EUROMON: De Nederlandsche Bank’s multi-country model

Maria Demertzis and Peter Van Els and H.M.M. Peeters

De Nederlandsche Bank

2002

Online at https://mpra.ub.uni-muenchen.de/29634/
MPRA Paper No. 29634, posted 21 March 2011 12:40 UTC
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Research Memorandum WO no 718
December 2002

De Nederlandsche Bank
ABSTRACT

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M. Demertzis, P.J.A. van Els and H.M.M. Peeters

The paper presents a guide to the theoretical properties of EUROMON, the Nederlandsche Bank's multicountry model for implementing policy analysis. It is written with a view to expanding Chapter 2 of the DNB Monetary Monograph 19, which provides for a model description. EUROMON is an aggregate neo-Keynesian model where output is described in the long run by a vertical supply curve, but is strongly affected by demand factors in the short run. At the same time, the model incorporates a wage bargaining framework which makes the long-run equilibrium unemployment rate dependent on real factors (for example tax policies and terms of trade). Our future use of the model will require further strengthening of internal theoretical consistencies, including the introduction of forward looking elements. We present four indicative simulations that summarise the properties of the model.

Keywords: Econometric Model Building, EMU, Policy analysis, EUROMON

JEL Codes: C3, C5, E1

SAMENVATTING

EUROMON: Het meerlandenmodel van De Nederlandsche Bank

M. Demertzis, P.J.A. van Els en H.M.M. Peeters

Dit rapport beoogt de theoretische eigenschappen van EUROMON, het meerlandenmodel voor macroeconomische beleidsanalyse van de Nederlandsche Bank, nader in kaart te brengen. Daarbij bouwt het voort op DNB Monetair Monografie nr. 19, waarin een eerdere versie van het model gedetailleerd is beschreven. EUROMON is een nieuw-Keynessiaans model. Op de lange termijn is de productie gegeven door een verticale aanbodscurve, maar op de korte termijn is de vraag vooral bepalend voor de productie. Het model bevat een onderhandelingsmodel voor de loonvorming waarbij de lange-termijn evenwichtswerkloosheid afhankelijk is van reële factoren zoals de belastingdruk, de ruilverkoop en de arbeidsproductiviteit. Het toekomstig gebruik van het model vereist een verdere versterking van de theoretische fundering, waaronder ook het incorporeren van forward looking modelconsistentie verwachtingen wordt begrepen. In het rapport worden de eigenschappen van de huidige modelversie geïllustreerd met behulp van vier simulaties.

Trefwoorden: Econometrische Modelbouw, EMU, Beleidsanalyse, EUROMON

JEL Codes: C3, C5, E1
In the remainder of the paper we focus on the information documented in the DNB’s Quarterly Bulletin. While the appreciation of the model’s potential to inform policy and economic management has increased, the realisation of these results and the extent to which the model’s use towards informed policy and economic management is extended by the model’s appreciation and policy implementation is crucial. The results of these analyses of the DNB’s Quarterly Bulletin indicate that the appreciation of the model’s potential to inform policy and economic management has increased.

EUROMON is the DNB’s macroeconomic multi-country model which was developed in the 1990s. EUROMON is an EUROMON is an EUROMON is an EUROMON is an EUROMON is an EUROMON is an EUROMON is...
2 THEORETICAL PROPERTIES OF EUROMON

Composition

EUROMON is an estimated multi-country model. The current version includes 13 individual country blocks plus a trade block that provides for international linkages. The 13 countries included are most EMU-participants - Germany, France, Italy, Spain, Netherlands, Belgium, Austria and Finland, three EU-countries - United Kingdom, Sweden and Denmark, and finally the United States and Japan. The uses of the model (previously but also currently) necessitated an attempt to capture as many country differences as possible, beyond the country size. These are essential in the policy realm because they 1) enhance our understanding of the Euro area as a whole, 2) help us analyse the role of spillovers between the Euro area and the other large countries/regions in the world economy and, 3) provide an understanding of the ways that countries in the Euro area differ and therefore, anticipate the effects of shocks and policies. To this end, we have made the following choice: country models share the same basic structure but have distinct values of model parameters and speeds of adjustment. In a few cases slightly different specifications of equations are allowed as well, in order to deal with country specific institutional features. The long run properties of the model are for the moment derived only theoretically and we have not examined the long run simulation properties beyond their stability in the medium run. In terms of theoretical structures, the model is in general terms neo-Keynesian, combining a vertical supply curve in the long-run with an important role for demand factors in what determines output in the short-run. The model encompasses a wage bargaining framework which renders the long-run supply curve dependent on real factors, such as tax policies. EUROMON is an aggregate model, with no further breakdown in sectors or categories of goods and services. Country models consist of 25 behavioural equations and 50 identities.

General Features

The current version of the model is backward looking in nature. Expectations are thus treated implicitly, through the inclusion of lags (adaptive expectations). The rationale behind this choice was that the model was originally built to help provide short term forecasts for the main macroeconomic variables of the individual countries and the aggregate Euro area. It was important therefore, to consider macroeconomic series that were able to track the history of the variables as closely as possible. Typically, this is best done when considering autoregressive series. With the adoption of the single currency however, the process of macroeconomic forecasting is centralised at the European Central Bank and there is no urgent need to provide alternative macroeconomic forecasts for the Euro area. EUROMON is therefore now freer to help evaluate policy analysis. To this end, we concentrate more and more on the internal theoretical consistency of the model and less on its ability to provide accurate short-term forecasts. As the model is used more and more for policy simulation analysis we are going to proceed with rational expectations consistent specifications. The latest version of the model discussed here is the result of our first attempt to strengthen its theoretical basis and identify what remains to be done in the future to enhance its consistency further.

Specification

EUROMON has some 1000 equations in total, 330 of which are estimated. The model is estimated using quarterly data over a sample period starting (if available) in 1970 up to 1999. We have applied Ordinary Least Squares in most cases, to estimate single equation systems. Detailed information on individual equations and parameters can be found in De Nederlandsche Bank (2000) or by contacting the authors directly for updated information. The model is constructed with the notion of equilibrium in mind. In other words, representing static economic theory, each equation takes the following form.

\[ Y_t = c + \sum_{i=1}^{m} \gamma_i X_{it} \]

where \( Y_t \) stands for the endogenous variables in the equations and \( X_{it} \) for the explanatory variables. But since the state of variables at any point in time does not necessarily reflect the state of equilibrium, we embed all equilibrium conditions in a dynamic framework and estimate the law of motion towards their equilibrium paths, in the following way.

\[ \Delta Y_t = c - \eta \left( Y_{t-1} - \sum_{i=1}^{m} \gamma_i X_{it-1} \right) + \alpha(\Delta Y_{t-1}) + \sum_{i=1}^{m} \eta_i (L) \Delta X_{it-1} \]

Typically therefore, behavioural equations are modelled within an Error Correction framework where the data is allowed to determine the significant timing of the series.

2.1 Aggregate Supply

Summary 1. Aggregate supply is given by a CES production technology, with two inputs capital and labour. In the long-run, output is determined by the supply of labour (largely exogenous), the equilibrium unemployment rate captured by the NAWRU, and technical progress which is measured by the development of total factor productivity. Equations for labour demand and the capital stock (non-residential) are derived from first-order conditions. Labour demand depends on output and real product wages. Non-residential private investment depends on the real user cost of capital and the capital-output ratio, in line with the CES production technology. The dynamics of investment are also affected by short-run changes in total sales and profitability.

1 The model is written in TROLL code.
Labour demand and Capital Stock

We assume a CES-production function for the non-government sector:
\[ y_{t} = A_{t}e^{ho t + l_{t}} \left( \frac{1}{(1-\delta)k_{t}^{-\rho} + \delta h_{t}^{-\rho}} \right)^{\frac{1}{1-\rho}}, \quad \rho > -1, \quad 0 < \delta < 1 \]
where
\[ A_{t}e^{ho t + l_{t}} \] = total factor productivity
\[ y_{t} \] = business production in real terms, value added at factor costs
\[ k_{t} \] = business capital stock (excluding dwellings) in real terms
\[ h_{t} \] = business employment (in labour hours)
\[ \delta \] = parameter measuring autonomous rate of technology progress
\[ \rho \] = distribution parameter
\[ t \] = deterministic linear trend
\[ c_{t} \] = technology shock, also known as the Solow-residual.

