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LATVIA'S MACROECONOMIC MODEL

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Fragments of the painting *White Move* (2005) by Juta Policja and Mareks Gureckis have been used in the design.

CONTENTS

ABBREVIATIONS

AWM – Area-Wide Model for the euro area
CPI – consumer price index
DSGE model – dynamic stochastic general equilibrium model
ECB – European Central Bank
ERM II – Exchange Rate Mechanism II
ESA 95 – European System of Accounts 1995
ESCB – European System of Central Banks
EU – European Union
EU15 – EU before expansion on May 1, 2004
GDP – Gross Domestic Product
LMM – Latvia's Macroeconomic Model
MCM – European System of Central Banks Multi-Country Model
NAIRU – non-accelerating inflation rate of unemployment
US – United States of America

ABSTRACT

The paper presents the first version of Latvia's Macroeconomic Model (LMM) built using the features and structure of an Area-Wide Model (AWM) for the euro area and Multi-Country Model (MCM) for a typical country block of the European System of Central Banks. This is one of the first attempts to create an econometric model that captures the Latvian economy as a whole and simultaneously modells the supply and demand sides, price and fiscal blocks, and the external sector.

Key words: *macroeconomic model, Latvia*

JEL classification codes: *C3, C5, E12, E17*

INTRODUCTION

The structural macroeconomic model is a traditional type of econometric models used by modern central banks while working out their monetary policies. Such a model outlines the main features of the economic system, providing an analytical framework that takes into account both historical data and theoretical foundations. The need for deeper understanding of processes taking place in the Latvian economy is a motivation to build a macroeconomic model for Latvia.

The paper presents the first version of Latvia's Macroeconomic Model (LMM) that is built using the features and structure of an Area-Wide Model (AWM) for the euro area and a typical country block of the European System of Central Banks Multi-Country Model (MCM). This is one of the first attempts to create an econometric model, which deals with the Latvian economy as a whole, simultaneously modelling the supply and demand sides, the price and fiscal blocks, and the external sector.

The choice of this type of model was determined mainly by its properties. The model is rather detailed and contains a sufficient number of variables needed for analytical purposes. At the same time, the structure of the model is relatively simple and comprehensible. The theoretical structure of the AWM and MCM is in line with the mainstream macroeconomic models where the supply side is determined by long-run equilibrium but the short-run dynamics follows the demand side. On the one hand, it is a very balanced model that ensures the consistency of the whole system over a long horizon, as the equations of the supply side are derived and calibrated using the economic theory. On the other hand, almost all dynamic equations are estimated improving their fit to historical data.

It is worth noting that building a structural macroeconomic model for Latvia is still in progress and this paper should be considered only as a first attempt. Availability of new data as well as further structural changes in the economy during the convergence process will require re-estimation of the model in the future.

The current version of the model is used by the Bank of Latvia only for policy simulations when assessing the reaction of the economy to various external and internal shocks; however, it is planned that eventually forthcoming versions of the model would be suitable for middle-term forecasting purposes. Moreover, this model can be viewed as a step towards more advanced and theoretically consistent macroeconomic models like the dynamic stochastic general equilibrium model (DSGE).

The paper is organised as follows. In the first section, we present the theoretical background and a brief structure of the model. In the second section, the main equations of the LMM supply and demand sides, the price and fiscal blocks, and the external sector are described. The third section presents the model baseline scenario. The fourth section deals with the simulations of standard reactions to shocks, including the reaction of the Latvian economy to changes in monetary and fiscal policy, external demand and exchange rates as well as oil price shocks. The last section concludes.

1. THEORETICAL BACKGROUND

This paper presents the first version of the LMM that incorporates the features and structure of an AWM (4) and a typical country block of the MCM (15; 14; 2; 5; 11; 7).

The choice of this type of model was determined mainly by its properties. It is rather detailed and contains a sufficient number of variables needed for analytical purposes. At the same time, the structure of the model is relatively simple and comprehensible. On the one hand, it is a very balanced model that ensures the consistency of the whole system over a long horizon; on the other hand, almost all dynamic equations are estimated improving their fit to historical data.

Aggregate supply drives the long run equilibrium of the model, while aggregate demand determines the short run dynamics. The supply curve is vertical in the long run, and output is determined solely by technology and labour force. Aggregate demand could deviate from the potential output in the short term, and these deviations cause price and wage adjustments, which bring the model back into the long run equilibrium.

In this section, we will first shortly discuss the difference between the steady state and intermediate target of the model. Afterwards, the supply side derived from the firm's maximisation problem as well as dynamic homogeneity conditions that are necessary for the model to converge to the steady state will be presented, and, finally, we will introduce the demand side as well as the price, fiscal and external blocks of the model.

1.1 Steady state and intermediate target

There is an important difference between the steady state of a variable and its intermediate target. The steady state of variable y means y^{**}, which is achieved when the whole model is in equilibrium and all variables have a stable growth path. Therefore, the equation for the steady state should include only long run equilibrium values of variables, or, in other words, y^{**} depends only on the steady state of explanatory variables x^{**}.

The intermediate target, in turn, is a desired level of the variable at a point in time, and the equation for desired variable y^{*} involves current values of explanatory variables x. The intermediate target indicates the value derived from the long-term equation using the current (not the long run) values of variables.

In our model, all variables are explained by two equations: a long-term equation for the intermediate target of the variable and a dynamic equation designed in traditional error correction manner:

$$\begin{aligned} y_t^* &= f(x_t) \\ \Delta y_t &= g(\Delta x_t) + \mu\left(y_{t-1} - y_{t-1}^*\right) \end{aligned} \qquad [1.1]$$

where
y is the dependent variable;
y^* is the intermediate target of variable y;
x is the set of exogenous variables;
μ is the speed of adjustment.

There are no equations determining the steady state in the model. The current value y converges to the intermediate target y^*, which then converges to the steady state y^{**}.

