieves structural identification of the parameters through a fully theory-dependent framework, ITEM is a data-driven model with focus on providing a satisfactory reduced-form characterization of the data. The specification of the equations in ITEM is not derived from an intertemporal maximisation framework with optimising agents endowed with rational expectations. Yet, ITEM features a rich dynamic set-up and the statistical adequacy of the model specification is verified by conducting several tests such as, for example, those for the homoscedasticity and lack of autocorrelation of the residuals. Moreover, the non-stationarity of the macroeconomic time-series is dealt with appropriately and the specification of each equation follows the error correction model (ECM) approach, so that the long-run equilibrium relationships among variables in (log) level are considered together with the short-run relationships among them (expressed in log difference).[5]

A data-oriented dynamic model like ITEM is able, for example, to evaluate a variety of fiscal policy issues in great detail, as a result of a detailed breakdown of fiscal variables in a large number of items on both the expenditure and revenue side. At the same time, in ITEM we explicitly consider the borrowing and the lending activities of the institutional sectors, thus enriching the variety of propagation mechanisms of each policy reform and increasing the information content of the model (see Cicinelli *et al.* 2008).

The properties and the main characteristics of ITEM have been documented in previous contributions (see Cicinelli *et al.* 2008, 2010 and Favero *et al.* 2000). The short-run level of real output is determined by demand conditions, while in the long run output depends on developments on the supply side. In ITEM the shocks generating permanent effects on output are associated with shifts affecting the tax wedge on labour and the user cost of capital, shifts to labour supply and variation in the (exogenous) structural component of TFP. On the contrary, changes in demand conditions only give rise to transitory effects and the real GDP long-term level qualitatively remains unchanged.

The demand side is formulated in a standard fashion. In the long run, private consumption ($C$) depends upon real labour disposable income ($YLD$), real households net financial assets ($HNFA$), as well as the real gross interest rate on short-term borrowing ($R$):

[5]On this respect, ITEM significantly departs from the traditional models built in line with the Cowles Commission approach (see Favero 2001), because it places emphasis on the statistical model implicit in the estimated structure.

$$C_t = \alpha_0\, YLD_t + (1-\alpha_0) HNFA_t - \gamma_0 R_t, \quad (5)$$

where $0 < \alpha_0 < 1$ and $\gamma_0 > 0$. Households net financial assets accumulation is characterized by the following equations:

$$\begin{aligned} HNFA_t &= HFA_t - HFL_t, \\ HFA_t &= (1 + app_t) HFA_{t-1} + ACC_t, \\ HFL_t &= \alpha_1 - \beta_1 SGDP_t, \end{aligned} \quad (6)$$

where $\alpha_1$ and $\beta_1 > 0$, $app$ is the rate of appreciation of financial assets (HFA), modeled as a function of the US stock prices (the Dow Jones index), the (structural components of) TFP growth and a measure of foreign inflation. Over time the value of financial assets ($HFA$) is adjusted by means of both itsappreciation (or depreciation) and the flows of households' savings ($ACC$). In addition, households financial liabilities ($HFL$) are negatively related to the structural component of real GDP ($SGDP$).

A key feature of ITEM is that real GDP is determined on the supply side, contrary to the standard macroeconometric modeling approach according to which models are "closed" on the demand side. In particular, we consider the following accounting identity, linking GDP to the value added:

$$GDP_t = VAM_t + VANM_t + TXNT_t, \quad (7)$$

where $VAM$ is the market value added, $VANM$ is non-market value added and $TXNT$ denotes net indirect taxes.

Then the model is closed on the supply side through inventory changes (INVCH) obtained as a buffer. That is, from the fundamental national accounting identity, it is inventory changes to be obtained as a residual:

$$INVCH_t = GDP_t - (C_t + I_t + G_t + X_t - M_t), \quad (8)$$

where private consumption, $C$, investment, $I$, export, $X$ and import, $M$, are modeled through behavioral equations and public expenditure, $G$ is assumed to be exogenous. Output (value added) of market sector (VAM) is described by a standard production function equation with constant returns to scale (CRTS):

$$VAM = TFP_t L_t^{\alpha_2} K_t^{1-\alpha_2}, \quad (9)$$

where $0 < \alpha_2 < 1$, $L$ and $K$ are labour and capital inputs and Total Factor Productivity ($TFP$) captures changes in technology and in organization of production activity. In our setup, the $TFP$ variable plays

the role of a bridge between the short and the long run. Indeed it is modeled in such a way that, in determining output, demand side conditions prevail in the short run, while supply side conditions are predominant in the long run. In particular, measured $TFP$ can be decomposed into two components: an exogenous structural component capturing the technical and organizational innovation ($TFP\_TP$) and a second component reflecting the cyclical variation in the extent of factor utilization ($IFU$). The latter component stems from the measurement problem in the available statistics of inputs, that fall short of gauging the degree of intensity of factor utilization along the business cycle. This causes measured productivity to be procyclical. Therefore, measured TFP changes can be expressed as

$$dlog(TFP_t) = dlog(TFP\_TP_t) + dlog(IFU_t), \tag{10}$$

and, taking advantage of CRTS, we have

$$VAM_t = TFP_{P_t}(IFU_t L_t)^{\alpha_2}(IFU_t K_t)^{1-\alpha_2}, \tag{11}$$

The second component, $IFU$, is modeled through the following statistical equation:

$$d\log(IFU_t) = dlog(TFP_t) - dlog(TFP\_TP_t)$$
$$= \alpha_3 + \beta_3\, dlog(DEM_t)$$
$$+ \mu\, ASAD_{t-1}, \tag{12}$$

where $\alpha_3, \beta_3$ and $\mu > 0$, $DEM$ represents aggregate demand and $ASAD_{t-1}$ is the ratio between lagged aggregate supply and lagged aggregate demand (for more details see Cicinelli *et al.* 2010).

