WORKING PAPER

10-00

The NIME Model

Specification and Estimation
of the Enterprise Sector

Federal
Planning Bureau
Economic analyses and forecasts

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December 2000

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I Introduction

In 1999, the Federal Planning Bureau (FPB) launched a research program to develop a macroeconometric world model. Since the early 1990s, the FPB has made extensive 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 aim of the FPB's new research programme is 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 economic and monetary framework. So far, the FPB's efforts have led to the construction of a first version of the New International Model for Europe (NIME), of which the different parts will be presented in several technical working papers [1].

The current version of NIME divides the world into six separate blocks: a EU block consisting of the countries that joined EMU in January 1999 minus Belgium [2], a non-EMU European country block (NE) consisting of the EU countries that did not join EMU [3], the United States, Japan and the rest of the world. The model describing the Belgian economy would consist of either the short term or the medium term macroeconometric model currently in use at the FPB [4]. These blocks are linked to each other through trade and financial flows.

The overall modelling strategy is as follows. First, in the short run, economic activity is primarily determined by demand, and output adjusts to meet demand, while prices adjust only sluggishly. Second, in the absence of any new shock, the model converges to a steady state where unemployment and production are at their "natural rate", expectations are realized fully, and where stock and flow variables are in equilibrium. Third, in each block of the NIME model, except for the "rest of the world" block, a household sector, an enterprise sector, a government sector, and a monetary sector are defined. 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. The monetary sector sets interest rates according to a Taylor rule, while fiscal policies are to a large extent determined outside the model. The "rest of the world" consists of a few equations describing overall economic activity.

1. 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 .
2. The ten EU block countries are: Austria, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.
3. The four NE block countries are: Denmark, Greece, Sweden, and the United Kingdom.
4. See, for example, Bossier et al. (2000).

This working paper describes the enterprise sector of the NIME model [1]. We start from the following assumptions to specify the enterprise sector. 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 that are consumed by the final users. The final users are the household sector, the public sector, the enterprise sector for investment purposes, and the other country blocks. Second, the available production factors are labour, capital, and imports. Third, a utility maximizing household sector supplies its labour and it bargains over the real wage rate with the enterprise sector. Fourth, the natural rate of unemployment and the steady state productivity growth of the production factors are exogenous.

In Chapter II, we specify equilibrium factor demand and equilibrium factor prices for the enterprise sector [2]. The starting point of the analysis is a sequential bargaining process whereby in a first stage a utility maximizing household sector and a profit-maximizing enterprise sector negotiate the real wage. Once the real wage is determined, the enterprise sector decides how much labour and other production factors it will use [3]. First, we specify the objective function of the different economic agents who participate in this bargaining process. Next, we derive a set of factor demand equations, and a wage setting equation in the tradition of the models that allow for the existence of equilibrium unemployment [4]. Third, we specify the equilibrium prices of the other production factors. Finally, we summarize the implications of the assumption that the natural rate of unemployment and factor productivity growth are exogenous.

In Chapter III, we show some empirical results for factor demand and factor prices. In the empirical section we make the additional assumption that in the short run adjustment costs prevent immediate adjustment of factor demand and prices to their equilibrium level.

In Chapter IV, we present the equilibrium output prices, following a similar price setting scheme as the one described in Chapter III, and then show some empirical results for these prices.

Finally, Chapter V concludes the paper with a summary of the theoretical specifications and main empirical findings.

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1. More specifically, the supply by the private sector. Demand is described in Meyermans and Van Brusselen (2000). The other parts of the model will be described in a future paper. See, for example, Laxton et al. (1998), Powell and Murphy (1997), Roeger and in ‘t Veld (1997), or Brayton and Tinsley (eds.) (1996), for the treatment of the supply side in other macroeconomic models.
2. The determination of employment in the public sector will be discussed in a future paper.
3. See, for example, Alogoskoufis and Manning (1991) on sequential bargaining in the labour market.
4. See, for example, Lindbeck (1993), and Layard, Nickell and Jackman (1994), for a general introduction to models with equilibrium unemployment.

II Equilibrium Factor Demand and Factor Prices: Some Analytical Results

In this chapter, we present the equilibrium conditions for factor demand and factor prices. The production factors are labour, capital goods, and imports. Although the demand for these different production factors is determined simultaneously, we will focus our attention primarily on the demand for labour. Our starting point is a sequential bargaining process whereby in a first step the household sector and the enterprise sector negotiate a real wage. Once the real wage rate and the prices of the other production factor are determined, the enterprise sector decides on the quantities of labour and other production factors that it will use in production [1].

In the first two sections, we specify the objective function of the enterprise sector and the household sector. The enterprise sector maximizes its profits, while the household sector maximizes its indirect utility, which is measured by the difference between the real after-tax labour income and its reservation wage. In the third section, we specify the factor demand equations, whereby factor demand is a function of a scale and the real factor price. In the fourth section, we specify a wage setting equation, whereby the equilibrium real wage is a weighted average of labour productivity and the reservation wage. The weights depend on the relative bargaining power of the enterprise sector. In the fifth and sixth section, we specify the equations for the price of capital goods and imports. In equilibrium, the real price of capital goods depends on capital productivity (growth), and the real interest rate. Because imports are primarily used as inputs in the production process, the price of imports is related to its productivity. In the seventh section, we investigate the implications of the assumption that the natural rate of unemployment and factor productivity are exogenous.

A. The enterprise sector's objective function

1. The objective function

The enterprise sector maximizes its intertemporal stream of profits, OSPU. Its strategy in period t is:

$$(1) \qquad Max \sum_{k=t}^{T} \left(\frac{1}{1+\mathrm{LI}_k}\right)^{k-t} \mathrm{OSPU}_k \qquad ,$$

1. See Alogoskoufis and Manning (1991).

with LI the discount rate and T the planning horizon.

Profits, OSPU, are equal to the difference between revenues from sales, REV, and production costs, COST:

$$(2) \qquad OSPU_t = REV_t - COST_t \ .$$

The enterprise sector hires labour, invests in capital goods, buys intermediary imports, and pays indirect taxes on production. In other words, production costs are:

$$(3) \qquad COST_t = NP_t WRP_t + CIPO_t \, PCIP_t + MPO_t \, PMP_t + NITR_t \, ASPO_t \, PASP_t \ ,$$

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,
$NITR_t$: the net indirect tax rate [1],
NP_t : total employment in the private sector,
$PASP_t$: the price of goods and services supplied by enterprises,
$PCIP_t$: the price of the capital stock owned by enterprises,
PMP_t : the price of (intermediary) imports,
WRP_t : the nominal per capita wage rate in the private sector.

Total available means, REV, are equal to the total sale of output plus the capital stock inherited from the past, i.e.:

$$(4) \qquad REV_t = PASP_t \, ASPO_t + CIPO_{t-1}(1 - gip\_rh) \ PCIP_t \ ,$$

with the parameter gip_rh the rate of depreciation of the private capital stock.

Using equations (3) and (4), we can rewrite equation (2) as:

$$(5) \quad OSPU_t = PASP_t \, (1 - NITR_t) \, ASPO_t - NP_t \, WRP_t - GIPO_t \, PCIP_t - MPO_t \, PMP_t \ ,$$

with gross fixed capital formation, GIPO, defined as:

$$(6) \qquad GIPO_t = CIPO_t - CIPO_{t-1} \, (1 - gip\_rh) \ .$$

1. The net indirect tax rate is defined as:
NITR = (IT-SUB) / (ASPO PASP-(IT-SUB)), with IT gross indirect taxes, and SUB subsidies.

2. The production technology

The enterprise sector produces output to meet final demand by hiring labour and fixed capital services, and buying imports [1]. The enterprise sector's production technology is modelled by a Cobb-Douglas production function, i.e.:

$$(7) \qquad ASPO_t = asp\_l0 \;\; NP_t^{asp\_l1} \;\; CIPO_t^{asp\_l2} \;\; MPO_t^{asp\_l3} \quad .$$

For the parameters of equation (7) it holds that asp_l0, asp_l1, asp_l2, asp_l3 > 0. We impose the additional constraint of constant returns to scale, i.e.:

$$(8) \qquad asp\_l1 + asp\_l2 + asp\_l3 = 1 \; .$$

B. The household sector's objective function

The household sector supplies labour and expects to be paid a wage that compensates for the disutility of work [2]. In other words, the household sector will accept to provide labour only if the after-tax real wage is greater than its real reservation wage. The reservation wage is the income that is received when unemployed, and it is function of, among others, the unemployment benefit, the wage earned in the gray and black economy, and household production.

Here, we postulate that households bargain for a real wage that maximizes the surplus between the after-tax real wage bill and the after-tax real reservation wage bill:

$$(9) \quad B_t = \left(\frac{WRP_t(1-DTHR_t)(1-SSRHR_t)}{PCH_t} - \frac{BEN_t(1-DTHR_t)(1-SSRHR_t)}{PCH_t} \right) NP_t$$

with:

BEN_t : the nominal reservation wage,
$DTHR_t$: the direct tax rate on labour income,
NP_t : private sector employment,
PCH_t : the consumer price index,
$SSRHR_t$: the social security contributions rate.

1. We assume that the decision to produce goods and services is separable from the decision to hold inventories.
2. In a previous working paper describing household behaviour, i.e. Meyermans and Van Brusselen (2000), we assumed separability between the decision to consume goods and services, on the one hand, and the decision to take leisure, on the other hand. This implies that we can study the decisions related to the consumption of goods and services separately from the decisions related to the supply of labour. See also Deaton and Muellbauer (1987) on separability.

A similar objective function has been proposed by Dixon and Rankin (1995).

In a second step, once the real wage rate has been set, the enterprise sector determines the amount of production factors needed to maximize profits, subject to the production technology, and the predetermined set of factor prices, output prices, and demand.

In the following two sections, we will examine these two steps in greater detail.

C. Factor demand

Once the factor prices are determined, the enterprise sector decides how much of each factor it will demand. In Appendix A we show that profit maximization implies the following factor demand equations [1]:

$$\text{(10.a)} \qquad \ln(\mathrm{NP}_t) = \ln(\mathrm{asp\_l1}) + \ln(\mathrm{ASPO}_t) - \ln\left(\frac{\mathrm{WRP}_t}{(1-\mathrm{NITR}_t)\,\mathrm{PASP}_t}\right),$$

$$\text{(10.b)} \qquad \ln(\mathrm{CIPO}_t) = \ln(\mathrm{asp\_l2}) + \ln(\mathrm{ASPO}_t) - \ln\left(\frac{\mathrm{USERIP}_t}{(1-\mathrm{NITR}_t)\,\mathrm{PASP}_t}\right),$$

$$\text{(10.c)} \qquad \ln(\mathrm{MPO}_t) = \ln(\mathrm{asp\_l3}) + \ln(\mathrm{ASPO}_t) - \ln\left(\frac{\mathrm{PMP}_t}{(1-\mathrm{NITR}_t)\,\mathrm{PASP}_t}\right).$$

Equations (10.a) to (10.c) determine the demand for labour, capital, and imports and can be interpreted as follows. The enterprise sector hires labour until its marginal productivity is equal to the (predetermined) real wage rate, i.e. WRP / ((1-NITR) PASP). Capital is accumulated until its marginal productivity is equal to the (predetermined) real user cost of capital, i.e. USERIP / ((1-NITR) PASP). Finally, the enterprise sector will buy imports until its marginal productivity is equal to the (predetermined) real import price, i.e. PMP / ((1-NITR) PASP).

It should be noted that the specification in equations (10.a) to (10.c) implies 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.

1. See equation (A.6) of Appendix A.

D. The wage setting equation

The bargaining process in the labour market consists of two steps. In the first step, the household sector and the enterprise sector negotiate a real wage. Assuming that the bargaining period covers one period, the wage setting can be seen as the outcome of an asymmetric Nash bargaining procedure [1]:

$$(11) \qquad \underset{\frac{\mathrm{WRP}}{\mathrm{PASP}(1-\mathrm{NITR})}}{MAX} \quad \mathrm{OSPU}^{q}\ \mathrm{B}^{(1-q)} \quad , \qquad \text{with} \quad 0 \le q \le 1 \ .$$

where q is a parameter measuring the relative bargaining power of the household sector and the enterprise sector. If the household sector has no impact on wage setting, then q = 1. If the household sector sets unilaterally the wage, then q = 0.

In Appendix B, we show how the bargaining process described in equation (11), and conditional on demand equations (10.a) to (10.c), solves for the following wage setting equation [2]:

$$(12) \qquad \ln\left(\frac{\mathrm{WRP}_t}{(1-\mathrm{NITR}_t)\mathrm{PASP}_t}\right) = \mathrm{wrp\_l1}\ \ln\left(\frac{\mathrm{BEN}_t}{(1-\mathrm{NITR}_t)\mathrm{PASP}_t}\right)$$
$$+ (1-\mathrm{wrp\_l1})\ \ln(\mathrm{asp\_l1}\,\mathrm{YNP}_t) + \mathrm{wrp\_l2}\ (\mathrm{UR}_t - \mathrm{HP\_UR}_t)$$

with labour productivity, YNP, defined as:

$$(13) \qquad \mathrm{YNP}_t = \frac{\mathrm{ASPO}_t}{\mathrm{NP}_t} \ ,$$

and with:

$\mathrm{UR_t}$: the contemporaneous unemployment rate,
$\mathrm{HP\_UR_t}$: the natural unemployment rate.

The parameters of equation (12) satisfy the conditions:

$$(14.a) \qquad 0 \le \mathrm{wrp\_l1} \le 1 \ ,$$

and

$$(14.b) \qquad \mathrm{wrp\_l2} \le 0 \ .$$

1. For analytical convenience, we assume here a planning horizon of one period. See Alogoskoufis and Manning (1991) for a discussion of alternative wage bargaining models.
2. See equation (B.13) of Appendix B. See also Blanchard and Katz (1999), who postulate a similar equation.

Equation (12) 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 wage setting, then wrp_l1 = 1. If the labour union sets unilaterally the wage, then we have that wrp_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).

E. The price of the private capital good

The user cost of capital, USERIP, is defined as [1]:

$$(15) \qquad \mathrm{USERIP}_t = \frac{\mathrm{LI}_t + \mathrm{gip\_rh} - \left(\frac{\mathrm{PCIP}_{t+1}}{\mathrm{PCIP}_t} - 1\right)(1 - \mathrm{gip\_rh})}{1 + \mathrm{LI}_t}\,\mathrm{PCIP}_t \ .$$

Equation (15) states that the user cost of capital has three determinants. First, in order to hold 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 present value of these three effects is captured by equation (15).

In this section we specify the equilibrium price of the capital goods. As a general equilibrium condition we find that, after substituting equation (15) into equation (10.b):

$$(16) \qquad \mathrm{PCIP}_t = \mathrm{PCIP}_{t+1}\frac{1 - \mathrm{gip\_rh}}{1 + \mathrm{LI}_t} + \mathrm{asp\_l2}\,(1 - \mathrm{NITR}_t)\,\mathrm{PASP}_t\,\frac{\mathrm{ASPO}_t}{\mathrm{CIPO}_t} \ .$$

Forward substitution of equation (16), yields:

$$(17) \qquad \mathrm{PCIP}_t = \sum_{i=0}^{\infty}\left(\prod_{k=0}^{i}\left(\frac{1 - \mathrm{gip\_rh}}{1 + \mathrm{LI}_{t+k}}\right)\right)\mathrm{asp\_l2}(1 - \mathrm{NITR}_{t+i})\mathrm{PASP}_{t+i}\mathrm{YCP}_{t+i} \ ,$$

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

$$\mathrm{YCP}_{t+i} = \frac{\mathrm{ASPO}_{t+i}}{\mathrm{CIPO}_{t+i}} \ .$$

1. See equation (A.5) of Appendix A.

Equation (17) states that the price of capital is equal to the discounted future -after tax- market value of the marginal productivity of capital [1]. The discount factor is equal to the interest rate adjusted for the rate of depreciation.

Assuming that net indirect taxes, NITR, remain constant, and that output prices, PASP, and productivity, YCP, grow at their steady state rates [2], i.e.:

(18.a) $d\ \ln(PASP_t) = G\_PASP$,

(18.b) $d\ \ln(YCP_t) = G\_YCP$,

and that the interest rate is at its steady state value:

(18.c) $LI = HP\_LI$,

we obtain for equation (17) that:

$$PCIP_t = asp\_l2(1 - NITR_t)$$
$$\left(\sum_{i=0}^{\infty}\left(\frac{1 - gip\_rh}{1 + HP\_LI}\right)^i (1 + G\_PASP)^i PASP_t (1 + G\_YCP)^i YCP_t\right) =$$
$$asp\_l2\ (1 - NITR_t)\ PASP_t\ YCP_t \sum_{i=0}^{\infty} R^i$$

with

$$R = \frac{(1 - gip\_rh)(1 + G\_PASP)(1 + G\_YCP)}{(1 + HP\_LI)} .$$

If $0 < R < 1$ then the previous equation can be rewritten as [3]:

(19) $$\frac{PCIP_t}{(1 - NITR_t)\ PASP_t} = asp\_l2\ YCP_t \frac{1}{1 - R}$$

$$= \frac{asp\_l2\ \ YCP_t}{\dfrac{(1 + HP\_LI) - (1 - gip\_rh)(1 + G\_PASP)(1 + G\_YCP)}{(1 + HP\_LI)}}$$

Equation (19) shows how the real price of capital goods is equal to the discounted net value of the marginal productivity of capital goods.

