S3BE: A small supply-side model for the Belgian economy

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Abstract

The Federal Planning Bureau produces model-based short-term macroeconomic forecasts and medium-term projections for the Belgian economy. It also constructs long-term scenarios of age-related budgetary expenditures on behalf of the Study Group on Ageing. However, in this context, the underlying scenario regarding productivity and employment growth beyond the medium-term horizon is generated using an ad-hoc methodology. This working paper presents a new small supply-side model for the Belgian economy, developed in view of producing long-term macroeconomic scenarios.

Keywords: Long-term projection, supply side, economic growth

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1. Introduction

The Federal Planning Bureau (FPB) uses the quarterly macro-econometric model MODTRIM (Hertvedt and Lebrun, 2003) to produce its short-term forecasts and the annual multi-industry model HERMES (Bossier et. al., 2004) for its medium-term projections. In both cases, output is determined essentially by the level of aggregate demand. For projections over a longer horizon, more emphasis has to be put on supply-side factors (Carnot et. al, 2004). In order to evaluate the level of potential output, international institutions such as the OECD (Giorni et. al., 1995) or the European Commission (Denis et. al., 2006) have developed methodologies that rely on a production function. The CPB Netherlands Bureau for Economic Policy has also elaborated its own methodology to assess the growth potential of the Dutch economy (Draper et. al., 2001). Gradual refinements have led to the construction of a true structural model of wage bargaining, price setting and labour demand for the Netherlands (Broer et. al, 2006). This model, based upon assumptions regarding the evolution of supply-side conditions, serves as an anchor for the medium-term scenario (CPB, 2006). A similar approach is used by the OECD to construct its so-called medium-term baseline (Beffy et. al., 2006).

The FPB constructs long-term scenarios of age-related budgetary expenditures on behalf of the Study Group on Ageing (Conseil Supérieur des Finances, 2008). However in this context, the underlying macro-economic assumptions regarding productivity and employment growth beyond the medium-term horizon are generated using a normative scenario. In order to fill this methodological gap, the FPB decided to construct a small supply-side model, complementary to its two larger macro-econometric models, with the objective of working out long-term macro-economic scenarios.

Based upon the seminal work of the CPB, this paper presents a small supply-side model estimated on Belgian data. Chapter 2 details the theoretical framework. In product markets, firms face monopolistic competition and a CES technology. In the labour market, trade unions and employers bargain according to a “right-to-manage” model. Combining the labour share deduced from profit maximization with the one originating from the wage bargaining process provides an expression for the equilibrium rate of unemployment. By introducing real rigidities, a concept of the unemployment rate depending upon the level of the capital-output ratio is derived. Chapter 3 describes the strategy adopted to estimate the main structural parameters and presents the econometric results. The following chapter provides the full set of equations of the model in its steady-state and dynamic version and shows that it can be solved recursively. The model properties are examined in chapter 5 by imposing a number of exogenous shocks. Chapter six concludes by summarising the main features of the model and discussing future model applications.

2. The theoretical framework

The core of the model consists of labour and capital demand equations, a price and a wage equation. As will be shown in chapter 4, the model is completed by a set of auxiliary relationships.

2.1. The product market

Following the specifications proposed by Draper et. al. (2001), we assume that the firms' technology is characterized by a CES production function with two input factors (labour and capital), labour-augmenting technical progress and constant returns to scale:

$$Y = \beta^{-1}\left[\theta^{1/\sigma} L_e^{(\sigma-1)/\sigma} + (1-\theta)^{1/\sigma} K^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \tag{1}$$

where Y represents value added at constant prices, L_e employment in efficiency units, K the capital stock, β the scale parameter, θ the distribution parameter and σ the elasticity of substitution between labour and capital, with:

$$L_e = Lhe^{vl} \tag{2}$$

where L stands for labour inputs per capita, h the average working time et vl technical progress improving labour efficiency[3].

Given the production function (1), the minimal total cost function C can be specified as follows:

$$C = \beta Yc \tag{3}$$

$$c = \left[\theta p_l^{1/\sigma} + (1-\theta) \; p_k^{1/\sigma}\right]^{1/(\sigma-1)} \tag{4}$$

where c denotes the minimal unit cost index, p_l the labour cost expressed in efficiency units and p_k the capital cost. With:

$$p_l = \frac{w}{he^{vl}} \tag{5}$$

where w represents the nominal wage cost per worker.

[3] This is a common assumption in growth theory, taking as a starting point that capital accumulation generally goes along with an increase in capital deepening.

Minimization of total production costs by firms leads to the following expressions for demand for labour and capital:

$$\ln L = \ln\beta + \ln\theta + \ln Y - \sigma\ln\left(\frac{p_l}{c}\right) - vl \quad (6)$$

$$\ln K = \ln\beta + \ln(1-\theta) + \ln Y - \sigma\ln\left(\frac{p_k}{c}\right) \quad (7)$$

Profit maximization under monopolistic competition implies a price of value added *p* obtained as a mark-up *M* over marginal costs[4] given by βc:

$$\ln p = \ln M + \ln\beta c \quad (8)$$

2.2. Wage determination

Following Draper et. al. once again, we postulate that wages are set according to a bargaining process of the "right-to-manage" type between employers and employees. In its linearized version the wage equation can be written as:

$$\ln w = \chi_0 + \ln\frac{Y}{L} + \ln p + \chi_1 \ln wedge + \chi_2 \ln rp - \chi_3 u \quad (9)$$

where *w* denotes the nominal wage cost per worker, *wedge* the tax wedge, *i.e.* the ratio between the real wage cost borne by the firm and the real take-home wage for the worker, *rp* the replacement rate, *i.e.* the ratio between unemployment benefits and take-home wage, and *u* the unemployment rate.

2.3. The unemployment rate

2.3.1. The equilibrium rate of unemployment

To determine the equilibrium unemployment rate, we follow once more Draper et. al. On the one hand, equation (7) can be rewritten as:

$$\frac{p_k K}{\beta c Y} = (1-\theta)\left(\frac{p_k}{c}\right)^{1-\sigma} \quad (10)$$

4 The minimal average cost given by (4) will be equal to the marginal costs at the optimum.

Or by expressing its complement to one, we obtain the following equation:

$$\frac{wL}{\beta cY} = 1 - (1-\theta)\left(\frac{p_k}{c}\right)^{1-\sigma} \tag{11}$$

By substituting (8) in (11) we derive an expression for the equilibrium labour income share:

$$\frac{wL}{pY} = \left(1 - (1-\theta)\left(\frac{p_k}{c}\right)^{1-\sigma}\right)M^{-1} \tag{12}$$

This equation describes the labour share at the optimum for the firms, i.e. the wage share that guarantees the expected return (defined by the mark-up) to the firms given the capital cost.