Prices and wages equations are modeled as in standard econometric models, with prices depending on unit labour costs and a measurement of capacity utilization, and wages depending on labour productivity, the unemployment rate and the tax wedge on labour. Contrary to the DGE modeling approach, in ITEM real and nominal frictions are not derived from a microfounded theoretical set-up, but stem from the dynamic specification of equations that introduces some degree of inertia and arguably allows to replicate the main empirical implications of those frictions.

The long-run demand for labour and capital services is modeled consistently with the predictions of firms' maximisation problem (see Cicinelli *et al.* 2008). In particular, on the one side, employment is positively related to output and negatively related to the real wage; on the other, capital (positively) depends on employment and (negatively) on the ratio between the user cost of capital and unit labour cost. The latter approximates the relative price of the capital input.

## 3. Simulations

Our comparative assessment focuses on the simulation results of different reform scenarios obtained with the two models under consideration (QUEST III and ITEM).These exogenous policy shifts range from pro-competitive policy interventions to tax shift in the burden of taxation from labour to consumption, to policy reforms that affect the amount of public expenditure. We also analyse the implications of a permanent increase in productivity.

For each reform scenario we evaluate the simulation results of the two models, trying to compare the main transmission channels and identify the key sources of differences in the dynamic response of the main macroeconomic variables. Several differences in the short as well as in the long run can be explained on the ground of specific features of the two models and on the different emphasis put on data and theory in the two approaches to macroeconomic modelling. Indeed, in the long run, outcomes are driven by supply side and the quantitative differences will depend on aspects related to technology and on the evolution recorded in the factors of production. In the short run, outcomes are mainly determined by aggregate demand conditions and a relevant element underlying the different response to shocks, especially for consumption, is arguably the forward-looking nature of QUEST compared to ITEM. Notably, with forward-looking agents the implications of the policy changes for the future path of variables affect current economic decisions.

In the comparison we consider the following array of policy shifts:

1. Increase in public consumption (permanent and temporary)
2. Exogenous improvement of productivity
3. Competition enhancing policy in the product market
4. Tax shift from labour to consumption

It is worth noticing that the selection of shocks in this paper is narrower than that analysed in D'Auria *et al.* (2009) and Roeger *et al.* (2008). Our more limited choice is motivated by the need of comparing results from the two models and this of course restricts the set of shocks that each model in isolation can potentially allow for. In each scenario of policy shift, we adopt hypotheses on the shocks which are standardised as much as possible across the two models. In some cases, however, the differences between them do not allow to design policy impulses which are identical across the two models.

In QUEST, in order to render all variables stationary, the non-stationary variables are expressed in efficiency units to remove the deterministic trend of total factor productivity and population. On the contrary, in the econometric specification of all equations in ITEM there is an ECM representation, so that the variables enter the equations in first-difference (to achieve difference stationarity) and a long-run relationship between variables expressed in levels is featured.

We provide a graphical comparison of the response of the main aggregate variables to the policy shift in each of the four scenarios. We focus on the implications for output, real private consumption, investment, real wages, the terms of trade and labour. For each of these variables we plot the percentage deviations from the initial steady state over a 40-year time horizon, so to be able to investigate also the long-run implications of each policy shift in the models.

In addition, in order to disentangle the role played by the forward-looking behaviour of agents in shaping the response of the economy in QUEST III during the earlier stages of the transition process, for each policy shift we also report the simulation results under the assumption that the policy changes are perceived as being temporary during the first ten-years of the simulation. Specifically, we assume that up to the tenth year agents perceive the policy intervention as being an unexpected one-period only policy shift. In this way the future path of variables, such as, for example, lifetime income, is not affected by the policy change and thus future developments associated with the policy shift have no effect on the current decisions made by households and firms during the first ten years of the simulation. On the contrary, since the eleventh year onwards, agents realize that the policy shift is permanent and in fact they face a structural break induced by the policy regime change.[6] Arguably, this assumption can be interpreted as reflecting some initial lack of credibility of the implemented policy program on the part of agents, contrary to the standard case, in which policies are immediately perceived as credible, with households and firms believing government interventions to be permanent and fully anticipating the long-run character of the policy change.

### 3.1 Increase in public consumption

In this scenario we consider a permanent increase in government consumption equal to 1 percent of GDP for each year (see Figure 1). We also consider the effects of a 1 percent (of GDP) temporary increase of public consumption (see Figure 2). This shock can be considered as traditional shock generally posted in model comparison exercises in order to evaluate the response to temporary demand shifts.

In the first place consider the effects of a permanent increase in public consumption. We notice that the results are quite different in ITEM (dotted lines) and QUEST (continuous lines), although they show a slowdown of private consumption in the long run and a weak increase of investment and employment. As elucidated above, because in ITEM the short-run level of real output is determined by demand conditions, while in the long run output depends on the supply-side conditions, an increase in public spending will produce a different effect on output in the short and in the long run. In fact, from

[6] This artificial experiment is devised in order to sterilize the effects of having forward-looking behaviour into the model and therefore ensures a comparison between the two models once they have been made more similar along an important dimension.

Figure 1 we note that government spending induces an immediate expansion of output in ITEM as well as in QUEST. In the former the government spending multiplier does not exceed unity reflecting a weak rise of consumption and household net wealth. The sharp fall of aggregate consumption and investment in long-run period reflects the crowding-out effect connected with the decline of household financial wealth and higher tax burden connected to higher government spending. However, during the first decade, consumption increases following a bell-shaped dynamic adjustment. In this sense ITEM predicts a positive co-movement between private and public consumption consistently with data.

