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SEAM: A Small-Scale Euro Area Model With Forward-Looking Elements*

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Abstract

This paper presents a small-scale estimated macro model for the euro area (SEAM) designed primarily to generate forecasts and to evaluate the dynamic response of the economy to unanticipated and anticipated shocks. One crucial feature of SEAM is the presence of forward-looking elements, which makes the model forecasts more robust to the 'Lucas critique', since it allows economic decisions to be moulded by the future impact of 'surprise' policy actions. In what concerns the reliability of the model-simulations, the inclusion of forward-looking behaviour enriches the dynamics of the response of the model's endogenous variables to exogenous shocks. Although the SEAM does not have the richness of full-scale macroeconomic models, as apparent *inter alia*, by the absence of a steady-state analogue and also of some relationships important for a better characterisation of the euro area economy, the model has been shown to deliver reasonable forecasts and responses to shocks that are consistent with conventional wisdom.

JEL Classification: C3; C5; E2

Keywords: Euro area, macroeconomic modelling.

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1 Introduction

The launch of Stage II of the Economic and Monetary Union (EMU) in 1999 marked the beginning of a common monetary policy for the countries that have adopted the euro. The emergence of the new currency area begged an effort of acquaintance with the euro area's economy viewed as a single block that granted a pivotal role to macroeconomic models. Given its tender age as a full-blown economic entity, the euro area has so far been the subject of few macroeconomic modelling attempts. Notwithstanding, as the scope and reliability of the data increases and the process of conducting monetary policy matures, some modelling endeavours aimed at forecasting and policy analysis have been cropping up. The model described in this paper, which has been given the name of SEAM, constitutes one such endeavour. Its presiding purpose consists of furnishing a flexible and ready-to-use instrument with which to generate forecasts and to evaluate the dynamic response of the economy to unanticipated and anticipated shocks. However, this flexibility and readiness-to-use of SEAM comes at a cost: the model is a highly stylised representation of the underlying economy that has been put together without many concerns for theoretical consistency.

As it is well known among forecasters, a perennial question in model design lays on the choice of whether to tilt towards a framework with more rigorous theoretical foundations and possible less forecasting ability, or to privilege the forecasting performance to the detriment of theoretical consistency. The already existing models for the euro area form a modelling spectrum that ranges from medium-sized fully estimated macroeconomic models with a more or less *ad hoc* structure tailored essentially at forecasting over the short to medium run, to very small general equilibrium models derived from first principles and calibrated with the sole intent of producing policy analysis. On the one end of the modelling spectrum stands the Area Wide Model (AWM) (see Fagan, Henry and Mestre, 2001), which is a medium-sized, quarterly, fully estimated model developed by the European Central Bank (ECB) with the main intent of providing an assessment of the economic conditions and macroeconomic forecasts for the euro area. This model does not rest on a general equilibrium optimising framework and is utterly backward-looking. Its main strength stems from the ability of providing forecasts for a considerable number of key macroeconomic variables. The two highly aggregated models for the euro area of Coenen and Wieland (2000) and Djoudad and Gauthier (2003) seat on the opposite end of the spectrum. The former is a calibrated model targeted essentially at evaluating alternative monetary policy strategies, whereas the latter is an estimated 'New Keynesian' model aimed at capturing the transmission mechanism of monetary policy.

In-between these two extremes, there are two other models, one proposed by Smets and Wouters (2003) and the other by Kortelainen (2002). The Smets and Wouters (2003) model is an estimated, closed-economy, dynamic stochastic general equilibrium (DSGE) model with nominal rigidities. Its main advantage follows from the rigour with which the model is constructed and also from its Bayesian

estimation methodology, which combines time series techniques with the predictions of a well-specified theoretical model calibrated for the euro area, and thus produces meaningful forecasts for seven key macroeconomic variables. Ironically, its theoretical rigour, by imposing a tight structure to the model, is at the base of its most conspicuous insufficiency, which consists of the limited detail with which the model characterises the economy and on its consequent inability of generating forecasts of a wider set of variables. The model presented by Kortelainen (2002), which is known by EDGE, is also a DSGE model containing nominal rigidities. The model is calibrated to fit the euro area data and is aimed primarily at policy analysis. The fact that the EDGE is not estimated makes it less suitable for forecasting.

In the middle of the spectrum, however, there is still an immense void of modelling categories waiting to be filled. In this context, the SEAM constitutes an incursion into the uncharted waters of the category of small-scale estimated models aimed at both forecasting and simulation-based policy analysis in the euro area. Since our main concern is with building a simple tool for forecasting, we are ready to compromise on the theoretical rigour of the sort present in the Smets and Wouters (2003) or the EDGE, for a model that delivers a good forecasting performance on a specific set of price aggregates and activity measures and at the same time allows running simulations that illustrate how the economy digests some standard shocks. Such a tool is currently unavailable from the shallow pool of existing macro models for the euro area. For what we would like to have is a model whose dimension stands between the AWM and the two very small models of Coenen and Wieland (2000) and Djoudad and Gauthier (2003) and that at the same time could be fully estimated with historical data on the euro area. Building a model with such features is what we propose in this paper.

One crucial feature of SEAM is the presence of forward-looking elements. The inclusion of forward-looking behaviour has some *a priori* advantages. First, it has some theoretical appeal in the sense that endowing some of the relations of the model with forward-looking elements make them bear greater resemblance to the Euler equations of a standard intertemporal optimising model with rational expectations. In what concerns the reliability of the model-simulations, the inclusion of forward-looking behaviour enriches the dynamics of the response of the model's endogenous variables to exogenous shocks. In what concerns the forecasting performance, it makes the model forecasts more robust to the 'Lucas critique', since it allows economic decisions to be moulded by the future impact of 'surprise' policy actions.

The remaining of the paper is structured as follows. In section 2, the theoretical background that involves each of the SEAM's equations is described and generic specifications for each of the equations, proposed. The main aim is to illustrate the measure by which each of the model's equations can be derived from well-established economic theories. Section 3 deals with all the issues that concern the econometric estimation of the SEAM. In section 4, the simulation and forecasting performance of the model is evaluated. For that purpose, a baseline simulation that can be used as a model-based

forecast is presented and discussed. This is followed by a detailed analysis of the results of the simulations pertaining to the responses of the model's endogenous variables to a host of permanent and temporary exogenous shocks. Section 5 concludes.

2 The Model in Theory

2.1 Overview

The SEAM consists of seven behavioural equations and several accounting identities (see Appendix). The equations of the model can be grouped into two main blocks: prices and activity. The former comprises the equations for consumer prices (HICP energy, HICP unprocessed food and HICP excluding these two components) and nominal wages, whereas the latter consists of an IS-type relation and an Okun's Law that embody some supply-side elements. The two blocks are linked by a monetary policy rule. The model is entirely estimated and designed primarily to evaluate economic developments over the short to medium term, since the steady-state is not formally modelled. Notwithstanding, some effort was put in endowing each individual equation with mechanisms that foster convergence of variables towards their long run equilibrium levels.

In what concerns the modelling strategy applied to the model's prices block, the SEAM's architecture privileges the modelling of the overall price level indirectly via its components, leaving the Phillips curve representation to the modelling of nominal wages. Consumer prices are modelled as a mark-up over costs and other variables deemed relevant for the price dynamics. The specification chosen for the wages equation is quite eclectic. By making wages dependent on consumer prices, it nests a standard labour demand function. Also, by featuring the unemployment gap and lagged and led wages it encompasses the 'New' Phillips curve representation. Finally, by including an attractor term that forces real wages to gravitate around labour productivity, it resembles an error-correction model (ECM).

In the SEAM, output is essentially demand-determined. In order to account for some inertia and forward-lookingness in the output dynamics, lagged and led terms of output were also introduced. Last but not least, an output gap term was included in order to confer some supply-side features to our modelling of domestic economic activity. This term is pivotal in ensuring that output converges to its potential level in the medium to long run. The model also includes an Okun's Law that links the unemployment and output gaps. Together with the Phillips curve, the Okun's Law is meant to capture the short run behaviour of the supply-side of the economy. Finally, a monetary policy rule that closes the model is specified in a form similar to that proposed by Taylor (1993).

Although our primary concern is with evaluating the dynamic behaviour of the economy in the short to medium term, we still have to grapple with the long run characteristics of the model because the economy gravitates permanently around its long run trend, even in the nearest short term. In

the SEAM, the economy's long run capacity is fully characterised by a single quantity: potential output. The model's steady-state is thus obtained when the output gap, defined as the difference between actual and potential output, collapses to zero. In these circumstances, the economy settles on a 'balanced-growth path' in which all variables grow at constant rates forever. It follows that the whole model, including the prices' block, is anchored at the potential output.

Since the model is not endowed with an explicit production function, we employ the Hodrick-Prescott (HP) filter to extract potential GDP from observed GDP. In this context, the crucial issue regarding solving and simulating the model is whether to exogenously impose a path for potential output or let the model determine it endogenously. The characterisation entailed by an exogenous potential output implicitly carries the idea that no shock can have a long run impact on real variables. Conversely, the alternative route of endogenising the potential output consists of embracing an endogenous growth theory approach by assuming that all shocks impart changes in the steady-state behaviour of the economy.

In a certain way, potential GDP is endogenous in the estimation period as it is obtained from the HP filter computed on observed GDP. It would therefore seem natural to replicate the same logic to the simulation period in which the model is solved endogenously. By doing that we would be securing consistency between the estimation and the simulation of the model and simultaneously harnessing the model to endogenously produce a steady-state characterisation of the economy. As it turns out, in this type of model endogenising potential output seems not to be an option. This follows from the fact that with forward-lookingness, if potential output is endogenous it will 'follow' GDP wherever it goes and the output gap will always be close to zero. Since the model is anchored at potential output, it consistently converges to a stable trajectory even when the simulated GDP growth rate drifts considerable away from the pre-imposed initial scenario. The overall implication is that the use of an exogenously determined potential output does not follow from a deliberate modelling choice but rather from the impossibility of endogenising potential output within the framework that underlies the SEAM.

2.2 The Output Equation

Output is modelled as a single-equation representation of a forward-looking version of an IS-type function that combines aggregate demand determinants with an attractor term in the output gap and a nonlinear term in the price of oil. The last two components are aimed at forcing the supply-side into an otherwise exclusively demand-determined relation. The specification proposed therefore allows output to meander about in response to different demand stimuli in the short run, but compels it to converge to its potential level in the medium to long term. Before laying down the particular specification for the output equation proposed for the model, it is worthwhile to make a detour in

search of theoretical underpinnings for it.

2.2.1 Theoretical Foundations of the Output Equation

The aim of this detour is not so much to provide a tight structural framework for the output equation but more to mitigate the theoretical arbitrariness that otherwise would certainly be attached to it. Given that the core of SEAM's output equation resembles a textbook IS curve if it was not for its forward-lookingness, in what follows the argument of McCallum and Nelson (1999) is explored to show that the chosen formulation can be broadly derived from a dynamic optimising general equilibrium model. The general argument for the modification of the IS curve into a forward-looking relation is that rational agents take into account their expected future stream of utility and their intertemporal budget constraint when deciding the present level of consumption, such that present demand variables depend on expected future levels.

McCallum and Nelson (1999) present a dynamic optimising representative agent model, where agents consume a huge variety of goods but specialise in production. In particular, at time t the typical agent maximises the following time-separable intertemporal utility function:

$$\sum_{\tau=0}^{\infty} \beta^{\tau} u(c_{t+\tau}, c_{t+\tau}^F) \quad (1)$$

where c_t denotes household consumption of the domestic composite good at time t , c_t^F , household consumption of the foreign composite good at time t and $\beta \in (0, 1)$ is the household's discount factor.

Each household produces a single good according to the following production function:

$$y_t = f(l_t, k_t) \quad (2)$$

where y_t is output, l_t is labour input and k_t is the stock of capital held by the household at the start of period t .

It is also assumed that each agent inelastically supplies one unit of labour per period to the labour market in which producers hire labour inputs at the market on-going wage rate, w_t . In what concerns the external relations of the economy it is assumed that the typical household imports a foreign composite good for the unit price of $S_t P_t^F$, where S_t denotes the nominal exchange rate, and P_t^F the foreign price level. Each household exports x_t units of domestic composite good at the unit price of P_t , the domestic price level. For the time being we leave the role of the domestic government aside in order to avoid unwarranted complications that would ensue from mixing an active domestic fiscal policy with the possibility of non-zero current account balances. However, it is assumed that in each period foreigners issue one-period bonds on which the real interest rate is r_t , so that $(1 + r_t)^{-1}$ is the price of the bond. These foreign bonds may be purchased by both foreign and domestic households.

