WORKING PAPER

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The NIME Model

A Macroeconometric World Model

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Economic analyses and forecasts

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This working paper describes the first version of the New International Model for Europe (NIME). The NIME model is a macroeconometric world model to study the transmission of the effects of economic policies and exogenous shocks on the Belgian and European economy.

The current version of NIME divides the world into six separate blocks: Belgium (BE), the EU block consisting of the countries that joined EMU in 1999 minus Belgium, the NE block consisting of the countries of the European Union that did not join EMU in 1999, the United States (US), Japan (JP) and the "rest of the world" (RW). These country blocks are linked to each other through trade and financial flows.

In the EU, NE, US and JP block, we distinguish a household sector, an enterprise sector, a monetary sector, and a public sector. The long run behavioural relationships of the household sector and the enterprise sector are derived from an explicit optimization problem. However, in the short run, rigidities prevent immediate adjustment towards these long run plans. Error correction mechanisms and partial adjustment schemes are used to capture these sluggish adjustment processes. In the short run, supply is determined by demand, while in the long run, supply is at its "natural" level. The monetary authorities set interest rates according to a Taylor rule, while the exchange rate equilibrates the current account. The fiscal policies, including the debt to GDP target, are to a large extent determined outside the model.

The Belgian block consists of a macroeconometric model currently in use at the BFPB. The RW block consists of a few equations capturing trade and financial feedbacks, ensuring coherence with the rest of the model blocks.

The paper starts with a summary of the NIME model, followed by a presentation of technical simulations. These simulations show that in the long run money is neutral, and that relative prices and real scale variables adjust to equilibrate total demand and total supply. Short run adjustment is determined by the adjustment costs in price setting and demand, the policy reaction functions, and expectations. The spill-over effects between blocks depend primarily on the nature of the shock, and they are rather limited, reflecting the fact that the blocks are large and relatively closed economies.

Federal Planning Bureau

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The BFPB's activities are primarily focused on macro-economic forecasting, analysing and assessing policies in the economic, social and environmental fields.

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I Introduction

In the past, the Belgian Federal Planning Bureau (BFPB) made intensive use of the HERMES-Link world model for its recurrent tasks, such as the medium term economic forecasts, and for its international research programmes. The HERMES-Link system of macrosectoral econometric models was developed in the eighties by a consortium of European research centres, under the auspices of the European Commission [1]. However, this system, composed of eight large sectoral national models and four bilateral trade flow models, had gradually become outdated since it was much too large to be overhauled by the BFPB on its own, and it did not reflect the recent developments in the European monetary and economic environment. Therefore, it was decided in 1999 to build a new, easier to maintain, world model, capable of fulfilling the main tasks that were traditionally performed by HERMES-Link, but that would better reflect the new European framework. So far, the BFPB's efforts have led to the construction of a first version of a New International Model for Europe (NIME), of which the different parts are presented in several technical working papers [2]. This Working Paper gives a general overview of the NIME model [3].

A. The modelling philosophy

The current version of NIME divides the world into six separate blocks: the EU block consisting of the countries that joined EMU in January 1999 minus Belgium [4], the NE block consisting of the countries of the European Union that did not join EMU in January 1999 [5], the United States (US), Japan (JP), and the rest of the world (RW). The sixth block, describing the Belgian economy, would consist of the short term or the medium term macroeconomic model currently in use at the BFPB (see, for example, Bossier et al. (2000) and Bossier and Vanhorebeek (2000)). These six country blocks are to be linked to each other through trade and financial flows.

1. For a description of the HERMES-Link model, see Commission of the European Communities (1993).
2. See Meyermans and Van Brusselen (2000.a) for a description of the household sector, and Meyermans and Van Brusselen (2000.b) for a description of the enterprise sector. These Working Papers are available at http://www.plan.be. Comments on these working papers are welcome and should be mailed to Eric Meyermans at em@plan.be or Patrick Van Brusselen at pvb@plan.be.
3. Other recent macroeconometric models described in the literature are, for example, Brayton and Tinsley (eds.) (1996), Laxton et al. (1998), National Institute of Economic and Social Research (s.a.), Powell and Murphy (1997), Roeger and in 't Veld (1997).
4. The ten EU block countries are : Austria, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.
5. The four NE block countries are : Denmark, Greece, Sweden, and the United Kingdom.

The structure of the six different country blocks of the NIME model differs to some extent. First, the EU, NE, US and JP block have the same theoretical structure. In each of these country blocks, we distinguish a household sector, an enterprise sector, a public sector, and a monetary sector. In each of these blocks, a similar set of behavioural equations and accounting identities is specified for each sector, while the parameter values of the equations are obtained using econometric techniques applied to the aggregated data of the different blocks. Second, the "rest of the world" block consists of only a very limited number of equations describing overall economic activity in the rest of the world. Third, for the block describing the Belgian economy, one of the existing BFPB models will be used. These models have been developed independently from the NIME project, and they have their own specific structure, (see, for example, Bossier et al. (2000) and Bossier and Vanhorebeek (2000)). Note that if we use the expression "NIME model" in this paper, we refer to the EU, NE, US and JP blocks.

The NIME model makes an analytical distinction between three time horizons. First, the short run is the period during which the plans of the different sectors are not fully realised, because of adjustment costs during the implementation of these plans. In the short run, prices adjust sluggishly and output adjusts to meet demand. Second, the medium run is the period during which the plans are realised, but they may still change because the other endogenous variables have not yet fully adjusted to their steady state value. Third, the steady state is the period during which changes in nominal variables have no real effects, and during which, for example, the unemployment rate is equal to its natural rate, the expectations are realised fully, where the public debt to Gross Domestic Product (GDP) ratio and the foreign debt to GDP ratio are stabilised, and where the economy is on a balanced growth path.

There corresponds a set of behavioural equations to each time horizon. The medium run behavioural relations of the household and enterprise sector are derived from an explicit optimization problem, while error correction mechanisms and partial adjustment schemes are used to capture sluggish short run adjustment to these equilibrium plans. In the steady state, factor productivity, the natural rate of unemployment, secular inflation, the steady state real interest rate, the participation rate, and population growth are exogenous, while the steady state values of the other variables are determined by these exogenous variables and the structural equations of the model. For example, in the steady state the natural output level and the employment level are determined by the production function and the (exogenous) natural unemployment rate.

The policy reaction functions of the monetary and fiscal authorities are designed in such a way that the model can be simulated so that it converges to a steady state. However, the model can also be simulated under alternative fiscal or monetary policies [1]. Of particular interest is to note that money is neutral in the long run. In this context, it should be pointed out that special attention is paid, in specifying the price equations, that relative prices do not change in the steady state, when there is an increase in the general price level [2]. Note also that the public debt to GDP ratio stabilizes at a rate determined outside the model. It is the direct labour income tax rate which adjusts to reach this target.

1. It should be noted that in this case, convergence to a steady state is not guaranteed.
2. In the short run relative prices may change as prices follow different adjustment paths.

The expectations of the economic agents are partly forward looking, and partly backward looking. For example, in the foreign exchange market the expectations of the exchange rate are partly determined by “chartists”, who look at past movements of the exchange rate, and partly by “fundamentalists” who look at the “fundamentals” of the exchange rate [1].

The stock variables have several feedbacks to the rest of the model. First, the equilibrium exchange rate is the exchange rate that stabilizes the foreign stock of assets to GDP ratio. Second, the equilibrium direct labour income tax rate is the tax rate that stabilizes the public debt to GDP ratio to its predetermined target value. Third, the total purchasing power of the household sector is to a large extent determined by the stock of accumulated savings.

Population growth and the composition of the population, e.g., the number of pensioners and children, are determined outside the model.

The different blocks are linked to each other through trade and financial flows. Here, we assume multilateral trade. The country blocks export their goods and services to an international warehouse, and they import goods and services from this warehouse. In other words, we do not examine the bilateral trade flows between the different blocks. The international financial flows affect, depending on the exchange rate regime, the exchange rate and the domestic interest rates.

Once we have specified the deterministic part of a behavioural equation, we add a stochastic term to the equation to capture randomness in human behaviour. Unless otherwise specified, these stochastic terms are assumed to be uncorrelated over time and independent of time, and to have a constant variance. The equations are estimated with a single equation technique. In practice, this means ordinary least squares or an instrumental variables estimator [2]. Error correction mechanisms are estimated with the Two-Step Engle-Granger estimator, (see Engle and Granger (1991)). In some cases outliers were detected, and were remedied by the inclusion of dummies in the equations. These dummies usually refer to German re-unification, the oil shocks of 1973, 1979, and 1986, and the currency crises in the European Monetary System.

Annual data are used, and the sample size ranges from 1970 until 1996. The data are compiled according the countries’ own national account system based on the former European system of accounts (ESA79). Work to update the databank according to the new European system of accounts (ESA95) is in progress.

All estimations and simulations presented in this Working Paper are made with the BFPB’s IODE software [3].

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1. In the current version of the model, the expectations of the “fundamentalists” are “quasi rational” expectations, in the sense that the economic agents have model consistent expectations about the steady state values, but the speed at which the contemporaneous variables are expected to converge to this steady state is not determined by the underlying structural parameters of the model, but are directly estimated using a reduced form. Work to introduce “rational” expectations is in progress.
2. See, Johnston (1984), Charemza and Deadman (1993), Cuthberston e.a. (1992), Maddala and Kim (1999), Hendry (1995), for the techniques used in this working paper.
3. See www.plan.be for more details regarding this software.

B. A general description of the model

This paper presents the NIME model as it is currently available. In two earlier papers, Meyermans and Van Brusselen (2000.a, and 2000.b), the household sector and enterprise sector are described. In this paper we will specify the other sectors of the model. However, for ease of reference we will summarize first the most important features of the household and enterprise sector in Chapter II and III of this paper.

In Chapter II, the household sector is presented [1]. First, we derive a set of demand equations for private consumption, money, residential buildings, and financial assets. Here, special attention is paid to the specification of the transmission mechanism of changes in the interest rate. More precisely, we identify, in addition to the income and wealth effect, three channels through which the interest rate affects demand: a liquidity effect, an intertemporal substitution effect, and an effect due to the user cost of residential buildings. Next, we make the additional assumptions that rigidities prevent the household sector from adjusting its expenditures immediately to its long run equilibrium plan, and we assume that the adjustment process to the long run equilibrium can be captured by an error correction model or a partial adjustment process. Finally, we show estimates for the long and short run responses of private consumption, money demand, and investment in residential buildings, to changes in a scale variable, the nominal and real interest rates, and the user cost of residential buildings.

In Chapter III, the enterprise sector is described [2]. In the analytical section, we start from the following assumptions. First, for each country block there exists a representative agent capturing the behaviour of the entire enterprise sector. This agent maximizes its profits by hiring production factors, and selling goods and services to the final users. Second, the available production factors are labour, capital, and intermediary imports, and a Cobb-Douglas production function with constant returns to scale describes the production technology. Third, a utility maximizing household sector supplies labour and bargains over the real wage rate with the profit maximizing enterprise sector. Fourth, the natural rate of unemployment and the steady state productivity growth of the production factors are exogenous. In the empirical section, we deal first with the problem that the reservation wage is not observed, and we make the additional assumption that price adjustment occurs sluggishly because of menu costs and backward looking behaviour. We present estimation results for factor demand, factor prices and output prices for the four main country blocks of the NIME model.

In Chapter IV, the monetary sector is presented. First, we assume that the short run interest rate is set by the monetary authorities. The short run interest rate may deviate from the steady state interest rate because policy variables deviate from their target. These policy targets refer to inflation, economic activity, and the exchange rate. Next, we model the contemporaneous long run interest rate as a function of the short run interest rate and the steady state interest rate. Finally, we derive an equation for the spot exchange rate from the interest rate parity condition and an expectations scheme whereby the expectations are partly determined

1. This chapter is based on Meyermans and Van Brusselen (2000.a). However, some changes have been made in the empirical section as we no longer measure the scale variable by disposable income, but by the total available means of the household sector.
2. This chapter is based on Meyermans and Van Brusselen (2000.b).

by “chartists”, who are backward looking, and partly by “fundamentalists” who look at the “fundamentals”.

In Chapter V, the public sector is described. Tax revenues are determined by the tax base and tax rates, while most public expenditure items grow at the steady state growth rate of GDP, sometimes adjusted for cyclical effects. We assume also that the government has an explicit target for the public debt to GDP ratio, and that it is the direct labour income tax rate that adjusts to reach this target.

In Chapter VI, we illustrate the properties of the NIME model with the simulation of a fiscal shock, a monetary shock, and a labour market shock. These simulations show that in the long run money is neutral, and that the relative prices and the real scale variables adjust to equilibrate total demand with total supply. Short run adjustment is determined by the adjustment costs in price setting and demand, the policy reaction functions, the speed of gross capital formation, and the speed at which expectations are revised. The spill-over effects between blocks are rather limited, and depend to a large extent on the nature of the shock. The simulations presented in this chapter are technical variants to study the properties of the NIME model. Policy variants will be made in due course.

For convenience, Appendix A lists the variables of the NIME model.

II The Household Sector [1]

This chapter describes the household sector of the NIME model. In the first section, we assume that the household sector maximizes its intertemporal utility function subject to an intertemporal budget constraint, and we derive a set of equilibrium demand equations for private consumption, money demand, and gross fixed capital formation in residential buildings. Here, we pay special attention to the specification of the transmission mechanism of the interest rate on household demand. More precisely, we identify, in addition to the income and wealth effect, three channels through which the interest rate affects demand: a liquidity effect, an intertemporal substitution effect, and an effect due to the user cost of residential buildings.

In the second section, we postulate that there exist adjustment costs which prevent immediate adjustment of expenditures to their equilibrium level. An error correction mechanism or partial adjustment scheme are used to capture this sluggish adjustment. We assume also that in the short run the household sector is somewhat liquidity constrained, i.e., in the short run a fraction of total private consumption is financed by disposable income. Estimation results are shown for private consumption, money demand, and gross fixed capital formation in residential buildings. We find, for example, that the short run interest rate elasticities are smaller than the long run interest rate elasticities.

A. The specification of the demand equations

1. A constrained intertemporal optimization problem

It is assumed that there exists a representative economic agent for each of the household sectors of the EU, NE, JP, and US block. This representative economic agent maximizes its intertemporal utility subject to its intertemporal budget constraint.

The total available means of the households are equal to the stock of assets inherited from the past, plus the income generated by these assets, plus the income generated by the contemporaneous and future supply of labour. Households also receive transfers from the public sector, and they pay taxes. The total available means are spent on the consumption of commodities, money, residential buildings, and other assets.

1. This chapter is based on Meyermans and Van Brusselen (2000.a). However, it should be noted that a major change in the empirical section has been introduced, as we now define the scale variable as disposable income plus assets inherited from the past, plus expected future non asset income, instead of only disposable income.

The utility function is a well behaved, twice differentiable continuous intertemporal utility function which is strongly quasi-concave and which is defined over a set of contemporaneous and future consumption goods, CPO, a real money stock, M/PCH, which renders monetary services, and residential buildings, CIRO, which render housing services. The household sector can save by holding financial assets, CAOU, which have a yield equal to LIC. At the end of their planning horizon T, the household sector leaves a bequest, Z_T, which comprises all assets held at T, and future non-asset income. Further a priori structure is given to the preference ordering of the household sector by assuming separability between the decision to consume goods and services, on the one hand, and the decision to take leisure, on the other hand. This assumption allows to study the decisions related to the consumption of goods and services separately from the decisions related to the supply of labour [1].

Maximizing the intertemporal utility function subject to the intertemporal budget constraint, Meyermans and Van Brusselen (2000.a) derive the following quantity vector, Y, and price vector, Π, for the household sector:

$$\text{(II.1.a)} \quad Y'_t = \left(CPO_t, \frac{M_t}{PCH_t}, CIRO_t, Z_t\right),$$

and

$$\text{(II.1.b)} \quad \Pi'_t = (PCH_t, PM_t, USERIR_t, PZ_t)$$

$$\equiv \left(PCH_t, \frac{LIC_t}{(1+LIC_t)} PCH_t, PCIR_t - \frac{PCIR_{t+1}(1-gir\_rh)}{1+LIC_t}, \frac{PCH_{t+1}}{1+LIC_t}\right)$$

with the bequest, Z_t, defined as:

$$\text{(II.1.c)} \quad Z_t = \frac{M_t + CIRO_t(1-gir\_rh)\,PCIR_{t+1} + INVHO_t(1-inh\_rh)\,PINVH_{t+1}}{PCH_{t+1}}$$

$$+ \frac{CAOU_t(1+LIC_t)}{PCH_{t+1}} + EZY_t,$$

where:

CPO_t: consumption of goods and services (other than monetary services and services generated by residential buildings), in constant prices,

$CAOU_t$: net other assets, in current prices,

$CIRO_t$: the stock of residential buildings, in constant prices,

EZY_t: the discounted future non-asset income, in constant prices [2],

$INVHO_t$: the stock of inventories, in constant prices,

LIC_t: the interest rate for the household sector [3],

M_t: the nominal money stock,

PCH_t: the consumer price index,

1. The latter is discussed in Chapter III and Appendix F.
2. See below, equation (II.4.c) for a definition.
3. LIC is an average of SI and LI, with SI the short run interest rate and LI the long run interest rate.

$PCIR_t$: the price of residential buildings,

$PINVH_t$: the price of household inventories,

PM_t : the opportunity cost of money [1],

PZ_t : the price of the bequest [2],

$USERIR_t$: the user cost of residential buildings [3],

gir_rh: the rate of depreciation of the stock of residential buildings,

inh_rh: the rate of depreciation of inventories.

The vector Y_t consists of consumption goods, real money balances, residential buildings, and net other assets, while the vector of prices, Π_t, consists of the corresponding prices and opportunity costs. The interpretation of these prices and opportunity costs is as follows.

The price of one unit of CPO_t is equal to PCH_t. The interpretation of the opportunity cost of money is as follows. In order to acquire one unit of real money balances, M_t / PCH_t, one has to spend PCH_t units of the currency. By holding PCH_t units of money instead of an interest-bearing financial asset, one foregoes a yield equal to $LIC_t\ PCH_t$. The present value of this is:

$$\text{(II.2.a)} \qquad PM_t = \frac{LIC_t}{(1 + LIC_t)}\ PCH_t\ .$$

The interpretation of the user cost of residential buildings is as follows. Buying one unit of housing in period *t* costs $PCIR_t$. Using this house during the period *t* will depreciate its value by gir_rh percent, so that one will get a price equal to $PCIR_{t+1}(1 - \text{gir\_rh})$ when one sells that house in period *t+1*.

The present value in period *t* of the latter is equal to $\dfrac{PCIR_{t+1}(1 - \text{gir\_rh})}{1 + LIC_t}$.

In other words, the user cost of owning the house during one period is equal to:

$$USERIR_t = PCIR_t - \frac{PCIR_{t+1}(1 - \text{gir\_rh})}{1 + LIC_t}$$

which can also be rewritten as:

$$\text{(II.2.b)} \qquad USERIR_t = \frac{(1 + LIC_t) - \left(\dfrac{PCIR_{t+1}}{PCIR_t}\right)(1 - \text{gir\_rh})}{1 + LIC_t}\ PCIR_t\ .$$

Finally, bonds [4] are a means to transfer purchasing power from one period to the other. These bonds have an interest rate equal to LIC_t. The expected purchasing power in period *t+1* of one unit bought in period *t* is equal to $(1+LIC_t) / PCH_{t+1}$.

1. See below, equation (II.2.a) for a definition.
2. See below, equation (II.2.c) for a definition.
3. See below, equation (II.2.b) for a definition.
4. “Bonds” refers here to all other assets of the household sector.

If one wants to obtain one real unit of purchasing power in the next period, by holding bonds, one has to pay today the unit price:

$$\text{(II.2.c)} \qquad PZ_t = \frac{PCH_{t+1}}{1 + LIC_t} \ .$$

2. A set of differentiable demand equations

a. A set of log-linear demand equations

Meyermans and Van Brusselen (2000.a) postulate that the interactions between the price and quantity vector (II.1.a) and (II.1.b) are captured by the following log-linear equation:

$$\text{(II.3)} \qquad \ln(Y_t) = y\_l0 + y\_lb \ln(SCALEH_t) + y\_l1 \ln(PCH_t) + y\_l2 \ln(PM_t) + y\_l3 \ln(USERIR_t) + y\_l4 \ln(PZ_t) + y\_l5\ H_t \ ,$$

for $Y_t = CPO_t\ , M_t / P_t\ , CIRO_t\ , Z_t\ ,$ and with y = cp, m, cir, z.

The following three remarks should be made regarding equation (II.3).

First, in equation (II.3), the scale variable, SCALEH, is a measure of total real purchasing power of the household sector, and is defined as the sum of the assets inherited from the past, plus contemporaneous income, plus the discounted stream of future non-asset income:

$$\text{(II.4.a)} \qquad SCALEH_t = \frac{CAOU_{t-1}(1+LIC_{t-1}) + CIRO_{t-1}\ \ PCIR_t\ \ (1 - gir\_rh)}{PCH_t} + \frac{INVHO_{t-1} PINVH_t (1 - inh\_rh) + M_{t-1}}{PCH_t} + ZY_t + EZY_t \ ,$$

with real non-asset income, ZY, defined as:

$$\text{(II.4.b)} \qquad ZY_t = \frac{WRP_t NP_t + WRG_t NG_t + TRANSH_t + NOIH_t - DTH_t}{PCH_t} \ ,$$

and the discounted future non-asset income, EZY, is defined as:

$$\text{(II.4.c)} \qquad EZY_t = \sum_{k = t+1} ZY_k \left(\frac{1}{1 + LIC_t}\right)^{(k-t)} \ ,$$

where:

DTH_t : direct tax revenue from labour income,

NG_t : employment in the public sector,

$NOIH_t$: net other income of the household sector,

NP_t : total employment in private sector,

$TRANSH_t$: public sector transfers to the household sector,

WRG_t : the wage in the public sector, in current prices,

WRP_t : the wage in the private sector, in current prices.

Second, in equation (II.3), the variable H_t is short for every other relevant explanatory variable which may affect the allocation decisions of the household sector [1].

Third, using the definitions of (II.1.a) and (II.1.b), and imposing the homogeneity condition:

$$y\_l1 + y\_l2 + y\_l3 + y\_l4 = 0 ,$$

equation (II.3) is rewritten as:

$$\text{(II.5)} \quad \ln(Y_t) = y\_l0 + y\_lb \ln(SCALEH_t) + y\_l2 \ln\left(\frac{LIC_t}{1 + LIC_t}\right)$$
$$+ y\_l3 \ln\left(\frac{(1 + LIC_t)PCIR_t - PCIR_{t+1}(1 - gir\_rh)}{(1 + LIC_t)PCH_t}\right)$$
$$- y\_l4 \ln\left(\frac{(1 + LIC_t)PCH_t}{PCH_{t+1}}\right) + y\_l5 H_t ,$$

for $Y_t = CPO_t , M_t / P_t , CIRO_t , Z_t$, and with $y = cp, m, cir, z$.

Equation (II.5) determines the demand for goods and services as a function of the available means, the nominal interest rate, the user cost of residential buildings, the real interest rate, and the taste variable, H [2].

b. The transmission mechanism of interest rate changes

In equation (II.5), the interest rate influences demand through different channels. First, there are the income effect and the wealth effect which affect demand differently. Next, there are the substitution effects.

1. For example, in the empirical section we include a dummy for German re-unification.
2. In the empirical section, we estimate the equation (II.5) for private consumption, and money demand. The equation for the stock of residential buildings, CIRO, will be modified to fit better the specification of a partial adjustment scheme. No equation for Z has been estimated directly. This equation can be derived indirectly from the adding-up condition and the estimation results of the other demand equations.

i. The income and wealth effect

First, there is the income effect affecting the SCALEH variable through its impact on the yield on assets, i.e., $CAOU_{t-1}\ LIC_{t-1}$. If the interest rate increases, the asset income, and thus SCALEH, will increase in the next period. This will induce an increase in demand [1].

Second, there is the wealth effect affecting the SCALEH variable through its impact on the discounted future stream of non-asset income, EZY. When the discount rate increases, the value of the future stream of non-asset income will decrease, and thus also SCALEH. This will induce a drop in demand [2].

ii. The substitution effects

There are three substitution effects: the liquidity effect, the intertemporal substitution effect, and the user cost effect.

First, there is the liquidity effect, measured by the term:

(II.6.a) $y\_l2 \ln(LIC_t / (1+LIC_t))$,

for y = cp, m, cir, z.

When the nominal interest rate increases, the opportunity cost of money will increase and the demand for money will fall. The impact on the demand for the other goods and services is less clear a priori: it is an empirical issue to determine the exact sign of the elasticity. To know the semi-elasticity of the nominal interest rate one has to calculate [3]:

(II.6.b) $y\_l2 / (LIC_t (1+LIC_t))$.

Second, there is the intertemporal substitution effect, measured by the term:

(II.6.c) $- y\_l4 \ln((PCH_t(1+LIC_t)) / PCH_{t+1})$.

When the real interest rate increases, we expect that, ceteris paribus, the household sector will reduce its contemporaneous consumption and save more by holding interest-bearing assets. As a consequence we expect a negative relation between the real interest rate and contemporaneous consumption. The semi-elasticity of the interest rate through intertemporal substitution is found to be [4]:

(II.6.d) $- \dfrac{y\_l4}{1 + LIC_t}$.

1. Provided y_lb > 0 .
2. Provided y_lb > 0 .
3. Here use has been made of the fact that: $dln(LIC / (1+LIC)) = dln(LIC) - dln(1+LIC) = d\ LIC\ /\ LIC - d\ (1+LIC)\ /\ (1+LIC) = 1 / (LIC\ (1+LIC))\ \ d\ LIC$.
4. Here it should be remembered that $dln(1+LIC) = 1 / (1+LIC)\ d\ LIC$.

Third, there is the impact of the interest rate on the user cost of residential buildings, measured by the term:

$$\text{(II.6.e)} \qquad y\_l3 \ln\left(\frac{PCIR_t}{PCH_t} - \frac{PCIR_{t+1}(1 - gir\_rh)}{PCH_t(1 + LIC_t)}\right) .$$

An increase in the nominal interest rate increases the user cost of residential buildings, and will decrease the demand for residential buildings. It is not a priori clear how the change in the user cost will affect the demand for consumption goods and the demand for money; they may be substitutes or complements.

The semi-elasticity of the interest rate through the user cost is found to be:

$$\text{(II.6.f)} \qquad \frac{y\_l3}{1 + LIC_t - \frac{PCIR_{t+1}}{PCIR_t}(1 - gir\_rh)} - \frac{y\_l3}{(1 + LIC_t)} .$$

Collecting terms, i.e. equations (II.6.b), (II.6.d) and (II.6.f), the overall semi-interest rate elasticity can be written as:

$$\text{(II.6.g)} \qquad \frac{y\_l2}{LIC_t(1 + LIC_t)} - \frac{y\_l4}{1 + LIC_t} + \frac{y\_l3}{1 + LIC_t - \frac{PCIR_{t+1}}{PCIR_t}(1 - gir\_rh)} - \frac{y\_l3}{(1 + LIC_t)} .$$

It is an empirical issue to determine the net impact of all these effects.

B. The data

Before we show estimates of the demand equations, we will give a brief overview of the data.

Annual data are used, and the sample size ranges from 1970 until 1996. Several sources have been used to construct the databank: New Cronos published by EUROSTAT, the National Accounts published by the OECD (to a large extent also available in the EU Commission's AMECO databank), and the International Financial Statistics of the International Monetary Fund. When these databanks proved to be incomplete, the missing observation units were interpolated (see, for example, Barten (1984)). The data are compiled according the countries' own national account system based on the former European system of accounts (ESA79). Work to update the databank according to the new European system of accounts (ESA95) is in progress.

Aggregates of the EU and NE block in current and constant prices are calculated with a purchasing power parity (PPP) exchange rate [1]. The corresponding price levels are obtained dividing the aggregate in current prices by the aggregate in

1. Remember that the EU and NE blocks are composed as follows. The ten EU block countries are Austria, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. The four NE block countries are Denmark, Greece, Sweden, and the United Kingdom. For the blocks consisting of more than one country, a new currency unit has been defined. For the EU block this currency unit is the euro . For the NE block the unit is a weighted average of the currencies of Denmark, Greece, Sweden, and the United Kingdom.

constant prices. The short and long term interest rates of each block are a weighted average of the short and long term interest rate of the individual countries. The weights are the share of the country's GDP in total GDP of the block. Money is M1 [1]. LIC, the interest rate of the household sector, is a weighted average of the nominal long run interest rate, and the nominal short run interest rate. For each block, the weight is equal to 0.5.

Here, it should be noted that there may be an aggregation bias in the monetary data of the EU and NE block. Indeed, during much of the period covered by our model, the exchange rates of the countries constituting the EU and NE block were in the Exchange Rate Mechanism of the European Monetary System. However, during some periods there were quite significant crises, e.g., 1992-1993, characterized by significant interest rates hikes and major portfolio shifts between countries, often followed by a realignment of the exchange rates. At the aggregate level, shifts between currencies of the countries of a particular block do not show up in the currency aggregate of that block. However, because the aggregate interest rate of a block is the weighted average of the interest rates of the individual countries, the aggregate interest rate will reflect the variability of the interest rates at the country level. In other words, the aggregate interest rate will show a higher variability then the monetary aggregate. To capture this effect, we use dummies in the demand for money functions of the EU and NE block for 1992-1993.

The steady state values of the exogenous variables are calculated with a Hodrick-Prescott filter. The procedure is implemented with the smoothing parameter lambda set to 100. See also Canova (1998.a, and 1998.b) and Burnside (1998) on this.

More details regarding the data can be found in Appendix B of Meyermans and Van Brusselen (2000.a), and Appendix D of Meyermans and Van Brusselen (2000.b).

C. The estimation of the demand equations

It is assumed that in the short run rigidities prevent immediate adjustment to the equilibrium plans described in equation (II.5). To capture this sluggish adjustment, private consumption and the demand for money are estimated with an error correction mechanism, while the dynamics of the expenditures on residential buildings are estimated with a partial adjustment scheme.

It should be noted that in the empirical application, all the expenditures are defined as expenditures per capita, i.e., we divide the expenditures by total population, NPO.

1. I.e., line 34, Money, of International Financial Statistics, International Monetary Fund.

1. Private consumption and money demand: an error correction mechanism

The error correction mechanism for per capita expenditures on CPO and M was estimated with the Two-Step Engle-Granger method (see Engle and Granger (1991)). In the first stage we estimated the long run equilibrium equation:

$$\text{(II.7)} \quad \ln\left(\frac{Y_t}{NPO_t}\right) = (y\_l0 + DUM7281\ y\_ld0) + y\_lb \ln\left(\frac{SCALEH_t}{NPO_t}\right)$$
$$+ (y\_l2 + DUM7281\ y\_ld2) \ln\left(\frac{LIC_t}{(1+LIC_t)}\right)$$
$$+ (y\_l3 + DUM7281\ y\_ld3) \ln\left(\frac{(1+LIC_t)\ PCIR_t - \widehat{PCIR}_{t+1}(1-gir\_rh)}{(1+LIC_t)\ PCH_t}\right)$$
$$- (y\_l4 + DUM7281\ y\_ld4) \ln\left(\frac{(1+LIC_t)\ PCH_t}{\widehat{PCH}_{t+1}}\right)$$
$$+ y\_l\_05\ DUMGE_t + y\_l\_06\ UKBUILD_t + y\_l\_07\ DUMEMS_t$$

for $Y_t = CPO_t$, M_t/P_t , y = cp, m, and with the $\frown$ symbol indicating a “rational expectations” value. For more details on the latter, see Appendix D of Meyermans and Van Brusselen (2000.a) [1]. NPO is total population.

The scale variable, SCALEH, is determined by wealth inherited from the past, plus contemporaneous total income, plus the discounted stream of future non-asset income (see equation (II.4.a) [2]).

Dummies were added to the original specification. DUMGE is a dummy to capture the effect of German re-unification, while DUMEMS is a dummy to capture the EMS crisis in 1992-1993. UKBUILD is a dummy to capture the shift in the UK money data which was due to the inclusion of deposits of the building societies in the monetary aggregates as of 1987. The dummy DUM7281 is equal to one for the period ranging from 1972 until 1981, and equal to zero after 1981. The period until 1981 was a period of high inflation, and of significant inflation differences between countries of the EU and NE blocks. The dummies in equation (II.7) capture a structural break in aggregate household behaviour once the period of high inflation ends.

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1. Briefly summarized, the procedure is as follows. Under rational expectations we have for the variable X: $X_{t+1} = E_t(X_{t+1}) + u_{t+1}$, with E(.) the expectations operator and u a stochastic component with expected value equal to zero. In practice, $E_t(X_{t+1})$ and u_{t+1} are not observed. Hence, X_{t+1} can be used as a proxy for $E_t(X_{t+1})$. However, in this case instrumental variables have to be used to deal with the “errors in variables” problem. See, for example, Cuthberston e.a. (1992). To be more precise, we used the fitted values of the equations described in Chapter III, section C.4.
2. The observations for the contemporaneous income and money balances are readily available in the national and financial accounts. The stock of residential buildings, CIRU, and net other assets, CAOU, are equal to the cumulated investment and savings flows, adjusted for depreciation in the case of residential buildings. For the value of the discounted future stream of non-asset income, EZY, we assume that the expected future real non-asset income grows at a constant rate, which the households extrapolate to be equal to the trend in the Hodrick-Prescott filtered series.

In a second step we estimated the short run adjustment mechanism:

$$\text{(II.8)} \quad \Delta \ln\left(\frac{Y_t}{NPO_t}\right) =$$

$$y\_sb1 \left\{ y\_sb2 \, \Delta \ln\left(\frac{SCALEH_t}{NPO_t}\right) + (1\text{-}y\_sb2) \, \Delta \ln\left(\frac{DIH_t}{PCH_t NPO_t}\right) \right\}$$

$$+ y\_s2 \, \Delta \ln\left(\frac{LIC_t}{1 + LIC_t}\right) + y\_sd2 \, \Delta \left(DUM7281 \ln\left(\frac{LIC_t}{1 + LIC_t}\right) \right)$$

$$+ y\_s3 \, \Delta \ln\left(\frac{(1 + LIC_t)\, PCIR_t - \widehat{PCIR}_{t+1}(1 - gir\_rh)}{(1 + LIC_t)\; PCH_t}\right)$$

$$+ y\_sd3 \, \Delta \left(DUM7281 \ln\left(\frac{(1 + LIC_t)\, PCIR_t - \widehat{PCIR}_{t+1}(1 - gir\_rh)}{(1 + LIC_t)\; PCH_t}\right) \right)$$

$$- y\_s4 \, \Delta \ln\left(\frac{(1 + LIC_t)\, PCH_t}{\widehat{PCH}_{t+1}}\right) - y\_sd4 \, \Delta \left(DUM7281 \ln\left(\frac{(1 + LIC_t)\, PCH_t}{\widehat{PCH}_{t+1}}\right) \right)$$

$$+ y\_s5 \, \Delta \; DUMGE_t + y\_s6 \, \Delta \; UKBUILD_t + y\_s7 \, \Delta \; DUMEMS_t$$

$$+ y\_sl \; ECM_{t-1} \, ,$$

for $Y_t = CPO_t$, M_t / P_t , y = cp, m, and where ECM_t is the error correction term derived from equation (II.7).

In equation (II.8), we define the scale variable as a weighted average of the total available means, SCALEH, and disposable income [1], DIH, implying that in the short run a fraction (1-y_sb2) of total household expenditure is financed by disposable income, i.e., the fraction of consumption for which no credit can be obtained.