The distribution parameter \( \delta \) measures the degree to which the production technology is labour intensive. Based on conventional terminology, output \( y_{t} \) can be divided into an 'explained' part \( f(k_{t-1}, l_{t}) \) and an 'unexplained' part \( A_{t}e^{ho t + l_{t}} \), identified with total factor productivity. Under profit maximisation, the marginal products for labour and capital move in line with output and real factor prices. The first order conditions, provide the long-run specification of the relationship for labour demand and capital stock, respectively:
\[ \log h_{t} = \beta_{2} + \log y_{t} + \gamma \log \left( \log w_{t} - \log p_{t} \right) - (1 + \sigma) \eta t \]
\[ \log k_{t-1} = \beta_{4} + \log y_{t} + \gamma \log \left( \log w_{t} - \log p_{t} \right) - (1 + \sigma) \eta t \]
with \( \beta_{2} \) and \( \beta_{4} \) constants, \( \sigma = \frac{1}{1+\rho} \) and
\[ \log w_{t} \] = non-government wage rate (per hour)
\[ p_{t} \] = price deflator value added at factor costs (index, 1990=100)
\[ \rho \] = user cost of capital in real terms
\[ t \] = deterministic linear trend.

Hence, the logarithms of the labour-output and capital-output ratios depend linearly on the relative factor costs and a time trend. Investment expenditure adjusts the real capital stock to its 'steady state level' in the long run. The user cost of capital in real terms \( acc \) is defined at a quarterly basis as:
\[ acc = \frac{1}{800} (r_{t2} + r_{t}) - \frac{1}{400} p_{t} + h_{t} + \text{inflation} \]

5 The choice of a CES rather than Cobb-Douglas production function is based on the empirical finding that the real product wage elasticity of labour demand lies between 0 and -1 and may differ between countries.

comprising of a real interest rate, calculated as a weighted average of the long- and short-term interest rate. Further more, we incorporate both the physical capital depreciation rate \( \delta \), as well as a risk premium \( \gamma \), defined here as \( w_{t} \). We formulate the equation for investment from the way capital stocks evolve, i.e.:
\[ k_{t+1} = k_{t} + (1 - \delta)k_{t-1} \]
where
\[ k_{t} \] = business capital stock (excluding dwellings) in real terms
\[ i_{t} \] = business investment in real terms
\[ \delta \] = depreciation rate business capital stock.

The estimated dynamic model equations for labour demand and business investment contain the first-order conditions from the optimisation procedure as error-correction terms. Beyond these however, we also include several other factors that have empirically been proven to affect investment in the short run. First, we include lagged changes in investment to allow for persistence in the investment process. Second, we include changes in real sales, \( s_{t} \), in order to capture possible accelerator effects. Third, changes in the output gap are included to capture potential business cycle effects. Fourth, the existence of any liquidity constraints is taken into account by including a measure of the liquidity position of firms, calculated as changes in the net cash flow deflated by the GDP-price. Last, we include the real change in the interest rate to capture the short run influence of a change in the cost of borrowing.

Estimating the labour demand equation provides values for the long-term parameters \( \sigma \) and \( \eta \), and the substitution parameter \( \rho \). These estimates, denoted \( \hat{\sigma}, \hat{\eta} \) and \( \hat{\rho} \) respectively, are used in calibrating potential output as well as in estimating the business investment equation.

Potential production factors and labour supply

To determine potential output and hence the output gap, we define the stock of potential capital \( k^{*}_{t} \) and potential business employment \( h^{*}_{t} \), as follows: First, \( k^{*}_{t} = kp_{t} \) on the grounds that the actual series does not fluctuate much by itself. Potential employment in the non-government sector is calculated on the basis of the NAWRU, the level of unemployment consistent with constant nominal wage inflation. We have applied the technique described in Bolt and van Els (2000) which in itself uses the Elmeskov (1993) method applied at the OECD to construct a time-varying NAWRU. Potential employment is thus
calculated as:

\[ lb' = y_t l_t (1 - u^N_t) - y_f l_f \]  \hspace{1cm} (6)

where

\[ lb' = \] potential business employment (in labour hours)
\[ y_t = \] annual hours worked per person (in thousands per year)
\[ l_t = \] total labour force (in persons)
\[ u^N = \] NAWRU; non-accelerating wage rate of unemployment (in %)
\[ l_f = \] government employment (in persons).

As equation 6 demonstrates, a lower (higher) natural rate of unemployment leads to higher (lower) potential business employment, for given labour supply. This reflects the increase in excess demand as the natural rate of unemployment falls. Furthermore, potential employment increases with labour supply, (either in persons \( l_t \)) or more working hours per person \( y_t \). For a constant labour supply, a shift from employment in the government sector to the business sector also increases potential employment in businesses. In the current version of EUROMON labour supply is largely exogenous, and is assumed to grow at a constant rate over time. For specific simulation experiments, labour supply can be made to be influenced by real disposable income and discouraged or encouraged worker effects.

Potential production and the output gap

Potential business production is given by:

\[ \log y'_{eb} = -\frac{1}{\delta} \log \left( (1 - \delta) (\hat{\delta} (\delta_l - \delta) + \hat{\delta}) \right) + t f p' \]  \hspace{1cm} (7)

where \( t f p' \) is calculated as the HP-trend of the logarithm of actual total factor productivity. The distribution parameter \( \delta \) is not invariant to units of measurement. To overcome this, we convert the factor inputs to indices, by dividing them by their sample means when measuring potential output and trend total factor productivity. They are denoted \( \hat{\delta}_0 \) and \( \hat{\delta}_l \). Parameter \( \delta \) was approximated by the value of the average wage share in total production during the sample period, denoted \( \hat{\delta} \). The output gap then equals

\[ \text{gap}_p = 100 \left( \log y_{eb} - \log y'_{eb} \right) \]  \hspace{1cm} (8)

The gap is used throughout the model as an indicator of cyclical tensions with respect to price determination, capital formation and imports.

2.2 Aggregate Demand

Summary 2. The three main components of aggregate demand, private consumption, residential and government investment and inventory formation, are determined as follows: Private consumption depends on real disposable household income and real financial and non-financial wealth, with the housing and capital stocks measured at market value. The direct substitution effect is captured by the inclusion of the long-term interest rate in the equation. In the short-run private consumption is also affected by changes in the unemployment rate capturing the role of confidence. Residential investment is determined by real disposable household income, and by real long and short-term interest rates. Government investment is largely exogenous or constant in terms of GDP (optional). Inventory formation acts as a buffer for accommodating shocks in the short-run. Following Fair’s (1984) approach, the inventory stocks-to-sales ratio returns to equilibrium in the long-run. In the short-run deviations may also be caused by changes in real interest rates.

Consumption

Private consumption is derived from a standard model of utility optimisation, whereby households optimise their expected discounted household utility:

\[ \max_{c_t} c_t = \sum_{t=0}^{\infty} \phi^t (C_t) \]

subject to a wealth accumulation constraint (human and financial). Furthermore, the optimisation procedure satisfies the no-Ponzi game condition such that the present value of consumption is equal to total wealth which is the sum of non human wealth and the present value of the stream of labour income anticipated. \( \phi \) is the discount rate and is inversely proportional to the interest rate.

The presence of disposable income at current prices implies that a proportion of households are “liquidity constrained” in the short to medium run. The remaining households’ consumptions however, is determined by both their current but also their longer run wealth position. The inclusion of the interest rate is there to capture the effects of both the initial value of non-financial wealth as well as households’ propensity to consume out of their personal disposable income. The inclusion of the long-term interest rate in the equation captures the direct substitution effect between consumption and savings.

Beyond the theoretical description above there are also a number of variables that enter in the dynamic part of consumption. Changes in unemployment capture a confidence factor and is on the whole an important determinant of current consumption (consistently negative and very significant). The government financial position is also part of financial wealth in as much as the private sector is its owner. Finally, short term interest rates capture the short run effects on the consumption/savings patterns.
Private consumption is for all EUROMON-countries the main component of GDP. It is influenced by household disposable income and by real financial and non-financial net wealth. Net wealth includes the market value of domestic equity but also the market value of the housing stock. Linear homogeneity in both income and net wealth is such that a 1% increase in both income and wealth leads, ceteris paribus, to a 1% increase in real consumption. In the short-run private consumption is also affected by changes in the unemployment rate.

\[
\log c_t = \beta_0 + \beta_1 \log \frac{PDI}{p_t} + (1 - \beta_1) \log \frac{NW_{AV}^c}{P_t} - \beta_2 r_s + \beta_3 (\gamma_s - p_t) \beta_5 (\gamma_s - p_t) - \beta_5 (\gamma_s - p_t)
\]  

(9)

where

\[
\begin{align*}
  c & = \text{private consumption in real terms} \\
  PDI & = \text{personal disposable income} \\
  p & = \text{price deflator private consumption (index, 1990=100)} \\
  NW_{AV} & = \text{net financial wealth private sector at market values} \\
  r_s & = \text{nominal short-term interest rate (in %)} \\
  \gamma_s & = \text{nominal long-term interest rate (in %)} \\
  p & = \text{inflation (in %)}.
\end{align*}
\]

**Residential Investment**

In deciding the general features of the model, we have made the choice to consider residential investment as part of aggregate demand. This choice is based on two reasons, the first being that we do not view investment in housing as part of the productive process, in the sense that houses are not inputs in the same way machinery are; and second we consider it to have a direct and significant impact on households' consumption. Government investment is largely exogenous or constant in terms of GDP (optional).