The typical household's budget constraint in real terms is thus:

$$f(l_t, k_t) \geq c_t + k_{t+1} - (1 - \delta)k_t + w_t(l_t - 1) + \frac{b_{t+1}^F}{1 + r_t} - b_t^F - [x_t - S_t(P_t^F/P_t)c_t^F] \quad (3)$$

where b_t^F is the domestic household's net holdings of the foreign bond in period t .

The household's problem consists of maximising utility subject to the budget constraint, which involves optimising the following Lagrangean function

$$L_t = \sum_{\tau=0}^{\infty} \beta^\tau u(c_{t+\tau}, c_{t+\tau}^F) - \sum_{\tau=0}^{\infty} \left[\beta^\tau \lambda_{t+\tau} \left(c_{t+\tau} + k_{t+1+\tau} - (1 - \delta)k_{t+\tau} + w_{t+\tau}(l_{t+\tau} - 1) + \frac{b_{t+1+\tau}^F}{1+r_{t+\tau}} - b_{t+\tau}^F - f(l_{t+\tau}, k_{t+\tau}) - x_{t+\tau} \right) \right] \quad (4)$$

It can be shown that under some specific assumptions regarding the utility function, the solution to this optimisation problem gives rise to the following relation:

$$\ln(y_t) = b_0 + d_1 b_1' r_t + E_t \ln(y_{t+1}) + d_3' \ln[x_t(Q_t, y_t^F)] \quad (5)$$

where r , y , Q and y^F denote, respectively, the real interest rate, the domestic output, the real exchange rate and the foreign output. Equation (5) provides a forward-looking output relation in an open-economy environment that can be incorporated into a business cycle model.

The framework of McCallum and Nelson (1999) can still accommodate the incorporation of government expenditure as a determinant of aggregate demand. For that we need to grant an active role to government as a tax raiser, spender and bond issuer. Thus, to the above setup we add the following elements: each period t the government spends g_t per household, levies a lump-sum tax of v_t per household and issues one-period bonds on which the real interest rate is r_t , where $(1 + r_t)^{-1}$ is the price of the government bond. As before, and for the sake of simplicity, we avoid mixing an active fiscal policy with the possibility of non-zero current account balances and so 'shutdown' the external sector of the economy. This implies setting $b^F = c^F = 0$ for all periods.

After appropriately transformed to accommodate the changes in the economy's environment, the household's budget constraint in real terms becomes:

$$f(l_t, k_t) - v_t \geq c_t + k_{t+1} - (1 - \delta)k_t + w_t(l_t - 1) + \frac{b_{t+1}}{1 + r_t} - b_t \quad (6)$$

where b_{t+1} is the number of real bonds purchased in t .

It can be shown that the optimisation of the consumer's problem under this revised setup yields the following equation for domestic output:

$$\ln(y_t) = b_0 + b_1 r_t + E_t \ln(y_{t+1}) + b_3 \ln(g_t) \quad (7)$$

Equation (7) legitimates the presence of government expenditure in a forward-looking version of an IS-type interpretation of the business cycle.

It turns out that both equations (5) and (7) resemble standard IS function but for the presence of future output as a determinant of current output¹. However, it is precisely this additional element that gives the above relations a forward-looking aspect and as such confers some theoretical underpinnings to the modelling strategy pursued for the output equation in the SEAM. Moreover, in spite of having been derived separately, these two equations provide the basis for the inclusion of the determinants of net exports and of the government expenditure.

2.2.2 The Specification of the Output Equation

The analysis explored above suggests that the output equation should feature as output determinants the following elements: (i) expected future output; (ii) real interest rate, which can be split into the nominal interest rate and overall price inflation; (iii) real exchange rate, which can be split into the nominal exchange rate and a measure of the foreign relative to the domestic price level (which in the setting of McCallum and Nelson (1999) also corresponds to the terms of trade); (iv) foreign output and (v) government expenditure.

The simplistic nature of McCallum and Nelson's model makes the above stated IS functions restrictive for our, essentially empirical, purposes. First and foremost, it lacks enough dynamics in the form of lags and extra leads of the left-hand side variable and lags of the right-hand side variables. The inclusion of these extra terms will prove instrumental in delivering a reasonable fit for the subsequent econometric estimation. This added feature could be accommodated in the above setup by assuming an autoregressive structure of the variables and rationalised on the account of habit persistence in consumption, adjustment costs and accelerator effects in investment. Moreover, and in spite of the model containing a supply relation in the form of a Phillips curve, it turns out that the (corrective) effect of prices in our output equation possesses a rather limited empirical strength, which spurred us to include an equilibrium-attraction term (the output gap) that would force output to gravitate around its long run equilibrium level in a quantitatively suitable fashion. Finally, given the empirical importance of the price of a special commodity –oil– we also introduced an oil price variable into the output equation.

The specification chosen and subsequently estimated is log-linear and in first-differences:

¹Naturally, the fact that the coefficient on the output lead term is unity results from the specific functional form of the utility function adopted here solely for illustrative purposes. Therefore, this result should not constitute a binding constraint for the empirical estimation of the parameters of the SEAM's output equation.

$$\begin{aligned}
\Delta LY_t &= a_0 + \sum_{i=1} a_{1i} \Delta LY_{t+i} + \sum_{i=1} a_{2i} \Delta LY_{t-i} + \sum_{i=0} a_{3i} \Delta R_{t-i}^{3M} + \sum_{i=0} a_{4i} \Delta R_{t-i}^{10Y} + \sum_{i=0} a_{5i} \Delta LG_{t-i} \\
&+ \sum_{i=0} a_{6i} \Delta LEER_{t-i} + \sum_{i=0} a_{7i} \Delta LDX_{t-i} + \sum_{i=0} a_{8i} \Delta LTT_{t-i} + \sum_{i=0} a_{9i} \Delta^2 LP_{t-i} \quad (8) \\
&+ \sum_{i=0} a_{10i} NLOIL_{t-i} + \sum_{i=0} a_{11i} \Delta LY_{t-i}^{gap} + \varepsilon_t \\
R^{3M} &= I3M_t - \Delta_4 LP_{t+4} \\
R^{10Y} &= I10Y_t - \Delta_4 LP_{t+4}
\end{aligned}$$

where the prefix L denotes natural logarithms, Δ and Δ^2 denote the first and second differences operators, respectively, and $Y^{gap}, P, I3M, I10Y, G, EER, DX$ and TT pertain to the euro area's economy and stand for respectively, output gap, HICP, nominal three-month interest rate, nominal ten-year bond yield, government expenditure, nominal effective exchange rate index, foreign demand proxied by a weighted average of the GDP of the euro area's main trading partners and terms of trade. $NLOIL$ represents a nonlinear transformation of the oil price².

In what concerns the specification proposed in (8), a few remarks are in order. When specifying an IS relation it is common practice to consider a single interest rate, which implies selecting one rate and thus one maturity out of a myriad available for the economy being modelled. The fact that the euro area is quite heterogenous in its constituent countries as to the way economic activity is financed prompted us to pick two interest rates pertaining to opposite ends of the yield curve in order to account for the eventual idiosyncrasies of the workings of each country's financial systems. In the end, whether one or both rates are used in the model is an empirical matter. Still in what respects the interest rates, the real rates were computed assuming forward-looking inflation expectations by deflating the nominal rates by the one-year ahead inflation rate.

2.3 The Consumer Prices Equations

The prices' block includes three behavioural equations (HICP energy, HICP unprocessed food, and HICP excluding unprocessed food and energy) and an identity equation (where overall HICP is computed as a weighted average of the three price components).

The modelling and estimation approach pursued for the consumer prices is based on a framework of rational behaviour under frictions, which accommodates the fact that there is a cost of adjusting prices. Under this hypothesis, agents face a two-stage decision process. In the first stage, agents decide on an 'equilibrium' level of prices. This 'equilibrium' level is presumably derived from an optimising framework, which under some standard assumptions turns out to be a markup over costs,

² $NLOIL_t = \Delta(\text{oil price})_t$, if $\Delta(\text{oil price})_t > 0.10$, and $= 0$ otherwise. The reason for adopting such formulation is related to the fact that only sharp changes in the price of oil are bound to exert any significant effect on real output.

i.e. unit labour costs, import prices and energy prices. In the second stage, agents formulate an optimal time-path towards the 'equilibrium' price level, which will be dependent on the temporary fluctuations of the various cost items and other variables perceived relevant in the short term.

This two-step logic is carried over to the estimation strategy. Specifically, the procedure implemented consists of, first, empirically determining the 'equilibrium' price level by the means of cointegration analysis. This cointegration analysis also allows assessing the validity of the hypothesis of long run linear homogeneity of prices in costs. This first-step is followed by the estimation of an ECM. The fact that the adjustment process of consumer prices in the short run is mainly an empirical matter requires, apart from an 'error-correction' term, a quite broad dynamic specification that contemplates four types of effects: the first involves a process of gradual adjustment towards the 'equilibrium' level, the second reflects the existence of inflation persistence, the third consists of the short term response of consumer prices to changes in wages, import prices and energy prices, and the fourth captures the business cycle influence on price aggregates.

The price equations to be estimated come in the following generic form:

$$\begin{aligned} \Delta LP_t^j = & \alpha^j + \sum_{i=1} \beta_i^j \Delta LP_{t-i}^j + \sum_{i=0} \gamma_i^j \Delta LW_{t-i} + \sum_{i=0} \delta_i^j \Delta LPIM_{t-i} + \sum_{i=0} \phi_i^j \Delta X_{t-i} \\ & \sum_{i=0} \eta_i^j \Delta LOIL_{t-i} + \sum_{i=0} \theta_i^j \Delta LEUSD_{t-i} + \sum_{i=0} \zeta_i^j \Delta LEER_{t-i} + \\ & \pi^j [LP^j - \mu_1 ULC - \mu_2 (LPIM - LEER) - \mu_3 (LOIL - LEUSD)]_{t-1} \end{aligned} \quad (9)$$

$$\text{with } \sum_i \mu_i = 1$$

where L denotes natural logarithms, P^j is either HICP energy (PEN) or HICP excluding unprocessed food and energy (PSUNEN) and W , PIM , EER , OIL , $EUSD$, ULC , X stand for, respectively, the nominal wage rate, a proxy for the euro area's imports price deflator, the nominal (effective) exchange rate index of the euro, oil prices denominated in U.S. dollars, the bilateral euro-U.S. dollar exchange rate, unit labour costs and a measure of economic activity to be specified later on.

As for the HICP unprocessed food, since it appears as there are no obvious structural driving forces, we chose to model it as a pure time series process, in particular as an ARIMA.

2.4 The Wages Equation

For the wages equation we chose an eclectic specification that embeds a forward-looking Phillips curve-type of relation that ties the wages' variations to the business cycle, coupled with a long run attractor term that forces nominal wages to evolve in such a way as to allow real wages to converge to the level of labour productivity. Notwithstanding these extra components, the wages equation echoes in essence a Phillips curve formulation, the theoretical foundations of which are sought in what follows.

2.4.1 Theoretical Foundations of the Wages Equation

The wage dynamics in the SEAM are modelled through a type of relation inspired in the 'New' Phillips curve. When compared to the traditional, fully backward-looking formulation, the most distinctive feature of the 'New' Phillips curve is its forward-looking aspect, while its main advantage is the fact that the 'New Keynesian' economics confers it sound microfoundations and so makes it theory-consistent.

Often, wage and price inflation have been modelled empirically through the traditional Phillips curve, which relates inflation (π) to some cyclical indicator (\hat{y}) as well as its own lagged values. A simple version of it can be put as:

$$\pi_t = \pi_{t-1} + \delta \hat{y}_t + \varepsilon_t \quad (10)$$

In spite of lacking theoretical underpinnings, the traditional Phillips curve has in some circumstances produced satisfactory empirical results, since it has been able to capture two, almost omnipresent, features of the data on inflation: persistence and dependence on the business cycle. The crucial innovation introduced by the 'New Keynesian' theory consists of providing microfoundations to nominal rigidities by admitting costs to price-adjustment in a rational expectations context. In this framework, the agents' optimal response to unforeseen shocks might be to abstain from adjusting prices that would cease to be optimal in an otherwise flexible-price setting. The 'New Keynesian' theory offers two key insights regarding the Phillips curve relation. First, by validating nominal rigidities theoretically it legitimises the 'non-neutrality' that characterised previous Keynesian models including the traditional Phillips curve. Second, the combination of agents' rationality with sticky prices motivated by price-adjustment costs, implies that agents must take into account (expected) future prices when setting prices, giving rise to a 'New' Phillips curve, which is utterly forward-looking in contrast to the utterly backward-looking nature of the traditional Phillips curve.