Tables II.1 and II.2 show estimates of the long run price and scale elasticities for private consumption and money demand for the EU, NE, US and JP blocks. Tables II.3 and II.4 show the estimates of the (semi-)elasticities for the error correction mechanism. Note that we impose a unit elasticity for the scale elasticity, except for the short run consumption equation.

The tables show also some diagnostic statistics. First, there is the traditional adjusted R-squared and the Durbin-Watson (see Johnston (1984)), or the Durbin h statistic when a lagged dependent variable is included [2]. The Dickey-Fuller (DF)

1. With $DIH_t = ZY_t \, PCH_t + LIC_{t-1} \, CAOU_{t-1}$.
2. The Durbin h test statistic is computed by adjusting the Durbin-Watson statistic for the fact that the equation includes a lagged dependent variable (see Johnston (1985)). Reject the null hypothesis of no autocorrelation at the 5 percent level of significance in favour of the hypothesis of a positive first-order correlation if the test statistic is greater than 1.645. Reject the null hypothesis of no autocorrelation at the 5 percent level of significance in favour of the hypothesis of a negative first-order correlation if the test statistic is smaller than -1.645.

statistic refers to the order of integration of the error term of the long run equations (see Charemza and Deadman, (1993)) [1].

TABLE II.1 - Long run (semi-)elasticities for private consumption

	EU	NE	US	JP
cp_l0	-3.05	-3.20	-3.04	-2.45
cp_lb	1.00	1.00	1.00	1.00
cp_l2	-0.03	-0.02	-0.07	0.06
cp_l3	0.02	-0.04	0.03	-0.01
-cp_l4	-0.74	-0.08	-0.58	-1.65
Implicit interest semi-elasticity [a]	-0.47	-1.15	-0.73	-1.04
Diagnostic statistics				
Adjusted R	0.98	0.99	0.97	1.00
Durbin - Watson	0.90	2.33	1.30	1.34
Dickey - Fuller	-2.51	-6.00	-4.24	-3.51
Augmented Dickey - Fuller	-2.45	-5.87	-4.17	-3.43

a. See equation (II.6.g), evaluated for 10 percent.

TABLE II.2 - Long run (semi-)elasticities for money demand

	EU	NE	US	JP
m_l0	-3.89	-2.65	-4.66	-3.73
m_lb	1.00	1.00	1.00	1.00
m_l2	-0.13	-0.04	-0.17	-0.13
m_l3	0.10	0.04	0.00	-0.01
-m_l4	-2.44	-1.81	-1.12	-0.80
Implicit interest semi-elasticity [a]	-1.60	-1.22	-2.52	-1.97
Diagnostic statistics				
Adjusted R	0.90	0.99	0.89	0.95
Durbin - Watson	1.04	1.82	1.59	1.35
Dickey - Fuller	-2.81	-4.36	-3.10	-3.43
Augmented Dickey - Fuller	-2.74	-4.26	-2.99	-3.35

a. See equation (II.6.g), evaluated for 10 percent.

All own-price effects should be negative. The a priori sign of the cross-price elasticities is less evident. Comparing the results across the different blocks, we see that most parameters have the same sign. For example, the elasticity of the real interest rate is negative in all private consumption and money demand equations. The elasticity of the opportunity cost of holding money, i.e. the nominal interest rate, is negative in all the money demand equations. Finally, note that the sign of the elasticity of the user cost of residential buildings in private consumption and in the money demand function differs across countries.

1. Here, the null-hypothesis of no cointegration is tested against the alternative hypothesis of cointegration. The area of rejection of the null-hypothesis is the area for which the DF test statistic without intercept is smaller than -1.99 (the test is indecisive for values between -1.99 and -1.84) at the 5 percent confidence level, and the area for which the DF test statistic with intercept is smaller than -2.33 (the test is indecisive for values between -2.33 and -2.11) at the 5 percent confidence level.

The row “Implicit interest semi-elasticity” measures the total impact of a change in the interest rate, as defined in equation (II.6.g). Indeed, recall that the interest rate affects demand through three channels: the liquidity effect, the intertemporal substitution effect, and the user cost effect. The numbers presented in this row summarize the total impact of a 100 points increase in the interest rate. We see that an interest rate increase, decreases the demand for goods, money and residential buildings in the short run as well as in the long run. Moreover, the interest semi-elasticities are bigger in the long run than in the short run. In addition, money demand is more sensitive to interest rate changes than private consumption. The implications of these elasticities will become clear in Chapter VI, when we discuss alternative technical simulations.

In the short run, the disposable income as well as the total available means have a significant impact on private consumption and money demand. All error correction terms are between 0 and -1.

TABLE II.3 - Short run (semi-)elasticities for private consumption

	EU	NE	US	JP
cp_sb1	1.12	1.03	1.20	1.05
	(0.07)	(0.11)	(0.15)	(0.07)
cp_sb2	0.43	0.63	0.44	0.81
	(0.08)	(0.14)	(0.17)	(0.16)
cp_s2	0.00	-0.01	-0.02	0.00
	(0.01)	(0.02)	(0.02)	-.-
cp_s3	0.01	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
-cp_s4	-0.35	-0.12	-0.16	-0.12
	(0.09)	(0.12)	(0.17)	(0.09)
cp_sl	-0.23	-0.74	-0.14	-0.43
	(0.09)	(0.20)	(0.12)	(0.19)
Implicit interest semi-elasticity [a]	-0.16	-0.22	-0.30	-0.15
Diagnostic statistics				
Adjusted R	0.88	0.80	0.66	0.70
Durbin - Watson	2.41	1.64	1.84	1.40

a. See equation (II.6.g), evaluated for 10 percent.

TABLE II.4 - Short run (semi-)elasticities for money demand

	EU	NE	US	JP
m_sb1	1.00	1.00	1.00	1.00
	-.-	-.-	-.-	-.-
m_sb2	0.00	0.00	0.15	0.00
	-.-	-.-	(0.55)	-.-
m_s2	-0.06	-0.01	-0.17	-0.17
	(0.06)	(0.08)	(0.06)	(0.03)
m_s3	0.02	0.03	-0.01	-0.01
	(0.04)	(0.02)	(0.02)	(0.01)
-m_s4	-0.75	-0.68	-0.67	-0.22
	(0.67)	(0.70)	(0.59)	(0.22)
m_sl	-0.44	-0.31	-0.34	-0.65
	(0.22)	(0.22)	(0.38)	(0.19)
Implicit interest semi-elasticity [a]	-0.85	-0.16	-2.26	-1.88
Diagnostic statistics				
Adjusted R	0.76	0.80	0.62	0.74
Durbin - Watson	2.12	1.24	1.18	1.49

a. See equation (II.6.g), evaluated for 10 percent.

2. Gross fixed capital formation of residential buildings: a partial adjustment scheme

We assume that there exist rigidities which prevent the contemporaneous stock of residential buildings, $CIRO_t$, from adjusting itself immediately to its desired level. This adjustment mechanism reads as follows [1]:

$$\text{(II.9.a)} \qquad CIRO_t - CIRO_{t-1} = gir\_sl\,(CIROL_t - CIRO_{t-1})$$

with $CIROL_t$ defined as the desired stock of residential buildings at moment t, in constant prices, which is function of disposable income and its user cost, i.e.:

$$\text{(II.9.b)} \qquad CIROL_t = gir\_l0 + gir\_lb\left(\frac{DIH_t}{PCH_t}\right) + gir\_l1\left(\frac{USERIR_t}{PCH_t}\right),$$

with: $gir\_l1 < 0$ and $gir\_lb > 0$.

Let gross capital formation of residential buildings, GIRO, be defined as:

$$\text{(II.9.c)} \qquad GIRO_t = (CIRO_t - CIRO_{t-1}) + CIRO_{t-1}\; gir\_rh \;.$$

where gir_rh is the rate of depreciation.

1. See, for example, Deaton and Muellbauer (1987), on household consumption of durable goods.

Combining the equations (II.9.a) - (II.9.c), we derive the following per capita expenditures on gross capital formation of residential buildings:

$$\text{(II.10)} \quad \frac{GIRO_t}{NPO_t} = gir\_l0\ gir\_sl\ gir\_rh$$
$$+ gir\_sl\ gir\_lb \left\{ \left(\frac{DIH_t}{PCH_t\ NPO_t}\right) - (1 - gir\_rh) \left(\frac{DIH_{t-1}}{PCH_{t-1}\ NPO_{t-1}}\right) \right\}$$
$$+ gir\_sl\ gir\_l1 \left\{ \left(\frac{USERIR_t}{PCH_t}\right) - (1 - gir\_rh) \left(\frac{USERIR_{t-1}}{PCH_{t-1}}\right) \right\}$$
$$+ (1 - gir\_sl) \frac{GIRO_{t-1}}{NPO_{t-1}} .$$

Table II.5 shows the estimates for gross fixed capital formation [1]. Here, the parameters of the adjustment scheme have the expected sign, but we also note some important differences across countries.

TABLE II.5 - Elasticities for gross fixed capital formation of residential buildings

	EU	NE	US	JP
Short Run [a]				
Scale	1.00	1.74	1.54	2.37
User cost of res. building	-0.11	-0.44	-1.41	-0.20
Long Run				
Scale	0.34	0.49	0.66	0.62
User cost of res. building	-0.04	-0.12	-0.60	-0.05
Coefficients				
gir_sl	0.03	0.08	0.06	0.12
	(0.01)	(0.03)	(0.05)	(0.06)
gir_rh	0.01	0.02	0.03	0.03
	-.-	-.-	-.-	-.-
gir_l0	0.00	0.00	0.00	0.00
	-.-	-.-	-.-	-.-
gir_lb	2.84	1.43	1.54	1.70
	(0.60)	(0.20)	(0.37)	(0.21)
gir_l1	-2.66	-16.14	-20.29	-289.10
	(5.60)	(16.79)	(22.70)	(726.54)
Diagnostic statistics				
Adjusted R	0.75	0.79	0.77	0.75
Durbin h	1.20	1.72	-0.11	-0.48

a. See Appendix C of Meyermans and Van Brusselen (2000.b).

1. The fit improved when we added the variable (UR_{t-1}-HP_UR_{t-1}), i.e, the deviation of lagged unemployment from the lagged steady state unemployment rate.

III The Enterprise Sector [1]

This chapter describes the enterprise sector of the NIME model. The specification of the enterprise sector starts from the following assumptions. First, for each country block there exists a representative agent capturing the behaviour of the entire enterprise sector. This agent maximizes its profits by hiring production factors, and selling goods and services to the final users. Second, the available production factors are labour, capital, and intermediary imports, and a Cobb-Douglas production function with constant returns to scale describes the production technology. Third, a utility maximizing household sector supplies labour and bargains over the real wage rate with the profit maximizing enterprise sector. Fourth, the natural rate of unemployment and the steady state productivity growth of the production factors are exogenous.

In the first section, we derive a set of equilibrium factor demand equations and factor price equations from a bargaining process between a profit maximizing enterprise sector and a utility maximizing household sector. In equilibrium, the demand for the production factors depends on total final demand and real factor prices. The parameters of the equilibrium demand equations are determined by the parameters of the Cobb-Douglas production function. The equilibrium real wage is a function of the household's reservation wage and labour productivity, while the real price of private capital goods is equal to the discounted net value of the marginal productivity of capital goods. Starting from the assumptions that the natural rate of unemployment and trend productivity are exogenous, we derive some analytical expressions for the steady state level of output, employment, and output prices.

In the second section, we present estimation results for factor demand and factor prices. First, we deal with the problem that the reservation wage is not observed, by postulating that the reservation wage is function of the labour wage and the past reservation wage, and we derive and estimate a dynamic wage setting equation. Second, we specify a short run price setting scheme, based on the assumption that price adjustment is sluggish because of menu costs and "rule of thumb" behaviour, and we estimate a price setting scheme for the price of the capital goods and intermediary imports. Next, we estimate an error correction mechanism for labour demand and import demand, and a partial adjustment mechanism for gross fixed capital formation. Here, special attention is paid to the fact that the restrictions on the parameters of the short run adjustment schemes are such that the natural rate of unemployment is not affected by trend productivity and population growth.

1. This chapter is based on Meyermans and Van Brusselen (2000.b).

In the last section, we show estimation results for the prices for final users, and we also specify price expectations. In the steady state, the prices for final users are determined by the supplier's price. However, in the short run the prices adjust sluggishly to this equilibrium, because of menu costs and "rule of thumb" behaviour.

A. Equilibrium factor demand and factor prices: some analytical results

In this section, we specify the equilibrium factor demand and factor prices. The available production factors are labour, capital goods, and intermediary imports. Our starting point is a sequential bargaining process whereby in a first stage, a profit maximizing enterprise sector and a utility maximizing household sector bargain over the factor prices. In a second stage, the enterprise sector decides on the quantities of labour and the other production factors that it will use in production [1].

For analytical convenience, we start the discussion with a derivation of the demand equations, conditional on a set of predetermined prices, which are derived in the second subsection.

1. The enterprise sector's factor demand

The enterprise sector maximizes its profits, given the production technology, the output price, and the prices of the production factors.

First, the production technology is modelled by a Cobb-Douglas production function with constant returns to scale:

$$\text{(III.1)} \qquad ASPO_t = asp\_l0 \; NP_t^{asp\_l1} \; CIPO_t^{asp\_l2} \; MPO_t^{asp\_l3} \quad ,$$

with:

$ASPO_t$: the output of the enterprise sector, in constant prices,
$CIPO_t$: the private capital stock, in constant prices,
MPO_t : the (intermediary) imports, in constant prices,
NP_t : total employment in the private sector.

For the parameters of equation (III.1) it holds that:

$$asp\_l0, asp\_l1, asp\_l2, asp\_l3 > 0 \; .$$

The assumption of constant returns to scale implies:

$$\text{(III.2)} \qquad asp\_l1 + asp\_l2 + asp\_l3 = 1 \; .$$

1. See Alogoskoufis and Manning (1991) for a similar sequential bargaining process.

Second, the prices of the production factors are determined elsewhere in the model. The wage, WRP, is set by the bargaining process between the enterprise sector and the household sector, see below equation (III.7). The user cost of capital, USERIP, is defined as [1]:

$$\text{(III.3)} \qquad USERIP_t = \frac{LI_t + gip\_rh - \left(\frac{PCIP_{t+1}}{PCIP_t} - 1\right)(1 - gip\_rh)}{1 + LI_t} PCIP_t \ .$$

Equation (III.3) states that the user cost of capital has three determinants. First, in order to acquire one unit of real capital good, $CIPO_t$, one has to spend $PCIP_t$ units of the local currency. By holding $PCIP_t$ units of money in capital goods instead of in interest-bearing financial assets, one foregoes a yield equal to LI_t $PCIP_t$. Second, the use of capital goods during one period will depreciate the value of this capital good by gip_rh $PCIP_t$. Hence, this loss should be added to the yield foregone. Third, the price of the capital good may change over time, generating losses or gains in the value of the capital good.

The price of intermediary imports, PMP, is derived below in equation (III.12). The produced output is sold, and the pre tax price, (1-NITR) PASP, is received per unit of output.

Third, profit maximisation yields the following equilibrium factor demand equations:

$$\text{(III.4)} \qquad \ln(NP_t) = \ln(asp\_l1) + \ln(ASPO_t) - \ln\left(\frac{WRP_t}{(1 - NITR_t)\ PASP_t}\right) ,$$

$$\text{(III.5)} \qquad \ln(CIPO_t) = \ln(asp\_l2) + \ln(ASPO_t) - \ln\left(\frac{USERIP_t}{(1 - NITR_t)\ PASP_t}\right) ,$$

$$\text{(III.6)} \qquad \ln(MPO_t) = \ln(asp\_l3) + \ln(ASPO_t) - \ln\left(\frac{PMP_t}{(1 - NITR_t)\ PASP_t}\right) ,$$

where:

$NITR_t$: the net indirect tax rate,

$PASP_t$: the price of goods and services supplied by enterprises, (including indirect taxes),

PMP_t : the price of (intermediary) imports,

$USERIP_t$: the user cost of capital of the enterprise sector,

WRP_t : the nominal per capita wage rate in the private sector.

1. See equation (A.5) of Appendix A in Meyermans and Van Brusselen (2000.b).

Equations (III.4) to (III.6) imply that in the long run, the output elasticity of factor demand is equal to 1, the own price elasticity equal to -1, and the cross-price elasticities equal to 0.

2. The wage setting equation

The household sector supplies labour and expects to be paid a wage that compensates for the disutility of work. We postulate that the household sector bargains for a real wage that maximizes the surplus between the after-tax real wage bill and the after-tax real reservation wage bill, and it will accept to provide labour only if the after-tax real wage is greater than its real reservation wage [1]. The enterprise sector wants to pay its labour force a wage that will maximize its profits.

The outcome of the bargaining between the household sector and the enterprise sector is the following wage setting equation [2]:

$$(III.7)\qquad \ln\left(\frac{WRP_t}{(1-NITR_t)PASP_t}\right) = wrp\_l1\ \ln\left(\frac{BEN_t}{(1-NITR_t)PASP_t}\right) + (1-wrp\_l1)\ \ln(asp\_l1\,YNP_t) + wrp\_l2\ (UR_t - HP\_UR_t)$$

with:

BEN_t : the nominal reservation wage,

UR_t : the contemporaneous unemployment rate,

HP_UR_t : the natural unemployment rate,

YNP_t : the average productivity of labour.

and where: $0 \le wrp\_l1 \le 1$, $wrp\_l2 \le 0$.

Equation (III.7) states that the real wage is an average of the reservation wage and labour productivity. The weights depend on the relative bargaining power of the household sector and the enterprise sector. If the household sector has no impact on the wage setting, then wrp_l1 = 1. If the household sector sets unilaterally the wage, then we have that wrpl_l1 = 0. The power to set wages varies with the extent that the unemployment rate deviates from its steady state rate, as measured by the term wrp_l2 (UR-HP_UR).

3. The price of the private capital good

Combining equations (III.3) and (III.5), and solving for PCIP, yields:

$$PCIP_t = PCIP_{t+1}\frac{1-gip\_rh}{1+LI_t} + asp\_l2\,(1-NITR_t)\,PASP_t\,\frac{ASPO_t}{CIPO_t}\ .$$

1. See Appendix B of Meyermans and Van Brusselen (2000.b).
2. See equation (B.13) of Appendix B in Meyermans and Van Brusselen (2000.b).

Forward substitution of the previous equation, and assuming that net indirect taxes, NITR, remain constant, and that output prices and productivity grow at their steady state rates, G_PASP and G_YCP, respectively, and that the interest rate is at its steady state value, HP_LI, the real price of the private capital stock solves for [1]:

$$\text{(III.8)} \quad \frac{PCIP_t}{(1 - NITR_t)\ PASP_t} = \frac{asp\_l2\ \ YCP_t}{\dfrac{(1 + HP\_LI) - (1 - gip\_rh)(1 + G\_PASP)(1 + G\_YCP)}{(1 + HP\_LI)}}$$

with the average productivity of capital, YCP, defined as:

$$YCP_t = \frac{ASPO_t}{CIPO_t} \ .$$

Equation (III.8) shows how the real price of private capital goods is equal to the discounted net value of the marginal productivity of capital goods.

4. The price of imports

We assume multilateral trade. The country blocks export their goods and services to an international warehouse, and they import goods and services from this warehouse. Imports are used by the home country to produce goods and services. In this process the warehouse has some power to set prices. This power is determined by the openness of the economy [2].

The import price measured in local currency is related to the export price of the other blocks by the following arbitrage condition:

$$\text{(III.9)} \qquad PMP_t = \exp^{pmt\_l0} TR\_MP_t^{\ pmt\_l1} (EFEX_t\ EFPXT_t) \ ,$$

with:

- PMP_t : the price of imports, in local currency,
- TR_MP_t : the market power of the warehouse,
- $EFEX_t$: the effective nominal exchange rate, amount of local currency per unit of foreign currency [3],
- $EFPXT_t$: the (effective) price of exports by other countries, in foreign currency,

---

1. If $0 < \dfrac{(1 - gip\_rh)(1 + G\_PASP)(1 + G\_YCP)}{(1 + HP\_LI)} < 1$. If the latter expression lies outside the interval]0, 1[, then the price of capital is undefined.
2. In the empirical section, we will assume that market power is measured by the openness of the economy, i.e., the trend of the sum of exports plus imports divided by total supply by the private sector. This trend is calculated with a Hodrick-Prescott filter.
3. See Chapter IV for a definition of the effective exchange rate.

and where the export price, EFPXT, is set such that it equalizes the marginal productivity of imports [1]:

$$\text{(III.10)} \qquad EFPXT_t = \frac{PASP_t(1 - NITR_t)}{EFEX_t} \; asp\_l3 \; YMP_t \; ,$$

where average productivity of imports is defined as:

$$\text{(III.11)} \qquad YMP_t = \frac{ASPO_t}{MPO_t} \; .$$

Inserting equation (III.10) into equation (III.9) yields the following equilibrium real import price equation:

$$\text{(III.12)} \qquad \frac{PMP_t}{PASP_t(1 - NITR_t)} = \exp^{pmt\_l0} \; TR\_MP_t^{\;pmt\_l1} \; asp\_l3 \; YMP_t \; .$$

Equation (III.12) shows how the real price of imports is proportional to the marginal productivity of intermediary imports.

5. The steady state

In this section, we discuss some straightforward properties of the steady state of the NIME model [2]. The steady state is the period during which changes in the endogenous variables are solely due to changes in the exogenous variables of the model. In this section, we use the label HP_*X* to indicate the steady state value of the variable *X*.

Trend factor productivity, the natural rate of unemployment, secular inflation, and the steady state real interest rate are exogenous, while the steady state values of the other variables are determined by the exogenous variables and the structural equations of the model. Let us now have a look at some of these steady state values.

First, with a predetermined natural rate of unemployment, labour supply, and public sector employment, the natural level of employment in the private sector is determined as [3]:

$$\text{(III.13.a)} \qquad HP\_NP = (1 - HP\_UR)HP\_LS - HP\_NG \; ,$$

with:

HP_NG: the steady state public sector employment,
HP_LS: the steady state labour supply.

1. See equation (III.6).
2. See also Appendix C of Meyermans and Van Brusselen (2000.b).
3. See equation (C.2) of Appendix C, in Meyermans and Van Brusselen (2000.b).

Second, the Cobb-Douglas production function implies that the natural level of output of the private sector is determined as [1]:

(III.13.b) $HP\_ASPO = HP\_NP\ HP\_YNP$,

so that also,

(III.13.c) $\Delta\ \ln(HP\_ASPO) = \Delta\ \ln(HP\_NP) + \Delta\ \ln(HP\_YNP)$.

Third, real factor prices are proportional to factor productivity [2], i.e.:

(III.13.d) $$\ln\left(\frac{WRP}{(1-NITR)PASP}\right) = \ln(asp\_l1\ HP\_YNP)\ ,$$

(III.13.e) $$\ln\left(\frac{USERIP}{(1-NITR)PASP}\right) = \ln(asp\_l2\ \ HP\_YCP)\ ,$$

(III.13.f) $$\ln\left(\frac{PMP}{(1-NITR)PASP}\right) = \ln(asp\_l3\ \ HP\_YMP)\ ,$$

so that real factor prices change in proportion with factor productivity:

(III.13.g) $$\Delta\ \ln\left(\frac{WRP}{(1-NITR)PASP}\right) = \Delta\ \ln(HP\_YNP)\ ,$$

(III.13.h) $$\Delta\ \ln\left(\frac{USERIP}{(1-NITR)PASP}\right) = \Delta\ \ln(HP\_YCP)\ ,$$

(III.13.i) $$\Delta\ \ln\left(\frac{PMP}{(1-NITR)PASP}\right) = \Delta\ \ln(HP\_YMP)\ .$$

Fourth, a precondition that the relative factor prices remain unchanged in the steady state, is that steady state relative factor productivity does not change [3]:

(III.13.j) $\Delta\ \ln(HP\_YMP) = \Delta \ln(HP\_YNP) = \Delta \ln(HP\_YCP)$.

Fifth, output prices are not affected by productivity growth [4]:

(III.13.k) $\Delta\ \ln(PASP) = 0$.

1. See equation (C.13) of Appendix C, in Meyermans and Van Brusselen (2000.b).
2. See equations (III.4) to (III.6).
3. See equation (C.18) of Appendix C, in Meyermans and Van Brusselen (2000.b).
4. See equation (C.21) of Appendix C, in Meyermans and Van Brusselen (2000.b).

B. Factor prices and factor demand: the empirical results

In this section, we show some empirical results for factor prices and factor demand. First, we estimate the factor prices. Here, we deal with the problem that the reservation wage of the household sector is not observed, and that prices adjust sluggishly because of menu costs and rule of thumb behaviour. Next, we estimate factor demand. Here, we assume that the adjustment of factor demand to its equilibrium is sluggish. In this paper, we do not derive how such an adjustment process may come about, we simply postulate it. More specifically, we assume an error correction mechanism for the demand for labour and imports, and a partial adjustment process for gross fixed capital formation. However, special care has been paid to the fact that the restrictions on the parameters of the short run adjustment scheme are such that the natural rate of unemployment is not affected by trend productivity and population growth. Finally, we also assume that in the short run supply is determined by total final demand.

The data used in this section are to a large extent described in Meyermans and Van Brusselen (2000.b).

1. The price of labour

No observations for the reservation wage are available. Hence, before equation (III.7) can be made fully operational, we have to make some additional assumptions regarding the reservation wage. We assume that in the medium run, the reservation wage is proportional to the net wage earned in the private sector, and that the reservation wage gradually converges to this equilibrium level. In other words, we postulate the following error correction mechanism for the reservation wage:

$$\Delta\ln\left(\frac{BEN_t(1-DTHR_t)(1-SSRHR_t)}{PCH_t}\right) = (ben\_1 - 1)$$
$$\left\{\ln\left(\frac{BEN_{t-1}(1-DTHR_{t-1})(1-SSRHR_{t-1})}{PCH_{t-1}}\right) + \left(\frac{ben\_0}{ben\_1 - 1}\right)\right.$$
$$\left. - \ln\left(\frac{WRP_{t-1}(1-DTHR_{t-1})(1-SSRHR_{t-1})}{PCH_{t-1}}\right)\right\}$$

with: $0 \le ben\_1 \le 1$

and where:

SSRHR: the social security contributions rate,
DTHR: the direct income tax rate.

Combining equation (III.7), which describes wage setting, and the previous equation, which determines the reservation wage, yields the following short run equation for the real wage [1]:

$$\text{(III.14)}\quad \Delta \ln\left(\frac{WRP_t}{(1-NITR_t)PASP_t}\right) =$$

$$(1\text{- } wrp\_l1)\,[\,\ln(asp\_l1\ YNP_t) - \ln(asp\_l1\ YNP_{t-1})\,]$$

$$+\ wrp\_l2\,[\,(UR_t - HP\_UR_t) - (UR_{t-1} - HP\_UR_{t-1})\,]$$

$$+\ wrp\_l1\ wrp\_l2\ (1\text{-}ben\_1)\ (UR_{t-1} - HP\_UR_{t-1})$$

$$-\ wrp\_l1\,[\,\ln(TAXWP_t) - \ln(TAXWP_{t-1})\,]$$

$$+\ (wrp\_l1\text{-}1)\ (1\text{-}ben\_1)\ [\,\ln\left(\frac{WRP_{t-1}}{(1-NITR_{t-1})PASP_{t-1}}\right)$$

$$-\ln(asp\_l1\,YNP_{t-1}) - wrp\_l2\,(UR_{t-1} - HP\_UR_{t-1}) + \frac{wrp\_l1\ \ ben\_0}{(wrp\_l1-1)(1-ben\_1)}\ ]$$

with: $wrp\_l2 \le 0$, $-1 \le (wrp\_l1-1)(1-ben\_1) \le 0$,

and with the tax wedge, TAXWP, defined as:

$$TAXWP_t = (1-NITR_t)(1-DTHR_t)(1-SSRHR_t)\ \frac{PASP_t}{PCH_t}\ .$$

Equation (III.14) states that in the short run, the wage responds to changes in labour productivity, changes in the unemployment rate and the natural rate of unemployment, the lagged unemployment rate and lagged natural unemployment rate, changes in the tax wedge, and an error correction term.

Table III.1 presents the estimation results for equation (III.14). The table shows the point estimates, the corresponding standard errors between brackets, the adjusted R-squared, and the Durbin-Watson statistic.

All the parameters have the expected sign, and the diagnostic statistics are fairly high. The coefficient of the error correction term, (wrp_l1-1) (1-ben_1), is low in absolute value in the EU, i.e. -0.08, when compared to the same coefficients in the other blocks. This low value is to a large extent explained by parameter (1-ben_1).

The lagged unemployment rate has a very low impact on the change in the real wage of the EU and US block. However, a change in the unemployment rate induces important changes in the real wage in all country blocks. Finally, note that in the short run, a change in the tax wedge generates the strongest response in the NE block, and the lowest in the EU block.

1. See Appendix E of Meyermans and Van Brusselen (2000.b) for a derivation of this result.

TABLE III.1 - The private sector wage rate, WRP

	EU	NE	US	JP
ben_0	-0.08	0.01	0.00	-0.03
	(0.24)	(0.01)	(0.01)	(0.04)
ben_1	0.91	0.06	0.63	0.47
	(0.08)	(0.40)	(0.11)	(0.16)
wrp_l1	0.10	0.62	0.34	0.22
	(0.27)	(0.14)	(0.20)	(0.25)
wrp_l2	-0.49	-0.66	-0.21	-1.39
	(0.53)	(0.31)	(0.21)	(1.63)
Pro memori				
(wrp_l1-1) (1-ben_1) (Error correction term)	-0.08	-0.36	-0.24	-0.41
wrp_l1 wrp_l2 (1-benp_1) (Lagged unemployment level)	0.00	-0.38	-0.03	-0.16
Diagnostic statistics				
Adjusted R	0.73	0.67	0.74	0.83
Durbin - Watson	1.71	2.04	2.50	1.73

2. A short run price setting mechanism

In each block of the model the enterprise sector produces a composite good that is sold to different final users. This composite good is sold at a price which adjusts itself only gradually to its equilibrium level because of menu costs, and “rule of thumb” behaviour. First, because of menu costs, the seller adjusts the price of only a fraction of the composite good to a new price, PXL, which we call the “reset price”. Let (1-px_sl) be the fraction of prices that is revised. Second, the “reset price”, PXL, is calculated partly “rationally”, and partly by “rule of thumb”. Setting the price to its “rational” value, PXR, requires a lot of accounting work on behalf of the producer. The producer could expect that the cost of such an exercise would outweigh the expected benefit, and he could therefore decide to do this exercise for only (1-px_sw) percent of the composite good for which he wants to change the price. For the other fraction of the good, the producer follows a simple rule of thumb, setting the new price equal to the old price adjusted for the cost push inflation that can be observed at negligible cost. For example, we assume that contemporaneous financial variables are observable at negligible cost, while the contemporaneous unit factor costs are not observable at negligible cost.

Let the parameter px_sl be the fraction of the composite good for which the price is kept at its old price, and let the parameter px_sw be the fraction of the prices that are revised according to a rule of thumb. Then, the price of composite good X is set according to the following rule [1]:

1. See Appendix B, or Appendix F in Meyermans and Van Brusselen (2000.b).

$$\ln(PX_t) - \ln(PX_{t-1}) = (px\_sl-1)\,[\ln(PX_{t-1}) - \ln(PXR_{t-1})] \quad \text{(III.15.a)}$$
$$+ (1-px\_sl)\,[\ln(PXR_t) - \ln(PXR_{t-1})]$$
$$- (1-px\_sl)\, px\_sw\,[\ln(PXR_t) - \ln(PX_{t-1})]$$
$$+ (1-px\_sl)\, px\_sw\,[\ln(UX_t) - \ln(UX_{t-1})]\ ,$$

with:

PX_t : the price of good X,

PXR_t : the equilibrium price or rational reset price of good X,

UX_t : cost push inflation, observable at negligible cost.

Equation (III.15.a) shows how prices are changed in response to an error correction term, a change in the equilibrium price, a partial adjustment term, and cost push inflation.

Note also that:

$$0 \le px\_sl\,,\ px\_sw \le 1\ , \quad \text{(III.15.b)}$$

so that for the parameter of the error correction term, it holds that:

$$-1 \le (px\_sl - 1) \le 0\ , \quad \text{(III.15.c)}$$

and for the parameter of the partial adjustment term, it holds that:

$$0 \le (1 - px\_sl)px\_sw \le 1\ . \quad \text{(III.15.d)}$$

3. The price of capital and imports

a. Capital goods

Applying specification (III.15) to capital goods gives the following short run price setting scheme:

$$\ln(PCIP_t) - \ln(PCIP_{t-1}) = (pcip\_sl-1)\,[\ \ln(PCIP_{t-1}) - \ln(PCIPR_{t-1})\ ] \quad \text{(III.16.a)}$$
$$+ (1-pcip\_sl)\,[\ \ln(PCIPR_t) - \ln(PCIPR_{t-1})\ ]$$
$$- (1-pcip\_sl)\, pcip\_sw\,[\ \ln(PCIPR_t) - \ln(PCIP_{t-1})\ ]$$
$$+ (1-pcip\_sl)\, pcip\_sw\,[\ \ln(PCIP_{t-1}) - \ln(PCIP_{t-2})\ ]\ ,$$

where the rational reset price, PCIPR, is defined in equation (III.8), and where we assumed that the “rule of thumb” reset price is equal to the lagged price adjusted for the past increase in PCIP [1].

Table III.2 shows the estimation results of the short run adjustment scheme for the price of private capital goods, PCIP. The error correction parameter and partial adjustment coefficient show that adjustment is fastest in the US block, and slowest in the JP block. Note also the high value of pcip_sw, indicating that prices are to a large extent set according to a “rule of thumb”.

TABLE III.2 - The price of private capital, PCIP

	EU	NE	US	JP
pcip_sl	0.16	0.18	0.19	0.73
	(0.05)	(0.07)	(0.08)	(0.10)
pcip_sw	0.99	0.97	0.99	0.69
	(0.02)	(0.03)	(0.03)	(0.16)
Pro memori				
Error correction parameter [a]	-0.84	-0.82	-0.81	-0.27
Partial adjustment parameter [b]	0.84	0.80	0.79	0.19
Diagnostic statistics				
Adjusted R	0.86	0.78	0.75	0.82
Durbin h	0.44	-0.46	-0.24	0.85

a. See equation (III.15.c).

b. See equation (III.15.d).

b. Intermediary imports

The rational reset price of imports is defined in equation (III.12), while a similar price setting scheme as specified in equation (III.15) is assumed for the short run. Now we assume also that the “rule of thumb” reset price is equal to the lagged import price, adjusted for the past increase in the import price and the contemporaneous change in the effective exchange rate, EFEX:

$$\text{(III.16.c)} \quad \Delta\ \ln(UMP_t) = \Delta\ \ln(PMP_{t-1}) - \Delta\ \ln(EFEX_{t-1}) + \Delta\ \ln(EFEX_t)\ ,$$

so that the price setting scheme reads as:

$$\begin{aligned}\text{(III.16.d)} \quad \ln(PMP_t) - \ln(PMP_{t-1}) = {} & (pmp\_sl-1)\ [\ \ln(PMP_{t-1}) - \ln(PMPR_{t-1})\ ] \\ & + (1-pmp\_sl)\ [\ \ln(PMPR_t) - \ln(PMPR_{t-1})\ ] \\ & - (1-pmp\_sl)\ pmp\_sw\ [\ \ln(PMPR_t) - \ln(PMP_{t-1})\ ] \\ & + (1-pmp\_sl)\ pmp\_sw\ [\ \Delta\ \ln(PMP_{t-1}) - \Delta\ \ln(EFEX_{t-1}) + \Delta\ \ln(EFEX_t)\ ]\ .\end{aligned}$$

1. In other words, we may write:
(III.16.b) $\Delta\ \ln(UCP_t) = \Delta\ \ln(PCIP_{t-1})$.

The point estimates and diagnostic statistics for the short run adjustment scheme are shown in Table III.3. All estimates of the parameters are between zero and one. The low partial adjustment coefficient, (1-pmp_sl) pmp_sw, indicates, for example, that the pass through of an exchange rate change to input prices is slow.