In QUEST output displays a slight permanent increase, contrary to ITEM that predicts zero long-run effects on GDP. Private consumption exhibits a permanent fall and a rise of labour supply due to the negative wealth effect. A higher level of worked hours accounts for most of the observed increase in long-run output. Non-liquidity constrained households (which are assumed to be half of the population according to the calibration used) anticipate future increases in taxes and then reduce their consumption in accordance with the decline of the present value of future flows of disposable income (intertemporal substitution effect). Lower consumption implies a lower marginal rate of substitution between leisure and consumption affecting the wage equation, so that the model predicts more hours worked and lower real wages.

The crowding-out effect on private consumption in response to an increase in public consumption is a standard feature of many DGE models (i.e. Coenen and Straub 2005) and its size depends on the fraction of liquidity-constrained consumers (see Galí *et al.* 2007), on the persistence of the public spending process and on the calibrated value of the labour adjustment cost parameters. The inclusion of both non-Ricardian agents and adjustment cost in the labour market provide an effective channel for increasing the capability of DGE models to account for dynamic responses more consistent with the empirical evidence and similar to those obtained in existing econometric analyses (see e.g. Blanchard and Perotti 2002). Notably, the degree of consumption crowding out in response to higher public spending is lower the higher the share of non-Ricardian agents, the lower the labour adjustment costs and the lower the persistence of the public consumption increase. Despite the fact that in QUEST adapted for Italy non-Ricardian consumers represent half of the population, the high adjustment costs characterizing the labour market coupled with a permanent increase in public consumption are sufficient to produce a lack of co-movement between private and public consumption.

Finally, it should be emphasized that in QUEST the positive effects on long-run GDP and worked hours of a permanent increase in public consumption crucially depends on the assumption made about the budget closure rule according to which lump-sum taxes obey a feedback rule ensuring fiscal solvency.

Let us now consider the QUEST simulation results under the assumption that agents perceive the policy shift as temporary during the first ten years of the simulation (see the dashed lines in the graph). We observe the following. First, in QUEST consumption under non-forward looking assumption declines much less than in the standard case, narrowing the gap with respect the response

attained with ITEM. Intuitively, this is due to the fact that households now perceive the increase in public consumption as temporary and do not anticipate the negative consequences for their lifetime disposable income due anticipation of a higher future taxation. Second, also the initial drop of private investment is smaller under the perception that the policy change is temporary. Third, as a consequence of the higher aggregate demand, in QUEST with no-forward looking behavior during the first ten years there is a strong terms of trade improvement as in ITEM. Third, since the eleventh period onwards of the simulation, we notice that the dynamic of variables in QUEST gradually mimics the dynamic of the same variables under the standard scenario, converging together towards the new long-run steady state.

Overall, this experiment seems to confirm that part of the differences observed between the two models, during the first stages of the simulation horizon, are ascribed to the forward looking nature of QUEST, where agents fully anticipate in current decisions the future benefits and costs of permanent policy interventions.

Figure 2 shows the responses of the six selected variables to a one-percent temporary increase in government consumption over a 20-quarter time horizon. In both QUEST III and ITEM we assume that the policy shock imparted in period zero is very persistent with an autocorrelation coefficient set at 0.95. As a result of the higher demand and price stickiness, output will expand in both models. At the same time, higher government spending crowds out consumption and investments in QUEST but not in ITEM, where consumption and investment positively react to the shock and they both revert back to the original level only in the long run. This explains why, at least initially, the expansionary effects on output are much larger in ITEM than in QUEST. Labour hours increase and the terms of trade improve, leading in both models to a short-run substitution towards imported goods .

### 3.2 Exogenous improvement of productivity

In this scenario, an exogenous 1 percent productivity improvement has been implemented. It should be noted that in this context we interpret a productivity improvement as the result of some controlled policy actions aimed at improving the business environment and enhance economic efficiency.[7] In other words, we have in mind reforms aimed at ameliorating the functioning institutions, easing bureaucracy and reducing the administrative burden. The latter are expected to improve productivity similarly to policies aimed at improving the efficiency of infrastructure.[8]

This shock is obtained in QUEST III by varying the exogenous factor $\boldsymbol{A^{exog}}$ in the production function of final output (see equation 3). This shock gives rise to a permanent positive effects on output,

[7] Mapping reforms onto the model is a difficult task and requires many simplifying hypotheses. In this sense the evaluation of reform interventions is necessarily approximate.

[8] In QUEST III there are a number of policy variables which can be altered to simulate policies favoring business. By contrast, in ITEM the only available channel to explore the implications of these policies is a TFP variation. This is the reason why, for the sake of comparability, we have opted to focus on the effects of a permanent productivity improvement.

consumption and investment. In ITEM, the same shock is imparted to the structural component of TFP to mimic an exogenous 1 percent increase in productivity. Figure 3 presents the dynamic response of selected macroeconomic variables to the shock. The effect on output is amplified in QUEST with respect to ITEM because of the endogenous R&D response to a productivity shock. In QUEST, the channel through which a shock transmits to output is the intermediate sector: the entry of new firms in this sector induces a higher demand of intermediate output and, as a consequence, a higher supply of patents (i.e. R&D activities is procyclical). Indeed, during the adjustment towards the new equilibrium the endogenous growth mechanism ensures higher growth rates than those observed in a neoclassical model, thus positively affecting the new steady-state level of income. By disentangling the contribution of production inputs to output growth, it can be shown that, for this shock, all the difference in the output response between the two models ascribes to the contribution of the R&D sector to growth in QUEST III.