Next, we try to pin down the essence of the arguments put forward by Taylor (1980) and Fuhrer and Moore (1995) to see how a forward-looking Phillips curve can be obtained. In the Taylor (1980) model, when contracting labour deals, agents are assumed to compare the current wage contract with other wage contracts negotiated previously and still in effect and contracts expected to be negotiated over the duration of the contract. Agents are also assumed to pay attention to the labour market conditions, which are proxied by a measure of cyclical excess demand in the economy. Thus, Taylor's staggered wages model can be formalised as follows:

$$w_t = \frac{1}{2} (w_{t-1} + E_t w_{t+1}) + \gamma \hat{y}_t \quad (11)$$

where w and \hat{y} denote the natural logarithms of wages and excess demand, respectively.

Defining wage inflation π_t^w as the first difference of w_t , equation (11) can be re-arranged as to

produce a forward-looking Phillips curve type-relation:

$$\pi_t^w = \pi_{t+1}^w + \tilde{\gamma}\hat{y}_t \quad (12)$$

Although not demonstrated here but shown in Fuhrer and Moore (1995), Taylor's implicit Phillips curve does not generate any overall price level inflation persistence beyond the persistence intrinsic to the shocks hitting the economy. As argued by Fuhrer and Moore (1995), this is an unfortunate shortcoming, since overall price index inflation persistence seems to be one of the most conspicuous regularities of the data. To overcome this limitation, Fuhrer and Moore envisage an environment in which wage setters care about the price level-adjusted value of wages implicit in neighbouring contracts rather than their nominal value. In other words, Fuhrer and Moore (1995) contend that a setting in which agents negotiate contracts to keep up with neighbouring contracts in real rather than in nominal terms is a more reasonable representation of the underlying reality. In practice, Fuhrer and Moore's model entails a slight modification of Taylor's staggered wages equation to:

$$w_t - p_t = \frac{1}{2} [w_{t-1} - p_{t-1} + E_t(w_{t+1} - p_{t+1})] + \tilde{\gamma}\hat{y}_t \quad (13)$$

where p denotes the overall price level. As before, we can re-arrange equation (13) to obtain a Phillips curve-like relation:

$$\pi_t^w = \pi_t^p + \pi_{t+1}^w - \pi_{t+1}^p + \tilde{\gamma}\hat{y}_t \quad (14)$$

where π^p stands for overall price level inflation. It can be shown that Fuhrer and Moore (1995) formulation imparts significant inertia to the rate of inflation, as desired. Moreover, equation (14) suggest that expected future overall price level inflation affect, side-by-side with expected future wage inflation, the current wage inflation.

In sum, it has been shown that forward-looking relationships that resemble the fully theoretical-borne 'New' Phillips curve can be obtained from relatively 'loose' models of wage contracts that generate price stickiness by assuming a staggered wage contracting process.

2.4.2 The Specification of the Wages Equation

As discussed in §2.4.1, the 'New' Phillips curve points to the presence of only led terms in wage inflation on the right-hand side of the equation. In spite of being the feature that distinguishes the *ad hoc* traditional formulation from the theory-consistent approach, many authors have pointed out that the patterns of the data appear to be more consistent with the traditional, backward-looking Phillips curve than the more theoretically appealing 'New' Phillips curve (see e.g. Fuhrer, 1997, Rudd and Whelan, 2001). The empirical letdown of the 'New' Phillips curve has prompted the addition of lagged terms in inflation to the 'New' Phillips curve, resulting in what has become known as the 'hybrid' Phillips curve, which in its simplest form can be written as:

$$\pi_t^w = \lambda_b \pi_{t-1}^w + \lambda_f \pi_{t+1}^w + \tilde{\gamma}y_t \quad (15)$$

The available empirical research seems to vindicate the superiority of this 'hybrid' Phillips curve over its 'pure' specifications³. With the aim of getting the best possible empirical adherence to the euro area data, we chose to model the wage inflation dynamics as an 'hybrid' Phillips curve combined with lagged terms in the overall price level inflation as implicit in Fuhrer and Moore (1995) and an 'error-correction' term that forces nominal wages to adjust as to make real wages converge to labour productivity in the long run. Since we are modelling wage inflation, it seems more appropriate to use the unemployment rather than the output gap as the measure of cyclical excess demand. Thus, the proposed specification models changes in nominal wages as follows:

$$\Delta LW_t = a_0 + \sum_{i=1}^4 a_{1i} \Delta LW_{t-i} + \sum_{i=1}^4 a_{2i} \Delta LW_{t+i} + \sum_{i=0}^4 a_{3i} \Delta LP_{t-i} + \sum_{i=0}^4 a_{4i} U_{t-i}^{gap} + \alpha_1 LECMW_{t-1} + \varepsilon_t \quad (16)$$

where L denotes natural logarithms and W , P and U^{gap} are the wage rate, the overall price level and the unemployment gap, respectively, and $ECMW$ denotes deviations of the real wage from labour productivity.

2.5 The Okun's Law

The Okun's law consists of a reduced-form cyclical inverse relationship between the levels, changes or deviations from the long run equilibrium levels of output and the unemployment rate. In spite of its empirical consistency (for the United States economy, at least), the Okun's Law must be seen more as an empirical 'rule of thumb' rather than a theoretically derived economic law⁴. In fact, output does not depend directly on unemployment but rather on the labour input. Thus, the relation between output and the unemployment rate is indirect and channelled by a putatively stable and strong association between labour services and the unemployment rate. Moreover, Okun's estimate implies much greater benefits (in terms of output) from the reduction of the unemployment rate than an elasticity estimated from any reasonable production function would predict. This means that the determinants (other than unemployment) of output must move in tandem with the unemployment rate for such a 3-to-1 ratio to obtain. This is, of course, a quite stringent assumption that cannot always be assumed to hold empirically. The stringency of the assumptions implicit in the Okun equation led Prachowny (1993) to attempt to derive the Okun's relation from first principles.

³See Chadha, Masson and Meredith (1992) and Fuhrer (1997), among others.

⁴The fact that this relation has grown to bear 'law' status stems from its remarkable empirical stability in the U.S. prior to the first oil-shock. In its original contribution, Okun (1962) estimated for the U.S. that a one-percentage point decrease in the unemployment rate gives rise to an output expansion of roughly three percent.

2.5.1 Theoretical Foundations of the Okun's Equation

Prachowny (1993) starts off with a Cobb-Douglas production function in labour and capital, which is expressed as:

$$y = \alpha (k + c) + \beta (\gamma n + \delta h) + \tau \quad (17)$$

where lower-case denotes natural logarithms, y is output, k is the capital input and c its utilisation rate, n represents the number of workers, h the number of hours per worker and τ denotes a catch-all measure of productivity. The parameters α and β are the elasticities of capital and labour, respectively, and γ and δ stand for the contributions of workers and hours to the labour input, respectively.

Potential output, denoted by y^* , is obtained by plugging the long run values of the variables into the production function. This yields the following output gap representation:

$$y - y^* = \alpha (k - k^*) + \alpha (c - c^*) + \beta \gamma (n - n^*) + \beta \delta (h - h^*) + (\tau - \tau^*) \quad (18)$$

where the superscript $(*)$ denotes long run equilibrium.

Letting l be the natural logarithm of the labour force, so that the unemployment rate, u , is defined as $u = l - n$, and the 'natural' rate of unemployment as $u^* = l^* - n^*$. Assuming that $k = k^*$ and $\tau = \tau^*$, but letting the remaining determinants of output to deviate from their long run equilibrium levels, we can re-write equation (18) as:

$$y - y^* = \alpha (c - c^*) + \beta \gamma (l - l^*) + \beta \gamma (u - u^*) + \beta \delta (h - h^*) \quad (19)$$

This last representation unveils two features of the output determination process that according to Prachowny (1993) would suffice to undermine both the Okun's relation and the Okun's estimated coefficient. For the Okun's Law and the respective estimated coefficient would only be valid under the restrictions that all variables but unemployment would always be at their long run values or that otherwise would be perfectly correlated with unemployment and at ratio compatible with the three-to-one factor found by Okun. Using data for the U.S., Prachowny (1993) finds that deviations of the capacity utilisation, labour force and hours worked from their long run equilibrium values, along with the unemployment gap are statistically significant in explaining the output gap, arguably rendering the Okun's relation misspecified. This led Prachowny (1993) to find a much smaller estimated impact of unemployment on output. In spite of the theoretical rigor introduced by Prachowny (1993) in the derivation of the Okun's relation, his econometric methodology arguably contains several deficiencies that cast doubts on the validity of the estimates obtained. Using the same dataset but a different econometric approach⁵, Attfield and Silverstone (1997) found that the output determinants other

⁵Prachowny (1993) claims not being able to reject the presence of unit roots in his constructed 'gap' variables and draws on this to propose a first-difference specification of a variation of equation (19). This choice is unfortunate for two

than unemployment were statistically insignificant thereby 'rehabilitating' the Okun's relation. The upshot of the overall debate is that the Okun's law is a restricted version of a more complex model, but one that has in some instances yielded satisfactory empirical results. However, the validity of the Okun's Law requires the empirical verification and stability of those implied restrictions.

2.5.2 The Specification of the Okun's Equation

Okun (1962) put forward two alternative model specifications for the relation between output and the unemployment rate: one in gaps and the other in first-differences. In spite of their apparent dissimilarity, both approaches are in fact equivalent provided that the unemployment rate and output are integrated of order one and mutually cointegrated, such that an ECM representation of the relationship between those variables exist (see Attfield and Silverstone, 1998). However, in practice they are bound to yield different results since the implementation of each approach entails the adoption of different statistical procedures. We chose the 'gap' approach because it establishes a relation between the output and unemployment gaps and so is particularly suitable for inference on the time series behaviour of the modelled variables over the business cycle, which is our main aim.

Unlike Okun's seminal contribution, the literature's standard has relied on autoregressive-distributed lag (henceforth ADL) models, i.e. on the addition of lagged values of both the unemployment rate and output gaps to the basic specification. The specification chosen for the 'gap' model is given by the following ADL equation reparameterised into an ECM:

$$\Delta U_t^{gap} = a_0 + \sum_{i=1}^4 a_{1i} \Delta U_{t-i}^{gap} + \sum_{i=0}^4 a_{2i} \Delta LY_{t-i}^{gap} + \alpha_1 U_{t-1}^{gap} + \alpha_2 LY_{t-1}^{gap} + \varepsilon_t \quad (20)$$

where the variables take on the usual meaning.

2.6 Monetary Policy Rule

The inclusion of a monetary policy rule in the SEAM constitutes an important step in the sense that it allows the model to 'close'. In what concerns the modelling of the monetary policy rule we follow the bulk of the related empirical literature and resort to the estimation of a Taylor-type reaction function.

Taylor (1993) puts forward a very simple and stylised characterisation of the monetary authority reaction function, which depends on two clear objectives of monetary policy: deviations of current inflation from an inflation target and deviations of real output from its long-run trend. The original reasons. First, it seems quite odd to admit that the 'gap' variables are non-stationary as it implies that those variables never converge to their long run equilibrium levels. Second, if the variables are in fact integrated of first order, than an ECM approach that would capture any cointegration relation, if one existed, would be more appropriate. These shortcomings cast doubts on the validity of the estimates obtained by Prachowny (1993). Although still treating the 'gap' variables as nonstationary, Attfield and Silverstone (1997) did employ an ECM approach to the estimation.

monetary policy rule proposed by Taylor decomposes the target nominal interest rate (i_t^T , the Taylor interest rate henceforth) into three different components: current inflation plus the equilibrium real interest rate ($\pi_t + r_t^*$), the response to deviations of current inflation from its target ($\pi_t - \bar{\pi}_t$), and deviations of output from its long-run level, the output gap (y_t^{gap}). That is,

$$i_t^T = r_t^* + \pi_t + (\beta - 1)(\pi_t - \bar{\pi}_t) + \alpha y_t^{gap} \quad (21)$$

In order to operationalise this rule, Taylor (1993) proposed to set the parameters to: $\beta = 1.5$, $\alpha = 0.5$, $r_t^* = \bar{\pi}_t = 0.02$.