TABLE III.3 - The price of imports, PMP

	EU	NE	US	JP
pmp_sl	0.35	0.14	0.29	0.37
	(0.14)	(0.07)	(0.11)	(0.18)
pmp_sw	0.24	0.09	0.40	0.23
	(0.10)	(0.07)	(0.11)	(0.09)
Pro memori				
Error correction term	-0.65	-0.86	-0.71	-0.63
Partial adjustment term	0.16	0.08	0.29	0.14
Diagnostic statistics				
Adjusted R	0.77	0.90	0.85	0.83
Durbin h	1.15	1.94	0.92	-0.32

4. Factor demand

In equations (III.4) to (III.6), we specified a set of equilibrium factor demand equations. Here, we assume that the adjustment of factor demand to its equilibrium is sluggish, and follows an error correction mechanism for the demand for labour and imports, and a partial adjustment process for gross fixed capital formation. Moreover, we assume that in the short run supply, ASPO, is determined by demand, i.e.,

$$ASPO_t = ADPO_t ,$$

where ADPO is final demand for goods supplied by the private sector, in constant prices.

We will now specify how this predetermined output level, together with the predetermined prices, determine factor demand in the short run. But first we estimate the equilibrium factor demand equations.

a. The equilibrium factor demand equations

The long run equilibrium factor demand equations are specified in equations (III.4) to (III.6). The coefficients in these equations correspond to the technical coefficients of the production function (III.1). Table III.4 shows the point estimates of the technical coefficients.

TABLE III.4 - The technical coefficients of the production function

	EU	NE	US	JP
asp_l1	0.54	0.53	0.60	0.66
asp_l2	0.30	0.22	0.29	0.24
asp_l3	0.16	0.25	0.11	0.11

Note that the point estimates of these coefficients add up to one, reflecting the assumption of constant returns to scale. As expected, the coefficient of labour, asp_l1, is highest. The rather high value for the import coefficient, asp_l3, of the NE block corresponds with the relative openness of the UK economy. The estimates in Table III.4 are used in the next sections to calculate the error correction term in the short run adjustment scheme for factor demand.

b. The short run adjustment schemes

i. The short run demand for labour

In the short run, changes in the demand for labour is function of changes in output, real factor prices, and an error correction term [1], i.e.:

(III.17)
$$\Delta \ln(NP_t) = np\_sb \; \Delta \ln(ASPO_t)$$
$$+ np\_s1 \; \Delta\ln\left(\frac{WRP_t}{(1-NITR_t)\,PASP_t}\right) + np\_s2 \; \Delta\ln\left(\frac{USERIP_t}{(1-NITR_t)\,PASP_t}\right)$$
$$+ (-np\_sb-np\_s1-np\_s2) \; \Delta\ln\left(\frac{PMP_t}{(1-NITR_t)\,PASP_t}\right)$$
$$+ np\_sl \,[\, \ln(NP_{t-1}) - \ln(HP\_NP_{t-1}) \,] + (1-np\_sb)\, G\_LS_t \,,$$

with: $-1 \le np\_sl \le 0$, and where G_LS is the growth rate of labour supply.

We expect that the real wage elasticity is negative, i.e. np_s1 < 0. It is an empirical issue to determine the sign of the elasticities of the user cost of capital and the price of imports. In the short run they may be substitutes or complements. However, it should be remembered that due to the Cobb-Douglas nature of the production function, the long run output elasticity is equal to 1, the long run wage elasticity is equal to -1, and the cross-price elasticities are equal to 0.

1. See equation (G.26) of Appendix G, in Meyermans and Van Brusselen (2000.b).

The particular parametrization in equation (III.17) implies that the natural unemployment rate is not affected by secular productivity and population growth (see also Appendix G of Meyermans and Van Brusselen (2000.b)).

Table III.5 shows the point estimates and the standard errors of the error correction mechanism for labour [1]. All the parameters of the error correction term, i.e. np_sl, have the expected sign. Data mining showed that the most appropriate lag structure for the error correction term is 2 years, except for Japan where it is 4 years. In each block the short run real wage elasticity is negative. The cross-elasticities of the other production factors are rather small. The diagnostic statistics are fairly good.

TABLE III.5 - Labour demand, NP

	EU	NE	US	JP
np_sb	0.16	0.23	0.50	0.10
	(0.14)	(0.10)	(0.08)	(0.02)
np_s1	-0.21	-0.30	-0.49	-0.10
	(0.12)	(0.10)	(0.10)	(0.02)
np_s2	0.03	0.07	-0.00	0.01
	(0.04)	(0.04)	(0.03)	(0.00)
(-np_sb-np_s1-np_s2)	0.02	-0.01	-0.00	-0.01
np_sl [a]	-0.29	-0.55	-0.22	-0.27
	(0.27)	(0.20)	(0.14)	(0.18)
Diagnostic statistics				
Adjusted R	0.71	0.63	0.84	0.95
Durbin - Watson	0.61	0.77	1.80	1.10

a. The lag for the error correction term is -4 for the JP block and -2 elsewhere.

ii. Short run gross capital formation

Here we present the results for a partial adjustment mechanism for gross capital formation. We define gross capital formation, GIPO, as:

$$\text{(III.18)} \quad GIPO_t = (CIPO_t - CIPO_{t-1}) + CIPO_{t-1}\ gip\_rh\ ,$$

with gip_rh the rate of depreciation of the capital stock, and $CIPO_t$ the capital stock in period *t*.

In equation (III.5), we specified the equilibrium capital stock, CIPOL, as:

$$\ln(CIPOL_t) = \ln(asp\_l2) + \ln(ASPO_t) - \ln\left(\frac{USERIP_t}{(1 - NITR_t)\ PASP_t}\right) .$$

1. The labour demand equation (III.17) was estimated with instrumental variables.

Now we assume that there are rigidities which prevent the contemporaneous capital stock, $CIPO_t$, from adjusting immediately to its equilibrium level. The adjustment mechanism reads as follows:

$$(III.19) \quad CIPO_t - CIPO_{t-1} = gip\_l \, (CIPOL_t - CIPO_{t-1}) \, .$$

For the parameter gip_l, which measures the speed of adjustment, it holds that:

$$0 < gip\_l < 1 \, .$$

Using equations (III.18) and (III.19), and making the proper substitutions, we derive the following partial adjustment mechanism for gross fixed investment:

$$(III.20) \quad \frac{GIPO_t}{NPO_t} = gip\_l \left(\frac{CIPOL_t}{NPO_t} - (1-gip\_rh) \frac{CIPOL_{t-1}}{NPO_{t-1}} \right) + (1 - gip\_l) \frac{GIPO_{t-1}}{NPO_{t-1}} \, .$$

Equation (III.20) explains contemporaneous gross fixed investment as a function of the change in the desired capital stock, and lagged gross fixed capital formation.

Table III.6 shows the estimation results for equation (III.20). Here, we see that the short run responses are highest in the US block, and lowest in the JP block.

TABLE III.6 - Gross fixed capital formation of the enterprise sector, GIPO

	EU	NE	US	JP
Short run elasticities [a]				
output	0.21	0.27	0.76	0.11
real user cost	-0.21	-0.27	-0.76	-0.11
Technical coefficients				
gip_l	0.02	0.02	0.06	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
gip_rh [b]	0.07	0.05	0.06	0.06
Diagnostic statistics				
Adjusted R	0.93	0.93	0.88	0.95
Durbin - Watson	0.38	1.74	1.14	1.54

a. For the calculation of the short run elasticities, see Appendix H in Meyermans and Van Brusselen (2000.b).

b. For the calculation of the rate of depreciation, see Appendix D, Section C, in Meyermans and Van Brusselen (2000.b).

iii.The short run demand for imports

Similar to the labour demand equation, the short run demand for imports is specified as:

$$\text{(III.21)} \quad \Delta\ \ln(MPO_t) = mp\_sb\ \Delta\ \ln(ASPO_t)$$

$$+\ mp\_s1\ \Delta\ln\left(\frac{WRP_t}{(1-NITR_t)\,PASP_t}\right)$$

$$+\ mp\_s2\ \Delta\ln\left(\frac{USERIP_t}{(1-NITR_t)\,PASP_t}\right)$$

$$+\ (-mp\_sb-mp\_s1-mp\_s2)\ \Delta\ln\left(\frac{PMP_t}{(1-NITR_t)\,PASP_t}\right)$$

$$+\ mp\_sl\ [\ \ln(MPO_{t-1}) - \ln\left(\frac{asp\_l3\ ASPO_{t-1}PASP_{t-1}(1-NITR_{t-1})}{PMP_{t-1}}\right)\ ]$$

$$+\ (1-mp\_sb)\ G\_LS_t\ ,$$

with: $-1 \le mp\_sl \le 0$, and with the error correction term derived from equation (III.6), and with the parameter estimates of asp_l3 shown in Table III.4.

Table III.7 shows the point estimates and standard errors of the short run adjustment scheme for imports.

TABLE III.7 - Demand for imports, MPO

	EU	NE	US	JP
mp_sb	2.30	1.80	2.32	1.33
	(0.37)	(0.21)	(0.42)	(0.59)
mp_s1	-1.50	-0.91	-1.47	-0.99
	(0.30)	(0.22)	(0.53)	(0.54)
mp_s2	0.04	-0.22	-0.25	-0.22
	(0.13)	(0.11)	(0.16)	(0.11)
(-mp_sb-mp_s1-mp_s2)	-0.83	-0.67	-0.60	-0.12
mp_sl (Error correction parameter)	-0.11	-0.15	-0.11	-0.22
	(0.07)	(0.09)	-.-	(0.06)
Diagnostic statistics				
Adjusted R	0.60	0.69	0.62	0.40
Durbin - Watson	2.04	1.65	1.86	1.20

Data mining showed that the most appropriate lag for the error correction term was 3 years for the JP block, and 1 year for the other blocks. Note also that we included a dummy variable in the equation of the EU block to capture the effects of German re-unification. All direct price elasticities are negative, and all scale elasticities are positive. However, note the rather high values of the elasticities if compared with the elasticities of the other production factors.

C. The prices for final users

1. The price of total supply for final demand

In view of the assumptions regarding the production function, the equilibrium price of total supply for final demand, PASP, is determined as [1] :

(III.22.a) $\ln(PASP_t) = constant - \ln(1\text{-}NITR_t) + asp\_l1 \ln(WRP_t)$

$+ asp\_l2 \ln(USERIP_t) + asp\_l3 \ln(PMP_t)$,

and in the short run as :

(III.22.c) $PASP_t = \frac{ASPU_t}{ASPO_t}$,

with:

$ASPO_t$: total supply for final demand by the enterprise sector, in constant prices,
$ASPU_t$: total supply for final demand by the enterprise sector, in current prices.

2. The price of supply for final demand

Output produced by the domestic enterprise sector is demanded by the domestic private and public sector, and by the rest of the world. The modelling strategy for the price of public consumption, PCGGS, the price of public investment, PCIG, the price of investment in residential buildings, PCIR, and the price of exports, PXT, is as follows.

First, we assume that the rational reset price for X = CGGS, CIR, CIG, is defined as:

(III.23.a) $\ln(PXR) = px\_l0 + \ln(PASP)$,

and for exports [2] as:

(III.23.b) $\ln(PXTR_t) = pxt\_l0$

$+ pxt\_l1 \ln(EFEX_t\, EFPASP_t\, (1\text{-}EFNITR_t)\, EFYMP_t)$

$+ pxt\_l2 \ln(TR\_MP)$.

---

1. With:
(III.22.b) $constant = - [\ln(asp\_l0) + asp\_l1 \ln(asp\_l1) + asp\_l2 \ln(asp\_l2) + asp\_l3 \ln(asp\_l3)]$.
See Appendix A of Meyermans and Van Brusselen (2000.b).
2. The exports of one block are the imports of the other blocks, where they are used in the production process. In this production process, exports have a productivity equal to EFYMP. Hence, we specify the export equation in analogy with equation (III.12). See also Chapter IV of Meyermans and Van Brusselen (2000.b).

Next, we assume that in the short run, prices are set according to a scheme similar to the one described in equation (III.15), whereby the cost push that is observed at negligible cost, UX, is now defined as [1]:

$$\text{(III.23.c)}\quad \Delta\ \ln(UX_t) = \Delta\ \ln(1\text{-}NITR_t) + (asp\_l1+asp\_l2)\ \Delta\ \ln(PX_{t-1}\ (1\text{-}NITR_{t-1})) + asp\_l3\ \Delta\ \ln(PMP_t / HP\_YMP_{t-1})\ ,$$

for X = CGGS, CIR, CIG,

and,

$$\text{(III.23.d)}\quad \Delta\ \ln(UX_t) = \Delta\ \ln(PXT_{t-1})\ ,$$

for X = XT .

Section E of Appendix B reports the point estimates and some diagnostic statistics of the equations for the price of public consumption, the price of residential buildings, the price of public capital goods, and the price of exports.

3. The price of private consumption

We assume that in equilibrium the price of private consumption clears the goods market, and that in the short run prices are set according to a scheme similar to the one described in equation (III.15). Based on these assumptions, we derive in Appendix B that the contemporaneous change in the consumer price is function of the lagged output gap, secular inflation [2], and short run cost push inflation, i.e. [3]:

$$\text{(III.24.a)}\quad \ln(PCH_t) - \ln(PCH_{t-1}) = (1\text{-}pch\_sl)\ (pch\_sw\text{-}1)\ pch\_s1\ [\ln(ASPO_{t-1}) - \ln(HP\_ASPO_{t-1})] - (1\text{-}pch\_sl)\ (pch\_sw\text{-}1)\ G\_PCH_t + (1\text{-}pch\_sl)\ pch\_sw\ [\ln(UCH_t) - \ln(UCH_{t-1})]\ ,$$

with the cost push component, UCH, defined as:

$$\text{(III.24.b)}\quad \Delta\ \ln(UCH_t) = -\ \Delta\ \ln(1\text{-}NITR_t) + (asp\_l1+asp\_l2)\ \Delta\ \ln(PCH_{t-1}(1\text{-}NITR_{t-1})) + asp\_l3\ \Delta\ \ln(PMP_t / HP\_YMP_{t-1})\ ,$$

with:

G_PCH: secular inflation [4].

1. See Appendix B for a derivation of UX.
2. In the empirical application, secular inflation, G_PCH, is calculated by applying a Hodrick-Prescott (HP) filter to the original PCH series.
3. See equations (B.15.a) and (B.15.b) of Appendix B.
4. With $G\_PCH_t = \ln(HP\_PCH_t) - \ln(HP\_PCH_{t-1})$, where HP_PCH is the steady state price of private consumption.

Remember that the parameter pch_sl measures the fraction of the composite price which is kept at its old price, and that the parameter pch_sw measures the fraction of the composite price which is revised according to a rule of thumb [1]. We expect these two parameters to be between zero and one. The parameter pch_s1 refers to the feedback of the output gap to the adjustment of the contemporaneous price to its equilibrium value (see equation (B.13) of Appendix B). We expect this parameter to be negative. Summarizing, we expect that in equation (III.24.a) the reduced form parameters have the following signs:

$$(1\text{-pch\_sl})\ (\text{pch\_sw-1})\ \text{pch\_s1} > 0\ ,$$

$$0 \le -(1 - \text{pch\_sl})(\text{pch\_sw} - 1) \le 1\ ,$$

$$0 \le (1 - \text{pch\_sl})\text{pch\_sw} \le 1\ .$$

Table III.8 shows point estimates, standard errors between brackets, and some diagnostic statistics for equation (III.24.a). Here, the values of pch_sl and pch_sw are between zero and one. However, note the rather low value of pch_sl across the country blocks, indicating that only a small fraction of the prices are left unchanged. The evidence shows that the response of prices to the output gap is highest for the EU block, i.e. 0.39, and lowest for the US block, i.e. 0.13.

TABLE III.8 - The consumer price, PCH

	EU	NE	US	JP
pch_sl	0.02	0.10	0.05	0.09
	(0.04)	(0.03)	(0.02)	(0.04)
pch_sw	0.51	0.70	0.80	0.25
	(0.12)	(0.10)	(0.08)	(0.10)
pch_s1	-0.82	-0.99	-0.70	-0.40
	(0.27)	(0.49)	(0.34)	(0.14)
output gap: (1-pch_sl) (pch_sw-1) pch_s1	0.39	0.27	0.13	0.27
secular inflation: -(1-pch_sl) (pch_sw-1)	0.48	0.27	0.19	0.68
cost push inflation: (1-pch_sl) pch_sw	0.50	0.63	0.76	0.23
Diagnostic statistics				
Adjusted R	0.89	0.97	0.97	0.96
Durbin h	-0.68	0.53	0.76	0.65

1. In other words, (1-px_sw) measures the fraction of the price of public consumption that is revised to the “rational reset price”.

4. Price expectations

Based on the previous price equations, we will now derive an equation for the expected future price level. Mutatis mutandis, equation (III.24.a) holds for all periods, including period *t+1*. In other words, the consumer price in period *t+1* is equal to:

$$\text{(III.25.a)}\quad \ln(PCH_{t+1}) = \ln(PCH_t) + (1\text{-}pch\_sl)\,(pch\_sw\text{-}1)\,pch\_s1\,[\ln(ASPO_t) - \ln(HP\_ASPO_t)] - (1\text{-}pch\_sl)\,(pch\_sw\text{-}1)\,G\_PCH_{t+1} + (1\text{-}pch\_sl)\,pch\_sw\,[\ln(UCH_{t+1}) - \ln(UCH_t)]\ ,$$

with:

$$\text{(III.25.b)}\quad \ln(UCH_t) = -\ln(1\text{-}NITR_t) + (asp\_l1+asp\_l2)\ln(PCH_{t-1}(1\text{-}NITR_{t-1})) + asp\_l3\ln(PMP_t\,/\,HP\_YMP_{t-1})\ .$$

Assuming that NITR and G_PCH are determined outside the model, and assuming that the expected increase in the price of the other goods is equal to the expected increase in PCH, all the right hand side variables and parameters of equation (III.25) are known in period *t*, and can be inserted into the equation to fit a series of expected future price PCH_{t+1} in period *t*.

The other prices, PX, are expected to increase at the same rate as the growth rate of private consumption, i.e.:

$$\text{(III.26)}\quad \ln(PX_{t+1}) - \ln(PX_t) = \ln(PCH_{t+1}) - \ln(PCH_t)\ .$$

IV The Monetary Sector

This chapter describes the monetary sector of the NIME model. The importance of the monetary sector is twofold. First, as shown in the previous two chapters, the interest rate and the exchange rate have an important impact on the expenditure decisions of the household sector and the enterprise sector. Second, the monetary sector consists of one of the channels through which the different country blocks of the NIME model are linked to each other [1], because domestic interest rates and exchange rates interact through international financial flows.

In the first section of this chapter, we discuss how in each block the short run interest rate is set by the monetary authorities in such a way that it deviates from the steady state interest rate to the extent that the policy variables deviate from their target values. These policy variables are inflation, economic activity (or unemployment), and the exchange rate. Furthermore, we also assume that the monetary authorities dislike discrete jumps in the short run interest rates, and try to smooth changes in the interest rate. The policy reaction function described in this section is the default equation of the NIME model. However, alternative reaction function could also be considered.

In the second section, we specify and estimate an equation for the long run interest rate, based on the term structure of interest rates and an expectations scheme, whereby the contemporaneous interest rate is expected to converge to the steady state interest rate. The obtained equation determines the contemporaneous long run interest rate as a function of the contemporaneous short run interest rate and the steady state interest rate.

In the third section, we derive an equation for the exchange rate from the interest rate parity condition, and the assumptions that in equilibrium the exchange rate stabilizes the foreign assets to GDP ratio, and that expectations are formed, partly by backward looking behaviour, and partly by the “fundamentals”. The obtained equation explains the spot exchange rate by the equilibrium exchange rate, the lagged spot exchange rate, the nominal interest rate differential, and the expected inflation differential.

Finally, it should be remembered that the demand for money is described in Chapter II.

1. The other channel is international trade.

A. The short run interest rate

In this section, we present some empirical results for the short run interest rate, SI.

1. A policy reaction function

It is assumed that the monetary authorities set the short run interest rate according to the following policy reaction function [1]:

$$\ln\left(\frac{1+SI_t}{1+HP\_LI_t}\right) = si\_s1\ [\ln\left(\frac{PCH_t}{PCH_{t-1}}\right) - \ln\left(\frac{TPCH_t}{TPCH_{t-1}}\right)\ ] + si\_s2\ \ln\left(\frac{UR_t}{TUR_t}\right) + si\_s3\ \ln\left(\frac{EFEX_t}{TEFEX_t}\right)\ , \quad \text{(IV.1)}$$

with:

EFEX: the effective exchange rate, number of domestic units per foreign unit [2],

HP_LI: the steady state nominal interest rate,

SI: the short run nominal interest rate,

TEFEX: the target effective exchange rate, number of domestic units per foreign unit,

TPCH: the target consumer price,

TUR: the target unemployment rate.

The parameters of equation (IV.1) have the following sign:

$$si\_s1 \geq 0\ , \quad \text{(IV.2.a)}$$

$$si\_s2 \leq 0\ , \quad \text{(IV.2.b)}$$

$$si\_s3 \geq 0\ . \quad \text{(IV.2.c)}$$

Equation (IV.1) states that the short run interest rate deviates from the steady state interest rate because of deviations of inflation, unemployment and the effective exchange rate from their target values.

We assume that the targets of the monetary authorities are consistent with the underlying structure of the economy, i.e.:

$$TEFEX = HP\_EFEX\ , \quad \text{(IV.3.a)}$$

$$TUR = HP\_UR\ , \quad \text{(IV.3.b)}$$

$$TPCH = HP\_PCH\ , \quad \text{(IV.3.c)}$$

with the label HP referring to steady state values. The equilibrium exchange rate stabilizes the foreign debt to GDP ratio [3].

1. For a recent survey on monetary policy, see Clarida et al. (1999).
2. The effective exchange rate, as well as the effective interest rate, are defined in Section A of Appendix D.

2. Interest rate smoothing

Setting the domestic interest rates rigorously according to scheme (IV.1) may lead to discrete jumps in the domestic interest rates. Monetary authorities may dislike such jumps, and they may try to smooth interest rate changes. Therefore, we postulate in the empirical section that interest rate are smoothed according to:

$$\ln(1 + SI_t) - \ln(1 + SI_{t-1}) = si\_sl\ [\ln(1 + TSI_t) - \ln(1 + SI_{t-1})\ ]\ ,$$

or:

$$\text{(IV.4)} \quad \ln(1 + SI_t) = si\_sl\ \ln(1 + TSI_t) + (1 - si\_sl)\ \ln(1 + SI_{t-1})\ ,$$

with $\ln(1+TSI_t)$ the interest rate defined by equation (IV.1), and with $0 \le si\_sl \le 1$.

Inserting equation (IV.1) into equation (IV.4), we obtain:

$$\begin{aligned}
\text{(IV.5.a)} \quad \ln(1 + SI_t) = {} & si_sl\ \{\ln(1 + HP_LI_t) \\
& + si_s1\ [\ln\left(\frac{PCH_t}{PCH_{t-1}}\right) - \ln\left(\frac{TPCH_t}{TPCH_{t-1}}\right)] \\
& + si_s2\ \ln\left(\frac{UR_t}{TUR_t}\right) + si_s3\ \ln\left(\frac{EFEX_t}{TEFEX_t}\right)\} \\
& + (1 - si_sl)\ \ln(1 + SI_{t-1})\ ,
\end{aligned}$$

or,

$$\begin{aligned}
\text{(IV.5.b)} \quad \ln\left(\frac{1+ SI_t}{1 + SI_{t-1}}\right) = {} & si_sl\ \{\ln\left(\frac{1+ HP_LI_t}{1 + SI_{t-1}}\right) \\
& + si_s1\ [\ln\left(\frac{PCH_t}{PCH_{t-1}}\right) - \ln\left(\frac{TPCH_t}{TPCH_{t-1}}\right)] \\
& + si_s2\ \ln\left(\frac{UR_t}{TUR_t}\right) + si_s3\ \ln\left(\frac{EFEX_t}{TEFEX_t}\right)\}\ .
\end{aligned}$$

3. The equilibrium exchange rate specified in equations (IV.12.b) and (IV.12.c). See below.

3. The empirical results

Table IV.1 shows for the four blocks of the NIME model, the estimation results for equation (IV.5) [1], which is estimated with instrumental variables [2]. When the unrestricted estimate did not have the expected sign, we imposed the restriction that the value of this parameter is equal to zero. The exchange rate target performed very poorly in all the blocks. For the NE block we also found that the estimate of the parameter of the inflation target had the wrong sign.

TABLE IV.1 - The short run interest rate, SI

	EU	NE	US	JP
si_s1	0.47	0.00	1.89	0.70
	(0.25)	-.-	(1.04)	(0.10)
si_s2	-0.14	-0.17	-0.40	-0.08
	(0.07)	(0.07)	(0.27)	(0.02)
si_s3	0.00	0.00	0.00	0.00
	-.-	-.-	-.-	(0.00)
si_sl	0.52	0.34	0.18	0.82
	(0.15)	(0.11)	(0.11)	(0.08)
Diagnostic statistics				
Adjusted R	0.72	0.75	0.85	0.93
Durbin h	0.29	0.94	1.36	0.08

B. The long run interest rate

In this section we show some empirical results for the long run interest rate, LI.

1. An equation for the long run interest rate

Using the term structure of the interest rates, and postulating an expectation scheme whereby the long run interest rate is expected to converge to the steady state rate, HP_LI, we derive in Appendix C that:

$$\text{(IV.6)} \qquad LI_t = li\_l0 + li\_l1\ SI_t + li\_l2\ HP\_LI_t\ ,$$

$$\text{with:} \qquad li\_l1,\ li\_l2 \quad \geq \quad 0\ .$$

Equation (IV.6) states that the contemporaneous long run interest rate is function of a constant, the steady state interest rate, and the contemporaneous short run interest rate (see equation (C.10) of Appendix C).

1. For a critical assessment of policy rule estimates, see Section 6 of Christiano et al. (1999).
2. For the US, a better fit was obtained when we added a dummy, DU8083, to the interest equation of the US block. The dummy DU8083 is equal to one for the years 1980 until 1983, i.e., the years when the US Federal Reserve experimented with targets for the monetary aggregates. For the other years this dummy is equal to zero.

Note that in the case where there is no risk premium in the bond market, equation (IV.6) reduces to:

(IV.7) $LI_t = li\_l1\ SI_t + (1\text{-}li\_l1)\ HP\_LI_t$,

i.e. the contemporaneous long run interest rate is weighted average of the spot interest rate and the steady state interest rate (see equation (C.11) of Appendix C).

2. The empirical results

Table IV.2 shows the point estimates for equation (IV.6). Except for the constants, all coefficients are very significant.

TABLE IV.2 - The long run interest rate, LI

	EU	NE	US	JP
li_l0	0.00	0.00	-0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
li_l1	0.51	0.29	0.32	0.26
	(0.08)	(0.09)	(0.07)	(0.07)
li_l2	0.54	0.77	0.90	0.61
	(0.15)	(0.17)	(0.13)	(0.13)
Diagnostic statistics				
Adjusted R	0.87	0.77	0.89	0.83
Durbin - Watson	1.23	0.92	1.30	1.14

C. The exchange rate

In this section we derive an exchange rate equation, and we show some empirical results. The starting point is the interest rate parity condition, and an expectations scheme, whereby we assume that the spot exchange rate gradually converges to its equilibrium level. The equilibrium exchange rate is the exchange rate that stabilizes the foreign debt to GDP ratio. Temporary deviations between the spot and equilibrium exchange rate may arise because of backward looking behaviour in the exchange market, “chartists”, and rigidities in the economy, as reflected by the (real) interest rate differential.

For mathematical convenience, we will make the following analysis in terms of the effective foreign variables, i.e., weighted averages of the foreign variables. These variables are defined in Section A of Appendix D.

1. The interest rate parity condition

In the short run the interest rate parity condition holds, i.e.:

(IV.8) $\ln[E(EFEX_{t+1})] - \ln(EFEX_t) = ex\_1\,[\ln(1+SI_t) - \ln(1+EFSI_t)] + ex\_0$,

with:

E(.) : the expectations operator, conditional on information available at period *t*,
EFSI : the effective foreign nominal short run interest rate.

Note also that ex_1 > 0 .

Equilibrium condition (IV.8) links the domestic money market of the different blocks by relating the interest rate differential to the expected change in the exchange rate.

Absence of "risk" is defined as the case where:

$ex\_0 = 0$, and, $ex\_1 = 1$,

so that equation (IV.8) can be rewritten as:

(IV.9) $\ln[E(EFEX_{t+1}) - \ln(EFEX_t)] = \ln(1+SI_t) - \ln(1+EFSI_t)$.

2. Exchange rate expectations

We assume that there are two kinds of traders in the foreign exchange market: "chartists", who extrapolate expected future exchange rate changes from past changes, and "fundamentalists", who use "fundamentals" to predict exchange rate movements. Let ex_a be the share of "chartists" in the market, so that (1-ex_a) is the share of "fundamentalists" in the market, with $0 \leq ex\_a \leq 1$.

a. The "chartists"

Here, we assume that the "chartists" follow a simple rule of thumb by extrapolating expected future developments from past experiences, i.e.:

(IV.10) $\ln[E(EFEX_{t+1})] - \ln(EFEX_t) = \ln(EFEX_t) - \ln(EFEX_{t-1})$,

i.e., the expected change of the effective exchange rate of the chartist is equal to the last observed change.

b. The “fundamentalists”

We postulate the following expectations scheme for the “fundamentalists”:

$$\text{(IV.11)}\quad \ln[E(EFEX_{t+1})] - \ln(EFEX_t) = ex\_2\,\{\ln(HP\_EFEX_t) - \ln(EFEX_t)\} + \{\ln[E(HP\_EFEX_{t+1})] - \ln(HP\_EFEX_t)\},$$

where HP_EFEX_t is the steady state exchange rate, and with $ex\_2 > 0$.

According to equation (IV.11), the expected change in the spot exchange rate is equal to the gap between the spot effective exchange rate and its steady state value, plus the expected change in the steady state exchange rate [1].

The equilibrium nominal exchange rate, HP_EFEX, is the exchange rate which stabilizes the foreign debt to GDP ratio. This exchange rate is derived in Appendix D as:

$$\text{(IV.12.a)}\quad HP\_EFEX_t = \frac{PASP_t}{EFPASP_t}\ HP\_EFREX_t ,$$

with the real exchange rate, HP_EFREX, defined as:

$$\text{(IV.12.b)}\quad HP\_EFREX_t = \frac{(1\text{-}NITR)}{(1\text{-}EFNITR)} * \left(\frac{asp\_l3\ \ ASPO}{efasp\_l3\ \ EFASPO\ \ EFEX_{1990}} - \frac{ROW}{efasp\_l3\ \ EFASPO\ \ EFEX_{1990}}\right).$$

where:

$$\text{(IV.12.c)}\quad ROW_t = \frac{NFIROW_t + NCTROW_t - FBOND_{t-1}[\Delta\ln(GDPU_t) + \Delta\ln(f\_l0)]}{(1 - NITR_t)PASP_t},$$

with:

FBOND: the stock of foreign assets, denominated in local currency,

GDPU: gross domestic product, in current prices, denominated in local currency,

NCTROW: net current transfers from the rest of the world, in local currency,

NFIROW: net factor income from the rest of the world, in local currency.

See equations (D.16.a) and (D.16.b) of Appendix D.

1. A similar expectations scheme has been proposed by, for example, Dornbush (1976) and Frankel (1979).

Equation (IV.12.a) defines the nominal exchange rate that stabilizes the stock of foreign assets to GDP ratio. The nominal exchange rate is equal to the relative price level, multiplied by the real exchange rate. The real exchange rate, defined in equation (IV.12.b), is determined by relative indirect taxes, the relative level of economic activity, corrected for a term related to the ratio of net factor income and net current transfers to the output of the rest of the world.

Equation (IV.12) shows that if the domestic price level increases, ceteris paribus, then the nominal exchange rate will also increase, i.e., the domestic currency will depreciate. This result reflects the fact that in the steady state, purchasing power parity, adjusted for the real exchange rate, must hold. If domestic output increases, ceteris paribus, then the real exchange rate will depreciate. The latter effect is due to the fact that if domestic output increases, then the import volume will also increase [1]. To maintain equilibrium in the current account, the exchange rate has to depreciate.

c. Market expectations

The market expectation is the weighted average of the depreciation expected by the “chartists” (equation (IV.10)), and the depreciation expected by the “fundamentalists” (equation (IV.11)), i.e.:

(IV.13) $$\begin{aligned} \ln[E(EFEX_{t+1})] - \ln(EFEX_t) = {} & ex\_a\,[\ln(EFEX_t) - \ln(EFEX_{t-1})] \\ & + (1-ex\_a)\,\{\, ex\_2\,[\,\ln(HP\_EFEX_t) - \ln(EFEX_t)\,] \\ & \qquad + [\,\ln[E(HP\_EFEX_{t+1})] - \ln(HP\_EFEX_t)\,]\,\}\,. \end{aligned}$$

Equation (IV.13) states that the exchange rate is expected to depreciate at a rate proportional to the lagged exchange rate change, plus the gap between the spot exchange rate and the equilibrium exchange rate, plus the expected change in the steady state exchange rate. The first term is due to the “chartists”, the last two terms are due to the “fundamentalists”.

3. An exchange rate equation

Inserting equation (IV.13) into equation (IV.8) yields:

(IV.14) $$\begin{aligned} ex\_1\,[\ln(1+SI_t) - \ln(1+EFSI_t)] + ex\_0 = {} & ex\_a\,[\ln(EFEX_t) - \ln(EFEX_{t-1})] \\ & + (1-ex\_a)\,\{ex\_2\,[\ln(HP\_EFEX_t) - \ln(EFEX_t)] \\ & \qquad + \{\ln[E(HP\_EFEX_{t+1})] - \ln(HP\_EFEX_t)\}\}\,. \end{aligned}$$

1. It should be noted that this is a partial equilibrium. This depreciation may be offset by the appreciation which is induced by the increase in the short run interest rate, caused by the interventions of the monetary authorities. See the policy reaction function (IV.5).

Equation (IV.14) can be solved for the spot exchange rate as:

$$\text{(IV.15)}\quad \ln(EFEX_t) = \frac{ex\_0}{ex\_a-(1-ex\_a)\,ex\_2}$$
$$- \frac{(1-ex\_a)\,ex\_2}{ex\_a-(1-ex\_a)\,ex\_2}\ \ln(HP\_EFEX_t)$$
$$+ \frac{ex\_a}{ex\_a-(1-ex\_a)\,ex\_2}\ \ln(EFEX_{t-1})$$
$$- \frac{ex\_1}{ex\_a-(1-ex\_a)\,ex\_2}\ [\ln(1+EFSI_t) - \ln(1+SI_t)]$$
$$- \frac{(1-ex\_a)}{ex\_a-(1-ex\_a)\,ex\_2}\ \{\ln(HP\_EFEX_{t+1}) - \ln(HP\_EFEX_t)\}\ ,$$

with the equilibrium exchange rate, HP_EFEX, defined in equation (IV.12).