In a similar way to private consumption, housing investment depends on real personal disposable income and the real interest rate. The long-term interest rate captures the cost of housing investment except in the case of the UK where housing investment depends on variable mortgage rates.\(^5\) Hence, for the UK the short-term interest rate is used as an explanatory variable.

\[
\log i_t = \log \frac{PDI}{p_t} + \beta_0 (\gamma_s - p_t)
\]  

(10)

where

\[
\begin{align*}
  i_t & = \text{housing investment in real terms} \\
  PDI & = \text{personal disposable income} \\
  p & = \text{price deflator private consumption (index, 1990=100)} \\
  \gamma_s & = \text{nominal long-term interest rate (in %)} \\
  p & = \text{inflation (in %)}.
\end{align*}
\]

The housing stock, that plays a role in determining private sector wealth, accumulates in a similar way to non-residential capital:

\[
k_{t+1} = k_t + (1 - \kappa) k_{t-1}
\]

where

\[
\begin{align*}
  k_t & = \text{housing stock in real terms} \\
  i_t & = \text{housing investment in real terms} \\
  \kappa & = \text{depreciation rate of housing stock}
\end{align*}
\]

**Inventory formation**

Instead of modelling inventory formation as a separate behavioural equation, we adopt Fair's (1984) approach. An equation for total final expenditures, \(y_t\), defined as the sum of total sales (determined by the sum of private consumption, investment, non-wage government spending, plus exports) and the change in inventory stocks, is postulated and estimated. Following Fair (1984) the long-run specification of the relationship for total final expenditures is

\[
y_t = \beta_0 + \beta_1 s + \beta_2 v + \beta_3 \text{dum}_t + \beta_4 v_{t-1}.
\]  

(11)

where

\[
\begin{align*}
  y_t & = \text{total final expenditures in real terms} \\
  s & = \text{sales in real terms} \\
  v & = \text{inventory stock in real terms} \\
  \text{dum} & = \text{dummy equal to 1 from 1980 or 1985 onwards, 0 otherwise} \\
  t & = \text{deterministic linear trend}.
\end{align*}
\]

Several elements underlie the Fair approach. First, it is assumed that there is some optimal ratio of the inventory stock to total sales. This ratio may be time-dependent to reflect technological changes in inventory management. Second, inventory formation depends on the discrepancy between the desired stock of inventories and the actual stock at the end of the previous period (allowing therefore, for the lagged inventory stock enters the equation). Third, it is assumed that due to costs of adjustment there is a tendency to smooth total final expenditures relative to total sales, confirmed by the estimation results. In
the short-run fluctuations in inventories may also be caused by changes in real interest rates. Inventory formation then follows from

$$\Delta v_t = y_{t+1} - s_t$$

and the inventory stock itself, as the accumulation of the changes in inventory stock, i.e.

$$v_t = v_0 + \Delta v_t$$

Foreign Trade

In defining export and import volumes, we assume that domestic and foreign goods are not perfect substitutes. This implies that the volume of exports will depend on world demand and competitiveness captured by relative export prices (competitors’ export prices relative to domestic export prices). Similarly, imports depend on final demand captured by total sales and the output prices of foreign competitors relative to domestic prices.

The long-run relationship for exports of goods and services is therefore specified as follows:

$$\log x_t = \log m^x + \beta_x \log m^x + \beta_x \frac{p^x_s}{p^x_s}$$

where

- $x$ = exports of goods and services in real terms
- $m^x$ = relevant world trade (index, 1990=100)
- $p^x_t$ = price deflator exports of goods and services (index, 1990=100)
- $p^x_s$ = foreign export price (index, 1990=100).

Real imports of goods and services change as sales and relative import prices vary:

$$\log m_t = \log s_t + \beta_m \log p^{m/s}_t$$

where

- $m_t$ = imports of goods and services in real terms
- $s_t$ = sales in real terms
- $p^{m/s}_t$ = price deflator imports of goods and services (index, 1990=100)
- $p^s$ = price deflator gross domestic product (index, 1990=100).

The long-run import price equation is described as follows:

$$\log p^{m/s}_t = \beta_{p^m} \log p^{x^*}_t + \beta_{p^m_2} \log p^{x^*}_t + (1 - \beta_{p^m - \beta_{p^m_2}}) \log P^{x^*}_t$$

with

- $p^{x^*}_t$ = price deflator imports of goods and services (index, 1990=100)
- $p^{x^*}_t$ = weighted import price (in national currency, index, 1990=100)
- $p^{x^*}_t$ = commodity prices including oil (in national currency, index, 1990=100)
- $o_{out}$ = nominal exchange rate, domestic currency per USD
- $P^{x^*}_t$ = GDP deflator at factor costs (index, 1990=100).

The current version of the model has pricing to markets for imports appearing only as a short-run
phenomenon. This implies that in most cases $\beta_{\text{rent1}} + \beta_{\text{rent2}} = 0$ and domestic prices as well as unit labour costs affect prices only the short-run. We plan to apply this in the long run as well in our future work.

Wages and prices

EUROMON embeds a collective bargaining model of wage and price determination, in which it is possible to derive an expression for the Non-Accelerating Inflation Rate of Unemployment (NAIRU) from the core supply side. This is very similar to the process described in Layard et al. (1992). Workers are assumed to seek a given real consumption wage that satisfies their aspirations, whereas firms are seeking to achieve a given mark-up over costs. These competing claims may not be consistent. Only when unemployment is at its equilibrium level, are competing claims reconciled and is inflation stable. The long-run wage setting in EUROMON, suppressing for convenience’s sake the logarithms, is given by:

$$w_R = \kappa_p + (1 - \kappa)\beta_p + \gamma_R - \gamma_R \kappa + \gamma_R \kappa \tau.$$  

(18)

where $w_R, p_R, \beta_p, \gamma_R$ are the non-government wage rate, the consumer expenditures deflator, the value added deflator at factor cost and average labour productivity, $\kappa$ is the unemployment rate (in levels) and $\tau$ is a proxy for the incidence of direct taxation on the wage rate. This equation can be interpreted as the equilibrium level for consumption wage satisfying workers’ aspirations. With respect to pricing behaviour, the consumer expenditures deflator is determined as a mark-up on import and unit labour costs, allowing for long run indirect tax effects ($\gamma_{\text{ind}}$ represents the indirect tax wedge term between consumer and producer prices.):

$$p_R = \gamma_{\text{ind}} (w_R - \lambda p_R) + (1 - \gamma_{\text{ind}}) p_R + (1 + \gamma_{\text{ind}}).$$  

(19)

The equation representing the equilibrium level for producer prices reads as follows:

$$p_R = p_R - (1 + \gamma_{\text{ind}}).$$  

(20)

The level of unemployment which reconciles firms’ and unions’ real claims can thus be determined by solving for the equilibrium levels of wages and prices. Combining the import price equation and the three equations above yields the following equation for the equilibrium level of unemployment:

$$\kappa = \frac{1}{\gamma_{\text{ind}}} \left\{1 - \gamma_{\text{ind}} (\beta_p - \beta_p) + (1 + \gamma_{\text{ind}}) + \gamma_R \kappa \tau \right\}.$$  

(21)

There are two distinct advantages in applying this formulation. The first is that the natural rate of unemployment is now a function of the real exchange rate and tax wedge terms. This process endogenises the supply side of the model. The second advantage is that this specification can be re-arranged to solve for an explicit Phillips Curve in which wages and prices are equal to their anticipated values, the actual level of unemployment is equal to this equilibrium value.\(^6\)

\(^6\) Although the model solves for the NAIRU implicitly, the simulations performed in actual fact make use of the natural rate derived through Elmestad’s procedure as described in the Aggregate Supply section. This is an inconsistency that we plan to amend in our future work on the model.