The behaviour of labour is instead more complex. In the very short run technical progress has a negative impact on labour. Intuitively, this is due to the fact, because of price rigidities, firms do not fully adjust their prices downward to the new lower level of marginal costs.[9] In the medium run the effect is positive, in light of the increase in the supply capacity. In the long run, the effect becomes slightly negative as a consequence of the deterioration of the terms of trade (see Roeger *et al.* 2008).

Consumption and investment dynamics depend on the balance between substitution and income effects. Indeed, on the one hand consumers are willing to reduce saving and investment because more output can now be obtained with the same level of capital; on the other hand, the higher return of capital may induce consumers to save more. In the long run labour shows a permanent decline since more productive agents substitute working hours with leisure (i.e. the income effect prevails over the substitution effect). It should be noted, instead, that when agents initially perceive the shock as temporary, consumption increases by less than in the standard case (see the dashed lines). Also in this case the gap in the response of consumption between ITEM and QUEST is strongly reduced by removing the forward-looking feature of agents' behaviour. On the contrary, for private investments the two models diverge by more.

In ITEM the transmission mechanism is different and can be explained by recalling the short- and long-run properties of the model. In the short run, the productivity increase gives rise to a reduction of unit labour cost, which, in turn, determines a price decrease. This latter effect is also driven by a lower degree of capacity utilization, approximated in the model by the wedge between measured (and procyclical) TFP and its structural component reflecting technical and organizational innovation. The reduction of prices fosters competitiveness of domestic products in the international markets, inducing an increase in exports. Higher real wages drive up disposable income. Turning to the long-run response of the economy, the percentage increase in real wages matches the increase of both

[9]The negative response of employment to a productivity shock is a typical feature of New Keynesian model (see Galí 2008).

structural TFP and labour productivity; real GDP is 0.80 percentage points above its baseline level, while employment stays unchanged and the capital stock stabilises at a level which is 0.66 percentage points above its initial level.

From this analysis we can draw two main policy implications. First, policy actions addressed to attain a productivity improvement will produce a long-run effect on output that is larger the more the economy is capable of turning productivity improvements into endogenous innovative activities. Second, we observe a striking difference in terms of quantitative impact on consumption and real wage and, consequently, on households' welfare. In particular, in QUEST the long-run positive effect on consumption (fostered by the wage increase) is twice as large as the one in ITEM. In the QUEST model the effect on consumption is amplified by the presence of liquidity constrained households.

We conclude that the effect on welfare of productivity-enhancing policies will turn to be relatively weak if the economy under consideration is not able to use the endogenous "push" driven by the R&D sector.

### 3.3 Competition policy in the product market

In this scenario we simulate policies enhancing competition among firms as they reduce the rents related to the existence of non-competitive markets.

In QUEST, this shock directly affects the demand for labour for each kind of skill (low, medium and high). The policy intervention is mapped onto the model as a reduction of the price markup by one percent in the final goods sector. In ITEM, the shock is introduced to the value added deflator of the market sector in such a way that it yields an ex-ante 1 percent permanent decrease of prices.

In QUEST a higher degree of competition in the final goods sector transmits its effects to the intermediate sector and, consequently, to the R&D sector thereby boosting knowledge accumulation and so economic growth. In the long run, we observe a higher level of output, consumption, capital and wages with respect to the baseline scenario, combined with a deterioration of the terms of trade (see Figure 4).

In ITEM the product price reduction fosters competitiveness increasing exports. Moreover, prices go down by more than nominal wages and the resulting rise of real wages drives up disposable income, bringing about a permanent decline of the equilibrium unemployment rate. The associated increase of employment is such that, in the long run, employment levels are about half percentage point above the level in the baseline scenario. In the long run real GDP is also higher than the level of the baseline scenario (by 0.60 percentage points).

In this scenario we also observe that the dynamic responses of the main macroeconomic aggregates differ considerably across the two models. In QUEST, the long-run effect on output and wages is driven by endogenous growth. We note that the increase of ideas/patents, representing the endogenous growth's mechanism of QUEST, explains half of the long-run output increase. Without this endogenous

channel output growth in QUEST would be quantitatively similar to that of ITEM.

The expansionary effect on consumption, induced by the enhanced competition between firms, is stronger in ITEM than in QUEST; this is explained by the different theoretical framework for consumption decisions in the two models, but also by the presence in QUEST of liquidity constrained consumers. As a matter of fact, since liquidity constrained households may only consume their current income, they benefit only partially from the price decrease, and as a result of this, their consumption increases by less. However, by removing the forward looking component, consumption in QUEST III increases by more in the first ten years, and again the gap between the two models is reduced during the early stages of adjustment. This can be easily explained by the fact that non-liquidity constrained households perceive the increased competition as a temporary phenomenon and so they consume more today to take advantage of the price reduction. The same is also true for investments which initially react less to the competition policy when the policy action is perceived as temporary, confirming that the anticipation of future events explains some of the observed dynamics.

Of particular interest is the long-run effect on employment in the two models. We observe that the enhanced competition scenario has a permanent positive impact on employment in ITEM and a null impact in QUEST. The different effect hinges on the way in which the two models characterize the labour market, the skill composition of the labour force and the wage setting mechanism. In ITEM labour supply is quite elastic, workers have no skill differentiation and wages are set in accordance with labour productivity. Under these circumstances, an increase in the demand for labour generates a permanent positive effect on employment and on real wages.

In QUEST the reduction of the price mark-up induces an increased demand for capital (tangible and intangible) as a consequence of the entry of new firms. Similarly, the reduction of the price mark-up gives rise to an increase in the demand for labour which translates into higher employment for low skilled workers (whose labour supply is more elastic given their lower employment level) and to an increase in the skill premium of medium and high skilled workers. In the long run, at the aggregate level, the latter effect dominates the former.