Note that for the parameters associated with $\ln[E(HP\_EFEX_t)]$ and $\ln(EFEX_{t-1})$, it holds that:

$$\text{(IV.16)}\quad - \frac{(1-ex\_a)\,ex\_2}{ex\_a-(1-ex\_a)\,ex\_2} + \frac{ex\_a}{ex\_a-(1-ex\_a)\,ex\_2} = 1\ .$$

Equation (IV.15) shows how the nominal exchange rate is determined by a weighted average of the equilibrium exchange rate and the lagged exchange rate, by the interest rate differential, and by the expected change in the equilibrium exchange rate.

Finally, it should also be noted that, making use of equation (IV.8) and assuming that there is no risk premium in the steady state, the expected rate of depreciation of the equilibrium exchange rate is equal to:

$$\text{(IV.17)}\quad \ln[E(HP\_EFEX_{t+1})] - \ln(HP\_EFEX_t) = \ln(1+HP\_LI_t) - \ln(1+HP\_EFLI_t)\ .$$

Furthermore, in the steady state the nominal interest rate, HP_LI, is determined by the Fisher equation as:

$$\text{(IV.18.a)}\quad 1 + HP\_LI_t = (1 + HP\_RLI_t)\left(\frac{HP\_PCH_{t+1}}{HP\_PCH_t}\right)\ ,$$

$$\text{(IV.18.b)}\quad 1 + HP\_EFLI_t = (1 + HP\_EFRLI_t)\left(\frac{HP\_EFPCH_{t+1}}{HP\_EFPCH_t}\right)\ ,$$

with:

HP_RLI: the steady state real interest rate [1].

1. The steady state real interest rate is determined outside the model.

Assuming that in the steady state the real interest rates are equalized across blocks, and inserting equation (IV.18) into (IV.17), we get that:

$$\text{(IV.19)} \quad \ln[E(HP\_EFEX_{t+1})] - \ln(HP\_EFEX_t) = \Delta \ln(HP\_PCH_{t+1}) - \Delta \ln(HP\_EFPCH_{t+1}) .$$

Combining equations (IV.15) and (IV.19), we estimated the following exchange rate equation with instrumental variables:

$$\text{(IV.20)} \quad \ln(EFEX_t) = ex\_s0 + ex\_s1 \ln(HP\_EFEX_t) + (1-ex\_s1) \ln(EFEX_{t-1}) + ex\_s2 [\ln(1+EFSI_t) - \ln(1+SI_t)] + ex\_s3 \{\Delta \ln(HP\_PCH_t) - \Delta \ln(HP\_EFPCH_t)\} ,$$

where use has been made of condition (IV.16). In other words, the nominal exchange rate is determined by a weighted average of the equilibrium exchange rate and the lagged exchange rate, by the interest rate differential, and by the expected inflation differential.

4. The empirical results

Table IV.3 shows the point estimates, standard errors between brackets, and some diagnostic statistics for equation (IV.20) [1].

TABLE IV.3 - The nominal effective exchange rate, EFEX

	EU	NE	US	JP
ex_s0	0.00	0.00	0.00	0.00
	-.-	-.-	-.-	-.-
ex_s1	0.48	0.38	0.29	0.47
	(0.12)	(0.15)	(0.11)	(0.10)
ex_s2	0.53	1.27	0.50	1.93
	(0.94)	(0.49)	-.-	(1.16)
ex_s3	0.65	0.25	0.62	1.72
	(0.52)	(0.46)	(0.36)	(0.71)
Diagnostic statistics				
Adjusted R	0.99	0.99	0.99	0.98
Durbin h	1.85	1.77	0.42	0.14

1. Estimated with instrumental variables.

V The Public Sector

This chapter describes the public sector of the NIME model. The public sector comprises the expenditures and revenues of the general government. The behavioural relations of the public sector are not derived from an explicit optimization problem, they are simply postulated. It is assumed that the tax revenues are determined by the tax base and tax rates, while most public expenditure items grow at the steady state growth rate of GDP, sometimes adjusted for cyclical effects. Finally, it should be noted that the equations describing the fiscal variables can be changed in a flexible way if the need arises to investigate particular policy variants. However, in such a case convergence to a steady state is not guaranteed.

This chapter is structured as follows. First, we review the public expenditures which include the wage bill, consumption of goods and services, transfers, interest payments, and capital expenditures. Next, we have a look at the public revenues which include direct taxes on labour and capital income, and net indirect taxes. Third, we describe a policy reaction function whereby the direct labour income tax rate adjusts in such a way that a predetermined target public debt to GDP ratio is attained in the steady state.

A. Public sector expenditures

Public sector expenditures consist of current expenditures, CGU, and capital transactions, IGU.

1. Public sector current expenditures

Total current expenditures are defined as:

(V.1) $$CGU_t = WBGU_t + CGGSU_t + TRANS_t + CGINT_t \, ,$$

with:

CGGSU: public consumption of goods and services, exclusive the wage bill, in current prices,

CGINT: interest payment on public debt, in current prices,

CGU: total expenditures by the public sector, in current prices,

TRANS: public sector transfers, in current prices,

WBGU: the wage bill of the public sector, in current prices.

Let us now have a look at each of these items.

a. The public sector wage bill

The wage bill of the public sector is equal to:

(V.2) $WBGU_t = WGR_t \, NG_t$,

with:

NG: the employment in the public sector,
WGR: the wage rate per capita in the public sector.

i. The public sector wage rate

We postulate that, in the medium run, the wage rate in the public sector, WRG, is proportional to the wage rate in the private sector, WRP. Short run fluctuations in the relative wage rate are captured by an error correction term, and by the extent that the contemporaneous unemployment rate deviates from its steady state rate, i.e.:

(V.3) $$\Delta \ln\left(\frac{WRG_t}{WRP_t}\right) = wrg\_sl\,[\,\ln\left(\frac{WRG_{t-1}}{WRP_{t-1}}\right) - wrg\_s0\,] + wrg\_s1\,(UR_t - HP\_UR_t) \ .$$

Note that: $-1 \le wrg\_sl \le 0$.

Table V.1 shows empirical results for equation (V.3) [1].

TABLE V.1 - The public sector wage rate, WRG

	EU	NE	US	JP
wrg_s0	0.05	-0.27	0.23	0.63
	(0.07)	(0.01)	(0.01)	(0.02)
wrg_s1	-0.70	0.64	0.44	0.00
	(0.30)	(0.43)	(0.27)	-.-
wrg_sl	-0.09	-0.82	-0.31	-0.12
	(0.08)	(0.23)	(0.12)	-.-
Diagnostic statistics				
Adjusted R	0.28	0.38	0.47	0.23
Durbin - Watson	2.13	1.58	2.12	1.63

1. Two dummies are added to the equation during estimation. First, the dummy DU7081 is equal to 1 for the period from 1970 until 1981, and 0 after 1981. This dummy reflects loose fiscal policies in the seventies. Second, in the EU block, a dummy DUM91 for German re-unification.

ii. Public sector employment

In the steady state employment in the public sector, HP_NG, is predetermined, and it grows at the growth rate of the labour supply, G_LS, i.e.:

$$\text{(V.4)} \qquad \Delta \ln(HP\_NG) = G\_LS \, .$$

In the short run we allow for fluctuations in public sector employment. These fluctuations are function of an error correction term, the change in the real wage, and (lagged) trend growth, i.e.:

$$\text{(V.5)} \qquad \Delta \ln(NG_t) = ng\_sl \, [\ln(NG_{t-1}) - \ln(HP\_NG_{t-1})] + ng\_s1 \, \Delta \, [\ln(WRG_t) - \ln(PCH_t)] + \Delta \ln(HP\_NG_{t-1}) \, ,$$

with the parameters expected to satisfy the conditions:

$$-1 \le ng\_sl \le 0 \, , \qquad ng\_s1 \le 0 \, .$$

Table V.2 shows point estimates for equation (V.5).

TABLE V.2 - Demand for employees by the public sector, NG

	EU	NE	US	JP
ng_s1	-0.06	0.00	-0.35	-0.06
	(0.08)	-.-	(0.09)	(0.03)
ng_sl	-0.34	-0.33	-0.15	-0.33
	(0.13)	(0.14)	(0.10)	(0.09)
Diagnostic statistics				
Adjusted R	0.76	0.71	0.65	0.93
Durbin - Watson	0.89	1.32	1.62	1.48

b. Public consumption of goods and services, exclusive the wage bill

The growth of public consumption of goods and services, exclusive the wage bill, in constant prices, CGGSO, is determined by lagged trend growth, and a lagged cyclical component:

$$\text{(V.6)} \qquad \Delta \ln(CGGSO_t) = cg\_s1 \ln\left(\frac{ASPO_{t-1}}{HP\_ASPO_{t-1}}\right) + G\_YNP_{t-1} + G\_LS_{t-1} \, ,$$

with: $cg\_s1 \le 0$ [1].

1. In the current version of the NIME model, the parameter cg_s1 is not estimated but set by the user of the model. The default is cg_s1 = 0.

Public consumption of goods and services, exclusive the wage bill, in current prices, CGGSU, is determined by:

(V.7) $CGGSU_t = CGGSO_t \; PCGGS_t$,

with the price PCGGS specified in Chapter III.

c. Interest payments on public debt

Interest payments on the public debt is equal to:

(V.8) $CGINT_t = GBOND_{t-1} \; LIG_{t-1}$

with:

GBOND: the stock of public debt, in current prices,
LIG: the interest rate of public debt [1].

d. Public sector transfers

We distinguish three types of public sector transfers.

i. Transfers to households

Transfers to households are function of the level of benefits and the number of recipients, i.e.:

$$TRANSH_t = WC_t \; NPOC_t + WO_t \; NPOO_t + UB_t \; UR_t \; LS_t + TRANSH\_0 ,$$

with:

LS: labour supply,
NPOC: number of children,
NPOO: number of pensioners,
TRANSH_0: other public transfers to the household sector,
UB: benefits accruing to the unemployed,
UR: unemployment rate,
WC: benefits accruing to children,
WO: benefits accruing to pensioners.

---

1. Note that LIG is calculated as: $LIG_{t-1} = \frac{CGINT_t}{GBOND_{t-1}}$. We fit the interest rate on public debt as a weighted average of the short run and long run interest rate, i.e., $LIG_t = w\_lig \; SI_t + (1-w\_lig) \; LI_t$, with $0 \le w\_lig \le 1$.

After the proper manipulations, we obtain that equation (V.8) can be rewritten as [1]:

$$\text{(V.9)} \qquad \Delta \ln\left(\frac{TRANSH_t}{PCH_t}\right) = G\_YNP_{t-1}$$

$$+ trh\_s2\ \Delta \ln(NPOC_t) + trh\_s3\ \Delta \ln(NPOO_t) + trh\_s4\ \Delta \ln(UR_t\ LS_t)$$

$$+ (1\text{-}trh\_s2\text{-}trh\_s3\text{-}trh\_s4)\ \Delta \ln(NPO_t)\ .$$

Table V.3 shows empirical results for equation (V.9).

TABLE V.3 - Transfers to households by the public sector, TRANSH

	EU	NE	US	JP
trh_s1	1.00	1.00	1.00	1.00
	-.-	-.-	-.-	-.-
trh_s2	0.54	0.48	-0.35	2.10
	(0.30)	(0.53)	(0.52)	(0.54)
trh_s3	0.71	1.82	1.65	2.15
	(0.30)	(0.63)	(0.71)	(0.41)
trh_s4	0.15	0.12	0.18	0.15
	(0.03)	(0.03)	(0.03)	(0.07)
Diagnostic statistics				
Adjusted R	0.64	0.47	0.61	0.63
Durbin - Watson	1.99	1.73	0.88	1.61

ii. Transfers to enterprises

For the specification of subsidies to the enterprise sector, SUBP, see Section B.3 of this chapter.

1. Differentiating both sides, dividing both sides by TRANSH, and noting that for small changes $\Delta \ln X = \Delta X / X$, equation (V.8) can be rewritten as:

$$\Delta \ln(TRANSH_t) = trh\_s2\ \Delta \ln(NPOC_t) + trh\_s2\ \Delta \ln(WC_t)$$

$$+ trh\_s3\ \Delta \ln(NPOO_t) + trh\_s3\ \Delta \ln(WO_t)$$

$$+ trh\_s4\ \Delta \ln(UR_t\ LS_t) + trh\_s4\ \Delta \ln(UB_t)$$

$$+ trh\_s5\ \Delta \ln(TRANSH\_0_t)\ .$$

Noting that the budget shares, trh_sx, add up to one :
$trh\_s2 + trh\_s3 + trh\_s4 + trh\_s5 = 1$,
and assuming that real benefits are indexed to lagged productivity growth, i.e.:

$$\Delta \ln\left(\frac{WC_t}{PCH_t}\right) = \Delta \ln\left(\frac{WO_t}{PCH_t}\right) = \Delta \ln\left(\frac{UB_t}{PCH_t}\right) = G\_YNP_{t-1}\ ,$$

and that other transfers, TRANSH_0, increases accordingly, i.e.:

$$\Delta \ln\left(\frac{TRANSH\_0_t}{PCH_t}\right) = G\_YNP_{t-1} + \Delta \ln(NPO_t)\ ,$$

we obtain equation (V.9).

iii. Transfers to the rest of the world

Transfers to the rest of the world, TRANSR, are a assumed to represent a fixed proportion of nominal GDP:

(V.10) $TRANSR_t = trr\_s1\ GDPU_t$,

where the parameter trr_sl is the sample average of the ratio $\frac{TRANSR}{GDPU}$.

iv. Total transfers

Summarizing, the total amount of transfers of the public sector is defined as:

(V.11) $TRANS = TRANSH + SUBP + TRANSR$.

2. The public sector capital transactions

The capital transactions of the public sector, IGU, are defined as:

(V.12) $IGU_t = IGCU_t + GIGOU_t$,

with:

IGU: total net capital transactions of the public sector,
IGCU: net fixed capital formation by the public sector,
GIGOU: net other capital transactions by the public sector.

Note that:

(V.13) $IGCU_t = GIGCU_t - DEPGCU_t$,

with:

GIGCU: gross fixed capital formation by the public sector, in current prices,
DEPGCU: depreciation of the public sector capital stock.

Gross fixed capital formation in constant prices, GIGCO, is specified as:

(V.14.a)
$$GIGCO_t = gig\_sl\ (gig\_l0 + gig\_lb\ GDPO_t) - gig\_sl\ (1\text{-}gig\_rh)\ (gig\_l0 + gig\_lb\ GDPO_{t-1}) + (1\text{-}gig\_sl)\ GIGCO_{t-1} ,$$

with: $0 \le gig\_sl \le 1$.

In the steady state, the desired public capital stock is proportional to GDP. The parameter gig_rh is the rate of depreciation of the public capital stock. Estimation results for equation (V.14.a) are shown in Table V.4. [1].

TABLE V.4 - Gross fixed capital formation by the public sector, GIGCO

	EU	NE	US	JP
gig_l0	0.00	0.00	0.00	0.00
	-.-	-.-	-.-	-.-
gig_lb	1.28	0.56	0.51	1.00
	(0.31)	(0.37)	(0.08)	-.-
gig_sl	0.02	0.04	0.04	0.05
	(0.01)	(0.04)	-.-	(0.04)
gig_rh	0.01	0.02	0.04	0.01
Diagnostic statistics				
Adjusted R	0.84	0.83	0.92	0.96
Durbin - Watson	1.26	1.56	1.44	1.14

Net other capital transactions, GIGOU, is specified as:

(V.14.b) $\Delta \ln(GIGOU_t) = \Delta \ln(GDPU_{t-1})$.

B. Public sector revenue

We distinguish the following revenue items: direct taxes on labour income, direct taxes on capital income, total indirect taxes, social security contributions, and net other taxes. These items are specified as follows.

1. Direct taxes on income from labour

It is assumed that direct taxes on labour income are levied according to:

(V.15) $DTH_t = DTHR_t\,(WBU_t + TRANSH_t)$,

with:

DTH: direct tax revenue from labour income,
DTHR: the direct income tax rate.

In the next section, we show how the direct labour income tax rate, DTHR, is set in such a way that the debt to GDP ratio stabilizes at a predetermined ratio.

1. Dummies have been added during estimation.

2. Direct taxes on income from capital

Direct taxes on capital income, DTCP, accrue according to:

(V.16) $\Delta \ln(DTCP_t) = \Delta \ln(GDPU_t)$,

with:

DTCP: direct tax revenue from income on capital,
GDPU: gross domestic product, in current prices.

3. Indirect taxes and subsidies

Net indirect taxes are defined as indirect taxes [1] minus subsidies to the enterprise sector. Net indirect taxes are generated by the following equation [2]:

(V.17) $NITP_t = NITPR_t [(ASU_t - (ITP_t - SUBP_t)]$.

The net indirect tax rate, NITPR, is determined outside the model.

If one wants to manipulate subsidies so that the net indirect tax rate remains constant, then subsidies are set according to:

(V.18) $SUBP_t = ITP_t - \frac{NITPR_t}{1 + NITPR_t} ASU_t$.

1. Indirect taxes, ITP, is a gross concept, defined as indirect taxes and excise duties on the production, sale, purchase or use of goods and services; also included are the import duties.
2. The implicit gross indirect tax rate is calculated as:

$$ITPR_t = \frac{ITP_t}{ASU_t - ITP_t} ,$$

with:
ITPR: the gross indirect tax rate,
ITP: indirect taxes,
ASU: total supply of goods and services.
The net indirect tax rate is calculated as:

$$NITPR_t = \frac{ITP_t - SUBP_t}{ASU_t - (ITP_t - SUBP_t)} ,$$

with SUBP the public sector transfers to the enterprise sector.

4. Social security contributions

Social security contributions are levied according to:

(V.19) $SSRH_t = SSRHR_t\,(WBU_t + TRANSH_t)$,

with:

SSRH: social security contributions,
SSRHR: the social security contributions rate.

The social security contribution rate is determined outside the model.

5. Net other tax revenue

The net other tax revenue, OT, accrues according to:

(V.20) $OT_t = OT_{t-1}\,(1+G\_YNP_t)\,(1+G\_NPO_t)\,(1+G\_PCH_t)$.

6. Total tax revenue

We summarize by defining total tax revenue, TOTREV, as:

(V.21) $TOTREV_t = DTH_t + DTCP_t + ITP_t + SSRH_t + OT_t$.

C. Deficits, debt, and direct taxes

1. Deficits and debt accumulation

Net savings of the public sector, NSG, is defined as the difference between total revenue and current expenditures, i.e.:

(V.22) $NSG_t = TOTREV_t - CGU_t$,

with TOTREV defined in equation (V.21), and CGU defined in equation (V.1).

Net lending by the public sector, NLG, is defined as:

(V.23) $NLG_t = - NSG_t + IGU_t$,

with total net capital transactions of the public sector, IGU, defined in equation (V.12).

Assuming that the monetary authorities do not lend to the public sector, interest bearing bonds are accumulated according to:

(V.24) $GBOND_t = GBOND_{t-1} + NLG_t$.

2. Direct taxes

We assume that the public sector targets a predetermined debt to GDP ratio in the long run. We also assume that it is the direct labour income tax rate that adjusts to reach this target. We will now derive a policy reaction function which guarantees this outcome in the steady state.

In the steady state the direct income tax rate, DHTR, is set such that:

(V.25) $$\frac{GBOND_t}{GDPU_t} = R\_GBOND \ ,$$

with:

GDPU: gross domestic product, in current prices,
R_GBOND: the target debt to GDP ratio.

In Appendix E, we propose the following policy rule to make the debt to GDP ratio converge to its steady state target:

(V.26.a) $$\Delta\left(\frac{DTH_t}{GDPU_t}\right) = dth\_sl\left(\left(\frac{DTH_{t-1}}{GDPU_{t-1}}\right) - \left(\frac{HP\_DTH_{t-1}}{GDPU_{t-1}}\right)\right) + dth\_s1\left(\left(\frac{GBOND_{t-1}}{GDPU_{t-1}}\right) - R\_GBOND_t\right) ,$$

with HP_DTH defined as [1]:

(V.26.b) $$HP\_DTH = CGX - (DTCP + ITP + SSRH + OT) + \{ HP\_LI\,(1 - G\_YNP - G\_LS - G\_PCH) - G\_YNP - G\_LS - G\_PCH \}\, R\_GBOND\ GDPU \ ,$$

and with the parameters satisfying the conditions:

$$dth\_sl < 0 \quad \text{and} \quad dth\_s1 > 0 \ .$$

The implicit direct labour income tax rate, DTHR, for which the debt to GDP ratio is equal to its steady state target level is equal to:

(V.27) $DTHR = DTH / (WBU + TRANSH)$,

with DTH defined in equation (V.26.a).

1. See equation (E.13) of Appendix E.

VI The Properties of the Model: Multiplier Analysis

In the previous chapters, we presented the most important equations of the NIME model [1]. We will now study the properties of the model by examining the adjustment path of the endogenous variables under alternative scenarios.

In the first section, we summarize briefly the major adjustment channels in the NIME model. Next, we elaborate further on the impact of expectations on the speed of adjustment. In the subsequent sections, we discuss the simulation results of a permanent labour market shock, a permanent fiscal shock, and a permanent monetary shock. Note that the simulations presented in this chapter are technical variants to study the properties of the NIME model. Policy variants will be made in due course.

A. Adjustment in the NIME model

In the steady state, all the flow and stock variables are in equilibrium, and expectations are realised fully. Summarizing the previous chapters, the principal adjustment channels to reach equilibrium are the prices, the scale variables, the monetary policies (i.e., the interest rate and the exchange rate), the fiscal policies (i.e., the direct income tax rate), and the expectations regime.

First, there are the factor and goods prices which adjust to restore equilibrium. Real factor prices adjust to reflect changes in factor productivity (see Chapter III). Relative prices of supply for final demand change to induce a reallocation between the components of final demand (see Chapter II and III). Finally, the consumer price deflates the nominal scale variable in the demand equations of the household sector, so that a change in the price level affects household demand via its wealth effect (see Chapter II).

Second, there are the scale variables, of which the most important are the following. First, the total available means of the household sector changes in response to changes in the (expected) non-asset income. In other words, household demand increases if there is an expected increase in future wages. Second, total supply adjusts to meet total demand in the short run. Third, international trade accommodates total domestic demand in the short run. Fourth, savings are used to adjust the capital stocks to their equilibrium level.

1. In Appendix F, we present some additional behavioural relations, including exports, inventory demand, labour supply, and the “rest of the world” (RW) block.

Third, there is the interest rate and the exchange rate. A change in the interest rate affects the different components of total demand. First, the interest rate has an effect on household demand through its liquidity effect, its intertemporal substitution effect, its effect on the user cost of residential buildings, and its wealth and income effect (see Chapter II). Next, a change in the interest rate changes the user cost of capital, which affects gross fixed capital formation by the enterprise sector (see Chapter III). Third, an increase in the interest rate increases interest payments on public debt, necessitating an increase in tax revenue via a rise in the direct labour income tax rate (see Chapter V). Finally, changes in the interest rate induce changes in the exchange rate (see Chapter IV), which are subsequently passed on to the export and import prices (see Chapter III).

Fourth, the direct labour income tax rate adjusts so that in equilibrium the target debt to GDP ratio is met. However, in the short run this tax rate may deviate from its equilibrium level to speed up adjustment (see Chapter V).

B. The available information set and the speed of adjustment

The way expectations are formed is the fifth adjustment channel in the NIME model. If the agents learn only gradually about a shock, it will take more time before prices or expenditure plans are adjusted, than if a shock is observed at negligible cost and agents are able to act immediately on this information.

In this Working Paper, we distinguish two expectations regimes: one regime with fully informed agents [1], and one regime with gradual learning. We will now discuss how these two expectations regimes affect the perceived stream of future non-asset income and price setting. The implications of these two alternative regimes will become clear when we present the scenarios.

1. Future non-asset income

In Chapter II, we showed how household demand depends on the scale variable SCALEH (see equation (II.4.a)). An important component of the scale variable is the expected stream of future non-asset income, EZY. Remember that EZY is to a large extent determined by trend productivity, HP_YNP. Indeed, if trend productivity increases, the future real wage (see equation (III.13.g)), and future transfers will also increase (see equation (V.9)). We will now define two cases regarding the perception of a change in trend productivity.

In the case of gradually learning agents, we assume that it is with a lag that the households revise their expected stream of future income, because they gradually revise their expectations regarding trend productivity. For illustrative purposes, we assume here that the household sector perceives the change in trend productivity according to:

(VI.1) $$\Delta \ln(EHP\_YNP_t) = eynp\_sl\,[\ln(HP\_YNP_t - EHP\_YNP_{t-1})]\,,$$

1. I.e., the case in which the information regarding the shock is available at negligible cost.

where EHP_YNP is the perceived trend productivity, with eynp_sl > 0 [1].

In the case of fully informed agents, we assume that once a shock occurs, the household sector is fully informed about this shock and acts accordingly, i.e.:

(VI.2) $EHP\_YNP_t = HP\_YNP$.

2. Price setting

In Chapter III, we discussed how price setting is, to a large extent, determined by the cost at which the information regarding the underlying cost push inflation is available.

In the case of gradually learning agents, we assume that the information regarding the nature of the shock is not available at negligible cost, i.e., the available information set consists of equations (B.5.a) to (B.5.d) of Appendix B.

In the case of fully informed agents, we assume that all prices that are reset, are set to the rational reset price [2]. Referring to the price setting scheme described in Chapter III and Appendix B, especially equation (III.15), this assumption implies that the proportion of revised prices that will be reset to the rational reset price is equal to 1, i.e.:

(VI.3.a) $(1-px\_sw) = 1$, or $px\_sw = 0$.

In other words, the price setting scheme (III.15) can now be rewritten as:

(VI.3.b) $\ln(PX_t) - \ln(PX_{t-1}) = (px\_sl-1)\,[\ln(PX_{t-1}) - \ln(PXR_t)]$,

so that a small value for px_sl implies speedy adjustment of the price PX.

In a similar way, we assume that, in the case of fully informed agents, there are no chartists operating in the foreign exchange market. Thus, in equation (IV.20) we have that:

(VI.3.c) $ex\_s1 = 1$.

1. The default value is 0.5.
2. Due to menu costs, the remaining fraction, px_sl, stays at its old level.

C. Three scenarios and their variants

The NIME model is simulated under three alternative scenarios: a permanent labour market shock, a permanent fiscal shock, and a permanent monetary shock. For each of these scenarios we investigate the new steady state, the adjustment path towards the new steady state, and the spill-over effects between the different blocks.

Each scenario starts from a steady state to which we apply a shock [1]. Next, we simulate the model to the new steady state. A priori, it is only possible to make quantitative statements about the new steady state values of the endogenous variables. The exact adjustment path to this new steady state is shown in the following tables. The numbers in these tables show deviations in percentage between the initial steady state and the new adjustment path. In the year 0, the economy is in an equilibrium. In year 1, a shock is introduced. The first 10 columns show the adjustment path of the main endogenous variables for the first 10 years. The last column refers to the new steady state (ss), which is obtained simulating the model for a prolonged period.

Depending on the assumptions regarding the exchange rate regime and the expectations regime, several variants of each shock can be studied. By default, we assume a flexible exchange rate regime, i.e., the exchange rate is determined according to equation (IV.20). However, if relevant, we also simulate the model under a fixed exchange rate regime. Under a (credible) fixed exchange rate regime [2], the nominal exchange rate of block XX does not change, i.e.:

(VI.4.a) $XX\_EFEX_t = XX\_EFEX_{t-1}$,

while the short run interest rate of block XX is set as [3]:

(VI.4.b) $XX\_SI = XX\_EFSI$.

The alternative perception regimes have been discussed in the previous section.

1. The initial steady state is obtained simulating the model under the assumption of zero productivity growth, zero secular inflation, zero population growth, and equalization of the real interest rates across country blocks.
   Interpreting the following results one should be aware that in the steady state, i.a., the current account is equal to zero, inventory building is equal to zero, and gross capital formation is equal to the depreciation of the capital stock, so that net capital formation is equal to zero. Furthermore, in the steady state, in the absence of secular inflation, the real interest rate is equal to the nominal interest rate.
   In order to focus solely on the properties the NIME model, we did not link the NIME model with the Belgian model. In other words, the Belgian economy is kept exogenous.
2. The exchange rate is fixed during the first 10 years. After 10 years, the exchange rate is free to adjust to its new equilibrium level.
3. See equation (IV. 8), where we assume for convenience that ex_0 = 0, and that $E(EFEX_{t+1}) = EFEX_t$.

D. Scenario 1: A productivity shock in the EU block

In a first scenario we consider a permanent one percent increase in trend labour productivity of the EU block, i.e.:

$$\Delta \ \ln(EU\_HP\_YNP) = 1.00 \qquad \text{in period 1,}$$

and

$$\Delta \ \ln(EU\_HP\_YNP) = 0.00 \qquad \text{afterwards.}$$

At the same time, we assume that there is a flexible exchange rate regime, but we will investigate two alternative variants regarding the expectations regime. The results are shown in tables VI.1 until VI.4. Table VI.1 and VI.2 show the results under the assumption that the economic agents are immediately fully aware that the economic shock has occurred, while Table VI.3 and VI.4 show the results under the assumption that the economic agents gradually learn about the shock.

First, we discuss the new steady state of the EU block. Next, we show the adjustment path in the EU block under alternative assumptions regarding the expectations. Finally, we show the spill-over effects to the other blocks.

1. The new steady state of the EU block

The steady state results can be found in the last column, labelled (ss), of tables VI.1 until VI.4. The main results for the EU block are as follows.

If trend productivity in the EU block increases by 1 percent, then, in the steady state, total supply of the EU block also increases by 1 percent, see equation (III.13.c) [1]. Let us now investigate how this increased supply is absorbed.

First, there are the scale effects. First, when labour productivity increases permanently by 1 percent, the (future) real wage must also increase by 1 percent, and the household sector will feel richer. This wealth effect raises private consumption, investment in residential buildings, and asset holdings, see equation (II.5). Next, a permanent increase in total supply requires a proportional permanent increase in the capital stock of the enterprise sector, see equation (III.5). Finally, it should also be noted that while the domestic components of demand increase, the export volume does not increase because, in the steady state, total domestic demand and supply in the other blocks remain unchanged.

Second, there are the price effects. Taking the previous scale effects into account, any remaining excess supply will be absorbed by price changes. Remember that it is the price of private consumption which adjusts to clear the goods market, see equation (III.24). As a consequence, the price of private consumption drops by 0.3 percent.

1. Since a similar shock does not occur in the other blocks, the steady state output in the other blocks remains unchanged.

As a result of these scale and price effects, private consumption increases by 1.26 percent, while gross fixed capital formation increases by 1.04 percent.

In the current account, the import volume increases by 1 percent [1], and the export volume does not change [2]. It should also be noted that the productivity of the intermediary imports does not change, so that its price, measured in local currency, does not change. Hence, in order to maintain equilibrium in the current account, measured in local currency, the price of exports, measured in local currency, must increase by 1 percent. Next, the exports are used as intermediary imports in the other countries. However, the productivity of these intermediary imports does not change, so that the price of exports, denominated in foreign currency, must remain at its initial level. Given the 1 percent rise of the price of exports in local currency, the price in foreign currency can only be kept constant if the exchange rate depreciates by 1 percent.

In the labour market, the unemployment rate is not affected by the increase in productivity. However, the real wage - deflated by the producer price index - increases by 1 percent, while the real price of the other production factors does not change.

In the financial markets, the interest rates and the real effective exchange rate [3] do not change in the steady state, while the nominal effective exchange rate depreciates by 1 percent. The stock of capital goods increases by 1.11 percent [4].

The government debt to GDP ratio is maintained, while the government budget is in equilibrium. The direct labour income tax rate drops by 0.05 percentage points. This drop is caused by the decline in government expenditures, which fall because nominal transfers to the household sector are indexed to the consumer price (see equation (V.9)), and the consumer price level drops by 0.27 percent compared to the GDP deflator.

Finally, it should be noted that the steady state is not affected by the assumption regarding the expectations regime.

1. Reflecting the Cobb-Douglas nature of the production function, see equation (III.6). I.e., inputs are used as intermediary inputs in production, which increases by 1 percent.
2. Reflecting the absence of a similar productivity shock, and increase in the natural output level, in the other country blocks.
3. With the real exchange rate defined here as EFEX EFPASP / PXT.
4. The private sector capital stock, CIPO, and the public sector capital stock, CIGCO, both increase by 1 percent, while the household stock of residential buildings, CIRO, increases by 1.26 percent, reflecting the increased purchasing power of households due to the drop in the price of private consumption.