2.4 Government Sector

Government revenues

The government sector is treated in some detail. At the revenue-side income taxes, social security premiums, corporate taxes and indirect taxes are all modelled separately. Direct taxes on personal income are the product of an average tax rate and a tax base, consisting of the wage sum and other household income including net transfers received from the government (net of social security contributions paid to the government). Likewise, corporate taxes are the product of the corporate tax rate and a tax base which equals cash flow net of depreciation allowances and interest payments by firms. Indirect taxes are linked to private consumption.

Government expenditures

Five expenditure categories are distinguished: wages, non-wage government consumption and investment, transfers, interest payments on government debt, and other expenditures. Government employment is exogenous, whereas government wages move in line with private sector wages. Non-wage government consumption and government investment are either fixed in real terms or move in line with real GDP. Basically, government transfers are a constant fraction of GDP, unless unemployment moves. If unemployment rises, transfers increase relative to GDP. Other government expenditures are constant in terms of GDP.

Fiscal solvency

In the current model version fiscal solvency is implemented by targeting the government deficit-to-GDP ratio, using personal income tax rates as instruments. However, in principle expenditure categories could also be used for stabilising government finances in the long run.

2.5 Monetary and Financial Sector

Summary 4. The three-month short-term interest rate plays the role of the instrument of monetary policy. Various feedback rules, such as the Taylor-rule, are optional. The monetary and financial sector of the model consists further of behavioural equations for long-term interest rates, broad money (M3), bank loans to the private sector, and equations for exchange rates and equity and house prices. Long-term interest rates depend on short rates and potentially on other variables such as inflation and government financial balances. Various options for modelling long rates may be considered. Money demand is homogenous in income and private sector net financial wealth, and furthermore depends on short and long-term interest rates and inflation. The demand for bank loans in the long-run is determined by
the condition that interest payments on bank loans evolve in line with nominal income. Note that M3 and bank loans are not fully recursive. Changes in both feed into aggregate demand via the income channel of monetary transmission. This effect is however typically small. Exchange rates may be fixed in real terms, or be determined by use or by a combination of long-term ppp and short-term use. Equity prices depend on profitability and interest rates, and real house prices are determined by real disposable income relative to the housing stock, real interest rates and the relative price of residential investment. Equity and house prices affect private consumption via endogenous private sector net wealth measured at market value.

Short-term interest rates

The main instrument of monetary policy in EUROMON is the three-month short-term interest rate. In the current version of the model it may be treated as an exogenous variable or may follow from a policy instrument feedback rule. Possible rules include fixed real interest rates, strict or flexible inflation targeting (Taylor rule), and money growth targeting. EMU, US, UK and Japan have an independent monetary policy. For the sake of brevity we now only focus on the Taylor rule (ignoring constants):

\[
r_{t+1} = \rho r_{t+1} \Delta + \left(1 - \rho\right)\frac{\Delta \theta}{\Delta} + \theta \Delta \text{gap}
\]

(22)

where

\[
\begin{align*}
\rho &= \text{nominal short-term interest rate (in \%)} \\
\Delta \theta &= \text{weight on the inflation target in the interest rate rule} \\
\theta &= \text{inflation (in \%)} \\
\Delta \text{gap} &= \text{inflation target (in \%).} \\
\text{gap} &= \text{weight on output gap in the interest rate rule} \\
p &= \text{output gap (in \%)}. \\
\Delta &= \text{degree of policy smoothing}
\end{align*}
\]

Although Denmark and Sweden are not EMU members, their policy-controlled interest rate is assumed to follow that of the euro-area.

Long-term interest rates

European countries' long-term interest rates (10 year government bond rate) have converged within Europe since the beginning of the 1980s. This has been the result of international capital market liberalisation and, for the more recent past, the advent of EMU. Three modelling options are available for long-term interest rates. The first allows for an empirical explanation from short rates, inflation rates and government financial balances. The second adheres strictly to a backward looking term structure. The third allows for a forward looking term structure relationship.

OPTION 1

With reference to the first approach, the long-term interest rates in Germany (superscript DE), the UK and Japan are assumed to be affected in the long run by their US or German counterparts, the domestic short-term interest rate, the domestic inflation rate and by domestic government financial balances as a percentage of GDP, i.e.

\[
r_{i} = \beta_{1} r_{DE} + \beta_{2} r_{DE} + \beta_{3} \left(\frac{\Delta g_{i}}{\Delta g_{i}}\right) + \beta_{4} \Delta g_{i} + \beta_{5} GFBY
\]

(23)

where

\[
\begin{align*}
\rho &= \text{nominal long-term interest rate Germany, UK, Japan or US} \\
\Delta &= \text{US nominal long-term interest rate (in \%)} \\
\Delta &= \text{German nominal long-term interest rate (in \%)} \\
\Delta &= \text{nominal short-term interest rate Germany, UK, Japan or US (in \%)} \\
\Delta &= \text{inflation Germany, the UK, Japan or the US (in \%)} \\
GFBY &= \text{government financial balance ratio (\% GDP)}
\end{align*}
\]

The German long rate is partially explained by the US long rate in the long run, so that \(\beta_{1} \neq 0\) and \(\beta_{2} = 0\). The UK and Japanese long rates are explained by both the German and the US long rate, so \(\beta_{1} \neq 0\) and \(\beta_{2} \neq 0\). The US long rate, however, dominates world capital markets, so that for the US \(\beta_{1} = \beta_{2} = 0\). Equations for all remaining European countries have been estimated over the sample period covering the last two decades. We attempt to explain each country's long-term interest rate differential with Germany in terms of short-term interest differentials, inflation differentials and differentials in government financial balances, as a proportion of national GDP as explanatory factors, i.e.

\[
r_{DE} - r_{DE} = \beta_{6} \left(\frac{\Delta g_{i}}{\Delta g_{i}}\right) + \beta_{7} \Delta g_{i} + \beta_{8} \left(\frac{\Delta g_{i}}{\Delta g_{i}}\right) + \beta_{9} \left(\frac{\Delta g_{i}}{\Delta g_{i}}\right) + \beta_{10} \left(\frac{\Delta g_{i}}{\Delta g_{i}}\right)
\]

(24)

OPTION 2

As a second option, long-term interest rates can be specified as a backward looking term-structure rule. This is specified, like in NIGEM, as

\[
\Delta r_{DE} = 0.8 \Delta r_{DE} + 0.2 \left(\frac{\Delta g_{i}}{\Delta g_{i}}\right) + 0.5
\]

OPTION 3

The long-term interest rate can also be forward looking. In this case the long rate follows the current and future three-month rate over a period of 40 quarters (i.e. 10 years) as a geometric average (see also
(log \left(1 + \frac{r_{ss}}{100}\right) = \frac{39}{40} \sum_{i=3}^{39} \log \left(1 + \frac{r_{x+i}}{100}\right). \quad (26)

\textbf{Broad money}

This equation is based on a standard model in which the demand for real money holdings depends in the long run on a measure of output and a vector of returns on various assets \( R \), i.e. Beyond these, inflation enters as the opportunity cost of holding money rather than real assets and allows for explicit testing of long-run price homogeneity of money demand (see Coenen and Vega, 1999 and Fafre, 1998). In practice we model the demand for broad money in the long run using the following regressors: 1) real GDP as a measure of the volume of transactions, 2) net financial wealth to reflect the portfolio role for money\(^7\), and 3) short- or long-term interest rates and inflation. The specification of the long-run relationship therefore reads:

\[
\log \frac{M3}{Pc} = \beta_{M1} \log Y_t + (1 - \beta_{M1}) \log \frac{NW}{Pc} + \beta_{M2} r_{ss} + \beta_{M3} r_{ss} + \beta_{M4} Pc \\
\quad \text{where} \\
M3 & = \text{broad money} \\
Pc & = \text{price deflator private consumption (index, 1990=100)} \\
y & = \text{gross domestic product in real terms} \\
NW & = \text{net financial wealth private sector} \\
r_{ss} & = \text{nominal short-term interest rate (in \%)} \\
r_{ss} & = \text{nominal long-term interest rate (in \%)} \\
Pc & = \text{inflation (in \%)}.
\]

Linear homogeneity is assumed in real GDP and real net financial wealth, implying that as they increase by 1 percent, the real money demand increases also by 1 percent. The short-term interest rate has a positive and significant effect on money demand because the latter is measured in a broad sense which includes short-term savings deposits. An increase (decrease) in the short-term interest rate raises (lowers) the demand for these deposits. Long-term interest rates and inflation, on the contrary, affect money demand negatively. For some countries we also allow for the effect of the output gap in the short run, to reflect potential additional cyclical effects on the demand for money (precautionary savings motive).