The major reason why the intermediate target rather than steady state values is used is that it improves the statistical fit of the empirical model. This is helpful when in-sample values of variables are far away from their steady state values, which doubtlessly is the case of the Latvian economy where significant structural changes are taking place.

Although intermediate targets have a better statistical fit than the steady state, within the sample they can still be far away from the current values of the variables. Therefore, the equation for the intermediate target could be adjusted by help of additional deterministic components (the time trend and dummy variables):

$$\log\left(y_t^*\right) = \alpha_1 \log\left(x_{1t}\right) + \ldots + \alpha_n \log\left(x_{nt}\right) + c_0 + c_1 t^{-1} + c_2 d_t \qquad [1.2]$$

where
c_0, c_1 and c_2 are the estimated coefficients;
t is the time trend;
d is a set of dummy variables.

This approach is widely used in other country blocks of the MCM (see (5) for the Austrian block, (11) for the Greek block, and (2) for the French block).

We include adjustment deterministic terms in the intermediate target equations to ensure that the gaps between the current values and intermediate targets are stationary. The deterministic terms used in our model progressively go to $c_0 + c_2 d_t$ in the out-of-sample simulations. The dummy variables included in the equation of intermediate target reflect changes in statistical methodology and other one-off shocks, which could not be explained by the model. The inclusion of additional terms was optional and depended on statistical significance.

1.2 Supply side

On the supply side of the LMM, we use the standard theory of monopolistic firm. Profits of an individual firm are determined by returns from sales with costs of labour and capital subtracted, while the production process is represented by a simple Cobb-Douglas function. The firm has a downward sloping demand curve, therefore, the demand for the firm's output negatively depends on the price of the product. The supply side of the model is derived solving the maximisation problem where the firm chooses the levels of labour, capital and prices to maximise its profits (see (2)):

$$\begin{cases} \Pi\left(Y_i\right) \xrightarrow[L_i, K_i]{} \max \\ \Pi\left(Y_i\right) = P_i Y_i - wL_i - cK_i \\ Y_i = Y\left(\dfrac{P}{P_i}\right)^{\varepsilon} \\ Y_i = AK_i^{\beta}\left(e^{\gamma t} L_i\right)^{1-\beta} \end{cases} \qquad [1.3]$$

where
Y_i is the output of the firm i;
L_i is the labour force used by the firm;
K_i is the capital stock of the firm;
P_i is the price of goods produced by the firm;
Y is the aggregate supply of generic goods;
P is the price of generic goods;
ε is the elasticity of the demand for goods produced by the firm i to their relative price;
γ is the exogenous growth rate of technological progress;
β is the elasticity of production factors;
w is the nominal wage level;
c is the nominal cost of capital with $c = P(r + \delta)$ by definition where r is the real rate of interest, but δ is the physical depreciation rate of capital.

Solving the maximisation problem by using the first order conditions in the symmetric equilibrium $\left(P_i = P, Y_i = Y, L_i = L, K_i = K \quad \forall i\right)$, we obtain the following system of equations (for more details see Appendix 1, part A1.1):

$$\begin{cases} L = e^{-\gamma t}\left(\dfrac{Y}{AK^{\beta}}\right)^{\frac{1}{1-\beta}} \\ K = \dfrac{Y}{Ae^{(1-\beta)\gamma t}}\left(\dfrac{\beta w}{(1-\beta)P(r+\delta)}\right)^{1-\beta} \\ \dfrac{w}{P} = \dfrac{(1-\beta)(\varepsilon-1)}{\varepsilon}\dfrac{Y}{L} \end{cases} \qquad [1.4]$$

where
K is the aggregate capital stock;
L is the total labour force.

Parameters of the long-term supply side equations are not estimated using the traditional econometric technique. Instead, similar to F. Boissay and J. Villetelle (2), we calibrated the parameters of equation [1.4] using in-sample means (for more details see Appendix 1, part A1.2).

Table 1.1
Calibration of parameters of supply side equations[1]

Calibration	Comments
$\hat{\beta}=\overline{\left(\frac{(r+\delta)K}{\frac{w}{P}L+(r+\delta)K}\right)}$	Parameter $\hat{\beta}$ of the Cobb-Douglas production function is equal to the in-sample mean of the ratio of real capital costs to total real production costs.
$\hat{\varepsilon}=\overline{\left(\frac{PY}{PY-wL-cK}\right)}$	The elasticity of the demand for a commodity to its relative price is determined by the in-sample mean of the inverse profitability ratio. The lower the demand elasticity, the higher is the monopolistic power and the profit ratio.
$\hat{\gamma}=\overline{\left(\left(\Delta\log\left(\frac{Y}{L}\right)-\hat{\beta}\Delta\log\left(\frac{K}{L}\right)\right)\frac{1}{1-\hat{\beta}}\right)}$	The exogenous growth rate of technological progress is equal to the in-sample mean of real output growth per employee plus changes in the labour-capital ratio (by it the effect of increasing capital per employee is removed).
$\hat{A}=\overline{\left(\frac{Y}{K^{\hat{\beta}}\left(e^{\hat{\gamma}t}L\right)^{1-\hat{\beta}}}\right)}$	Parameter $\hat{A}$ is calculated from the inverse Cobb-Douglas function.

[1] By $\overline{(\cdot)}$ we denote the in-sample mean operator.