The original Taylor rule has been scrutinised in recent studies at both the theoretical and empirical level. At the theoretical level, despite its simplicity, the Taylor rule seems to stabilise inflation and output in a way close to optimal policy rules in macroeconomic models (see Taylor, 1999). At the empirical level, it has been extended in several directions. One of the extensions allows for interest rate smoothing in order to mirror the fact that central banks typically adjust official interest rates gradually over time to their target levels (see e.g. Goodfriend, 1991). In another extension, forward-looking versions of the Taylor rule were proposed and estimated (Clarida, Galí and Gertler, 1998).

2.6.1 Specification of the Monetary Policy Rule

The specification we elected for the monetary policy rule is just a reparameterisation of equation (21) and constitutes the simplest version of the Taylor rule found in the literature and the one put forward in Taylor (1993):

$$i_t^T = r^* + \bar{\pi}_t + \beta(\pi_t - \bar{\pi}_t) + \alpha y_t^{gap} + \varepsilon_t \quad (22)$$

Empirical work on Taylor rules has frequently concentrated on the estimation of the reaction parameters α and β , assuming more or less arbitrarily the value for the equilibrium real interest rate and the inflation target. Regarding the equilibrium real interest rate, two approaches have typically been followed: fix it at an arbitrary value or compute it as the average of the *ex-post* real interest rate over the period of estimation. Since the third stage of the European Monetary Union (EMU henceforth) has only started in 1999 and so the length of data available for estimation is rather short, we opted for the former approach and fixed the equilibrium interest rate at 2.5 per cent. As for the choice of the inflation target, since the ECB has not elected a point-target but rather a range for price stability, we took an 'agnostic' view and threw the issue to the data by estimating $\bar{\pi}$ jointly with α and β .

3 The Model in Practice: Estimation

In this section we lay out the methodological issues concerning the estimation of the model. As referred previously, we chose to estimate each equation separately. We adopted the ECM specification

as the basic framework for the estimation and drew on the idiosyncrasies of each equation for the choice of the particular estimation method/procedure.

3.1 The Endogeneity Problem

The estimation of equations with forward-looking elements, in particular 'hybrid' versions that allow for both forward and backward-looking adjustment, presents some challenges as the OLS requirement that regressors are independent of the disturbance term is not met. To illustrate the point, consider the following arbitrary regression equation:

$$y_t = b_0 + b_1 y_{t-1} + b_2 y_{t+1|t}^e + e_t$$

where $y_{t+1|t}^e$ denotes the expectation formulated in period t of y_{t+1} . Writing $y_{t+1|t}^e$ as

$$y_{t+1|t}^e = b_0 + b_1 y_t + b_2 y_{t+2|t+1}^e + e_{t+1}$$

it turns out that, since y_t contains e_t , $cov\left(y_{t+1|t}^e, e_t\right) = b_1 \sigma_e^2 \neq 0$, rendering the regressor $y_{t+1|t}^e$ endogenous. In this case, the use of OLS results in inconsistent estimates and so an alternative estimation method must be sought. The traditional way out to this problem consists of using some instrumental variable approach. In empirical macroeconomics, GMM has become standard in dealing with the endogeneity problem associated with forward-looking equations for various reasons. In terms of efficiency, since GMM is an over-identifying estimation method, it allows the use of several instruments and the concomitant use of the information embedded in those instruments. In terms of inference, the fact that GMM enables 'robustifying' the estimation for the presence of serially correlated and heteroskedastic errors, makes it superior to other instrumental variable methods.

The use of the GMM method also entails several potential problems. First, most results on the properties of the estimators and test statistics are asymptotic and the rates of convergence are extremely slow, casting doubts on the accuracy of the estimates and the sampling distributions of test statistics in small samples, typically the ones we have access to. Second, the use of 'weak' instruments have been shown to impart severe distortions to the distributions of the estimators and test statistics, thus invalidating conventional inference (see Stock, Wright and Yogo, 2002, Staiger and Stock, 1997). Third, it is well known that GMM suffers from a trade-off between efficiency and bias in finite samples. It turns out that, on the one hand, a reckless implementation of the GMM method can lead to erroneous point estimates and sampling distributions of the regressors, thereby undermining the confidence on the overall estimation results and inference. On the other hand, inasmuch as the specification tests procedures, namely the over-identifying restrictions test, become unreliable one becomes subject to misspecification undetectability with the possible consequence that the magnitude and significance of the estimated parameters become extremely sensitive to the

particular choice of instruments (see Mavroeidis, 2001). This calls for caution when implementing GMM in the estimation of our model, something we took into consideration.

3.2 The Estimated Model

The equations of SEAM were estimated according to the following guidelines. The backward-looking equations were estimated by OLS, and a general-to-specific approach based on standard inference procedures was employed to select the final specification. For the forward-looking equations, we resorted to GMM to unveil the parameters estimates as well as the companion estimators and specification test statistics. As for the choice of estimator for the GMM's weighting matrix, there exists a wide variety of estimators, some parametric and others kernel-based (or non-parametric). Within the latter category the most widely used are the Bartlett kernel due to Newey and West (1987) and the quadratic spectral kernel due to Priestley (1981). We chose to use the latter as it exhibits better asymptotic and other properties relative to the former (see Andrews, 1991, Cushing and McGarvey, 1999).

Finally, three notes are in order. First, the estimated equations differ from the specifications outlined in section 2 in that the former might contain deterministic components not present in the latter aimed at capturing idiosyncratic features of the data, such as seasonal patterns, outliers or changes in the structure of the underlying DGP. Second, the reported estimated relations will also differ from the proposed specifications in that statistically insignificant variables present in the former were dropped from the latter. Third, all data are in quarterly frequency and the time span of the data set used in the estimation is not uniform across individual equations. A description of the data used in the estimations can be found in table 1.

3.2.1 Behavioural Equations

The estimated final specifications for each of the behavioural equations of the model are presented and their main features and results, discussed. In the equations outlined below, lower-case letters denote natural logarithms.

Output Equation

$$\begin{aligned} \Delta y_t = & \underset{(-7.7)}{-0.006} + \underset{(7.21)}{0.54} \Delta y_{t+1} + \underset{(2.25)}{0.10} \Delta y_{t-1} + \underset{(9.28)}{0.35} \Delta y_{t-4} - \underset{(-4.81)}{0.19} \Delta R_{t-7}^{10Y} + \underset{(7.23)}{0.30} \Delta g_t + \\ & \underset{(5.59)}{0.39} \Delta dx_{t-1} - \underset{(-7.55)}{0.10} \Delta eer_{t-2} - \underset{(-1.66)}{0.29} \Delta^2 p_{t-2} - \underset{(-3.77)}{0.01} nloil_{t-3} - \underset{(-2.8)}{0.11} y_{t-1}^{gap} \\ & - 0.007D88q23 - 0.01D89q3 + 0.01D92q1 - 0.01D93q1 \end{aligned} \quad (23)$$

Estimation Method: GMM.

Additional Instruments: $\Delta dx_t, \Delta dx_{t+2}, \Delta eer_{t+1}, \Delta eer_{t+2}$.

Covariance Matrix Estimation: Quadratic spectral Kernel, with a fixed bandwidth of 5.

Sample: 1987q2-2000q4.

Hansen's J-Statistic: 0.04 [0.9998].

The last four terms of equation (23) consist of pulse dummies and the remaining variables are as in equation (8). The output gap was computed with the HP filter with a smoothing parameter of 1600 and the figures in parenthesis refer to 't-ratios'.

Equation (23) suggests an intricate dynamic behaviour of output in the euro area, since it not only exhibits a forward-looking behaviour but also transpires a significant degree of persistence. The fact that the (long) real interest rate appears with a lag of seven quarters suggests that the monetary policy transmission mechanism takes almost two years to deliver the full brunt of its effects on output, an outcome that conforms with other empirical studies for the euro area (see e.g. Peersman and Smets, 2003). Overall, the low value of Hansen's specification test statistic combined with the strong statistical significance of the estimated parameters, in particular of the led term in output, are supportive of the forward-looking version of the modified IS curve proposed and of the method employed to estimate it.

HICP Energy (PEN) As mentioned in §2.3, in the first step of the estimation strategy, some search was done in order to find a cointegration relationship and to test for the long run homogeneity hypothesis. The following results were found for the cointegration equation:

$$pen_t = 1.23 + 0.26pime_t + 0.12oile_t + 0.66ulc_{t-4} \quad (24)$$

where the variables take on the same meaning as in equation (9) and $pime = (pim - eer)$ and $oile = (oil - eusd)$ denote, respectively, the euro area's import prices and the oil prices, both in local currency (euro).

Bearing on this estimation results, we could not reject the long run linear homogeneity hypothesis. Therefore, we re-estimated equation (24) imposing the linear homogeneity hypothesis, which yielded the following cointegration relationship:

$$pen_t = 1.33 + 0.23pime_t + 0.13oile_t + 0.64ulc_{t-4} \quad (25)$$

In a second step, we estimated equation (9) as outlined in section § 2.3, using the residuals of the long run equation (25) as the error correction term (ecm). The final specification is presented below:

$$\begin{aligned} \Delta pen_t = & \frac{0.22}{(3.66)} \Delta pen_{t-3} + \frac{0.11}{(12.2)} \Delta oil_t + \frac{0.39}{(2.52)} \Delta ulc_t - \frac{0.20}{(-5.12)} \Delta eer_t + \frac{0.25}{(1.92)} y_{t-3}^{gap} \\ & - \frac{0.26}{(-4.28)} ecm_{t-1} - 0.02D92q2 + 0.02D94q1 \end{aligned} \quad (26)$$

Estimation Method: OLS.

Sample: 1991q3-2002q3.

The last two terms on the right-hand side of equation (26) correspond to pulse dummies and the figures in parenthesis refer to 't-ratios'.

Notice that the estimated short run elasticity of oil prices is approximately 0.10, which conforms to the rule of thumb of 10-to-1 relation between oil price increases and their impact on energy prices. Usually, this type of 'markup' models allow for cyclical variations in the perceived demand elasticities and marginal costs of production, which in the present dynamic setting are captured by the output gap term.

HICP Unprocessed Food (PUN) As mentioned in §2.3, this price component is modelled as a pure time series process. It turned out that the best fit for HICP unprocessed food is given by the following ARIMA(3,1,0) model:

$$\Delta pun_t = 0.004 + 0.41 \Delta pun_{t-1} - 0.63 \Delta pun_{t-2} + 0.42 \Delta pun_{t-3} \quad (27)$$

(1.84) (2.98) (-5.27) (2.95)

Estimation Method: Maximum likelihood.

Sample: 1991q2-2002q4.

where, as before, the figures in parenthesis refer to 't-ratios'.

HICP Excluding Unprocessed Food and Energy (PSUNEN) The estimation procedure for the HICP excluding unprocessed food and energy follows broadly the one adopted for the HICP energy and generically described in equation (9). Again, some search was done in order to find a long run relationship and to test for the long run linear homogeneity hypothesis. The following cointegration results were obtained:

$$psunen_t = 0.17 + 0.11pime_{t-1} + 0.96ulc_{t-4} \quad (28)$$

As the hypothesis of linear homogeneity of non-energy prices in the long run could not be rejected, we adopted the same procedure as for the HICP energy and re-estimated (28) imposing linear homogeneity and used the resulting residuals to implement the second step outlined in §2.3. However, visual inspection and unit root testing suggested that those residuals might not be stationary. Therefore, we modelled the dynamic equation assuming that the dependent variable (PSUNEN) is integrated of second order, implying that the dynamic equation should contain two error-correction terms, one for the variables in first-differences and the other for the variables in levels. The estimated results are as follows:

$$\begin{aligned} \Delta^2 psunen_t = & 0.002 + 0.013 \Delta^2 pime_{t-3} + 0.081 \Delta^2 ulc_t - 0.443 \Delta psunen_{t-1} + 0.134 \Delta ulc_{t-1} \\ & (4.17) \quad (2.44) \quad (3.16) \quad (-5.29) \quad (3.30) \\ & - 0.045 ecm_{t-1} + 0.001 S14 + 0.005 D93q1 \\ & (-3.43) \end{aligned} \quad (29)$$

Estimation Method: OLS

Sample: 1991q2-2000q4.