On the other hand, equation (9) can be easily rewritten as:

$$\ln\frac{wL}{pY} = \chi_0 + \chi_1 \ln wedge + \chi_2 \ln rp - \chi_3 u \tag{13}$$

This equation can be interpreted as the outcome of the bargaining process in terms of labour income share.

Suppose now that this share is above the optimum given by equation (12). The actual return is in this case below the expected one and layoffs will occur. The rise in unemployment will erode the union's bargaining power and will consequently temper wage evolutions until the labour share reaches its optimum. The unemployment rate will, at this point, correspond to its equilibrium level, *i.e.* the level satisfying both equations (12) and (13):

$$u^* = \frac{1}{\chi_3}\left[\chi_0 + \chi_1 \ln wedge + \chi_2 \ln rp + \ln M - \ln\left(1-(1-\theta)\left(\frac{p_k}{c}\right)^{1-\sigma}\right)\right] \tag{14}$$

Equation (14) shows that the unemployment rate will be driven up (down) following an increase (decrease) in the tax wedge, the mark-up or the real cost of capital[5].

With a free allocation of production factors, the quantity demanded of a factor will depend upon its price. Applied to the capital demand equation (7), causality runs from the user cost to the demand for capital in such a way that the optimal level for the capital stock satisfies the condition that its marginal productivity equals its user cost. The latter depends, in its most simple form, upon the deflator of corporate investments *piq*, the depreciation rate of capital δ and the discount rate τ[6]:

5 An increase (decrease) in the user cost of capital will indeed induce a rise (decline) in unemployment rate as long as $\sigma<1$. As is shown in the next chapter, this condition is satisfied at an empirical level.

6 See for instance the specification used in the LABMOD model (Hendrickx et. al., 2003).

$$p_k = f\left(piq, \delta, \tau\right) \qquad (15)$$

The equilibrium unemployment rate is given by the combination of equations (14) and (15).

2.3.2. The unemployment rate in transitional dynamics

Most structural approaches to measure potential GDP (Denis et. al, op. cit. or CPB, 2006) use the existing level of the capital stock and not its optimal level to calculate the contribution of capital inputs. Given the existence of real rigidities, it is very likely that the effective capital stock does not correspond to its desired level at every moment in time. The shadow price of the existing capital stock[7] will, under these circumstances, not necessarily equal its user cost. The causality expressed by the left and right-hand side of equation (7) will be reversed if the level of the capital stock is given.

Because each input factor in the production function exhibits diminishing returns[8], the capital stock and its shadow price will move in opposite directions. Thus, if the existing capital stock is below its optimum then its marginal productivity will exceed the user cost of capital as defined by equation (15). Firms facing this situation will invest up to the point where the shadow price once again equals the user cost of capital and the capital stock will return to its optimum.

During the adjustment period, equation (7) will determine the evolution of the shadow price of capital as follows:

$$p_k = c\left((1-\theta)^{1/\sigma} \beta^{1/\sigma} \left(\frac{K}{Y}\right)^{-(1/\sigma)} \right) \qquad (16)$$

Equation (16) indicates that the shadow price of capital and the capital-output ratio will move in opposite directions. The unemployment rate in transitional dynamics corresponds to the rate defined by expression (14) but where the cost of capital is now given by equation (16) instead of (15).

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[7] The shadow price is defined as the value of its marginal productivity.

[8] A production function with constant returns to scale will exhibit diminishing marginal products to each of the inputs (Barro and Sala-i-Martin, 2004).

3. Estimation of structural parameters on Belgian data

Before describing the full model in the next chapter, we will expose the strategy adopted to estimate the main structural parameters and present the econometric results.

3.1. The estimation strategy

The set of parameters included in the equations presented in the theoretical part of the previous chapter may be estimated using a system of equations made up of the labour demand equation, the price equation and the wage equation. The equation for capital demand could in principle be added to the system. But because the capital stock and the user cost of capital are measured rather inaccurately, it is a fairly common procedure to impose the coefficients resulting from the estimation of the labour demand equation onto the capital demand equation (CPB, 2003). The simultaneous estimation of the labour demand and price equation nonetheless requires a preliminary stage consisting in the computation of the labour efficiency series which is not directly observable. In order to do so, we adopt the non parametric method proposed by Broer et. al. (2006). Starting with a linearized version of the production function:

$$\ln Y = \lambda \ln L_e + (1-\lambda)\ln K \tag{17}$$

and replacing L_e by its expression given by (2), we obtain :

$$\ln Y = \lambda \ln(LH) + (1-\lambda)\ln K + \lambda vl \tag{18}$$

where λvl stands for total factor productivity.

Labour efficiency vl may now be computed as a residual:

$$vl = \frac{1}{\lambda}\ln Y - \ln(LH) - \frac{(1-\lambda)}{\lambda}\ln K \tag{19}$$

The parameter λ may be approximated by dividing compensation of employees by value added at current prices. The structural component of labour efficiency, called vl^*, may then be defined as the series obtained from equation (19) smoothed with the Hodrick-Prescott filter[9]. The wage cost in efficiency units may consequently be calculated as:

$$p_l = \frac{w}{he^{vl^*}} \tag{20}$$

9 A traditional method that is used to reduce the sensitivity of the filter to revisions and additional observations (the so-called "end-point bias") consists in extending the historical series with forecasts. Considering the unusually high degree of uncertainty surrounding the forecasts for 2009-2010, we chose to restrict our sample extension to 2008.

3.2. The estimated system of equations

The first equation corresponds to the labour demand equation (6) where the minimal unit cost has been replaced by its CES form given by (4) and labour efficiency computed as described in the previous section:

$$\ln L = \ln \beta + \ln \theta + \ln Y - \sigma \ln\left(p_l \,/ \left(\theta p_l^{1/\sigma} + (1-\theta)\;\; p_k^{1/\sigma}\right)^{1/(\sigma-1)} \right) - vl^* \tag{21}$$

The second equation is equal to the value added price equation (8) where the minimal unit cost has been replaced by its CES combination (4) and where the mark-up *M* is composed of a constant μ_0 plus a variable part depending upon the gap between domestic costs and the price charged by foreign competitors p_{fc}:

$$\ln p = \ln \mu_0 + \mu_1\left(\ln p_{fc} - \ln \beta\left(\theta p_l^{1/\sigma} + (1-\theta)\;\; p_k^{1/\sigma}\right)^{1/(\sigma-1)} \right) + \ln \beta\left(\theta p_l^{1/\sigma} + (1-\theta) p_k^{1/\sigma}\right)^{1/(\sigma-1)} \tag{22}$$

The third equation corresponds to the wage equation (9) adapted to match the specification proposed for Belgium by Hendrickx et al. (2003) for the LABMOD model:

$$\ln w = \ln \frac{Y}{L} + \ln p + \chi_1 \ln twedge + \chi_2 \ln rp - \chi_3 u_{-4} \tag{23}$$

By defining *te* as the combined rate for personal-income taxes and employees' social-security contributions (difference between gross and take-home wage expressed relative to the net wage), *tlsub* as the wage subsidy rate (wage subsidies expressed relative to the wage cost before subsidy deductions), *td* as the rate for employers' social-security contributions (difference between wage cost and gross wage relative to the wage cost before subsidy deductions) and *pc* as the private consumption deflator, the tax wedge can be written as[10] :

$$wedge = \frac{(1+te)(1-tlsub)pc}{(1-td)p} \tag{24}$$

$$twedge = \frac{wedge - 1}{wedge} \tag{25}$$

With such a transformation, it is no longer necessary to introduce a constant in equation (23) and the computation of the elasticity of the wage cost to its wedge becomes straightforward (see Hendrickx et al., op. cit., page 22). Following the same authors we introduce the unemployment rate with a lag of four quarters.

