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iAGS

MODEL FOR EURO AREA MEDIUM TERM PROJECTIONS

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In this paper, we describe a new macro model, the goal of which is to produce annual projections of public debt ratios in the Euro Area. These projections are part of the Independent Annual Growth Survey (hereafter IAGS) project.

The aim of the new model is to provide a tractable and simplified toolkit (a small scale dynamic model) based on sound theoretical foundations. This reduced-form model has to be flexible enough to analyse various scenarios of policy mix with different sets of possible hypothesis.

The first and principal use of the model is to assess the path of the policy-mix in euro area, taking into account trade interdependencies between European countries, and with the rest of the world. The public policy debate currently focuses on an issue of critical importance for the future of the EU: the sustainability of fiscal policies. Hence, the first release of the model will be mainly devoted to it. We project to extend this framework on the following years to encompass more issues such as internal and external imbalances, competitiveness, deflation, long term growth, infrastructure policy or low carbon transition.

The paper is structured as follows: the first part describes the structure of the model. The second part details the calibration of the parameters. In the third part, we present some simulations. We show comparisons with other euro area models, mainly the QUEST III model used by the DG ECFIN of the European Commission (Ratto *et al.*, 2009).

Description of the model

The IAGS model is a macro model that combines structural and reduced-form non linear equations. Since one of its goals is to model numerous euro area countries (and other EU countries in the future), we use simple reduced-form equations to model supply and demand complex mechanisms that can be heterogeneous across countries. Hence the model is not the product of optimal behaviour: there are multiple competing ways to obtain them though no consensus has emerged so far on best modelling strategies[1]. Moreover, Dynamic Standard General Equilibrium (DSGE) models proved to perform poorly during the crisis, underestimating the deepness of the crisis. These models also do not allow to model nonlinearities such as variable fiscal multipliers over the business cycle, since these models are linearised around a single point. We then prefer simplicity in modelling, as it allows us to simply calibrate the impact of specific effects of fiscal policy on output gap and potential GDP.

[1] See for example Wieland *et al* (2012) for a comparison of fiscal policy effects on output gap for a large set of DSGE models. These models make different assumptions on the share of liquidity constrained households for example, a point that is crucial to assess the fiscal multiplier.

Some key features of the model follow:

- The model allows for an explicit representation of the main countries of the euro area: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. An aggregated euro area is also computed in order to deal with global analysis and monetary policy.
- On the demand side, an open economy aggregate demand function is modelled which embodies fiscal and monetary policy, external demand (a channel for intra EU interdependencies) as well as exogenous shocks on the output gap (the gap between actual and potential GDP). This equation also takes into account possible long run effects of macroeconomic policies such as long term fiscal policy, threshold effects or hysteresis on potential output. The parameterization allows simulating standard hypothesis as well as alternatives, checking to show the dependence of results on different sets of hypotheses. Furthermore, the size of fiscal multipliers is allowed to on the stage of the business cycle, and on the level of public debt. The effectiveness of monetary policy is allowed to differ when monetary policy hits zero lower bound.
- External demand is modelled using a bilateral trade matrix representing interdependencies between countries. That trade matrix will also be used as a basis for imbalances analysis.
- We model prices by a generalized Phillips curve relating current and expected inflation to economic activity, imported inflation and other exogenous shocks. Expectations can be modelled as adaptive (backward-looking) or rational (forward-looking).
- A Taylor rule sums up monetary policy. Fiscal policy can be modelled with some kind of rule adjusting spending or taxes to debt or unemployment goals for example. Such rules can be unplugged to deal with optimal or alternate policy scenarios.
- Fiscal policy, that is to say the public balance, separates interest payments, cyclically-adjusted balance and cyclical components, in order to properly assess the fiscal stance, *i.e.* the part of fiscal policy which is under the direct control (discretion) of current governments. We then deduce public debt projections for euro area countries. This module will help to assess fiscal sustainability issues, as it incorporates issues related to the impact of the market interest rate (government-bond yield).

Aggregate demand and supply

First, in the model GDP is written as a gap between the actual level of GDP and a baseline trajectory determined by a constant potential growth. However, we distinguish this baseline from the potential GDP, which can differ from the baseline due to possible hysteresis effects of recession or fiscal policy on potential GDP (see Figure 1 below). As a result, we model three gaps for GDP:

- $\tilde{y}_c$ is the gap between log of real GDP Y of country c, and its baseline trajectory $\bar{Y}$ which is exogenous.
- y_c^* is the gap between log of potential GDP Y^* of country c and the baseline $\bar{Y}$.
- dropping country subscripts, y is the output gap: it is defined as the gap between log of real GDP Y and log of potential GDP Y^*.

y is driven by aggregate demand:

$$y = efi + \delta_l.(R^{pri} - \bar{R}^{pri}) + \beta_l.ad$$

efi is the effective fiscal impulse (in % of GDP), which sums up the fiscal policy effects on aggregate demand (see the following sections). R^{pri} is the long term real interest rate on private bonds and $\bar{R}^{pri}$ is its long run equilibrium value. $\delta_l.(R^{pri} -$ $Rpri$ sums up the effect of monetary policy on aggregate demand *via* its impact on financial markets and expectations of future inflation.($\beta_l.ad$) sums up the impact of addressed demand by trade partners. Since $y = \tilde{y} - y^*$, we deduce $\tilde{y}^{LR}$, the long run gap between real GDP and the baseline:

$$\tilde{y}^{LR} = y^* + efi + \delta_l.(R^{pri} - \bar{R}^{pri}) + \beta_l.ad$$

In the model, the short run dynamics of $\tilde{y}$ follows an error correction equation with restricted dynamics. To obtain the resulting equation, start first from the unrestricted error correction[2] form:

$$\Delta(\tilde{y}_t^{UNR}) = -\lambda.[\tilde{y}_{t-1} - (y_{t-1}^* - \tilde{y}_{t-1}^{LR})] + \alpha.\Delta(\tilde{y}_{t-1}) + \Delta(efi_t) + \delta_s.\Delta\left(R_t^{pri} - \bar{R}_t^{pri}\right) + \beta_s.\Delta(ad_t) + \varepsilon_t^d$$

efi is the cumulated sum of past and current *ex ante* effective fiscal impulses, and its variation gives the short run impact of fiscal policy on $\tilde{y}$. This impact depends on the endogenous fiscal multiplier μ_t which is discussed later. ε_t^d is an exogenous shock on aggregate demand. The idea behind the restricted dynamics is the following: when the gap is wide open, the error correction model implies a growth rate that can be very large, whereas recovery growth can be bound. Hence we limit the variation of $\tilde{y}$ to a maximum equal to $\Delta\left(\bar{\bar{\tilde{y}}}_t\right)$ before effects of monetary policy, fiscal policy and external trade:

(1) $$\Delta\left(\bar{\bar{\tilde{y}}}_t\right) = max[-\lambda.[\tilde{y}_{t-1} - y_{t-1}^*] + \alpha.\Delta(\tilde{y}_{t-1}); 0.025]$$

$(\tilde{y}_t) = \tilde{y}_t - \tilde{y}_{t-1}.$

The restriction implies a maximum growth rate – before effects of monetary policy, fiscal policy and external trade – equal to the potential growth rate plus 2.5%. Eventually, the resulting constrained short run dynamics for $\tilde{y}$ follows from the combination of equations (1) and (2):

$$(2) \qquad \Delta(\tilde{y}_t) = \Delta(\bar{\bar{\tilde{y}}}_t) + \lambda.\left[efi_{t-1} + \delta_l.\left(R_{t-1}^{pri} - \bar{R}_{t-1}^{pri}\right) + \beta_l.ad_{t-1}\right] + \Delta(efi_t) + \delta_s.\Delta\left(R_t^{pri} - \bar{R}_t^{pri}\right) + \beta_s.\Delta(ad_t) + \varepsilon_t^d$$

Second, the gap between potential GDP and the baseline depends on a hysteresis effect, a long run impact of fiscal policy and a negative public debt effect:

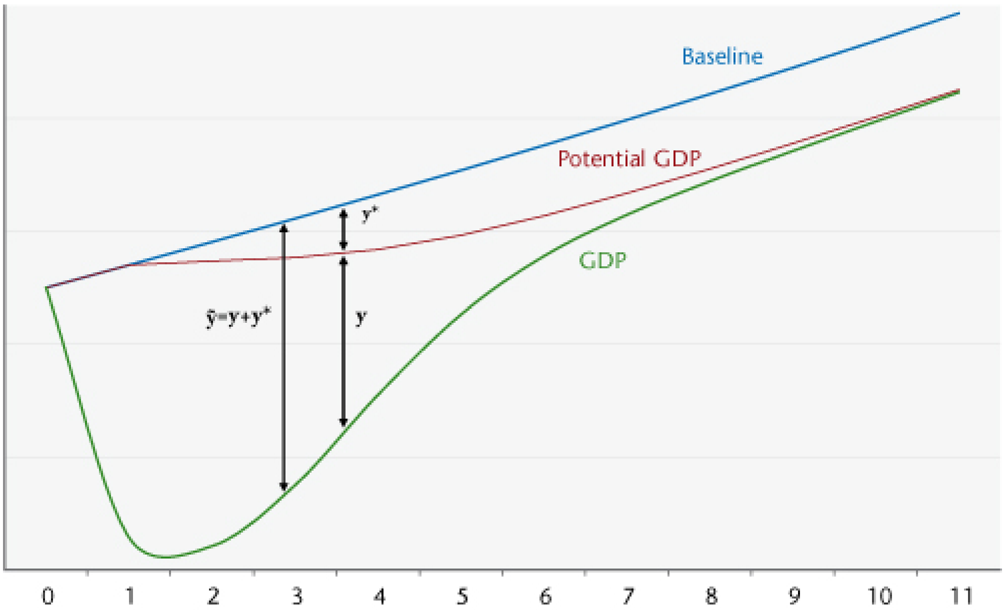
$$(3) \qquad y_t^* = y_{t-1}^* + H.y_t + \psi_\propto \Delta\left(\widetilde{fi}_t\right) + \zeta.(b_t - b^*) + \varepsilon_t^s$$

H is an hysteresis parameter, $\psi_\propto$ assesses the long run impact of fiscal policy on potential GDP (we discuss this point in the Fiscal policy section hereafter), ζ stands for a Barro-Laffer effect, b^* is a public debt target and ε_t^s an exogenous shock on aggregate supply.

The Barro-Laffer effect mixes the requirement to increase private savings to match lower public savings – the Barro-Ricardo effect – with the requirement to levy higher taxes in the future to repay debt and interests. The latter is associated with disincentives to produce according to the Laffer effect. Lower private savings and higher disincentives to produce would drag potential output[3].

[3] There may also be some non-linearities as regards the relationship between public debt and real economic growth. Some argue (Reinhart and Rogoff, 2010, Ceccheti et al., 2011) that above a certain threshold of public debt, the latter reduces economic growth, though Panizza and Presbitero (2012) tend to reverse the causality. Panizza and Presbitero (2012) also highlight that high debt country may fear a loss of confidence from their creditors (the market) and may decide upon a fiscal contraction that drags economic growth, hence a negative causality between high debt and economic growth.

Figure 1. Example: GDP path and potential GDP path with hysteresis



Source: iAGS model, OFCE.