1. It should be note that the marginal productivity is equal to asp_l2 YCP.
2. See section G of this chapter regarding these assumptions.
3. Note that if R lies outside the interval]0, 1[then the price of capital is undefined.

F. The price of imports

In this section we specify the equilibrium price of imports. We assume multilateral trade. The country blocks export their goods to an international warehouse, and they import goods and services from this warehouse. In this process the warehouse has some market power to set prices. In other words, the import price measured in local currency is related to the export price of the other blocks by the following arbitrage condition:

$$(20) \qquad PMP_t = \exp^{pmt\_l0} TR\_MP_t^{pmt\_l1} (EFEX_t \; EFPXT_t) \; ,$$

with:

PMP_t : the price of imports, in local currency,
TR_MP_t : the market power of the warehouse [1],
$EFEX_t$: the effective nominal exchange rate, amount of local currency per unit of foreign currency,
$EFPXT_t$: the (effective) price of exports by other countries, in foreign currency.

Imports are used by the home country to produce goods and services. In equilibrium the exporting blocks set their export prices, EFPXT, such that it equalizes its marginal productivity, i.e. [2]:

$$(21.a) \qquad EFPXT_t = \frac{PASP_t(1 - NITR_t)}{EFEX_t} \; asp\_l3 \; YMP_t \; ,$$

where average productivity of imports is defined as:

$$(21.b) \qquad YMP_t = \frac{ASPO_t}{MPO_t} \; .$$

Inserting equation (21.a) and (21.b) into equation (20) yields:

$$(22) \qquad \frac{PMP_t}{PASP_t(1 - NITR_t)} = \exp^{pmt\_l0} \; TR\_MP_t^{pmt\_l1} \; asp\_l3 \; YMP_t \; .$$

Equation (22) states that in equilibrium the real price of imports is equal to the marginal productivity of the production factor imports, adjusted for market power in international trade.

1. 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.
2. See equation (10.c).

G. The steady state

The NIME model distinguishes three time horizons:

- the short run is the period during which plans are not fully realised, because of adjustment costs during the implementation of these plans;
- 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;
- 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.

So far we specified the medium run. The short run will be discussed in the empirical section. In this section, we will discuss the steady state of the model. The results shown in this section are derived in Appendix C.

We assume that the natural rate of unemployment and the steady state productivity growth of the production factors are determined outside the model [1]. In this section we summarize some of the implications of these assumptions on the steady state. Note that we use the label HP_*X* to indicate the steady state value of the variable *X*.

First, with a predetermined natural rate of unemployment, labour supply, and government employment, the natural level of employment in the private sector is determined as [2]:

$$\text{(23.a)} \qquad HP\_NP = (1 - HP\_UR)HP\_LS - HP\_NG$$

with:

HP_NG: the steady state government level of employment,
HP_LS: the steady state labour supply.

Second, the natural level of output of the private sector is determined as [3]:

$$\text{(23.b)} \qquad HP\_ASPO = HP\_NP\ HP\_YNP.$$

1. In the empirical section we will calculate these variables using a Hodrick-Prescott filter.
2. See equation (C.2) of Appendix C.
3. See equation (C.13.a) of Appendix C.

Third, real factor prices change in proportion with factor productivity [1], i.e.:

$$(23.c) \qquad d\ln\left(\frac{WRP}{(1-NITR)PASP}\right) = d\ln(YNP) \ ,$$

$$(23.d) \qquad d\ln\left(\frac{USERIP}{(1-NITR)PASP}\right) = d\ln(YCP) \ ,$$

$$(23.e) \qquad d\ln\left(\frac{PMP}{(1-NITR)PASP}\right) = d\ln(YMP) \ .$$

Fourth, a precondition that the relative factor prices remain unchanged in the steady state, is that relative factor productivity does not change in the steady state [2], i.e.:

$$(23.f) \qquad d\ln(HP\_YMP) = d\ln(HP\_YNP) = d\ln(HP\_YCP) \ .$$

Fifth, output prices are not affected by productivity growth [3], i.e.:

$$(23.g) \qquad d\ln(PASP) = 0 \ .$$

Sixth, in the steady state, the private supply grows at a rate determined by productivity growth and population growth:

$$(23.h) \qquad d\ln(HP\_ASPO) = d\ln(HP\_NPO) + d\ln(HP\_YNP) \ ,$$

which follows from equation (23.b).

1. See equation (C.19) of Appendix C.
2. See equation (C.18) of Appendix C.
3. See equation (C.21) of Appendix C.

III Factor Prices and Factor Demand: The Empirical Results

In this chapter, we will show some empirical results for factor prices and factor demand. The data that we use is annual data and the sample ranges from 1970 until 1996 [1]. The major data sources are New Cronos of EUROSTAT and the National Accounts, as published by the OECD, and available in the AMECO databank. In this chapter we show estimation results for the four main country blocks of the NIME model: the EU, NE, US, and JP block. Remember that the composition of the two aggregate country blocks, EU and NE, are 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.

In the first section of this chapter, we show estimates for the wage setting equation. However, before we can do this we have to deal with the problem that the reservation wage is not observed. We do this by assuming that the reservation wage gradually catches up with the real after-tax wage. The resulting wage equation is an error correction mechanism whereby changes in productivity, in the unemployment rate, and in the tax wedge, and the level of the lagged unemployment rate relative to the steady state unemployment rate, affect the short run behaviour of the real wage.

In the second section, we show the empirical results for the other factor prices. In Chapter II, we derived the equilibrium prices, or “rational reset price” of the capital goods and the imports. However, the prices of capital goods and imports adjust only sluggishly to these equilibrium prices because of menu costs and backward looking behaviour. In the first subsection, we start by specifying a price setting scheme that captures these rigidities. In the second subsection we show some empirical results for the price of capital goods and imports.

In the third section, we show estimation results for an error correction mechanism for labour demand and imports, and a partial adjustment scheme for investments.

The following general remarks are also of some interest. First, unless otherwise indicated, we use the Engle-Granger Two-Step Estimator to estimate the error correction mechanisms [2]. Second, all equations are estimated with the Federal Planning Bureau’s IODE software [3].

1. For a more thorough description, see Appendix D.
2. See Engle and Granger (1991).
3. See http://www.plan.be for more details regarding this software.

Third, the sample size ranges from 1970 until 1996. Fourth, the steady state values such as, for example, steady state productivity growth are calculated using a Hodrick-Prescott filter [1]. Fifth, unless otherwise specified, we make the following assumptions regarding the stochastic part of the behavioural equations. Once we have specified the deterministic part of an equation and we want to estimate the equation, we add to it a stochastic term to capture randomness in human behaviour, and we assume that the stochastic term is independent of time, and that there is no intertemporal correlation of the disturbance terms.

A. The price of labour

1. Towards empirical application: the reservation wage

No observations for the reservation wage, BEN, are available. Hence, before equation (12) 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. The reservation wage converges to this equilibrium as a function of an error correction term. In other words, we postulate the following error correction mechanism for the reservation wage [2]:

$$\Delta\ln\left(\frac{\mathrm{BEN}_t(1-\mathrm{DTHR}_t)(1-\mathrm{SSRHR}_t)}{\mathrm{PCH}_t}\right) = (\mathrm{ben\_1}\ -1)$$
$$\left\{\ln\left(\frac{\mathrm{BEN}_{t-1}(1-\mathrm{DTHR}_{t-1})(1-\mathrm{SSRHR}_{t-1})}{\mathrm{PCH}_{t-1}}\right)+\left(\frac{\mathrm{ben\_0}}{\mathrm{ben\_1}-1}\right)-\right.$$
$$\left.\ln\left(\frac{\mathrm{WRP}_{t-1}(1-\mathrm{DTHR}_{t-1})(1-\mathrm{SSRHR}_{t-1})}{\mathrm{PCH}_{t-1}}\right)\right\}$$

or, on rewriting terms:

$$\ln\left(\frac{\mathrm{BEN}_t(1-\mathrm{DTHR}_t)(1-\mathrm{SSRHR}_t)}{\mathrm{PCH}_t}\right) = \mathrm{ben\_0} \tag{24}$$
$$+\ \mathrm{ben\_1}\ \ln\left(\frac{\mathrm{BEN}_{t-1}(1-\mathrm{DTHR}_{t-1})(1-\mathrm{SSRHR}_{t-1})}{\mathrm{PCH}_{t-1}}\right)$$
$$+\ (1-\mathrm{ben\_1})\ \ln\left(\frac{\mathrm{WRP}_{t-1}(1-\mathrm{DTHR}_{t-1})(1-\mathrm{SSRHR}_{t-1})}{\mathrm{PCH}_{t-1}}\right)$$

with: $0 \le \mathrm{ben\_1} \le 1$.

1. The procedure is implemented with the smoothing parameter lambda set to 100.
2. A similar assumption has been made in Blanchard and Katz (1999).

In equation (E.5) of Appendix E, we show how equation (12), which describes wage setting, and equation (24), which describes the reservation wage, yield the following short run equation for the real wage:

$$(25) \quad \Delta \ln\left(\frac{\mathrm{WRP}_t}{(1-\mathrm{NITR}_t)\mathrm{PASP}_t}\right) =$$

$$(1\text{-wrp\_l1}) \; [\ \ln(\text{asp\_l1 YNP}_t) - \ln(\text{asp\_l1 YNP}_{t-1})\ ]$$

$$+ \text{wrp\_l2} \; [\ (\mathrm{UR}_t - \mathrm{HP\_UR}_t) - (\mathrm{UR}_{t-1} - \mathrm{HP\_UR}_{t-1})\ ]$$

$$+ \text{wrp\_l1 wrp\_l2 (1-ben\_1)} \; (\mathrm{UR}_{t-1} - \mathrm{HP\_UR}_{t-1})$$

$$- \text{wrp\_l1} \; [\ \ln(\mathrm{TAXWP}_t) - \ln(\mathrm{TAXWP}_{t-1})\ ]$$

$$+ (\text{wrp\_l1-1}) \; (1\text{-ben\_1}) \; [\ \ln\left(\frac{\mathrm{WRP}_{t-1}}{(1-\mathrm{NITR}_{t-1})\mathrm{PASP}_{t-1}}\right)$$

$$- \ln(\text{asp\_l1 YNP}_{t-1}) - \text{wrp\_l2} \; (\mathrm{UR}_{t-1} - \mathrm{HP\_UR}_{t-1}) + \frac{\text{wrp\_l1 ben\_0}}{(\text{wrp\_l1}-1)(1-\text{ben\_1})} \ ]$$

with: $\quad \text{wrp\_l2} \le 0$,

and with the tax wedge, TAXWP, defined as:

$$\mathrm{TAXWP}_t = (1-\mathrm{NITR}_t)(1-\mathrm{DTHR}_t)(1-\mathrm{SSRHR}_t)\,\frac{\mathrm{PASP}_t}{\mathrm{PCH}_t} \; .$$

Equation (25) shows 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. Note that for the parameters associated with the error correction term, it holds that:

$$-1 \le (\text{wrp\_l1}-1)(1-\text{ben\_1}) \le 0 \; .$$

Note also that in the medium run, the real wage is determined as:

$$(26.a) \quad \ln\left(\frac{\mathrm{WRP}}{(1-\mathrm{NITR})\mathrm{PASP}}\right) = \ln(\text{asp\_l1 YNP}) - \frac{\text{wrp\_l1 ben\_0}}{(\text{wrp\_l1}-1)(1-\text{ben\_1})}$$

$$+ \text{wrp\_l2} \; (\mathrm{UR} - \mathrm{HP\_UR}) \; ,$$

and, in the steady state, when UR = HP_UR :

$$(26.b) \qquad \ln\left(\frac{WRP}{(1-NITR)PASP}\right) = \ln(asp\_l1\ YNP) - \frac{wrp\_l1\ \ ben\_0}{(wrp\_l1-1)(1-ben\_1)}\ .$$

Equation (26.b) states that in the steady state the real wage is proportional to the marginal productivity of labour.

2. The empirical results for the wage setting equation

Table 1 presents the estimation results for equation (25) [1]. 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 indicates that it takes more time to adjust to a shock in the European labour market than in the labour markets of the other blocks. This low value is to a large extent explained by the low speed at which households revise their reservation wage, i.e. parameter (1-ben_1) in equation (24).

TABLE 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				
Adj. R	0.73	0.67	0.74	0.83
Durbin - Watson	1.71	2.04	2.50	1.73
Log likelihood value	89.40	80.12	99.88	81.48

The lagged unemployment rate has a very low impact on the change in the real wage of the EU and US block, i.e., almost equal to zero as measured by the term wrp_l1 wrp_l2 (1-ben_1) in equation (25). However, a change in the unemploy-

1. Equation (25) was estimated with instrumental variables. Dummies were added to equation (25) to capture some specific disturbances in the labour market, e.g., German re-unification in 1991, liberalisation in the UK as of 1980, oil shocks as of 1973.

ment rate induces important changes in the real wage in all country blocks, i.e. parameter wrp_l2 which is, for example, equal to -0.49 in the EU block and -0.21 in the US block. Hence, an increase in unemployment by one percent will induce, ceteris paribus, a 0.49 percent drop in the real wage of the EU block. Finally, note that in the short run, a change in the tax wedge generates the strongest response in the NE block, i.e. parameter wrp_l1, and the lowest in the EU block.

B. The price of capital and imports

1. A short run price setting scheme

In each block of the model there is an enterprise sector, producing 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 “rational reset price”. 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 potential benefit, and he could therefore decide to do this exercise for only (1-px_sw) percent of the good for which he thinks it is profitable to change the price. For the remainder of the composite good, he follows a simple rule according to which the new price is equal to the old price adjusted for past wage inflation.

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 [1]. We show in equation (F.10) of Appendix F that the price of composite good X is set according to the following rule:

$$
\begin{aligned}
(27)\qquad \ln(PX_t) - \ln(PX_{t-1}) = {} & (px\_sl-1)\,[\ln(PX_{t-1}) - \ln(PXR_{t-1})] \\
& + (1-px\_sl)\,[\ln(PXR_t) - \ln(PXR_{t-1})] \\
& - (1-px\_sl)\,px\_sw\,[\ln(PXR_t) - \ln(PX_{t-1})] \\
& + (1-px\_sl)\,px\_sw\,[\ln(PX_{t-1}) - \ln(PX_{t-2})]\,,
\end{aligned}
$$

with:

PX_t : the price of good X,
PXR_t : the equilibrium price of good X (i.e., the rational reset price).

Equation (27) shows how prices are changed in response to an error correction term, a change in the equilibrium values of the medium term determinants, a partial adjustment term, and the lagged change in the price.

1. In other words, (1-px_sw) measures the proportion of revised prices that are set to their “rational” reset price.

Note also that:

$$(28.a)\qquad 0 \le px\_sl\,,\; px\_sw \le 1 \;\;,$$

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

$$(28.b)\qquad -1 \le (px\_sl - 1) \le 0 \;\;,$$

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

$$(28.c)\qquad 0 \le (1 - px\_sl)px\_sw \le 1 \;\;.$$

2. Empirical results for the price of private capital goods

The rational reset price of capital goods reads as [1]:

$$(29)\qquad \frac{PCIPR_t}{(1 - NITR_t)\; PASP_t} = \frac{asp\_l2\;\; YCP_t}{\dfrac{(1 + HP\_LI) - (1 - gip\_rh)(1 + G\_PCH)(1 + G\_YCP)}{(1 + HP\_LI)}} \;.$$

Applying the specification derived in equation (27) to capital goods gives the following short run adjustment scheme:

$$\begin{aligned}(30)\qquad & \ln(PCIP_t) - \ln(PCIP_{t-1}) = (pcip\_sl-1)\,[\,\ln(PCIP_{t-1}) - \ln(PCIPR_{t-1})\,]\\ & + (1-pcip\_sl)\,[\,\ln(PCIPR_t) - \ln(PCIPR_{t-1})\,]\\ & - (1-pcip\_sl)\; pcip\_sw\,[\,\ln(PCIPR_t) - \ln(PCIP_{t-1})\,]\\ & + (1-pcip\_sl)\; pcip\_sw\,[\,\ln(PCIP_{t-1}) - \ln(PCIP_{t-2})\,]\;.\end{aligned}$$

with: $\quad 0 \le pcip\_sl\,,\; pcip\_sw \le 1 \;\;.$

Table 2 shows the point estimates and diagnostic statistics [2] for the short run adjustment scheme for the price of private capital goods, PCIP. All the parameters are between zero and one. The error correction parameter and partial adjustment coefficient are calculated using the point estimates of pcip_sl and pcip_sw, and applying equations (28.b) and (28.c). These parameters give us an indication of the speed at which prices adjust to their equilibrium level. We see that adjustment is slowest in the JP block. The diagnostic statistics are fairly good.