The last two terms on the right-hand side of equation (29) correspond to a seasonal and a pulse dummy, respectively and ecm denotes the error correction term given by the residual of the cointegration relation in levels after imposing linear homogeneity, as in:

$$psunen_t = 0.52 + 0.11pime_{t-1} + 0.89ulc_{t-4} \quad (30)$$

Wages Equation

$$\begin{aligned} \Delta w_t = & \frac{0.29}{(2.59)} \Delta w_{t+4} + \frac{0.33}{(5.08)} \Delta w_{t-4} + \frac{0.34}{(2.10)} \Delta p_t + \frac{0.23}{(4.13)} \Delta prod_t - \frac{0.23}{(-3.32)} w_{t-3}^{gap} \\ & - \frac{0.18}{(-6.27)} ecm_{t-1} - 0.01D91q1 + 0.01D92q1 \end{aligned} \quad (31)$$

Estimation Method: GMM.

Additional Instruments: $\Delta y_t, \Delta y_{t+1}, w_{t+1}^{gap}, \Delta eer_{t+2}$.

Covariance Matrix Estimation: Quadratic spectral kernel, with a fixed bandwidth of 3.

Sample: 1986q3-2000q3.

Hansen's J-Statistic: 0.073 [0.9993].

where the variables take on the same meaning as in equation (16). The last two terms on the right-hand side of equation (31) are pulse dummies. The unemployment gap, as the output gap before, was computed with the HP filter with a smoothing parameter of 1600. The figures in parenthesis refer to 't-ratios'. The variable ecm_t was obtained as the residuals of the following regression:

$$(w_t - p_t - prod_t) = -4.57 - 0.002DT^* \quad (32)$$

where $DT^* = t - t^*$ if $t > t^*$, and 0 otherwise, and t^* is the break date estimated by way of the testing procedure proposed by Zivot and Andrews (1992), as the date that provides maximum evidence against the null of a unit root and in favour of the alternative of a structural break in the series of the difference between real wages and labour productivity⁶. Notice that a 'coast-to-coast' trend does not feature in the equation as it was found to be not significant.

Equation (31) vindicates the adoption of the 'hybrid' Phillips curve formulation for the dynamic behaviour of nominal wages, as both the lagged and led terms appear highly significant. It is interesting to notice that changes in prices hold the most prominent influence in the changes of nominal wages. This was expected, since both demanders and suppliers of labour care fundamentally about real wages. However, since the prices' coefficient is smaller than one it means that short run price fluctuations are not fully passed onto nominal wages. The magnitude of the coefficient found for the unemployment gap variable signals that the wage formation process is also influenced by the cyclical pressures in the labour market. Finally, the statistical significance of the coefficient of the ecm

⁶In the present case, t^* has been estimated to be 1993q1.

variable suggests that nominal wages are set as to promote the convergence of real wages towards labour productivity, although the relatively small magnitude of the estimated parameter indicates that such convergence takes some time to be achieved.

Okun's Law For the reasons presented in §2.5.2, we chose to estimate the 'gap' approach as in (20).

$$\Delta u_t^{gap} = \underset{(3.31)}{0.267} \Delta u_{t-1}^{gap} + \underset{(3.61)}{0.303} \Delta u_{t-4}^{gap} - \underset{(-2.37)}{0.037} \Delta y_{t-3}^{gap} - \underset{(-3.25)}{0.053} \Delta y_{t-4}^{gap} - \underset{(-6.81)}{0.296} u_{t-1}^{gap} - \underset{(-5.06)}{0.092} y_{t-1}^{gap} \quad (33)$$

Estimation Method: OLS.

Sample: 1978q2-2000q4.

Note that the 'gap' variables were obtained as deviations from 'potential' levels calculated by the HP filter with a smoothing parameter of 1600 and the figures in parenthesis refer to 't-ratios'.

Looking at the estimated results, changes in the unemployment gap exhibit an autoregressive structure quite common in quarterly models and reacts with a delay to changes in the output gap. This seems to fit quite well in the stylised fact according to which the unemployment rate reacts only with a lag to the cyclical fluctuations. Equation (33) has an implicit 'Okun coefficient' of $-\frac{0.092}{-0.296} = -0.311$, which is slightly different from the ones reported for the euro area in Schnabel (2002), who finds 'Okun's coefficients' of 0.23 for the 1966-2000 period and of 0.67 for the 1992-2000 subperiod.

Monetary Policy Rule The task of unveiling the parameters of the monetary policy rule stands out as problematic because the third stage of EMU only started in the beginning of 1999 and so we have only four years of data available for the euro's interest rates. Therefore, the estimates reported here should be seen as tentative and considered with caution.

Since the specification to be estimated is nonlinear in the parameters of interest, we resorted to a grid-search procedure that 'estimates' the parameters by minimising a given criterion, which in the present case has been chosen to be the mean squared deviation between the fitted Taylor's rate and the actual values of the ECB's reference interest rate.

Fixing the real interest rate at 2.5 per cent, we obtained the following estimated 'Taylor Rule':

$$i_t^T = \bar{r} + 1.9 + 1.45 (\pi_t - 1.9) + 2.46 y_t^{gap} \quad (34)$$

It is interesting to notice that the estimated inflation target is very close to the upper bound of the ECB's interval definition of price stability pertaining to the estimation period. The coefficient attached to the inflation deviations is close to 1.5, the value originally advanced in Taylor (1993) for the United States and in accordance to the results reported for the euro area by Gerlach and

Schnabel (2000) and Gerdesmeier and Roffia (2003)⁷. In contrast, the estimated coefficient on the output gap is higher than the values obtained by the cited authors, something that we readily admit to be probably caused by a small-sample bias stemming from the very limited time span covered by our dataset. Against this background, in the simulations presented in the next section we choose to use the coefficient for the output gap proposed by Taylor (1993).

4 The Model in Action: Simulations

The SEAM has been designed with the dual intent of providing a framework that is capable of producing forecasts and also of conducting policy analysis. As such, the SEAM should be able to generate reasonable forecasting profiles along with sensible response to standard shocks in terms of magnitude and speed of convergence towards long run levels. Thus, the aim of this section is to evaluate the SEAM's performance through the illustration of some of its forecasting and simulation capabilities.

4.1 Methodology

The introduction of rational expectations raises non-trivial methodological issues that stem from the numerical complexity of solving and simulating forward-looking models. These issues concern, in a first instance, model convergence, that is, the ability of the method to project relatively smooth trajectories towards the pre-imposed terminal conditions, and in a second instance, the speed with which convergence is achieved. In the present case, the choice of the method to solve and simulate the SEAM is simplified by the fact that first, the SEAM is linear, which facilitates convergence and, second, it contains relatively few equations, which plays down computational issues. Against this background, we chose to adopt a method known as the Laffarge-Boucekkine-Juillard (henceforth L-B-J), which is the industry's standard method for solving macroeconomic models.

Briefly, the L-B-J method consists of a sequence of steps that guarantees convergence to a solution, if one exists. The first step consists of transforming the model into T homogeneous systems of equations, each system pertaining to each of the T periods of the horizon for which the model is to be solved/simulated. In a second step, a 'big system' of equations is formed by stacking together all the T individual systems. The idea of constructing a 'big system' of equations is to allow the values of the endogenous variables for each of the T periods to be solved simultaneously. This second step is the most distinctive feature of L-B-J method, since by stacking the systems it guarantees that the solutions obtained for each of the T periods are mutually consistent. The third step consists of applying the Newton-Raphson solution algorithm to iteratively find the solution to the stacked

⁷Note that both these papers estimate monetary policy rules for the euro area based on data prior to the launch of the third stage of EMU in 1999 and so do not lend themselves to direct comparison with our results.

system⁸.

4.2 Baseline

In order to illustrate the forecasting potential of the forward-looking version of the SEAM, we simulated the model from the first quarter of 2003 over a period of thirty years. The rationale for choosing the observations pertaining to 2002Q4 as the initial conditions for the baseline, thus overlaying the last four quarters of the available dataset with the initial four simulated periods, is to provide the means for pinning down the simulation trajectories to the latest observed data. By doing that, we can use the simulation's intrinsic dynamics to generate a model-based forecast.

Before engaging in forecasting and simulation exercises, one must first solve the model for a horizon beyond our dataset in order to benchmark the time path of the model's endogenous variables for a sufficiently long period into the future. Therefore, one has to impose terminal conditions for the endogenous variables and also assume future trajectories for model's exogenous variables over the whole simulation period.

In what concerns exogenous variables, the baseline was computed using a quarterly profile consistent with the assumptions of the Eurosystem Staff Macroeconomic Projections exercise of the Spring 2004 for its forecasting horizon (2004-2005)⁹. The terminal conditions for all the variables, exogenous and endogenous, were fixed at values conformable with a 1.9 per cent¹⁰ and 2.25 per cent annual growth rates for the overall price index and real GDP, respectively.

Table 2 displays the annual growth rates of the SEAM's endogenous variables implicit in the baseline trajectories computed as described above along with those from other international organisations and the Eurosystem staff. Naturally, these sets of forecasts are not strictly comparable, since they were carried out in different points in time and use a different set of assumptions regarding financial and foreign variables. In particular, in contrast to the Eurosystem Staff projections, the SEAM's and other institutions forecasts are not conditioned on the assumption of constant short-term interest rates.

The SEAM entails an acceleration of real GDP from 0.5 per cent in 2003 to 1.6 per cent in 2004 and 2.5 per cent in 2005. Consequently, the unemployment rate declines gradually over this period, reflecting the lagged response of the labour market to the acceleration of economic activity. This is broadly in line with the forecasts of other international organisations and those of the Eurosystem Staff, although GDP growth rate for 2005 is higher than the majority of other euro area forecasts.

(Insert Table 2 here)

⁸For a description of the L-B-J method see Juillard, Laxton, McAdam and Pioro (1998).

⁹See ECB June 2004 Monthly Bulletin for a more detailed description.

¹⁰This is the inflation rate target estimated for the monetary policy rule. If we had chosen a different value, the future paths of prices would not be compatible with the monetary policy rule and the model would never 'close'.

In what concerns inflation, the SEAM generates a gradual decline in the annual HICP growth rate from 2.1 per cent in 2003 to 2.0 per cent in 2004 and 1.7 per cent in 2005. Compensation per employee growth is expected to be moderate in 2004 and 2005, which together with the recovery of labour productivity, translates into a significant deceleration of unit labour costs. This takes some time, however, to feedback into consumer price inflation. The SEAM's forecasts for the overall HICP annual growth rate stand close to the average point of the range reported by the Eurosystem Staff for 2004-2005, but are above those reported by the OECD, the European Commission and the IMF.

Summing up, although some differences can be spotted, it seems that the overall pattern of SEAM's set of forecasts is not much dissimilar to those of other organisations produced at approximately the same time of the year. Figure 1 displays the plots of annual growth rates of each endogenous variable of the SEAM implicit in this particular baseline.

(Insert figure 1 here)

4.3 Response to Shocks

The baseline can also be used as a benchmark for the analysis of the impact of exogenous, permanent or temporary, unanticipated or anticipated shocks. The simulation of shocks constitutes a very useful exercise for mainly two reasons. First, it serves as a diagnostic test for the reasonability and quality of the model. For if the impact of shocks differ markedly in direction, magnitude and speed of convergence towards long run levels from the predictions of the theory and of well-established empirical models, it must be the case that the model in hand can hardly be relied upon for forecasting and policy analysis. Second, the outcome of the shocks simulations provide a road map to the likely reaction of the economy under analysis to standard economic shocks.

4.3.1 Permanent Shocks

By comparing the time trajectories in the baseline with those obtained after the occurrence of the shocks, one can evaluate the magnitude of the response to the shocks and also the speed at which the model absorbs them. The simulation results presented in this section refer to unanticipated and permanent shocks since they are introduced at the first simulation period (2003Q1) and last for the entire simulation horizon.

(Insert Table 3 here)

Government Expenditure The effects of a permanent increase of 1 per cent of GDP in the government expenditure are shown in figure 2 and table 3. On impact, the surge in government expenditure creates an expansionary effect on output that causes an acceleration of productivity and, to a lesser extent, wages due to the presence of inertia in wage inflation. Therefore, unit labour costs

fall relative to the baseline and so do prices. As wages catch up with productivity, unit labour costs and concomitantly price inflation, rise. As a result, the fiscal impulse is crowded out by the increase of the nominal interest rate, which along with the loss of external competitiveness brought about by the increase in inflation and supply-side constraints conveyed by the error-correction mechanism, force output to return to the baseline. Note, however, that in the medium term the accumulated reaction of the model's cost variables is such as to bring output temporarily below the baseline level. This cyclical pattern of the output response crops up because the reaction of the cost variables in the model takes some delay to gain momentum, which in turn takes some time to impact back on output.