Level and Growth rates of GDP

The growth rate of the baseline for real GDP is set exogenously:

(4) $\Delta\overline{Y}_t = \overline{Y}_t - \overline{Y}_{t-1}$

The growth rate of potential GDP is equal to the baseline one if there is no long run impact of fiscal policy, no hysteresis and no Barro-Laffer effect:

(5) $\Delta Y_t^* = \Delta y_t^* + \Delta\overline{Y}_t + \varepsilon_t^s$

The growth rate of real GDP is given by that of potential GDP and the output gap, the growth rate of nominal GDP takes into account the inflation rate, and the level of nominal GDP follows:

(6) $\Delta Y_t = \Delta Y_t^* + y_t$

(7) $\Delta Q_t = \Delta Y_t + \pi_t$

(8) $Q_t = Q_{t-1}(1 + \Delta Q_t)$

Public finances

fs is the fiscal surplus in % of nominal GDP. We decompose it between a structural primary surplus sps and a cyclical surplus cs, minus government interest payments on public debt gip:

(9) $fs_t = sps_t + cs_t - gip_t$

(10) $sps_t = sps_{t-1} - fi_t + \Phi.\Delta y_t^*$

(11) $cs_t = \Phi.y_t$

(12) $gip_t = \overline{\iota_t^B}.b_{t-1}/(1 + \Delta Q_t)$

(13) $\overline{\iota_t^B} = 1/MAT\,.R_t^{pub} + (1 - 1/MAT).\overline{\iota_{t-1}^B}$

(14) $b_t = b_{t-1}/(1 + \Delta Q_t) - fs_t + sfl_t$

The structural primary surplus evolves according to the fiscal impulse and changes in taxes due to variations in the gap between potential production and the baseline (eq. (10)). This latter point means that a permanent downward shift of potential production relative to the baseline would entail a permanent fall in taxes, hence a permanent fall in the structural primary surplus.

The cyclical surplus depends on Φ, the overall sensitivity of revenues and expenditures to the business cycle (eq. (11)). Interest payments on debt (in % of GDP at time *t*) depend on the stock of debt times its average interest rate, and deflated by the nominal GDP growth rate[4] (eq. (12)).

The average interest rate on debt evolves according to the long term nominal interest rate on newly issued public bonds. MAT stands for the average maturity of public debt, and is assumed to be constant. $1/_{MAT}$ then gives the share of debt refinanced every year (eq. (13)).

Public debt (in % of nominal GDP) evolves according to past debt deflated by the nominal growth rate of GDP, minus the fiscal surplus, augmented with an exogenous stock-flow adjustment variable (eq. (14)).

Fiscal policy

The impact of fiscal policy is modelled according to the state of the economy. This modelling strategy has been growing recently in the literature (Parker, 2011), after empirical papers show that the fiscal multiplier differs according to the position of the economy in the cycle. For example, using regime-switching models, Auerbach and Gorodnichenko (2010) estimate effects of tax and spending policies that can vary over the business cycle. They find large differences in the size of fiscal multipliers in recessions and expansions: fiscal policy is considerably more effective in recessions than in expansions. Assuming that the economy can endogenously switch between regimes, they find that historical multipliers can vary between 0

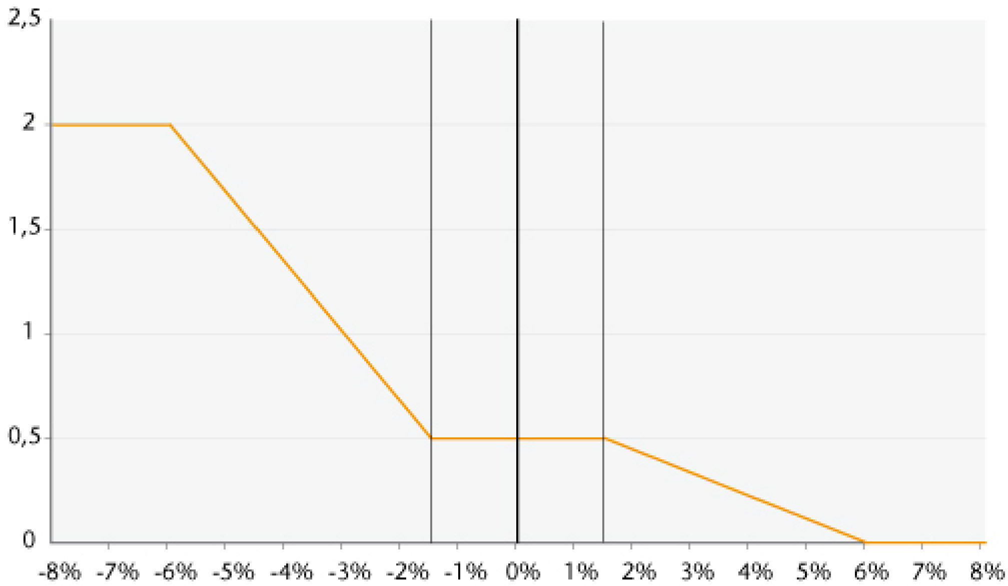
[4] Indeed, we can write interest payments in value as follows: $GIP_t = \overline{\iota_t^B}.B_{t-1}$. In % of GDP it gives $\frac{GIP_t}{Q_t} = \overline{\iota_t^B}.\frac{B_{t-1}}{Q_t} \Leftrightarrow gip_t = \overline{\iota_t^B}.\frac{B_{t-1}}{Q_{t-1}}.\frac{Q_{t-1}}{Q_t} \Leftrightarrow gip_t = \overline{\iota_t^B}.b_{t-1}.\frac{1}{1+\Delta Q_t \Delta Q_t}$

and 0.5 during expansions and between 1 and 1.5 during recessions[5]. The fiscal multiplier μ_t is modelled as follows:

$$\begin{aligned}
&\text{If } y_{t-1} < y_{min} \text{ then } \mu_t = \mu_{max} \\
&\text{if } y_{t-1} > y_{max} \text{ then } \mu_t = \mu_{min} \\
&\text{if } y_{inf} \leq y_{t-1} \leq y_{sup} \text{ then } \mu_t = \mu_0 \\
&\text{if } y_{min} \leq y_{t-1} \leq y_{inf} \text{ then } \mu_t = \mu_{max} + (\mu_0 - \mu_{max})/(y_{inf} - y_{min}) * (y_{t-1} - y_{min}) \\
&\text{if } y_{sup} \leq y_{t-1} \leq y_{max} \text{ then } \mu_t = \mu_0 + (\mu_{min} - \mu_0)/(y_{max} - y_{sup}) * (y_{t-1} - y_{sup})
\end{aligned}$$

The value of the multiplier is maximal in very bad times, whereas it is minimal in very good times (see Figure 1).