Using equation system [1.4], we obtain the following equation for the desired level of capital stock:

$$\log\left(K^{*}\right)=\log(Y)+\left(1-\hat{\beta}\right)\left(\log\left(\frac{\hat{\beta}w}{\left(1-\hat{\beta}\right)P(r+\delta)}\right)-\hat{\gamma}\,t\right)-\log\left(\hat{A}\right) \qquad [1.5].$$

The desired level of real wage rate is represented by:

$$\log\left(\frac{w^{*}}{P}\right)=\log\left(\frac{\left(1-\hat{\beta}\right)\left(\hat{\varepsilon}-1\right)}{\hat{\varepsilon}}\right)+\log\left(\frac{Y}{L}\right) \qquad [1.6].$$

The potential output is given as:

$$\log\left(Y^{*}\right)=\log\left(\hat{A}\right)+\hat{\beta}\log(K)+\left(1-\hat{\beta}\right)\log\left(L^{NAIRU}\right)+\left(1-\hat{\beta}\right)\hat{\gamma}\,t \qquad [1.7].$$

The potential level of employment L^{NAIRU} is determined by labour force $\widetilde{L}$, and the long-run non-accelerating rate of unemployment (NAIRU) is denoted as u^{NAIRU}:

$$L^{NAIRU}=\left(1-u^{NAIRU}\right)\widetilde{L} \qquad [1.8].$$

The desired level of labour, similar to the AWM and all MCMs, is defined as the inverse of the production function:

$$\log\left(L^*\right) = \frac{1}{1-\hat{\beta}}\left(\log(Y) - \hat{\beta}\log(K) - \log\left(\hat{A}\right)\right) - \hat{\gamma}t \qquad [1.9].$$

By using this notation, we link the employment gap to the output gap.

Equations [1.5], [1.6], [1.7] and [1.9] form the long-term supply side of the model.

As to the short-term demand side of the model, there are three main dynamic equations – for labour demand, wage rate and GDP deflator.

The labour demand dynamic equation assumes that the short-term demand for labour depends on changes in the economic activity and real wage rate. As we use the standard error correction mechanism in dynamic equations, the short-term labour demand adjusts to the desired level defined from the inverse of the production function in equation [1.9]:

$$\Delta\log\left(L_t\right) = b_{L0} + \sum_i b_{L1i}\Delta\log\left(Y_{t-i}\right) + \sum_i b_{L2i}\Delta\log\left(\frac{w_{t-i}}{P_{t-l}}\right) + \mu_L \log\left(\frac{L_{t-1}}{L^*_{t-1}}\right) \qquad [1.10].$$

Changes in the short-term real wage depend on changes in labour productivity. In an economy where firms and employees bargain for the level of nominal wages, real wages are driven also by the unemployment rate or by the difference between the actual and potential employment:

$$\Delta\log\left(\frac{w_t}{P_t}\right) = b_{w0} + \sum_i b_{w1i}\Delta\log\left(\frac{Y_{t-i}}{L_{t-i}}\right) + \sum_i b_{w2i}\log\left(\frac{L_{t-i}}{L^{NAIRU}_{t-l}}\right) + \mu_w \log\left(\frac{w_{t-1}}{P_{t-1}}\frac{P^*_{t-1}}{w^*_{t-1}}\right)$$
[1.11].

The inclusion of this employment gap is necessary for bringing the model to a long run equilibrium through wage and price adjustments. In the steady state of the model where the level of employment is equal to its potential level, the employment gap will be zero and the real wage rate will solely depend on productivity.

Next is the short-term equation of the GDP deflator – the most important price in the model for the reason that the GDP deflator influences all other domestic prices as showed below. Explanatory variables used are the import deflator, unit labour costs and output gap. Similar to the employment gap in equation [1.11], the usage of the output gap in the dynamic equation of domestic prices ensures the equality of the supply and demand sides in the steady state via the price adjustment mechanism.

$$\Delta\log\left(P_t\right) = b_{p0} + \sum_i b_{p1i}\Delta\log\left(P^M_{t-i}\right) + \sum_i b_{p2i}\Delta\log\left(\frac{w_{t-i}L_{t-i}}{Y_{t-i}}\right) + $$
$$+ \sum_i b_{p3i}Y^{GAP}_t + \mu_p \log\left(\frac{P_{t-1}}{w_{t-1}}\frac{w^*_{t-1}}{P^*_{t-1}}\right) \qquad [1.12]$$

where
P^M is the import deflator;
Y^{GAP} is the output gap.

There are no special long-term equations for the nominal wage and GDP deflator in the LMM. Therefore, the desired level of real wage is used in both the nominal wage dynamic equation [1.11] and GDP deflator dynamic equation [1.12].

Another feature required for achieving the long run equilibrium is the dynamic homogeneity condition. This paragraph shortly describes the conditions, under which the supply side of the economy converges to the steady state.(2)

We use an error correction mechanism in this model; therefore, all dynamic equations take the following general form:

$$\phi(l)\Delta\log(y_t) = \varphi(l)\Delta\log(x_t) - \mu(\log(y_{t-k}) - b\log(x_{t-k})) + \varepsilon_t \qquad [1.13]$$

where
$\log(y_{t-k}) - b\log(x_{t-k})$ is the error correction term;
$\phi(\cdot)$ and $\varphi(\cdot)$ – are polynomials;
l is the lag operator.

If x and y grow at constant rates g_x and g_y in the long run, the steady state levels of x^{**} and y^{**} satisfy the relationship (it should be noted that the intermediate targets match the steady state levels in the long run):

$$\phi(1)g_y = \varphi(1)g_x - \mu(\log(y^{**}) - b\log(x^{**})) \qquad [1.14].$$

The long-run relationship $\log(y^{**}) = b\log(x^{**})$ implies that $g_y = bg_x$, therefore, the short-term equation matches the long run growth path if, and only if

$$\phi(1)g_y = \varphi(1)g_x \quad \text{or} \quad b\phi(1) = \varphi(1) \qquad [1.15].$$

It was found that the short-term equations of the supply side estimated without any restrictions did not satisfy the dynamic homogeneity conditions and did not ensure the adjustment to the steady state.

To achieve convergence to the steady state on the supply side of the model, we imposed the restriction of equation [1.15] on the dynamic equations that determine labour demand, nominal wage rate and GDP deflator.