1. See equation (19).
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.

TABLE 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 term	-0.84	-0.82	-0.81	-0.27
Partial adjustment term	0.84	0.80	0.79	0.19
Diagnostic statistics				
Adj. R	0.86	0.78	0.75	0.82
Durbin h	0.44	-0.46	-0.24	0.85

3. Empirical results for the price of imports

The rational reset price of imports reads as [1]:

$$\text{(31)} \qquad PMPR_t = \exp^{pmt\_l0}\, MP_t^{\,pmt\_l1}\, asp\_l3\;\; YMP_t\; PASP_t\;(1 - NITR_t)\;\; ,$$

while a similar price setting scheme as formulated in equation (27) is assumed for the short run. The point estimates and diagnostic statistics for the short run adjustment scheme are shown in Table 3. All the parameters are between zero and one.

TABLE 3 - The price of imports, PMP

	EU	NE	US	JP
pmp_sl	0.24	0.11	0.20	0.23
	(0.13)	(0.07)	(0.10)	(0.20)
pmp_sw	0.46	0.22	0.42	0.33
	(0.10)	(0.08)	(0.08)	(0.09)
Pro memori				
Error correction term	-0.76	-0.89	-0.80	-0.77
Partial adjustment term	0.35	0.19	0.34	0.25
Diagnostic statistics				
Adj. R	0.83	0.88	0.87	0.84
Durbin h	0.46	0.83	1.55	-0.59

1. See equation (22).

C. The empirical results for factor demand

In Chapter II, we specified a set of equilibrium factor demand equations (i.e. equations (10.a) to (10.c). Here, we assume that the adjustment of factor demand to its equilibrium is sluggish. At the same time, we also assume that in the short run supply is determined by demand. 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.

We estimated the error correction mechanism in two steps using the Engle-Granger Two-Step estimator. In a first step we estimated the long run equilibrium relations. In a second step we estimated the error correction mechanisms (see Engle and Granger (1991)).

1. The equilibrium factor demand equations

The long run equilibrium factor demand equations are specified in Chapter II, by equations (10.a) to (10.c). Remember that the coefficients in these equations correspond to the coefficients of the production function (see equation (7)). Table 4 shows the point estimates of the technical coefficients.

TABLE 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	0.19	0.29	0.24
asp_l3	0.16	0.28	0.11	0.11

Note that the point estimates of these coefficients add up to one, reflecting the assumption of constant returns to scale [1]. 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 4 are used to calculate the error correction term in the short run adjustment scheme for factor demand.

2. The short run adjustment schemes

a. Short run supply and demand

In the short run, supply is completely determined by demand, i.e.:

$$\text{(32)} \qquad ASPO_t = ADPO_t ,$$

where ADPO is final demand for goods supplied by the private sector, in constant prices [2].

1. See also Section E of Appendix A.
2. See Meyermans and Van Brusselen (2000) for the specification of some of the components of final demand.

We will now specify how this predetermined output level, together with the predetermined prices, determine factor demand in the short run.

b. The short run demand for labour

The error correction mechanism for the demand for labour reads as [1]:

(33)
$$\Delta \ln(NP_t) = np\_sb\ \Delta \ln(ASPO_t)$$
$$+ np\_s1\ \Delta\ln\left(\frac{WRP_t}{(1-NITR_t)\,PASP_t}\right) + np\_s2\ \Delta\ln\left(\frac{USERIP_t}{(1-NITR_t)\,PASP_t}\right)$$
$$+ (-np\_sb-np\_s1-np\_s2)\ \Delta\ln\left(\frac{PMP_t}{(1-NITR_t)\,PASP_t}\right)$$
$$+ np\_sl\ [\ \ln(NP_{t-1}) - \ln(HP\_NP_{t-1})\ ] + (1-np\_sb)\ G\_NPO_t\ ,$$

with $-1 \le np\_sl \le 0$, and where G_NPO is steady state population growth.

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.

Note also that the specific parametrization in equation (33) guarantees that in the steady state, when labour supply and productivity grow at their steady state rates, the unemployment rate is equal to its natural rate [2].

Table 5 shows the point estimates and the standard errors of the error correction mechanism for labour [3]. Data mining showed that the most appropriate lag for the error correction term was 2 years, except for the JP block where the time lag was 4 years. Note also that we included a dummy variable in the equation of the EU block to capture the effects of German re-unification.

All the parameters of the error correction mechanism, i.e. np_sl, have the expected sign, and are fairly similar across country blocks, except for the US block where they are larger than in the other blocks. In each block the short run real wage elasticity is negative. The cross-elasticities of the other production factors are small. The diagnostic statistics are fairly high.

1. See equation (G.26) of Appendix G.
2. See also Appendix G.
3. The labour demand equation (33) was estimated with the instrumental variables method.

TABLE 5 - Labour demand, NP

	EU	NE	US	JP
np_sb	0.27	0.21	0.60	0.26
	(0.17)	(0.11)	(0.07)	(0.04)
np_s1	-0.31	-0.23	-0.59	-0.24
	(0.15)	(0.11)	(0.09)	(0.04)
np_s2	0.02	0.04	-0.02	0.02
	(0.04)	(0.04)	(0.04)	(0.01)
(-np_sb-np_s1-np_s2)	0.02	-0.02	0.01	-0.04
np_sl (Error correction parameter) [a]	-0.36	-0.78	-0.17	-0.74
	(0.36)	(0.22)	(0.15)	(0.43)
Diagnostic statistics				
Adj. R	0.56	0.59	0.82	0.64
Durbin - Watson	0.73	1.16	1.81	1.48

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

c. Short run gross capital formation

Here we present the results for a partial adjustment mechanism for gross investment [1].

We defined gross investment, GIPO, in equation (6) as:

(34) $$GIPO_t = (CIPO_t - CIPO_{t-1}) + CIPO_{t-1}\ gip\_rh\ ,$$

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

In equation (10.b) we specified the equilibrium capital stock. 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:

(35) $$CIPO_t - CIPO_{t-1} = gip\_l\ (CIPOL_t - CIPO_{t-1}) + gip\_x\ (X_t - X_{t-1})\ ,$$

with:

$CIPO_t$: the capital stock in period *t*, in constant prices,
$CIPOL_t$: the desired capital stock in period *t*, in constant prices,
X_t : a short run adjustment variable.

1. See, for example, Deaton and Muellbauer (1987, section 13.2) for a similar approach for durable consumption goods.

For gip_l, the parameter that measures the speed of adjustment of the effective capital stock to its desired level, it holds that: $0 < gip\_l < 1$.

Inserting equation (35) into equation (34), yields:

$$\text{(36.a)} \quad GIPO_t = gip\_l\ (CIPOL_t - CIPO_{t-1}) + CIPO_{t-1}\ gip\_rh + gip\_x\ (X_t - X_{t-1})\ .$$

This equation holds, mutatis mutandis, also for period *t-1*, i.e.:

$$\text{(36.b)} \quad GIPO_{t-1} = gip\_l\ (CIPOL_{t-1} - CIPO_{t-2}) + CIPO_{t-2}\ gip\_rh + gip\_x\ (X_{t-1} - X_{t-2})\ .$$

On subtracting (1-gip_rh) times equation (36.b) from equation (36.a), we obtain:

$$\begin{aligned} \text{(36.c)} \quad GIPO_t - (1-gip\_rh)\ GIPO_{t-1} &= gip\_l\ (CIPOL_t - (1-gip\_rh)\ CIPOL_{t-1}) \\ &+ gip\_l\ (CIPO_{t-1} - (1-gip\_rh)\ CIPO_{t-2}) \\ &+ gip\_rh\ (CIPO_{t-1} - (1-gip\_rh)\ CIPO_{t-2}) \\ &+ gip\_x\ [\ (X_t - X_{t-1}) - (1-gip\_rh)\ (X_{t-1} - X_{t-2})\ ]\ . \end{aligned}$$

On rearranging terms, and using the definition of $GIPO_t$, equation (36.c) can be rewritten as:

$$\begin{aligned} \text{(37)} \quad GIPO_t &= gip\_l\ (CIPOL_t - (1-gip\_rh)\ CIPOL_{t-1}) + (1-gip\_l)\ GIPO_{t-1} \\ &+ gip\_x\ [\ (X_t - X_{t-1}) - (1-gip\_rh)\ (X_{t-1} - X_{t-2})\ ]\ , \end{aligned}$$

with the long run capital stock defined as:

$$CIPOL_t = asp\_l2\ ASPO_t\ (1-NITR_t)\ PASP_t\ /\ USERIP_t\ ,$$

i.e. equation (10.b).

Equation (37) explains contemporaneous gross fixed investment as a function of the change in the desired capital stock, lagged gross fixed capital formation, and any other variable *X* that may affect adjustment in the short run.

Making a particular selection for the variable *X* that affects the short run, we estimated the following per capita variant of equation (37):

$$(37.a)\qquad \frac{GIPO_t}{NPO_t} = gip\_l\left(\frac{CIPOL_t}{NPO_t} - (1\text{-}gip\_rh)\frac{CIPOL_{t-1}}{NPO_{t-1}}\right) + (1 - gip\_l)\frac{GIPO_{t-1}}{NPO_{t-1}}$$

$$+ gip\_sb\left[\Delta\ln\left(\frac{ASPO_t}{NPO_t}\right) - (1\text{-}gip\_rh)\,\Delta\ln\left(\frac{ASPO_{t-1}}{NPO_{t-1}}\right)\right]$$

$$+ gip\_s1\left[\Delta\ln\left(\frac{WRP_t}{(1-NITR_t)PASP_t}\right)\right.$$

$$\left. - (1\text{-}gip\_rh)\,\Delta\ln\left(\frac{WRP_{t-1}}{(1-NITR_{t-1})PASP_{t-1}}\right)\right]$$

$$+ gip\_s2\left[\Delta\ln\left(\frac{USERIP_t}{(1-NITR_t)PASP_t}\right)\right.$$

$$\left. - (1\text{-}gip\_rh)\,\Delta\ln\left(\frac{USERIP_{t-1}}{(1-NITR_{t-1})PASP_{t-1}}\right)\right]$$

$$+ (\text{-}gip\_sb\text{-}gip\_s1\text{-}gip\_s2)\left[\Delta\ln\left(\frac{PMP_t}{(1-NITR_t)PASP_t}\right)\right.$$

$$\left. - (1\text{-}gip\_rh)\,\Delta\ln\left(\frac{PMP_{t-1}}{(1-NITR_{t-1})PASP_{t-1}}\right)\right].$$

Table 6 shows point estimates and diagnostic statistics for equation (37.a). The short run elasticities are derived in Appendix H. The short run elasticity of output is high across country blocks. The elasticity of the real wage differs across blocks, i.e. negative in the EU and NE block, and positive in the US and JP block. The short run elasticity of the user cost is low in the EU and NE block, if compared to the US and JP block. The long run elasticities for the demand for capital stock goods follow directly from equation (10.b), i.e. 1 for total output, and -1 for the user cost of capital.

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

	EU	NE	US	JP
Short run elasticities [a]				
output	0.78	1.02	0.84	0.59
real wage	-0.60	0.32	-0.06	-0.38
real user cost	-0.13	-0.98	-0.71	-0.27
real import price	-0.04	-0.36	-0.07	0.05
Technical coefficients				
gip_l	0.04	0.04	0.06	0.02
	(0.02)	-.-	(0.03)	-.-
gip_rh [b]	0.07	0.05	0.06	0.06
Diagnostic statistics				
Adj. R	0.91	0.87	0.76	0.92
Durbin - Watson	0.97	0.75	0.93	0.89

a. See equation (H.3) of Appendix H for the calculation of the short run elasticities of gross fixed capital formation.

b. See Appendix D, Section C, for the calculation of the rate of depreciation.

d. The short run demand for imports

The short run demand for imports is specified as:

$$(38) \quad \Delta\ \ln(MPO_t) = mp\_sb\ \Delta\ \ln(ASPO_t)$$

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

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

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

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

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

with: $-1 \leq mp\_sl \leq 0$,

and with the error correction term derived from equation (10.c). Note also that the specific parametrization in equation (38) guarantees that in the steady state, when population and productivity grow at their steady state rates, imports will also reach their steady state [1].

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

TABLE 7 - Demand for imports, MPO

	EU	NE	US	JP
Short run elasticities				
mp_sb	2.20	1.79	2.16	1.32
	(0.35)	(0.17)	(0.32)	(0.49)
mp_s1	-1.42	-0.98	-1.35	-0.98
	(0.29)	(0.19)	(0.42)	(0.45)
mp_s2	0.10	-0.17	-0.20	-0.22
	(0.13)	(0.09)	(0.15)	(0.11)
(-mp_sb-mp_s1-mp_s2)	-0.88	-0.65	-0.61	-0.11
mp_sl (Error correction parameter)	-0.12	-0.14	-0.08	-0.22
	(0.07)	(0.08)	-.-	(0.06)
Diagnostic statistics				
Adj. R	0.59	0.76	0.66	0.40
Durbin - Watson	1.79	1.83	2.10	1.21

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. Note the rather high values of the elasticities if compared with the elasticities of the other production factors. Note also that all direct price elasticities are negative.

1. See equation (G.7) of Appendix G.

IV The Prices for Final Users

Output produced by the domestic enterprise sector is demanded by the domestic private and public sector, and by the rest of the world. In this chapter we determine the price of private consumption, PCH, public consumption, PCGGS, the price of residential buildings, PCIR, the price of public capital goods, PCIG, the price of exports, PXT, and the deflator of aggregate supply by the private sector, PASP.

As discussed in Section B.1 of Chapter III, we derived in Appendix F a price setting scheme based on the assumption that prices are not fully flexible because of menu costs, and because of backward looking behaviour. Applying this price setting scheme, we will now look at the empirical results for each of the prices for final users [1].

A. The price of private consumption goods

The change in the consumer price is function of the output gap, secular inflation, and short run cost push inflation, i.e. [2]:

$$
\begin{aligned}
\text{(39.a)}\quad & \ln(PCH_t) - \ln(PCH_{t-1}) = \\
& (1\text{-}pch\_sl)\,(pch\_sw\text{-}1)\,pch\_s1\,[\ln(ASPO_{t-1}) - \ln(HP\_ASPO_{t-1})] \\
& - (1\text{-}pch\_sl)\,(pch\_sw\text{-}1)\,G\_PCH_t \\
& + (1\text{-}pch\_sl)\,pch\_sw\,[\ln(UCH_t) - \ln(UCH_{t-1})]\,,
\end{aligned}
$$

with the cost push component, UCH, defined as:

$$
\begin{aligned}
\text{(39.b)}\quad & \Delta\ln(UCH_t) = -\,\Delta\ln(1\text{-}NITR_t) + (asp\_l1+asp\_l2)\,\Delta\ln(PCH_{t-1}(1\text{-}NITR_{t-1})) \\
& \qquad + asp\_l3\,\Delta\ln(PMP_t / HP\_YMP_{t-1})\,,
\end{aligned}
$$

and with:

ASPO: the supply for private demand by the private sector,

1. Three remarks should be made here. First, for the results shown in the following tables it should be noted that the parameters without a standard error between brackets have been restricted to zero. Second, in a few cases dummies were used to improve the overall fit. More specifically, we added three dummies to the dynamic price setting scheme, to capture lagged adjustment to the three oil price shocks. Third, see footnote 2 of page 18 for Durbin's h test statistic.
2. See equation (F.14.a) and (F.14.b) of Appendix F.

G_PCH: secular inflation [1],
HP_ASPO: the steady state supply for private demand by the private sector,
PCH: the price of private consumption.

Remember that the parameter px_sl measures the fraction of the composite price which is kept at its old price, and that the parameter px_sw measures the fraction of the composite price which is revised according to a rule of thumb [2]. 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 (F.13) of Appendix F). We expect this parameter to be smaller than zero. Summarizing, we expect that in equation (39.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 8 shows point estimates, standard errors between brackets, and some diagnostic statistics for equation (39). Secular inflation is calculated by applying a Hodrick-Prescott (HP) filter to the original PCH series.

TABLE 8 - The consumer price index, PCH

	EU	NE	US	JP
pch_sl	0.02	0.04	0.05	0.09
	(0.04)	(0.04)	(0.02)	(0.04)
pch_sw	0.51	0.81	0.80	0.25
	(0.12)	(0.13)	(0.08)	(0.10)
pch_s1	-0.82	-2.33	-0.70	-0.40
	(0.27)	(1.81)	(0.34)	(0.14)
Pro memori				
output gap (1-pch_sl) (pch_sw-1) pch_s1	0.39	0.43	0.13	0.27
secular inflation -(1-pch_sl) (pch_sw-1)	0.48	0.19	0.19	0.68
cost push inflation (1-pch_sl) pch_sw	0.50	0.77	0.76	0.23
Diagnostic statistics				
Adj. R	0.89	0.92	0.97	0.96
Durbin h	-0.68	-1.21	0.76	0.65

All point estimates have the expected sign, but it should be noted that the value of pch_sl is rather low. We also show in this table the reduced form point estimates of the output gap, secular inflation, and the cost push inflation. Table 8 shows, for example, that the output gap will increase inflationary pressures in all country blocks. The response is highest in the EU and NE block, and lowest in the US block.

1. With $G\_PCH_t = \ln(HP\_PCH_t) - \ln(HP\_PCH_{t-1})$, where HP_PCH is the steady state price of private consumption.
2. In other words, (1-px_sw) measures the fraction of the price of public consumption that is revised to the “rational reset price”.