Figure 2. Example of the value of the multiplier according to the output gap



Note: $\mu_{max} = 2$, $\mu_0 = 0.5$, $\mu_{min} = 0$, $y_{min} = -6\%$, $y_{inf} = -1.5\%$, $y_{sup} = 1.5\%$, and $y_{max} = 6\%$. Values are taken as illustrative and may vary across countries.

Source: OFCE.

Fiscal policy, *via* the fiscal impulse (in % of GDP), drives the structural primary surplus. The fiscal impulse sums up discretionary decisions on government spending and taxes. We then compute an effective fiscal impulse: It is the *ex ante*[6] cumulative real effect of current and past fiscal impulses at time *t*. Thus, with $\psi_k . \mu_{t-k}$. the fiscal multiplier at time t of a fiscal impulse that occurred k years ago, we can write:

[5] See Baum and Koester (2011) for empirical estimates for Germany and Creel *et al.* (2011) for France; see Michaillat (2012) for a theoretical approach.

[6] It is an *ex ante* multiplier in the sense that it does not take into account monetary policy effects and feedback effects of external trade on GDP following a fiscal impulse.

(15) $\Delta efi_t = \psi_0.\mu_t.fi_t + \psi_1.\mu_{t-1}.fi_{t-1} + \psi_2.\mu_{t-2}.fi_{t-2} + \psi_3.\mu_{t-3}.fi_{t-3} + \psi_4.\mu_{t-4}.fi_{t-4} + \psi_5.\mu_{t-5}.fi_{t-5} + \psi_6.\mu_{t-6}.fi_{t-6} + \psi_7.\mu_{t-7}.fi_{t-7}$

(16) $\widetilde{fi}_t = \widetilde{fi}_{t-1} + \mu_t.fi_t$

Equation (15) ensures that the impact of a fiscal impulse depends on the fiscal multiplier that prevailed at the date the fiscal impulse occurred. In the baseline case of the model, equation (15) verifies $\sum_{k=0}^{7} \psi_k = 0$. We retain seven lags to account for the possibility of long lasting effects of fiscal impulses and to smooth the lagged impact of fiscal impulses on GDP.

We also assume that efi can take into account a long run effect of fiscal policy. It is the case if $\psi_\propto = \sum_{k=0}^{7} \psi_k \neq 0$, since in that case efi is not necessarily null in the long run.

The long run impact of a sequence of fiscal impulses on potential GDP is in this case computed using the accumulation of fiscal impulses times the multiplier (eq ((16)), and following equation (3) the long run impact on potential GDP is $\mu_\propto.tfi_t$.

External trade

We model external trade using trade matrix between euro area countries. Imports of each country grow up relative to the baseline imports when output rises. The strength of the increase depends on sensitivity of imports to the output gap (eq. (17)).

Imports of one country divide into exports of the other countries. Each country faces an addressed demand composed of imports of trade partners. The addressed demand to country *c* is the sum of imports of other *j* countries times the share of imports of country *j* coming from country *c* (eq. (18)).

(17) $m_t = \Omega.y_t$

(18) $ad_t = \sum_j w_{m,j,c} m_t$

Monetary policy and financial markets

We use a Taylor rule to describe monetary policy (Taylor, 1993). The short term interest rate varies according to the gap between euro area inflation π_t^{EA} and the ECB target π^* on the one hand, and with the euro area output gap y_t^{EA} on the other hand (eq. (19)). r^* is the ECB long run target, hence the real equilibrium interest rate. We also account for a zero lower bound. The rate set by ECB is then the max of these two rates (eq. (20)).

According to the expectations theory, the long term interest rate for German public bonds is set equal to the expected sum of future short term interest rates (eq. (21); see Shiller, 1979).

The long term public rate for Germany is considered risk free, and long term public rates of other countries include a risk premium $\varepsilon_t^{I_{pub}}$ that is set exogenously (eq. (22)). We also temporarily set exogenously the long rate for countries that entered the EFSF to account for a lower interest rate on debt refinancing. Finally, for each country the long term interest rate on private bonds is equal to the public one plus a risk premium that is set exogenously (eq. (23)). The long term real interest rate on private bonds is then equal to the private nominal long term rate minus long run expected inflation (eq. (24)).

(19) $i_t^{Taylor} = r^* + \pi_t^{EA} + \Psi_1.(\pi_t^{EA} - \pi^*) + \Psi_2.y_t^{EA}$

(20) $i_t^{ECB} = max(i_{min}; i_t^{Taylor})$

(21) $I_t^{EA} = \tau.I_{t+1}^{EA} + (1-\tau).i_t^{ECB}$

(22) $I_t^{pub} = I_t^{EA} + \varepsilon_t^{I_{pub}}$

(23) $I_t^{pri} = I_t^{pub} + \varepsilon_t^{I_{pri}}$

(24) $R_t^{pri} = I_t^{pri} - \pi_t^{e,lr}$

Prices

We model the growth rate of GDP price as a new Keynesian hybrid Phillips curve (NKHPC hereafter). Inflation depends on past inflation, expected inflation one period ahead, output gap, and the variation of overseas inflation weighted by the share of imports coming from country c (eq. (25)).

Different possible formations of inflation expectations can be introduced. Expectations can be rational as in a standard NKHPC equation ($\pi_{t+1}^e = \pi_{t+1}$), or they can be adaptive (eq. (26)). In this last case, we assume that inflation is expected to converge to the ECB target at a speed depending on the value of the κ parameter.

For financial markets, long run expected inflation is modelled as the discounted sum of future inflation rates (eq. (27)), in the same way as nominal long term rates, in order to keep expectations consistent on both sides. This assumption could also be relaxed insofar as expectations may not be fully rational on financial markets.

(25) $\pi_t = \eta_1.\pi_{t-1} + (1-\eta_1).\pi_{t+1}^e + \eta_2.y_t + \eta_3.\sum_j w_{m,j,c}(\Delta\pi_t^c) + \varepsilon_t^{\pi}$

(26) $\pi_{t+1}^e = \pi_{t-1} + \kappa.(\pi_{t-1} - \pi^*) + \varepsilon_t^{\pi^e}$ *with* $0 \geq \kappa \geq -1$

(27) $\pi_t^{e,lr} = \tau.\pi_{t+1}^{e,lr} + (1-\tau).\pi_t$

Euro area aggregates

Euro area's nominal GDP is the sum of countries' nominal GDP (eq. (28)). Country's weight is then derived from equation (28), in order to compute other aggregates such as euro area inflation and output gap (eq. (29)-(31)).