\textbf{Bank credit to the private sector}

As part of total private sector financial assets, outstanding bank credit to the private sector consists of mortgages and of corporate and other loans to households and businesses. Credit is assumed to depend

\(\text{on the disposable income of households, the cash flow of firms and the level of interest rates. Here, the long-run relationship is specified as}

\[
\log CRD = \log (PDL - OL + CF - T_{lob}) - \log \left(1 + \frac{1}{1600} \sum_{i=3}^{39} (\Omega_{CROD} \Omega_{CROD} (1 - \Omega_{CROD}) r_{ss-i})
\quad \text{where}
\begin{align*}
CRD & = \text{bank credit to private sector} \\
PDL & = \text{personal disposable income} \\
OL & = \text{other household income} \\
CF & = \text{cash flow} \\
T_{lob} & = \text{corporate taxes} \\
r_{ss} & = \text{nominal long-term interest rate (in \%)} \\
r_{ss} & = \text{nominal short-term interest rate (in \%)} \\
\Omega_{CROD} & = \text{share long-term credit in total bank credit to businesses} \\
\Omega_{CROD} & = \text{share long-term credit in total bank credit to households} \\
\Omega_{CROD} & = \text{share businesses in total bank credit to private sector} \\
\end{align*}
\]

The assumption underlying this relationship is that total interest payments on credit as a percentage of household and business sector income is constant in the long term. The relevant interest rate is constructed as a weighted average of the long- and short-term interest rates and its long-run elasticity assumed to be \(-1\).

\textbf{Exchange rates}

Different options are available with respect to the exchange rate. We distinguish three options here: fixed real exchange rates, a combination of UIP and long-run PPP (backward looking), and forward looking UIP. The exchange rates of the euro, the pound sterling and the yen vis-à-vis the dollar are therefore, modelled as follows:

\[
\Delta \log e_{DOL} = \Delta \log P_{CER} - \Delta \log P_{DOL} \\
UIP/PPP \quad \log e_{DOL} = \beta_0 + \beta_1 \log e_{DOL,t-1} + (1 - \beta_1) \log \left(P_{CER}/P_{DOL}\right) \\
\quad \text{where} \\
\quad (r_{ss} - r_{ss}^*)_t + \beta_1 (r_{ss} - r_{ss}^*)_{t-1} \\
UIP-forward \quad \log e_{DOL} = \log e_{DOL,t-1} - \frac{1}{2} \log \left(1 + \frac{\Delta r_{ss}}{100}\right) + \frac{1}{2} \log \left(1 + \frac{\Delta r_{ss}}{100}\right) \\
\]

\(\text{The two are constrained to have a total elasticity of one for the purposes of identifying a good fit.}\)
\( \epsilon_{DOL} \) = nominal exchange rate, domestic currency per USD

\( \pi_e \) = inflation (in %)

\( \pi_e^{US} \) = inflation US (in %)

\( r_f \) = nominal short-term interest rate (in %)

\( r_f^{US} \) = nominal short-term interest rate US (in %).

**Equity prices**

The equity price for each country in EUROMON is explained by a long-run relationship combining the GDP-deflator, the labour income share measured as the share of private sector wages in gross value added of businesses at factor costs and the nominal long-term interest rate. So,

\[
\log(p_{eq}) = \log(p_{eq}) + \beta_{eq1} \ln I + \beta_{eq2} r_f
\]

where

\( p_{eq} \) = equity price (index, 1990=100)

\( p_{eq} \) = price deflator gross domestic product (index, 1990=100)

\( I \) = business labour income share

\( r_f \) = nominal long-term interest rate (in %).

The equity price is assumed to be homogeneous in the GDP-deflator \( p_{eq} \), to avoid price level shifts affecting real equity returns in the long run. Labour income share \( I \) is assumed to affect the equity price negatively. The higher the labour income share the lower the profitability in the business sector. If profitability decreases, equity prices fall, so \( \beta_{eq1} < 0 \). The long-term interest rate serves as a proxy for the required yield on equity with a negative impact on equity prices, so \( \beta_{eq2} < 0 \). Equity prices across EMU-countries and the US have displayed a strikingly similar pattern. For this reason the estimated effects in the long-run relationship have been assumed to be equal across countries, by imposing cointegration restrictions on parameters \( \beta_{eq1} \) and \( \beta_{eq2} \). Short-term effects and adjustment speeds towards the long-term relationship may however differ across countries.

**House prices**

The housing market is characterized by an inelastic supply curve and house prices are mainly influenced by demand factors. As the main determinant of financing opportunities, personal disposable income is an important determinant of house prices. Furthermore, equity prices are used as a short-run indicator of private wealth and provide an alternative measure of purchasing power. Mortgage opportunities are dependent on both the short-term as well as the long-term interest rates.

On the supply side, there are two important determinants; first, the housing stock which naturally deter-
3 SIMULATION PROPERTIES

EUROMON's system properties are analysed by conducting four simulation experiments:
- A two-year 100 basis points decrease in the euro area short-term interest rate.
- A one-year 1% increase in prices in the euro area.
- A one-year 1% increase in wages in the euro area.
- A permanent 1% in GDP terms increase in government expenditure in the euro area.

Simulations are based on a standard Taylor rule with no smoothing, the backward looking term-structure rule for the determination of long-term interest rates (OPTION 2) and a combined UIP/PPP exchange rate rule. The results of these experiments for the aggregate euro area are presented in Tables 1 through 4 below. The main results are summarised as follows. The two-year 100 basis points decrease in short-term interest rates (shown in Table 1) triggers moderate aggregate effects on output and prices in the euro area. In the short-run, the depreciation of the exchange rate affects the competitiveness of euro-area producers beneficially as it helps increase exports. Lower interest rates also increase private consumption. Stronger demand and lower user cost of capital help boost investment. Positive international spillovers also contribute to the size of the output gain, in the short-run domestic prices increase because of higher import prices. The increase in unit labour costs in the medium term in response to lower unemployment generates some further price increases.

The arbitrary increase in prices (see Table 2) leads to lower real wages and therefore, reduces consumption. Monetary policy reacts to counteract the increase in prices (seen in the increase of interest rates) contributing further to the reduction in output and employment. Further, as prices increase exporters suffer, but imports soon follow as income reduces.

We experiment also with a similar increase in wages (see Table 3). The effects are very similar to what we described above, expect the pass through from prices to wages is quicker and bigger than the reverse. Accordingly, monetary policy is less reactive to the observed price increases.

The permanent 1% GDP increase in government expenditures on goods and services is followed by a drop in unemployment and positive accelerator effects on investment. The rise in output and, as from year 2, inflation is followed by higher (real) short-term and long-term interest rates. As the fiscal sovereignty rule is imposed, tax rates increase to counteract the increase in the government deficit. This leads to a reduction in private consumption and investment from year 4 onwards. In the medium term, price rises are fairly large and partly pushed by higher wage demands because of increases in income tax rates.