[10] Formal derivation of equation (24) is provided in annex.

3.3. The econometric estimation results

Data used for the econometric estimation come from the data base of the quarterly model MODTRIM of the Federal Planning Bureau (Hertveldt et Lebrun, 2003) and relate to the business sector, employees and self-employed excluding specific subsidized categories of employment. The concepts of wage cost and tax wedge that are used include the impact of wage subsidies.

Simultaneous estimation of the system of equations (21), (22) and (23) was performed on the sample from 1985Q1 to 2007Q4 using the SURE (Seemingly Unrelated REgression) method and imposing the cross-equation restrictions. Results are presented by equation in Tables 1, 2 and 3, without repeating in Table 2 the coefficients that already appear in the previous table. Two versions are given below. The second one is unrestricted and provides a not very credible value for the mark-up, in comparison to the value obtained for the Netherlands. By restricting the value of the distribution parameter θ to the average share of compensation of employees in value added[11], the value for the mark-up becomes more realistic without deteriorating the overall quality of the estimation. These results are given in line 1 and these are the ones we will comment upon.

By authorizing a level shift during the fourth quarter of 1994, we obtain a satisfactory statistical fit for the labour demand equation and a value for the elasticity of substitution between capital and labour around 0.5, which is comparable to results found in other empirical studies on Belgian data (Federal Planning Bureau, 2006). If no level shift is introduced, the equation generates a systematic underestimation of employment before 1995 and an overestimation thereafter, causing a downward bias to the elasticity of substitution.

Table 1 - Labour demand equation (21)

	β	β'	θ	σ	R^2	se	DW	DF
1. Restricted	0.92	0.89	0.66	0.52	0.97	0.008	0.49	-4.03
	(0.002)	(0.001)	(-)	(0.04)				
2. Unrestricted	0.76	0.74	0.79	0.64	0.97	0.008	0.51	-4.04
	(0.03)	(0.02)	(0.03)	(0.08)				

Notes: β : value for the period 1985Q1-1994Q3 ; β' : value for the period 1994Q4-2007Q4.
The standard error of the coefficients is given in brackets.

As Table 2 indicates, it is necessary to introduce a level shift in the fixed part of the mark-up from 2004 onwards to account for the slower evolution of the indicator of the labour cost in efficiency units relative to the value added price. The results also indicate a significant impact on the mark-up of the price of foreign competitors.

[11] Note that this restriction is an approximation because the distribution coefficient is strictly equal to the wage share only if the elasticity of substitution tends to one, see Arpaia et Pérez Ruiz (2008).

Table 2 - Value added price equation (22)

	μ_o	μ_0'	μ_1	R^2	se	DW	DF
1. Restricted	1.13	1.17	0.04	0.99	0.02	0.35	-3.61
	(0.002)	(0.004)	(0.006)				
2. Unrestricted	1.36	1.42	0.02	0.98	0.02	0.40	-3.66
	(0.04)	(0.05)	(0.006)				

Notes: μ_0 : value for the period 1985Q1-2003Q4 ; μ_0' : value for the period 2004Q1-2007Q4.
The standard error of the coefficients is given in brackets.

As mentioned previously, the specification for the wage equation does not require in principle the addition of a constant. Nonetheless, the notorious instability of this type of relationship for Belgium forced us to introduce binary variables on two sub-periods to obtain stationary residuals. As the coefficient associated with the replacement rate was small and had the wrong sign, it was restricted to zero. Note that the estimated values for the coefficients associated with the tax wedge and the unemployment rate are slightly higher than the ones obtained by Hendrickx et al., op. cit., based on annual data.

Table 3 - Wage equation (23)

	χ_1	χ_2	χ_3	R^2	se	DW	DF
1. Restricted	0.61	-	-1.26	0.99	0.02	0.83	-4.90
	(0.01)		(0.06)				
2. Unrestricted	0.62	-	-1.18	0.99	0.02	0.78	-4.68
	(0.01)		(0.06)				

Notes: Two binary variables have been introduced: one for the period 1992Q3-1996Q4, the other for the period 2004Q1-2007Q4.
The standard error of the coefficients is given in brackets.

4. The structural model

In order to evaluate the growth potential of the Dutch economy, the CPB developed a comprehensive structural model (Broer et. al., op. cit.). This model is composed of a recursive system of equations whose theoretical foundation relies upon the equations presented in chapter 2. The solving principle of the model is nonetheless modified in comparison with the logic of the equations introduced in chapter 2 in the sense that the variable appearing on the left-hand-side of the equation does not necessarily correspond in the model to the endogenous variable of the equation. This peculiarity will become clear once we describe the functioning of the model.

The model is composed of a static and a dynamic version, using respectively the concepts of equilibrium unemployment rate and unemployment rate in transitional dynamics. The static version corresponds to the steady state where all variables are at their desired level, including the capital stock. In this case, the user cost of capital is given by equation (15) and the causality runs from capital cost to capital stock. If the assumption is made that the capital stock adjusts only sluggishly to its desired level, the causality between the user cost of capital and capital stock is reversed during the adjustment process as is described in chapter 2. The existence of these adjustment costs leads to the dynamic version of the model.

We will introduce in a first stage the structural model at the steady state. In the second section we will present the dynamic version and comment upon its limitations. The main structural parameters correspond to the ones given in chapter 3. A few less sophisticated price equations have been added and the estimation results are provided in annex.

4.1. The model at the steady state (static version)

The set of equations for the model at the steady state is given in Box 1. The model can be solved recursively based on the property that the real variables of the model depend upon relative prices and not upon a particular price level[12]. This property is satisfied through homogeneity conditions imposed on the price and wage equations and implies in particular that no trade-off exists between inflation and unemployment, i.e. the equilibrium unemployment rate is independent of the inflation rate.