(28) $Q_t^{EA} = \sum_c Q_t^c$

(29) $w_{t,c}^Q = Q_t^c / Q_t^{EA}$

(30) $\pi_t^{EA} = \sum_c w_{t,c}^Q . \pi_t^c$

(31) $y_t^{EA} = \sum_c w_{t,c}^Q . y_t^c$

Calibration

Aggregate demand and supply

We calibrate equation (2) by distinguishing short run and long run effects of monetary policy and external trade on GDP. Long run effect of long term yields is higher than the short run one, to take into account delays in monetary policy effects on output.

We set β_l equal to the share of exports in country's GDP, and β_s equal to half β_l.

Table 1. Calibration of monetary policy and external demand effects on output

	δ_s	δ_l	β_s	β_l
Austria	-0.20	-0.50	0.29	0.58
Belgium	-0.20	-0.40	0.40	0.81
Finland	-0.20	-0.45	0.23	0.46
France	-0.20	-0.50	0.13	0.27
Germany	-0.30	-0.50	0.25	0.50
Greece	-0.40	-0.80	0.13	0.25
Ireland	-0.30	-0.70	0.50	1.00
Italy	-0.40	-0.75	0.14	0.28
Netherlands	-0.20	-0.45	0.40	0.79
Portugal	-0.40	-0.80	0.17	0.34
Spain	-0.30	-0.70	0.15	0.30

Source: iAGS Model, OFCE.

The critical point in calibrating equation (2) is to set the speed of convergence of output to its long run equilibrium. This speed depends on values of λ and α, that are the same across countries. We fix α to 0.1 and λ to -0.3.These values ensure that the speed of convergence of output to its long run value is comparable in normal times to that of standard DSGE models (see part III). With these values, the output gap is closed about 5 years after a shock.

Concerning equation (3), long run effects on potential GDP can come from hysteresis effects, a Barro-Laffer effect of debt on potential GDP and a long run effect of fiscal policy.

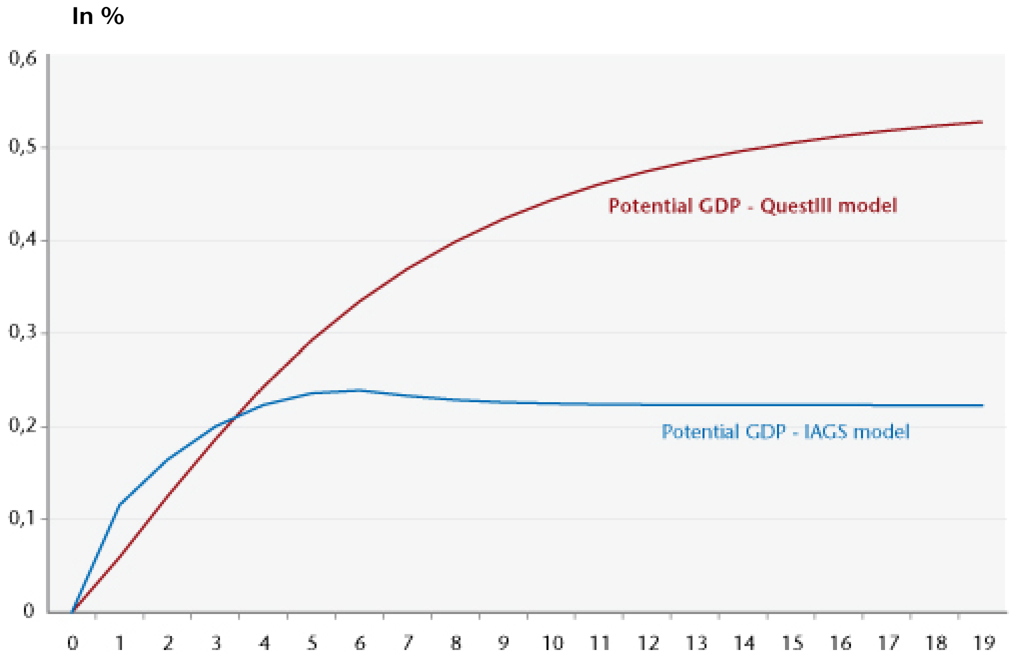
Table 2. Calibration of hysteresis, Barro-Laffer and long run effect of fiscal policy

Hysteresis	Barro-Laffer	Barro-Laffer
H	ζ	μ_∞
0.15	0	0

Source: iAGS Model, OFCE.

Barro-Laffer and fiscal policy effects on potential GDP are set to 0 for standard simulations. The impact of non-zero values will be discussed in future work. We calibrate the hysteresis effect to 0.15 in order to obtain qualitatively similar impacts of transitory and permanent fiscal impulses on potential growth, as those obtained with QUEST III (see Figure 3).

Figure 3. Calibration of hysteresis effects of fiscal policy on potential GDP



Notes: results are in difference from baseline.
Sources: Macroeconomic Model Database - Wieland *et al.* (2012), iAGS Model, OFCE.

We used the Macroeconomic Model Database to perform deterministic simulations of the QUEST III model. For the simulation, fiscal policy rules are disconnected and shocks are done on the share of government consumption to GDP ratio.

Public finances

The most important parameter to set for public finances is Φ, the overall sensitivity of revenues and expenditures to the business cycle. To do so we use the European Commission estimates. To compute the average interest rate on public debt, we compute an average maturity of public debts using national sources on public debt maturity structures in 2011.