For imposing the dynamic homogeneity conditions, we need to determine the growth rates of variables in the long run g_x and g_y. As the supply curve is vertical in the long run and the output is determined solely by technology and labour force, the balanced growth path for all aggregate real variables is the sum of productivity and demographic growth rates. The balanced growth path for the main categories of variables is showed in Table 1.2.

Table 1.2
Balanced growth path

Variables	Balanced growth path
Labour force and employment	$\hat{n}$, equal to in-sample mean of labour force growth: $\hat{n} = \overline{\left(\Delta \log\left(\tilde{L}\right)\right)}$
All prices	$\hat{\pi}$, equal to in-sample mean of world prices growth: $\hat{\pi} = \overline{\left(\Delta \log\left(P^W\right)\right)}$
All per capita real variables (productivity, real wage, etc)	$\hat{\gamma}$
All aggregate real variables (Real GDP, capital, investment, consumption, etc.)	$\hat{n} + \hat{\gamma}$

Imposing the constraint of equation [1.15] and using balanced growth rates in the long run from Table 1.2, equations [1.10], [1.11] and [1.12] take the following form:

$$\Delta \log(L_t) = \left(\hat{n} - \sum_i b_{L1i}(\hat{\gamma} + \hat{n}) - \sum_i b_{L2i}\hat{\gamma}\right) + \sum_i b_{L1i}\Delta \log(Y_{t-i}) + \sum_i b_{L2i}\Delta \log\left(\frac{w_{t-i}}{P_{t-l}}\right) + $$
$$+ \mu_L \log\left(\frac{L_{t-1}}{L^*_{t-1}}\right) \qquad [1.16],$$

$$\Delta \log\left(\frac{w_t}{P_t}\right) = \left(1 - \sum_i b_{w1i}\right)\hat{\gamma} + \sum_i b_{w1i}\Delta \log\left(\frac{Y_{t-i}}{L_{t-i}}\right) + \sum_i b_{w2i} \log\left(\frac{L_{t-i}}{L^{NAIRU}_{t-l}}\right) + $$
$$+ \mu_w \log\left(\frac{w_{t-1}}{P_{t-1}}\frac{P^*_{t-1}}{w^*_{t-1}}\right) \qquad [1.17],$$

$$\Delta \log(P_t) = \left(1 - \sum_i b_{p1i} - \sum_i b_{p2i}\right)\hat{\pi} + \sum_i b_{p1i}\Delta \log\left(P^M_{t-i}\right) + \sum_i b_{p2i}\Delta \log\left(\frac{w_{t-i}L_{t-i}}{Y_{t-i}}\right) + $$
$$+ \sum_i b_{p3i} Y^{GAP}_t + \mu_p \log\left(\frac{P_{t-1}}{w_{t-1}}\frac{w^*_{t-1}}{P^*_{t-1}}\right) \qquad [1.18].$$

1.3 Demand side

The demand side of the model is represented by equations for GDP expenditure components. Real GDP is divided into real private consumption, real government consumption, real gross fixed capital formation (hereinafter, investment), changes in inventories, real exports of goods and services, and real imports of goods and services. Real government consumption is treated as exogenous.

The desired level of private consumption C is as a rule determined by the real disposable income Y^D and real financial wealth W. Real disposable income is a sum of wage compensation wL, government transfers to households net of direct taxes ($TR - TD$), and other income OI, which is deflated by the private consumption deflator P^C. Real financial wealth W is composed of the private capital stock K^P, net foreign assets NFA and public debt GD, deflated by the private consumption deflator:

$$\log\left(C^*\right) = \alpha_{c0} + \alpha_{c1}\log\left(Y^D\right) + \left(1-\alpha_{c1}\right)\log(W) \qquad [1.19],$$

$$Y^D = \frac{wL + TR - TD + OI}{P^C} \qquad [1.20],$$

$$W = K^P + \frac{NFA + GD}{P^C} \qquad [1.21].$$

Using the standard capital accumulation equation

$$K = (1-\delta)K_{-1} + I \qquad [1.22]$$

where I is the investment, we can also derive the intermediate target for investment (for more details see Appendix 1, part A1.3):

$$\log\left(I^*\right) = \log\left(\frac{\hat{\gamma} + \hat{n} + \hat{\delta}}{1 + \hat{\gamma} + \hat{n}}\right) + \log\left(K^*\right) \qquad [1.23].$$

Desired changes in real inventories St are treated as a constant fraction of real GDP and are calculated using the following equation:

$$St^* = \alpha_{s1} Y \qquad [1.24].$$

Logarithms are not used in equation [1.24], as changes in real inventories could be in-sample negative.

Intermediate target levels of exports X and imports M depend on the demand (external for exports and domestic for imports) and real exchange rate (or the ratio of domestic to world prices).

Real exports are determined by the foreign demand WD and real exchange rate. The real exchange rate for export equation is traditionally defined as the ratio of the domestic export deflator P^X to competitors' export prices P^{WX} denominated in domestic currency:

$$\log\left(X^*\right) = \alpha_{x0} + \log(WD) + \alpha_{x1}\log\left(\frac{P^x}{P^{wx}}\right), \quad \alpha_{x1} < 0 \qquad [1.25].$$

The sign of the coefficient before the real exchange rate variable should be negative, as the relative increase in domestic export deflator worsens the competitiveness of Latvian exporters in the world market.

The domestic demand for imports WE is a weighted sum of private and government consumption, investment, changes in inventories and exports. The weights of components in the total demand for imports were derived using expert judgements and statistical data from the latest input-output table available:

$$\log\left(M^*\right) = \alpha_{m0} + \log(WE) + \alpha_{m1}\log\left(\frac{P^M}{P}\right), \quad \alpha_{m1} < 0 \qquad [1.26].$$

The real exchange rate of imports equals the ratio of import deflator P^M to domestic prices represented by the GDP deflator. The sign before the relative price is also expected to be negative.