B. The price of the other goods

The price equations of the other goods, i.e PCGGS, PCIR, and PCIG, are specified as follows [1]:

$$
\begin{aligned}
(40.a) \quad \ln(PX_t) - \ln(PX_{t-1}) = {} & (px\_sl-1) [\ln(PX_{t-1}) - \ln(PXR_{t-1})] \\
& + (1-px\_sl) [\ln(PXR_t) - \ln(PXR_{t-1})] \\
& - (1-px\_sl)\, px\_sw [\ln(PXR_t) - \ln(PX_{t-1})] \\
& + (1-px\_sl)\, px\_sw [\ln(UX_t) - \ln(UX_{t-1})] ,
\end{aligned}
$$

for X = CGGS, CIR, CIG, and with $0 \le px\_sl, px\_sw \le 1$.

The rational reset price, PXR, is defined as:

$$(40.b) \quad \ln(PXR) = px\_l0 + px\_l1 \ln(PASP) ,$$

with [2] $px\_l1 = 1$.

Remember that cost push inflation is defined as [3]:

$$
\begin{aligned}
(40.c) \quad \Delta \ln(UX_t) = {} & -\Delta \ln(1-NITR_t) + (asp\_l1+asp\_l2)\, \Delta \ln(PX_{t-1} (1-NITR_{t-1})) \\
& + asp\_l3\, \Delta \ln(PMP_t / HP\_YMP_{t-1}) ,
\end{aligned}
$$

Equation (40.a) describes how the price converges to its equilibrium, while equation (40.b) defines the equilibrium. In equilibrium, the final users' prices are equal to the marginal cost of production. Let us now turn to the empirical results for each of these price equations.

1. The price of the public consumption goods

Table 9 shows the point estimates for adjustment scheme (40) for the price of the public consumption goods, PCGGS. This table gives the point estimates, their standard error between brackets, and some diagnostic statistics. Most parameters are between zero and one, while the diagnostic statistics indicate a fairly good fit. Using equations (28.b) and (28.c), we also calculated the corresponding parameter of the error correction term, and the partial adjustment term. Note the rather high value of the error correction terms, which reflects the low value of pcggs_sl, i.e. the fraction of the composite good that is kept at its old price.

1. See equation (F.10) of Appendix F.
2. Note that this restriction is necessary to ensure long run neutrality of money. Note also that PXR in equation (40.a) is the fitted value obtained after estimating equation (40.b) with ordinary least squares. Because of the super consistency properties of the first stage estimates, when we estimate the cointegrating vector, i.e. equation (40.a), we do not require the assumption that the regressors are uncorrelated with the error term.
3. See equation (F.7.a) of Appendix F.

TABLE 9 - The government consumption price index, PCGGS

	EU	NE	US	JP
pcggs_sl	0.00	0.00	0.02	0.09
	-.-	(0.04)	(0.02)	(0.11)
pcggs_sw	0.41	0.25	0.80	0.40
	(0.09)	(0.11)	(0.09)	(0.07)
Pro memori				
Error correction term	-1.00	-1.00	-0.98	-0.91
Partial adjustment term	0.41	0.25	0.78	0.37
Diagnostic statistics				
Adj. R	0.93	0.93	0.95	0.96
Durbin h	1.28	1.63	0.37	1.86

2. The price of the public sector capital stock

Table 10 shows the point estimates for adjustment scheme (40) for the price of the public capital stock, PCIG. Most point estimates are between zero and one. For Japan we restricted the parameter pcig_sl to zero, because the free estimates yielded a negative value.

TABLE 10 - The price of public investments, PCIG

	EU	NE	US	JP
pcig_sl	0.17	0.05	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)
Pro memori				
Error correction term	-0.83	-0.95	-0.91	-1.00
Partial adjustment term	0.61	0.63	0.82	0.03
Diagnostic statistics				
Adj. R	0.79	0.92	0.83	0.93
Durbin h	0.60	1.68	0.20	1.11

3. The price of residential buildings

Table 11 shows the estimation results for adjustment scheme (40) for the price of the residential buildings, PCIR. All point estimates are between zero and one. The diagnostic statistics are fairly good.

TABLE 11 - 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)
Pro memori				
Error correction term	-0.90	-0.93	-0.98	-0.81
Partial adjustment term	0.73	0.74	0.77	0.09
Diagnostic statistics				
Adj. R	0.74	0.77	0.89	0.83
Durbin h	-0.41	1.10	0.81	0.77

4. The price of exports

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, in analogy with equation (22), in equilibrium the local exporters set their export price according to the following rule:

$$\text{(41)} \qquad \ln(PXTR_t) = pxt\_l0 + pxt\_l1 \ln(EFEX_t\, EFPASP_t\, (1\text{-}EFNITR_t)\, EFYMP_t) + pxt\_l2 \ln(TR\_MP) \,,$$

with:

$PXTR_t$: the “rational reset” export price in local currency,
$EFEX_t$: the effective nominal exchange rate, amount of local currency per unit of foreign currency,
$EFYMP_t$: the productivity of imports in the production process of the rest of the world,
$EFPASP_t$: the effective foreign price level,
$EFNITR_t$: the effective net indirect tax rate.

In the short run, the export prices, PXT, are set according to:

(42) $$\ln(PXT_t) - \ln(PXT_{t-1}) = (pxt\_sl-1)\,[\,\ln(PXT_{t-1}) - \ln(PXTR_{t-1})\,] + (1-pxt\_sl)\,[\,\ln(PXTR_t) - \ln(PXTR_{t-1})\,] - (1-pxt\_sl)\,pxt\_sw\,[\,\ln(PXTR_t) - \ln(PXT_{t-1})\,] + (1-pxt\_sl)\,pxt\_sw\,[\,\ln(PXT_{t-1}) - \ln(PXT_{t-2})\,]\,.$$

Table 12 shows the point estimates for the short run adjustment scheme. All parameters have the expected order of magnitude. Here, we see relatively higher values for pxt_sl, indicating that for exports the price is kept unchanged for a longer period, when compared with the other prices.

TABLE 12 - The price of exports, PXT

	EU	NE	US	JP
pxt_sl	0.20	0.13	0.33	0.68
	(0.08)	(0.06)	(0.09)	(0.10)
pxt_sw	0.96	0.47	0.56	0.04
	(0.05)	(0.10)	(0.11)	(0.33)
Pro memori				
Error correction term	-0.80	-0.87	-0.67	-0.32
Partial adjustment term	0.76	0.41	0.38	0.01
Diagnostic statistics				
Adj. R	0.74	0.87	0.84	0.84
Durbin h	-0.32	0.72	1.20	1.24

5. The price of aggregate supply by the private sector

Finally, the price of aggregate supply for final demand by the private sector, PASP, is obtained by:

(43) $$PASP_t = \frac{ASPU_t}{ASPO_t}\,,$$

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.

V Summary

In this working paper we specified the supply side of the NIME model [1]. First, we formulated a set of assumptions regarding the production technology and the structure of the markets on which goods and production factors are traded. Second, we derived a set of equilibrium factor demand equations and factor price equations from an optimization problem whereby the enterprise sector maximizes its profits and the household sector its indirect utility function. In equilibrium, the demand for production factors depends on total demand and the real factor prices. The real wage is an average of the reservation wage and labour productivity, with the weights determined by the relative bargaining power of the household sector. Third, we specified the real price of private capital goods as the discounted net value of the marginal productivity of capital goods. Finally, we discussed some steady state properties of the model.

In the empirical section, we dealt with the problem that the reservation wage of the household sector cannot be observed. We postulated that the reservation wage is function of the labour wage and the past reservation wage, and we estimated a dynamic wage setting equation for the four main country blocks of the NIME model. The estimates show 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 price adjustment towards its equilibrium value is sluggish because of menu costs and “rule of thumb” behaviour. We also showed estimation results for the price of capital goods and intermediary imports for the four main country blocks. With respect to imports, the estimations show that the share of prices that is revised is generally greater than the share that is kept constant due to menu costs.

Next, we estimated an error correction mechanism for labour demand and the demand for imports, and a partial adjustment mechanism for gross fixed capital formation. We started by estimating the equilibrium factor demand equations. The parameters of these equations correspond to the technical coefficients of the production function. As expected, we found high values for the labour coefficients. We also noted the relatively higher import coefficient of the NE block, mainly due to the relative openness of the UK economy. Next, we estimated the short run factor demand equations. The labour demand estimations give relatively high values for the output and real wage elasticities for the US if compared with the elasticities of the other blocks. The estimations also show that the import elas-

1. Parts of the demand side of the NIME model are described in Meyermans and Van Brusselen (2000). The other parts will be described in a future paper.

ticities are generally higher than those of the other production factors. We also noted that the output and direct price elasticities of imports are particularly high for the EU and US block.

We ended the empirical section of the paper by showing estimation results for the prices for final users. There, we showed once more that price revisions are generally not very constrained by menu costs, leading to relatively high values for the parameter of the error correction term. Price revisions are largely based on rule of thumb.

VI Appendix A: The Optimization Problem of the Enterprise Sector

This appendix summarizes some straightforward analytical results.

A. The intertemporal optimization problem

For a predetermined set of factor and output prices, the intertemporal objective function of the profit-maximizing firm is:

$$\text{(A.1)} \qquad \underset{NP_k,\ CIPO_k,\ MPO_k}{Max} \quad \sum_{k=t}^{T} \left(\frac{1}{1+LI_k}\right)^{k-t} (REV_k - COST_k)$$

or, using equations (3) and (4) of the main text:

$$\underset{NP_k,\ CIPO_k,\ MPO_k}{Max}$$

$$\sum_{k=t}^{T} \left(\frac{1}{1+LI_k}\right)^{k-t} \{(PASP_k\, ASPO_k + CIPO_{k-1}(1 - gip\_rh)\ PCIP_k)$$

$$-\ (NP_k WRP_k + CIPO_k PCIP_k + MPO_k PMP_k + NITR_k ASPO_k PASP_k)\}$$

or, using equation (7) of the main text to replace ASPO and rearranging terms:

$$\text{(A.2)} \qquad \underset{NP_k,\ CIPO_k,\ MPO_k}{Max} \quad \sum_{k=t}^{T} \left(\frac{1}{1+LI_k}\right)^{k-t}$$

$$\{\ [(1\text{-}NITR_k)\ PASP_k\ asp\_l0\ NP_k^{asp\_l1}\ CIPO_k^{asp\_l2}\ MPO_k^{asp\_l3}]$$

$$-\ [NP_k\ WRP_k + (CIPO_k\ PCIP_k - CIPO_{k-1}\ (1\text{-}gip\_rh)\ PCIP_k)$$

$$+\ MPO_k\ PMP_k]\ \}\ .$$

The first order conditions for an optimum are:

$$\text{(A.3.a)} \quad asp\_l1\ ASPO_k\ ((1\text{-}NITR_k)\ PASP_k / NP_k) - WRP_k = 0\ ,$$

$$\text{(A.3.b)} \quad asp\_l2\ ASPO_k\ ((1\text{-}NITR_k)\ PASP_k / CIPO_k) - PCIP_k + PCIP_{k+1} \frac{1 - gip\_rh}{1 + LI_k} = 0\ ,$$

$$\text{(A.3.c)} \quad asp\_l3\ ASPO_k\ ((1\text{-}NITR_k)\ PASP_k / MPO_k) - PMP_k = 0\ .$$

B. The user cost of capital

We define the user cost of capital, USERIP, as:

$$\text{(A.4)} \quad USERIP_k = PCIP_k - PCIP_{k+1} \frac{1 - gip\_rh}{1 + LI_k}\ .$$

Buying one unit of capital stock in period k costs $PCIP_k$. Using this stock of capital during the period *k* will depreciate its value by gip_rh percent, so that one will get a price equal to $PCIP_{k+1}(1 - gip\_rh)$ when one sells the capital stock in period *k+1*.

The present value in period *k* of the latter is equal to $\dfrac{PCIP_{k+1}(1 - gip\_rh)}{1 + LI_k}$.

The user cost of capital is equal to the difference between these two costs.

Note that equation (A.4) can be rewritten as:

$$\text{(A.5)} \quad USERIP_k = \frac{PCIP_k(1 + LI_k) - PCIP_{k+1}(1 - gip\_rh)}{1 + LI_k}$$

$$= \frac{(1 + LI_k) - \dfrac{PCIP_{k+1}}{PCIP_k}(1 - gip\_rh)}{1 + LI_k}\ PCIP_k$$

$$= \frac{LI_k + gip\_rh - \left(\dfrac{PCIP_{k+1}}{PCIP_k} - 1\right)(1 - gip\_rh)}{1 + LI_k}\ PCIP_k\ .$$

Inserting equation (A.5) into equation (A.3.b) yields:

$$\text{(A.3.b.bis)} \quad asp\_l2\ ASPO_k\ ((1\text{-}NITR_k)\ PASP_k / CIPO_k) - USERIP_k = 0\ .$$

C. The factor demand equations

The first order conditions (A.3) yield the following factor demand equations for labour, capital and imports:

(A.6.a) $NP_k = asp\_l1 \ ASPO_k \ ((1\text{-}NITR_k) \ PASP_k / WRP_k)$,

(A.6.b) $CIPO_k = asp\_l2 \ ASPO_k \ ((1\text{-}NITR_k) \ PASP_k / USERIP_k)$,

(A.6.c) $MPO_k = asp\_l3 \ ASPO_k \ ((1\text{-}NITR_k) \ PASP_k / PMP_k)$.

D. The unit cost function

We obtain the unit cost function, corresponding to the Cobb-Douglas production function, by inserting equations (A.6.a), (A.6.b), and (A.6.c) into equation (7) of the main text, i.e.:

(A.7)
$$ASPO_k = asp\_l0 \ \{asp\_l1 \ ASPO_k \ ((1\text{-}NITR_k) \ PASP_k / WRP_k)\}^{asp\_l1}$$
$$\{asp\_l2 \ ASPO_k \ ((1\text{-}NITR_k) \ PASP_k / USERIP_k)\}^{asp\_l2}$$
$$\{asp\_l3 \ ASPO_k \ ((1\text{-}NITR_k) \ PASP_k / PMP_k)\}^{asp\_l3} .$$

Under the assumption of constant returns to scale, we can rewrite equation (A.7) in log form as:

(A.8.a)
$$\ln(PASP_k) = constant - \ln(1\text{-}NITR_k) + asp\_l1 \ln(WRP_k)$$
$$+ asp\_l2 \ln(USERIP_k) + asp\_l3 \ln(PMP_k) ,$$

with:

(A.8.b)
$$constant = - [\ln(asp\_l0) + asp\_l1 \ln(asp\_l1) + asp\_l2 \ln(asp\_l2)$$
$$+ asp\_l3 \ln(asp\_l3)] .$$

Equation (A.8.a) determines the equilibrium price of private supply for final demand in terms of the cost of the production factors.

E. Constant returns to scale and profit maximization

Adding conditions (A.6.a), (A.6.b) and (A.6.c), we obtain:

$$(A.9) \qquad NP_k\ WRP_k + CIPO_k\ USERIP_k + MPO_k\ PMP_k$$
$$= (asp\_l1 + asp\_l2 + asp\_l3)\ ASPO_k\ (1\text{-}NITR_k)\ PASP_k\ ,$$

which can be rewritten under the assumption of constant returns to scale as:

$$(A.10) \qquad NP_k\ WRP_k + CIPO_k\ USERIP_k + MPO_k\ PMP_k = ASPO_k\ (1\text{-}NITR_k)\ PASP_k\ ,$$

implying that factor payments exhaust total production under constant returns to scale. In other words, this means that no profits are made in equilibrium.

F. Gross fixed capital formation and the capital stock

Let $OSPU_k$ be profits in period *k*. By definition, we have that [1]:

$$COST_k + OSPU_k = REV_k\ ,$$

so that using equation (3) and (4) of the main text, we have:

$$NP_k\ WRP_k + PCIP_k\ CIPO_k + MPO_k\ PMP_k + NITR_k\ PASP_k\ ASPO_k + OSPU_k$$
$$= PASP_k\ ASPO_k + PCIP_k\ CIPO_{k-1}\ (1\text{-}gip\_rh)\ .$$

On defining gross investment as:

$$GIPO_k = CIPO_k - CIPO_{k-1}\ (1\text{-}gip\_rh)\ ,$$

the two previous equations yield:

$$(A.11) \qquad NP_k\ WRP_k + PCIP_k\ GIPO_k + MPO_k\ PMP_k + OSPU_k$$
$$= ASPO_k\ (1\text{-}NITR_k)\ PASP_k\ .$$

1. See equation (2) of the main text.

Noting that the right hand sides of equations (A.10) and (A.11) are the same, we find that:

$$NP_k\ WRP_k + PCIP_k\ GIPO_k + MPO_k\ PMP_k + OSPU_k$$
$$= NP_k\ WRP_k + CIPO_k\ USERIP_k + MPO_k\ PMP_k\ ,$$

so that, on rearranging terms, we obtain that:

$$PCIP_k\ GIPO_k + OSPU_k = CIPO_k\ USERIP_k\ ,$$

and, on using (A.5) and rearranging terms, we obtain that:

$$\text{(A.12.a)}\quad \frac{GIPO_k}{CIPO_k} = \frac{LI_k + gip\_rh - \left(\frac{PCIP_{k+1}}{PCIP_k} - 1\right)(1 - gip\_rh)}{1 + LI_k} - \frac{OSPU_k}{CIPO_k PCIP_k}$$

implying that the gross growth rate of the private capital stock is equal to the real interest rate plus the rate of depreciation, minus the rate of profit.