Table 1
Effects of a two-year 100 basis points decrease in short-term interest rates
Cumulative changes in percentages, unless otherwise stated

<table>
<thead>
<tr>
<th>Euro area</th>
<th>Result 1</th>
<th>Result 2</th>
<th>Result 3</th>
<th>Result 4</th>
<th>Result 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real gross domestic product</td>
<td>0.17</td>
<td>0.53</td>
<td>0.63</td>
<td>0.40</td>
<td>0.29</td>
</tr>
<tr>
<td>Real private consumption</td>
<td>0.28</td>
<td>0.47</td>
<td>0.67</td>
<td>0.27</td>
<td>0.35</td>
</tr>
<tr>
<td>Real gross investment (net savings)</td>
<td>0.88</td>
<td>2.01</td>
<td>2.41</td>
<td>1.96</td>
<td>0.81</td>
</tr>
<tr>
<td>Real investments in dwellings</td>
<td>0.22</td>
<td>0.65</td>
<td>1.54</td>
<td>1.46</td>
<td>0.23</td>
</tr>
<tr>
<td>Real exports of goods and services</td>
<td>0.08</td>
<td>0.34</td>
<td>0.41</td>
<td>0.33</td>
<td>0.69</td>
</tr>
<tr>
<td>Real imports of goods and services</td>
<td>0.05</td>
<td>0.46</td>
<td>1.04</td>
<td>1.15</td>
<td>0.94</td>
</tr>
<tr>
<td>Output gap</td>
<td>0.20</td>
<td>0.53</td>
<td>0.51</td>
<td>0.21</td>
<td>0.24</td>
</tr>
<tr>
<td>Business employment</td>
<td>0.24</td>
<td>0.52</td>
<td>0.45</td>
<td>0.48</td>
<td>0.36</td>
</tr>
<tr>
<td>Unemployment rate (as % of labour force)</td>
<td>0.02</td>
<td>0.17</td>
<td>0.24</td>
<td>0.27</td>
<td>0.29</td>
</tr>
<tr>
<td>Business labour productivity</td>
<td>0.15</td>
<td>0.37</td>
<td>0.19</td>
<td>0.27</td>
<td>0.15</td>
</tr>
<tr>
<td>Wage gap (nominal)</td>
<td>0.01</td>
<td>0.12</td>
<td>0.39</td>
<td>0.64</td>
<td>0.53</td>
</tr>
<tr>
<td>Unit labour cost</td>
<td>0.14</td>
<td>0.35</td>
<td>0.14</td>
<td>0.66</td>
<td>1.09</td>
</tr>
<tr>
<td>Private consumption deflator</td>
<td>0.62</td>
<td>0.69</td>
<td>0.24</td>
<td>0.46</td>
<td>0.79</td>
</tr>
<tr>
<td>Export deflator</td>
<td>0.07</td>
<td>0.14</td>
<td>0.11</td>
<td>0.16</td>
<td>0.32</td>
</tr>
<tr>
<td>Import deflator</td>
<td>0.01</td>
<td>0.01</td>
<td>0.03</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Gross domestic product deflator</td>
<td>0.01</td>
<td>0.00</td>
<td>0.02</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Inflation (consumer prices, percentage points)</td>
<td>0.02</td>
<td>0.27</td>
<td>0.15</td>
<td>0.24</td>
<td>0.32</td>
</tr>
<tr>
<td>Cash flow (real)</td>
<td>0.27</td>
<td>0.76</td>
<td>0.51</td>
<td>0.57</td>
<td>0.66</td>
</tr>
<tr>
<td>Personal disposable income (nominal)</td>
<td>0.37</td>
<td>0.83</td>
<td>1.06</td>
<td>1.16</td>
<td>1.40</td>
</tr>
<tr>
<td>Current account balance to GDP (average)</td>
<td>0.23</td>
<td>-0.09</td>
<td>-0.14</td>
<td>-0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>Government debt to GDP (period end)</td>
<td>-0.28</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Government financial balance to GDP (period end)</td>
<td>0.06</td>
<td>0.49</td>
<td>0.23</td>
<td>0.03</td>
<td>-0.46</td>
</tr>
<tr>
<td>Short-term interest rate (percentage points)</td>
<td>-1.00</td>
<td>-0.10</td>
<td>0.00</td>
<td>0.51</td>
<td>0.50</td>
</tr>
<tr>
<td>Long-term interest rate (percentage points)</td>
<td>-0.00</td>
<td>0.04</td>
<td>0.00</td>
<td>0.44</td>
<td>0.47</td>
</tr>
<tr>
<td>Exchange rate (EUR per USD)</td>
<td>1.00</td>
<td>1.02</td>
<td>0.95</td>
<td>0.98</td>
<td>0.05</td>
</tr>
<tr>
<td>Share price index</td>
<td>0.10</td>
<td>0.27</td>
<td>0.00</td>
<td>0.49</td>
<td>0.46</td>
</tr>
<tr>
<td>House price</td>
<td>0.17</td>
<td>0.68</td>
<td>1.14</td>
<td>1.27</td>
<td>1.48</td>
</tr>
<tr>
<td>M3</td>
<td>0.25</td>
<td>1.25</td>
<td>0.64</td>
<td>0.09</td>
<td>0.07</td>
</tr>
<tr>
<td>Bank credits</td>
<td>0.18</td>
<td>1.43</td>
<td>0.99</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Net wealth private sector</td>
<td>-0.16</td>
<td>-0.79</td>
<td>-1.44</td>
<td>-1.87</td>
<td>-1.59</td>
</tr>
<tr>
<td>Effective exchange rate **</td>
<td>0.74</td>
<td>-0.73</td>
<td>0.44</td>
<td>0.07</td>
<td>0.14</td>
</tr>
<tr>
<td>World trade (volume)</td>
<td>0.64</td>
<td>0.31</td>
<td>0.72</td>
<td>0.34</td>
<td>0.71</td>
</tr>
<tr>
<td>World export prices of goods and services</td>
<td>0.46</td>
<td>0.59</td>
<td>-0.23</td>
<td>-0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Weighted import prices of goods and services</td>
<td>0.45</td>
<td>0.47</td>
<td>-0.20</td>
<td>-0.09</td>
<td>0.06</td>
</tr>
</tbody>
</table>

A: Difference from base level
F: Percentage change from base level
** 1) excludes depreciation of the USD
1) excludes appreciation
Table 3
1 percentage point increase in prices for one year in the Euro area
Cumulative changes in percentages, unless otherwise stated

<table>
<thead>
<tr>
<th>Euro area</th>
<th>Results</th>
<th>year 1</th>
<th>year 2</th>
<th>year 3</th>
<th>year 4</th>
<th>year 5</th>
<th>year 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real gross domestic product</td>
<td>-0.10 -0.38 -0.41 -0.39 -0.32 -0.21 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real private consumption</td>
<td>-0.15 -0.48 -0.52 -0.51 -0.42 -0.29 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real gross investment (incl. dwellings)</td>
<td>-0.29 -0.74 -0.79 -0.76 -0.64 -0.15 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real investments in dwellings</td>
<td>-0.06 -0.35 -0.43 -0.49 -0.43 -0.21 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real exports of goods and services</td>
<td>-0.11 -0.13 -0.25 -0.31 -0.25 -0.33 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real imports of goods and services</td>
<td>0.01 -0.19 -0.20 -0.23 -0.43 -0.53 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output gap</td>
<td>0.15 -0.39 -0.39 -0.23 -0.25 -0.11 A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business employment</td>
<td>0.04 -0.13 -0.23 -0.24 -0.20 -0.22 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployment rate (as % labour force)</td>
<td>-0.03 -0.15 -0.17 -0.23 -0.24 -0.17 A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business labour productivity</td>
<td>-0.23 -0.29 -0.22 -0.12 -0.04 -0.21 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage rate in businesses (per employee)</td>
<td>0.72 1.25 1.43 1.54 1.64 1.45 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit labour cost</td>
<td>0.90 1.55 1.66 1.67 1.68 1.45 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private consumption deflator</td>
<td>1.60 1.40 1.71 1.79 1.70 1.26 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export deflator</td>
<td>0.13 0.52 0.89 1.12 1.52 1.28 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Import deflator</td>
<td>-0.22 -0.20 0.05 0.22 0.29 0.91 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross domestic product deflator</td>
<td>0.16 1.26 1.43 1.76 1.71 1.78 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation (consumer prices, percentage points)</td>
<td>1.00 0.40 0.30 0.98 0.09 0.18 A</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Cash flow (nominal)</td>
<td>0.32 0.55 1.33 1.72 1.50 1.47 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Personal disposable income (nominal)</td>
<td>0.50 0.81 0.93 1.02 1.00 1.06 P</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Government deficit in GDP (period end)</td>
<td>-0.06 0.03 0.30 0.37 0.37 0.20 A</td>
<td></td>
<td></td>
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<tr>
<td>Government financial balance in GDP (period end)</td>
<td>-0.27 -0.26 -0.21 -0.06 0.03 0.19 A</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Short-term interest rate (percentage points)</td>
<td>1.33 0.50 0.17 0.13 0.31 0.36 A</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Long-term interest rate (percentage points)</td>
<td>1.15 0.56 0.22 0.07 0.25 0.34 A</td>
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<tr>
<td>Exchange rate (EUR/USD)</td>
<td>1.24 0.91 0.33 0.81 1.13 1.29 P</td>
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<tr>
<td>Share price index</td>
<td>0.23 -0.75 -0.69 -0.99 0.36 0.26 P</td>
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<tr>
<td>House price</td>
<td>0.87 1.14 1.22 1.12 0.81 0.80 P</td>
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<tr>
<td>MS</td>
<td>0.31 0.22 0.45 1.16 1.66 1.09 P</td>
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<tr>
<td>Real wealth-private sector</td>
<td>0.13 0.39 0.51 0.87 0.20 0.30 P</td>
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<tr>
<td>Effective exchange rate</td>
<td>0.25 -0.39 -0.36 -0.38 0.34 0.32 P</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>World trade volume</td>
<td>1.81 0.10 0.26 0.34 0.25 0.10 P</td>
<td></td>
<td></td>
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<tr>
<td>World import prices of goods and services</td>
<td>0.14 0.49 0.18 0.16 0.17 0.17 P</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Weighted import prices of goods and services</td>
<td>-0.45 0.59 0.60 0.97 1.17 1.25 P</td>
<td></td>
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</table>