While estimating short-term equations of the demand side, the main goal was to improve the statistical fit; therefore, the dynamic equations of the demand side, as well as those of all other LMM blocks, except the supply side block, were estimated without imposing any dynamic homogeneity restrictions.

1.4 Price block

Following the standard approach used in the AWM and MCMs, the public consumption and investment deflators P^G and P^I are modelled as weighted averages of domestic (GDP deflator) and world prices (import deflator):

$$\log\left(P^{G*}\right) = \alpha_{g0} + \alpha_{g1}\log(P) + \left(1 - \alpha_{g1}\right)\log\left(P^M\right) \qquad [1.27],$$

$$\log\left(P^{I*}\right) = \alpha_{i0} + \alpha_{i1}\log(P) + \left(1 - \alpha_{i1}\right)\log\left(P^M\right) \qquad [1.28].$$

The deflator of private consumption consists of three parts: core inflation P^{CORE} modelled as weighted averages of the GDP deflator and imports deflator; prices of fuel P^{FUEL} modelled from world oil prices (denominated in domestic currency) P^{OIL} and domestic prices; administered prices P^{ADM}, treated as exogenous:

$$P^{C*} = \left(P^{CORE*}\right)^{1-w_{fuel}-w_{adm}}\left(P^{FUEL*}\right)^{w_{fuel}}\left(P^{ADM}\right)^{w_{adm}} \qquad [1.29],$$

$$\log\left(P^{CORE*}\right) = \alpha_{h0} + \alpha_{h1}\log(P) + \left(1 - \alpha_{h1}\right)\log\left(P^M\right) \qquad [1.30],$$

$$\log\left(P^{FUEL*}\right) = \alpha_{f0} + \alpha_{f1}\log(P) + \left(1 - \alpha_{f1}\right)\log\left(P^{OIL}\right) \qquad [1.31]$$

where w_{fuel} and w_{adm} are shares of fuel and products whose prices are regulated in the consumption basket.

The intermediate targets of export and import deflators are modelled from competitors' export prices (P^{WX}) and import prices (P^{WM}) denominated in domestic currency, which depend on the nominal effective exchange rate of the lats and competitors' export and import prices denominated in foreign currency. In addition, world prices of oil are included in the long-term equation of import deflator. We assume a complete pass-through of the exchange rate and world prices to the import deflator:

$$\log\left(P^{M*}\right) = \alpha_{pm0} + \alpha_{pm1}\log\left(P^{WM}\right) + \left(1 - \alpha_{pm1}\right)\log\left(P^{OIL}\right) \qquad [1.32].$$

Following the standard structure used in the AWM and MCMs, the export deflator is modelled as a weighted average of domestic and competitors' export prices:

$$\log\left(P^{X*}\right) = \alpha_{px0} + \alpha_{px1}\log(P) + \left(1 - \alpha_{px1}\right)\log\left(P^{WX}\right) \qquad [1.33].$$

The deflator of changes in inventories is derived as a residual.

1.5 Fiscal block

Government expenditures and government revenues are modelled separately in the LMM. The government expenditures were disaggregated into four parts: government consumption, government capital formation, government transfers and government interest payments. The government real consumption and capital formation were treated as exogenous variables that are derived by political decisions; the government transfers are modelled as a function of the nominal GDP, while the government interest payments depend on the level of government debt and interest rate.

The government revenues consist of three components: revenues from direct taxes, revenues from indirect taxes and other revenues. For reasons of simplicity, nominal GDP was used as a tax base in all three government revenue equations. Effective tax rates are exogenous, with the only exception for the effective direct tax rate, which is assumed to be endogenous. The effective direct tax rate is defined by the calibrated fiscal policy rule that ensures a balanced government budget in the long run (this fiscal rule is similar to those used by G. Fagan, J. Henry and R. Mestre in the AWM (4)):

$$T = T_{-1} - k\frac{GL_{-1}}{Y_{-1}} \qquad [1.34].$$

The effective direct tax rate T is increasing when government lending GL is negative and decreasing when it is positive. Parameter k defines the speed of the tax rate adjustment.

1.6 External block

The external block of the model contains equations for external trade of goods and services (see equations [1.25] and [1.26]), net factor income and net transfers. The net factor income is determined by net foreign assets of Latvian residents and the nominal interest rate. Net transfers with the rest of the world are treated as a constant ratio to nominal GDP in the long run.

2. LMM

The LMM consists of 125 variables: 87 endogenous, 11 exogenous and 27 dummy variables as well as a time trend. Only 19 dynamic equations are estimated without imposing any restrictions on the coefficients. The model covers the time period from 1995 to the first half of 2005 on a quarterly basis.

The task of following the standard AWM and MCM structure was seriously complicated by the lack of statistical data and shortness of time series. Some data series were unavailable or incomplete, and there was a need to create them using indirect data sources and expert judgments. To the extent possible, the data from national accounts are used in the LMM. This, however, gives rise to a problem, as data in line with the ESA 95 (e.g. fiscal accounts, personal disposable income, etc) are not available on a quarterly basis. Further efforts, therefore, need to be made in order to bring the results and projections from the model in line with the ESA 95 standards. The shortness of time series and distortions of data are possibly a reason for instability in some coefficient estimates. This shortness can be reduced by re-estimating the model when a set of better and longer data series is available.

The estimations were run using the Ordinary Least Squares (OLS) Method. The behavioural equations are estimated in the form of error correction models, and, though the dynamic homogeneity conditions are imposed where necessary, in some cases a more complex specification of the dynamic adjustment process is not currently possible due to the existing data constraints. It implies that, e.g. autocorrelation could not be completely eliminated from the residual terms in all cases. Moreover, given the relatively small number of observations, there is a possibility that via a very strict abidance by standard statistical inference procedures some relevant explanatory variables may be omitted. Out of concern about oversimplified structure of the model, a judgment-based building of behavioural relationships was often preferred. In this model, only adaptive or backward-looking expectations are captured through the lagged values of variables.