If profits are equal to zero, then:

$$\text{(A.12.b)}\quad \frac{GIPO_k}{CIPO_k} = \frac{LI_k + gip\_rh - \left(\frac{PCIP_{k+1}}{PCIP_k} - 1\right)(1 - gip\_rh)}{1 + LI_k}\quad .$$

VII Appendix B: The Wage Setting Equation

In this appendix, we derive the wage setting equation. For notational convenience we do not use time subscripts.

A. The bargaining process

As discussed in Chapter II, the first stage of the wage bargaining process is defined as:

$$\text{(B.1)} \qquad \underset{\frac{WRP}{PASP(1-NITR)}}{Max} \quad OSPU^{q} B^{(1-q)} \; .$$

Profits, OSPU, are equal to [1]:

$$\mathrm{OSPU} = \mathrm{PASP}\,(1-\mathrm{NITR})\,\mathrm{ASPO} - \mathrm{NP}\;\mathrm{WRP} - \mathrm{GIPO}\;\mathrm{PCIP} - \mathrm{MPO}\;\mathrm{PMP} \;,$$

or, making use of the demand for labour equation (10.a) of the main text to eliminate the first term on the right hand side:

$$OSPU = \left(\frac{1-\mathrm{asp\_l1}}{\mathrm{asp\_l1}}\right) WRP\;NP - PCIP\;GIPO - PMP\;MPO \;.$$

After multiplying and dividing by (1-NITR) PASP, this expression becomes:

$$\text{(B.2)} \qquad OSPU = \left(\frac{1-\mathrm{asp\_l1}}{\mathrm{asp\_l1}}\right)\frac{WRP}{(1-NITR)PASP}(1-NITR)\;PASP\;NP - PCIP\;GIPO - PMP\;MPO$$

The objective function of the household sector is defined as:

$$\mathrm{B} = \left(\frac{\mathrm{WRP}(1-\mathrm{DTHR})(1-\mathrm{SSRHR})}{\mathrm{PCH}} - \frac{\mathrm{BEN}(1-\mathrm{DTHR})(1-\mathrm{SSRHR})}{\mathrm{PCH}}\right)\mathrm{NP} \;,$$

i.e. equation (9) of the main text.

1. See equation (5) of the main text.

This equation can be rewritten to capture the fact that the household sector and the enterprise sector bargain over the wage deflated by the producer price [1]:

(B.3) $$B = \left(\frac{WRP}{(1-NITR)PASP} - \frac{BEN}{(1-NITR)PASP}\right) TAXWP\ NP \quad ,$$

with the tax wedge, TAXWP, defined as:

$$\mathrm{TAXWP} = (1-\mathrm{NITR})(1-\mathrm{DTHR})(1-\mathrm{SSRHR})\ \frac{\mathrm{PASP}}{\mathrm{PCH}}\ .$$

Inserting equations (B.2) and (B.3) into equation (B.1) yields:

(B.4) $$\underset{\frac{WRP}{PASP(1-NITR)}}{Max}$$

$$\left(\frac{1-\text{asp\_l1}}{\text{asp\_l1}}\ \frac{WRP}{(1-NITR)PASP}\ (1-NITR)\ PASP\ NP - PCIP\ GIPO - PMP\ MPO\right)^{q}$$
$$\left(\left(\frac{WRP}{(1-NITR)PASP} - \frac{BEN}{(1-NITR)PASP}\right) TAXWP\ NP\right)^{(1-q)}$$

The first order condition for an optimum is:

(B.5) $$q\ \mathrm{OSPU}^{(q\text{-}1)}\ \frac{1-\text{asp\_l1}}{\text{asp\_l1}}\ ((1\text{-}\mathrm{NITR})\ \mathrm{PASP})\ \mathrm{NP}\ \mathrm{B}^{(1\text{-}q)}$$
$$+\ \mathrm{OSPU}^{q}\ (1\text{-}q)\ \mathrm{B}^{(\text{-}q)}\ \mathrm{TAXWP}\ \mathrm{NP} = 0\ .$$

On collecting terms, we find that the first order condition can be rewritten as:

(B.6) $$q\ \frac{1-\text{asp\_l1}}{\text{asp\_l1}}\ \mathrm{PASP}\ (1\text{-}\mathrm{NITR})\ \mathrm{B} + \mathrm{OSPU}\ (1\text{-}q)\ \mathrm{TAXWP} = 0\ ,$$

with OSPU and B defined in equations (B.2) and (B.3), respectively.

1. We assume that the household sector does not suffer from tax illusion.

Equation (B.6) can be solved for $\frac{WRP}{(1-NITR)PASP}$, yielding the following expression:

(B.7.a) $$\frac{WRP}{(1-NITR)PASP} = \frac{BEN}{(1-NITR)PASP}\, w + asp\_l1\ YNP\ (1-w)\ ,$$

with labour productivity, YNP, defined as:

$$YNP = \frac{ASPO}{NP}\ ,$$

and the weight w defined as:

(B.7.b) $$w = \frac{q\,(1-asp\_l1)}{q-asp\_l1}\ .$$

Equation (B.7.a) states that the real wage is a weighted average of labour productivity and the reservation wage.

B. Derivation of the wage equation (B.7.a) and (B.7.b)

Equations (B.7.a) and (B.7.b) are derived from equation (B.6) as follows.

Inserting equation (B.3) into equation (B.6), we get:

(B.8) $$WRP\ NP = BEN\ NP - OSPU\ \frac{1-q}{q}\ \frac{asp\_l1}{1-asp\_l1}\ .$$

Profits are defined as:

$$OSPU = PASP\,(1-NITR)\,ASPO - NP\ WRP - GIPO\ PCIP - MPO\ PMP\ ,$$

while the demand for imports is, according to equation (A.3.c) of Appendix A:

$$MPO\ PMP = asp\_l3\ PASP\ (1\text{-}NITR)\ ASPO\ .$$

Using the demand for imports equation, we rewrite profits as:

$$OSPU = (1\text{-}asp\_l3)\ PASP\ (1\text{-}NITR)\ ASPO - WRP\ NP - PCIP\ GIPO\ .$$

Inserting this result into equation (B.8) and dividing both sides of the expression by (1-NITR) PASP, we obtain:

$$\frac{WRP}{(1-NITR)PASP} = \frac{BEN}{(1-NITR)PASP}$$

$$- [\ (1\text{-}asp\_l3)\ \frac{ASPO}{NP} - \frac{WRP}{(1-NITR)PASP}$$

$$- \frac{PCIP \quad GIPO}{(1-NITR)\ PASP\ NP}\ ]\ \frac{1-q}{q}\ \frac{asp\_l1}{1-asp\_l1}\ .$$

Solving for $\frac{WRP}{(1-NITR)PASP}$, we get:

(B.9) $$\frac{WRP}{(1-NITR)PASP} = \frac{BEN}{(1-NITR)PASP}\ \frac{q(1-asp\_l1)}{q-asp\_l1}$$

$$- [\ (1\text{-}asp\_l3)\ \frac{ASPO}{NP} - \frac{PCIP \quad GIPO}{(1-NITR)\ PASP\ NP}\ ]$$

$$\frac{asp\_l1(1-q)}{(q-asp\_l1)}\ .$$

Equation (B.9) can be simplified further by noting that:

(B.10.a) $$\frac{q(1-asp\_l1)}{q-asp\_l1} - \frac{asp\_l1(1-q)}{(q-asp\_l1)} = 1\ ,$$

so that if we define that:

(B.10.b) $$w = \frac{q(1-asp\_l1)}{q-asp\_l1}\ ,$$

then we get also that:

(B.10.c) $$(1 - w) = - \frac{asp\_l1(1-q)}{(q-asp\_l1)}\ .$$

Next, note that in equilibrium [1]:

(B.11) PCIP GIPO = USERIP CIPO = asp_l2 PASP (1-NITR) ASPO .

Using (B.10) and (B.11), and assuming constant returns to scale in the production process [2], we can rewrite equation (B.9) as:

$$\frac{WRP}{(1-NITR)PASP} = \frac{BEN}{(1-NITR)PASP}\ w + asp\_l1\ YNP\ (1-w)\ ,$$

i.e., equation (B.7.a).

C. The bargaining power and the unemployment rate

So far we assumed that the bargaining power of the household sector, *q*, is constant. Now we relax this assumption and assume that *q* depends on the extent that the contemporaneous unemployment rate UR, deviates from the natural rate of unemployment, HP_UR:

(B.12) $q = q0 + (UR - HP\_UR)\ z\ ,\quad \text{with}\quad z < 0\ .$

Inserting (B.12) and (B.7.b) into (B.7.a), a log-linearized version of equation (B.7.a) would then be of the form:

$$\text{(B.13)}\quad \ln\left(\frac{WRP}{(1-NITR)PASP}\right) = wrp\_l1\ \ln\left(\frac{BEN}{(1-NITR)PASP}\right)$$
$$+ (1-wrp\_l1)\ \ln(asp\_l1\ YNP) + wrp\_l2\ (UR - HP\_UR)\ ,$$

with the parameters wrp_l1 and wrp_l2, satisfying the conditions:

$$0 \le wrp\_l1 \le 1\ ,\ wrp\_l2 \le 0\ .$$

1. See equations (A.3.b), (A.5) and (A.12.b) of Appendix A.
2. i.e. asp_l1 = 1 - asp_l2 - asp_l3.

VIII Appendix C: Some Steady State Properties of the NIME Model

This appendix elaborates further on the steady state properties of the NIME model. We assume that the natural rate of unemployment and trend productivity are determined outside the model. Here, we derive the private sector natural rate of employment, and the private sector natural level of output. We also examine the steady state relation between factor costs and output prices, and factor productivity.

In what follows, the label HP_X is used to indicate the steady state value of variable X.

A. The natural level of employment

In the steady state equilibrium, the following accounting identity holds:

$$\text{(C.1)} \qquad HP\_UR = \frac{HP\_LS - HP\_NP - HP\_NG}{HP\_LS}$$

with:

HP_UR: steady state unemployment, (or the "natural rate of unemployment"),
HP_LS: steady state labour supply,
HP_NP: steady state employment in the private sector,
HP_NG: steady state employment in the public sector.

Equation (C.1) solves for the steady state level of employment in the private sector, HP_NP, as:

$$\text{(C.2)} \qquad HP\_NP = (1 - HP\_UR)HP\_LS - HP\_NG \ .$$

The right hand side variables are predetermined by "structural" parameters. However, the specification of these "natural rates" lies outside of the scope of the current NIME project.

B. The natural level of output and factor productivity

In this section we derive the natural level of production.

1. Output and production factors

Assuming the Cobb-Douglas production function of the main text, i.e. equation (7) of the main text, we have that in the steady state:

$$\text{(C.3.a)} \qquad \ln(HP\_ASPO) = \ln(asp\_l0) + asp\_l1 \ln(HP\_NP) + asp\_l2 \ln(HP\_CIPO) + asp\_l3 \ln(HP\_MPO)$$

with:

$$\text{(C.3.b)} \qquad asp\_l1 + asp\_l2 + asp\_l3 = 1 \, ,$$

and:

$$\text{(C.3.c)} \qquad asp\_l0,\ asp\_l1,\ asp\_l2,\ asp\_l3 > 0 \, .$$

Profit maximization implies the following steady state factor demand equations:

$$\text{(C.4.a)} \quad \ln(HP\_NP) = \ln(asp\_l1) + \ln(HP\_ASPO) - \ln\left(\frac{HP\_WRP}{HP\_PASP\ (1\text{-}HP\_NITR)}\right) ,$$

$$\text{(C.4.b)} \quad \ln(HP\_CIPO) = \ln(asp\_l2) + \ln(HP\_ASPO) - \ln\left(\frac{HP\_USERIP}{HP\_PASP\ (1\text{-}HP\_NITR)}\right) ,$$

$$\text{(C.4.c)} \quad \ln(HP\_MPO) = \ln(asp\_l3) + \ln(HP\_ASPO) - \ln\left(\frac{HP\_PMP}{HP\_PASP\ (1\text{-}HP\_NITR)}\right) .$$

2. Output and factor prices

From equations (C.4.a) and (C.4.b) it follows that:

$$\text{(C.5.a)} \qquad \ln(HP\_CIPO) = [\ \ln(asp\_l2) - \ln(asp\_l1)\ ] + [\ \ln(HP\_WRP) - \ln(HP\_USERIP)\ ] + \ln(HP\_NP) \, ,$$

and from equations (C.4.a) and (C.4.c):

$$\text{(C.5.b)} \qquad \ln(HP\_MPO) = [\ \ln(asp\_l3) - \ln(asp\_l1)\ ] + [\ \ln(HP\_WRP) - \ln(HP\_PMP)\ ] + \ln(HP\_NP) \, .$$

Inserting equations (C.5.a) and (C.5.b) into equation (C.3.a) yields:

$$\text{(C.6)} \quad \ln(HP\_ASPO) = \ln(asp\_l0) + asp\_l1 \ln(HP\_NP)$$
$$+ asp\_l2 [\ln(asp\_l2) - \ln(asp\_l1) + \ln(HP\_WRP) - \ln(HP\_USERIP) + \ln(HP\_NP)]$$
$$+ asp\_l3 [\ln(asp\_l3) - \ln(asp\_l1) + \ln(HP\_WRP) - \ln(HP\_PMP) + \ln(HP\_NP)] ,$$

or, on adding and subtracting HP_PASP (1-HP_NITR) and rearranging terms:

$$\text{(C.7)} \quad \ln(HP\_ASPO) = \ln(asp\_l0) + (asp\_l1 + asp\_l2 + asp\_l3) \ln(HP\_NP)$$
$$+ asp\_l2 \left[-\ln(asp\_l1) + \ln\left(\frac{HP\_WRP}{HP\_PASP\ (1-HP\_NITR)}\right)\right.$$
$$\left. + \ln(asp\_l2) - \ln\left(\frac{HP\_USERIP}{HP\_PASP\ (1-HP\_NITR)}\right)\right]$$
$$+ asp\_l3 \left[-\ln(asp\_l1) + \ln\left(\frac{HP\_WRP}{HP\_PASP\ (1-HP\_NITR)}\right)\right.$$
$$\left. + \ln(asp\_l3) - \ln\left(\frac{HP\_PMP}{HP\_PASP\ (1-HP\_NITR)}\right) \right] .$$

Equation (C.7) explains output by the natural rate of employment and the real factor prices.

3. Output and factor productivity

We proceed by assuming that, in the long run, factor productivity is determined outside the model, so that the marginal equilibrium conditions (C.4) can be written as:

$$\text{(C.8.a)} \quad \ln\left(\frac{HP\_WRP}{HP\_PASP\ (1-HP\_NITR)}\right) = \ln(asp\_l1) + \ln(HP\_YNP) ,$$

$$\text{(C.8.b)} \quad \ln\left(\frac{HP\_USERIP}{HP\_PASP\ (1-HP\_NITR)}\right) = \ln(asp\_l2) + \ln(HP\_YCP) ,$$

$$\text{(C.8.c)} \quad \ln\left(\frac{HP\_PMP}{HP\_PASP\ (1-HP\_NITR)}\right) = \ln(asp\_l3) + \ln(HP\_YMP) ,$$

where steady state average factor productivity is defined as:

$$\text{(C.9.a)} \quad HP\_YNP = \frac{HP\_ASPO}{HP\_NP} ,$$

$$\text{(C.9.b)} \quad HP\_YCP = \frac{HP\_ASPO}{HP\_CIPO} ,$$

$$\text{(C.9.c)} \quad HP\_YMP = \frac{HP\_ASPO}{HP\_MPO} .$$

Inserting equations (C.8.a) to (C.8.c) into equation (C.7), yields:

$$\text{(C.10)} \quad \ln(HP\_ASPO) = \ln(asp\_l0) + \ln(HP\_NP) + asp\_l2\,[\,\ln(HP\_YNP) - \ln(HP\_YCP)\,] + asp\_l3\,[\,\ln(HP\_YNP) - \ln(HP\_YMP)\,]\ ,$$

where use has been made of condition (C.3.b).

Equation (C.10) defines the steady state production level as a function of the natural level of employment, relative factor productivity and total factor productivity.

Equation (C.10) has two important implications. First, (C.10) implies that:

$$\text{(C.11)} \quad \ln(HP\_ASPO) - \ln(HP\_NP) = \ln(asp\_l0) + asp\_l2\,[\,\ln(HP\_YNP) - \ln(HP\_YCP)\,] + asp\_l3\,[\,\ln(HP\_YNP) - \ln(HP\_YMP)\,]\ ,$$

or, on using definition (C.9.a) and condition (C.3.b):

$$\text{(C.12)} \quad asp\_l1\ \ln(HP\_YNP) + asp\_l2\ \ln(HP\_YCP) + asp\_l3\ \ln(HP\_YMP) = \ln(asp\_l0)\ .$$

Equation (C.12) sets a constraint on marginal productivity: the sum of the marginal productivities of the different production factors must equal total factor productivity.