TABLE VI.1 - A productivity shock in the EU block - full information regime : main own effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
GDPO	0.00	0.82	0.99	0.95	0.92	0.90	0.88	0.87	0.86	0.86	0.85	1.00
GDPU	0.00	0.79	1.02	0.97	0.94	0.91	0.90	0.88	0.87	0.87	0.86	1.02
Selected components of aggregate demand												
CPO	0.00	0.93	1.24	1.19	1.14	1.10	1.07	1.04	1.03	1.01	1.01	1.26
GIO	0.00	0.72	1.02	1.01	0.99	0.97	0.95	0.94	0.93	0.92	0.91	1.04
CGGSO+WBGO	0.00	0.49	0.84	0.85	0.86	0.86	0.86	0.87	0.87	0.88	0.88	1.00
XTO	0.00	0.17	0.10	0.08	0.03	0.01	-0.00	-0.00	-0.00	-0.00	-0.00	0.00
MTO	0.00	0.51	1.20	0.99	0.85	0.76	0.70	0.66	0.63	0.61	0.61	1.00
Household sector												
SCALEH	0.00	0.87	0.92	0.92	0.93	0.93	0.94	0.95	0.96	0.97	0.98	1.25
DIH/PCH	0.00	0.78	1.24	1.26	1.27	1.27	1.27	1.27	1.26	1.25	1.24	1.26
NSH/DIH *	0.00	-0.15	-0.01	0.07	0.13	0.17	0.20	0.22	0.23	0.24	0.24	0.00
Prices												
PGDP	0.00	-0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.03
PCH/PGDP	0.00	-0.20	-0.27	-0.26	-0.26	-0.26	-0.26	-0.25	-0.25	-0.25	-0.25	-0.27
PMP/PGDP	0.00	0.05	-0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	-0.00
PXT/PGDP	0.00	0.86	0.95	0.99	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.00
Labour market												
WRP/PCH	0.00	1.06	1.12	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.18	1.27
WRP/(PASP*(1-NITR))	0.00	0.85	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.92	1.00
NP	0.00	-0.05	-0.01	-0.01	-0.02	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	0.00
UR *	0.00	0.05	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	-0.00
Financial sector												
SI *	0.00	-0.11	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	0.00
SI-(EPCH/PCH-1) *	-0.00	-0.11	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	0.00
LI *	0.00	-0.07	0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00
EFEX	0.00	1.07	1.04	1.04	1.03	1.04	1.04	1.04	1.04	1.04	1.03	1.03
EFEX*EFPASP/PXT	-0.00	0.25	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.00
M	0.00	0.73	1.13	1.01	0.91	0.86	0.82	0.80	0.79	0.78	0.78	1.04
Enterprise sector												
ASPO/HP_ASPO	0.00	-0.20	0.07	0.00	-0.05	-0.09	-0.12	-0.14	-0.15	-0.16	-0.17	-0.00
GIPO	0.00	0.23	0.31	0.31	0.31	0.31	0.31	0.32	0.32	0.33	0.34	0.99
Public sector												
TOTREV/PGDP	0.00	0.74	0.66	0.64	0.62	0.61	0.61	0.63	0.65	0.67	0.70	0.87
CGU/PGDP	0.00	0.29	0.80	0.83	0.83	0.84	0.85	0.85	0.86	0.87	0.88	0.87
NLG/GDPU *	0.00	-0.20	0.06	0.09	0.10	0.11	0.11	0.10	0.10	0.09	0.08	0.00
GBOND/GDPU *	0.00	-0.67	-0.75	-0.64	-0.52	-0.40	-0.28	-0.17	-0.06	0.03	0.12	-0.00
DTHR *	0.00	0.03	-0.13	-0.14	-0.15	-0.15	-0.15	-0.14	-0.13	-0.11	-0.10	-0.05
Memo items												
CA/GDPU *	0.00	0.07	-0.02	0.01	0.02	0.03	0.04	0.05	0.05	0.05	0.06	0.00
TBU/GDPU *	0.00	0.07	-0.02	0.01	0.02	0.03	0.04	0.05	0.05	0.05	0.05	0.00
CIRO+CIPO+CIGCO	0.00	0.02	0.05	0.07	0.10	0.12	0.15	0.17	0.19	0.21	0.24	1.11

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

TABLE VI.2 - A productivity shock in the EU block - full information regime : main spill-over effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
NE block												
GDPO	0.00	0.02	0.01	0.01	0.00	-0.00	-0.01	-0.01	-0.01	-0.02	-0.02	0.00
CPO	0.00	-0.07	-0.09	-0.09	-0.10	-0.10	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11
XTO	0.00	0.26	0.29	0.28	0.28	0.28	0.28	0.27	0.27	0.27	0.27	0.35
MTO	0.00	-0.02	-0.03	-0.04	-0.04	-0.04	-0.03	-0.03	-0.03	-0.02	-0.02	0.00
PGDP	0.00	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.02
PCH/PGDP	0.00	0.10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
PXT/PGDP	0.00	-0.30	-0.34	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35
PMP/PGDP	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00
SI *	0.00	-0.01	-0.02	-0.01	-0.01	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
LI *	0.00	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
EFEX	0.00	-0.45	-0.38	-0.39	-0.40	-0.40	-0.41	-0.40	-0.40	-0.40	-0.40	-0.39
EFEX*EFPASP/PXT	-0.00	-0.15	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	0.00
TBU/GDPU *	0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	0.00
US block												
GDPO	0.00	0.02	0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.01	0.00
CPO	0.00	-0.02	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.02	-0.03	-0.02
XTO	0.00	0.31	0.27	0.08	0.04	0.07	0.12	0.16	0.17	0.15	0.13	0.17
MTO	0.00	0.04	0.02	-0.04	-0.05	-0.03	-0.02	-0.01	-0.00	-0.01	-0.01	0.00
PGDP	0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
PCH/PGDP	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
PXT/PGDP	0.00	-0.11	-0.14	-0.16	-0.16	-0.16	-0.17	-0.17	-0.17	-0.17	-0.17	-0.17
PMP/PGDP	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	-0.00	-0.00
SI *	0.00	0.01	0.01	-0.00	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.00	-0.00
LI *	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	-0.00
EFEX	0.00	-0.20	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.17
EFEX*EFPASP/PXT	-0.00	-0.10	-0.03	-0.02	-0.01	-0.00	-0.00	-0.00	-0.01	-0.01	-0.00	-0.00
TBU/GDPU *	0.00	0.02	0.01	-0.00	-0.01	-0.01	-0.00	0.00	0.00	-0.00	-0.00	-0.00
JP block												
GDPO	0.00	0.00	0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00
CPO	0.00	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.03
XTO	0.00	0.10	0.10	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.13
MTO	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00
PGDP	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02
PCH/PGDP	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
PXT/PGDP	0.00	-0.05	-0.08	-0.10	-0.12	-0.12	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13
PMP/PGDP	0.00	-0.00	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00
SI *	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	-0.00
LI *	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
EFEX	0.00	-0.20	-0.16	-0.16	-0.17	-0.17	-0.17	-0.16	-0.16	-0.16	-0.16	-0.15
EFEX*EFPASP/PXT	-0.00	-0.15	-0.06	-0.05	-0.04	-0.03	-0.03	-0.02	-0.02	-0.01	-0.01	0.00
TBU/GDPU *	0.00	0.01	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00
RW block												
XTO	0.00	0.67	1.12	1.10	1.09	1.05	1.00	0.96	0.93	0.90	0.89	0.34
MTO	0.00	0.76	0.84	0.85	0.88	0.88	0.87	0.85	0.83	0.81	0.79	0.00
EFEX*EFPASP/PXT	0.00	1.14	0.96	0.83	0.78	0.77	0.78	0.78	0.75	0.72	0.68	-0.04

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

TABLE VI.3 - A productivity shock in the EU block - gradual learning : main own effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
GDPO	0.00	0.61	0.87	0.89	0.89	0.87	0.86	0.85	0.85	0.85	0.85	1.00
GDPU	0.00	0.61	0.71	0.72	0.69	0.65	0.62	0.57	0.53	0.49	0.45	1.02
Selected components of aggregate demand												
CPO	0.00	0.51	0.91	0.94	0.94	0.93	0.92	0.92	0.93	0.95	0.98	1.26
GIO	0.00	0.52	0.89	0.91	0.91	0.90	0.90	0.90	0.90	0.90	0.91	1.04
CGGSO+WBGO	0.00	0.53	0.78	0.85	0.88	0.88	0.88	0.87	0.88	0.88	0.89	1.00
XTO	0.00	0.19	0.38	0.51	0.53	0.50	0.45	0.37	0.29	0.20	0.12	0.00
MTO	0.00	-0.19	0.69	0.79	0.78	0.76	0.71	0.68	0.66	0.65	0.66	1.00
Household sector												
SCALEH	0.00	0.34	0.59	0.69	0.74	0.78	0.81	0.85	0.88	0.91	0.95	1.25
DIH/PCH	0.00	0.63	1.09	1.12	1.14	1.16	1.18	1.19	1.21	1.23	1.25	1.26
NSH/DIH *	0.00	0.12	0.18	0.18	0.21	0.23	0.26	0.27	0.28	0.28	0.27	0.00
Prices												
PGDP	0.00	-0.00	-0.17	-0.18	-0.20	-0.22	-0.25	-0.28	-0.32	-0.36	-0.40	0.03
PCH/PGDP	0.00	0.01	-0.04	-0.08	-0.10	-0.12	-0.14	-0.17	-0.19	-0.22	-0.25	-0.27
PMP/PGDP	0.00	0.01	0.15	0.07	0.02	-0.01	-0.00	0.01	0.02	0.03	0.04	-0.00
PXT/PGDP	0.00	0.02	0.21	0.26	0.34	0.42	0.51	0.60	0.70	0.79	0.88	1.00
Labour market												
WRP/PCH	0.00	0.87	0.92	0.97	0.99	1.02	1.05	1.08	1.11	1.15	1.18	1.27
WRP/(PASP*(1-NITR))	0.00	0.85	0.86	0.88	0.89	0.90	0.90	0.91	0.91	0.92	0.92	1.00
NP	0.00	-0.11	-0.05	-0.02	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	-0.00
UR *	0.00	0.08	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Financial sector												
SI *	0.00	-0.05	-0.18	-0.11	-0.08	-0.06	-0.06	-0.07	-0.07	-0.08	-0.08	0.00
SI-(EPCH/PCH-1) *	-0.00	0.16	-0.04	-0.05	-0.02	0.00	0.02	0.02	0.02	0.02	0.02	0.00
LI *	0.00	-0.03	-0.17	-0.06	-0.05	-0.04	-0.04	-0.05	-0.05	-0.06	-0.06	0.00
EFEX	0.00	0.30	0.56	0.69	0.73	0.72	0.70	0.67	0.64	0.61	0.57	1.03
EFEX*EFPASP/PXT	0.00	0.29	0.52	0.60	0.57	0.50	0.41	0.31	0.22	0.13	0.06	0.00
M	0.00	0.57	0.96	0.79	0.72	0.65	0.59	0.54	0.49	0.45	0.42	1.04
Enterprise sector												
ASPO/HP_ASPO	0.00	-0.52	-0.11	-0.08	-0.10	-0.12	-0.14	-0.15	-0.16	-0.17	-0.17	0.00
GIPO	0.00	0.12	0.26	0.28	0.28	0.29	0.29	0.30	0.31	0.32	0.33	1.00
Public sector												
TOTREV/PGDP	0.00	0.62	0.69	0.69	0.70	0.71	0.72	0.74	0.77	0.79	0.82	0.87
CGU/PGDP	0.00	0.37	0.94	0.88	0.90	0.90	0.90	0.90	0.89	0.89	0.88	0.87
NLG/GDPU *	0.00	-0.11	0.12	0.09	0.09	0.09	0.08	0.07	0.06	0.04	0.03	0.00
GBOND/GDPU *	0.00	-0.48	-0.42	-0.34	-0.23	-0.12	-0.02	0.08	0.16	0.23	0.29	-0.00
DTHR *	0.00	0.00	-0.13	-0.14	-0.13	-0.12	-0.11	-0.10	-0.09	-0.08	-0.06	-0.05
Memo items												
CA/GDPU *	0.00	0.05	-0.03	-0.01	0.01	0.02	0.03	0.04	0.04	0.04	0.04	-0.00
TBU/GDPU *	0.00	0.05	-0.03	-0.01	0.01	0.02	0.03	0.04	0.04	0.04	0.04	-0.00
CIRO+CIPO+CIGCO	0.00	0.01	0.04	0.06	0.09	0.11	0.13	0.15	0.18	0.20	0.22	1.11

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

TABLE VI.4 - A productivity shock in the EU block - gradual learning : main spill-over effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
NE block												
GDPO	0.00	0.02	0.03	0.01	0.01	0.01	0.00	0.00	0.00	-0.00	-0.01	-0.00
CPO	0.00	0.00	-0.01	-0.03	-0.06	-0.07	-0.09	-0.10	-0.10	-0.11	-0.11	-0.11
XTO	0.00	0.13	0.24	0.16	0.15	0.18	0.23	0.26	0.29	0.30	0.30	0.35
MTO	0.00	0.05	0.08	0.01	-0.04	-0.06	-0.06	-0.05	-0.05	-0.04	-0.04	-0.00
PGDP	0.00	-0.00	-0.01	-0.04	-0.07	-0.10	-0.12	-0.13	-0.14	-0.15	-0.15	-0.02
PCH/PGDP	0.00	0.00	0.02	0.05	0.09	0.11	0.12	0.13	0.13	0.13	0.13	0.12
PXT/PGDP	0.00	-0.02	-0.09	-0.18	-0.26	-0.33	-0.37	-0.40	-0.41	-0.41	-0.42	-0.35
PMP/PGDP	0.00	0.00	-0.01	-0.01	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00
SI *	0.00	0.00	-0.00	-0.01	-0.03	-0.03	-0.03	-0.02	-0.02	-0.01	-0.01	-0.00
LI *	0.00	-0.00	-0.01	-0.02	-0.03	-0.03	-0.02	-0.01	-0.01	-0.01	-0.01	-0.00
EFEX	0.00	-0.10	-0.29	-0.35	-0.37	-0.37	-0.37	-0.38	-0.40	-0.42	-0.43	-0.39
EFEX*EFPASP/PXT	0.00	-0.07	-0.24	-0.19	-0.10	-0.02	0.03	0.05	0.03	0.02	-0.00	-0.00
TBU/GDPU *	0.00	0.02	0.02	-0.00	-0.02	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	0.00
US block												
GDPO	0.00	0.01	0.02	0.00	-0.01	-0.01	-0.01	-0.00	0.00	0.00	-0.00	0.00
CPO	0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
XTO	0.00	0.13	0.28	0.12	0.01	-0.01	0.04	0.11	0.15	0.17	0.15	0.17
MTO	0.00	0.03	0.07	0.01	-0.03	-0.05	-0.04	-0.02	-0.01	-0.01	-0.01	0.00
PGDP	0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.03	-0.03	-0.01
PCH/PGDP	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.02
PXT/PGDP	0.00	-0.01	-0.03	-0.07	-0.11	-0.13	-0.16	-0.17	-0.18	-0.19	-0.19	-0.17
PMP/PGDP	0.00	0.00	-0.01	-0.02	0.00	0.01	0.01	0.01	0.01	0.00	0.00	-0.00
SI *	0.00	0.00	0.01	0.01	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00	0.00
LI *	0.00	0.00	0.00	0.00	-0.00	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	0.00
EFEX	0.00	-0.04	-0.11	-0.13	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.17
EFEX*EFPASP/PXT	0.00	-0.03	-0.10	-0.09	-0.07	-0.05	-0.03	-0.02	-0.01	-0.01	-0.01	0.00
TBU/GDPU *	0.00	0.01	0.02	0.01	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	0.00
JP block												
GDPO	0.00	0.01	0.01	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
CPO	0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.03
XTO	0.00	0.06	0.11	0.06	0.06	0.07	0.08	0.09	0.10	0.10	0.10	0.13
MTO	0.00	0.01	0.01	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00
PGDP	0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03	-0.02
PCH/PGDP	0.00	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
PXT/PGDP	0.00	-0.01	-0.07	-0.11	-0.12	-0.12	-0.13	-0.13	-0.13	-0.13	-0.14	-0.13
PMP/PGDP	0.00	0.00	-0.00	-0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
SI *	0.00	-0.00	-0.01	-0.00	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
LI *	0.00	-0.00	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
EFEX	0.00	-0.05	-0.17	-0.16	-0.13	-0.12	-0.11	-0.10	-0.10	-0.10	-0.10	-0.15
EFEX*EFPASP/PXT	0.00	-0.03	-0.11	-0.07	-0.03	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00
TBU/GDPU *	0.00	0.00	0.00	-0.00	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00	0.00
RW block												
XTO	0.00	-0.10	0.39	0.50	0.55	0.55	0.52	0.48	0.46	0.46	0.46	0.34
MTO	0.00	0.18	0.42	0.51	0.57	0.58	0.56	0.53	0.49	0.44	0.39	0.00
EFEX*EFPASP/PXT	0.00	0.34	0.38	0.34	0.25	0.21	0.22	0.26	0.28	0.28	0.26	-0.04

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

2. Adjustment in the EU block under alternative expectations regimes

Let us now examine how the economy reaches the new steady state under two alternative expectations regimes: one in which the household sector is immediately fully aware that the productivity shock has occurred, and one in which the household sector gradually learns about the productivity shock.

a. Variant 1.A: all information available at negligible cost

Here, we assume that the household sector is immediately fully aware that a productivity shock has occurred, see equation (VI.2). The first ten columns of Table VI.1 show the adjustment path for the first ten years for this variant.

When the productivity shock occurs, the household sector, the enterprise sector and the public sector revise their expenditure plans. However, short run rigidities prevent these plans from being immediately fully implemented, thereby undershooting the new steady state. We see, for example, that in the first period private consumption increases by 0.93 percent, compared to 1.26 percent in the new steady state, while gross fixed capital formation by the enterprise sector increases by 0.72 percent, compared to 1.04 percent in the new steady state. As a consequence, total demand is 0.20 percent lower than the natural output level. This output gap causes a drop in the prices and the interest rate, which stimulates demand further. This process will continue until the different components of demand have reached their new steady state values, in particular, gross fixed capital formation. Indeed, the total stock of capital goods adjusts very slowly, i.e., it increases by about 0.03 percent per year. All in all, this slow stock adjustment slows down adjustment in the rest of the economy.

Note that the price of private consumption adjusts almost immediately to its steady state level, reflecting low menu costs in price setting [1]. In the first year, the real exchange rate depreciates because the strong nominal exchange rate depreciation is not accompanied by a similar immediate rise in the export price, which is due to menu costs in the setting of export prices [2]. However, after 2 years this competitive advantage has almost completely disappeared.

In the current account, we see that imports increase to reach their new steady state level, while exports get a temporary boost from the temporary real exchange rate depreciation.

The unemployment rate increases by 0.05 percent in the first year, while the real wage, deflated by the producer price, increases by 0.85 percent in the first year, and continues to rise thereafter.

The public debt to GDP ratio declines because the nominal stock of debt inherited from the past is unaffected by the productivity shock, while nominal GDP increases by about 0.8 percent in the first year. This creates room for a temporary drop in the direct income tax rate.

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1. I.e., eu_pch_sl = 0.02 in Table III.8.
2. I.e., eu_pxt_sl = 0.20 in Table B.4 of Appendix B.

b. Variant 1.B: gradual learning

Table VI.3 shows the simulation results for the case in which the household sector learns gradually about the productivity shock, see equation (VI.1). The steady state is not affected by this slower learning process. However, the adjustment process is much slower now, as reflected, for example, by the fact that GDP in the EU block increases only by 0.61 percent in the first year, compared to 0.82 percent in the previous full information variant.

The most important result is that in the first year, private consumption remains low if compared with the new steady state. As a consequence, the output gap increases sharply, putting further downward pressure on prices and interest rates. The slump in demand in the first period is also responsible for the strong drop in imports. Import demand starts to increase in the second period, as private consumption starts to pick up.

3. The spill-over effects to the other blocks

Table VI.2 and VI.4 summarize the main spill-over effects to the other blocks. Here, it should be remembered that in the steady state the total production capacity of the NE, US, JP, and RW block does not change. However, the export volume of these blocks has to increase to meet the increased EU imports. In other words, there has to be a reallocation of their supply from domestic absorption to exports through an adjustment of the relative prices. At the same time, in spite of the increased export volume, long run equilibrium in the current account has to be maintained. The price changes which generate this result are as follows.

First, the price of private consumption increases gradually to reduce private consumption, thereby freeing output that can be exported to the EU block. Second, the increased exports of the NE, US, JP, and RW block create a surplus in their current account, measured in local currency. Hence, a fall in the price of the exports, measured in their local currency, will restore current account equilibrium. Moreover, because it is assumed that the labour productivity shock does not affect the productivity of intermediary inputs (in the EU block), the price of the exports, measured in foreign currency, has to remain unchanged. Hence, the need for an appreciation of the nominal exchange rate, which must be equal to the fall in the export price.

In Table VI.2 and VI.4, we see that the largest steady state adjustments are in the NE block, reflecting the fact that the NE block is the largest exporter to the EU block. In the NE block the relative consumer price index increases by 0.12 percent, compared to 0.02 percent in the US and 0.03 percent in JP block, respectively, while relative export prices fall by 0.35, 0.17, and 0.13 percent, respectively. Real GDP is unaffected in the steady state, while exports rise by 0.35, 0.17, and 0.13 percent in the NE, US, and JP block, respectively.

The short run dynamics in tables VI.2 and VI.4 show, for example, that while exports gradually increase, and private consumption decreases, the net impact on real GDP is rather limited.

We conclude by noting that the supply shock in the EU block does not affect total supply in the other blocks, but it does affect the allocation of their final demand in the steady state, and it is the changes in the domestic relative prices which induce this reallocation.

E. Scenario 2: A fiscal shock in the EU block

In the second scenario, we consider a 1 percent permanent increase in government consumption of goods and services, i.e., EU_CGGSO is set in such a way that:

$$\Delta\ \ln(EU\_CGGSO+EU\_WBGO) = 1.00 \qquad \text{in period 1,}$$

and

$$\Delta\ \ln(EU\_CGGSO+EU\_WBGO) = 0.00 \qquad \text{afterwards.}$$

At the same time, we assume that the public sector does not change its debt to GDP target, that the monetary authorities accommodate this policy in the short run [1], and that there is a flexible exchange rate regime [2]. The simulation results are shown in Table VI.5 and VI.6. The last column, labelled (ss), shows to what extent the new steady state deviates from the initial steady state. The first ten columns show the deviations from the initial steady state for the first 10 years of the adjustment process. Table VI.5 summarizes the main own effects, while Table VI.6 shows the main spill-over effects.

1. The new steady state

The main characteristics of the new steady state of the EU block are as follows. First, this shock does not affect the production capacity of the economy. In other words, the natural output level and real GDP do not change. Second, public consumption increases permanently by 1 percent, while private consumption decreases permanently by 0.26 percent. Third, the higher government spending is compensated by an increase in the direct income tax rate, thereby keeping the debt to GDP ratio at its target level. Note also that this tax increase is the main mechanism responsible for the reduction in private consumption. Fourth, the current account and the real exchange rate do not change. Fifth, the enterprise sector's gross fixed capital formation and capital stock do not change, reflecting the fact that production capacity does not change, and thus that the same level of capital stock is needed as before. Finally, economic activity in the other blocks is not affected by the demand shock.

1. I.e., the short run interest rate is determined by equation (IV.5).
2. I.e., the exchange rate is determined by equation (IV.20).

TABLE VI.5 - A fiscal shock in the EU block : main own effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
GDPO	0.00	0.15	0.12	0.09	0.06	0.04	0.02	0.01	-0.00	-0.01	-0.02	-0.00
GDPU	0.00	0.17	0.21	0.22	0.23	0.23	0.23	0.22	0.21	0.20	0.18	-0.08
Selected components of aggregate demand												
CPO	0.00	0.02	-0.04	-0.11	-0.17	-0.21	-0.25	-0.27	-0.29	-0.30	-0.31	-0.26
GIO	0.00	0.09	0.05	0.00	-0.03	-0.07	-0.09	-0.11	-0.13	-0.15	-0.16	-0.04
CGGSO+WBGO	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
XTO	0.00	0.07	0.12	0.13	0.13	0.13	0.13	0.12	0.10	0.08	0.06	0.00
MTO	0.00	0.50	0.36	0.23	0.13	0.04	-0.02	-0.07	-0.11	-0.13	-0.15	0.00
Household sector												
SCALEH	0.00	-0.01	-0.05	-0.09	-0.12	-0.15	-0.17	-0.20	-0.21	-0.23	-0.25	-0.26
DIH/PCH	0.00	0.00	-0.05	-0.10	-0.15	-0.20	-0.24	-0.28	-0.31	-0.34	-0.37	-0.26
NSH/DIH *	0.00	-0.02	-0.01	0.01	0.02	0.02	0.01	-0.01	-0.02	-0.04	-0.06	-0.00
Prices												
PGDP	0.00	0.02	0.09	0.14	0.17	0.19	0.21	0.21	0.21	0.21	0.20	-0.08
PCH/PGDP	0.00	-0.02	0.00	0.02	0.04	0.05	0.05	0.06	0.05	0.05	0.05	0.00
PMP/PGDP	0.00	-0.01	-0.03	-0.04	-0.04	-0.03	-0.02	-0.01	-0.00	0.00	0.01	-0.00
PXT/PGDP	0.00	-0.01	-0.08	-0.11	-0.13	-0.14	-0.13	-0.12	-0.10	-0.08	-0.06	0.00
Labour market												
WRP/PCH	0.00	0.02	0.01	-0.02	-0.03	-0.04	-0.04	-0.04	-0.03	-0.03	-0.02	-0.00
WRP/(PASP*(1-NITR))	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.00
NP	0.00	0.03	0.03	0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01	-0.01	-0.00
UR *	0.00	-0.02	-0.02	-0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Financial sector												
SI *	0.00	0.02	0.08	0.08	0.07	0.05	0.03	0.01	0.00	-0.01	-0.01	0.00
SI-(EPCH/PCH-1) *	-0.00	-0.07	-0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.00
LI *	0.00	0.02	0.08	0.07	0.05	0.03	0.02	0.01	0.00	-0.01	-0.01	0.00
EFEX	0.00	0.11	0.15	0.17	0.18	0.18	0.18	0.19	0.18	0.18	0.17	-0.08
EFEX*EFPASP/PXT	0.00	0.10	0.14	0.15	0.14	0.13	0.12	0.11	0.09	0.06	0.04	0.00
M	0.00	0.02	-0.03	-0.06	-0.09	-0.10	-0.09	-0.08	-0.06	-0.05	-0.04	-0.33
Enterprise sector												
ASPO/HP_ASPO	0.00	0.22	0.17	0.11	0.07	0.04	0.02	-0.00	-0.02	-0.03	-0.04	0.00
GIPO	0.00	0.07	0.05	0.04	0.03	0.02	0.01	0.01	0.00	-0.00	-0.01	-0.00
Public sector												
TOTREV/PGDP	0.00	0.09	0.11	0.13	0.17	0.21	0.26	0.31	0.36	0.40	0.44	0.40
CGU/PGDP	0.00	0.39	0.40	0.44	0.46	0.47	0.48	0.48	0.48	0.48	0.48	0.40
NLG/GDPU *	0.00	0.14	0.13	0.14	0.13	0.12	0.10	0.08	0.06	0.04	0.02	0.00
GBOND/GDPU *	0.00	0.04	0.14	0.28	0.41	0.53	0.63	0.72	0.78	0.83	0.85	0.00
DTHR *	0.00	0.01	0.04	0.07	0.10	0.13	0.16	0.19	0.22	0.25	0.28	0.23
Memo items												
CA/GDPU *	0.00	-0.06	-0.04	-0.02	-0.01	-0.00	0.01	0.01	0.02	0.02	0.02	0.00
TBU/GDPU *	0.00	-0.06	-0.04	-0.02	-0.01	-0.00	0.01	0.01	0.02	0.02	0.02	0.00
CIRO+CIPO+CIGCO	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.01	-0.01	-0.01	-0.02	-0.11

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

TABLE VI.6 - A fiscal shock in the EU block : main spill-over effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
NE block												
GDPO	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-0.00
CPO	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	-0.00
XTO	0.00	0.08	0.05	0.06	0.06	0.05	0.03	0.01	-0.01	-0.03	-0.03	0.00
MTO	0.00	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.01	-0.00	-0.01	0.00
PGDP	0.00	0.00	0.01	0.02	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.00
PCH/PGDP	0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	-0.00
PXT/PGDP	0.00	-0.00	-0.00	0.01	0.03	0.05	0.06	0.06	0.06	0.05	0.04	0.00
PMP/PGDP	0.00	-0.00	-0.00	0.00	-0.00	-0.01	-0.00	-0.00	-0.00	0.00	0.00	0.00
SI *	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-0.00	0.00
LI *	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	-0.00	-0.00	0.00
EFEX	0.00	-0.02	0.02	0.04	0.05	0.04	0.03	0.01	0.00	-0.01	-0.02	0.03
EFEX*EFPASP/PXT	0.00	-0.01	0.04	0.06	0.05	0.02	-0.01	-0.03	-0.04	-0.04	-0.03	-0.00
TBU/GDPU *	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.00
US block												
GDPO	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00
CPO	0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XTO	0.00	0.10	0.03	0.00	0.00	0.02	0.02	0.01	-0.00	-0.02	-0.03	0.00
MTO	0.00	0.03	0.00	-0.00	-0.00	0.01	0.01	0.01	0.00	-0.00	-0.00	0.00
PGDP	0.00	-0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00
PCH/PGDP	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
PXT/PGDP	0.00	-0.00	-0.00	0.00	0.01	0.02	0.03	0.03	0.03	0.03	0.02	-0.00
PMP/PGDP	0.00	-0.00	-0.01	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00
SI *	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00
LI *	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00
EFEX	0.00	-0.02	-0.00	0.01	0.01	0.01	0.00	-0.00	-0.01	-0.02	-0.02	0.01
EFEX*EFPASP/PXT	0.00	-0.01	0.01	0.02	0.02	0.02	0.01	-0.00	-0.01	-0.01	-0.01	-0.00
TBU/GDPU *	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00
JP block												
GDPO	0.00	0.01	0.00	0.01	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00
CPO	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00
XTO	0.00	0.05	0.03	0.03	0.02	0.01	-0.00	-0.01	-0.01	-0.01	-0.01	0.00
MTO	0.00	0.01	0.00	0.01	0.01	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00
PGDP	0.00	-0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
PCH/PGDP	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	-0.00
PXT/PGDP	0.00	0.00	0.01	0.02	0.01	0.01	-0.00	-0.01	-0.01	-0.01	-0.00	0.00
PMP/PGDP	0.00	0.00	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.00	0.00	0.00	-0.00
SI *	0.00	-0.00	0.01	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00
LI *	0.00	-0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00
EFEX	0.00	0.00	0.02	0.02	-0.01	-0.03	-0.04	-0.05	-0.04	-0.04	-0.03	0.01
EFEX*EFPASP/PXT	0.00	0.00	0.02	0.01	-0.00	-0.01	-0.01	-0.01	-0.00	0.00	0.00	0.00
TBU/GDPU *	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00
RW block												
XTO	0.00	0.25	0.21	0.17	0.14	0.10	0.08	0.06	0.05	0.04	0.03	-0.00
MTO	0.00	0.09	0.12	0.16	0.17	0.18	0.18	0.17	0.17	0.15	0.14	-0.00
EFEX*EFPASP/PXT	0.00	0.04	0.04	0.06	0.10	0.14	0.16	0.17	0.16	0.14	0.12	0.00

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

2. The adjustment path and the spill-over effects

The short run dynamics are shown in the first ten columns of Table VI.5 and VI.6. The most important results are the following.

First, during the first few years, the increased demand by the EU public sector is to a large extent met by increased imports, which rise by 0.50 percent in the first year. Private consumption in the EU block adjusts only gradually to its new lower steady state level, i.e., a drop of 0.04 percent in the second year of the simulation, compared to a drop of 0.26 percent in the steady state.

Second, the fiscal balance of the public sector deteriorates immediately, e.g., the public deficit rises to 0.14 percent of GDP in the first year, but a gradual increase in the direct income tax rate restores equilibrium during the course of time.

Third, exports of the other country blocks increase in the short run, but start to fall once adjustment in the EU block progresses and EU imports fall. All in all, the spill-over effects are small in the short run, reflecting the fact that most blocks are large and relatively closed economies, and that their steady state equilibrium is not affected by this shock.

F. Scenario 3: A monetary shock in the US

In the third scenario, we consider a permanent one percent increase in the money supply of the US block [1], i.e.:

$\Delta \ln(US\_M) = 1.00$ in period 1,

and

$\Delta \ln(US\_M) = 0$ afterwards.

We examine one variant with flexible exchange rates and one variant with fixed exchange rates. In both variants, we assume that the agents gradually learn about the monetary shock [2], and that they adjust their expectations accordingly.

The simulation results for a flexible and fixed exchange rate regime are shown in tables VI.7 to VI.8 and VI.9 to VI.10, respectively. Under a flexible exchange rate regime, the exchange rate is determined by equation (IV.20). Under a fixed exchange rate regime, all the exchange rates are kept fixed (for 10 years), implying that the short run interest rates in the other blocks are set as [3]:

(VI.5) $XX\_SI = US\_SI$ for XX = EU, NE, JP, RW .

1. The new steady state of the US block

The steady state results for the US block are shown in the last column, labelled (ss), of Table VI.7 and VI.9.

The steady state implications of a monetary expansion are straightforward for the US block. The US nominal variables increase by 1 percent, while the real variables do not change. The effective nominal exchange rate depreciates by 1 percent, while the effective real exchange rate remains unchanged. These results highlight the long run neutrality of money in the NIME model.

1. Technically speaking, in this scenario the short run interest rate drops by the amount which is necessary to induce the household sector to hold an additional one percent of nominal money balances. Such an interest rate reaction function is obtained solving the short run money demand function, i.e., equation (II.8), for the short run interest rate, and evaluating this function for the target money supply. It should also be noted that this shock implies that in the steady state the general price level will increase by one percent, and that price expectations adjust accordingly.
2. I.e., similar to equation (VI.1), we assume that:
   $\Delta \ln(EHP\_M_t) = em\_sl [\ln (HP\_M_t - EHP\_M_{t-1})]$,
   with EHP_M_t the perceived money stock at moment t, and with the parameter em_sl = 0.5.
3. See the interest rate parity condition (IV. 8). Here we assume that the parameter ex_0 = 0, i.e., no risk premium, and that $E(EFEX_{t+1}) = EFEX$, i.e., a credible fixed exchange rate regime. Note that in a model where equilibrium in the foreign exchange market had been derived from a mean-variance optimization problem, the parameter ex_0 would have been a time varying variable, reflecting the risk aversion of the economic agents, the relative supply of bonds denominated in different currencies, and the covariance between the returns on these bonds. Sterilized intervention would then imply that the monetary authorities could achieve a specific exchange rate target by changing the relative supply of bonds instead of changing the interest rate. Since we do not have data on the relative supply of bonds, we replaced the time varying risk premium by a constant. In the NIME model, sterilized intervention could be modelled - in an ad hoc way - by adjusting ex_0 such that XX_EFSI = XX_SI + xx_ex_0.