The level of import prices, defined as the weighted average of import prices excluding energy and oil prices (equation (A.11)), may then serve as a nominal anchor for the model. The level of the value added price may consequently be chosen so as to be consistent with the assumption made on the terms of trade. Indeed, as imported and nationally produced goods

[12] This model property is clearly illustrated in chapter 5 by simulating a symmetric shock on all prices.

represent a different basket (and this is particularly true for energy products) it is perfectly possible that import prices and the value added price evolve at different paces. [13]

The deflator of private consumption (equation (A.12)), corrected for the VAT level, may subsequently be computed as a function of value added price and import price, isolating the specific effect of the oil price. As import prices do not necessarily follow the price of nationally produced goods and services, modifications in domestic terms of trade may appear.

The deflator of corporate investments is expressed as a weighted average of national and import prices excluding energy (equation (A.13)). Given the depreciation rate of capital and the discount rate, equation (A.4) allows for the computation of the user cost of capital. For a given value added price level, equation (A.6) [14] makes it possible to measure the unit cost index and equation (A.5) to determine the labour cost in efficiency units. The wage cost per worker may then be computed using equation (A.3), given exogenous values for the working time and labour efficiency.

Equations (A.8) and (A.9) define the tax wedge, for which the various payroll tax rates and employment subsidies are taken as exogenous variables. The equilibrium unemployment rate may subsequently be determined using equation (A.7). Equation (A.10) provides the identity defining the unemployment rate and can be used, given the labour force and employment level for other categories (non-market sector and special subsidized categories of employment), to calculate the employment level in the business sector. Equation (A.1) determines value added in the business sector and the optimal level of the capital stock is then given by (A.2).

Finally, the equations (A.14) and (A.15) provide the level of GDP given value added in the non-market sector and other exogenous categories[15] and taxes minus subsidies on products.

[13] The impact of a change in terms of trade, i.e. the ratio between the value added price and the import price, is illustrated in the next chapter.

[14] The variable M in equation (A.6) is defined as $\ln M = \ln \mu_o + \mu_1 (\ln p_{fc} - \ln \beta c)$ on the observed sample but is treated as a simple constant in the model, considering that in the long run national and foreign competitors' prices converge. Considering the way the model is solved, authorizing variations in the mark-up would also imply a change in relative prices of input factors.

[15] The procedure developed takes into account the link between the evolution of employment and value added when determining the future values for these categories.

Box 1: The equations of the model at the steady state

Production block

$\ln L = \ln\beta + \ln\theta + \ln Y - \sigma\ln\left(\frac{p_l}{c}\right) - vl*$	endogenous: *Y*	(A.1)
$\ln K = \ln\beta + \ln(1-\theta) + \ln Y - \sigma\ln\left(\frac{p_k}{c}\right)$	endogenous: *K*	(A.2)
$p_l = \frac{w}{he^{vl*}}$	endogenous: *w*	(A.3)
$p_k = piq\left(1 - \frac{(1-\delta)}{1+\tau}\right)$	endogenous: p_k	(A.4)
$c = \left[\theta p_l^{1/\sigma} + (1-\theta)\ p_k^{1/\sigma}\right]^{1/(\sigma-1)}$	endogenous: p_l	(A.5)
$\ln p = \ln M + \ln\beta c$	endogenous: *c*	(A.6)

Labour market block

$u = \frac{1}{\chi_3}\left[\chi_0 + \chi_1\ln wedge + \ln M - \ln\left(1-(1-\theta)\left(\frac{p_k}{c}\right)^{1-\sigma}\right)\right]$	endogenous: *u*	(A.7)
$wedge = \frac{(1+te)(1-tlsub)pc}{(1-td)p}$	endogenous: *wedge*	(A.8)
$twedge = \frac{wedge-1}{wedge}$	endogenous: *twedge*	(A.9)
$u = \frac{N - L - \sum_i L_i}{N}$	endogenous: *L*	(A.10)

Price block

$\ln pm = \omega_0 + \omega_1\ln pmee + (1-\omega_1)\ln brent$	endogenous: *pm*	(A.11)
$\ln pc = \gamma_0 + \ln(1+vat) + \gamma_1\ln p + \gamma_2\ln pmee + (1-\gamma_1-\gamma_2)\ln brent$	endogenous: *pc*	(A.12)
$\ln piq = \eta_0 + \eta_1\ln p + (1-\eta_1)\ln pmee$	endogenous: *piq*	(A.13)

GDP block

$IT = \kappa Y$	endogenous: *IT*	(A.14)
$GDP = Y + \sum_i Y_i + IT - SUB$	endogenous: *GDP*	(A.15)

Exogenous variables: *h, vl*,* δ, τ, *te, tlsub, td, N,* L_i, *p, pmee, vat, brent, Yi, IT, SUB*

4.2. The model in transitory state (dynamic version)

This version corresponds to the theoretical part defining the unemployment rate in transitional dynamics due to the sluggish adjustment of the capital stock. This partial adjustment process is expressed by equation (B.1), where *K** corresponds to the level of the capital stock based upon the system of equations from (A.1) to (A.13) given in Box 1. During the whole adjustment process, the user cost of capital will correspond to its shadow price defined by equation (B.2).

Box 2: Equations of the model in transitory state

Production block

The equations (A.1), (A.3), (A.5) and (A.6) remain the same as in Box 1.

The equations (A.2) and (A.4) are replaced by:

$\ln K = (1-\varphi)\ln K_{-1} + \varphi \ln K^*$	endogenous: K	(B.1)
$p_k = c\left((1-\theta)^{1/\sigma}\beta^{1/\sigma}\left(\frac{K}{Y}\right)^{-(1/\sigma)}\right)$	endogenous: p_k	(B.2)

The other blocks are identical to the ones presented in Box 1.

When simulated with the same exogenous variables as the static version, the model will converge progressively to the steady state as the shadow price of capital will itself converge towards the value given by equation (A.4). The dynamics will be illustrated in the next chapter by performing a set of standard shocks. Note that the convergence in level of the capital stock using equation (B.1) will only occur if the equilibrium level is itself stationary. We will come back to this issue in the following chapter.

5. The model properties

The purpose of this chapter is to analyse the dynamic and steady-state properties of the model through a range of exogenous shocks. But before discussing the results of these shocks, we will describe the procedure developed to initiate the reference scenario and the necessary conditions for a proper functioning of the dynamic version.

5.1. The procedure to initiate the reference scenario

The Federal Planning Bureau releases twice a year the so-called the "economic budget". The quarterly macro-econometric model Modtrim serves as a central tool for producing these short-term forecasts but the model's results, however, are adapted to take into account the most recent business cycle information (Dobbelaere et. al., 2003). The FPB produces also medium-term macroeconomic projections for the Belgian economy each spring (with an update in autumn). This medium-term outlook takes as a starting point the forecasts for the current year (as published in the economic budget, possibly revised on the basis of new business cycle information) and covers a five-year period. The baseline and variants for the Belgian economy are produced using the HERMES model (Bossier et al., 2004).