The swinging movement of output around the baseline is mimicked by the remaining variables except the price indices, which converge smoothly towards the respective baseline levels. The simulation results show that the model takes around ten years to fully digest the impact of the shock, although much of the adjustment is achieved in a half of that time.

(Insert figure 2 here)

Exchange Rate The effects of a permanent 10 per cent appreciation of the euro are shown in figure 3 and table 3. The appreciation dents the external competitiveness of the economy leading to a short term reduction of output of around 1 per cent below the baseline. In response to the appreciation, the overall price index initiates a downward trajectory towards a permanent lower level relative to the baseline. As expected, the short-term effects of the appreciation are more pronounced on the energy prices component, given the fact that the exchange rate pass through is usually faster and of higher magnitude than in the case of other HICP components¹¹. The unfolding dynamics of output and prices triggers an expansionary response by the monetary authority consubstantiated in a decline of the interest rate relatively to the baseline that reaches approximately 1 per cent one year after the occurrence of the shock. The joint dynamics of output and prices propels a significant decline of nominal wages relative to the baseline.

(Insert figure 3 here)

Foreign Demand The effects of a permanent increase of world demand by 1 per cent are shown in figure 4 and table 3. The overall pattern of the model's response is, in all respects, similar to the dynamics that follow the fiscal shock. That is hardly surprising given the IS-type structure used to model aggregate demand.

(Insert figure 4 here)

¹¹See, for example, Campa and Goldberg (2002).

Oil Price The effects of a permanent 20 per cent rise in the oil price are shown in figure 5 and table 3. As expected, a permanently higher oil price impacts predominantly on the energy component of the HICP. The magnitude of such impact is close to the 10-to-1 ratio. The dynamics that follow the oil price shock are entirely driven by the response of energy prices and so its effects on output and labour market variables are quite small both in terms of size and duration.

(Insert figure 5 here)

4.3.2 Temporary Shocks

With the intent of further exploring the mechanics of the SEAM, we next present the simulation results associated with temporary shocks. The simulations presented here consist of shocking the exogenous variables through the four quarters pertaining to the year of 2004. Bearing in mind the forward-looking nature of the model and that the simulations start in the first quarter of 2003, these shocks can be considered as anticipated. As a consequence, the adjustment of the variables starts even before the occurrence of the shock. As with the permanent shocks, in all simulations analysed, the real variables always return to the baseline within the simulation horizon.

(Insert Table 4 here)

Government Expenditure The effects of a temporary decrease of 1 per cent of GDP in the government expenditure are shown in figure 6 and table 4. As the simulation results show, the adjustment begins before the occurrence of the shock, a feature that is attributable to the agents' forward-lookingness. Due to its temporary nature, the shock generates a short cycle in output, since the correction of the original shock constitutes, as far as the model is concerned, a shock of opposite direction. As a result, the swings in the variables' trajectories relative to the baseline are more pronounced with the temporary shock than with a permanent shock of similar magnitude. Overall, the simulation results suggest that a half-hearted commitment to fiscal consolidation by fiscal authorities generates a perverse effect in the form of macroeconomic volatility.

(Insert figure 6 here)

Exchange Rate The effects of a temporary 10 per cent appreciation of the euro in the year 2004 are shown in figure 7 and table 4. The temporary appreciation of the euro immediately leads to a loss of competitiveness which translates into a fall of real GDP below the baseline. In the same way, the reversion of the shock bolsters external competitiveness and so output, generating a short term cycle in the product market. Consumer prices also decline as a result of the appreciation of the euro, especially those of energy, although with some lag. One interesting feature of the response to this

shock is that, contrary to the case of the permanent shock, prices eventually return to their baseline values, as the shock is reversed and its impact fully absorbed.

Not surprisingly, the initial reduction of prices and output enacts an expansionary monetary policy that conducts the interest rate to a trough of less than one percentage point relative to the baseline in the year the shock occurs, immediately before the moment the shock is undone. Therefore, according to the model's predictions the reaction of the monetary authority is too heavy-handed since, as it can be seen in the figure 7, it magnifies the output cycle engendered by the temporary shock. Part of this behaviour of the interest rate derives from the choice of modelling the monetary policy reaction function as depending on the contemporaneous output gap and not on expected future gaps.

(Insert figure 7 here)

Foreign Demand The effects of a temporary increase of world demand by 1 per cent in 2003 are shown in figure 8 and table 4. The dynamics that precede and follow the occurrence of the temporary shock in foreign demand are much alike those of the government expenditure temporary shock. The anticipation of agents of a future increase in aggregate demand triggers an immediate upwards adjustment of output, which is followed by a correction after the reversion of the shock that overshoots the baseline. Just like with the temporary government expenditure shock, the shortness of the cycle set off by the foreign demand shock produces only a mild reaction of the price indices and the interest rate.

(Insert figure 8 here)

Oil Price The effects of a temporary 20 per cent rise in the oil price in 2003 are shown in figure 9 and table 4. As the simulation results show, a temporary spike of the oil price is a rather featureless event. The overall impact of the shock consists of a short-lived acceleration of energy prices, which prompts only a meager reaction of the remaining endogenous variables of the model.

(Insert figure 9 here)

5 Conclusion

The model presented in this paper is a small-scale macro model designed primarily to convey a dynamic picture of the main macroeconomic interactions in the euro area. As such, the model does not have the richness of full-scale macroeconometric models, as apparent *interalia*, by the absence of a steady-state analogue of the model and also of some relationships important for a better characterisation of the euro area economy. Still, the SEAM has been shown to deliver forecasts that seem reasonable, at least in comparison to those produced by widely regarded international institutions, and responses to shocks that are consistent with conventional wisdom.

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Appendix - Identity Equations

HICP

$$P_t = P_{Dec02} \left[0.076 \left(\frac{PUN_t}{PUN_{Dec02}} \right) + 0.082 \left(\frac{PEN_t}{PEN_{Dec02}} \right) + 0.842 \left(\frac{PSUNEN_t}{PSUNEN_{Dec02}} \right) \right]$$

where the subscript *Dec02* denotes the value of the price indices observed in December 2002, the year immediately before the chosen initial date for the simulation tasks. The weights for each component are the ones used by the Eurostat for aggregating HICP components in 2003.

Output Gap

$$Y_t^{gap} = \frac{Y_t - Y_t^*}{Y_t^*}$$

Unemployment Gap

$$U_t^{gap} = \frac{U_t - U_t^*}{U_t^*}$$

Real Wage

$$RW_t = \frac{W_t}{P_t}$$

Employment

$$E_t = L_t \cdot (1 - U_t)$$

where L_t denotes labour force.

Oil prices in euro

$$OILE_t = \frac{OIL_t}{EUSD_t}$$

Import prices in euro

$$PIME_t = \frac{PIM_t}{EER_t}$$

Productivity

$$PROD_t = \frac{Y_t}{E_t}$$

Unit Labour Costs

$$ULC_t = \frac{W_t}{PROD_t}$$

3-Month Interest Rate

$$I3M_t = i_t^{Taylor}$$

10-Year Interest Rate

$$I10Y_t = I3M_t + 0.007$$

where the 0.007 spread was computed as the ex-post sample mean of the differential between the long and the short interest rates.

Table 1: List of Variables

Acronym	Variables	Status	Source/Description
DX	Proxy for euro area foreign demand ^(a)	Exogenous	Thomson Financial Datastream
E	Total employment	Endogenous	AWM database and ECB
EER	Nominal 'effective' exchange rate index ^(b)	Exogenous	ECB
EUSD	Euro-dollar exchange rate	Exogenous	ECB
G	Nominal Government expenditure	Exogenous	AWM database and Eurostat ^(c)
iT	Taylor interest rate ^(d)	Endogenous	ECB
I3M	Short-term nominal interest rate (3 months)	Endogenous	Brand and Cassola (2000) and ECB ^(e)
I10y	Long-term nominal interest rate (10 years)	Endogenous	Brand and Cassola (2000) and ECB ^(e)
L	Labour force	Exogenous	AWM database and ECB
OIL	Oil prices (in USD per barrel)	Exogenous	Thomson Financial Datastream
P	Overall HICP	Endogenous	Eurostat
PEN	HICP energy	Endogenous	Eurostat
PUN	HICP unprocessed food	Endogenous	Eurostat
PSUNEN	HICP excl. unprocessed food and energy	Endogenous	Eurostat
PIM	Proxy for euro area import prices ^(f)	Exogenous	Thomson Financial Datastream
TT	Terms of trade	Exogenous	Ratio between PIM and HICP
U	Unemployment rate	Endogenous	Ratio between unemployment (L-E) and labour force
U*	Natural rate of unemployment	Exogenous	HP filter
W	Nominal Wages	Endogenous	ECB and AWM database
Y	Real GDP	Endogenous	Eurostat and AWM database
Y*	Potential real GDP	Exogenous	HP filter

Notes: (a) average of real GDP from the U.K., U.S., and Japan, weighted by their share in extra euro area export markets (1995-1997); (b) weighted average of the euro exchange rates vis-à-vis euro area main trading partners currencies (U.K., US, Japan and Switzerland) using import shares (1995-1997); (c) the AWM series was extended with the rate of change of final consumption expenditure of General Government from National Accounts data; (d) ECB's main refinancing interest rate; (e) the Brand and Cassola (2000) series were extended with the 3-months EURIBOR and the 10-year Government bond yield, respectively; (f) weighted average of the exports of goods and services deflator of the four euro area main trading partners (U.K., U.S., Japan and Switzerland) using import shares (1995-1997).

Table 2: Euro Area Forecasts

<i>Annual Average Growth</i>	SEAM			European Commission			OECD			IMF			Eurosystem Staff ^(a)		
	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
HICP	2.1	2.0	1.7	2.1	1.8	1.6	2.1	1.7	1.4	2.1	1.7	1.6	2.1	2.1	1.7
HICP excl. energy	2.0	1.9	1.8	-	-	-	-	-	-	-	-	-	-	-	-
HICP energy	3.0	3.0	0.4	-	-	-	-	-	-	-	-	-	-	-	-
Compensation per employee ^(b)	2.4	2.2	2.3	2.8	2.4	2.3	2.5	2.2	2.2	-	-	-	-	-	-
Unit labour costs	2.0	0.9	0.7	2.4	1.0	1.0	2.1	1.0	0.8	-	-	-	-	-	-
GDP	0.5	1.6	2.5	0.4	1.7	2.3	0.5	1.6	2.4	0.4	1.7	2.3	0.5	1.7	2.2
Employment	0.2	0.3	0.9	0.2	0.5	1.0	0.1	0.4	1.1	0.2	0.5	0.9	-	-	-
Unemployment Rate	8.8	8.7	8.4	8.8	8.8	8.6	8.8	8.8	8.5	8.8	9.1	8.9	-	-	-

Sources: European Commission Economic Forecasts Spring 2004 (April 2004); OCDE Economic Outlook, No. 75 - May 2004; IMF World Economic Outlook, April 2004 and Eurosystem Staff Macroeconomic Projections for the euro area, ECB Monthly Bulletin, June 2004.

^(a) The values presented in the table correspond to the mean of the range reported in the ECB Monthly Bulletin.

^(b) In the case of the OECD, unit labour costs refer to the business sector only.