Table 3. Calibration of public finances parameters

	Φ	MAT
Austria	0,47	8,1
Belgium	0,54	6,8
Finland	0,50	5,0
France	0,49	6,9
Germany	0,51	6,1
Greece	0,43	11,3
Ireland	0,40	6,9
Italy	0,50	6,6
Netherlands	0,55	7,0
Portugal	0,45	6,1
Spain	0,43	6,8

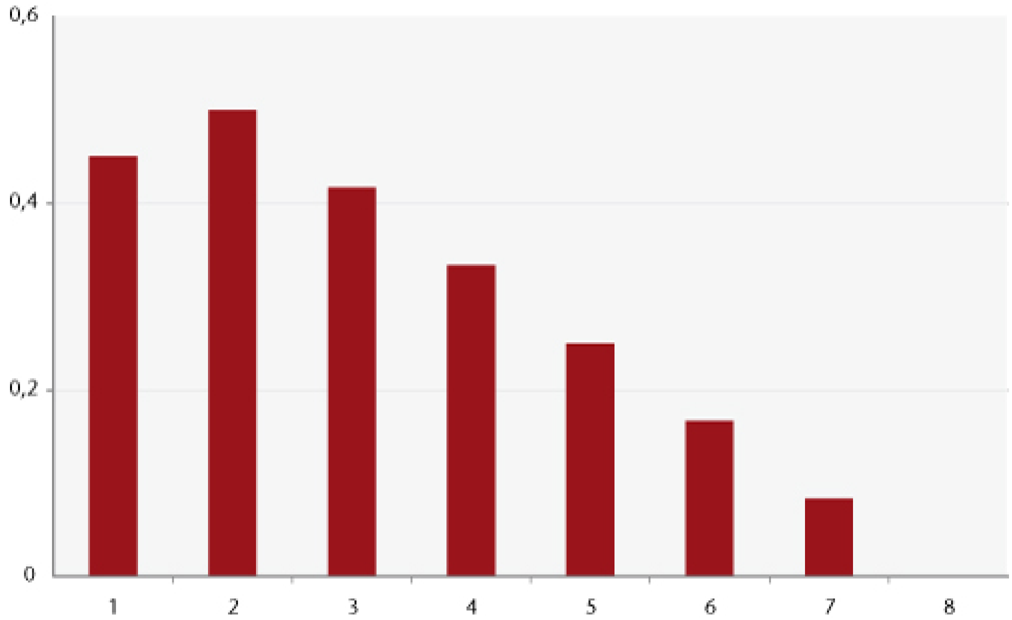
Sources: European Commission (2005), OFCE.

Fiscal policy

Calibration of fiscal policy parameters determines the duration impact of fiscal policy on GDP. We calibrate the effective fiscal impulse to return to 0 in seven years in normal times, *i.e.* when the output gap is close to 0 (see Figure 4). Indeed the effective fiscal impulse also depends on the value of the *ex ante* instantaneous fiscal multiplier μ_t, which can vary over time according to the output gap. More precisely, we define normal times as economic states in which output gap is greater than -1.5% and lesser than 1.5%. In that case, we fix the *ex ante* instantaneous fiscal multiplier to 0.5 for big countries (Germany, France, Italy and Spain), and to 0.3 for other countries, accounting for the fact that fiscal multipliers are generally smaller for small countries (see the recent estimates by Ilzetsky *et al.*, 2011). When output gap is over 1.5%, the *ex ante* instantaneous fiscal multiplier linearly decreases to 0, until output gap reaches 6%.

In bad times, the *ex ante* instantaneous fiscal multiplier increases as output gap deteriorates. We set its maximum value to 2 when output gap reaches -6%.

Figure 4. Effective fiscal impulse in normal times with $\mu_t = 0.5$ following a positive fiscal impulse (1% of GDP)



Source: OFCE.

External trade

We set the sensitivity of imports to output gap equal to the share of imports in country's GDP. The matrix of trade exchanges between countries comes from the Chelem Database for year 2003.

Table 4. Calibration of the sensitivity of imports to output gap

	Ω
Austria	0.5
Belgium	0.8
Finland	0.4
France	0.3
Germany	0.4
Greece	0.3
Ireland	0.8
Italy	0.3
Netherlands	0.7
Portugal	0.4
Spain	0.3

Source: OECD Economic outlook 91.

Monetary policy and financial markets

We choose standard values for the Taylor rule. The short term interest rate is bound at 0.05% to account for the zero lower bound on monetary policy. We fix $\tau = 0.82$, a value compatible with a long run nominal interest rate of 4% (see Shiller, 1979, or Fuhrer and Moore, 1995).

Table 5. Calibration of monetary policy parameters

Ψ_1	Ψ_2	π^*	i_{min}
0.5	0.5	2%	0.05%

Source: iAGS Model, OFCE.

Prices

Values for η_1 and η_2 are standard in empirical literature on New Keynesian Hybrid Phillips curve estimates (Rudd and Whelan, 2006; Paloviita, 2008).

Table 6. Calibration of Phillips curve and expected inflation parameters

η_1	η_2	η_3	κ
0.5	0.1	0.1	-0.8

Source: iAGS Model, OFCE.

Simulations – IAGS versus QUEST III

In this section, we present some properties of the model following fiscal and monetary policy shocks. When it is possible, we compare these deterministic simulations with those obtained with the QUEST III model. Simulations start from a steady state in which output gap is null, inflation is equal to the central bank target and the fiscal balance is at the level compatible with public debt stability.

The QUEST III model originally includes fiscal policy rules aiming at stabilising the public debt in the long run. Theses fiscal rules are discarded in these simulations since they induce endogenous fiscal impulses. Moreover, we drop the persistence of fiscal shocks since there is no such persistence in the IAGS model. Finally, the QUEST III model was calibrated on quarterly data, whereas we retain annual frequency for the IAGS model. So we aggregate all QUEST III quarterly outputs to obtain annual outputs.

Transitory fiscal impulse shock

The first simulation consists in a 1% positive fiscal impulse during one period, followed by a 1% negative fiscal impulse during one period. The structural primary surplus then returns to its starting point. For QUEST III, we simulate a transitory 1% shift of the government consumption for four quarters (see Figure 5).