The model S3BE (**S**mall **S**upply-**S**ide model for the **B**elgian **E**conomy) which has been described in the previous chapter, was developed in view of producing long-term macro-economic scenarios. In order to guarantee a full consistency between the medium and long run, a specific procedure has been elaborated within S3BE. This procedure takes as a starting point that the economy has reached its steady state at the end of the projection horizon. In terms of the static version of the model, this means that the data set for the ultimate observation of the projection must satisfy all equations contained in Box 1. To do so, a computer procedure transforms the constants in the equations (A.1), (A.2), (A.6), (A.7), (A.11), (A.12) and (A.13) into endogenous variables and computes their values consistent with the data set for the last observation of the projection. These values are then taken as the new constants for these equations and S3BE may be simulated. These computations allow avoiding a "blip" for certain endogenous variables for the first period of simulation, insofar as the constant estimated on the historical sample differs from the – implicit – value of the constant contained in the projection. Although this procedure was dictated by pragmatic reasons, it seems acceptable empirically to the extent that structural breaks were identified for the constants within the historical sample. It goes without saying that it is important to check whether the procedure does not generate implausible results in comparison to the values estimated on the historical sample.

Note that for the simulations presented below and based upon the quarterly data base of the economic budget, the first quarter of 2009 was used as a starting point for the S3BE reference scenario. Considering that this baseline is of a purely illustrative nature, the choice of the first year of the simulation is not critical and does not alter the principles of the procedure or the model properties.

5.2. The procedure for the dynamic model

As mentioned in the previous chapter, the capital stock will only converge to its equilibrium level with equation (B.1) if K^* is stationary. Indeed, in case the steady-state capital stock is growing, the partial adjustment model will lead to converge in growth rates, but will never allow the effective capital stock to reach its steady-state level. This implies in particular that the unemployment rate will not converge to its equilibrium level. Specifications using an error correction mechanism will allow convergence in levels even if the equilibrium value is growing, insofar as dynamic homogeneity has been imposed (see Allart-Prigent et. al., 2002). Such a condition implies a specification of the following type:

$$\Delta \ln K = \Delta \ln K^* - \phi(\ln K - \ln K^*)_{-1} \qquad (26)$$

Nonetheless, as the reference scenario has been initiated with the procedure described above, the second term of the right-hand side of the equation will be equal to zero for the first period of simulation. This means that any shock on the optimal level of the capital stock will be immediately and fully passed through to the effective level of the capital stock, implying that the dynamic version will be reduced to its static form. In order to generate a progressive adjustment of the capital stock starting from a situation where the capital stock is at its desired level, it is thus necessary to have a coefficient that is smaller than one for the first term of the right-hand side of the equation. But, under this restriction, the dynamic homogeneity condition no longer holds and the model will not converge to its steady state.

In order to take into account this limitation, the reference scenario used hereafter to measure the responses of the model to shocks is characterized by the absence of growth for the real variables (employment, capital, value added). Note that this restriction is not required to study only the steady-state properties of the model.

5.3. Model simulation

5.3.1. A symmetric shock on all prices

In this first scenario we assume an increase by an additional 1% during the first quarter of simulation on the two international prices (*pmee* et *brent*) as well as on the value added price (*p*). Afterwards, the growth rate for all three variables is identical to that of the baseline. The table below shows that such a global shock on prices has no impact on relative factor prices or on domestic terms of trade as all prices and costs are modified in the same manner. As a consequence, neither factor utilisation nor the unemployment rate is affected by the shock and all real variables remain unchanged. The simulation gives a good illustration of the absence of impact of the absolute level of inflation on the real variables in the model.

Table 4 – Global price increase

% difference from the baseline

	TQ1	TQ2	TQ3	TQ4	Steady state
Exogenous shock					
Import price	1.00	1.00	1.00	1.00	1.00
Value added price	1.00	1.00	1.00	1.00	1.00
Business sector					
Employment (number of workers)	0.00	0.00	0.00	0.00	0.00
Labour share (as % of value added)	0.00	0.00	0.00	0.00	0.00
Capital stock	0.00	0.00	0.00	0.00	0.00
COR (Capital stock/value added)	0.00	0.00	0.00	0.00	0.00
Labour productivity (per worker)	0.00	0.00	0.00	0.00	0.00
Value added	0.00	0.00	0.00	0.00	0.00
Prices and costs					
Business investment deflator	1.00	1.00	1.00	1.00	1.00
Private consumption deflator	1.00	1.00	1.00	1.00	1.00
Labour cost in efficient unites	1.00	1.00	1.00	1.00	1.00
Wage cost per worker	1.00	1.00	1.00	1.00	1.00
Tax wedge	0.00	0.00	0.00	0.00	0.00
User cost or shadow price of capital	1.00	1.00	1.00	1.00	1.00
Marginal production cost	1.00	1.00	1.00	1.00	1.00
Relative cost between labour and capital	0.00	0.00	0.00	0.00	0.00
Total economy					
Unemployment rate	0.00	0.00	0.00	0.00	0.00
Employment (number of workers)	0.00	0.00	0.00	0.00	0.00
Labour productivity (per worker)	0.00	0.00	0.00	0.00	0.00
GDP	0.00	0.00	0.00	0.00	0.00

5.3.2. A shock on the terms of trade

The shock on the import prices (a joint increase in the import price excluding energy and the oil price) is calibrated so that the terms of trade (the ratio between *p* and *pm*) increase by an additional 1% during the first quarter in comparison to the reference scenario and follow the same pattern afterwards.

At the steady state, the (relative) cost of capital is increased through the rise of import prices while the value added price this time remains unchanged. The domestic terms of trade (represented by the ratio between *pc* and *pm*) deteriorate and the wedge rises. According to equation (A.7), the unemployment rate is pushed upwards. Employment is reduced through this channel but decreases less than the capital stock because labour benefits from substitutions due to the higher user cost of capital. The wage share decreases nonetheless because the elasticity of substitution is lower than one. Due to the change in relative factor costs, private value added decreases less than the capital stock but more than employment.