Second, equations (C.10) and (C.12) imply that the natural rate of output is determined as:

$$\text{(C.13.a)} \quad HP\_ASPO = HP\_NP\ HP\_YNP\ ,$$

i.e. the natural output level is equal to the natural level of employment multiplied by the natural labour productivity.

In growth rates, we get that:

$$\text{(C.13.b)} \quad d\ \ln(HP\_ASPO) = d\ \ln(HP\_NP) + d\ \ln(HP\_YNP)\ .$$

C. Relative factor prices and relative factor productivity growth

Let us now assume that in the steady state the relative factor prices do not change. This has several implications. We investigate here the implications for relative factor productivity.

From equations (C.4.a) and (C.4.b), it follows that the relative demand for labour and capital is determined as:

$$\text{(C.14)} \qquad \ln\left(\frac{HP\_NP}{HP\_CIPO}\right) = [\ \ln(asp\_l1) - \ln(asp\_l2)\ ] + \ln\left(\frac{HP\_WRP}{HP\_USERIP}\right) .$$

The left hand side of equation (C.14) can be written as:

$$\text{(C.15)} \qquad \ln\left(\frac{HP\_NP}{HP\_ASPO}\right) - \ln\left(\frac{HP\_CIPO}{HP\_ASPO}\right) = \ln(HP\_YNP) - \ln(HP\_YCP) ,$$

so that using (C.15), equation (C.14) is rewritten as:

$$\text{(C.16)} \quad \ln(HP\_YNP) = \ln(HP\_YCP) + [\ \ln(asp\_l1) - \ln(asp\_l2)\ ] + \ln\left(\frac{HP\_WRP}{HP\_USERIP}\right) .$$

If we assume that in the steady state, the relative factor prices and the technical coefficients of the production function do not change, then it follows from equation (C.16) that:

$$\text{(C.17.a)} \quad d\ \ln(HP\_YNP) = d\ \ln(HP\_YCP) ,$$

i.e. labour productivity grows at the same rate as capital productivity.

In a similar way, we derive for imports that:

$$\text{(C.17.b)} \quad d\ \ln(HP\_YMP) = d\ \ln(HP\_YNP)$$

so that we obtain:

$$\text{(C.18)} \qquad d\ \ln(HP\_YMP) = d\ \ln(HP\_YNP) = d\ \ln(HP\_YCP) ,$$

i.e., if we want relative factor prices to remain constant in the steady state then the productivities of the different production factors have to grow at the same rate.

D. Real factor prices and productivity growth

It should be noted that although relative factor prices do not change, the real factor prices do change in proportion to real productivity growth. From equations (C.8.a) to (C.8.c) we derive that:

$$\text{(C.19.a)} \quad d\ \ln\left(\frac{HP\_WRP}{HP\_PASP\ \ (1\text{-}HP\_NITR)}\right) = d\ \ln(HP\_YNP)\ ,$$

$$\text{(C.19.b)} \quad d\ \ln\left(\frac{HP\_USERIP}{HP\_PASP\ \ (1\text{-}HP\_NITR)}\right) = d\ \ln(HP\_YCP)\ ,$$

$$\text{(C.19.c)} \quad d\ \ln\left(\frac{HP\_PMP}{HP\_PASP\ \ (1\text{-}HP\_NITR)}\right) = d\ \ln(HP\_YMP)\ .$$

E. Output prices and productivity growth

Evaluating equation (A.8.a) of Appendix A for the steady state values, yields:

$$\text{(C.20)} \quad \ln(HP\_PASP) = \text{constant} - \ln(1\text{-}HP\_NITR) + asp\_l1\ \ln(HP\_WRP) + asp\_l2\ \ln(HP\_USERIP) + asp\_l3\ \ln(HP\_PMP)\ ,$$

Assuming constant returns to scale [1], and taking first differences, we can rewrite equation (C.20) as:

$$\text{(C.21)} \quad d\ \ln(HP\_PASP) = d\ \ln(1\text{-}HP\_NITR) + asp\_l2\ d\ \ln\left(\frac{HP\_USERIP}{HP\_WRP}\right) + asp\_l3\ d\ \ln\left(\frac{HP\_PMP}{HP\_WRP}\right)\ .$$

Hence, it follows that if we assume that factor prices grow at the same rate [2], and that net indirect taxes remain unchanged, then the price of aggregate supply also remains unchanged.

1. See equation (8) of the main text.
2. i.e., when relative factor productivity growth remains unchanged.

IX Appendix D: The Data

This appendix describes the data. Two sources have been used to construct the databank: New Cronos published by EUROSTAT, and the National Accounts published by the OECD (to a large extent available in the AMECO databank). The sample size ranges from 1970 until 1996. When these databanks proved to be incomplete, the missing observation units were interpolated (see for example Barten (1984)).

In this appendix we will highlight some of the main features of the data. In what follows, we use the block label XX = EU, NE, US, JP to refer to the four blocks of the NIME model [1], while the lower case x refers to the countries composing an aggregate block.

A. Private supply for final demand

The supply for final demand produced by the private sector in current prices, XX_ASPU, is calculated as:

(D.1) XX_ASPU = XX_GDPU + XX_MTU - (XX_WBGU + XX_DEPGU)

with:

XX_GDPU: gross domestic product of block XX, in current prices,
XX_MTU: consolidated imports of block XX [2], in current prices,
XX_WBGU: the wage bill of government, in current prices,
XX_DEPGU: consumption of fixed capital by government, in current prices.

Similarly, we calculate supply for final demand produced by the private sector in constant prices, XX_ASPO, as:

(D.2) XX_ASPO = XX_GDPO + XX_MTO - (XX_WBGO + XX_DEPGO)

1. There is no explicit production sector for the “rest of the world” block.
2. See Section E of this appendix.

with:

XX_GDPO: gross domestic product of block XX, in constant prices,
XX_MTO: consolidated imports of block XX, in constant prices,
XX_WBGO: the wage bill of government, in constant prices,
XX_DEPGO: consumption of fixed capital by government, in constant prices.

The price of supply for final demand produced by the private sector of block XX is defined as:

(D.3) $$XX\_PASP = XX\_ASPU / XX\_ASPO .$$

B. Private sector employment

Private sector employment of block XX, XX_NP, is defined as private sector employees plus independent workers.

The private sector wage bill is equal to the wage bill of employees plus compensation of independents. The latter is equal to the operating surplus of the household sector, corrected for household consumption of residential buildings.

C. The capital stock of the enterprise sector

1. The capital stock in current prices

The capital stock of the enterprise sector is only calculated at the block level, and it is generated by the following relation:

(D.4) $$XX\_CIPU_t = \frac{XX\_CIPU_{t-1}}{XX\_PCIP_{t-1}} XX\_PCIP_t + XX\_GIPU_t - XX\_DEPPU_{t-1} ,$$

with:

XX_CIPU: stock of fixed capital held by the private sector of block XX, in current prices,
XX_DEPPU: consumption of fixed capital of the private sector of block XX, in current prices,
XX_GIPU: gross fixed capital formation by the private sector of block XX, in current prices,
XX_PCIP: price of capital goods held by the private sector of block XX.

Equation (D.4) states that the private capital stock in period *t* depends on the private capital stock of period *t-1*, and the net investment flow in period *t*. Clearly, the use of equation (D.4) requires a starting value for XX_CIPU. We derive this initial capital stock as follows.

2. The initial capital stock

We assume that the ratio of the capital stock to GDP in current prices at the beginning of the sample period is equal to the ratio of the capital stock to GDP in current prices at the end of the sample period:

$$(D.5) \qquad XX\_CIPU_{1970} / XX\_GDPU_{1970} = XX\_CIPU_{1996} / XX\_GDPU_{1996}$$

A simple numerical iterative algorithm is used to solve equations (D.4) and (D.5) for $CIPU_{1970}$.

3. The capital stock in constant prices

The private capital stock in constant prices is defined as:

$$(D.6) \qquad XX\_CIPO = XX\_CIPU / XX\_PCIP \ .$$

4. The rate of depreciation

The rate of depreciation of the private capital stock, gip_rh, is calculated as the average ratio of $\frac{DEPGU}{CIPU}$, computed over the period [1970 - 1996].

D. The user cost of capital

1. A series for the user cost

Once we have a data series for the capital stock we can calculate the user cost of capital, using equation (A.10) of Appendix A, as follows:

$$(D.7) \quad USERIP_k = (ASPO_k\,(1\text{-}NITR_k)\,PASP_k - (NP_k\,WRP_k + MPO_k\,PMP_k))\,/\,CIPO_k\,,$$

satisfying the assumption of constant returns to scale. Implicitly we assume here that the operating surplus of the enterprise sector accrues to capital.

It should be noted that, to the extent that there are stochastic disturbances in production, there will be stochastic errors in the measurement of USERIP. To remove these “errors in variables” we regressed the USERIP series on a set of instruments that are expected to be highly correlated with the USERIP series, but uncorrelated with the random disturbances in production. These instruments are the interest rate, the price of capital goods, a trend, and a trend squared.

2. A data generating mechanism

We assume that there exists a steady state value to which the user cost gradually converges, and that an error correction mechanism captures this adjustment process.

In equilibrium the user cost is equal to the marginal productivity of capital, i.e.:

(D.8) $$USERIP_t = asp\_l2 \; YCP_t \; PASP_t \; (1\text{-}NITR_t) \; .$$

In the steady state, when we have:

(D.9.a) $$YCP_t = HP\_YCP \; ,$$

(D.9.b) $$NITR_t = HP\_NITR \; ,$$

(D.9.c) $$PASP_t = HP\_PASP \; ,$$

(D.9.d) $$YCP_t = HP\_YCP \; ,$$

equation (D.8) can be written as:

(D.10) $$\frac{HP\_USIP}{HP\_PASP} = asp\_l2 \; HP\_YCP \; (1\text{-}HP\_NITR) \; ,$$

with HP_USIP defined as the steady state user cost of capital, deflated by the market price of output.

The error correction mechanism that captures the sluggish adjustment of the user cost is postulated to read as follows:

(D.11) $$\Delta \ln\left(\frac{USERIP_t}{PASP_t}\right) = us\_sl \, [\, \ln\left(\frac{USERIP_{t-1}}{PASP_{t-1}}\right) - (us\_l0 + us\_l1 \ln(HPUSIP_{t\text{-}1})\,]$$
$$+ \; us\_s1 \; \Delta \; \ln(1\text{+}US\_SI_t) + us\_s2 \; \Delta \; \ln(PCIP_t) \; ,$$

with:

(D.12.b) $$-1 < us\_sl < 0 \; ,$$
(D.12.c) $$us\_s1 > 0 \; ,$$
(D.12.d) $$us\_s2 > 0 \; ,$$
(D.12.e) $$us\_l1 > 0 \; .$$

E. The consolidated imports of the EU and NE blocks

Total imports in current and constant prices for the US and JP block are readily available from the AMECO databank. The import data for the EU and NE blocks have to take into account the fact that trade between countries of the same block cancel out at the block level.

For the EU and NE blocks, only the consolidated trade data can be used. This data is defined as follows:

$$\text{(D.13.a)} \quad \text{XX\_MTU} = \sum_{\forall x \in XX} \sum_{\forall y \notin XX} x\text{\_y\_MTU}$$

and

$$\text{(D.13.b)} \quad \text{XX\_MTO} = \sum_{\forall x \in XX} \sum_{\forall y \notin XX} x\text{\_y\_MTO}$$

with:

XX_MTU: total imports of XX, in current prices,
x_y_MTU: imports of country x from country y, in current prices,
XX_MTO: total imports of XX, in constant prices,
x_y_MTO: imports of country x from country y, in constant prices.

The price of imports is defined as:

$$\text{(D.14)} \quad \text{XX\_PMT} = \text{XX\_MTU} / \text{XX\_MTO} .$$

Appendix E: The Wage Dynamics

In this appendix, we derive a dynamic wage setting equation.

Note that for the period *t-1*, equation (12) of the main text can be rewritten as:

$$\ln[\, BEN_{t-1} / ((1\text{-}NITPR_{t-1})\ PASP_{t-1})\,] =$$
$$(1 / wrp\_l1) \ln[\, WRP_{t-1} / ((1\text{-}NITPR_{t-1})\ PASP_{t-1})\,]$$
$$- ((1\text{-}wrp\_l1) / wrp\_l1) \ln(asp\_l1\ YNP_{t-1})$$
$$- (wrp\_l2 / wrp\_l1)\ (UR_{t-1} - HP\_UR_{t-1}) ,$$

or,

(E.1) $$\ln[\, BEN_{t-1}(1\text{-}DTHR_{t-1})\ (1\text{-}SSRHR_{t-1}) / PCH_{t-1}] =$$
$$+ (1 / wrp\_l1) \ln(WRP_{t-1}(1\text{-}DTHR_{t-1})\ (1\text{-}SSRHR_{t-1}) / PCH_{t-1})$$
$$- (1\text{-}wrp\_l1) / wrp\_l1 \ln(asp\_l1\ YNP_{t-1})$$
$$- (wrp\_l2 / wrp\_l1)\ (UR_{t-1} - HP\_UR_{t-1})$$
$$+ (1 - (1 / wrp\_l1)) \ln[\,(1\text{-}NITR_{t-1})(1\text{-}DTHR_{t-1})(1\text{-}SSRHR_{t-1})PASP_{t-1} / PCH_{t-1}\,].$$

On inserting equation (E.1) into equation (24) of the main text, we obtain:

$$\ln(BEN_t\ (1\text{-}DTHR_t)\ (1\text{-}SSRHR_t) / PCH_t) = ben\_0$$
$$+ ben\_1 \{ (1 / wrp\_l1) \ln(WRP_{t-1}(1\text{-}DTHR_{t-1})(1\text{-}SSRHR_{t-1}) / PCH_{t-1})$$
$$- ((1\text{-}wrp\_l1) / wrp\_l1) \ln(asp\_l1\ YNP_{t-1})$$
$$- (wrp\_l2 / wrp\_l1)\ (UR_{t-1} - HP\_UR_{t-1})$$
$$+ (1\text{-}(1 / wrp\_l1)) \ln[\,(1\text{-}NITR_{t-1})(1\text{-}DTHR_{t-1})(1\text{-}SSRHR_{t-1})PASP_{t-1} / PCH_{t-1}\,] \}$$
$$+ (1\text{-}ben\_1) \ln(WRP_{t-1}\ (1\text{-}DTHR_{t-1})(1\text{-}SSRHR_{t-1}) / PCH_{t-1}) ,$$

which can also be written as:

(E.2) $$\ln(BEN_t / ((1\text{-}NITR_t)\ PASP_t)) = ben\_0$$
$$+ (\,(ben\_1 / wrp\_l1) + (1\text{-}ben\_1)\,) \ln(WRP_{t-1} / ((1\text{-}NITR_{t-1})\ PASP_{t-1}))$$
$$- (ben\_1\ (1\text{-}wrp\_l1) / wrp\_l1) \ln(asp\_l1\ YNP_{t-1})$$
$$- (ben\_1\ wrp\_l2 / wrp\_l1)\ (UR_{t-1} - HP\_UR_{t-1})$$
$$- [\, \ln((1\text{-}NITR_t)\ (1\text{-}DTHR_t)\ (1\text{-}SSRHR_t)\ PASP_t\ / PCH_t)$$
$$- \ln((1\text{-}NITR_{t-1})\ (1\text{-}DTHR_{t-1})\ (1\text{-}SSRHR_{t-1})\ PASP_{t-1}\ / PCH_{t-1})\,] .$$

Inserting equation (E.2) into equation (12) of the main text, yields:

$$\begin{aligned}
&\ln(WRP_t / ((1\text{-}NITR_t)\ PASP_t)) = \\
&+ wrp_l1 \{ ben_0 - ben_1\ wrp_l0 \\
&\quad + ((ben_1 / wrp_l1) + (1\text{-}ben_1)) \ln(WRP_{t-1} / ((1\text{-}NITR_{t-1})\ PASP_{t-1})) \\
&\quad - (ben_1\ (1\text{-}wrp_l1) / wrp_l1) \ln(asp_l1\ YNP_{t-1}) \\
&\quad - (ben_1\ wrp_l2 / wrp_l1) (UR_{t-1} - HP_UR_{t-1}) \\
&\quad - (\ln((1\text{-}NITR_t)\ (1\text{-}DTHR_t)\ (1\text{-}SSRHR_t)\ PASP_t\ / PCH_t) \\
&\qquad - \ln((1\text{-}NITR_{t-1})\ (1\text{-}DTHR_{t-1})\ (1\text{-}SSRHR_{t-1})\ PASP_{t-1} / PCH_{t-1})) \\
&+ (1\text{-}wrp_l1) \ln(asp_l1\ YNP_t) + wrpl_2\ (UR_t - HP_UR_t)\ ,
\end{aligned}$$

or, on subtracting $\ln(WRP_{t-1} / ((1\text{-}NITR_{t-1})\ PASP_{t-1}))$ from both sides and rearranging terms:

$$\begin{aligned}
\text{(E.3)}\quad &\Delta \ln(WRP_t / ((1\text{-}NITR_t)\ PASP_t)) = wrp_l1\ ben_0 \\
&+ (1\text{-}wrp_l1) [\ln(asp_l1\ YNP_t) - \ln(asp_l1\ YNP_{t-1})] \\
&+ wrp_l2 [(UR_t - HP_UR_t) - ben_1\ (UR_{t-1} - HP_UR_{t-1})] \\
&- wrp_l1 [\ln(TAXWP_t) - \ln(TAXWP_{t-1})] \\
&+ (wrp_l1\text{-}1)\ (1\text{-}ben_1) [\ln(WRP_{t-1} / ((1\text{-}NITR_{t-1})\ PASP_{t-1})) \\
&- \ln(asp_l1\ YNP_{t-1})]\ ,
\end{aligned}$$

where the tax wedge is defined as:

$$\text{(E.4)}\quad TAXWP = (1\text{-}NITR_t)\ (1\text{-}DTHR_t)\ (1\text{-}SSRHR_t)\ PASP_t\ / PCH_t\ .$$

Finally, adding and subtracting $(wrp\_l1\text{-}1)\ (1\text{-}ben\_1)\ wrp\_l2\ (UR_{t-1} - HP\_UR_{t-1})$ to equation (E.3) yields:

$$\begin{aligned}
\text{(E.5)}\quad &\Delta \ln(WRP_t / ((1\text{-}NITR_t)\ PASP_t)) = \\
&(1\text{-}wrp_l1) [\ln(asp_l1\ YNP_t) - \ln(asp_l1\ YNP_{t-1})] \\
&+ wrp_l2 [(UR_t - HP_UR_t) - (UR_{t-1} - HP_UR_{t-1})] \\
&+ wrp_l1\ wrp_l2\ (1\text{-}ben_1) [UR_{t-1} - HP_UR_{t-1}] \\
&- wrp_l1 [\ln(TAXWP_t) - \ln(TAXWP_{t-1})] \\
&+ (wrp_l1\text{-}1)\ (1\text{-}ben_1) [\ln(WRP_{t-1} / ((1\text{-}NITR_{t-1})\ PASP_{t-1})) \\
&- \ln(asp_l1\ YNP_{t-1}) - wrp_l2\ (UR_{t-1} - HP_UR_{t-1}) + \frac{wrp_l1\ \ ben_0}{(wrp_l1 - 1)(1 - ben_1)}]\ .
\end{aligned}$$

XI Appendix F: The Price Dynamics

In this appendix, we specify the 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 the good X [2].