TABLE VI.7 - A monetary expansion in the US block - flexible exchange rate regime : main own effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
GDPO	0.00	0.12	0.17	0.14	0.11	0.07	0.04	0.01	-0.01	-0.02	-0.03	0.00
GDPU	0.00	0.22	0.38	0.48	0.57	0.64	0.71	0.76	0.82	0.86	0.89	1.00
Selected components of aggregate demand												
CPO	0.00	0.14	0.20	0.17	0.12	0.08	0.04	0.00	-0.02	-0.04	-0.05	0.00
GIO	0.00	0.25	0.33	0.29	0.24	0.17	0.11	0.06	0.02	-0.02	-0.05	-0.00
CGGSO+WBGO	0.00	0.04	0.06	0.08	0.08	0.06	0.03	-0.00	-0.03	-0.04	-0.04	0.00
XTO	0.00	0.09	0.17	0.22	0.20	0.14	0.07	0.04	0.05	0.07	0.09	0.00
MTO	0.00	0.38	0.45	0.42	0.32	0.20	0.09	0.01	-0.04	-0.08	-0.11	0.00
Household sector												
SCALEH	0.00	0.00	0.00	-0.01	-0.04	-0.05	-0.07	-0.07	-0.08	-0.08	-0.08	0.00
DIH/PCH	0.00	0.04	0.14	0.14	0.12	0.10	0.08	0.06	0.05	0.03	0.02	0.00
NSH/DIH *	0.00	-0.10	-0.06	-0.03	-0.01	0.02	0.04	0.06	0.07	0.07	0.07	0.00
Prices												
PGDP	0.00	0.10	0.21	0.34	0.46	0.57	0.67	0.76	0.83	0.88	0.92	1.00
PCH/PGDP	0.00	0.00	0.04	0.05	0.07	0.09	0.10	0.10	0.10	0.10	0.10	0.00
PMP/PGDP	0.00	-0.06	0.03	-0.12	-0.13	-0.10	-0.07	-0.06	-0.05	-0.04	-0.03	-0.00
PXT/PGDP	0.00	-0.02	-0.04	-0.09	-0.13	-0.18	-0.22	-0.26	-0.28	-0.28	-0.27	-0.00
Labour market												
WRP/PCH	0.00	0.01	-0.04	-0.06	-0.08	-0.09	-0.10	-0.11	-0.11	-0.11	-0.11	-0.00
WRP/(PASP*(1-NITR))	0.00	0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.01	0.00
NP	0.00	0.08	0.13	0.10	0.05	0.00	-0.03	-0.05	-0.06	-0.06	-0.06	-0.00
UR *	0.00	-0.05	-0.08	-0.05	-0.02	0.00	0.02	0.03	0.03	0.03	0.03	0.00
Financial sector												
SI *	0.00	-0.23	-0.14	-0.11	-0.09	-0.06	-0.05	-0.03	-0.02	-0.02	-0.01	0.00
SI-(EPCH/PCH-1) *	-0.00	-0.32	-0.28	-0.24	-0.20	-0.17	-0.13	-0.10	-0.08	-0.05	-0.04	0.00
LI *	0.00	-0.06	-0.04	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	-0.00	-0.00	0.00
EFEX	0.00	0.38	0.37	0.40	0.44	0.49	0.54	0.59	0.64	0.69	0.73	1.00
EFEX*EFPASP/PXT	0.00	0.30	0.19	0.13	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.00
M	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Enterprise sector												
ASPO/HP_ASPO	0.00	0.15	0.18	0.14	0.11	0.08	0.05	0.02	0.01	-0.01	-0.02	0.00
GIPO	0.00	0.22	0.24	0.19	0.14	0.08	0.03	-0.00	-0.02	-0.04	-0.05	0.00
Public sector												
TOTREV/PGDP	0.00	0.30	0.01	-0.08	-0.16	-0.22	-0.27	-0.30	-0.30	-0.29	-0.26	0.00
CGU/PGDP	0.00	-0.04	-0.14	-0.10	-0.06	-0.01	0.02	0.05	0.07	0.09	0.10	0.00
NLG/GDPU *	0.00	-0.11	-0.05	-0.01	0.03	0.07	0.10	0.12	0.12	0.12	0.12	0.00
GBOND/GDPU *	0.00	-0.25	-0.39	-0.46	-0.48	-0.45	-0.39	-0.31	-0.22	-0.12	-0.02	0.00
DTHR *	0.00	0.01	-0.11	-0.13	-0.14	-0.15	-0.15	-0.15	-0.14	-0.13	-0.11	-0.00
Memo items												
CA/GDPU *	0.00	-0.02	-0.03	-0.02	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01	-0.00	-0.00
TBU/GDPU *	0.00	-0.02	-0.03	-0.02	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01	-0.00	-0.00
CIRO+CIPO+CIGCO	0.00	0.01	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-0.00

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

TABLE VI.8 - A monetary expansion in the US block - flexible exchange rate regime : main spill-over effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
EU block												
GDPO	0.00	-0.01	-0.01	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CPO	0.00	-0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	-0.00	-0.00	-0.00
XTO	0.00	-0.06	-0.03	-0.03	-0.02	-0.01	-0.00	0.01	0.02	0.02	0.03	0.00
MTO	0.00	-0.03	-0.00	-0.01	-0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00
PGDP	0.00	0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00
PCH/PGDP	0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00
PXT/PGDP	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	0.00
PMP/PGDP	0.00	-0.00	-0.02	0.01	0.01	0.01	0.00	-0.00	-0.00	-0.00	-0.00	-0.00
SI *	0.00	0.00	-0.00	-0.01	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00
LI *	0.00	0.00	-0.01	-0.01	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00
EFEX	0.00	-0.11	-0.11	-0.10	-0.09	-0.09	-0.08	-0.08	-0.08	-0.09	-0.09	-0.12
EFEX*EFPASP/PXT	0.00	-0.10	-0.08	-0.05	-0.02	-0.00	0.01	0.02	0.03	0.03	0.03	0.00
TBU/GDPU *	0.00	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00
NE block												
GDPO	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00	0.00
CPO	0.00	-0.00	-0.01	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01	-0.00	0.00
XTO	0.00	0.01	-0.02	-0.03	-0.02	-0.01	0.01	0.02	0.02	0.02	0.02	0.00
MTO	0.00	-0.00	-0.02	-0.04	-0.04	-0.03	-0.02	-0.01	0.00	0.01	0.02	0.00
PGDP	0.00	-0.01	-0.02	-0.03	-0.04	-0.05	-0.06	-0.06	-0.06	-0.06	-0.05	0.00
PCH/PGDP	0.00	0.01	0.01	0.02	0.03	0.03	0.03	0.02	0.01	0.01	0.00	-0.00
PXT/PGDP	0.00	-0.02	-0.04	-0.06	-0.08	-0.08	-0.08	-0.06	-0.05	-0.03	-0.02	0.00
PMP/PGDP	0.00	0.00	-0.01	0.01	0.01	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00
SI *	0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.00	0.00
LI *	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00	0.00	0.00	0.00	0.00
EFEX	0.00	-0.11	-0.14	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.15	-0.15	-0.10
EFEX*EFPASP/PXT	0.00	-0.08	-0.07	-0.04	0.00	0.03	0.04	0.04	0.03	0.02	0.01	0.00
TBU/GDPU *	0.00	-0.00	-0.01	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	-0.00	-0.00	0.00
JP block												
GDPO	0.00	-0.02	-0.04	-0.03	-0.02	-0.00	0.01	0.01	0.01	0.01	0.01	0.00
CPO	0.00	-0.02	-0.04	-0.04	-0.04	-0.02	-0.01	-0.00	0.01	0.01	0.01	0.00
XTO	0.00	-0.08	-0.11	-0.02	0.06	0.10	0.10	0.08	0.05	0.02	0.00	0.00
MTO	0.00	-0.04	-0.05	-0.03	-0.03	-0.02	-0.00	0.01	0.02	0.02	0.02	0.00
PGDP	0.00	-0.03	-0.04	-0.06	-0.06	-0.06	-0.05	-0.04	-0.04	-0.03	-0.03	0.00
PCH/PGDP	0.00	0.03	0.03	0.04	0.03	0.02	0.01	-0.00	-0.00	-0.00	-0.00	-0.00
PXT/PGDP	0.00	-0.22	-0.29	-0.23	-0.16	-0.09	-0.04	-0.01	-0.00	-0.00	-0.01	0.00
PMP/PGDP	0.00	0.02	-0.10	0.08	0.07	0.02	-0.01	-0.02	-0.02	-0.01	-0.01	-0.00
SI *	0.00	-0.03	-0.02	-0.04	-0.02	-0.00	0.01	0.01	0.01	0.01	0.01	0.00
LI *	0.00	-0.03	-0.01	-0.03	-0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00
EFEX	0.00	-0.75	-0.53	-0.35	-0.25	-0.22	-0.24	-0.28	-0.32	-0.36	-0.39	-0.38
EFEX*EFPASP/PXT	0.00	-0.47	-0.13	0.07	0.14	0.13	0.10	0.06	0.02	0.00	-0.01	0.00
TBU/GDPU *	0.00	-0.03	-0.02	-0.03	-0.01	0.00	0.01	0.01	0.00	0.00	-0.00	0.00
RW block												
XTO	0.00	0.12	0.10	0.04	-0.01	-0.04	-0.05	-0.07	-0.08	-0.10	-0.12	0.00
MTO	0.00	-0.08	-0.10	-0.10	-0.08	-0.06	-0.05	-0.04	-0.03	-0.02	-0.02	0.00
EFEX*EFPASP/PXT	0.00	-0.25	-0.35	-0.21	-0.17	-0.17	-0.18	-0.18	-0.15	-0.12	-0.07	-0.00

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

TABLE VI.9 - A monetary expansion in the US block - fixed exchange rate regime : main own effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
GDPO	0.00	0.12	0.14	0.11	0.08	0.05	0.03	0.01	-0.01	-0.03	-0.04	0.00
GDPU	0.00	0.20	0.33	0.42	0.49	0.56	0.62	0.67	0.70	0.73	0.74	1.00
Selected components of aggregate demand												
CPO	0.00	0.13	0.19	0.16	0.11	0.07	0.03	0.00	-0.02	-0.04	-0.06	0.00
GIO	0.00	0.24	0.30	0.25	0.19	0.13	0.08	0.04	-0.01	-0.04	-0.07	-0.00
CGGSO+WBGO	0.00	0.04	0.06	0.08	0.08	0.06	0.03	0.00	-0.02	-0.03	-0.03	0.00
XTO	0.00	0.05	0.03	0.00	-0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.00
MTO	0.00	0.35	0.45	0.32	0.22	0.13	0.05	-0.01	-0.06	-0.10	-0.14	0.00
Household sector												
SCALEH	0.00	-0.00	0.00	-0.02	-0.04	-0.06	-0.07	-0.08	-0.08	-0.09	-0.09	0.00
DIH/PCH	0.00	0.03	0.13	0.11	0.09	0.06	0.04	0.02	0.01	-0.01	-0.03	0.00
NSH/DIH *	0.00	-0.10	-0.06	-0.04	-0.02	-0.00	0.01	0.02	0.03	0.03	0.02	0.00
Prices												
PGDP	0.00	0.09	0.19	0.30	0.41	0.51	0.59	0.66	0.72	0.76	0.78	1.00
PCH/PGDP	0.00	0.01	0.04	0.08	0.11	0.13	0.14	0.15	0.15	0.16	0.16	0.00
PMP/PGDP	0.00	-0.05	-0.08	-0.09	-0.08	-0.07	-0.06	-0.05	-0.04	-0.03	-0.02	-0.00
PXT/PGDP	0.00	-0.09	-0.19	-0.30	-0.40	-0.49	-0.57	-0.64	-0.69	-0.72	-0.74	-0.00
Labour market												
WRP/PCH	0.00	0.00	-0.06	-0.08	-0.10	-0.12	-0.14	-0.14	-0.15	-0.15	-0.16	-0.00
WRP/(PASP*(1-NITR))	0.00	0.02	-0.01	-0.01	-0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00
NP	0.00	0.07	0.11	0.07	0.03	-0.01	-0.03	-0.05	-0.05	-0.06	-0.06	-0.00
UR *	0.00	-0.05	-0.07	-0.04	-0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.00
Financial sector												
SI *	0.00	-0.23	-0.15	-0.12	-0.10	-0.08	-0.07	-0.05	-0.05	-0.04	-0.04	0.00
SI-(EPCH/PCH-1) *	-0.00	-0.32	-0.28	-0.24	-0.21	-0.17	-0.14	-0.11	-0.09	-0.07	-0.06	0.00
LI *	0.00	-0.06	-0.04	-0.03	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	0.00
EFEX	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	1.00
EFEX*EFPASP/PXT	0.00	-0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
M	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Enterprise sector												
ASPO/HP_ASPO	0.00	0.14	0.15	0.11	0.08	0.06	0.04	0.02	-0.00	-0.02	-0.03	0.00
GIPO	0.00	0.20	0.22	0.15	0.10	0.06	0.02	-0.01	-0.03	-0.05	-0.06	0.00
Public sector												
TOTREV/PGDP	0.00	0.30	0.00	-0.07	-0.14	-0.19	-0.22	-0.24	-0.23	-0.22	-0.19	0.00
CGU/PGDP	0.00	-0.03	-0.12	-0.06	-0.02	0.02	0.06	0.08	0.10	0.12	0.13	0.00
NLG/GDPU *	0.00	-0.11	-0.04	0.00	0.04	0.07	0.09	0.11	0.11	0.11	0.11	0.00
GBOND/GDPU *	0.00	-0.23	-0.35	-0.40	-0.40	-0.37	-0.31	-0.23	-0.14	-0.05	0.05	0.00
DTHR *	0.00	0.01	-0.11	-0.13	-0.14	-0.14	-0.14	-0.14	-0.13	-0.11	-0.10	-0.00
Memo items												
CA/GDPU *	0.00	-0.03	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.06	-0.06	-0.06	-0.00
TBU/GDPU *	0.00	-0.03	-0.05	-0.05	-0.05	-0.05	-0.05	-0.06	-0.06	-0.06	-0.06	-0.00
CIRO+CIPO+CIGCO	0.00	0.01	0.02	0.03	0.04	0.04	0.05	0.05	0.04	0.04	0.04	-0.00

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

TABLE VI.10 - A monetary expansion in the US block - fixed exchange rate regime : main spill-over effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
EU block												
GDPO	0.00	0.02	0.03	0.04	0.03	0.02	0.01	0.00	-0.00	-0.01	-0.01	0.00
CPO	0.00	0.02	0.05	0.06	0.04	0.02	0.00	-0.02	-0.03	-0.04	-0.04	-0.00
XTO	0.00	0.02	0.06	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.00
MTO	0.00	0.05	0.11	0.13	0.10	0.06	0.02	-0.01	-0.04	-0.05	-0.05	0.00
PGDP	0.00	0.00	0.01	0.03	0.06	0.09	0.11	0.12	0.13	0.13	0.12	0.00
PCH/PGDP	0.00	-0.00	-0.00	0.00	0.01	0.02	0.03	0.03	0.03	0.03	0.03	-0.00
PXT/PGDP	0.00	-0.00	-0.01	-0.03	-0.05	-0.07	-0.08	-0.09	-0.08	-0.07	-0.06	0.00
PMP/PGDP	0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01	-0.01	-0.00	0.00	-0.00
SI *	0.00	-0.23	-0.15	-0.12	-0.10	-0.08	-0.07	-0.05	-0.05	-0.04	-0.04	0.00
LI *	0.00	-0.11	-0.07	-0.05	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	0.00
EFEX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.12
EFEX*EFPASP/PXT	0.00	0.01	0.02	0.04	0.06	0.07	0.08	0.08	0.08	0.08	0.07	0.00
TBU/GDPU *	0.00	-0.00	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.00	0.01	0.01	0.00
NE block												
GDPO	0.00	0.03	0.07	0.06	0.04	0.03	0.02	0.01	0.00	-0.00	-0.01	0.00
CPO	0.00	0.05	0.14	0.12	0.08	0.04	0.02	-0.00	-0.02	-0.03	-0.03	0.00
XTO	0.00	0.03	0.04	0.04	0.04	0.03	0.03	0.02	0.01	0.00	-0.00	0.00
MTO	0.00	0.10	0.19	0.15	0.09	0.03	-0.01	-0.04	-0.05	-0.06	-0.07	0.00
PGDP	0.00	0.00	0.01	0.04	0.08	0.12	0.14	0.16	0.18	0.18	0.18	0.00
PCH/PGDP	0.00	-0.00	0.00	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.03	-0.00
PXT/PGDP	0.00	0.00	-0.01	-0.03	-0.05	-0.06	-0.07	-0.07	-0.06	-0.06	-0.05	0.00
PMP/PGDP	0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.00	-0.00
SI *	0.00	-0.23	-0.15	-0.12	-0.10	-0.08	-0.07	-0.05	-0.05	-0.04	-0.04	0.00
LI *	0.00	-0.06	-0.03	-0.01	-0.00	0.00	0.00	0.00	-0.00	-0.01	-0.01	0.00
EFEX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.10
EFEX*EFPASP/PXT	0.00	0.01	0.02	0.02	0.03	0.03	0.02	0.01	0.00	-0.00	-0.01	0.00
TBU/GDPU *	0.00	-0.02	-0.04	-0.03	-0.02	-0.01	-0.01	-0.00	0.00	0.00	0.00	0.00
JP block												
GDPO	0.00	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
CPO	0.00	0.03	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.00
XTO	0.00	0.08	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.03	0.02	0.00
MTO	0.00	0.07	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.00
PGDP	0.00	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.00
PCH/PGDP	0.00	-0.00	0.00	-0.00	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.00
PXT/PGDP	0.00	0.01	0.02	0.05	0.07	0.10	0.13	0.16	0.18	0.19	0.20	0.00
PMP/PGDP	0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00
SI *	0.00	-0.23	-0.15	-0.12	-0.10	-0.08	-0.07	-0.05	-0.05	-0.04	-0.04	0.00
LI *	0.00	-0.07	-0.04	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	0.00
EFEX	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.38
EFEX*EFPASP/PXT	0.00	0.02	0.04	0.06	0.07	0.07	0.07	0.06	0.05	0.04	0.03	0.00
TBU/GDPU *	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
RW block												
XTO	0.00	0.21	0.27	0.19	0.11	0.03	-0.04	-0.09	-0.13	-0.15	-0.15	0.00
MTO	0.00	0.02	0.00	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	0.00
EFEX*EFPASP/PXT	0.00	-0.24	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.00

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

2. The adjustment path in the US block

Roughly speaking, the adjustment process in the US block runs as follows. The monetary expansion reduces the short run interest rate, which stimulates demand, including money demand. When total demand exceeds the natural output level, inflation rises. Inflation erodes the real value of the nominal money balances, and the resulting excess demand for real money balances triggers an interest rate hike. However, an interest rate hike reduces also total demand for goods, so that the output gap starts to fall and the inflationary pressures fall. This feedback between interest rates, money balances, total demand and inflation continues until the economy is back in equilibrium [1].

Under a flexible exchange rate regime, the short run interest rate drops by 0.23 base points in the first period. This fall in interest rates stimulates demand, and real GDP increases by 0.12 percent in the first year. Let us now have a look at the components of total demand. First, private consumption increases by 0.14 percent in the first year, primarily due to the real interest rate effect, the opportunity cost of money effect, and the user cost effect (see equation II.6.g). The wealth effect of a temporary rate cut is negligible [2]. However, as prices start to increase, the real value of inherited nominal assets declines, thereby reducing total available means. Second, gross fixed capital formation increases by 0.25 percent, in response to the interest rate drop, and to increased economic activity. Third, exports increase by 0.09 percent, mainly due to the real effective exchange rate depreciation of 0.30 percent. Summarizing these effects, we see that total demand is 0.15 percent above the natural output level in the first year, 0.18 percent in the second year, and gradually falling thereafter. As a consequence of this excess demand, the GDP deflator increases by 0.10 percent in the first year, and continues to rise towards its new steady state level.

Under a fixed exchange rate regime, the effects are somewhat smaller than under a flexible exchange rate regime, especially for exports which remain almost constant, reflecting the absence of a change in the real exchange rate.

Under both exchange rate regimes, the US trade balance and current account deteriorate during the first years. However, the decline is more persistent under a fixed exchange rate regime than under a flexible exchange rate regime. Under a fixed exchange rate regime, competitive pressures limit the scope of export price increases, denominated in local currency. As a consequence, while the export volume remains constant, the domestic value of exports does not keep up with domestic inflation. At the same time, the price of imports keeps up with domestic inflation. The result is that the value of imports increases more than the value of exports, and that the trade balance falls into deficit for the period over which the nominal exchange rate is kept constant. Under a flexible exchange rate regime, the strain on export prices, denominated in local currency, is less severe as the nominal exchange rate depreciates by 0.38 percent in the first period, followed by further depreciations. These depreciations allow the export prices, denominated in local currency, to be raised without loss of competitiveness.

1. This process is further influenced by the impact of changes in the real exchange rate, and by the impact of inflation expectations on the components of demand.
2. Households discount their future non-asset income on the basis of an exogenous discount rate, which is not affected by the temporary rate cut.

The fiscal stance in the US block is also affected. Indeed, when the price level increases, the real value of the stock of nominal government debt falls, thereby overshooting the debt to GDP target, allowing for a temporary reduction in the direct labour income tax rate [1].

3. The spill-over effects

In the new steady state, the nominal and real variables of the other blocks do not change, except for the nominal effective exchange rate which appreciates to compensate for the increase in the US price level [2].

Under a flexible exchange rate regime, the short run spill-over effects are primarily determined by trade flows. On the one hand, the increased activity in the US block stimulates the exports of each of the other blocks. On the other hand, the depreciation of the real effective exchange rate of the US block reduces the competitiveness of the other blocks, thereby depressing their exports. It is not a priori clear how these two effects will affect the exports of a particular block. If the exchange rate depreciation effect is strong enough, exports of a particular block may even drop. This is illustrated in Table VI.8 by the results for the JP block, where the real exchange rate appreciates by 0.47 percent in the first year, sufficiently to outweigh the scale effect and reduce exports by 0.08 percent. On the whole, the spill-over effects of a monetary expansion in the US block are very limited and temporary under a flexible exchange rate regime.

Under a fixed exchange rate regime, in addition to the trade effect, there is also a financial effect. First, the appreciation of the real exchange rate is now smaller than under a flexible exchange rate regime, mainly because the nominal exchange rate does not change. For example, in the EU block, the effective real exchange rate remains more or less stable in the first period, whereas it appreciates by 0.10 percent under the flexible exchange rate regime. Second, under a fixed exchange rate regime, the nominal interest rate drops in the other country blocks by the same amount as it does in the US block, see equation (VI.5). However, the real interest rate in the other blocks does not fall as much as in the US block, because the expected inflation in the other blocks stays close to zero [3]. Although the two former effects may stimulate activity in the other blocks, the evidence in Table VI.10 indicates that their net impact remains very limited.

4. A coordinated monetary expansion

In order to get a better understanding of the role played by inflation expectations, we also simulated a scenario in which the monetary authorities of the EU and US block simultaneously increase the money supply by 1 percent. Here, it should be noted that one important difference with the previous scenarios is that in this variant the agents in the EU block expect prices to rise by 1 percent in the long run.

1. See equation (V.27).
2. The appreciation of the effective exchange rate of block XX is proportional to the weight of the US in the trade of that block. See parameter xx_w_xtus in equation (D.1) of Appendix D.
3. Remember that in the other country blocks the monetary authorities are expected to stick to their initial price target.

The results of this simulation are shown in Table VI.11 and VI.12. In the steady state the price level of the EU and US block increase by 1 percent, while the real variables do not change. In the first year the quantity responses of the EU block are to a large extent similar to those of the US block. For example, in both blocks, GDP increases by about 0.12 percent in the first year. Note however that the underlying mechanisms differ somewhat. In the US block, there is a relatively high interest rate elasticity of demand, but a relatively low sensitivity of prices to the output gap and secular inflation. In the EU block, there is a low interest elasticity, combined with a relatively high sensitivity of prices to the output gap and secular inflation. The interaction of these effects gives a net result which is similar across blocks.

G. The properties of the NIME model: a summary

Here, we summarize some of the main findings of the technical simulations presented in this chapter.

First, in the steady state, total supply is determined by the supply side, while the relative prices and the real scale variables adjust to equilibrate total final demand with total supply. This is illustrated by the fact that an increase in productivity induces additional absorption through a decrease in the real price of private consumption, and that a fiscal expansion crowds out private consumption through an increase in the direct labour income tax rate.

Second, in the steady state, the order of magnitude of the spill-over effects between the country blocks depends on the nature of the shock. A real demand shock, e.g., an increase in public consumption, has no steady state spill-over effects on the other blocks, because equilibrium can be restored through domestic adjustment. However, a supply shock, e.g., an increase in trend productivity, increases imports of the block that experiences the supply shock, thereby changing the relative prices in the other blocks in order to induce a reallocation of their total supply from domestic consumption to exports.

Third, money is neutral in the long run, but it has some real effects in the short run. However, the real gains of a monetary expansion are short lived, and its spill-over effects are rather limited.

Fourth, short run adjustment is determined by the adjustment costs in price setting and demand, the policy reaction functions, the speed of gross fixed capital formation, and the speed at which expectations are revised. We illustrated this by simulating alternative variants regarding the expectations regime, and we also pointed out how slowly stocks of capital goods adjust.

TABLE VI.11 - A monetary expansion in the EU and US block - flexible exchange rate regime : own effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
EU block												
GDPO	0.00	0.12	0.15	0.04	-0.03	-0.06	-0.07	-0.06	-0.05	-0.05	-0.05	0.00
GDPU	0.00	0.34	0.62	0.74	0.82	0.85	0.86	0.86	0.85	0.83	0.81	1.00
Selected components of aggregate demand												
CPO	0.00	0.12	0.17	-0.03	-0.18	-0.26	-0.28	-0.27	-0.25	-0.21	-0.18	-0.00
GIO	0.00	0.16	0.23	0.11	0.02	-0.04	-0.07	-0.09	-0.09	-0.09	-0.09	-0.00
CGGSO+WBGO	0.00	0.07	0.07	0.04	-0.01	-0.04	-0.04	-0.03	-0.01	-0.00	-0.00	-0.00
XTO	0.00	0.38	0.46	0.53	0.58	0.60	0.60	0.56	0.50	0.42	0.33	0.00
MTO	0.00	0.48	0.58	0.30	0.02	-0.15	-0.22	-0.23	-0.21	-0.18	-0.16	0.00
Household sector												
GIRO	0.00	0.46	0.85	0.49	0.15	-0.11	-0.28	-0.39	-0.44	-0.45	-0.43	-0.00
SCALEH	0.00	-0.07	-0.15	-0.23	-0.27	-0.27	-0.26	-0.23	-0.21	-0.19	-0.17	0.00
DIH/PCH	0.00	0.13	0.28	0.15	0.04	-0.04	-0.10	-0.13	-0.14	-0.15	-0.14	0.00
NSH/DIH *	0.00	0.00	0.10	0.18	0.22	0.22	0.19	0.14	0.10	0.07	0.04	0.00
Prices												
PGDP	0.00	0.22	0.47	0.70	0.84	0.91	0.93	0.92	0.90	0.88	0.86	1.00
PCH/PGDP	0.00	0.03	0.10	0.16	0.22	0.25	0.26	0.25	0.23	0.20	0.17	0.00
PMP/PGDP	0.00	-0.12	-0.08	-0.22	-0.17	-0.10	-0.04	-0.01	0.00	0.01	0.01	-0.00
PXT/PGDP	0.00	-0.20	-0.41	-0.59	-0.67	-0.67	-0.61	-0.52	-0.41	-0.31	-0.22	-0.00
Labour market												
WRP/PCH	0.00	-0.03	-0.11	-0.19	-0.24	-0.26	-0.26	-0.24	-0.21	-0.18	-0.15	-0.00
WRP/(PASP*(1-NITR))	0.00	0.01	-0.00	-0.00	-0.00	0.00	0.01	0.01	0.02	0.02	0.02	-0.00
NP	0.00	0.02	0.04	0.01	-0.02	-0.03	-0.03	-0.02	-0.01	-0.01	-0.00	-0.00
NG	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	-0.00	-0.00	-0.00
UR *	0.00	-0.01	-0.02	-0.00	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.00
Financial sector												
SI *	0.00	-0.35	0.07	-0.05	-0.12	-0.17	-0.17	-0.16	-0.12	-0.10	-0.08	0.00
SI-(EPCH/PCH-1) *	-0.00	-0.54	-0.17	-0.22	-0.21	-0.19	-0.15	-0.11	-0.07	-0.05	-0.03	0.00
LI *	0.00	-0.17	0.03	-0.02	-0.06	-0.08	-0.08	-0.07	-0.06	-0.05	-0.04	0.00
EFEX	0.00	0.58	0.59	0.67	0.76	0.83	0.88	0.89	0.89	0.87	0.84	0.88
EFEX*EFPASP/PXT	0.00	0.56	0.55	0.59	0.62	0.63	0.60	0.54	0.45	0.36	0.26	0.00
M	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Enterprise sector												
ASPO/HP_ASPO	0.00	0.18	0.23	0.08	-0.02	-0.07	-0.09	-0.09	-0.08	-0.07	-0.07	0.00
GIPO	0.00	0.08	0.08	0.04	0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.00
Public sector												
TOTREV/PGDP	0.00	0.18	-0.23	-0.29	-0.28	-0.22	-0.14	-0.05	0.02	0.07	0.10	0.00
CGU/PGDP	0.00	0.03	0.01	0.06	0.08	0.10	0.11	0.11	0.11	0.10	0.09	0.00
NLG/GDPU *	0.00	-0.07	0.11	0.16	0.17	0.15	0.11	0.07	0.04	0.01	-0.01	0.00
GBOND/GDPU *	0.00	-0.27	-0.33	-0.24	-0.12	0.01	0.11	0.19	0.24	0.26	0.27	-0.00
DTHR *	0.00	0.01	-0.22	-0.21	-0.18	-0.14	-0.09	-0.04	-0.00	0.02	0.04	-0.00
Memo items												
CA/GDPU *	0.00	-0.03	-0.07	-0.02	0.00	0.02	0.03	0.04	0.04	0.04	0.03	-0.00
TBU/GDPU *	0.00	-0.03	-0.06	-0.02	0.01	0.03	0.04	0.04	0.04	0.04	0.04	-0.00
CIRO+CIPO+CIGCO	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-0.00	-0.00

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

TABLE VI.12 - A monetary expansion in the EU and US block - flexible exchange rate regime : own effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
US block												
GDPO	0.00	0.13	0.16	0.13	0.10	0.07	0.04	0.01	-0.01	-0.03	-0.04	0.00
GDPU	0.00	0.22	0.37	0.47	0.55	0.63	0.70	0.75	0.80	0.84	0.86	1.00
Selected components of aggregate demand												
CPO	0.00	0.14	0.20	0.17	0.12	0.07	0.04	0.00	-0.02	-0.04	-0.06	0.00
GIO	0.00	0.26	0.33	0.28	0.22	0.17	0.11	0.06	0.01	-0.03	-0.05	-0.00
CGGSO+WBGO	0.00	0.04	0.06	0.08	0.08	0.06	0.03	-0.00	-0.03	-0.04	-0.04	0.00
XTO	0.00	0.18	0.17	0.14	0.13	0.11	0.08	0.05	0.03	0.03	0.05	0.00
MTO	0.00	0.41	0.47	0.38	0.28	0.18	0.09	0.01	-0.05	-0.09	-0.12	0.00
Household sector												
GIRO	0.00	0.42	0.68	0.65	0.58	0.49	0.38	0.26	0.14	0.04	-0.05	-0.00
SCALEH	0.00	0.00	0.00	-0.01	-0.04	-0.06	-0.07	-0.07	-0.08	-0.08	-0.08	0.00
DIH/PCH	0.00	0.04	0.14	0.13	0.11	0.09	0.07	0.06	0.04	0.02	0.01	0.00
NSH/DIH *	0.00	-0.10	-0.06	-0.04	-0.01	0.02	0.04	0.05	0.06	0.06	0.06	0.00
Prices												
PGDP	0.00	0.09	0.21	0.33	0.45	0.56	0.66	0.74	0.81	0.86	0.90	1.00
PCH/PGDP	0.00	0.00	0.04	0.06	0.08	0.09	0.10	0.11	0.11	0.11	0.11	0.00
PMP/PGDP	0.00	-0.06	-0.02	-0.10	-0.11	-0.09	-0.07	-0.06	-0.04	-0.03	-0.02	-0.00
PXT/PGDP	0.00	-0.04	-0.09	-0.13	-0.18	-0.23	-0.27	-0.31	-0.34	-0.35	-0.34	-0.00
Labour market												
WRP/PCH	0.00	0.01	-0.05	-0.07	-0.08	-0.10	-0.11	-0.11	-0.12	-0.12	-0.12	-0.00
WRP/(PASP*(1-NITR))	0.00	0.02	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.00	0.01	0.00
NP	0.00	0.08	0.13	0.09	0.04	-0.00	-0.03	-0.05	-0.06	-0.06	-0.06	-0.00
NG	0.00	0.01	0.03	0.04	0.04	0.03	0.02	0.02	0.01	0.00	0.00	0.00
UR *	0.00	-0.06	-0.08	-0.05	-0.02	0.00	0.02	0.03	0.03	0.03	0.03	0.00
Financial sector												
SI *	0.00	-0.23	-0.15	-0.11	-0.09	-0.07	-0.05	-0.04	-0.03	-0.02	-0.02	0.00
SI-(EPCH/PCH-1) *	-0.00	-0.32	-0.28	-0.24	-0.20	-0.17	-0.14	-0.10	-0.08	-0.06	-0.04	0.00
LI *	0.00	-0.06	-0.04	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.00	0.00
EFEX	0.00	0.21	0.22	0.25	0.27	0.29	0.32	0.36	0.40	0.46	0.51	0.83
EFEX*EFPASP/PXT	0.00	0.19	0.17	0.15	0.12	0.09	0.07	0.06	0.06	0.07	0.08	0.00
M	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Enterprise sector												
ASPO/HP_ASPO	0.00	0.16	0.17	0.13	0.10	0.08	0.05	0.02	0.00	-0.01	-0.03	0.00
GIPO	0.00	0.23	0.24	0.18	0.12	0.08	0.03	0.00	-0.03	-0.04	-0.06	0.00
Public sector												
TOTREV/PGDP	0.00	0.31	0.01	-0.08	-0.16	-0.22	-0.26	-0.28	-0.29	-0.28	-0.25	0.00
CGU/PGDP	0.00	-0.04	-0.14	-0.09	-0.05	-0.01	0.03	0.05	0.08	0.09	0.11	0.00
NLG/GDPU *	0.00	-0.12	-0.05	-0.00	0.04	0.07	0.10	0.11	0.12	0.12	0.12	0.00
GBOND/GDPU *	0.00	-0.25	-0.39	-0.45	-0.46	-0.44	-0.38	-0.30	-0.21	-0.10	-0.00	0.00
DTHR *	0.00	0.01	-0.11	-0.13	-0.14	-0.15	-0.15	-0.15	-0.14	-0.13	-0.11	-0.00
Memo items												
CA/GDPU *	0.00	-0.02	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.00
TBU/GDPU *	0.00	-0.02	-0.04	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.00
CIRO+CIPO+CIGCO	0.00	0.01	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.04	-0.00

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

TABLE VI.13 - A monetary expansion in the EU and US block - flexible exchange rate regime : spill-over effects [a]

	00	01	02	03	04	05	06	07	08	09	10	ss
NE block												
GDPO	0.00	0.01	-0.02	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	0.00
CPO	0.00	-0.01	-0.02	-0.03	-0.03	-0.04	-0.04	-0.04	-0.03	-0.03	-0.03	0.00
XTO	0.00	0.06	-0.03	-0.05	-0.03	-0.02	-0.03	-0.04	-0.04	-0.04	-0.02	0.00
MTO	0.00	0.00	-0.03	-0.09	-0.07	-0.06	-0.07	-0.06	-0.06	-0.04	-0.02	0.00
PGDP	0.00	-0.02	-0.05	-0.08	-0.09	-0.11	-0.13	-0.16	-0.18	-0.20	-0.21	0.01
PCH/PGDP	0.00	0.02	0.03	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	-0.00
PXT/PGDP	0.00	-0.06	-0.13	-0.15	-0.17	-0.18	-0.18	-0.18	-0.18	-0.17	-0.16	0.00
PMP/PGDP	0.00	0.01	-0.04	0.04	0.01	0.00	0.00	0.01	0.01	0.01	0.01	-0.00
SI *	0.00	-0.01	-0.02	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	0.00
LI *	0.00	-0.02	-0.02	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	0.00
EFEX	0.00	-0.47	-0.43	-0.47	-0.56	-0.65	-0.73	-0.76	-0.77	-0.75	-0.74	-0.45
EFEX*EFPASP/PXT	0.00	-0.31	-0.08	0.03	0.04	0.01	-0.02	-0.03	-0.01	0.02	0.03	0.00
TBU/GDPU *	0.00	-0.00	-0.02	-0.04	-0.03	-0.03	-0.04	-0.04	-0.04	-0.04	-0.04	0.00
JP block												
GDPO	0.00	-0.03	-0.06	-0.04	-0.02	-0.01	0.00	0.01	0.01	0.01	0.01	0.00
CPO	0.00	-0.03	-0.05	-0.05	-0.05	-0.03	-0.02	-0.01	0.00	0.01	0.01	0.00
XTO	0.00	-0.11	-0.14	-0.03	0.06	0.09	0.08	0.06	0.04	0.02	-0.00	0.00
MTO	0.00	-0.05	-0.07	-0.03	-0.05	-0.03	-0.01	0.00	0.01	0.02	0.02	0.00
PGDP	0.00	-0.05	-0.05	-0.08	-0.08	-0.08	-0.07	-0.07	-0.06	-0.06	-0.06	0.00
PCH/PGDP	0.00	0.05	0.03	0.05	0.04	0.02	0.01	0.00	0.00	-0.00	0.00	-0.00
PXT/PGDP	0.00	-0.33	-0.39	-0.29	-0.20	-0.13	-0.08	-0.05	-0.04	-0.03	-0.03	0.00
PMP/PGDP	0.00	0.02	-0.16	0.15	0.08	0.01	-0.02	-0.02	-0.01	-0.01	-0.00	-0.00
SI *	0.00	-0.05	-0.03	-0.05	-0.02	-0.00	0.01	0.01	0.01	0.01	0.01	0.00
LI *	0.00	-0.05	-0.01	-0.04	-0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00
EFEX	0.00	-1.15	-0.66	-0.45	-0.40	-0.41	-0.43	-0.46	-0.48	-0.50	-0.52	-0.51
EFEX*EFPASP/PXT	0.00	-0.71	-0.08	0.13	0.16	0.13	0.09	0.06	0.04	0.02	0.00	0.00
TBU/GDPU *	0.00	-0.04	-0.03	-0.04	-0.02	-0.00	0.00	0.00	0.00	-0.00	-0.00	0.00
RW block												
XTO	0.00	0.53	0.62	0.45	0.29	0.20	0.18	0.19	0.21	0.23	0.25	0.00
MTO	0.00	0.38	0.43	0.50	0.59	0.65	0.69	0.70	0.70	0.68	0.65	0.00
EFEX*EFPASP/PXT	0.00	0.18	-0.12	-0.01	0.12	0.20	0.22	0.22	0.22	0.24	0.27	-0.04

a. Variables without *: deviation from baseline, in percent. Variables with *: deviation from baseline, in differences.