Table 5 – Terms of trade loss

% difference from the baseline

	TQ1	TQ2	TQ3	TQ4	Steady state
Exogenous shock					
Terms of trade	-1.00	-1.00	-1.00	-1.00	-1.00
Business sector					
Employment (number of workers)	-0.10	-0.11	-0.13	-0.14	-0.22
Labour share (as % of value added)	0.01	0.00	-0.01	-0.02	-0.09
Capital stock	-0.06	-0.11	-0.16	-0.20	-0.49
COR (Capital stock/value added)	0.03	0.00	-0.02	-0.04	-0.17
Labour productivity (per worker)	0.01	0.00	-0.01	-0.02	-0.10
Value added	-0.09	-0.11	-0.14	-0.16	-0.32
Prices and costs					
Business investment deflator	0.34	0.34	0.34	0.34	0.34
Private consumption deflator	0.19	0.19	0.19	0.19	0.19
Labour cost in efficient unites	0.03	0.00	-0.02	-0.04	-0.19
Wage cost per worker	0.03	0.00	-0.02	-0.04	-0.19
Tax wedge	0.19	0.19	0.19	0.19	0.19
User cost or shadow price of capital	-0.05	-0.00	0.04	0.08	0.34
Marginal production cost	0.00	0.00	0.00	0.00	0.00
Relative cost between labour and capital	0.08	0.00	-0.06	-0.12	-0.53
Total economy					
Unemployment rate	0.59	0.67	0.75	0.82	1.29
Employment (number of workers)	-0.08	-0.09	-0.10	-0.11	-0.17
Labour productivity (per worker)	0.00	-0.01	-0.02	-0.03	-0.10
GDP	-0.07	-0.10	-0.12	-0.14	-0.28

Contrary to the previous shock, the decrease in the desired level of capital triggers the dynamic version of the model. However, as the change in domestic terms of trade has an immediate negative impact on the unemployment rate, the initial decrease in the capital stock is inferior to that of value added. Hence, the shadow price of capital decreases slightly at the onset of the simulation period. As the capital stock is progressively reduced, the shadow price of capital will move upwards and the unemployment rate will continue to progress until the new steady state is reached.

5.3.3. A shock on the oil price

We suppose here a shock of 10 % on the oil price (*brent*) in comparison to the reference scenario during the first quarter. The domestic terms of trade are affected by the increase of the private consumption deflator as in the previous simulation, but this time the relative factor costs remain unchanged in the steady state. In the short run, however, the gradual adjustment of the capital stock to its new optimal level will cause a temporary drop in its shadow price. Labour productivity will be pushed up temporary through the substitution effect in favour of capital which has become relatively cheaper. Once the adjustment has been fully realized, factor costs will return to their baseline level. The increase in the tax wedge will exert its full influence on the unemployment rate and consequently on economic activity.

Table 6 – Oil price increase

% difference from the baseline

	TQ1	TQ2	TQ3	TQ4	Steady state
Exogenous shock					
Oil price	10.00	10.00	10.00	10.00	10.00
Business sector					
Employment (number of workers)	-0.14	-0.15	-0.15	-0.16	-0.19
Labour share (as % of value added)	0.04	0.03	0.03	0.03	0.00
Capital stock	-0.02	-0.04	-0.06	-0.08	-0.19
COR (Capital stock/value added)	0.08	0.07	0.06	0.05	0.00
Labour productivity (per worker)	0.04	0.04	0.03	0.03	0.00
Value added	-0.10	-0.11	-0.12	-0.13	-0.19
Prices and costs					
Business investment deflator	0.00	0.00	0.00	0.00	0.00
Private consumption deflator	0.31	0.31	0.31	0.31	0.31
Labour cost in efficient unites	0.08	0.07	0.06	0.06	0.00
Wage cost per worker	0.08	0.07	0.06	0.06	0.00
Tax wedge	0.31	0.31	0.31	0.31	0.31
User cost or shadow price of capital	-0.15	-0.13	-0.11	-0.10	0.00
Marginal production cost	0.00	0.00	0.00	0.00	0.00
Relative cost between labour and capital	0.23	0.20	0.18	0.16	0.00
Total economy					
Unemployment rate	0.83	0.86	0.89	0.91	1.09
Employment (number of workers)	-0.11	-0.12	-0.12	-0.12	-0.15
Labour productivity (per worker)	0.03	0.02	0.02	0.01	-0.02
GDP	-0.09	-0.10	-0.10	-0.11	-0.16

5.3.4. A shock on the user cost of capital

For this simulation we impose a shock on the user cost of capital through a 25 basis points increase in the discount rate τ (or an increase of 5 % of the rate). In this case we will only have part of the effects described in the second simulation because the domestic terms of trade are not altered. However, all effects here will be dynamic as the adjustment of each variable is determined by the pace of the reduction in the capital-output ratio.

Table 7 – User cost of capital increase

% difference from the baseline

	TQ1	TQ2	TQ3	TQ4	Steady state
Exogenous shock					
Discount rate	5.00	5.00	5.00	5.00	5.00
Business sector					
Employment (number of workers)	-0.03	-0.06	-0.09	-0.11	-0.28
Labour share (as % of value added)	-0.03	-0.06	-0.08	-0.10	-0.24
Capital stock	-0.12	-0.23	-0.32	-0.40	-0.99
COR (Capital stock/value added)	-0.06	-0.11	-0.15	-0.19	-0.46
Labour productivity (per worker)	-0.03	-0.06	-0.08	-0.10	-0.26
Value added	-0.07	-0.12	-0.17	-0.22	-0.53
Prices and costs					
Business investment deflator	0.00	0.00	0.00	0.00	0.00
Private consumption deflator	0.00	0.00	0.00	0.00	0.00
Labour cost in efficient unites	-0.06	-0.11	-0.16	-0.20	-0.49
Wage cost per worker	-0.06	-0.11	-0.16	-0.20	-0.49
Tax wedge	0.00	0.00	0.00	0.00	0.00
User cost or shadow price of capital	0.11	0.21	0.29	0.36	0.89
Marginal production cost	0.00	0.00	0.00	0.00	0.00
Relative cost between labour and capital	-0.17	-0.32	-0.45	-0.57	-1.37
Total economy					
Unemployment rate	0.20	0.37	0.53	0.66	1.62
Employment (number of workers)	-0.03	-0.05	-0.07	-0.09	-0.22
Labour productivity (per worker)	-0.03	-0.06	-0.08	-0.10	-0.24
GDP	-0.06	-0.11	-0.15	-0.19	-0.46

5.3.5. A shock on the labour force

We assume an increase in the labour force by 1% during the first quarter compared to the baseline. At the steady state, the shock has a very mechanical effect through the identity given by (A.10). Indeed, as the equilibrium unemployment rate remains unchanged, the increase in the labour force translates in a rise in private employment[16]. As private employment is more productive than the exogenous categories of employment, productivity is slightly higher due to the composition effect and consequently GDP rises a bit more than total employment. In the short run, the capital stock is unable to adapt immediately to the new situation which implies that the increase in the labour force translates into a temporary surge in the unemployment rate and a decrease in productivity. Value added and employment increase as the capital stock adjusts to its new optimal level. The unemployment rate falls back to its baseline level.