First, because of menu costs, the producer adjusts the price of only a fraction of the composite good. In other words, the price of px_sl percent of the composite good is kept at its old price, while the price of the rest is reset, i.e.:

$$\text{(F.1)} \qquad \ln(PX_t) = px\_sl \ln(PX_{t-1}) + (1-px\_sl) \ln(PXL_t) ,$$

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 reset price:

$$\ln(PXL_t) = (1\text{-}px\_sw)\ \ln(PXR_t) + px\_sw\ \ln(PXB_t)\ , \tag{F.2}$$

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, reflects the marginal cost of production. This reset price is specified for the different final users in equations (19), (22), (40.b), and (41) of the main text.

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.

1. The reset price of the goods CGGS, CIR, CIG

In equation (A.8.a) of Appendix A, we derived the unit cost function for private supply for final demand as:

$$\ln(PASP_t) = constant - \ln(1\text{-}NITR_t) + asp\_l1\ \ln(WRP_t) + asp\_l2\ \ln(USERIP_t) + asp\_l3\ \ln(PMP_t)\ , \tag{A.8.a}$$

with:

$$constant = -\ [\ \ln(asp\_l0) + asp\_l1\ \ln(asp\_l1) + asp\_l2\ \ln(asp\_l2) + asp\_l3\ \ln(asp\_l3)\ ]\ . \tag{A.8.b}$$

However, in equation (C.12) of Appendix C we derived also that:

$$asp\_l1\ \ln(YNP) + asp\_l2\ \ln(YCP) + asp\_l3\ \ln(YMP) = \ln(asp\_l0)\ , \tag{C.12}$$

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 (40.b) of the main text. Inserting the previous equation into equation (40.b) of the main text, yields:

$$\begin{aligned} \text{(F.3)} \qquad \ln(PX_t) = px\_l1 \{ &- [asp\_l1 \ln(asp\_l1) + asp\_l2 \ln(asp\_l2) \\ &+ asp\_l3 \ln(asp\_l3)] - \ln(1\text{-}NITR_t) + asp\_l1 \ln(WRP_t / YNP_t) \\ &+ asp\_l2 \ln(USERIP_t / YCP_t) + asp\_l3 \ln(PMP_t / YMP_t) \} + px\_l0\ , \end{aligned}$$

for X = CGGS, CIR, CIG.

Hence, 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 (F.3). However, it requires an effort to calculate the exact value of each of these cost components, and the producer may expect that this effort may outweigh the expected benefit. The producer expects that this will be the case for px_sw percent of the prices he will revise. For these prices, he bases his cost accounting 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 moment *t* at negligible cost, we get that the price at *t* is equal to:

$$\begin{aligned} \text{(F.4)} \qquad \ln(PXB_t) = \ln(PX_{t-1}) &- \Delta \ln(1\text{-}E\_NITR_t) + asp\_l1\ \Delta \ln(E\_WRP_t / E\_YNP_t) \\ &+ asp\_l2\ \Delta \ln(E\_USERIP_t / E\_YCP_t) \\ &+ asp\_l3\ \Delta \ln(E\_PMP_t / E\_YMP_t)\ , \end{aligned}$$

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 (F.4) are made.

The contemporaneous indirect tax rate, NITR, and the contemporaneous import prices, PMP, are observable at negligible cost, i.e.:

(F.5.a) $E\_NITR_t = NITR_t$,

(F.5.b) $E\_PMP_t = PMP_t$.

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.:

(F.5.c) $\Delta \ln(E\_WRP_t / E\_YNP_t) = \Delta \ln(E\_USERIP_t / E\_YCP_t)$
$= \Delta \ln[PX_{t-1}(1\text{-}NITR_{t-1})]$.

The expected change in contemporaneous productivity of intermediary imports is equal to lagged trend productivity, i.e.:

(F.5.d) $\Delta \ln(E\_YMP_t) = \Delta \ln(HP\_YMP_{t-1})$.

Third, inserting equations (F.5.a) to (F.5.d) into equation (F.4), yields:

(F.6) $\ln(PXB_t) = \ln(PX_{t-1})$
$- \Delta \ln(1\text{-}NITR_t) + (asp\_l1+asp\_l2)\, \Delta \ln[PX_{t-1}(1\text{-}NITR_{t-1})]$
$+ asp\_l3\, \Delta \ln(PMP_t / HP\_YMP_{t-1})$,

for X = CGGS, CIR, CIG .

Equation (F.6) states that the “rule of thumb” reset price, PXB for X = CGGS, CIR, CIG, is equal to the lagged price, plus the change in the 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:

(F.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 (F.6) can be rewritten as:

(F.7.b) $\ln(PXB_t) = \ln(PX_{t-1}) + \Delta \ln(UX_t)$,

for X = CGGS, CIR, CIG.

2. The 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.:

$$\text{(F.7.c)} \qquad \ln(PXB_t) = \ln(PX_{t-1}) + \Delta \ln(UX_t) \,,$$

with:

$$\text{(F.7.d)} \qquad \Delta \ln(UX_t) = \Delta \ln(PX_{t-1}) \,,$$

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 (F.2) into equation (F.1) yields:

$$\text{(F.8)} \quad \ln(PX_t) = px\_sl \ln(PX_{t-1}) + (1\text{-}px\_sl) \,[\, (1\text{-}px\_sw) \ln(PXR_t) + px\_sw \ln(PXB_t) \,] \,.$$

Inserting equation (F.7) into equation (F.8) yields:

$$\text{(F.9)} \quad \ln(PX_t) = px\_sl \ln(PX_{t-1}) + (1\text{-}px\_sl) \,\{\, (1\text{-}px\_sw) \ln(PXR_t) + px\_sw \ln(PX_{t-1}) \\ + px\_sw \,[\ln(UX_t) - \ln(UX_{t-1})] \,\} \,.$$

Subtracting $\ln(PX_{t-1})$ from both sides and rearranging terms yields:

$$\text{(F.10)} \quad \ln(PX_t) - \ln(PX_{t-1}) = (px\_sl\text{-}1) \,[\ln(PX_{t-1}) - \ln(PXR_{t-1})] \\ + (1\text{-}px\_sl) \,[\ln(PXR_t) - \ln(PXR_{t-1})] - (1\text{-}px\_sl)\, px\_sw \,[\ln(PXR_t) - \ln(PX_{t-1})] \\ + (1\text{-}px\_sl)\, px\_sw \,[\ln(UX_t) - \ln(UX_{t-1})] \,,$$

with UX defined in equation (F.7.a) for X = CGGS, CIR, CIG, and in equation (F.7.d) for X = CIP, MP, XT.

Equation (F.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 the lagged cost push inflation.

Equation (F.10) can be rewritten as:

$$\begin{aligned} \ln(PX_t) - \ln(PX_{t-1}) = {} & (px\_sl-1)\,[\ln(PX_{t-1}) - \ln(PXR_t)] \\ & + (1-px\_sl)\,px\_sw\,[\ln(PX_{t-1}) - \ln(PXR_t)] \\ & + (1-px\_sl)\,px\_sw\,[\ln(UX_t) - \ln(UX_{t-1})]\,, \end{aligned}$$

so that, on collecting terms, we find:

$$\begin{aligned} \text{(F.11)}\quad \ln(PX_t) - \ln(PX_{t-1}) = {} & (1-px\_sl)\,(px\_sw-1)\,[\ln(PX_{t-1}) - \ln(PXR_t)] \\ & + (1-px\_sl)\,px\_sw\,[\ln(UX_t) - \ln(UX_{t-1})]\,, \end{aligned}$$

for X = CH, CGGS, CIR, CIG, CIP, MP, XT.

Note that: $-1 \le (px\_sl - 1) \le 0$, and $0 \le (1 - px\_sl)px\_sw,\ (1 - px\_sl) \le 1$.

As indicated earlier, for most goods the rational reset prices are defined elsewhere (see equations (19), (22), (40.b), and (41) 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 problem 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 (F.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:

$$\begin{aligned} \text{(F.12)}\quad \ln(PCH_{t-1}) - \ln(PCHR_t) = {} & [\ln(PCH_{t-1}) - \ln(PCHR_{t-1})] \\ & - [\ln(PCHR_t) - \ln(PCHR_{t-1})]\,. \end{aligned}$$

We will now make the following assumptions regarding the right hand side variables of equation (F.12). First, if PCH is below its equilibrium level, PCHR, then contemporaneous demand is above steady state supply, and vice versa.

Formally speaking, we have [1]:

(F.13) $[\ln(PCH_{t-1}) - \ln(PCHR_{t-1})] = pch\_s1\ [\ln(ASPO_{t-1}) - \ln(HP\_ASPO_{t-1})]$,

with $pch\_s1 < 0$.

Second, we also assume that the reset price, PCHR, changes in line with secular inflation, G_PCH, i.e.:

(F.14) $[\ln(PCHR_t) - \ln(PCHR_{t-1})] = G\_PCH_t$.

Inserting (F.13) and (F.14) into (F.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 (F.12) yields for PCH:

(F.14.a)
$$\begin{aligned} &\ln(PCH_t) - \ln(PCH_{t-1}) = \\ &(1-pch\_sl)\ (pch\_sw-1)\ pch\_s1\ [\ln(ASPO_{t-1}) - \ln(HP\_ASPO_{t-1})] \\ &- (1-pch\_sl)\ (pch\_sw-1)\ G\_PCH_t \\ &+ (1-pch\_sl)\ pch\_sw\ [\ln(UCH_t) - \ln(UCH_{t-1})]\ , \end{aligned}$$

with UCH defined as:

(F.14.b)
$$\begin{aligned} &\Delta \ln(UCH_t) = - \Delta \ln(1-NITR_t) + (asp\_l1+asp\_l2)\ \Delta \ln(PCH_{t-1}(1-NITR_{t-1})) \\ &+ asp\_l3\ \Delta \ln(PMP_t / HP\_YMP_{t-1})\ , \end{aligned}$$

Equation (F.14.a) explains inflation by the output gap, secular inflation, and cost push inflation.

1. Remember that in the short run supply is determined by demand.

XII Appendix G: An Error Correction Mechanism for Labour and Imports

A. The short run factor demand equations

In this appendix, we derive the short run demand functions for labour and imports [1]. We start from the following autoregressive distributed lag system [2]:

$$
\begin{aligned}
\text{(G.1)}\qquad \ln(Y_t) = {} & y\_s0 + y\_sb\ \ln(ASPO_t) + y\_sb2\ \ln(ASPO_{t-1}) \\
& + y\_s1\ \ln(WRP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + y\_s12\ \ln(WRP_{t-1} / ((1\text{-}NITR_{t-1})\ PASP_{t-1})) \\
& + y\_s2\ \ln(USERIP_t / ((1\text{-}NITR_t) PASP_t)) \\
& + y\_s22\ \ln(USERIP_{t-1} / ((1\text{-}NITR_{t-1}) PASP_{t-1})) \\
& + y\_s3\ \ln(PMP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + y\_s32\ \ln(PMP_{t-1} / ((1\text{-}NITR_{t-1})\ PASP_{t-1})) \\
& + y\_s4\ \ln(NPO_t) + y\_s42\ \ln(NPO_{t-1}) + y\_sg\ \ln(Y_{t-1}),
\end{aligned}
$$

with: $Y = NP, MPO$ and $y = np, mpo$.

On rearranging terms, equation (G.1) can be rewritten as:

$$
\begin{aligned}
\text{(G.2)}\ \ln(Y_t) - \ln(Y_{t-1}) = {} & y\_s0 + y\_sb\ [\ln(ASPO_t) - \ln(ASPO_{t-1})] \\
& + (y\_sb+y\_sb2)\ \ln(ASPO_{t-1}) \\
& + y\_s1\ [\ln(WRP_t / ((1\text{-}NITR_t) PASP_t)) - \ln(WRP_{t-1} / ((1\text{-}NITR_{t-1}) PASP_{t-1}))] \\
& + (y\_s1+y\_s12)\ \ln(WRP_{t-1} / ((1\text{-}NITR_{t-1}) PASP_{t-1})) \\
& + y\_s2\ [\ln(USERIP_t / ((1\text{-}NITR_t) PASP_t)) - \ln(USERIP_{t-1} / ((1\text{-}NITR_{t-1}) PASP_{t-1}))] \\
& + (y\_s2+y\_s22)\ \ln(USERIP_{t-1} / ((1\text{-}NITR_{t-1}) PASP_{t-1})) \\
& + y\_s3\ [\ln(PMP_t / ((1\text{-}NITR_t)\ PASP_t)) - \ln(PMP_{t-1} / ((1\text{-}NITR_{t-1}) PASP_{t-1}))] \\
& + (y\_s3+y\_s32)\ \ln(PMP_{t-1} / ((1\text{-}NITR_{t-1})\ PASP_{t-1})) \\
& + y\_s4\ [\ln(NPO_t) - \ln(NPO_{t-1})] + (y\_s4+y\_s42)\ \ln(NPO_{t-1}) \\
& + (y\_sg-1)\ \ln(Y_{t-1})\,.
\end{aligned}
$$

1. The partial adjustment scheme for gross fixed capital formation is derived in Chapter III, Section C.2.c.
2. For the sake of argument we restrict the number of lags to one, though longer lags could also be considered.

For relations (10.a) and (10.c) of the main text to hold in the long run, i.e. when there is no change in the predetermined variables [1]:

$$\ln(Y_t) = \ln(Y_{t-1}) \,,$$

$$\ln(WRP_t) = \ln(WRP_{t-1}) \,,$$

$$\ln(PASP_t) = \ln(PASP_{t-1}) \,,$$

$$\ln(USERIP_t) = \ln(USERIP_{t-1}) \,,$$

$$\ln(PMP_t) = \ln(PMP_{t-1}) \,,$$

$$\ln(NPO_t) = \ln(NPO_{t-1}) \,,$$

the following restrictions have to be imposed on the parameters of equation (G.2).

For labour demand, NP, we have:

(G.3.a) np_s0 = - np_sl ln(asp_l1) ,

(G.3.b) (np_sb + np_sb2) = - np_sl ,

(G.3.c) (np_s1 + np_s12) = np_sl ,

(G.3.d) (np_s2 + np_s22) = 0 ,

(G.3.e) (np_s3 + np_s32) = 0 ,

(G.3.f) (np_s4 + np_s42) = 0 ,

(G.3.g) (np_sg - 1) = np_sl ,

and for import demand, MPO, we have:

(G.4.a) mp_s0 = - mp_sl ln(asp_l3) ,

(G.4.b) (mp_sb + mp_sb2) = - mp_sl ,

(G.4.c) (mp_s1 + mp_s12) = 0 ,

(G.4.d) (mp_s2 + mp_s22) = 0 ,

(G.4.e) (mp_s3 + mp_s32) = mp_sl ,

(G.4.f) (mp_s4 + mp_s42) = 0 ,

(G.4.g) (mp_sg - 1) = mp_sl .