Table 3: SEAM: Response to Permanent Shocks*Percentage deviations from baseline*

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10
<i>Increase of 1% of GDP in Government Expenditure</i>						
HICP	-0.04	0.03	0.06	0.07	0.07	0.02
HICP excl. un. Proc. Food & energy	-0.05	0.00	0.03	0.07	0.09	0.02
HICP energy	-0.02	0.35	0.35	0.16	0.01	-0.05
Compensation per employee	0.18	0.27	0.23	0.12	0.02	-0.04
Unit Labour costs	-0.23	0.18	0.33	0.16	-0.01	-0.02
Real GDP	0.49	0.29	-0.04	-0.13	-0.04	-0.04
Unemployment rate*	-0.07	-0.18	-0.05	0.08	0.07	0.01
<i>10% Euro Appreciation</i>						
HICP	-0.21	-0.69	-1.17	-1.51	-1.83	-3.05
HICP excl. un. Proc. Food & energy	-0.01	-0.40	-0.92	-1.38	-1.79	-3.14
HICP energy	-2.43	-4.29	-4.87	-4.47	-4.13	-5.14
Compensation per employee	-0.50	-1.27	-1.60	-1.65	-1.71	-3.06
Unit Labour costs	0.36	-0.70	-1.93	-1.93	-1.56	-3.01
Real GDP	-0.95	-1.07	0.02	0.52	0.15	-0.02
Unemployment rate*	0.08	0.46	0.29	-0.21	-0.28	-0.03
<i>1% Increase in Foreign Demand</i>						
HICP	-0.04	0.02	0.06	0.06	0.07	0.04
HICP excl. un. Proc. Food & energy	-0.04	-0.01	0.03	0.06	0.08	0.05
HICP energy	-0.05	0.30	0.37	0.18	0.00	0.03
Compensation per employee	0.15	0.26	0.23	0.12	0.03	0.05
Unit Labour costs	-0.22	0.11	0.33	0.19	-0.02	0.04
Real GDP	0.42	0.34	-0.02	-0.15	-0.03	0.00
Unemployment rate*	-0.05	-0.17	-0.08	0.07	0.08	0.01
<i>20% Increase in International Oil Price</i>						
HICP	0.21	0.28	0.31	0.34	0.38	0.58
HICP excl. un. Proc. Food & energy	0.02	0.06	0.11	0.16	0.21	0.43
HICP energy	2.32	2.75	2.67	2.60	2.67	2.82
Compensation per employee	0.11	0.24	0.29	0.34	0.39	0.57
Unit Labour costs	0.12	0.25	0.34	0.31	0.35	0.57
Real GDP	0.00	-0.02	-0.06	0.01	0.06	0.01
Unemployment rate*	0.00	0.00	0.01	0.02	-0.02	-0.01

* Absolute deviations from baseline.

Table 4: SEAM: Response to Temporary Shocks ^(a)*Percentage deviations from baseline*

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10
<i>Increase of 1% of GDP in Government Expenditure</i>						
HICP	-0.01	-0.04	0.12	0.03	0.00	-0.02
HICP excl. un. Proc. Food & energy	-0.01	-0.07	0.09	0.05	0.04	-0.02
HICP energy	-0.04	0.16	0.57	-0.16	-0.43	-0.04
Compensation per employee	0.09	0.27	0.06	-0.17	-0.23	-0.04
Unit Labour costs	-0.12	-0.18	0.69	0.09	-0.41	-0.08
Real GDP	0.22	0.66	-0.53	-0.57	-0.04	0.01
Unemployment rate [*]	-0.01	-0.19	-0.09	0.29	0.20	0.02
<i>10% Euro Appreciation</i>						
HICP	-0.01	-0.22	-0.51	-0.48	-0.35	-0.22
HICP excl. un. Proc. Food & energy	-0.01	-0.02	-0.41	-0.52	-0.46	-0.25
HICP energy	-0.01	-2.50	-1.98	-0.55	0.54	-0.10
Compensation per employee	-0.12	-0.55	-0.68	-0.24	0.01	-0.22
Unit Labour costs	-0.03	0.33	-1.10	-1.16	0.10	-0.13
Real GDP	-0.09	-1.02	0.02	1.19	0.48	0.01
Unemployment rate [*]	0.01	0.13	0.38	-0.24	-0.52	-0.10
<i>1% Increase in Foreign Demand</i>						
HICP	0.00	-0.04	0.07	0.04	0.00	-0.01
HICP excl. un. Proc. Food & energy	0.00	-0.05	0.05	0.04	0.03	-0.01
HICP energy	-0.01	0.01	0.41	0.01	-0.27	-0.02
Compensation per employee	0.04	0.17	0.09	-0.07	-0.15	-0.01
Unit Labour costs	-0.02	-0.20	0.41	0.19	-0.22	-0.04
Real GDP	0.07	0.47	-0.19	-0.42	-0.11	0.00
Unemployment rate [*]	0.00	-0.09	-0.12	0.15	0.17	0.03
<i>20% Increase in International Oil Price</i>						
HICP	0.00	0.21	0.07	0.04	0.03	0.04
HICP excl. un. Proc. Food & energy	0.00	0.02	0.04	0.06	0.05	0.04
HICP energy	0.01	2.32	0.42	-0.08	-0.06	0.02
Compensation per employee	0.02	0.11	0.11	0.05	0.05	0.03
Unit Labour costs	0.02	0.11	0.12	0.08	-0.03	0.02
Real GDP	0.00	-0.01	-0.01	-0.05	0.08	0.02
Unemployment rate [*]	0.00	0.00	0.00	0.01	0.00	-0.01

^(a) The shock is implemented in the second year of simulation, but given the forward looking nature of the model, the adjustment starts before its occurrence.

* Absolute deviations from baseline.

Figure 1: Baseline
Annual growth rates

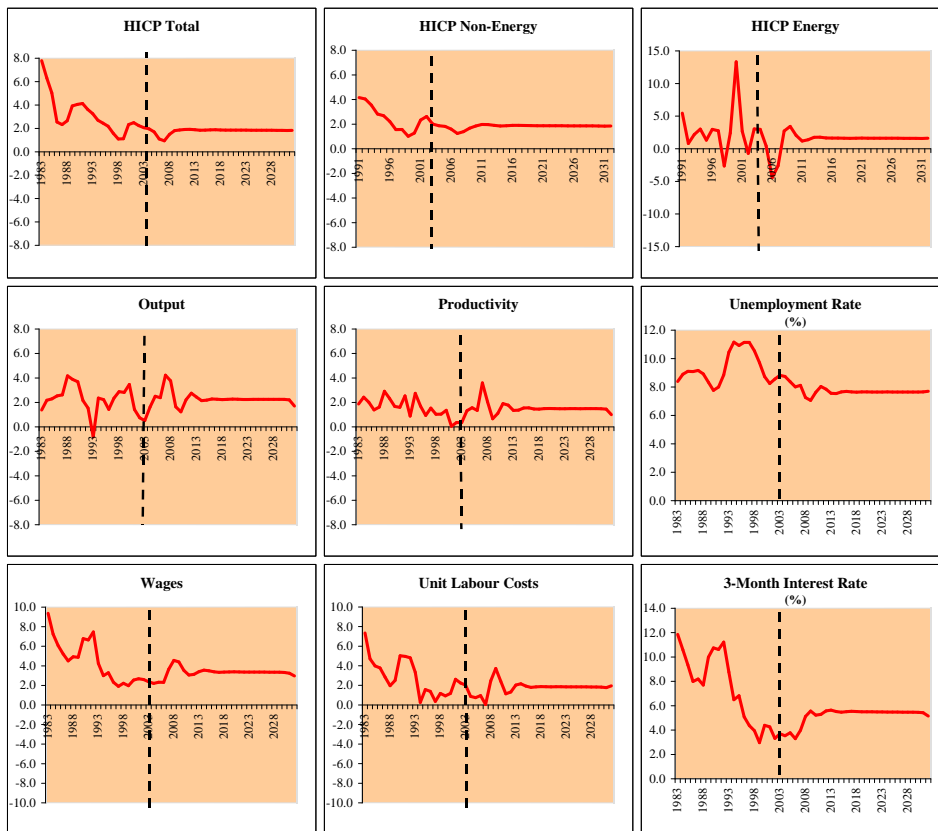
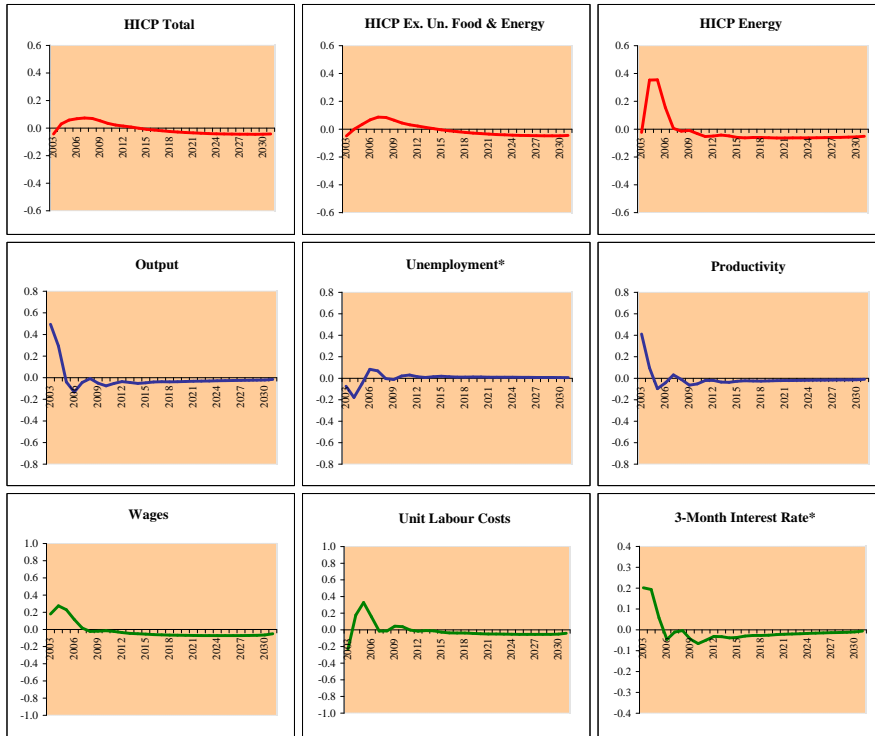
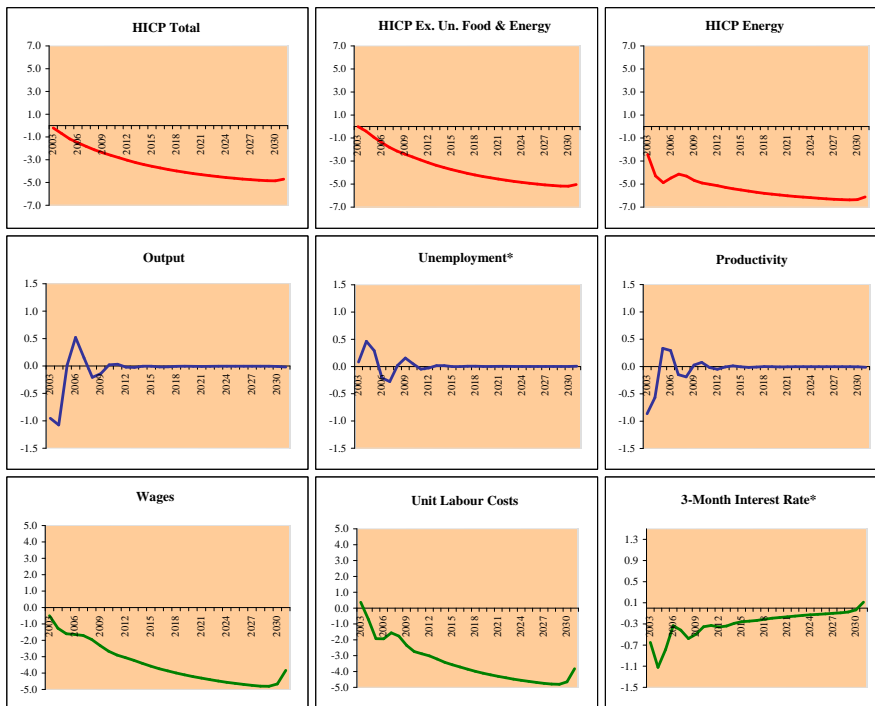


Figure 2: Permanent Government Expenditure Increase of 1 % of GDP
Percentage deviations from baseline



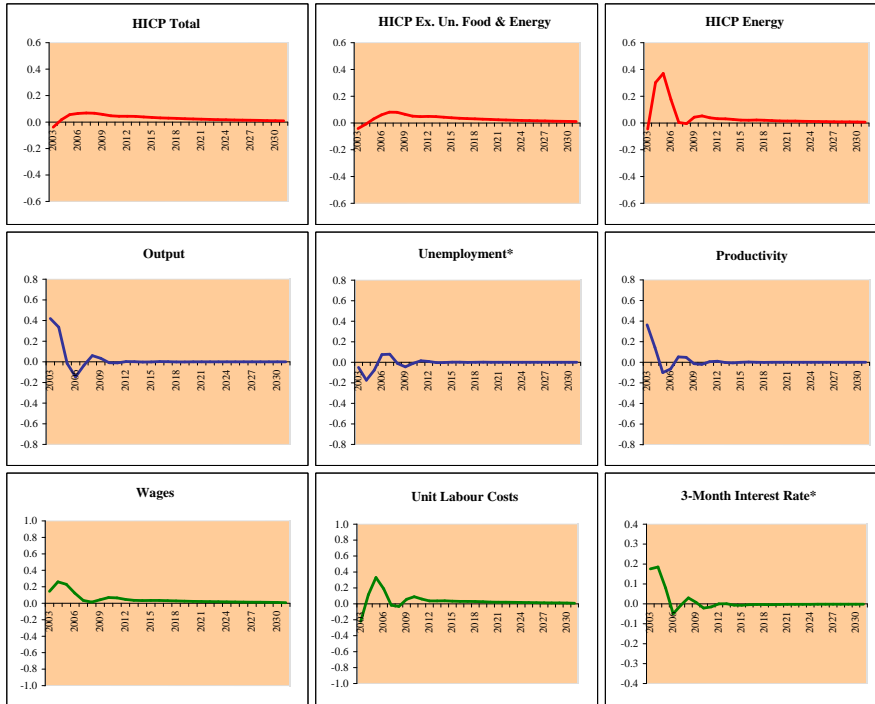
(*) Absolute deviations from baseline in percentage points.