### 3.4 Tax shift from labour to consumption

In this scenario we consider a tax shift from labour to consumption. In QUEST this policy shift is designed by reducing labour tax rates for each category of workers so as to obtain an ex-ante decrease of tax revenues equal to 1 percent of nominal GDP of the baseline simulation. At the same time, an increase of the consumption tax rate is introduced in such a way to generate an ex-ante increase of fiscal revenues equal to 1 percent of nominal GDP of the baseline simulation. In ITEM, it is the social security contributions rate paid by the employers that is reduced (so as to obtain an ex-ante decrease of labour tax revenues equal to 1 percent of nominal GDP), while the consumption tax rate is increased in exactly the same way as done in QUEST.

The simulations results of the two models, reported in Figure 5, turn out to be very similar for some key variables showing a positive effect on GDP, consumption and employment, although quantitative differences remain. In this case, endogenous growth plays an important role in explaining the GDP variation (0.37 percent), but the major contribution is given by employment (in QUEST as well as in ITEM).

In general, we observe that shifting the burden of taxation from labour to consumption reduces disincentives and distortions in the labour market giving rise to an increase in the level of employment and output.

In QUEST the positive effect on labour and output of the tax shift is enhanced by the endogenous growth mechanism and for this reason the beneficial effects of this policy reform continue to materialize 40 years after. The increase in labour is followed by an increase in investment until the optimal capital-labour ratio is re-established. The beneficial effect of the tax shift is also observed on consumption, since the positive effect derived from higher net labour income prevails over the negative effect of a higher tax rate on consumption. As expected, the expansion of output has a negative impact on the terms of trade.

In ITEM there is a permanent reduction of production costs that drives down producer prices. Hence, real wages go up. By contrast, consumer prices raise on impact, because of the higher tax rates on consumption. Notwithstanding the rise of real wage, we observe a permanent reduction of unemployment in the medium and in the long run. This expansionary effect on employment of the tax shift is due to the decline of the tax wedge on labour. Indeed, in the calculation of the tax wedge on labour a change in the consumption tax has a lower importance than an equal change of the labour tax and this implies that the tax shift designed in this simulation exercise implies a lower tax wedge on labour. In the long run, we estimate a rise of GDP that is 0.38 percentage point above the level of the baseline scenario. Employment and the capital stock are also above their levels in the baseline simulation by roughly the same percentage amount. Similarly, real wages tend to increase reducing the positive effect on employment.

Consider now the case of QUEST III solved under the assumption that initially the fiscal policy reform is perceived as temporary by agents. As in the previous cases, the consumption path is now much closer to that obtained in ITEM. Intuitively, at the beginning households undergo the increase in consumption taxes not being able to anticipate the future gains derived from a permanent decrease of taxation on their labour income. We also observe a hyper-reaction of labour, which is a direct consequence of the drop of labour taxes wrongly perceived as temporary. This boost of worked hours explains the observed upward jump of output.

In this simulation there are not any salient differences which are attributable to specific aspects of the two models, except the quantitative divergences driven by endogenous growth in QUEST. A note of caution associated with this exercise is that ITEM is not a suitable framework for analyzing redistributive policies. The reason is that heterogeneity across agents is not explicitly modeled. Since

the structure of labour tax rates is progressive and the structure of consumption tax rates is not, then a tax shift such as those devised in this policy reform scenario is likely to have redistributive effects that, admittedly, are not fully captured by the ITEM model.

### 3.5 Discussion

From the above analysis there are a number of results which are worth to discuss more in depth. In the first place, we notice that ITEM responses to policy shifts are in general more volatile in the short run, while the dynamic responses in QUEST do not reveal short-run overshooting behaviours as one would expect given the forward-looking nature of many economic variables. In QUEST III the lack of any visible overreactions on impact of the forward looking variables, such as consumption and investment, is mainly due to the existence of several sources of frictions and costs that make immediate adjustment very costly. Hence, despite in the QUEST model agents anticipate that policy shifts are permanent, they will find it optimal to adjust gradually to the new economic conditions. Furthermore, consumption does not jump too much given the presence of a strong habit component in the absence of which consumption would have a tendency to peak immediately. Finally, the fact that the results reported in the figures have been annualized from the quarterly frequency contributes to further smooth the dynamic response on impact of economic variables.

In the second place, the fact that short and medium-run responses between the two models are very different may have very important policy implications. For instance, fiscal expansions and pro-competitive policies are more expansionary in ITEM than in QUEST III, where the crowding out effects manifest themselves as agents take into account immediately the higher future taxation needed to finance a larger amount of government spending. Moreover, households, who own firms, undergo a reduction of profits due to the pro-competitive policy interventions. On the other hand, policies aimed at creating a more friendly business environment and boosting productivity are more expansionary in QUEST III, since agents anticipate the stronger long-run positive effects of these policy interventions, mainly driven by the R&D sector. Finally, also in the tax reform experiment, the DGE model produces larger positive effects on output, also in the very short run, since shifting partially the burden of taxation from labour to consumption has an immediate and direct positive effect on labour supply.

Last but by all-means not least, by removing the forward looking component from the QUEST results during the first ten years of the simulation we are able to substantially narrow the gap between the consumption paths of ITEM and QUEST and in some cases we also observe less differences in the response of output. However, when we do so we still observe some important differences in the response of the economy. Overall, we argue that much of these differences pertain to the different weight on theory and data placed in the specification of the two models.

## 4. Conclusion

An intensive reform agenda urges economic policy institutions to quantify the macroeconomic impact of single policy interventions as well as to evaluate the effects of complex reform scenarios through simulation analysis. To this purpose, institutions, such as central banks and finance ministries, rely on a variety of models which represent artificial economies, embedding several ad-hoc and specific assumptions to be borne in mind when mapping the policy interventions onto the model and interpreting the simulations results. From this point of view, no single model can possibly account for the many and varied policy interventions and/or shocks that matter for the policy maker so that one can only approximately evaluates the potential effects of structural reforms.