1. See Section B of this appendix for the case where there is steady state growth.

Inserting restrictions (G.3.a) to (G.3.g) and (G.4.a) to (G.4.g) into equation (G.2) yields the following short run labour demand equation:

$$
\begin{aligned}
\text{(G.5.a)}\quad \Delta\ \ln(NP_t) = {} & np\_sb\ \Delta\ \ln(ASPO_t) \\
& + np\_s1\ \Delta\ \ln(WRP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + np\_s2\ \Delta\ \ln(USERIP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + np\_s3\ \Delta\ \ln(PMP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + np\_sl\ [\ \ln(NP_{t-1}) - \ln(asp\_l1\ ASPO_{t-1}\ PASP_{t-1}\ (1\text{-}NITR_{t-1}) / WRP_{t-1})\ ] \\
& + np\_s4\ [\ \ln(NPO_t) - \ln(NPO_{t-1})\ ]\ .
\end{aligned}
$$

Similarly, we find the following equation for imports:

$$
\begin{aligned}
\text{(G.5.b)}\quad \Delta\ \ln(MPO_t) = {} & mp\_sb\ \Delta\ \ln(ASPO_t) \\
& + mp\_s1\ \Delta\ \ln(WRP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + mp\_s2\ \Delta\ \ln(USERIP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + mp\_s3\ \Delta\ \ln(PMP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + mp\_sl\ [\ \ln(NP_{t-1}) - \ln(asp\_l3\ ASPO_{t-1}\ PASP_{t-1}\ (1\text{-}NITR_{t-1}) / WRP_{t-1})\ ] \\
& + mp\_s4\ [\ \ln(NPO_t) - \ln(NPO_{t-1})\ ]\ .
\end{aligned}
$$

Equations (G.5.a) and (G.5.b) describe a standard error correction mechanism. However, if we want employment and imports to be in line with steady state growth of population and productivity, then we have to impose the following additional restrictions.

Restrictions for labour demand:

$$\text{(G.6.a)}\quad np\_s4 + np\_sb = 1\ ,$$

$$\text{(G.6.b)}\quad np\_s1 + np\_s2 + np\_s3 + np\_sb = 0\ ,$$

and for imports:

$$\text{(G.7.a)}\quad mp\_s4 + mp\_sb = 1\ ,$$

$$\text{(G.7.b)}\quad mp\_s1 + mp\_s2 + mp\_s3 + mp\_sb = 0\ .$$

In the following two sections we will show how restrictions (G.6.a) to (G.6.b) and (G.7.a) to (G.7.b) are derived.

Inserting equations (G.6.a) to (G.6.b) and (G.7.a) to (G.7.b) into equations (G.5.a) to (G.5.b) yields the following equation for labour demand:

$$\text{(G.8.a)} \quad \Delta \ln(NP_t) = np\_sb \; \Delta \ln(ASPO_t)$$
$$+ np\_s1 \; \Delta \ln(WRP_t / ((1-NITR_t) \; PASP_t))$$
$$+ np\_s2 \; \Delta \ln(USERIP_t / ((1-NITR_t) \; PASP_t))$$
$$+ (-np\_sb-np\_s1-np\_s2) \; \Delta \ln(PMP_t / ((1-NITR_t) \; PASP_t))$$
$$+ np\_sl \, [\ln(NP_{t-1}) - \ln(asp\_l1 \; ASPO_{t-1} \; PASP_{t-1} \, (1-NITR_{t-1}) / WRP_{t-1})]$$
$$+ (1-np\_sb) \; G\_NPO_t \, ,$$

where G_NPO is the trend growth rate of population.

Similarly, for imports we find:

$$\text{(G.8.b)} \quad \Delta \ln(MPO_t) = mp\_sb \; \Delta \ln(ASPO_t)$$
$$+ mp\_s1 \; \Delta \ln(WRP_t / ((1-NITR_t) \; PASP_t))$$
$$+ mp\_s2 \; \Delta \ln(USERIP_t / ((1-NITR_t) \; PASP_t))$$
$$+ (-mp\_sb-mp\_s1-mp\_s2) \; \Delta \ln(PMP_t / ((1-NITR_t) \; PASP_t))$$
$$+ mp\_sl \, [\ln(MPO_{t-1}) - \ln(asp\_l3 \; ASPO_{t-1} \; PASP_{t-1} \, (1-NITR_{t-1}) / PMP_{t-1})]$$
$$+ (1-mp\_sb) \; G\_NPO_t \, .$$

B. Factor demand and steady state growth

In this section we show how we derived restrictions (G.6.a), (G.6.b) and (G.7.a) and (G.7.b).

1. Productivity growth

Consider a steady state with zero secular inflation, G_PCH, zero population growth, G_NPO, and factor productivity growth, G_YNP, equal to x percent, i.e.:

$$\text{(G.9.a)} \quad G\_PCH = 0 \, ,$$
$$\text{(G.9.b)} \quad G\_NPO = 0 \, ,$$
$$\text{(G.9.c)} \quad G\_YNP = G\_YCP = G\_YMP = x \, .$$

In the steady state, employment is at its steady state level, i.e.:

$$NP_{t-1} = NP_t = NP_{t+1} = HP\_NP \, ,$$

or,

$$\text{(G.9.d)} \quad \Delta \ln(NP_t) = 0 \quad \text{and} \quad \Delta \ln(HP\_NP) = 0 \, .$$

In this case, output and factor prices grow at the steady state productivity growth rate, i.e. [1]:

(G.9.e) $\Delta\ \ln(ASPO_t) = G\_YNP$,

(G.9.f) $\Delta\ \ln(WRP_t / ((1\text{-}NITR_t)\ PASP_t)) = G\_YNP$,

(G.9.g) $\Delta\ \ln(USERIP_t / ((1\text{-}NITR_t)\ PASP_t)) = G\_YNP$,

(G.9.h) $\Delta\ \ln(PMP_t / ((1\text{-}NITR_t)\ PASP_t)) = G\_YNP$,

Inserting conditions (G.9.a) to (G.9.h) into equation (G.5.a) and rearranging terms yields [2]:

(G.10) $\ln(NP) = \ln(HP\_NP) + (np\_sb+np\_s1+np\_s2+np\_s3) / np\_sl\ G\_YNP$.

It follows that if:

(G.11) $(np\_sb+np\_s1+np\_s2+np\_s3)\ G\_YNP = 0$,

then we get in the steady state that: $\ln(NP) = \ln(HP\_NP)$.

Hence, if $G\_YNP \neq 0$, condition (G.11) requires that:

(G.12) $np\_sb + np\_s1 + np\_s2 + np\_s3 = 0$.

In other words, condition (G.12) is a restriction on the parameters that has to be met if one wants that the steady state be attained when productivity grows at its steady state rate. A similar result holds for imports.

2. Population growth

Consider now a steady state with zero secular inflation, G_PCH, zero productivity growth, G_YNP, and population growth, G_NPO, equal to x percent:

(G.13.a) $G\_PCH = 0$,

(G.13.b) $G\_YNP = 0$,

(G.13.c) $G\_NPO = x$.

1. See equations (C.13.b) and (C.19) of Appendix C.
2. Note also that in the steady state, the second part of the error correction term is equal to HP_NP.

In the steady state, labour supply [1] and output grow at the steady state population rate [2]:

(G.13.d) $\Delta\ \ln(NP_t) = G\_NPO$,

(G.13.e) $\Delta\ \ln(ASPO_t) = G\_NPO$,

while real factor prices remain constant, i.e.:

(G.13.f) $\Delta\ \ln(WRP_t / ((1\text{-}NITR_t)\ PASP_t)) = 0$,

(G.13.g) $\Delta\ \ln(USERIP_t / ((1\text{-}NITR_t)\ PASP_t)) = 0$,

(G.13.h) $\Delta\ \ln(PMP_t / ((1\text{-}NITR_t)\ PASP_t)) = 0$.

Inserting equations (G.13.a) to (G.13.i) into equation (G.5.a) and rearranging terms yields:

(G.14) $\ln(NP) = \ln(HP\_NP) + (np\_sb+np\_s4\text{-}1) / np\_sl\ G\_NPO$.

Hence, the condition that in the steady state:

$$\ln(NP) = \ln(HP\_NP) ,$$

requires that:

(G.15) $(np\_sb+np\_s4\text{-}1)\ G\_NPO = 0$.

If $G\_YNP > 0$, then condition (G.15) is only met if:

(G.16) $np\_sb + np\_s4 = 1$.

1. The unemployment rate is defined as: (G.17) $UR = (LS\text{-}NP\text{-}NG) / LS$. In the steady state, the unemployment rate is at its steady state rate, i.e.: (G.18) $UR = HP\_UR$. From equations (G.17) and (G.18), we derive: (G.19) $LS\ (1\text{-}HP\_UR) = NP + NG$, or in growth rates:
   (G.20) $\Delta\ \ln(LS) + \Delta\ \ln(1\text{-}HP\_UR) = \Delta\ \ln(NP+NG)$.
   Assuming that in the steady state:
   (G.21.a) $\Delta\ \ln(1\text{-}HP\_UR) = 0$,
   (G.21.b) $\Delta\ \ln(LS) = G\_NPO$,
   (G.21.c) $\Delta\ \ln(NG) = G\_NPO$,
   from equation (G.20) we find: $\Delta\ \ln(NP) = \Delta\ \ln(NPO) = G\_NPO$.
2. See next section.

C. The error correction mechanism of labour demand

In the medium run, the demand for labour is determined by:

(G.22) $\ln(NP) = \ln(asp\_l1) + \ln(ASPO) + \ln[PASP\ (1\text{-}NITR)] - \ln(WRP)$

or, adding and subtracting HP_NP and HP_ASPO and rearranging terms:

$$\ln(NP) = \ln\left(\frac{ASPO}{HP\_ASPO}\right) + \ln(asp\_l1\ \frac{HP\_ASPO}{HP\_NP}) - \ln\left(\frac{WRP}{PASP\ (1-NITR)}\right) + \ln(HP\_NP)\ ,$$

or, using equation (13) of the main text:

(G.23) $$\ln(NP) - \ln(HP\_NP) = [\ \ln(ASPO) - \ln(HP\_ASPO)\ ] + [\ \ln(asp\_l1\ HP\_YNP) - \ln\left(\frac{WRP}{PASP\ (1-NITR)}\right)]\ .$$

Equation (G.23) states that contemporaneous employment deviates from its natural rate to the extent that output deviates from its natural level, and that the real wage deviates from marginal productivity.

Assuming that in the steady state:

(G.24.a) $ASPO = HP\_ASPO\ ,$

and that:

(G.24.b) $\ln\left(\frac{WRP}{PASP\ (1-NITR)}\right) = \ln(asp\_l1\ HP\_YNP)\ ,$

equation (G.23) can be rewritten as:

(G.25) $\ln(NP) = \ln(HP\_NP)\ ,$

i.e., in the steady state, when conditions (G.24.a) and (G.24.b) are met, employment is equal to its steady state level.

Using steady state condition (G.25), equation (G.8.a) can be rewritten as:

$$
\begin{aligned}
\text{(G.26)}\quad \Delta \ln(NP_t) = {} & np\_sb\ \Delta \ln(ASPO_t) \\
& + np\_s1\ \Delta \ln(WRP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + np\_s2\ \Delta \ln(USERIP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + (\text{-}np\_sb\text{-}np\_s1\text{-}np\_s2)\ \Delta \ln(PMP_t / ((1\text{-}NITR_t)\ PASP_t)) \\
& + np\_sl\ [\ \ln(NP_{t-1}) - \ln(HP\_NP_{t-1})\ ] \\
& + (1\text{-}np\_sb)\ G\_NPO_t\ .
\end{aligned}
$$

XIII Appendix H: A Partial Adjustment Scheme for Gross Fixed Capital Formation by the Enterprise Sector

On taking differences of both sides of equation (37.a) of the main text, and dividing both sides by $\frac{GIPO_t}{NPO_t}$, we obtain [1]:

$$\text{(H.1)} \quad \Delta \ln\left(\frac{GIPO_t}{NPO_t}\right) =$$

$$\text{cip\_l1}\ \Delta \ln\left(\frac{CIPOL_t}{NPO_t}\right) - \text{cip\_l2 (1-gip\_rh)}\ \Delta \ln\left(\frac{CIPOL_{t-1}}{NPO_{t-1}}\right)$$

$$+ \text{cip\_l3}\ \Delta \ln\left(\frac{GIPO_{t-1}}{NPO_{t-1}}\right)$$

$$+ \text{cip\_sb}\ \Delta\Delta \ln\left(\frac{ASPO_t}{NPO_t}\right) - \text{cip\_sb (1-gip\_rh)}\Delta\Delta \ln\left(\frac{ASPO_{t-1}}{NPO_{t-1}}\right)$$

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

$$- \text{cip\_s1 (1-gip\_rh)}\ \Delta\Delta \ln\left(\frac{WRP_{t-1}}{(1-NITR_{t-1})PASP_{t-1}}\right)$$

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

$$- \text{cip\_s2 (1-gip\_rh)}\ \Delta\Delta \ln\left(\frac{USERIP_{t-1}}{(1-NITR_{t-1})PASP_{t-1}}\right)$$

$$+ \text{cip\_s3}\ \Delta\Delta \ln\left(\frac{PMP_t}{(1-NITR_t)PASP_t}\right)$$

$$- \text{cip\_s3 (1-gip\_rh)}\ \Delta\Delta \ln\left(\frac{PMP_{t-1}}{(1-NITR_{t-1})PASP_{t-1}}\right),$$

1. Use has been made of the fact that, at the limit, $\Delta \ln(X) = d \ln(X) = dX/X$.

with the parameters of equation (H.1) defined as:

(H.2.a) $cip\_l1 = gip\_l\ (CIPOL_t / GIPO_t)$,

(H.2.b) $cip\_l2 = gip\_l\ (CIPOL_{t-1} / GIPO_t)\ (NPO_t / NPO_{t-1})$,

(H.2.c) $cip\_l3 = (1\text{-}gip\_l)\ (GIPO_{t-1} / GIPO_t)\ (NPO_t / NPO_{t-1})$,

(H.2.d) $cip\_sb = gip\_sb\ (NPO_t / GIPO_t)$,

(H.2.e) $cip\_s1 = gip\_s1\ (NPO_t / GIPO_t)$,

(H.2.f) $cip\_s2 = gip\_s2\ (NPO_t / GIPO_t)$,

(H.2.g) $cip\_s3 = (-gip\_sb - gip\_s1 - gip\_s2)\ (NPO_t / GIPO_t)$.

Remember that the long run capital stock is defined as:

$$CIPOL_t = asp\_l2\ ASPO_t\ (1\text{-}NITR_t)\ PASP_t / USERIP_t\ .$$

This implies that the short run elasticity of output, ASPO, is equal to [1]:

(H.3.a) $cip\_l1 + cip\_sb$
$= gip\_l\ (CIPOL_t / GIPO_t) + gip\_sb\ (NPO_t / GIPO_t)$,

and of the user cost of capital, USERIP, equal to:

(H.3.b) $-cip\_l1 + cip\_s2$
$= -gip\_l\ (CIPOL_t / GIPO_t) + gip\_s2\ (NPO_t / GIPO_t)$.

1. Remember that $\Delta\ \Delta\ \ln(X_t) = \Delta\ [\ln(X_t) - \ln(X_{t-1})] = \Delta\ \ln(X_t) - \Delta\ \ln(X_{t-1})$.

For the wage rate, WRP, and the import price, PMP, the short run elasticities are, respectively:

(H.3.c) $\quad$ cip_s1 = gip_s1 $(NPO_t / GIPO_t)$,

and

(H.3.d) $\quad$ cip_s3 = (-gip_sb-gip_s1-gip_s2) $(NPO_t / GIPO_t)$,

The point estimates, standard errors between brackets, and diagnostic statistics of equation (37.a) are shown in Table H1. If no standard error is shown, then the point estimate has been fixed at the unrestricted point estimate plus (or minus) two times the standard error, except for the rate of deprecation, gip_rh, which has been calculated in Appendix D, Section C.

TABLE H1 - Gross fixed capital formation of the enterprise sector, GIPO

	EU	NE	US	JP
Short run elasticities				
Output	0.78	1.02	0.84	0.59
Real wage	-0.60	0.32	-0.06	-0.38
Real user cost of capital	-0.13	-0.98	-0.71	-0.27
Real import price	-0.04	-0.36	-0.07	0.05
Technical coefficients				
gip_l	0.04	0.04	0.06	0.02
	(0.02)	-.-	(0.03)	-.-
gip_rh	0.07	0.05	0.06	0.06
	-.-	-.-	-.-	-.-
gip_sb	0.54	3.69	0.33	225.25
	(0.73)	(4.26)	(1.06)	(356.72)
gip_s1	-0.94	2.64	-0.14	-192.83
	(0.57)	(2.99)	(1.45)	(322.39)
gip_s2	0.46	-3.36	-0.03	-60.12
	(0.28)	-.-	(0.71)	-.-
Diagnostic statistics				
Adj. R	0.91	0.87	0.76	0.92
Durbin - Watson	0.97	0.75	0.93	0.89

XIV References

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