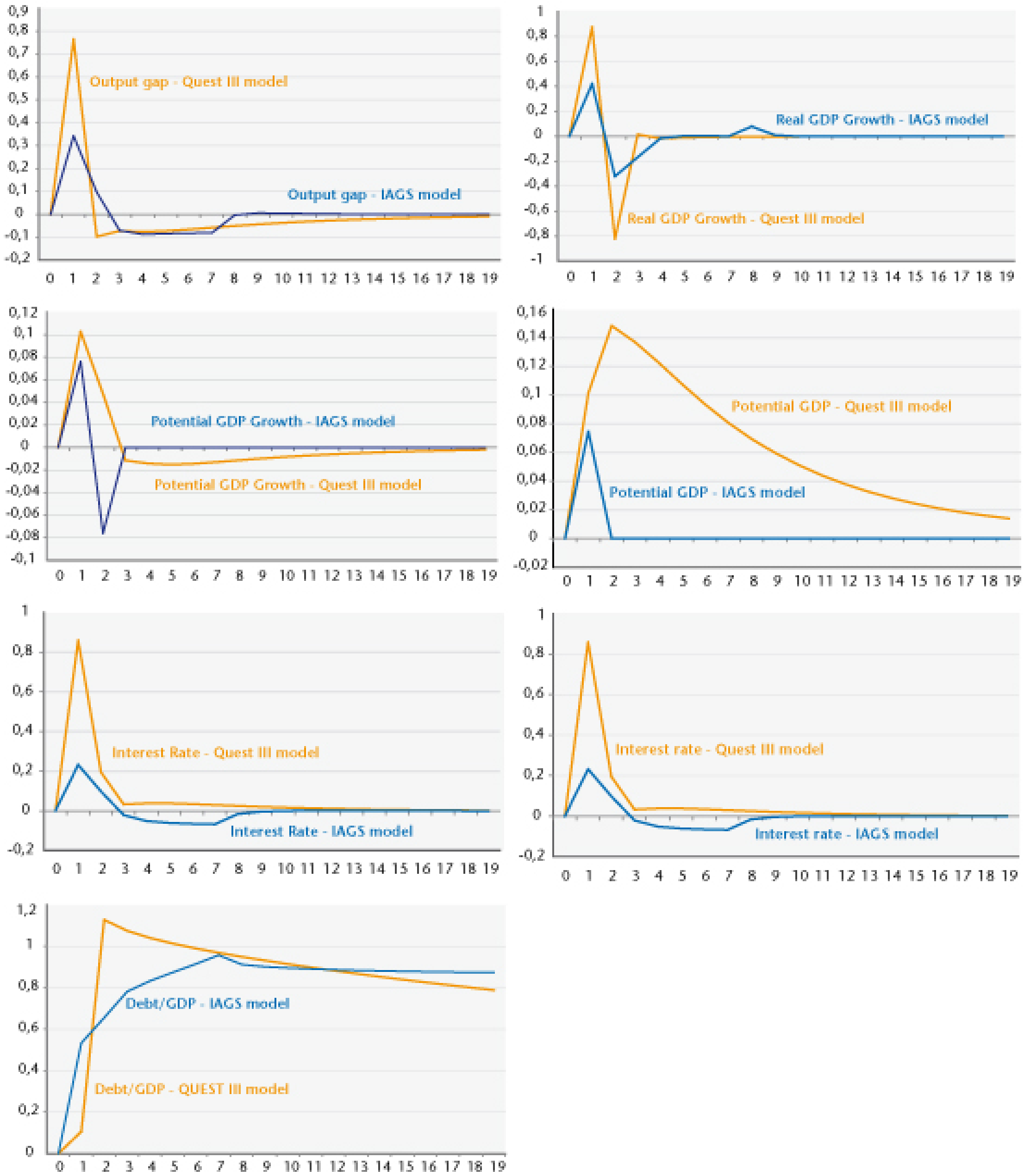
Permanent fiscal impulse shock

The following simulation consists in a 1% positive fiscal impulse. The structural primary surplus then falls of 1% of GDP. For QUEST III, we simulate a permanent 1% shift of the government consumption (see Figure 6).

Transitory monetary policy shock

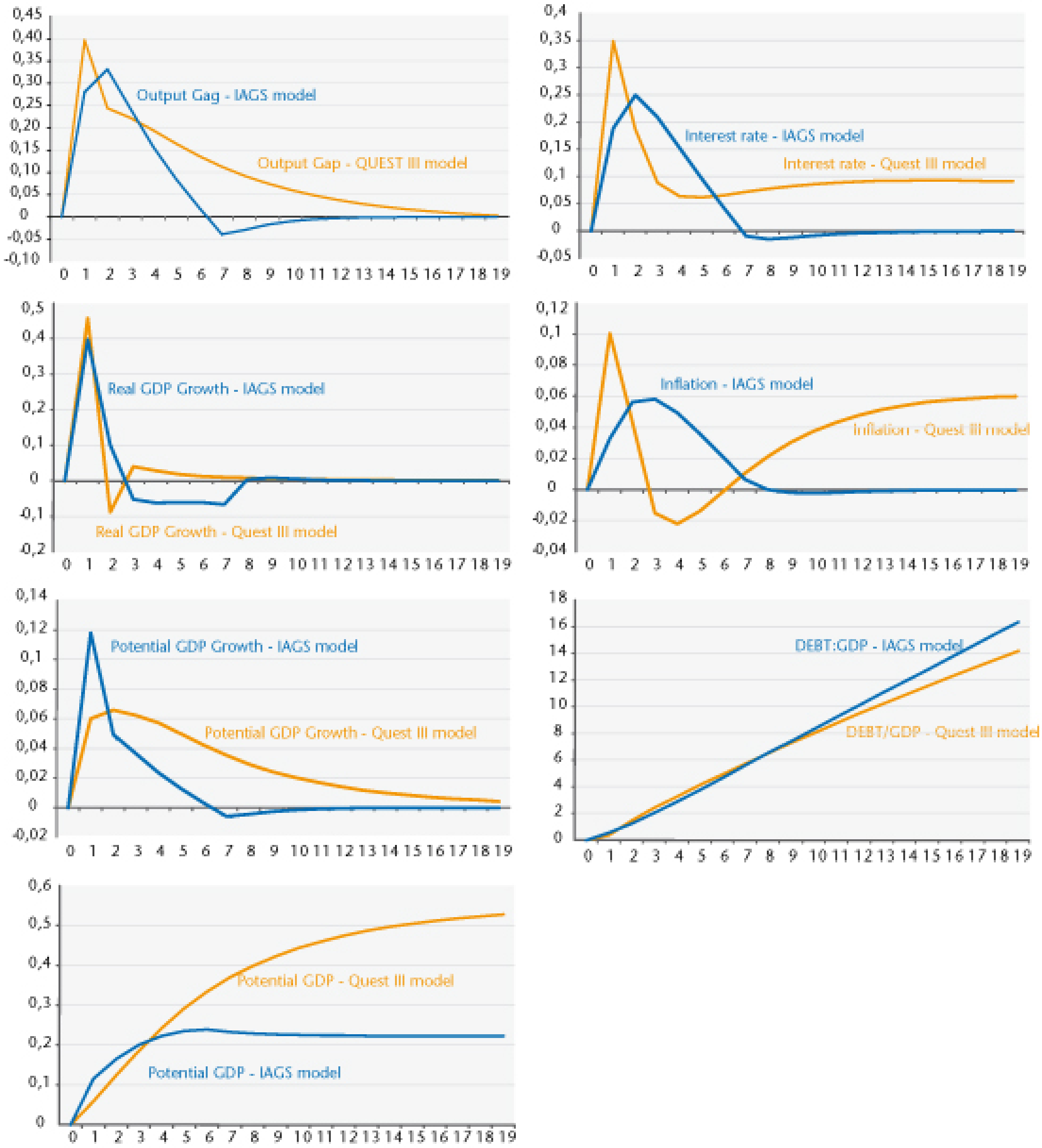
The next simulation consists in a shock on the central bank interest rate of 1% during one year (see Figure 7).