Table 8 – Labour force increase

% difference from the baseline

	TQ1	TQ2	TQ3	TQ4	Steady state
Exogenous shock					
Labour force	1.00	1.00	1.00	1.00	1.00
Business sector					
Employment (number of workers)	0.97	1.01	1.04	1.07	1.29
Labour share (as % of value added)	-0.27	-0.24	-0.21	-0.18	-0.00
Capital stock	0.16	0.30	0.42	0.52	1.29
COR (Capital stock/value added)	-0.52	-0.45	-0.40	-0.35	0.00
Labour productivity (per worker)	-0.29	-0.25	-0.22	-0.19	0.00
Value added	0.68	0.75	0.82	0.88	1.29
Prices and costs					
Business investment deflator	0.00	0.00	0.00	0.00	0.00
Private consumption deflator	0.00	0.00	0.00	0.00	0.00
Labour cost in efficient unites	-0.56	-0.49	-0.43	-0.38	0.00
Wage cost per worker	-0.56	-0.49	-0.43	-0.38	0.00
Tax wedge	0.00	0.00	0.00	0.00	0.00
User cost or shadow price of capital	1.01	0.88	0.77	0.68	0.00
Marginal production cost	0.00	0.00	0.00	0.00	0.00
Relative cost between labour and capital	-1.55	-1.36	-1.19	-1.05	0.00
Total economy					
Unemployment rate	1.83	1.61	1.41	1.23	0.00
Employment (number of workers)	0.76	0.79	0.82	0.84	1.01
Labour productivity (per worker)	-0.17	-0.14	-0.11	-0.08	0.10
GDP	0.59	0.65	0.71	0.76	1.12

[16] The more than proportional increase in private employment is due to the fact that the other employment categories remain unchanged compared to the baseline.

5.3.6. A shock on labour efficiency

We assume a shock of 1% on labour efficiency with the same modalities as in the previous simulations. At the steady state, this increase in efficiency leads to an equivalent rise in labour productivity and, consequently, in private value added because neither employment nor relative factor costs are modified. In the short run, the slow adjustment of the capital stock causes a temporary surge in the shadow price of capital and the unemployment rate will rise above its equilibrium during the adjustment process.

Table 9 – Labour efficiency increase

% difference from the baseline

	TQ1	TQ2	TQ3	TQ4	Steady state
Exogenous shock					
Labour efficiency	1.00	1.00	1.00	1.00	1.00
Business sector					
Employment (number of workers)	-0.24	-0.21	-0.19	-0.16	0.00
Labour share (as % of value added)	-0.21	-0.18	-0.16	-0.14	0.00
Capital stock	0.12	0.23	0.33	0.41	1.00
COR (Capital stock/value added)	-0.40	-0.35	-0.31	-0.27	0.00
Labour productivity (per worker)	0.77	0.80	0.83	0.85	1.00
Value added	0.53	0.59	0.64	0.68	1.00
Prices and costs					
Business investment deflator	0.00	0.00	0.00	0.00	0.00
Private consumption deflator	0.00	0.00	0.00	0.00	0.00
Labour cost in efficient unites	-0.43	-0.38	-0.33	-0.29	0.00
Wage cost per worker	0.56	0.62	0.66	0.70	1.00
Tax wedge	0.00	0.00	0.00	0.00	0.00
User cost or shadow price of capital	0.78	0.69	0.60	0.53	0.00
Marginal production cost	0.00	0.00	0.00	0.00	0.00
Relative cost between labour and capital	-1.21	-1.06	-0.93	-0.81	0.00
Total economy					
Unemployment rate	1.42	1.25	1.09	0.96	0.00
Employment (number of workers)	-0.19	-0.17	-0.15	-0.13	0.00
Labour productivity (per worker)	0.65	0.68	0.70	0.72	0.87
GDP	0.46	0.51	0.55	0.59	0.87

5.3.7. A shock on the tax wedge

We assume a rise by 1 percentage point of the combined rate for personal income taxes and employees' social-security contributions (or an increase by 1.71 % of this rate). Such a policy shock has a direct impact on the tax wedge and increases the unemployment rate, implying a drop in employment, in the capital stock and in value added. Total productivity declines slightly following the decrease in private employment. However, as the capital stock adjusts only slowly to the shock, the shadow price of capital will fall temporary below the cost of capital, causing the unemployment rate to remain below its new equilibrium during the adjustment process.

Table 10 – Tax wedge increase

% difference from the baseline

	TQ1	TQ2	TQ3	TQ4	Steady state
Exogenous shock					
Personal-income tax rate	1.71	1.71	1.71	1.71	1.71
Business sector					
Employment (number of workers)	-0.29	-0.30	-0.31	-0.32	-0.38
Labour share (as % of value added)	0.08	0.07	0.06	0.05	0.00
Capital stock	-0.05	-0.09	-0.12	-0.16	-0.38
COR (Capital stock/value added)	0.16	0.14	0.12	0.10	-0.00
Labour productivity (per worker)	0.09	0.08	0.07	0.06	-0.00
Value added	-0.20	-0.22	-0.24	-0.26	-0.38
Prices and costs					
Business investment deflator	0.00	0.00	0.00	0.00	0.00
Private consumption deflator	0.00	0.00	0.00	0.00	0.00
Labour cost in efficient unites	0.17	0.15	0.13	0.11	0.00
Wage cost per worker	0.17	0.15	0.13	0.11	0.00
Tax wedge	0.63	0.63	0.63	0.63	0.63
User cost or shadow price of capital	-0.30	-0.26	-0.23	-0.20	0.00
Marginal production cost	0.00	0.00	0.00	0.00	0.00
Relative cost between labour and capital	0.47	0.41	0.36	0.31	0.00
Total economy					
Unemployment rate	1.69	1.75	1.81	1.87	2.23
Employment (number of workers)	-0.23	-0.24	-0.24	-0.25	-0.30
Labour productivity (per worker)	0.05	0.04	0.03	0.02	-0.03
GDP	-0.18	-0.19	-0.21	-0.23	-0.33

Conclusion

The analysis of the simulations presented in the previous chapter was able to emphasize the following characteristics of the model:

- The level of economic activity is not influenced by the absolute level of inflation. It is affected only by changes in relative factor prices or domestic terms of trade. This implies that there exists no trade-off in the model between inflation and unemployment.

- At the steady state, value added growth is determined by the evolution of labour efficiency, the labour force, taxation on labour, terms of trade and the real cost of capital.

- In the absence of changes in relative prices and taxation levels, employment growth will be determined by the evolution of the labour force and productivity growth by the increase in labour efficiency.

- The pace at which the economy moves to the new steady state after a shock is determined by the speed of adjustment of capital to its desired level.

In our opinion, these theoretical properties combined with structural parameters which are estimated econometrically, make of S3BE an adequate tool for producing long-term macro-economic scenarios for the Belgian economy. Moreover, thanks to the calibration procedure that has been developed, these scenarios can be initiated with the medium-term projections.