A: Difference from base level
P: Percentage change from base level
* indicates expectation of the USDA
** indicates appreciation
<table>
<thead>
<tr>
<th>Euro area</th>
<th>Price index</th>
<th>2002Q2</th>
<th>2002Q3</th>
<th>2002Q4</th>
<th>2003Q1</th>
<th>2003Q2</th>
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<tbody>
<tr>
<td>Real gross domestic product</td>
<td>1.21</td>
<td>1.23</td>
<td>1.25</td>
<td>1.27</td>
<td>1.29</td>
<td>1.31</td>
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<tr>
<td>Real private consumption</td>
<td>1.18</td>
<td>1.20</td>
<td>1.22</td>
<td>1.24</td>
<td>1.26</td>
<td>1.28</td>
</tr>
<tr>
<td>Real gross investment (incl. dwellings)</td>
<td>1.15</td>
<td>1.17</td>
<td>1.19</td>
<td>1.21</td>
<td>1.23</td>
<td>1.25</td>
</tr>
<tr>
<td>Real investments in dwellings</td>
<td>1.12</td>
<td>1.14</td>
<td>1.16</td>
<td>1.18</td>
<td>1.20</td>
<td>1.22</td>
</tr>
<tr>
<td>Real imports of goods and services</td>
<td>1.10</td>
<td>1.12</td>
<td>1.14</td>
<td>1.16</td>
<td>1.18</td>
<td>1.20</td>
</tr>
<tr>
<td>Real exports of goods and services</td>
<td>1.12</td>
<td>1.14</td>
<td>1.16</td>
<td>1.18</td>
<td>1.20</td>
<td>1.22</td>
</tr>
<tr>
<td>Output gap</td>
<td>-0.20</td>
<td>-0.22</td>
<td>-0.24</td>
<td>-0.26</td>
<td>-0.28</td>
<td>-0.30</td>
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<tr>
<td>Business employment</td>
<td>0.20</td>
<td>0.21</td>
<td>0.22</td>
<td>0.23</td>
<td>0.24</td>
<td>0.25</td>
</tr>
<tr>
<td>Unemployment rate (as % labour force)</td>
<td>0.40</td>
<td>0.41</td>
<td>0.42</td>
<td>0.43</td>
<td>0.44</td>
<td>0.45</td>
</tr>
<tr>
<td>Business labour productivity</td>
<td>0.60</td>
<td>0.62</td>
<td>0.64</td>
<td>0.66</td>
<td>0.68</td>
<td>0.70</td>
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<tr>
<td>Wage rate in businesses (per employee)</td>
<td>0.87</td>
<td>0.88</td>
<td>0.90</td>
<td>0.91</td>
<td>0.92</td>
<td>0.94</td>
</tr>
<tr>
<td>Unit labour cost</td>
<td>0.85</td>
<td>0.87</td>
<td>0.89</td>
<td>0.91</td>
<td>0.93</td>
<td>0.95</td>
</tr>
<tr>
<td>Unit labour cost</td>
<td>0.84</td>
<td>0.86</td>
<td>0.88</td>
<td>0.90</td>
<td>0.92</td>
<td>0.94</td>
</tr>
<tr>
<td>Product consumption deflator</td>
<td>0.99</td>
<td>1.01</td>
<td>1.03</td>
<td>1.05</td>
<td>1.07</td>
<td>1.09</td>
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<tr>
<td>Export deflator</td>
<td>1.01</td>
<td>1.03</td>
<td>1.05</td>
<td>1.07</td>
<td>1.09</td>
<td>1.11</td>
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<tr>
<td>Import deflator</td>
<td>0.96</td>
<td>0.98</td>
<td>1.00</td>
<td>1.02</td>
<td>1.04</td>
<td>1.06</td>
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<tr>
<td>Gross domestic product deflator</td>
<td>0.68</td>
<td>0.70</td>
<td>0.72</td>
<td>0.74</td>
<td>0.76</td>
<td>0.78</td>
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<tr>
<td>Inflation (consumer prices, percentage points)</td>
<td>0.66</td>
<td>0.68</td>
<td>0.70</td>
<td>0.72</td>
<td>0.74</td>
<td>0.76</td>
</tr>
<tr>
<td>Cash flow (nominal)</td>
<td>1.88</td>
<td>1.90</td>
<td>1.92</td>
<td>1.94</td>
<td>1.96</td>
<td>1.98</td>
</tr>
<tr>
<td>Personal disposable income (nominal)</td>
<td>0.85</td>
<td>0.87</td>
<td>0.89</td>
<td>0.91</td>
<td>0.93</td>
<td>0.95</td>
</tr>
<tr>
<td>Current account balance to gdp (average)</td>
<td>0.16</td>
<td>0.18</td>
<td>0.20</td>
<td>0.22</td>
<td>0.24</td>
<td>0.26</td>
</tr>
<tr>
<td>Government debt to gdp (percentage)</td>
<td>0.39</td>
<td>0.41</td>
<td>0.43</td>
<td>0.45</td>
<td>0.47</td>
<td>0.49</td>
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<tr>
<td>Government financial balance to gdp (period end)</td>
<td>-0.03</td>
<td>-0.05</td>
<td>-0.07</td>
<td>-0.09</td>
<td>-0.11</td>
<td>-0.13</td>
</tr>
<tr>
<td>Short-term interest rate (percentage points)</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>Long-term interest rate (percentage points)</td>
<td>0.70</td>
<td>0.72</td>
<td>0.74</td>
<td>0.76</td>
<td>0.78</td>
<td>0.80</td>
</tr>
<tr>
<td>Exchange rate (Euro per US$)</td>
<td>0.80</td>
<td>0.82</td>
<td>0.84</td>
<td>0.86</td>
<td>0.88</td>
<td>0.90</td>
</tr>
<tr>
<td>Share price index</td>
<td>0.53</td>
<td>0.55</td>
<td>0.57</td>
<td>0.59</td>
<td>0.61</td>
<td>0.63</td>
</tr>
<tr>
<td>House price</td>
<td>0.64</td>
<td>0.66</td>
<td>0.68</td>
<td>0.70</td>
<td>0.72</td>
<td>0.74</td>
</tr>
<tr>
<td>MO</td>
<td>0.88</td>
<td>0.90</td>
<td>0.92</td>
<td>0.94</td>
<td>0.96</td>
<td>0.98</td>
</tr>
<tr>
<td>Bank credits</td>
<td>0.18</td>
<td>0.20</td>
<td>0.22</td>
<td>0.24</td>
<td>0.26</td>
<td>0.28</td>
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<tr>
<td>Net worth private sector</td>
<td>0.73</td>
<td>0.75</td>
<td>0.77</td>
<td>0.79</td>
<td>0.81</td>
<td>0.83</td>
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<tr>
<td>Effective exchange rate **</td>
<td>0.61</td>
<td>0.63</td>
<td>0.65</td>
<td>0.67</td>
<td>0.69</td>
<td>0.71</td>
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<tr>
<td>World trade (volume)</td>
<td>0.56</td>
<td>0.58</td>
<td>0.60</td>
<td>0.62</td>
<td>0.64</td>
<td>0.66</td>
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<tr>
<td>World import price of goods and services</td>
<td>0.38</td>
<td>0.40</td>
<td>0.42</td>
<td>0.44</td>
<td>0.46</td>
<td>0.48</td>
</tr>
<tr>
<td>Weighted import price of goods and services</td>
<td>0.26</td>
<td>0.28</td>
<td>0.30</td>
<td>0.32</td>
<td>0.34</td>
<td>0.36</td>
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</table>

* F: Difference from base level
** P: Percentage change from base level
*: (i) indicates depreciation of the US$
and consumption wages. This wedge consists of the effects of direct and indirect taxes and the terms of trade. Combining the firm and wage models implies that equilibrium unemployment is determined by the wedge, the replacement rate, the mark-up and the relative cost of capital (see Broer, Draper and Huizinga (2000) for an empirical application to the Netherlands).