2.1 Supply side

The desired levels of supply side variables are strictly based on equations [1.5], [1.6], [1.7] and [1.9]. The parameters used to compute intermediate targets were calibrated by the sample mean. The computed values of parameters are given in Table 2.1. The quarterly real depreciation rate $\hat{\delta}$ was calibrated to 2.5% using the national accounts data and expert judgements.

Table 2.1
Calibrated parameters of supply side equations

$\hat{\beta}$	$\hat{\gamma}$	$\hat{n}$	$\hat{\varepsilon}$	$\hat{A}$	$\hat{\pi}$	$\hat{\delta}$
0.325	0.0101	–0.00152	2.646	55.700	0.00509	0.0250

It is worth noting that these calibrated parameters cannot be used to forecast the behaviour of the Latvian economy in the long run. The parameters were calibrated as sample means and are constant in the model. By contrast, in reality these parameters could change over a long horizon due to Latvia's convergence toward the European Union, labour force migration, technology shocks, etc. The most obvious way to solve this problem is to treat the above mentioned parameters as trends, in such a way allowing for the convergence process and changes in fundamentals. An excellent example of this approach can be found in R. Kattai (7), where the convergence of income and price levels to the EU15 level is the underlying concept of modelling real growth and inflation in Estonia.

Nevertheless, we are not employing this methodology in the paper. First, characteristics of the trend will be very sensitive to such subjective assumptions as speed, regularity and horizon of convergence, intensity of migration, etc. Second, although the changes in parameters are important for the long-term solution of the model, they are not crucial for a 3-5 year horizon, which is used for policy simulations and medium-term forecasting. Therefore, we argue that the calibrated parameters from Table 2.1 are appropriate for describing the current state of the Latvian economy and policy simulations.

The supply side of the model is based on the Cobb-Douglas production function (see equation [1.7]):

$$\log(\text{YFT}) = \log(\hat{A}) + (1 - \hat{\beta}) * \log(\text{LNT}) + \hat{\beta} * \log(\text{KSR}) + \hat{\gamma} * (1 - \hat{\beta}) * \text{TREND} \quad [2.1]$$

$\hat{A} = 55.700$

$\hat{\beta} = 0.325$

$\hat{\gamma} = 0.0101$

where
YFT is the potential GDP;
LNT is the potential level of employment;
KSR is the real total capital stock;
TREND is the linear trend, 0 in Q1 1990.

The calibrated $\hat{\gamma}$ coefficient implies that the quarterly labour productivity growth in Latvia is 1.01% and corresponds to approximately 4.0% annual growth. Though compared to advanced economies, this coefficient is relatively high, it reflects transition and catch-up processes during the sample period. The calibrated value of coefficient $\hat{\beta}$ is equal to 0.325, indicating that the capital income share in the Latvian economy is approximately one third.

The desired capital stock was derived from the firm's maximisation problem first order conditions (see equation [1.5]; figures in brackets represent *t*-statistics):

$$\log(\text{KSRSTAR}) = \log((\text{WUN} * \hat{\beta} / ((1 - \hat{\beta}) * \text{YED} * (\text{LTR} + \hat{\delta})))\text{^}(1 - \hat{\beta}) *$$

$$* \text{YER} / (\hat{A} * \text{EXP}(\text{TREND} * \hat{\gamma} * (1 - \hat{\beta})))) +$$

$$\underset{(6.926)}{+ 0.429} - \underset{(-7.029)}{15.739} / \text{TREND} - \underset{(-4.822)}{0.211} * \text{DD0401} \quad [2.2]$$

$\hat{A} = 55.700$

$\hat{\beta} = 0.325$

$\hat{\gamma} = 0.0101$

$\hat{\delta} = 0.0250$

where
KSRSTAR is the intermediate target of real total capital stock;
YER is the real GDP;
WUN is the nominal compensation per employee;
YED is the GDP deflator;
LTR is the real long-term interest rate (quarterly);
DD0401 is the step dummy variable, 1 from Q1 2004, 0 otherwise;
TREND is the linear trend, 0 in Q1 1990.

To obtain the stationary gap between the actual and desired levels, intermediate targets for the capital stock and real wage rate were adjusted with a deterministic term. According to equation [1.6], the intermediate target level of real wage depends on productivity:

$$\log(\text{WURSTAR}) = \log((1 - \hat{\beta}) * (\hat{\varepsilon} - 1) / \hat{\varepsilon}) + \log(\text{YER} / \text{LNN}) -$$

$$\underset{(-8.576)}{-\,0.323} + \underset{(9.233)}{7.774} / \text{TREND} + \underset{(6.737)}{0.134} * \text{DD9701} \qquad [2.3]$$

$\hat{\beta} = 0.325$

$\hat{\varepsilon} = 2.646$

where
WURSTAR is the intermediate target of real compensation per employee;
YER is the real GDP;
LNN is employment;
DD9701 is the step dummy variable, 1 from Q1 1997, 0 otherwise;
TREND is the linear trend, 0 in Q1 1990.

Term $\frac{\hat{\varepsilon}}{\hat{\varepsilon} - 1}$, which is equal to 1.608, can be interpreted also as a mark-up, which is constant in our model.