In order to stick to the periodicity of the medium-term projections and of the scenarios for age-related budgetary expenditures, an annual version of the static model has also been built. This version should be useful for producing macro-economic scenarios without any major shock. Indeed, if the growth of the exogenous variables exhibits a smooth profile, the static version provides plausible evolutions for the endogenous variables. The dynamic version should only be used to evaluate the impact of specific shocks for which an immediate response of the economic system does not appear plausible.

S3BE will be used for the first time for the preparation of the 2009 report of the Study Group on Ageing. A macro-economic projection up to 2060 will take as starting point the results of the medium-term outlook released in May; it should integrate the latest population and public employment projections. But this work will also require formulating assumptions regarding the whole set of exogenous variables. This process constitutes a small revolution in comparison with the approach used up to now by the Study Group on Ageing to build its macro-economic scenario and will necessitate the development of a new work routine.

References

Allard-Prigent C., Audenis C., Berger K., Carnot N., Duchène S. et Pesin F. (2002), “Présentation du modèle Mésange”, Direction de la Prévision, Document de travail, mai.

Arpaia A. and Pérez Ruiz E. (2008), “Labour share dynamics in Europe: a time-horizon ap-proach”, paper presented at the International Conference on Policy Modeling in Berlin, July.

Beffy P.-O., Ollivaud P., Richardson P. and Sédillot F. (2006), “New OECD methods for supply-side and medium-term assessments: a capital services approach”, OECD Economic Depart-ment Working Paper n° 482, July.

Barro R. and Sala-i-Martin (2004), Economic Growth, MIT Press, second edition.

Bossier F., Bracke I., Gillis S., Vanhorebeek F. (2004), “Une nouvelle version du modèle HERMES”, Bureau fédéral du Plan, Working Paper 5-04, février.

Broer P., van Erp F., Smid B. (2006), “Potentiële groei volgens de Productiefunctie Benadering, versie 2006”, CPB Memorandum 156, juni.

Bureau fédéral du Plan (2006), Perspectives économiques 2006-2011, avril.

Carnot N., Koen V. and Tissot B. (2005), Economic Forecasting, Palgrave McMillan.

Conseil Supérieur des Finances (2008), Comité d’Etude sur le Vieillissement - Rapport annuel, juin.

CPB (2003), “JADE – A model for the Joint Analysis of Dynamics and Equilibrium”, CPB document n° 30, May.

CPB (2006), “Het groeipotentieel van de Nederlandse economie tot 2011”, CPB document n° 117, juni.

Denis C., Grenouilleau D., Mc Morrow K. and Röger W. (2006), “Calculating potential growth rates and output gaps - A revised production function approach -”, European Economy, Economic Paper n° 247, March.

Dobbelaere L., Hertveldt B., Hespel E. et Lebrun I. (2003), “Tout savoir sur la confection du budget économique”, Bureau fédéral du Plan, Working Paper 17-03, octobre.

Draper N., Huizinga F. and Kranendonk H. (2001), “Potentiële groei volgens de Productiefunctie Benadering”, CPB Memorandum 4, april.

Giorno. C., Richardson P., Roseveare D. and van den Noord P. (1995), “Estimating potential output, output gaps and structural budget balances”, OECD Economics Department Working Papers, No.152, February.

Hendrickx K., Joyeux C., Masure L. et Stockman P. (2003), “Un nouveau modèle macro-économétrique du marché du travail: estimation, simulation de base et simulations de politi-ques d’emploi”, Bureau fédéral du Plan, Working Paper 13-03, août.

Hertveldt B. and Lebrun I. (2003), “MODTRIM II: A quarterly model for the Belgian economy”, Working Paper 6-03, Federal Planning Bureau, May.

Annex I: Derivation of the expression for the tax wedge

The different tax and subsidy rates are defined as:

$$te = \frac{wf - wnet}{wnet} \quad \rightarrow \quad wnet = \frac{wf}{(1+te)}$$

$$td = \frac{wbf - wf}{wbf} \quad \rightarrow \quad wbf = \frac{wf}{(1-td)}$$

$$tlsub = \frac{wbf - w}{wbf} \quad \rightarrow \quad w = wbf(1-tlsub)$$

where *wf* denotes the gross wage, *wnet* the take-home wage and *wbf* the wage cost before subsidy deductions.

The tax wedge is defined as the ratio between the wage cost (corrected for wage subsidies) deflated by the value added price and the take-home wage deflated by the consumer price:

$$wedge = \frac{w}{wnet}\frac{pc}{p}$$

By replacing *w*, *wnet* and *wbf* by their respective definitions given above, the expression for the tax wedge as used in the model can be obtained:

$$wedge = \frac{(1+te)(1-tlsub)pc}{(1-td)p}$$

Annex II: Estimation results for the deflators

$$\ln pm = \omega_0 + \omega_1 \ln pmee + (1-\omega_1)\ln brent$$

The level of import prices (*pm*) is defined as the weighted average of import prices excluding energy and oil prices.

Table 11 - Equation for the deflator of total imports (A.11)

ω_0	ω_0’	ω_1	R^2	se	DW	DF
-0.63	-0.52	0.91	0.98	0.01	1.65	-7.99
(0.03)	(0.03)	(0.005)				

Notes: ω_0 : value for the period 1985Q1-2001Q4 ; ω_0’: value for the period 2002Q1-2007Q4.

$$\ln pc = \gamma_0 + \ln(1+vat) + \gamma_1 \ln p + \gamma_2 \ln pmee + (1-\gamma_1-\gamma_2)\ln brent$$

The deflator of private consumption, corrected for the VAT level (*vat*), is expressed as a weighted average of national (*p*) and import prices, distinguishing the effect of import prices excluding energy (*pmee*) from the specific impact of the oil price (*brent*).

Table 12 - Equation for the consumer price deflator (A.12)

γ_0	γ_1	γ_2	R^2	se	DW	DF
-0.32	0.81	0.16	0.99	0.01	0.42	-3.23
(0.001)	(0.03)	(0.01)				

Notes: estimation performed using 2SLS; the specific effect of the oil price is introduced only from 2002Q1onwards.

$$\ln piq = \eta_0 + \eta_1 \ln p + (1-\eta_1)\ln pmee$$

The deflator of corporate investments (*piq*) is expressed as a weighted average of national and import prices excluding energy.

Table 13 - Equation for the corporate investment deflator (A.13)

η_0	η_0’	η_0’’	η_1	R^2	se	DW	DF
-0.03	-0.05	-0.01	0.66	0.99	0.01	0.92	-5.24
(0.004)	(0.004)	(0.004)	(0.02)				

Notes: η_0 : value for the period 1985Q1-1989Q2; η_0’: value for the period 1989Q3-2000Q4; η_0’’: value for the period 2001Q1-2007Q4.