The current version of EUROMON does incorporate some of the elements of this approach (see Section 2). However, in the current version price setting and factor demand are not derived from the same firm problem explicitly and hence are not modelled simultaneously. For lack of time series data on the replacement rate in most countries, this potentially important explanatory factor of wages has not been included in the empirical analysis up to now. Finally, in the current version of EUROMON the consumption deflator is the central price variable in the model. For theoretical reasons however, it should be the output deflator at factor costs which should acquire the role of the central price equation in the model. Partly because of these imperfections, the implicit equilibrium unemployment rate is only affected by elements of the wedge in the current EUROMON version. As structural policies are and will continue to be an important aspect of policy in Europe, we consider a proper modelling of the impact of such policies on the supply side of the economy, a key issue in the success of future model applications.

REFERENCES

Balt, Wilko, and Peter van Els, 2000, Output Gap and Inflation in the EU, DNB Staff Reports, No. 44.

Bondt de, Gabe, Peter van Els and Ad Stokman, 1997, EUROMON: a macroeconometric multi-country model for the EU, DNB Staff Reports, No. 17.


A STYLISED REPRESENTATION OF THE ECONOMY

Explanatory notes first column:

b = behavioral equation
i = identity
e = exogenous or constructed
o = option

Monetary submodel

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta M_R = CB + \Delta D )</td>
<td>Net financial wealth private sector</td>
</tr>
<tr>
<td>( \Delta M_N = NW + \Delta x + y - p_x )</td>
<td>Market value domestic equity</td>
</tr>
<tr>
<td>( M_3 = f_1(p_y, 1/NW_N) )</td>
<td>Broad money</td>
</tr>
<tr>
<td>( \Delta M_3 = T A - M_3 = \Delta D + \Delta M_3 )</td>
<td>Private sector holdings of non-government bonds</td>
</tr>
<tr>
<td>( \Delta D_3 = \Delta M_3 - \Delta M_3 )</td>
<td>Private sector holdings of government debt</td>
</tr>
<tr>
<td>( \Delta M_F = CB + \Delta M_F )</td>
<td>Net financial assets owned by the private sector</td>
</tr>
<tr>
<td>( \Delta M_F = \Delta M_3 - \Delta D_3 )</td>
<td>Total private sector financial assets</td>
</tr>
<tr>
<td>( CRD = f_2(x, y, r, r_1, p_y, y, y) )</td>
<td>Personal disposable income</td>
</tr>
<tr>
<td>( COM = \gamma_1 + \gamma_2 )</td>
<td>Total wage compensation</td>
</tr>
<tr>
<td>( \Delta N = \gamma_3(r_1, y, x) )</td>
<td>Other household income</td>
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</table>

Financial submodel

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
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<tbody>
<tr>
<td>( \delta c = \min(m, 0) )</td>
<td>Nominal short-term interest rate</td>
</tr>
<tr>
<td>( \delta c = \max(m, 0) )</td>
<td>Nominal long-term interest rate</td>
</tr>
<tr>
<td>( \delta c = \delta c + \delta c )</td>
<td>Various options, EMU, UK, JP</td>
</tr>
<tr>
<td>( \delta c = \delta c + \delta c )</td>
<td>Nominal DM exchange rate</td>
</tr>
<tr>
<td>( \delta c = \delta c + \delta c )</td>
<td>Equity price</td>
</tr>
<tr>
<td>( \delta c = \delta c + \delta c )</td>
<td>Price deflator government bonds</td>
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Labour market and physical capital stock

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
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<tbody>
<tr>
<td>( b_0 = f(b_0, \beta) )</td>
<td>Business employment</td>
</tr>
<tr>
<td>( b_0 = f(b_0, \beta) )</td>
<td>Business investment</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>User cost of capital</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Business capital stock</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Potential business employment</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Total labour force</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Potential business production</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Output gap</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Business production</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Unemployment rate</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Business employment (in persons)</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Business labour productivity (per employee)</td>
</tr>
<tr>
<td>( \beta = \mu )</td>
<td>Business labour productivity (per hour)</td>
</tr>
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</table>

National income

<table>
<thead>
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<th>Equation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>( y = x + h_1 + h_2 )</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>( y = x + h_1 + h_2 )</td>
<td>Private consumption</td>
</tr>
<tr>
<td>( y = x + h_1 + h_2 )</td>
<td>Housing investment</td>
</tr>
<tr>
<td>( y = x + h_1 + h_2 )</td>
<td>Government stock</td>
</tr>
<tr>
<td>( y = x + h_1 + h_2 )</td>
<td>Government consumption</td>
</tr>
<tr>
<td>( y = x + h_1 + h_2 )</td>
<td>Change in inventories</td>
</tr>
<tr>
<td>( y = x + h_1 + h_2 )</td>
<td>Inventory stock</td>
</tr>
<tr>
<td>( y = x + h_1 + h_2 )</td>
<td>Sales</td>
</tr>
<tr>
<td>( y = x + h_1 + h_2 )</td>
<td>Total final expenditures</td>
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Foreign trade

<table>
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<tbody>
<tr>
<td>( C_B = a_b \times x )</td>
<td>Current account balance</td>
</tr>
<tr>
<td>( C_B = a_b \times x )</td>
<td>Export of goods and services</td>
</tr>
<tr>
<td>( C_B = a_b \times x )</td>
<td>Imports of goods and services</td>
</tr>
<tr>
<td>( C_B = a_b \times x )</td>
<td>Net exports primary income</td>
</tr>
<tr>
<td>( C_B = a_b \times x )</td>
<td>Net exports transfers</td>
</tr>
</tbody>
</table>

}\n
\[ \text{constant} \]
Wages and prices

\[ w_g = f(w_p, p_a, p_n, \Delta p, s_{w, x}) \]
\[ w_n = \frac{1}{2} w_n \]

Government wage rate (per employee)
\[ w_g = f(w_n) \]

Unit labour costs
\[ \text{ULC} = \frac{\Delta l_n}{\Delta l_n + \Delta l_o} \]

Business labour income share
\[ \text{LIS} = 100 \frac{\Delta l_n}{\Delta l_n + \Delta l_o} \]

Price deflator private consumption
\[ p_{c} = f(w_c, p, s_{t, c}, \Delta Y) \]

Price deflator government consumption
\[ p_{g} = f(w_g) \]

Price deflator government investment
\[ p_{i} = f(w_i) \]

Price deflator exports of goods and services
\[ p_{e} = f(w_e, p, s_{t, e}, \Delta Y) \]

Price deflator imports of goods and services
\[ p_{m} = f(w_m, p, s_{t, m}, \Delta Y) \]

Price deflator gross domestic product
\[ p_{gdp} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Price deflator business production
\[ p_{b} = \frac{1}{1 - p_{b}} (1 - p_{b}) \]

Inflation
\[ p_{i} = 100 \Delta p \log p \]

Public sector

Gross financial balance
\[ GFB = \Delta Y + G_{tr} + G_{di} - \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Government debt
\[ \Delta D = -GFB + D_{prev} \]

Direct taxes
\[ T_{tax} = \Delta Y + G_{tr} + G_{di} + \Delta D \]

Direct taxes on personal income
\[ T_{tax} = \Delta Y + G_{tr} + G_{di} + \Delta D + \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Corporate taxes
\[ T_{corporate} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Indirect taxes
\[ T_{indirect} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Social security contributions
\[ T_{social} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Government consumption
\[ G_{c} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Government investment
\[ G_{i} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Transfer
\[ T_{trans} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Net other government expenditures
\[ OGE = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Additional

Current balance ratio
\[ CBR = \frac{\Delta Y}{\Delta Y} \]

Government debt ratio
\[ DFR = \frac{\Delta D}{\Delta Y} \]

Government financial balance ratio
\[ GFBY = \frac{GFB}{\Delta Y} \]

World variables

World nominal long-term interest rate
\[ r_{n} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Eurozone variables referred to in Chapter 2

Broad money eurozone
\[ M_{3}^{E} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Inflation eurozone
\[ \pi_{M}^{E} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Gross domestic product eurozone
\[ Y_{E}^{EU} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]

Output gap eurozone
\[ y_{g}^{E} = \frac{1}{1 - p_{g}} (1 - p_{g}) \]