The dynamic equations for the nominal wage and GDP deflator are calibrated imposing dynamic homogeneity conditions to ensure the achievement of a steady state growth rate in the long run (see equations [1.17] and [1.18]):

$$\Delta\log(\text{WUN} / \text{PCD}) = (1 - 0.437) * \hat{\gamma} + \underset{(2.483)}{0.437} * \Delta\log(\text{YER}(-1) / \text{LNN}(-1)) -$$

$$\underset{(-4.927)}{-\,0.593} * \Delta\log(\text{PCD} / \text{YED}) - \underset{(-1.412)}{0.122} * (\log(\text{WUN}(-1) / \text{YED}(-1)) - \log(\text{WURSTAR}(-1))) +$$

$$+\,\theta^{U} * \log(\text{LNN} / \text{LNT}) - \underset{(-3.841)}{0.0595} * \text{D9601} + \underset{(5.529)}{0.0891} * \text{D9701} - \underset{(-2.583)}{0.0383} * \text{D0101} \qquad [2.4]$$

$\hat{\gamma} = 0.0101$
$\theta^{U} = 0.0250$

where
WUN is the nominal compensation per employee;
PCD is the private consumption deflator;
YER is the real GDP;
YED is the GDP deflator;
LNN is employment;
LNT is the potential level of employment;
WURSTAR is the intermediate target of real compensation per employee;
D9601 is the impulse dummy variable, 1 in Q1 1996, 0 otherwise;
D9701 is the impulse dummy variable, 1 in Q1 1997, 0 otherwise;
D0101 is the impulse dummy variable, 1 in Q1 2001, 0 otherwise.

In a short term, the nominal wages are driven by the changes in labour productivity, the employment gap and the ratio between the consumption and GDP deflators. In the case where the current employment level is above or below the potential long-term level represented by NAIRU employment, the growth of the nominal wage rate increases or decreases, initiating the wage-price adjustment mechanism that ensures the convergence of the system to the steady state. The coefficient before the employment gap was statistically insignificant; therefore, we calibrated it to 0.025 to get the adjustment mechanism working and to obtain plausible responses to shocks.

Long-term non-accelerating inflation rate of unemployment NAIRU is exogenous in the model and calibrated to 9% that is in line with R. Llaudes (8) estimates for the euro area. Due to the structural unemployment persisting in Latvia, it was assumed that, for the time being NAIRU is higher and converging slowly to its long run level. Its convergence is modelled using the autoregressive process AR(1):

$$NAIRU = u^{NAIRU} + \underset{(417.504)}{0.959} * (NAIRU(-1) - u^{NAIRU}) \qquad [2.5]$$

$$u^{NAIRU} = 9.0$$

where NAIRU is the structural or natural unemployment rate.

In the dynamic equation for GDP deflator, firms set their prices basing on the nominal wages and labour productivity represented by nominal unit labour cost changes:

$$\Delta\log(YED) = (1 - 0.421 - 0.164) * \hat{\pi} + \underset{(2.871)}{0.421} * \Delta\log(MTD) +$$

$$+ \underset{(1.561)}{0.164} * \Delta\log(WUN(-3) * LNN(-3) / YER(-3)) + \theta^{GAP} * YGA -$$

$$- \underset{(-0.698)}{0.0663} * (\log(YED(-1) / WUN(-1)) + \log(WURSTAR(-1))) +$$

$$+ \underset{(4.022)}{0.0632} * D9601 - \underset{(-3.331)}{0.0536} * D9701 + \underset{(3.001)}{0.0513} * D9901 \qquad [2.6]$$

$$\hat{\pi} = 0.00509$$
$$\theta^{GAP} = 0.100$$

where
YED is the GDP deflator;

MTD is the deflator of goods and services imports;
WUN is the nominal compensation per employee;
LNN is employment;
YER is the real GDP;
YGA is the output gap;
WURSTAR is the intermediate target of real compensation per employee;
D9601 is the impulse dummy variable, 1 in Q1 1996, 0 otherwise;
D9701 is the impulse dummy variable, 1 in Q1 1997, 0 otherwise;
D9901 is the impulse dummy variable, 1 in Q1 1999, 0 otherwise.

As Latvia is a small and open economy, the world price level (with a complete pass-through to the import deflator) affects the GDP deflator. The output gap captures the demand effect on internal prices and is the second channel through which the price-wage adjustment occurs (consistently with expert judgements and plausibility of simulations, the regression coefficient before the output gap was calibrated to 0.100). As in the dynamic equation of wage rate, the real wage is used as an intermediate target for the GDP deflator.

2.2 Demand side

The demand side of the LMM consists of equations that describe GDP from the expenditure side. The desired level of real private consumption is determined by real disposable income and real financial wealth (see equation [1.19]):

$$\log(PCRSTAR) = \underset{(-4.214)}{-0.316} + \underset{(17.580)}{0.874} * \log(PYR) + (1 - 0.874) * \log(FWR) - \underset{(-5.810)}{0.0768} * DD9901 \qquad [2.7]$$

where
PCRSTAR is the intermediate target of real private consumption;
PYR is the real disposable income of households;
FWR is the real private financial wealth;
DD9901 is the step dummy variable, 1 from Q1 1999, 0 otherwise.

The real disposable income is the main consumption-driving force, as the estimated coefficient before the disposable income is 0.874.

The intermediate target for real capital formation is derived from the desired level of capital stock (see equation [1.23]) using calibrated parameters from Table 2.1:

$$\log(ITRSTAR) = \log((\hat{n} + \hat{\gamma} + \hat{\delta}) / (1 + \hat{n} + \hat{\gamma})) + \log(KSRSTAR) \qquad [2.8]$$

$\hat{n} = -0.00152$

$\hat{\gamma} = 0.0101$

$\hat{\delta} = 0.0250$

where
ITRSTAR is the intermediate target of real gross fixed capital formation;
KSRSTAR is the intermediate target of real total capital stock.