Figure 3: Permanent 10 % Euro Appreciation
Percentage deviations from baseline



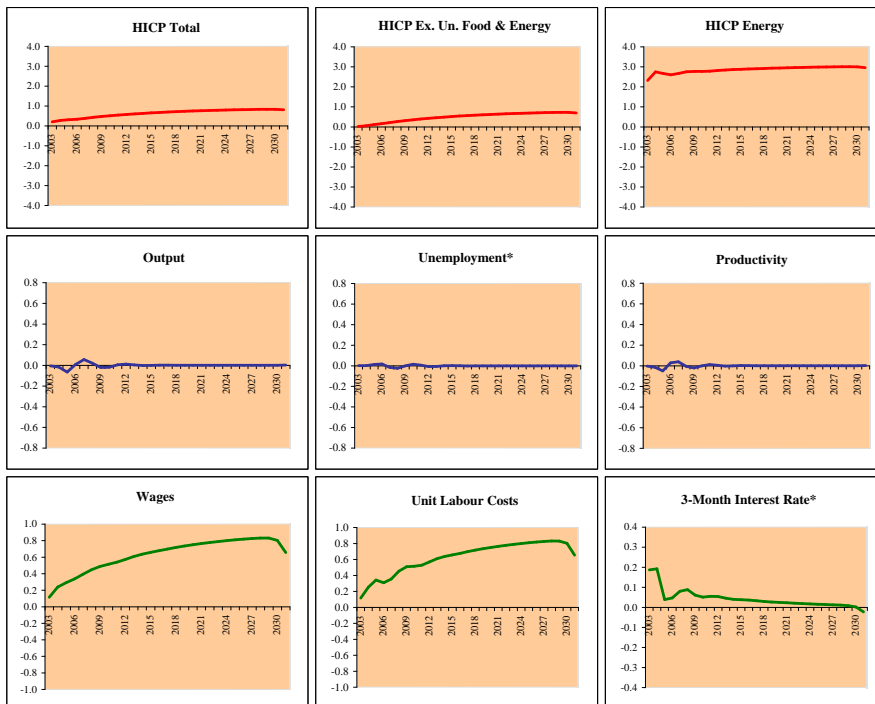
(*) Absolute deviations from baseline in percentage points.

Figure 4: Permanent Foreign Demand 1 % Increase
Percentage deviations from baseline



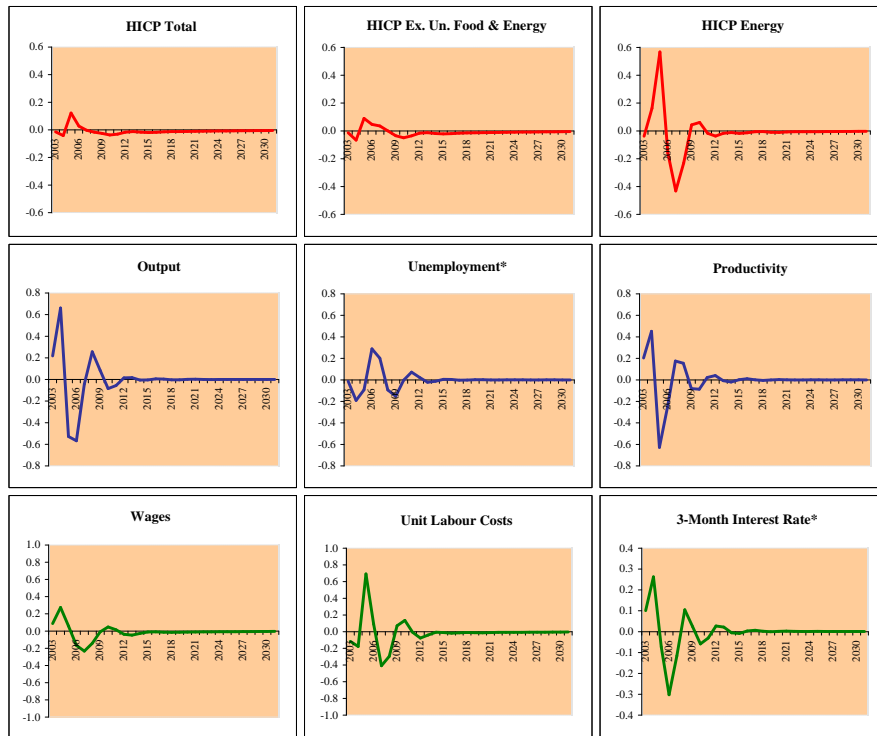
(*) Absolute deviations from baseline in percentage points.

Figure 5: Permanent Oil Price 20 % Increase
Percentage deviations from baseline



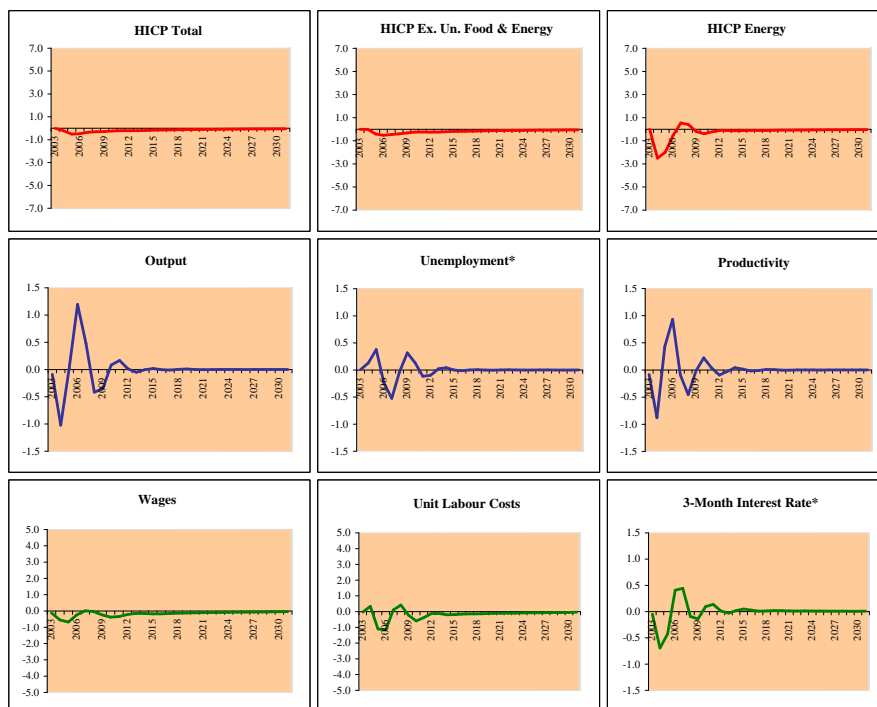
(*) Absolute deviations from baseline in percentage points.

Figure 6: Temporary Government Expenditure Increase of 1 % of GDP
Percentage deviations from baseline



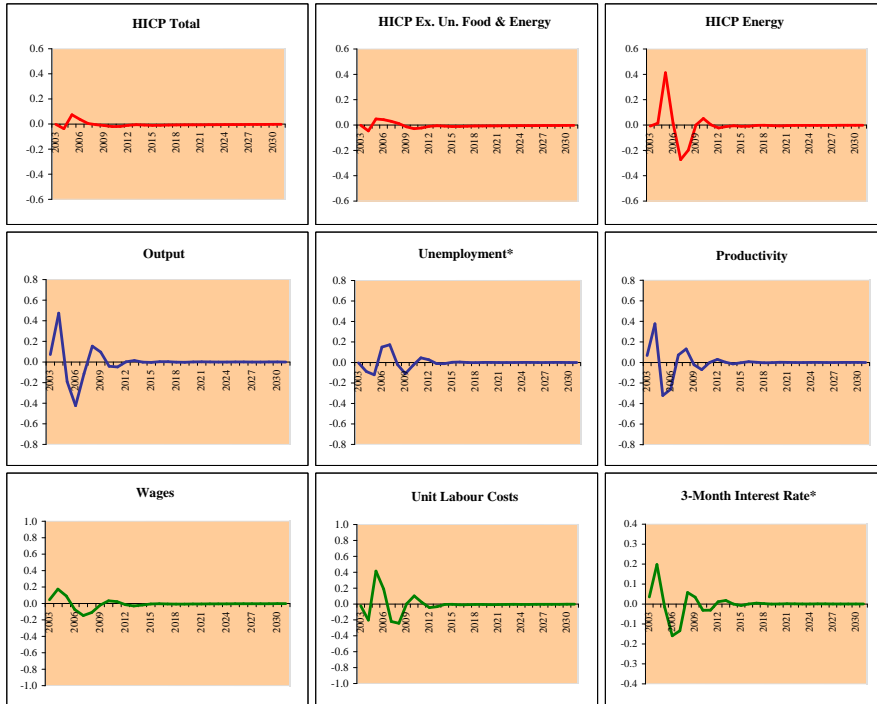
(*) Absolute deviations from baseline in percentage points.

Figure 7: Temporary 10 % Euro Appreciation
Percentage deviations from baseline



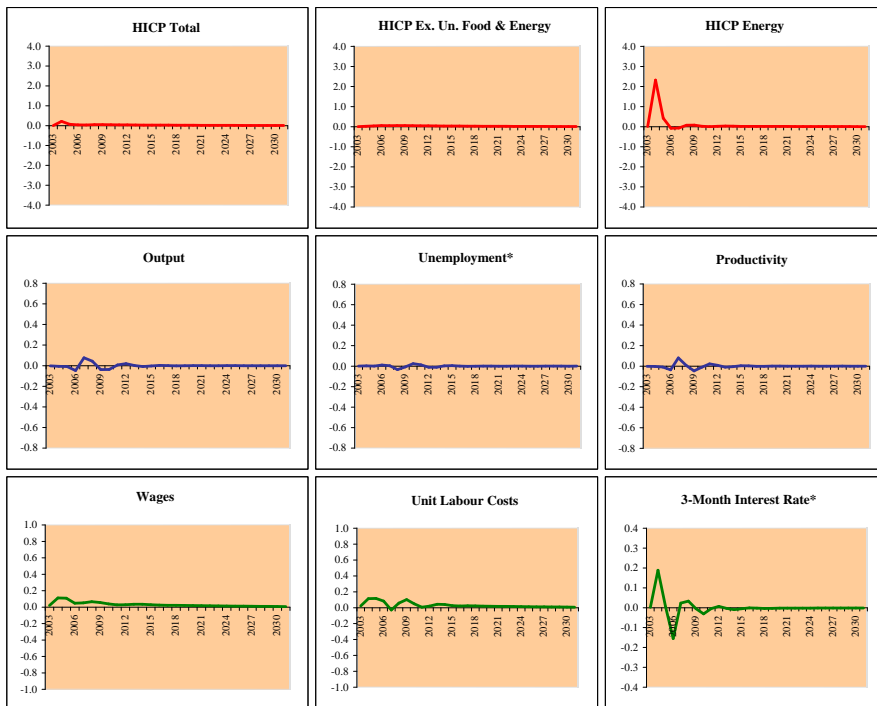
(*) Absolute deviations from baseline in percentage points.

Figure 8: Temporary Foreign Demand 1 % Increase
Percentage deviations from baseline



(*) Absolute deviations from baseline in percentage points.

Figure 9: Temporary Oil Price 20 % Increase
Percentage deviations from baseline



(*) Absolute deviations from baseline in percentage points.