This paper was motivated by the need to understand more in depth the functioning and the potential of two different simulation tools available at the Department of the Treasury of the Italian Ministry of Economy and Finance: QUEST III - Italy, the DGE model developed by the European Commission (DG ECFIN) for policy evaluation, and ITEM, the medium scale econometric model used for policy analysis and forecasting at the Italian Ministry of Economy and Finance.

We believe that in assessing the implications for the economy of a variety of policy shifts, the joint consideration of simulations obtained with empirically validated macroeconometric models and those obtained with DGE-types of models provides useful insights on the relevance of the shocks' transmission mechanisms considered in the two models.

Our comparisons involve examining the dynamic responses of macroeconomic aggregates to some shocks often analysed in policy work. The comparison shows that the short-run responses of QUEST are qualitatively similar to those of ITEM for some key macroeconomic variables, including output, consumption, investment and employment. On the other hand, our simulation results also show important quantitative differences in the responses to policy shifts. Arguably, a portion of the differences across the two models in the simulation results is associated to the forward-looking behaviour of agents in QUEST, while the endogenous growth mechanism characterizing the latter model accounts for the different behaviour in the very long run, especially of output. Of course, an important portion of the observed differences is to be ascribed to the different relative weights on theory and data placed in the specification of the two models.

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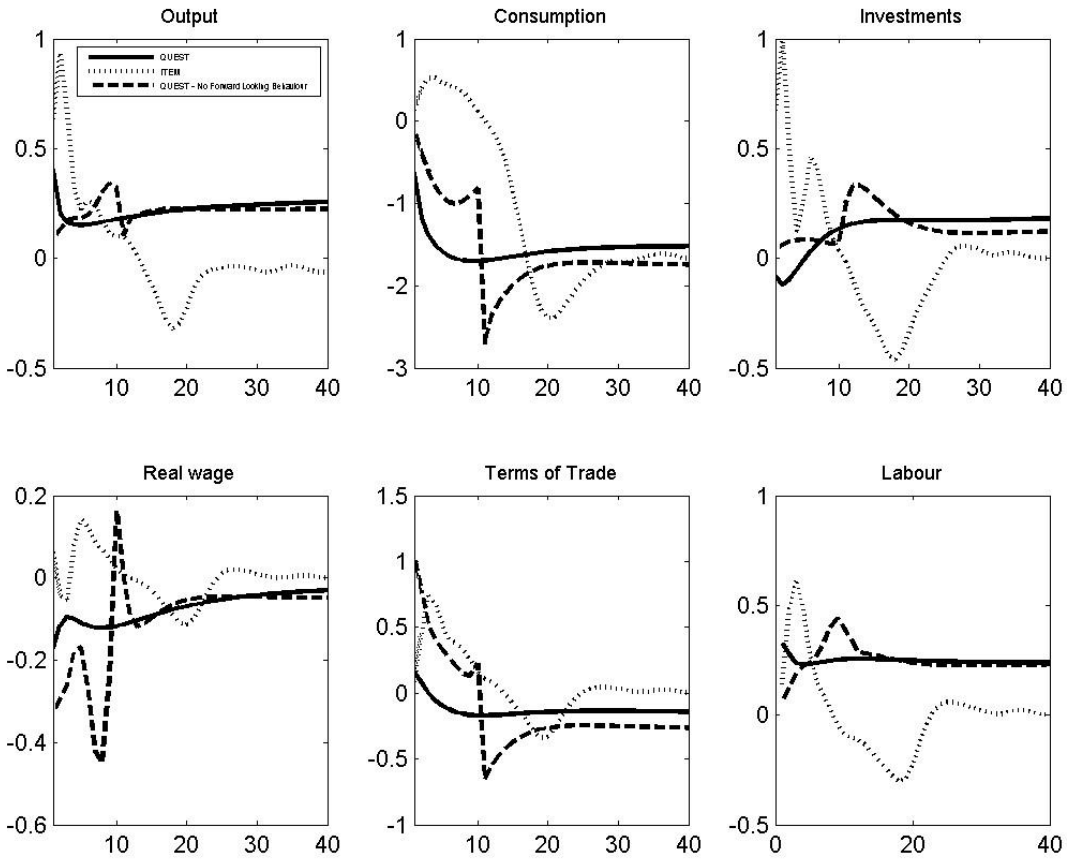
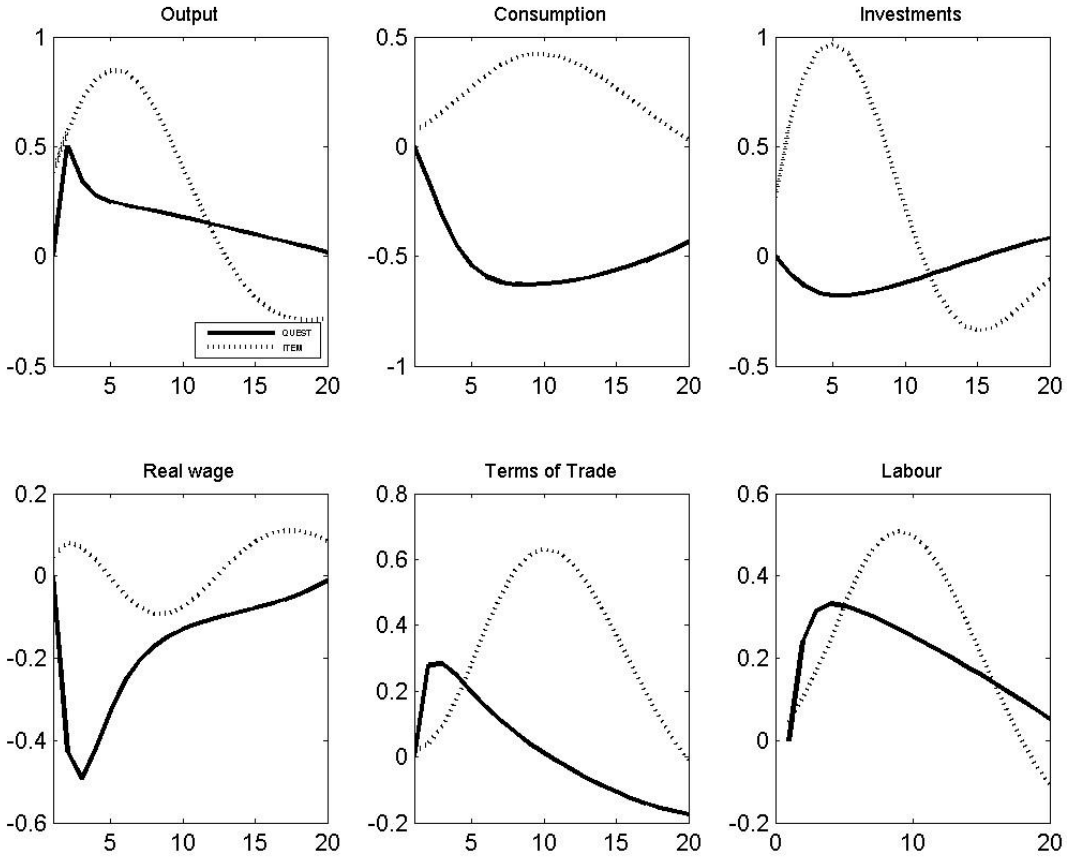
Figure1 - Permanent increase in public consumption *(40-year time horizon)*