VII Summary

This paper presented the current version of the NIME model. The NIME model is a macroeconometric world model to study the transmission of the effects of economic policy and exogenous shocks on the Belgian and European economy. The NIME model divides the world into six country blocks: Belgium, the EU, NE, US, JP and the RW block [1]. In the first five chapters of the paper, we presented the behavioural equations of the different sectors of the EU, NE, US, and JP blocks. These sectors are the household sector, the enterprise sector, the public sector, and the monetary sector. In the last chapter, we concluded with the discussion of three simulations, illustrating the properties of the model.

In Chapter II of this Working Paper, we described the household sector. In the first section of this chapter, we specified the long run expenditure plans of the household sector, and we showed how private consumption, the demand for money, and investment in residential buildings are determined by the total available means of the household sector, the nominal interest rate, the real interest rate, and the user cost of residential buildings. In the empirical section, we made the additional assumptions that rigidities prevent the household sector from adjusting immediately its current expenditures to its equilibrium plans, and that this adjustment process can be captured by an error correction model or a partial adjustment process. Here, we assumed also that the household sector is to some extent liquidity constrained. We concluded the chapter with the presentation of empirical results for the long and short run responses of private consumption, money demand, and investment, to changes in the available means, the nominal and real interest rates, and the user cost of residential buildings. There, a main finding was that in the short run, the semi-interest elasticities are somewhat lower than in the long run.

In Chapter III, we described the enterprise sector. In the first section, we formulated a set of assumptions regarding the production technology and the structure of the markets on which goods and production factors are traded. Next, a set of equilibrium factor demand equations and factor price equations was derived from a bargaining process between a profit maximizing enterprise sector and a utility maximizing household sector. We found that, in equilibrium, the demand for production factors depends on total supply and the real factor prices. The real wage depends on the reservation wage and labour productivity, while the real price of private capital goods is equal to the discounted net value of the productivity of capital goods. In that section, we also discussed some steady state

1. The EU block consists of the countries that joined EMU in January 1999 minus Belgium, the NE block consists of the EU countries that did not join EMU in January 1999, the US block covers the US economy, while the JP block covers the Japanese economy. The RW block consists of a few equations capturing the trade feedback between the main blocks of the model and the “rest of the world”.

properties of the model. In the empirical section of the chapter, we dealt first with the problem that the reservation wage of the household sector cannot be observed, by postulating that the reservation wage is function of the labour wage and the past reservation wage. After the proper substitutions, we estimated a dynamic wage setting equation for the four main country blocks of the NIME model. The estimates showed that the change in the unemployment rate has an important impact on real wages in all blocks, whereas the impact of the lagged level of the unemployment rate on real wages is negligible for the EU and US block. Next, we derived a short run price setting scheme, based on the assumption that there exist menu costs and that prices are partly revised on the basis of a “rule of thumb”. We showed estimation results for the different prices. There, we found, for example, that price revisions are generally not very constrained by menu costs, and that they are largely based on “rule of thumb” behaviour. Next, we estimated an error correction mechanism for the demand for labour and imports, and a partial adjustment mechanism for gross fixed capital formation. The parameters of the equilibrium demand equations are determined by the parameters of the Cobb-Douglas production function, while the restrictions on the parameters of the short run adjustment scheme are such that the natural rate of unemployment is not affected by trend productivity growth and population growth. The estimation results showed, for example, that the short run elasticities of imports are generally higher than those of the other production factors.

In Chapter IV, we presented the monetary sector. First, we assumed that in each block, the short run interest rate is set by the monetary authorities in response to deviations of the policy variables from their target values. These policy variables are inflation, unemployment, and the exchange rate. Next, we specified and estimated an equation for the long run interest rate, based on the term structure of interest rates and an expectations scheme, in which the contemporaneous interest rate is expected to converge to the steady state interest rate. The obtained equation explains the contemporaneous long run interest rate by the contemporaneous short run interest rate and the steady state interest rate. Finally, we specified the spot exchange rate as a function of the equilibrium exchange rate, the lagged spot exchange rate, the nominal interest rate differential, and the expected inflation difference. The equilibrium exchange rate stabilizes the foreign assets to GDP ratio.

In Chapter V, we described the public sector. The public sector comprises the expenditures and revenues of the general government. The behavioural relations of the public sector are not derived from an explicit optimization problem, they are simply postulated. First, we discussed the public expenditures which include the wage bill, public consumption of goods and services, transfers, interest payments, and capital expenditures. Next, we presented the public revenues which include direct taxes on labour and capital income, and net indirect taxes. Finally, we described a policy reaction function whereby the direct labour income tax rate adjusts in such a way that a predetermined target public debt to GDP ratio is attained in the steady state.

In Chapter VI, we presented three standard simulations. These simulations illustrate the main properties of the NIME model, which are the long run neutrality of money, the long run crowding out of private consumption by public consumption, and the long run output effects of an increase in trend productivity. The simulations show also how, during the adjustment process to the new steady state, the endogenous variables may initially over- or undershoot their steady state values, and that this adjustment process is primarily determined by the adjustment costs in price setting and demand, the policy reaction functions (including the exchange rate regime), the speed of gross fixed capital formation, and the speed at which expectations are revised. The spill-over effects between blocks are rather limited, and depend to a large extent on the nature of the shock.

Finally, the following issues could be covered in a further extension of the NIME project: an update of the databank according to the new European system of accounts (ESA95); the construction of a baseline projection; the introduction of rational expectations [1]; the modelling of the steady state variables which are treated as exogenous in the current version, e.g., the natural rate of unemployment, and trend productivity growth; the modelling of alternative international transmission mechanisms, e.g., currency substitution; the specification of short run demand equations based on an explicit adjustment cost function; and the modelling of a more desaggregated enterprise sector.

1. As opposed to “quasi” rational expectations used in this Working Paper.

VIII Appendix A: List of Variables of the NIME Model

ADPO: private final demand, in constant prices,

ADPU: private final demand, in current prices,

ADO: total final demand, in constant prices,

ADU: total final demand, in current prices,

ASGO: public supply for final demand, in constant prices,

ASGU: public supply for final demand, in current prices,

ASPO: private supply for final demand, in constant prices,

ASPU: private supply for final demand, in current prices,

ASO: total supply for final demand, in constant prices,

ASU: total supply for final demand, in current prices,

BEN: the nominal reservation wage of the household sector,

CA: current account, in current prices, measured in local currency,

CAOU: net other assets of the household sector, in current prices,

CGGSO: public sector consumption of goods and services, exclusive the wage bill, in constant prices,

CGGSU: public sector consumption of goods and services, exclusive the wage bill, in current prices,

CGINT: interest payments on public debt, in current prices,

CGU: the total expenditures by the public sector, in current prices,

CGX: the total expenditures by the public sector, excluding interest payments, in current prices,

CIGCO: the public sector capital stock, in constant prices,

CIGCU: the public sector capital stock, in current prices,

CIPO: the capital stock of the enterprise sector, in constant prices,

CIPU: the capital stock of the enterprise sector, in current prices,

CIRO: the stock of residential buildings, in constant prices,

CIRU: the stock of residential buildings, in current prices,

CPO: consumption of goods and services (other than monetary services and services generated by residential buildings), in constant prices, CPU: consumption of goods and services (other than monetary services and services generated by residential buildings), in current prices,

DEPGCU: depreciation of the public sector capital stock, in current prices,

DEPPU: depreciation of the capital stock of the enterprise sector, in current prices,

DEPRU: depreciation of the stock of residential buildings, in current prices,

DEPU: depreciation of the total capital stock, in current prices,

DIH: disposable income of household sector, in current prices,

DTC: the taxes on asset income, in current prices,

DTCP: direct tax revenue from income on capital, in current prices,

DTH: direct tax revenue from labour income, in current prices,

DTHR: the direct labour income tax rate,

EFASPO: the effective foreign output level,

EFEX: the effective nominal exchange rate, amount of local currency per unit of foreign currency,

EFPASP: the effective foreign price level,

EFSI: the effective foreign interest rate,

EPCH: the expected consumer price,

EZY: discounted future non-asset income, in constant prices,

FBOND: the stock of foreign assets, denominated in local currency,

G_ASPO: steady state growth of private supply for final demand,

G_LS: steady state growth of the labour supply,

G_NPO: steady state growth of total population,

G_PCH: steady state growth of the general price level,

G_YCP: steady state growth of productivity of the private sector capital stock,

G_YMP: steady state growth of productivity of intermediary imports,

G_YNP: steady state growth of labour productivity,

GBOND: the stock of public debt, in current prices,

GDPO: gross domestic product, in constant prices,

GDPU: gross domestic product, in current prices,

GIGCO: gross fixed capital formation by the public sector, in constant prices,

GIGCU: gross fixed capital formation by the public sector, in current prices,

GIGOU: net other capital transactions by the public sector, in current prices,

GIO: gross fixed capital formation of the whole economy, in constant prices,

GIPO: gross fixed capital formation of the enterprise sector, in constant prices, GIPU: gross fixed capital formation of the enterprise sector, in current prices,

GIRO: gross fixed capital formation in residential buildings, in constant prices,

GIRU: gross fixed capital formation in residential buildings, in current prices,

GIU: gross fixed capital formation of the whole economy, in current prices,

HP_RLI: the steady state real (long term) interest rate,

HP_XX: the steady state of variable XX,

IGCO: net fixed capital formation by the public sector, in constant prices,

IGCU: net fixed capital formation by the public sector, in current prices,

IGO: total net capital transactions of the public sector, in constant prices,

IGU: total net capital transactions of the public sector, in current prices,

INVHO: inventories held by the household sector, in constant prices,

INVHU: inventories held by the household sector, in current prices,

INVPO: inventories held by enterprise sector, in constant prices,

INVPU: inventories held by enterprise sector, in current prices,

ITR: the indirect tax rate,

L: leisure,

LI: the long term interest rate,

LIC: the interest rate of the household sector,

LIG: the interest rate on public debt,

LS: total labour supply,

M: the nominal money stock,

MPO: the (intermediary) imports, in constant prices,

MPU: the (intermediary) imports, in current prices,

MS: monetary services,

NCTROW: net current transfers to the rest of the world, measured in local currency,

NFIROW: net factor income from the rest of the world, measured in local currency,

NG: total employment in the public sector,

NITR: the net indirect tax rate,

NLG: net lending by the public sector, in current prices,

NOIH: net other income of the household sector, in current prices,

NOIP: net other income of the enterprise sector, in current prices,

NP: total employment in the enterprise sector, NPO: total population,

NPOC: number of children,

NPOO: number of pensioners,

NSH: net savings by the household sector, in current prices,

NSP: net savings by the enterprise sector, in current prices,

OSGU: operating surplus of the public sector, in current prices,

OSHU: operating surplus of the household sector, in current prices,

OSPU: operating surplus of the enterprise sector, in current prices,

OSU: operating surplus of the whole economy, in current prices,

OT: net other tax revenue, in current prices,

PASP: the price of goods and services supplied by the enterprise sector,

PCH: the price of private consumption,

PCIG: the price of the public sector capital stock,

PCIP: the price of the enterprise sector capital stock,

PCIR: the price of residential buildings,

PGDP: the deflator of gross domestic product,

PINVH: the price of inventories held by the household sector,

PINVP: the price of inventories held by the enterprise sector,

PM: the opportunity cost of money,

PMP: the price of imports, measured in local currency,

PXT: the price of exports, measured in local currency,

PX: the price of good X,

PXR: the “rational reset” price of good X,

PZ: the price of the bequest,

R_GBOND: the target debt to GDP ratio,

SCALEH: total available means of the household sector,

SI: the short term interest rate,

SSRH: the social security contributions, in current prices,

SSRHR: the social security contributions rate,

SUBP: public sector subsidies to the enterprise sector, in current prices,

T: the planning horizon of the household sector,

TBU: the trade balance, in current prices,

TOTREV: total tax revenue, in current prices,

TR_MP: the market power of the warehouse in international trade,

TRANSH_0: other net public sector transfers to the household sector, in current prices,

TRANSH: public sector transfers to the household sector, in current prices, TRANSR: public sector transfers to the rest of the world, in current prices,

UB: the unemployment benefits, in current prices,

USERIP: the user cost of capital of the enterprise sector,

USERIR: the user cost of residential buildings,

UR: the unemployment rate,

UX: cost push inflation for good X,

WBGO: the wage bill of the public sector, in constant prices,

WBGU: the wage bill of the public sector, in current prices,

WBO: the total wage bill, in constant prices,

WBPO: the wage bill of the private sector, in constant prices,

WBPU: the wage bill of the private sector, in current prices,

WBU: the total wage bill, in current prices,

WC: the benefits accruing to children,

WO: the benefits accruing to pensioners,

WRG: the nominal wage in the public sector,

WRP: the nominal wage in the private sector,

WS: the services generated by residential buildings,

XTO: exports, in constant prices,

XTU: exports, in current prices,

YCP: the productivity of the enterprise sector capital stock,

YMP: the productivity of intermediary imports,

YNP: the productivity of labour,

Z: the bequest of the household sector, in constant prices,

gig_rh: the rate of depreciation of the public sector's capital stock,

gip_rh: the rate of depreciation of the enterprise sector's capital stock,

gir_rh: the rate of depreciation of the stock of residential buildings,

inh_rh: the rate of depreciation of inventories.

IX Appendix B: The Price Dynamics

In this appendix, we specify short run price setting in the NIME model.

A. The assumptions

The following assumptions are at the core of the specification of the dynamic price equation [1].

In each block of the model, there is one enterprise sector, producing one composite good for each final user. Price adjustment is sluggish because of menu costs, and because of "rule of thumb" behaviour. Let PX be the price of good X [2].

First, because of menu costs, the producer adjusts the price of only a fraction of the composite good. In other words, px_sl percent of the price of the composite good is kept at its old price, while the rest of the price is reset, i.e.:

(B.1) $\ln(PX_t) = px\_sl \ln(PX_{t-1}) + (1-px\_sl) \ln(PXL_t)$,

with:

PX_t : the price of goods supplied by private sector in period *t*,
PXL_t : the "reset price" of goods supplied by private sector in period *t*,

and with: $0 \le px\_sl \le 1$.

Second, the "reset price", PXL, is calculated partly "rationally", and partly by "rule of thumb". Setting the price to its "rational" value, PXR, requires a lot of accounting work on behalf of the producer. The producer could expect that the cost of such an exercise would outweigh the expected benefit, and he could therefore decide to do this exercise for only (1-px_sw) percent of the composite good for which he wants to change the price. For the other fraction of the good, the producer follows a simple rule, setting the new price equal to the old price adjusted for cost push inflation that can be observed at negligible cost.

1. See Galí and Gertler (1999) for a similar modelling strategy.
2. PX may refer to the price of export goods, PXT, capital goods, PCIP and PCIR, consumption goods, PCH, etc...

Formally speaking, we postulate the following:

$$\text{(B.2)} \qquad \ln(PXL_t) = (1\text{-}px\_sw)\ln(PXR_t) + px\_sw\ln(PXB_t)\ ,$$

with:

PXR_t : the price set by "rational" rule,
PXB_t : the price set by backward looking "rule of thumb",

and with: $0 \le px\_sw \le 1$.

We will now specify the "rational" reset price and the "rule of thumb" reset price.

B. The "rational" reset price, PXR

The "rational" reset price, PXR, is specified for the different final users in equations (III.8), (III.12), (III.23.a), and (III.23.b) of Chapter III.

C. The "rule of thumb" reset price, PXB

In this section we will derive the "rule of thumb" reset price, PXB. Here, we make a distinction between the prices of private capital, intermediary imports, and exports, on the one hand, and the price of consumption goods on the other hand. We start with the consumption goods.

1. The "rule of thumb" reset prices for CGGS, CIR, CIG [1]

a. Unit factor costs and prices for final users

In equation (A.8.a) of Appendix A, in Meyermans and Van Brusselen (2000.b), we derived the unit cost function for private supply for final demand which corresponds to the Cobb-Douglas production function (III.1), as:

$$\text{(A.8.a)} \qquad \ln(PASP_t) = constant - \ln(1\text{-}NITR_t) + asp\_l1\ln(WRP_t) + asp\_l2\ln(USERIP_t) + asp\_l3\ln(PMP_t)\ ,$$

with:

$$\text{(A.8.b)} \qquad constant = -\left[\ln(asp\_l0) + asp\_l1\ln(asp\_l1) + asp\_l2\ln(asp\_l2) + asp\_l3\ln(asp\_l3)\right]\ .$$

1. The price of private consumption, PCH, will be discussed in section D.2.

However, in equation (C.12) of Appendix C, in Meyermans and Van Brusselen (2000.b), we derived also that:

$$\text{(C.12)} \quad asp\_l1 \ln(YNP) + asp\_l2 \ln(YCP) + asp\_l3 \ln(YMP) = \ln(asp\_l0) ,$$

i.e., a constraint between factor productivity and total factor productivity under constant returns to scale.

Inserting equations (C.12) and (A.8.b) into equation (A.8.a) allows us to rewrite the unit cost function as:

$$\begin{aligned} \ln(PASP_t) = &- [asp\_l1 \ln(asp\_l1) + asp\_l2 \ln(asp\_l2) + asp\_l3 \ln(asp\_l3)] \\ &- \ln(1\text{-}NITR_t) + asp\_l1 \ln(WRP_t / YNP_t) \\ &+ asp\_l2 \ln(USERIP_t / YCP_t) + asp\_l3 \ln(PMP_t / YMP_t) , \end{aligned}$$

The latter expression shows explicitly how the unit factor costs affect the output price.

The relationship between the producer price and the price paid by the final users is described in equation (III.23.a) of the main text. Inserting the previous equation for PASP into equation (III.23.a) yields:

$$\begin{aligned} \text{(B.3)} \quad \ln(PX_t) = px\_l1 \{ &- [asp\_l1 \ln(asp\_l1) + asp\_l2 \ln(asp\_l2) \\ &+ asp\_l3 \ln(asp\_l3)] - \ln(1\text{-}NITR_t) + asp\_l1 \ln(WRP_t / YNP_t) \\ &+ asp\_l2 \ln(USERIP_t / YCP_t) + asp\_l3 \ln(PMP_t / YMP_t) \} + px\_l0 , \end{aligned}$$

for X = CGGS, CIR, CIG.

Equation (B.3) determines the price for final users as a function of indirect taxes, and the unit factor cost of labour, capital and intermediary imports.

b. Simplified cost accounting

If one wants to calculate the price of total supply for final demand, one has to calculate all the cost components listed on the right hand side of equation (B.3). However, it takes an effort to calculate the exact value of each of these cost components, and the supplier may expect that this effort may outweigh the expected benefit. The supplier expects that this will be the case for px_sw percent of the prices he will revise. For these prices, he makes his cost accounting based on the following simplifying rules.

First, taking finite differences of the previous equation, and evaluating the cost components for the values as they are known at period *t* at negligible cost, we get that the price at *t* is equal to:

$$(B.4)\quad \ln(PXB_t) = \ln(PX_{t-1}) - \Delta \ln(1\text{-}E\_NITR_t) + asp\_l1\ \Delta \ln(E\_WRP_t / E\_YNP_t) + asp\_l2\ \Delta \ln(E\_USERIP_t / E\_YCP_t) + asp\_l3\ \Delta \ln(E\_PMP_t / E\_YMP_t)\ ,$$

with the label E_X_t indicating the expected value of variable X_t such as it is known at negligible cost at period *t*.

Second, the following assumptions regarding the observation of the different cost components listed in equation (B.4) are made.

The contemporaneous indirect tax, NITR, and the contemporaneous import prices, PMP, are observable at negligible cost, i.e.:

$$(B.5.a)\quad E\_NITR_t = NITR_t\ ,$$

$$(B.5.b)\quad E\_PMP_t = PMP_t\ .$$

The expected change in the unit labour cost and in the unit capital cost are assumed to be equal to the lagged change in the pre-tax price, i.e.:

$$(B.5.c)\quad \Delta \ln(E\_WRP_t / E\_YNP_t) = \Delta \ln(E\_USERIP_t / E\_YCP_t) = \Delta \ln[PX_{t-1}\ (1\text{-}NITR_{t-1})]\ .$$

The expected change in contemporaneous productivity of intermediary imports is equal to lagged trend productivity, i.e.:

$$(B.5.d)\quad \Delta \ln(E\_YMP_t) = \Delta \ln(HP\_YMP_{t-1})\ .$$

Third, inserting equations (B.5.a) to (B.5.d) into equation (B.3), yields:

$$(B.6)\quad \ln(PXB_t) = \ln(PX_{t-1}) - \Delta \ln(1\text{-}NITR_t) + (asp\_l1+asp\_l2)\ \Delta \ln[PX_{t-1}\ (1\text{-}NITR_{t-1})] + asp\_l3\ \Delta \ln(PMP_t / HP\_YMP_{t-1})\ ,$$

for X = CGGS, CIR, CIG.

Equation (B.6) states that for CGGS, CIR, and CIG, the "rule of thumb" reset price, PXB, is equal to the lagged price plus the change in indirect taxes, plus the weighted average of the change in the lagged price, and the change in contemporaneous import price.

For notational convenience, we now define:

(B.7.a) $$\Delta \ln(UX_t) = \Delta \ln(1\text{-}NITR_t) + (asp\_l1+asp\_l2)\ \Delta \ln(PX_{t-1}\ (1\text{-}NITR_{t-1})) + asp\_l3\ \Delta \ln(PMP_t / HP\_YMP_{t-1}),$$

for X = CGGS, CIR, CIG,

so that equation (B.6) can be rewritten as:

(B.7.b) $$\ln(PXB_t) = \ln(PX_{t-1}) + \Delta \ln(UX_t),$$

for X = CGGS, CIR, CIG.

2. The "rule of thumb" reset prices for CIP, MP, XT

For capital goods, imports, and exports we assume that the "rule of thumb" reset price is an extrapolation from past price developments, i.e.:

(B.7.c) $$\ln(PXB_t) = \ln(PX_{t-1}) + \Delta \ln(UX_t),$$

with:

(B.7.d) $$\Delta \ln(UX_t) = \Delta \ln(PX_{t-1}),$$

for X = CIP, MP, XT.

D. An adjustment scheme

In this section we specify the short run price setting equation, based on the equations derived in the previous sections.

1. The general case

Inserting equation (B.2) into equation (B.1) yields:

$$\text{(B.8)}\quad \ln(PX_t) = px\_sl \ln(PX_{t-1}) + (1\text{-}px\_sl)\,[(1\text{-}px\_sw) \ln(PXR_t) + px\_sw \ln(PXB_t)]\ .$$

Inserting equation (B.7.b) into equation (B.8) yields:

$$\text{(B.9)}\quad \ln(PX_t) = px\_sl \ln(PX_{t-1}) + (1\text{-}px\_sl)\,\{ (1\text{-}px\_sw) \ln(PXR_t) + px\_sw \ln(PX_{t-1}) + px\_sw\,[\ln(UX_t) - \ln(UX_{t-1})] \}\ .$$

Subtracting $\ln(PX_{t-1})$ from both sides and rearranging terms yields:

$$\text{(B.10)}\quad \ln(PX_t) - \ln(PX_{t-1}) = (px\_sl\text{-}1)\,[\ln(PX_{t-1}) - \ln(PXR_{t-1})] + (1\text{-}px\_sl)\,[\ln(PXR_t) - \ln(PXR_{t-1})] - (1\text{-}px\_sl)\, px\_sw\,[\ln(PXR_t) - \ln(PX_{t-1})] + (1\text{-}px\_sl)\, px\_sw\,[\ln(UX_t) - \ln(UX_{t-1})]\ ,$$

with UX defined in equation (B.7.a) for X = CGGS, CIR, CIG, and in equation (B.7.d) for X = CIP, MP, XT.

Equation (B.10) explains the change in PX by an error correction term, a term measuring the contemporaneous change in marginal costs (i.e. the rational reset price), a partial adjustment term, and lagged cost push inflation.

Equation (B.10) can be rewritten as:

$$\ln(PX_t) - \ln(PX_{t-1}) = (px\_sl\text{-}1)\,[\ln(PX_{t-1}) - \ln(PXR_t)] + (1\text{-}px\_sl)\, px\_sw\,[\ln(PX_{t-1}) - \ln(PXR_t)] + (1\text{-}px\_sl)\, px\_sw\,[\ln(UX_t) - \ln(UX_{t-1})]\ ,$$

so that, on collecting terms, we find:

(B.11) $\ln(PX_t) - \ln(PX_{t-1}) = (1\text{-px\_sl})\,(\text{px\_sw-1})\,[\ln(PX_{t-1}) - \ln(PXR_t)]$
$+ (1\text{-px\_sl})\,\text{px\_sw}[\ln(UX_t) - \ln(UX_{t-1})]$,

for X = CH, CGGS, CIR, CIG, CIP, MP, XT.

Note that: $-1 \le (\text{px\_sl} - 1) \le 0$, and $0 \le (1 - \text{px\_sl})\text{px\_sw}, (1 - \text{px\_sl}) \le 1$.

As indicated earlier, for most goods the rational reset prices are defined elsewhere (see equations (III.8), (III.12), (III.23.a), and (III.23.b) of the main text). However, so far we do not have an equation for the rational reset price of private consumption, PCHR. We will deal with this issue in the following subsection, starting from the assumption that the price of private consumption clears the goods market.

2. The consumer price

In order to make equation (B.11) for PCH operational for empirical application, we have to give empirical contents to the unobserved term:

$$\ln(PCH_{t-1}) - \ln(PCHR_t) ,$$

which can be rewritten as:

(B.12) $$\ln(PCH_{t-1}) - \ln(PCHR_t) = [\ln(PCH_{t-1}) - \ln(PCHR_{t-1})] - [\ln(PCHR_t) - \ln(PCHR_{t-1})] .$$

We will now make the following assumptions regarding the right hand side variables of equation (B.12). First, if PCH is below its equilibrium level, PCHR, then contemporaneous demand is above steady state supply, and vice versa.

Formally speaking [1]:

(B.13) $$[\ln(PCH_{t-1}) - \ln(PCHR_{t-1})] = \text{pch\_s1}\,[\ln(ASPO_{t-1}) - \ln(HP\_ASPO_{t-1})] ,$$

with $\text{pch\_s1} < 0$.

Second, we also assume that the reset price, PCHR, changes in line with secular inflation, i.e.:

(B.14) $$[\ln(PCHR_t) - \ln(PCHR_{t-1})] = G\_PCH_t .$$

1. Remember that in the short run supply is determined by demand.

Inserting (B.13) and (B.14) into (B.12), yields:

$$\ln(PCH_{t-1}) - \ln(PCHR_t) = pch\_s1\ [\ln(ASPO_{t-1}) - \ln(HP\_ASPO_{t-1})] - G\_PCH_t\ .$$

Inserting the latter into equation (B.11) yields for PCH:

(B.15.a) $\ln(PCH_t) - \ln(PCH_{t-1}) =$

$(1-pch\_sl)\ (pch\_sw-1)\ pch\_s1\ [\ln(ASPO_{t-1}) - \ln(HP\_ASPO_{t-1})]$

$-\ (1-pch\_sl)\ (pch\_sw-1)\ G\_PCH_t$

$+\ (1-pch\_sl)\ pch\_sw\ [\ln(UCH_t) - \ln(UCH_{t-1})]\ ,$

with UCH defined as:

(B.15.b) $\Delta\ \ln(UCH_t) = \Delta\ \ln(1-NITR_t) + (asp\_l1+asp\_l2)\ \Delta\ \ln(PCH_{t-1}\ (1-NITR_{t-1}))$

$+\ asp\_l3\ \Delta\ \ln(PMP_t\ /\ HP\_YMP_{t-1})\ ,$

Equation (B.15) explains inflation by the output gap, secular inflation, and cost push inflation.

E. Estimation results for PCGGS, PCIG, PCIR, PXT

In this section we show estimation results for PCGGS, PCIG, PCIR, and PXT. Estimation results for PCIP, PMP, and PCH are shown in Section III of the main text.

TABLE B.1 - The government consumption price, PCGGS

	EU	NE	US	JP
pcggs_sl	0.00	0.01	0.02	0.09
	-.-	(0.04)	(0.02)	(0.11)
pcggs_sw	0.41	0.26	0.80	0.40
	(0.09)	(0.11)	(0.09)	(0.07)
ECM[-1]	-1.00	-0.99	-0.98	-0.91
Partial adjustment term	0.41	0.26	0.78	0.37
Diagnostic statistics				
Adjusted R	0.93	0.93	0.95	0.96
Durbin h	1.28	1.58	0.37	1.86

TABLE B.2 - The price of public investments, PCIG

	EU	NE	US	JP
pcig_sl	0.17	0.06	0.09	0.00
	(0.08)	(0.05)	(0.08)	-.-
pcig_sw	0.73	0.66	0.91	0.03
	(0.09)	(0.09)	(0.09)	(0.07)
ECM[-1]	-0.83	-0.94	-0.91	-1.00
Partial adjustment term	0.61	0.62	0.82	0.03
Diagnostic statistics				
Adjusted R	0.79	0.92	0.83	0.93
Durbin h	0.60	1.62	0.20	1.11

TABLE B.3 - The price of residential buildings, PCIR

	EU	NE	US	JP
pcir_sl	0.10	0.07	0.02	0.19
	(0.08)	(0.07)	(0.04)	(0.08)
pcir_sw	0.82	0.80	0.79	0.12
	(0.08)	(0.07)	(0.07)	(0.13)
ECM[-1]	0.90	0.93	0.98	-0.81
Partial adjustment term	0.73	0.74	0.77	0.09
Diagnostic statistics				
Adjusted R	0.74	0.77	0.89	0.83
Durbin h	-0.41	1.10	0.81	0.77

TABLE B.4 - The price of exports, PXT

	EU	NE	US	JP
pxt_sl	0.20	0.18	0.36	0.63
	(0.08)	(0.08)	(0.10)	(0.11)
pxt_sw	0.96	0.74	0.67	0.07
	(0.05)	(0.11)	(0.11)	(0.29)
ECM[-1]	-0.80	-0.82	-0.64	-0.37
Partial adjustment term	0.77	0.60	0.43	0.03
Diagnostic statistics				
Adjusted R	0.74	0.76	0.79	0.83
Durbin h	-0.34	0.27	1.04	1.71

X Appendix C: An Equation for the Long Run Interest Rate

In this appendix, we derive an equation for the long run interest rate, based on the term structure of interest rates, and an expectation scheme for the interest rates.

A. The term structure of interest rates

We postulate that the term structure of interest rates relates the long run interest rate, LI, to the expected path of short run interest rates, SI, according to:

$$\text{(C.1)} \qquad LI_t = li\_0 + \sum_{i=0}^{n-1} \frac{li\_b^{i+1}}{n} E(SI_{t+i}) ,$$

with: $0 < li\_b \leq 1$.

Absence of risk is defined as the case where:

$$\text{(C.2)} \qquad li\_b = 1 \text{ , and } li\_0 = 0 ,$$

so that equation (C.1) can be written as:

$$\text{(C.3)} \qquad LI_t = \sum_{i=0}^{n-1} \frac{E(SI_{t+i})}{n} .$$

Before we can use equation (C.1), we need an assumption regarding the formation of expectations of the interest rates.

B. The expectations

The long run interest rate, LI, is expected to converge gradually to its steady state value, HP_LI, according to the following scheme:

$$\text{(C.4)} \qquad E(LI_{t+1}) - LI_t = \frac{li\_ll}{n} [HP\_LI_t - LI_t] ,$$

with $0 < \frac{li\_ll}{n} < 1$.

However, note that equation (C.1) holds also for period *t+1*, so that:

(C.5) $$E(LI_{t+1}) = li\_0 + \sum_{i=0}^{n-1} \frac{li\_b^{i+1}}{n} E(SI_{t+1+i}) .$$

Subtracting $\frac{1}{li\_b}$ times equation (C.1) from equation (C.5) yields:

(C.6) $$E(LI_{t+1}) - \frac{1}{li\_b} LI_t = (1- \frac{1}{li\_b}) li\_0 + \frac{li\_b^{n-1}}{n} E(SI_{t+n}) - \frac{1}{n} SI_t .$$

We now assume that in the steady state - i.e. after n periods, - it is expected that [1]:

(C.7) $$SI_{t+n} = LI_{t+n} = HP\_LI.$$

Inserting equation (C.7) into equation (C.6), yields:

(C.8) $$E(LI_{t+1}) - \frac{1}{li\_b} LI_t = (1- \frac{1}{li\_b}) li\_0 + \frac{li\_b^{n-1}}{n} HP\_LI_t - \frac{1}{n} SI_t .$$

It should also be noted that we can rewrite equation (C.4) as:

(C.9) $$E(LI_{t+1}) - \frac{1}{li\_b} LI_t = \frac{li\_ll}{n} [HP\_LI_t - LI_t] + \frac{li\_b -1}{li\_b} LI_t .$$

Finally, since the left hand sides of equations (C.8) and (C.9) are the same, it follows that:

$$\frac{li\_b -1}{li\_b} li\_0 + \frac{li\_b^{n-1}}{n} HP\_LI_t - \frac{1}{n} SI_t$$
$$= \frac{li\_ll}{n} HP\_LI + \frac{-li\_ll\ li\_b + (li\_b -1)n}{li\_b\ n} LI_t ,$$

1. Note that this implies that we assume that there is no risk premium in the steady state, so that equation (C.1) can be written as $LI_t = \sum_{i=0}^{n-1} \frac{E(SI_{t+i})}{n}$.
The steady state is defined as ... = $SI_{t-1} = SI_t = SI_{t+1}$ = ..., so that in the steady state SI = LI .

Solving for LI_t , we find:

$$LI_t = \frac{(1 - li\_b)\, n}{li\_ll\ \ li\_b - (li\_b - 1) n}\ li\_0 + \frac{li\_b}{li\_ll\ \ li\_b - (li\_b - 1)\, n}\ SI_t$$

$$+ \frac{(li\_ll - li\_b^{n-1})\, li\_b}{li\_ll\ \ li\_b - (li\_b - 1)\, n}\ HP\_LI_t ,$$

or,

(C.10.a) $LI_t = li\_l0 + li\_l1\ SI_t + li\_l2\ HP\_LI_t$,

with:

(C.10.b) $li\_l0 = \frac{(1 - li\_b)\, n}{li\_ll\ \ li\_b - (li\_b - 1) n}\ li\_0$,

(C.10.c) $li\_l1 = \frac{li\_b}{li\_ll\ \ li\_b - (li\_b - 1)\, n}$,

(C.10.d) $li\_l2 = \frac{(li\_ll - li\_b^{n-1})\, li\_b}{li\_ll\ \ li\_b - (li\_b - 1)\, n}$.

Equation (C.10) states that the contemporaneous long run interest rate is equal to a constant, the contemporaneous short run interest rate, and the steady state interest rate.

Note that if li_0 = 0 and li_b = 1, i.e., the case of no risk premium (cfr. equation (C.2)), then equation (C.10) can be rewritten as:

$$LI_t = \frac{1}{li\_ll}\ SI_t + \frac{li\_ll - 1}{li\_ll}\ HP\_LI_t ,$$

with: $\frac{1}{li\_ll} + \frac{li\_ll - 1}{li\_ll} = 1$,

or:

(C.11.a) $LI_t = li\_l1\ SI_t + (1 - li\_l1)\ HP\_LI_t$,

with:

(C.11.b) $li\_l1 = \frac{1}{li\_ll}$.