Figure 5. QUEST versus IAGS following a transitory positive fiscal impulse (1% of GDP)



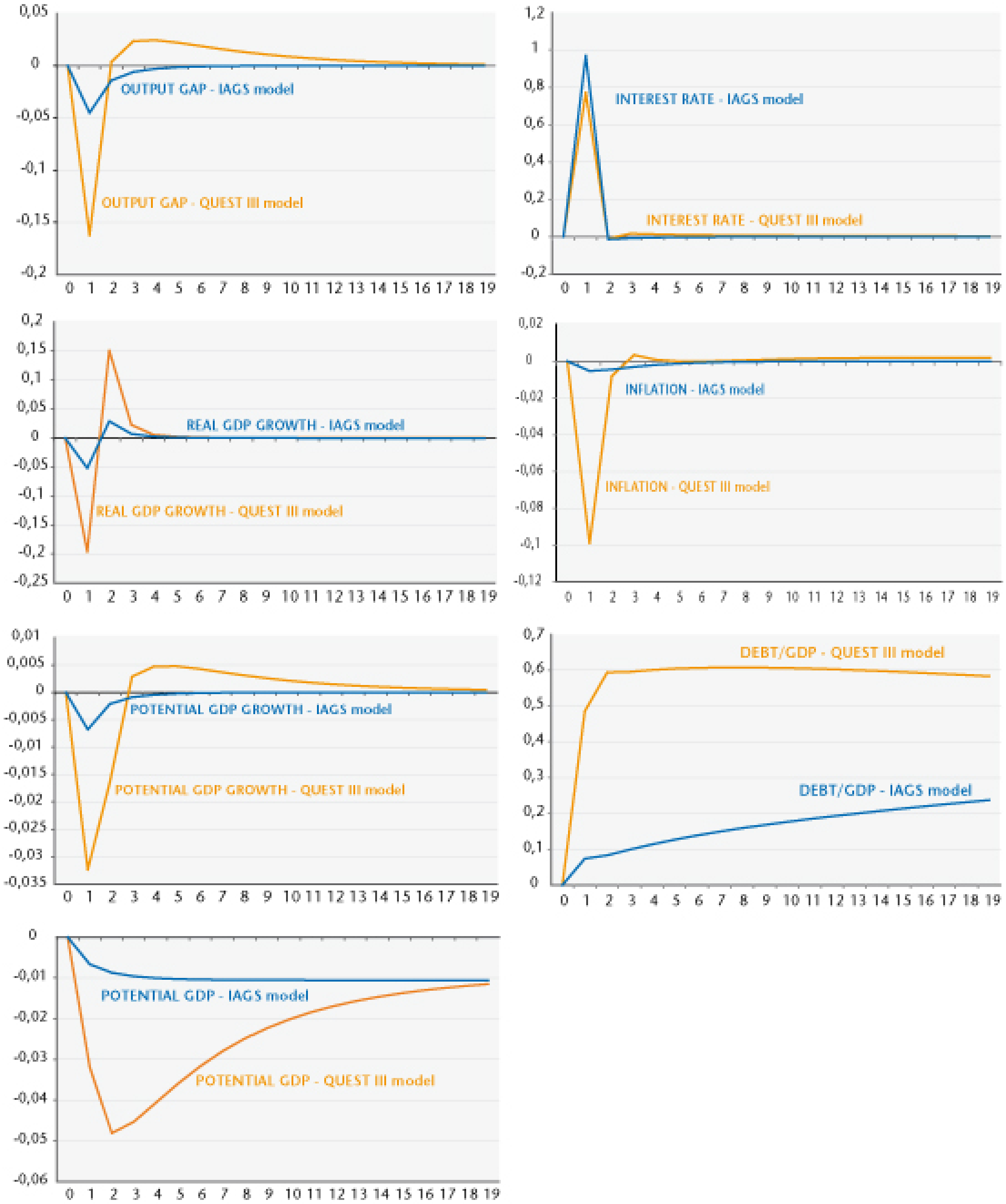
Sources: Macroeconomic Model Database - Wieland *et al.* (2012), iAGS Model, OFCE.

Figure 6. QUEST versus IAGS following a permanent positive fiscal impulse (1% of GDP)



Sources: Macroeconomic Model Database - Wieland *et al.* (2012), iAGS Model, OFCE.

Figure 7. QUEST versus IAGS following a transitory positive monetary policy shock



Sources: Macroeconomic Model Database - Wieland *et al.* (2012), iAGS Model, OFCE.

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