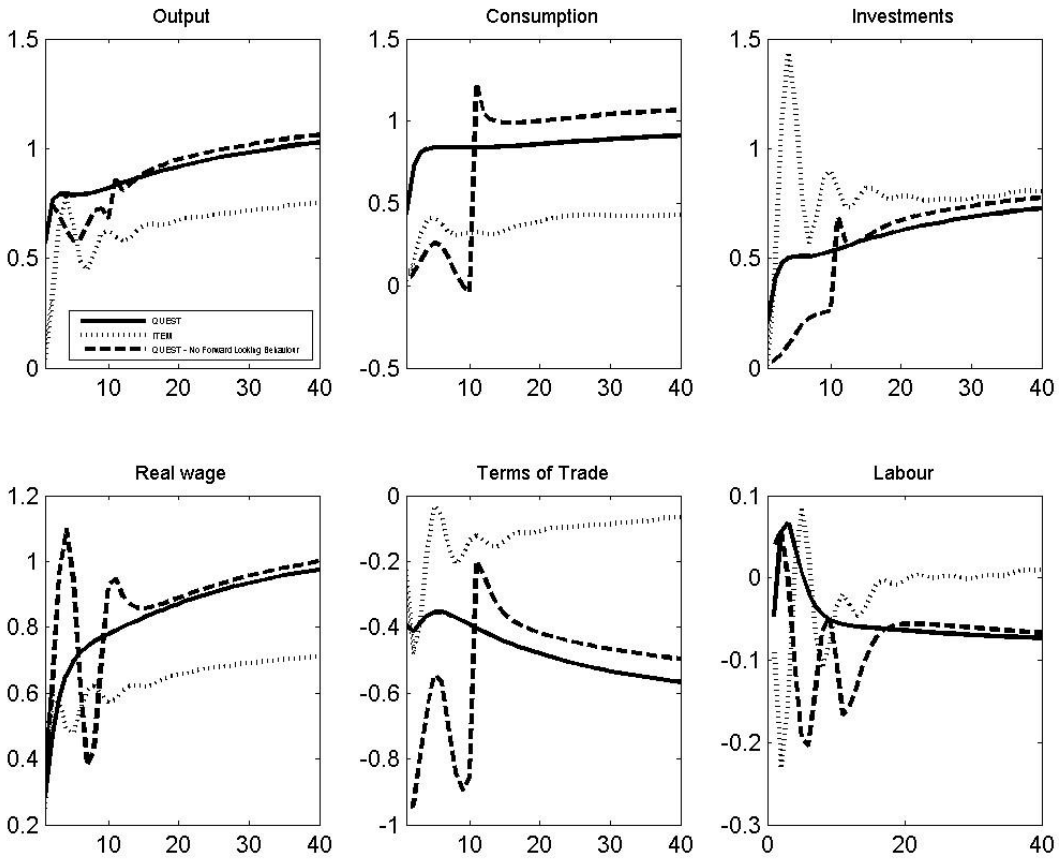

Note: Percentage deviations from baseline scenario

Figure 2 - Temporary increase in public consumption *(20 -quarter time horizon)*



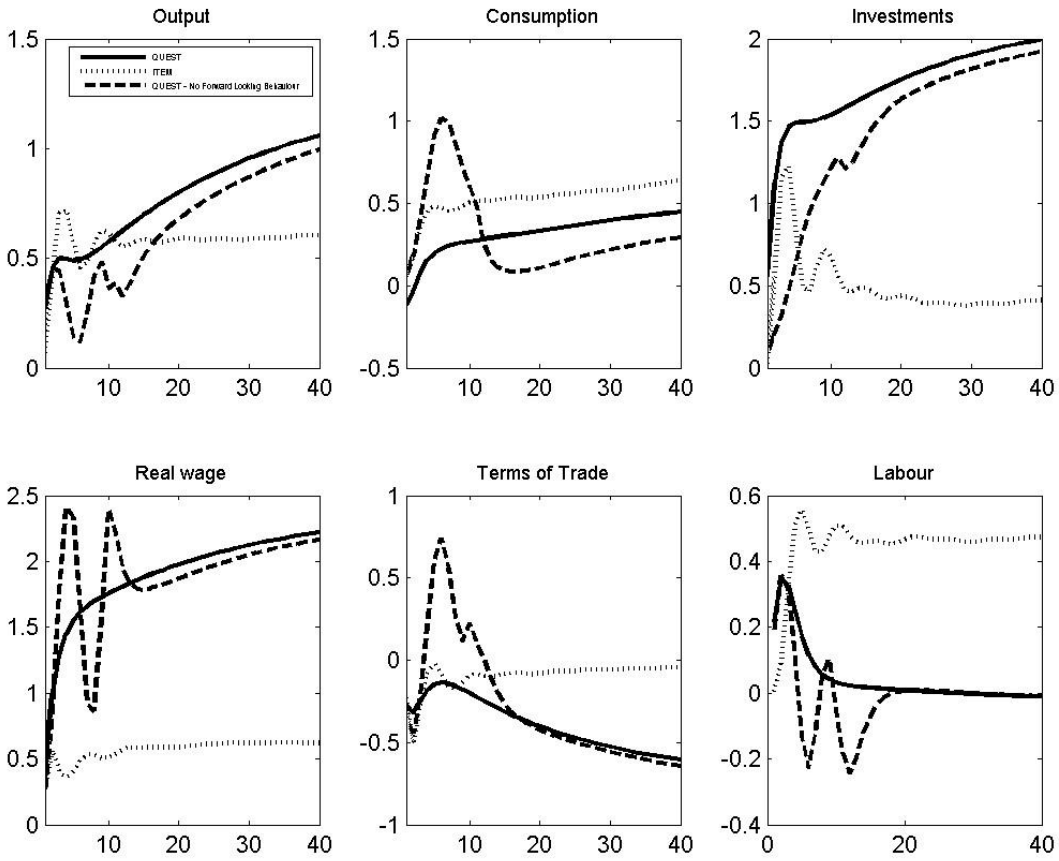

Note: Percentage deviations from baseline scenario

Figure 3 - Exogenous improvement of productivity *(40-year time horizon)*