Equation (C.11) states that the contemporaneous long run interest rate is a weighted average of the spot interest rate and the steady state interest rate.

XI Appendix D: The Equilibrium Exchange Rate

In this appendix, we derive the equilibrium effective exchange rate. The equilibrium effective exchange rate is the effective exchange rate that stabilizes the foreign debt to GDP ratio. First, we define some variables. Next, we derive the equilibrium effective exchange rate. Finally, we show how the bilateral exchange rates can be derived from the effective exchange rates.

A. Definition of variables and arbitrage conditions

Here we make use of the notation XX_Y to indicate variable Y of block XX.

First, the effective exchange rate of a block, XX_EFEX, is calculated as:

$$\text{(D.1)} \qquad XX\_EFEX = \prod_{YY=BE,EU,NE,US,JP,RW} EX\_XX\_YY^{xx\_w\_xtyy}$$

with:

XX_EFEX: the effective exchange rate of block XX, number of units of the currency of block XX per unit of the effective foreign currency,
EX_XX_YY: the bilateral exchange rate, number of units of the currency of block XX per unit of the currency of block YY,
xx_w_xtyy: the weight of block yy in the total trade of block xx.

with the weights satisfying the following conditions:

$$\text{(D.2.a)} \qquad xx\_w\_xtxx = 0 \,,$$

$$\text{(D.2.b)} \qquad \sum_{yy=\text{ eu, ne, us, jp, be, rw}} xx\_w\_xtyy = 1 \,,$$

and

$$\text{(D.2.c)} \qquad xx\_w\_xtyy \geq 0 \,.$$

In a similar way, we define the effective foreign price level, XX_EFPASP:

(D.3.a) $$XX\_EFPASP = \prod_{YY=BE,EU,NE,US,JP,RW} YY\_PASP^{xx\_w\_xtyy} ,$$

the effective short run interest rate, XX_EFSI:

(D.3.b) $$XX\_EFSI = \prod_{YY=BE,EU,NE,US,JP,RW} YY\_SI^{xx\_w\_xtyy} ,$$

and the effective long run interest rate, XX_EFLI:

(D.3.c) $$XX\_EFLI = \prod_{YY=BE,EU,NE,US,JP,RW} YY\_LI^{xx\_w\_xtyy} .$$

Second, assuming zero arbitrage costs, triangular arbitrage implies that:

(D.4) $$EX\_XX\_YY = \frac{EX\_XX\_EU}{EX\_YY\_EU} .$$

Note also that:

(D.5) $$EX\_XX\_XX = 1 .$$

These variables can be defined for each block. For notational convenience, we will drop in the following section the block label XX, and conduct the analysis for a single block. Mutatis mutandis, the derived results hold for all blocks.

B. The current account and the stock of foreign debt

In equilibrium, the stock of foreign debt to GDP ratio stabilizes at a predetermined ratio, f_l0, i.e.:

(D.6) $$\frac{FBOND_t}{GDPU_t} = f\_l0 ,$$

with:

FBOND: the stock of foreign assets, in local currency,
GDPU: gross domestic product, in current prices, in local currency.

In growth rates, equation (D.6) can be written as:

(D.7) $$\Delta \ln(FBOND_t) = \Delta \ln(f\_l0) + \Delta \ln(GDPU_t) .$$

The left hand side variable of equation (D.7) can be approximated as:

$$\text{(D.8)} \qquad \Delta \ \ln \text{FBOND}_t = \frac{FBOND_t - FBOND_{t-1}}{FBOND_{t-1}} = \frac{CA_t}{FBOND_{t-1}} \ ,$$

where CA is the current account measured in local currency, and where use has been made of the fact that:

$$\text{CA}_t = \text{FBOND}_t - \text{FBOND}_{t-1} \ ,$$

i.e., the net inflow (outflow) of assets is equal to the current account surplus (deficit).

Using equation (D.8), equation (D.7) can be rewritten as:

$$\text{(D.9)} \qquad \text{CA}_t = \text{FBOND}_{t-1} \ [\ \Delta \ \ln(\text{GDPU}_t) + \Delta \ \ln(\text{f\_l0})\ ] \ .$$

By definition, the current account reads as:

$$\text{(D.10)} \qquad \text{CA}_t = \text{XTO}_t \ \text{PXT}_t - \text{MTO}_t \ \text{PMT}_t + (\text{NFIROW}_t + \text{NCTROW}_t)$$

with:

NFIROW: net factor income from the rest of the world, in local currency,
NCTROW: net current transfers from the rest of the world, in local currency.

Inserting equation (D.10) into equation (D.9) yields:

$$\text{FBOND}_{t-1} \ [\ \Delta \ \ln(\text{GDPU}_t) + \Delta \ \ln(\text{f\_l0})\ ]$$
$$= \text{XTO}_t \ \text{PXT}_t - \text{MTO}_t \ \text{PMT}_t + (\text{NFIROW}_t + \text{NCTROW}_t)$$

or

$$\text{(D.11)} \qquad \text{XTO}_t \ \text{PXT}_t - \text{MTO}_t \ \text{PMT}_t + \text{ROW}_t \ \text{PASP}_t \ (1-\text{NITR}_t) = 0 \ ,$$

with:

$$\text{(D.12)} \ \text{ROW}_t = \frac{NFIROW_t + NCTROW_t - FBOND_{t-1}[\Delta\ln(GDPU_t) + \Delta\ln(\text{f\_l0})]}{(1 - NITR_t)PASP_t} \ .$$

In the steady state, the imports of a particular block are determined as [1]:

(D.13) $PMT_t \; MTO_t = asp\_l3 \; ASPO_t \; PASP_t \; (1\text{-}NITR_t)$.

The exports of the home block are the consolidated imports of the other blocks, i.e.:

(D.14.a) $XTO_t = EFMTO_t \; EFEX_{1990}$,

with:

XTO: exports of the home block, in constant prices and measured in the currency of the home country,
EFMTO: consolidated imports of the countries other than the home country, in constant prices and measured in the foreign currency,
EFEX: a numerate, the exchange rate in the base year 1990.

The other blocks have a similar production technology as the home block. In other words, their demand for imports is related to total production and the price of imports deflated by the price of total supply:

(D.14.b) $EFPMT_t \; EFMTO_t = efasp\_l3 \; EFASPO_t \; EFPASP_t \; (1\text{-}EFNITR_t)$,

with:

EFASPO: the effective foreign supply,
EFPASP: the effective foreign price level, denominated in foreign currency,
EFPMT: the effective price of imports of the countries other than the home country, denominated in foreign currency,
EFNITR: the effective foreign net indirect tax rate,

and where:

(D.14.c) $EFPMT_t \; EFEX_t = PXT_t$.

Combining equations (D.14.a), (D.14.b), and (D.14.c), we get that:

(D.15)
$$
\begin{aligned}
PXT_t \; XTO_t &= PXT_t \; EFMTO_t \; EFEX_{1990} \\
&= EFEX_{1990} \; EFEX_t \; [EFPMT_t \; EFMTO_t \,] \\
&= EFEX_{1990} \; EFEX_t \; efasp\_l3 \; EFASPO_t \; EFPASP_t \; (1\text{-}EFNITR_t) \; .
\end{aligned}
$$

1. See equation (III.6) of Chapter III.

C. The equilibrium exchange rate

1. EFEX

Inserting equations (D.13) and (D.15) into equation (D.11), yields:

$$\text{efasp\_l3 } EFASPO_t\ EFEX_{1990}\ EFEX_t\ EFPASP_t\ (1\text{-}EFNITR_t) - \text{asp\_l3 } ASPO_t\ PASP_t\ (1\text{-}NITR_t) + ROW_t\ PASP_t\ (1\text{-}NITR_t) = 0$$

which solves for the effective exchange rate, EFEX, as:

$$\text{(D.16.a)}\quad EFEX = \frac{PASP}{EFPASP}\ EFREX\ ,$$

with the real exchange rate, EFREX, defined as:

$$\text{(D.16.b)}\quad EFREX = \frac{(1\text{-}NITR)}{(1\text{-}EFNITR)} * \left(\frac{asp\_l3\ \ ASPO}{efasp\_l3\ \ EFASPO\ \ EFEX_{1990}} - \frac{ROW}{efasp\_l3\ \ EFASPO\ \ EFEX_{1990}}\right).$$

2. ROW

Finally, note the importance of the variable ROW in equation (D.16.b). ROW is defined in equation (D.12) as:

$$ROW_t = \frac{NFIROW_t + NCTROW_t - FBOND_{t-1}[\Delta\ln(GDPU_t) + \Delta\ln(f\_l0)]}{(1 - NITR_t)PASP_t}\ ,$$

assuring that the equilibrium exchange rate is such that it will stabilize the stock of foreign assets to GDP ratio.

If we define ROW as:

$$\text{(D.17.a)}\quad ROW_t = (NFIROW_t + NCTROW_t)\ /\ [PASP_t\ (1\text{-}NITR_t)]\ ,$$

then the real exchange rate will equilibrate the current account.

If we define ROW as:

$$\text{(D.17.b)}\quad ROW_t = 0\ ,$$

then the real exchange rate will equilibrate the trade balance.

D. The bilateral exchange rates

We are not only interested in the effective exchange rates, but also in the bilateral exchange rates. The bilateral exchange rates are calculated as follows.

Using the arbitrage condition (D.4), we can rewrite equation (D.1) as:

$$(D.18) \quad XX\_EFEX = (EX\_XX\_EU)**xx\_w\_xteu * \left(\frac{EX\_XX\_EU}{EX\_NE\_EU}\right)**xx\_w\_xtne * \left(\frac{EX\_XX\_EU}{EX\_US\_EU}\right)**xx\_w\_xtus * \left(\frac{EX\_XX\_EU}{EX\_JP\_EU}\right)**xx\_w\_xtjp * \left(\frac{EX\_XX\_EU}{EX\_BE\_EU}\right)**xx\_w\_xtbe * \left(\frac{EX\_XX\_EU}{EX\_RW\_EU}\right)**xx\_w\_xtrw .$$

In view of condition (D.2.b), we can rewrite equation (D.18) as:

(D.19) XX_EFEX = EX_XX_EU * EX_NE_EU**(-xx_w_xtne)
* EX_US_EU**(-xx_w_xtus) * EX_JP_EU**(-xx_w_xtjp)
* EX_BE_EU**(-xx_w_xtbe) * EX_RW_EU**(-xx_w_xtrw) .

Hence, we find that the bilateral exchange rate, EU_NE_EU, is determined as [1]:

(D.20.a) EX_NE_EU = NE_EFEX (EX_US_EU**ne_w_xtus
* EX_JP_EU**ne_w_xtjp * EX_BE_EU**ne_w_xtbe
* EX_RW_EU**ne_w_xtrw) ,

where use has been made of condition (D.2.a).

In a similar way we derive the bilateral exchange rates for US and JP, as:

(D.20.b) EX_US_EU = US_EFEX (EX_NE_EU**us_w_xtne
* EX_JP_EU**us_w_xtjp * EX_BE_EU**us_w_xtbe
* EX_RW_EU**us_w_xtrw) ,

and,

(D.20.c) EX_JP_EU = JP_EFEX (EX_NE_EU**jp_w_xtne
* EX_US_EU**jp_w_xtus * EX_BE_EU**jp_w_xtbe
* EX_RW_EU**jp_w_xtrw) .

Finally, it should be noted that for XX = EU and xx = eu, we find:

1. I.e., for XX = NE and xx = ne.

(D.21) EU_EFEX = EX_EU_EU * EX_NE_EU**(-eu_w_xtne)
* EX_US_EU**(-eu_w_xtus) * EX_JP_EU**(-eu_w_xtjp)
* EX_BE_EU**(-eu_w_xtbe) * EX_RW_EU**(-eu_w_xtrw) .

Condition (D.21) must be met at all times. However, by definition we have that EX_EU_EU = 1, while EU_EFEX is determined by the NIME model. This leaves the possibility that either EX_BE_EU or EX_RW_EU adjusts so that condition (D.21) holds.

Assuming that EX_BE_EU is fixed either by EMS or EMU, we solve condition (D.21) for EX_RW_EU as:

(D.22) EX_RW_EU = EX_NE_EU**(-eu_w_xtne / eu_w_xtrw)
* EX_US_EU**(-eu_w_xtus / eu_w_xtrw)
* EX_JP_EU**(-eu_w_xtjp / eu_w_xtrw)
* EX_BE_EU**(-eu_w_xtbe / eu_w_xtrw)] * EU_EFEX**(-1 / eu_w_xtrw) .

XII Appendix E: Direct Labour Income Taxes and the Debt to GDP Ratio

We assume that the public sector targets a debt to GDP ratio in the long run. We also assume that it is direct labour income taxes that adjust to reach this target. In this appendix, we derive how the direct labour income tax rate has to be set in order to reach the target debt to GDP ratio in the long run.

A. Deficits and debt

In the steady state, the direct labour income tax rate, DHTR, is set such that:

(E.1) $$\frac{GBOND_t}{GDPU_t} = \mathrm{R\_GBOND}\ ,$$

with:

GBOND: the stock of public debt, in current prices,
GDPU: gross domestic product, in current prices,
R_GBOND: the target debt to GDP ratio.

Bonds are accumulated according to:

(E.2) $$\Delta\ \mathrm{GBOND}_t = \mathrm{NLG}_t\ ,$$

where NLG, net lending by the public sector in current prices, is equal to:

(E.3) $$\mathrm{NLG}_t = (\mathrm{CGX}_t + \mathrm{CGINT}_t) - \mathrm{TOTREV}_t\ ,$$

with:

CGX: public expenditures, excluding interest payments,
CGINT: interest payments on public debt,
TOTREV: total revenue of public sector.

Furthermore:

(E.4.a) $CGINT_t = LIG_{t-1} \, GBOND_{t-1}$,

(E.4.b) $TOTREV_t = DTH_t + DTCP_t + ITP_t + SSRH_t + OT_t$,

(E.4.c) $CGX_t = TRANS_t + WBGU_t + CGGSU_t + IGU_t$,

with:

CGGSU: public sector consumption of goods of services, exclusive the wage bill, in current prices,
DTH: direct revenue from labour income, in current prices,
DTCP: direct tax revenue from income on capital, in current prices,
IGU: total net capital transactions of the public sector,
ITP: indirect tax revenue, in current prices,
LIG: interest rate on public debt,
OT: net other tax revenue, in current prices,
SSRH: social security contributions, in current prices,
TRANS: transfers by the public sector, in current prices,
WBGU: wage bill of the public sector, in current prices.

B. Stability of the debt to GDP ratio

Inserting equations (E.2) and (E.4.a) into equation (E.3), yields:

(E.5) $\Delta\ GBOND_t = CGX_t - TOTREV_t + LIG_{t-1} \, GBOND_{t-1}$.

Dividing both sides of equation (E.5) by nominal GDP, GDPU, yields:

(E.6)
$$\frac{\Delta GBOND_t}{GDPU_t} = \frac{CGX_t}{GDPU_t} - \frac{TOTREV_t}{GDPU_t} + \frac{LIG_{t-1} GBOND_{t-1}}{GDPU_t} .$$

The left hand side of equation (E.6) can be approximated as [1]:

(E.7)
$$\frac{\Delta GBOND_t}{GDPU_t} = \Delta\left(\frac{GBOND_t}{GDPU_t}\right) + \frac{GBOND_t}{GDPU_t}\left(\frac{\Delta GDPU_t}{GDPU_t}\right) .$$

1. It should be noted that in infinite differences:
$d\,(GBOND / GDPU) = d\,GBOND / GDPU - (GBOND / GDPU)\,(d\,GDPU / GDPU)$.

Combining equations (E.6) and (E.7), we get:

(E.8)
$$\Delta\left(\frac{GBOND_t}{GDPU_t}\right) = \frac{CGX_t}{GDPU_t} - \frac{TOTREV_t}{GDPU_t} + \frac{LIG_{t-1}GBOND_{t-1}}{GDPU_t} - \frac{GBOND_t}{GDPU_t}\left(\frac{\Delta GDPU_t}{GDPU_t}\right).$$

Equation (E.8) describes how the debt to GDP ratio will change over time as a function of the structural budget deficit, (CGX - TOTREV), interest payments on outstanding debt, and economic growth.

Remember that, in the steady state, nominal GDP grows as:

(E.9.a) $$\frac{\Delta GDPU_t}{GDPU_t} = G\_\text{YNP} + \text{G\_LS} + \text{G\_PCH} \;,$$

and that in the steady state, the interest rate is at its steady state rate HP_LI, so that:

(E.9.b) $LIG_{t-1} = LIG_t = HP\_LI$.

Note also that from equation (E.1) and (E.7), it follows that in the steady state:

$$\Delta R\_\text{GBOND} = \frac{\Delta GBOND_t}{GDPU_t} - \frac{GBOND_t}{GDPU_t}\left(\frac{\Delta GDPU_t}{GDPU_t}\right)$$

or,

(E.9.c) $$GBOND_{t-1} = GBOND_t - \left(\frac{\Delta GDPU_t}{GDPU_t}\right) GBOND_t - \Delta R\_\text{GBOND}\ \text{GDPU}_t .$$

Inserting equations (E.1) and (E.9.a) to (E.9.c) into equation (E.8), we find:

(E.10) $$(1 + HP\_\text{LI})\Delta\left(\frac{GBOND_t}{GDPU_t}\right) = \frac{CGX_t}{GDPU_t} - \frac{TOTREV_t}{GDPU_t}$$
$$+ (HP\_\text{LI}\ \ (1\text{- G\_YNP - G\_LS - G\_PCH})$$
$$\text{- G\_YNP - G\_LS - G\_PCH})\frac{GBOND}{GDPU} \quad .$$

If we impose the additional restriction that in the steady state the debt to GDP ratio does not change, and remains constant at a particular ratio, R_GBOND, i.e.:

$$\text{(E.11.a)} \quad \Delta\left(\frac{GBOND_t}{GDPU_t}\right) = \Delta R\_\text{GBOND} = 0 \,,$$

and

$$\text{(E.11.b)} \quad \left(\frac{GBOND_t}{GDPU_t}\right) = \text{R\_GBOND} \,,$$

then we get that equation (E.10) can be rewritten as:

$$\text{(E.12)} \quad (CGX_t - TOTREV_t) = -\{ HP\_LI\,(1 - G\_YNP - G\_LS - G\_PCH) - G\_YNP - G\_LS - G\_PCH \}\, R\_GBOND\; GDPU_t \,.$$

Equation (E.12) defines the structural budget deficit that generates a constant debt to GDP ratio in the steady state.

Inserting equation (E.4.b), into equation (E.12), yields:

$$CGX_t - (DTH_t + DTCP_t + ITP_t + SSRH_t + OT_t) = -\{ HP\_LI\,(1 - G\_YNP - G\_LS - G\_PCH) - G\_YNP - G\_LS - G\_PCH \}\, R\_GBOND\; GDPU_t \,,$$

which solves for direct taxes, DTH, as:

$$\text{(E.13)} \quad DTH_t = CGX_t - (DTCP_t + ITP_t + SSRH_t + OT_t) + \{HP\_LI\,(1 - G\_YNP - G\_LS - G\_PCH) - G\_YNP - G\_LS - G\_PCH\}\, R\_GBOND\; GDPU_t \,.$$

In other words, if one wants to reach in the steady state the target debt to GDP ratio, R_GBOND, then one has to collect taxes equal to the amount defined in equation (E.13).

The implicit direct income tax rate is derived as follows. Remember that:

(E.14) $DTH_t = DTHR\ (WBU_t + TRANSH_t)$,

with:

DTHR: the direct labour income tax rate,
WBU: the total wage bill, in current prices,
TRANSH: public sector transfers to the household sector.

From equation (E.14) it follows that the implicit direct labour income tax rate, DTHR, for which the debt to GDP ratio is equal to its steady state target level is equal to:

(E.15) $DTHR_t = DTH_t / (WBU_t + TRANSH_t)$,

with DTH defined in equation (E.13).

C. Tax smoothing

We now assume that the fiscal authorities dislike discretionary jumps in the direct tax rates, so that they do not set the contemporaneous direct labour income tax rate immediately equal to the steady state value described in equation (E.13). Instead, we postulate the following policy reaction function which measures direct labour income tax revenue as a percentage of GDP:

(E.16)
$$\Delta\left(\frac{DTH_t}{GDPU_t}\right) = \text{dth\_sl}\left(\left(\frac{DTH_{t-1}}{GDPU_{t-1}}\right) - \left(\frac{HP\_DTH_{t-1}}{GDPU_{t-1}}\right)\right) + \text{dth\_s1}\left(\left(\frac{GBOND_{t-1}}{GDPU_{t-1}}\right) - R\_\text{GBOND}\right) ,$$

with HP_DTH defined in equation (E.13), and with the parameters satisfying the conditions: $\text{dth\_sl} < 0$ and $\text{dth\_s1} > 0$.

The first term on the right hand side of equation (E.16) is an error correction term, while the second term measures the deviation of contemporaneous public debt to GDP ratio from its steady state target rate.

XIII Appendix F: Some Other Equations of the NIME Model

This section describes some additional equations of the NIME model: exports, inventory demand, labour supply, and the RW block.

A. Exports

Exports are estimated with the Two-Step Engle Ganger method.

First, in equation (D.14) of Appendix D, we specified the equilibrium export equation. In the empirical application, we added a trend, TIME, and we estimated the following equation:

$$\text{(F.1)} \quad \ln(XTO_t) = xto\_l0 + xto\_lb \ln(EFASPO_t)$$
$$+ xto\_l1 \{ \ln[EFPASP_t (1\text{-}EFNITR_t) EFEX_t] - \ln(PXT_t)\}$$
$$+ xto\_l2 \ln(TIME_t) .$$

Table F.1 shows the point estimates, and some diagnostic statistics.

TABLE F.1 - Exports : Long run elasticities

	EU	NE	US	JP
xto_lb	1.00	1.00	1.00	1.00
xto_l1	1.00	1.00	1.00	1.00
xto_l2	0.11	0.12	0.14	0.36
Diagnostic statistics				
Adjusted R	0.98	0.97	0.98	0.97
Durbin - Watson	1.40	1.04	1.04	1.43
Dickey - Fuller	-3.48	-2.59	-3.06	-4.17

Second, for the short run we estimated the following error correction mechanism:

(F.2) $$\Delta \ln(XTO_t) =$$
$$xto\_sb \{ xto\_swb \, \Delta \ln(EFASPO_t) + (1-xto\_swb) \, \Delta \ln(EFASPO_{t-1})\}$$
$$+ xto\_s1 \{xto\_sw1 \{ \Delta \ln[EFPASP_t (1-EFNITR_t) EFEX_t] - \ln(PXT_t)\}$$
$$+ (1 - xto\_sw1) \{ \Delta \ln[EFPASP_{t-1} (1-EFNITR_{t-1}) EFEX_{t-1}] - \ln(PXT_{t-1})\}\}$$
$$+ xto\_sl \, ECMXTO_{t-2} ,$$

with ECMXTO the error correction term derived from equation (F.1). Note that we use a time lag of two periods for the error correction term. The estimation results for equation (F.2) are shown in Table F.2.

TABLE F.2 - Exports: Short run elasticities

	EU	NE	US	JP
xto_sb	0.99	0.86	1.49	1.00
	(0.38)	(0.37)	(0.45)	-.-
xto_s1	0.75	0.49	0.71	0.64
	(0.16)	(0.16)	(0.15)	(0.20)
xto_sl	-0.32	-0.20	-0.57	-0.22
	(0.28)	(0.12)	(0.15)	(0.17)
Weights				
xto_swb	0.26	1.00	1.22	1.00
	(0.50)	-.-	(0.49)	-.-
xto_sw1	0.87	0.23	0.41	0.50
	(0.15)	(0.16)	(0.18)	(0.16)
Diagnostic statistics				
Adjusted R	0.62	0.62	0.80	0.50
Durbin - Watson	2.09	1.68	2.73	1.61

B. Inventory demand

1. The household sector

Inventory demand by the household sector in constant prices, is modelled by a partial adjustment model as:

(F.3.a) $$\ln(INVHO_t / NPO_t) = inh\_sl \{inh\_l0 + inh\_l1 \ln((DIH_t) / (PWH_t \, NP_tO))$$
$$+ inh\_l2 \, TIME_t + inh\_l3 \, (TIME_t \, TIME_t)\}$$
$$+ (1-inh\_sl) \ln(INVHO_{t-1} / NPO_{t-1}) .$$

Inventory demand by the household sector in current prices, INVHU, is:

(F.3.b) INVHU = INVHO PINVH ,

with the price of inventories determined by:

(F.3.c) Δ ln(PINVH) = Δ ln(PCH) .

TABLE F.3 - Elasticities for inventory building by households

	EU	NE	US	JP
invh_l0	-7.45	-5.06	-7.19	-6.94
	(0.50)	(4.35)	(0.24)	(0.04)
invh_l1	1.00	1.00	1.00	1.00
	-.-	-.-	-.-	-.-
invh_l2	0.10	-0.15	0.02	0.05
	(0.08)	(0.68)	(0.03)	(0.00)
invh_l3	-0.00	0.01	-0.00	-0.00
	(0.00)	(0.0)2	(0.00)	(0.00)
invh_sl	0.25	0.13	0.72	0.80
	(0.15)	(0.53)	(0.20)	(0.22)
Diagnostic statistics				
Adjusted R	0.91	0.66	0.21	0.99
Durbin - Watson	2.30	1.27	1.86	2.04

2. The enterprise sector

Inventory demand by the enterprise sector in constant prices, is modelled as:

(F.4.a) $$\ln(INVPO_t) = inp\_sl \{ inp\_l0 + inp\_l1 \ln(ASPO_t) + inp\_l2\ TIME + inp\_l3\ TIME\ TIME\} + (1\text{-}inp\_sl) \ln(INVPO_{t-1}) .$$

Inventory demand by the enterprise sector in current prices, INVPU, is :

(F.4.b) $$US\_INVPU_t = US\_INVPO_t\ US\_PINVH_t ,$$

with the price of inventories, PINVP, determined as:

(F.4.c) Δ ln(PINVP) = Δ ln(PASP) .

TABLE F.4 - Elasticities for inventory building by enterprise sector

	EU	NE	US	JP
invp_l0	-2.30	-3.28	-2.57	-1.94
	(0.11)	(0.18)	(0.02)	(0.08)
invp_l1	1.00	1.00	1.00	1.00
	-.-	-.-	-.-	-.-
invp_l2	0.05	0.07	0.05	-0.00
	(0.01)	(0.02)	(0.00)	(0.01)
invp_l3	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
invp_sl	0.51	0.66	1.00	0.44
	(0.10)	(0.04)	(0.10)	(0.07)
Diagnostic statistics				
Adjusted R	0.99	0.94	1.00	0.99
Durbin - Watson	2.40	1.53	2.54	2.82

C. Labour supply

The steady state labour supply is determined outside the model, i.e., in the steady state we have that:

(F.5) $LS_t = HP\_LS_t$.

A partial adjustment scheme captures adjustment towards the steady state, i.e.:

(F.6) $\ln(LS_t) = ls\_sl\ (HP\_LS_t) + (1\text{-}ls\_sl) \ln(LS_{t-1}) + ls\_s1 \ln(UR_t / HP\_UR_t)$
$+ ls\_s2 \ln(UR_{t-1} / HP\_UR_{t-1}) + ls\_s3\ DU91$,

with $0 \le ls\_sl \le 1$, and $ls\_s1, ls\_s2 \le 0$.

Point estimates are shown in Table F.5.

TABLE F.5 - Elasticities for labour supply

	EU	NE	US	JP
ls_sl	0.37	0.71	0.96	0.93
	(0.08)	(0.13)	(0.04)	(0.08)
ls_s1	-0.70	-2.06	-1.26	-3.08
	(1.37)	(0.80)	(0.66)	(1.12)
ls_s2	-0.46	-0.08	-1.36	-1.07
	(1.44)	(0.88)	(0.67)	(1.18)
ls_s3	0.07	0.00	0.00	0.00
	(0.01)	-.-	-.-	-.-
Diagnostic statistics				
Adjusted R	1.00	0.99	1.00	1.00
Durbin - Watson	0.94	0.84	0.54	1.25

D. The rest of the world block

This section describes the rest of the world (RW) block. The RW block consists of equations capturing the trade feedback between the main blocks of the NIME model and the countries which are not included in the main blocks of the NIME model. First, we describe briefly the data, next we discuss some equations.

1. The data

The RW aggregates are a weighted average of the relevant variables of the following countries and areas: Africa, Asia, Eastern Europe, the Middle East, the Western Hemisphere, Canada, Australia. Most of the data are available in the World and Area Tables of the International Financial Statistics of the International Monetary Fund, i.e.:

- economic activity: line 99b.r, or line 99bp.r, GDP at constant prices,
- price level: line 64, or line 64 x, consumer prices,
- exchange rate: line rf [1], exchange rates.

The RW aggregate is a geometric average of the area and country variables. The weights are calculated on the basis of 1995 GDP data.

Not discussed elsewhere, we describe here how the consolidated trade data of the EU, NE and RW block are calculated. For this exercise we used the desaggregated bilateral trade data for goods, available in the IMF's trade databank, and the data for total imports and exports in current and constant prices, available in the EU Commission's AMECO databank.

In a first step, the IMF bilateral trade data are collected, and the missing observations units are interpolated. In a second step, for each year of the sample period, bilateral trade flow import coefficients are computed for each of the countries featured in the model. These coefficients are defined as country i's imports from country j over country i's total imports. These import coefficients are applied to the AMECO data for total imports for each country, leading to bilateral trade import flows compatible with AMECO data. Next, in order to avoid inconsistencies in the bilateral trade data and difficulties when we sum over countries to constitute our block trade data, we must ensure that country i's imports from country j are equal to country j's exports to country i. To do this, we use the mirror trade approach to bilateral trade flows [2], and define country i's exports to country j as country j's imports from country i.

The total imports and exports of the EU and NE block are then computed as the sum of its member country's bilateral trade flows with extra-block countries, while intra-block trade simply cancels out. The RW block's total imports are computed as the sum of all other blocks' exports to the rest of the world, while the RW

1. If no area exchange rate is available the area exchange rate is calculated as the weighted average of the exchange rates of the major countries of that particular area.
2. On the handling of trade data, see for example EUROSTAT (1998).

block's total exports are computed as the sum of all other blocks' imports from the rest of the world. Once all current and constant price trade flows have been defined, the corresponding bilateral import and export price series are computed.

2. The equations

a. The current account variables

Imports of the RW block, RW_MPO, are estimated as:

$$(F.7)\quad \Delta \ln(RW\_MTO) = 0.84^{*} \Delta \ln(RW\_ASPO) -0.63^{*}(\Delta \ln(RW\_PMT/(RW\_PASP^{*}(1-RW\_NITR)/EX\_RW\_EU)) - \Delta \ln(RW\_HP\_YMP)) + 0.09^{*}DU80 + -0.13^{*}DU82 + -0.37^{*}RW\_U\_MTO_{-1},$$

where the error correction term reads as:

$$(F.8)\quad RW\_U\_MTO = \ln(RW\_MTO) - [2.10 + \ln(RW\_ASPO) - \ln(RW\_PMT/(RW\_PASP^{*}(1-RW\_NITR)/EX\_RW\_EU)) + 0.21^{*}(DU79 + DU80 + DU81) + 0.01^{*}TIME - 0.01^{*}TIME^{*}TIME].$$

RW_XTO and RW_XTU, are defined by the following world trade balance requirement:

$$(F.9.a)\quad RW\_XTO_t = WORLD\_XTO_t - \left(\frac{BE\_XTO_t}{EX\_BE\_EU_{1990}} + EU\_XTO_t + \frac{NE\_XTO_t}{EX\_NE\_EU_{1990}} + \frac{US\_XTO_t}{EX\_US\_EU_{1990}} + \frac{JP\_XTO_t}{EX\_JP\_EU_{1990}}\right),$$

and

$$(F.9.b)\quad RW\_XTU_t = WORLD\_XTU_t - \left(\frac{BE\_XTU_t}{EX\_BE\_EU_t} + EU\_XTU_t + \frac{NE\_XTU_t}{EX\_NE\_EU_t} + \frac{US\_XTU_t}{EX\_US\_EU_t} + \frac{JP\_XTU_t}{EX\_JP\_EU_t}\right),$$

where RW_XTO and RW_XTU are measured in euro, and where world trade, WORLD_XTO, is defined as:

$$(F.9.c)\quad WORLD\_XTO_t = RW\_MTO_t + \frac{BE\_MTO_t}{EX\_BE\_EU_{1990}} + EU\_MTO_t + \frac{NE\_MTO_t}{EX\_NE\_EU_{1990}} + \frac{US\_MTO_t}{EX\_US\_EU_{1990}} + \frac{JP\_MTO_t}{EX\_JP\_EU_{1990}},$$

and where WORLD_XTU is defined as:

$$\text{(F.9.b)} \quad WORLD\_XTU_t = RW\_MTU_t + \frac{BE\_MTU_t}{EX\_BE\_EU_t} + EU\_MTU_t + \frac{NE\_MTU_t}{EX\_NE\_EU_t} + \frac{US\_MTU_t}{EX\_US\_EU_t} + \frac{JP\_MTU_t}{EX\_JP\_EU_t} ,$$

where RW_MTO and RW_MTU are measured in euro.

Net transfers to the rest of the world, RW_NCTROW, and net factor income from the rest of the world, RW_NFIROW, are defined as:

$$\text{(F.10.a)} \quad RW\_NCTROW = -\left(\frac{BE\_NCTROW_t}{EX\_BE\_EU_t} + EU\_NCTROW_t + \frac{NE\_NCTROW_t}{EX\_NE\_EU_t} + \frac{US\_NCTROW_t}{EX\_US\_EU_t} + \frac{JP\_NCTROW_t}{EX\_JP\_EU_t}\right),$$

and

$$\text{(F.10.b)} \quad RW\_NFIROW = -\left(\frac{BE\_NFIROW_t}{EX\_BE\_EU_t} + EU\_NFIROW_t + \frac{NE\_NFIROW_t}{EX\_NE\_EU_t} + \frac{US\_NFIROW_t}{EX\_US\_EU_t} + \frac{JP\_NFIROW_t}{EX\_JP\_EU_t}\right).$$

where RW_NCTROW and RW_NFIROW are measured in euro.

The exchange rate is determined by equation (D.22) of Appendix D.

b. Prices

The domestic price level is exogenous, i.e.:

$$\text{(F.11)} \quad \Delta \ln(RW\_PASP) = RW\_G\_PCH ,$$

with RW_G_PCH determined outside the model.

Similarly to the import price equations of the other blocks, we estimated:

$$\text{(F.12)} \quad \Delta \ln(RW\_PMT) = (1-0.82) *(0.83-1) *(\ln(RW\_PMT)_{-1} - \ln(RW\_PMTR)) + (1-0.82) *0.83* \Delta \ln(RW\_PMT*(EU\_EFEX*EX\_RW\_EU) / (EU\_EFEX*EX\_RW\_EU)_{-1})_{-1} .$$

The price of exports is defined by:

(F.13) $$RW\_PXT = \frac{RW\_XTU}{RW\_XTO} \; .$$

c. Other domestic variables

The domestic interest rate, RW_SI, is set according to:

(F.14) $$RW\_SI = RW\_EFSI$$

with RW_EFSI a weighted average of the interest rates of the other blocks.

Domestic output is specified as:

(F.15) $$\ln(RW\_ASPO) = \ln(RW\_HPASPO) + 0.12 * \Delta \ln(RW\_XTO) \; ,$$

with

(F.16) $$\Delta \ln(RW\_HPASPO) = RW\_G\_YNP + RW\_G\_NPO \; ,$$

where trend productivity growth, RW_G_YNP, and trend population growth, RW_G_NPO, are determined outside the model.

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