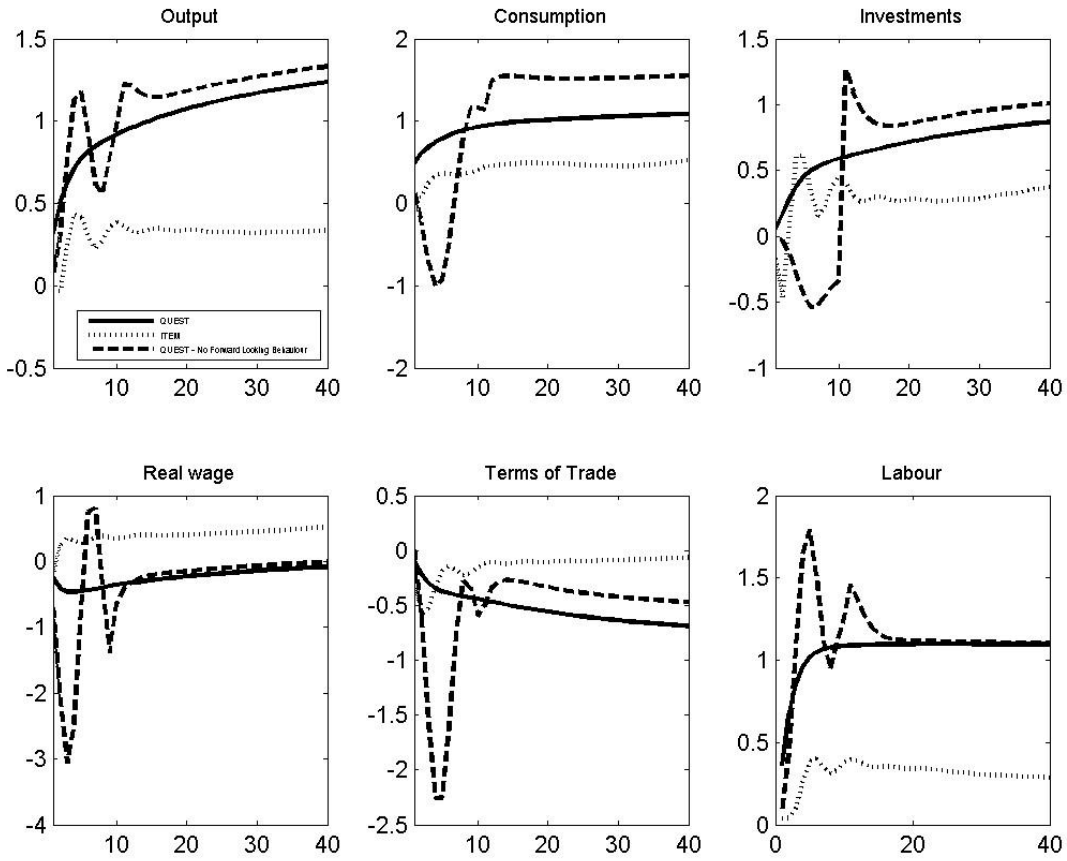

Note: Percentage deviations from baseline scenario

Figure 4 - Competition policy in the product market *(40-year time horizon)*




Note: Percentage deviations from baseline scenario

Figure 5 -Tax shift from labour to consumption *(40-year time horizon)*




Note: Percentage deviations from baseline scenario