The desired level of real exports of goods and services (see equation [1.25]) is modelled from the external demand with its elasticity calibrated to 1, which ensures a stable share of export markets in the long run. Although the estimated elasticity of real exports to real exchange rate was statistically significant and with the right sign, its value was too low to ensure the effective functioning of the adjustment mechanism, which moves the demand side to its steady state by changing the real exchange rate and hence also real exports and imports. The sum of the estimated export and import price elasticities was below 1; therefore, the elasticity of real exports to real exchange rate was calibrated to –1.0 (similar to (13)):

$$\log(XTRSTAR) = \underset{(173.008)}{6.649} + \log(WDR) + \theta^{XP} * \log(XTD / CXD) -$$

$$- \underset{(-17.992)}{17.566} / TREND - \underset{(-1.722)}{0.0312} * DD9803 + \underset{(3.171)}{0.0464} * D0402 \qquad [2.9]$$

$\theta^{XP} = -1.000$

where
XTRSTAR is the intermediate target of exports of goods and services;
WDR is the real effective imports of Latvia's major trade partners;
XTD is the exports of goods and services deflator;
CXD is the competitors' export price in domestic currency;
DD9803 is the step dummy variable, 1 from Q3 1998, 0 otherwise;
DD0402 is the step dummy variable, 1 from Q2 2004, 0 otherwise;
TREND is the linear trend, 0 in Q1 1990.

The intermediate target for real imports (see equation [1.26]) depends on the domestic demand with a unit elasticity that ensures a stable share of imports in total GDP:

$$\log(MTRSTAR) = \underset{(-23.946)}{-0.184} + \log(WER) + \theta^{MP} * \log(MTD / YED) \qquad [2.10]$$

$\theta^{MP} = -0.500$

where
MTDSTAR is the intermediate target of imports of goods and services;
WER is the weighted import demand indicator;
MTD is the imports of goods and services deflator;
YED is the GDP deflator.

The estimated import price elasticity was too low and was calibrated to –0.5 due to the reasons described above.

2.3 Price block

The private consumption deflator was divided into three parts: core inflation, fuel prices and administered prices, treated as exogenous. The desired level of the core price index (see equation [1.30]) was estimated as a weighted average of the domestic prices (GDP deflator) and external prices (import deflator), which was adjusted by the deterministic time trend and a step dummy variable representing the temporary increase of food prices in the middle of 2001:

$$\log(\text{CORESTAR}) = \underset{(-15.698)}{-0.133} + \underset{(12.347)}{0.747} * \log(\text{YED}) + (1 - 0.747) * \log(\text{MTD}) +$$

$$+ \underset{(17.549)}{5.849} / \text{TREND} + \underset{(2.874)}{0.0225} * \text{D0102\_0202} \qquad [2.11]$$

where
CORESTAR is the intermediate target of CPI, excluding fuel and administratively regulated prices;
YED is the GDP deflator;
MTD is the imports of goods and services deflator;
D0102_0202 is the impulse dummy variable, 1 from Q2 2001 to Q2 2002, 0 otherwise;
TREND is the linear trend, 0 in Q1 1990.

In the long run, the domestic fuel prices are affected by the world oil prices (in lats), domestic prices and dummy variables representing changes in the excise tax on fuel and other administrative decisions:

$$\log(\text{FUELSTAR}) = \underset{(-11.639)}{-0.671} + \underset{(10.861)}{0.201} * \log(\text{PEI}) + (1 - 0.201) * \log(\text{YED}) -$$

$$- \underset{(-7.204)}{0.117} * \text{DD9602} + \underset{(2.293)}{0.0668} * \text{DD9701} + \underset{(8.798)}{0.107} * \text{DD9801} + \underset{(4.273)}{0.0641} * \text{DD0402} \qquad [2.12]$$

where
FUELSTAR is the intermediate target of domestic fuel prices;
PEI is Brent oil prices (in lats);
YED is the GDP deflator;
DD9602 is the step dummy variable, 1 from Q2 1996, 0 otherwise;
DD9701 is the step dummy variable, 1 from Q1 1997, 0 otherwise;
DD9801 is the step dummy variable, 1 from Q1 1998, 0 otherwise;
DD0402 is the step dummy variable, 1 from Q2 2004, 0 otherwise.

2.4 Fiscal block

The fiscal rule ensures that the government budget will be balanced in the long-run, increasing the effective tax rate in response to budget deficit and decreasing it after budget surplus is achieved. We calibrated the coefficient k to 0.100 (see also (4)), due to which the effective direct tax rate would rise by 0.100%, if, in the previous quarter, the government budget deficit had been 1% of GDP:

$$\text{TDX} = \text{TDX}(-1) - k * \text{GLN}(-1) / \text{YEN}(-1) \qquad [2.13]$$

$k = 0.100$

where
TDX is the effective direct tax rate;
GLN is the government net lending;
YEN is the nominal GDP.

2.5 External block

The net factor income ratio to GDP is explained by a constant (that can be interpreted as net income from labour equal to 1.06% of GDP, which is independent of the interest rate and net foreign assets) and net foreign assets of the Latvian residents multiplied by the long-term interest rate:

$$NFNSTAR = \underset{(2.599)}{0.0106} * YEN + \underset{(5.164)}{0.748} * NFA(-1) * LTI / 4 + \underset{(2.270)}{15.044} * DD0001 \qquad [2.14]$$

where
NFNSTAR is the intermediate target of net foreign income from the rest of the world;
YEN is the nominal GDP;
NFA is the net foreign assets;
LTI is the long-term nominal interest rate (annual);
DD0001 is the step dummy variable, 1 from Q1 2000, 0 otherwise.

The intermediate target of net transfers from the rest of the world was modelled as a constant ratio to the nominal GDP:

$$TWNSTAR = \underset{(7.140)}{0.0132} * YEN + \underset{(3.874)}{0.0150} * DD0201 * YEN + \underset{(5.053)}{0.0193} * DD0301 * YEN \qquad [2.15]$$

where
TWNSTAR is the intermediate target of net transfers from the rest of the world;
YEN is the nominal GDP;
DD0201 is the step dummy variable, 1 from Q1 2002, 0 otherwise;
DD0301 is the step dummy variable, 1 from Q1 2003, 0 otherwise.

According to our estimates, the ratio of net transfers to GDP was 1.32% prior to 2002, increasing by 1.50 percentage points after 2002 and by 1.93 percentage points after 2003.

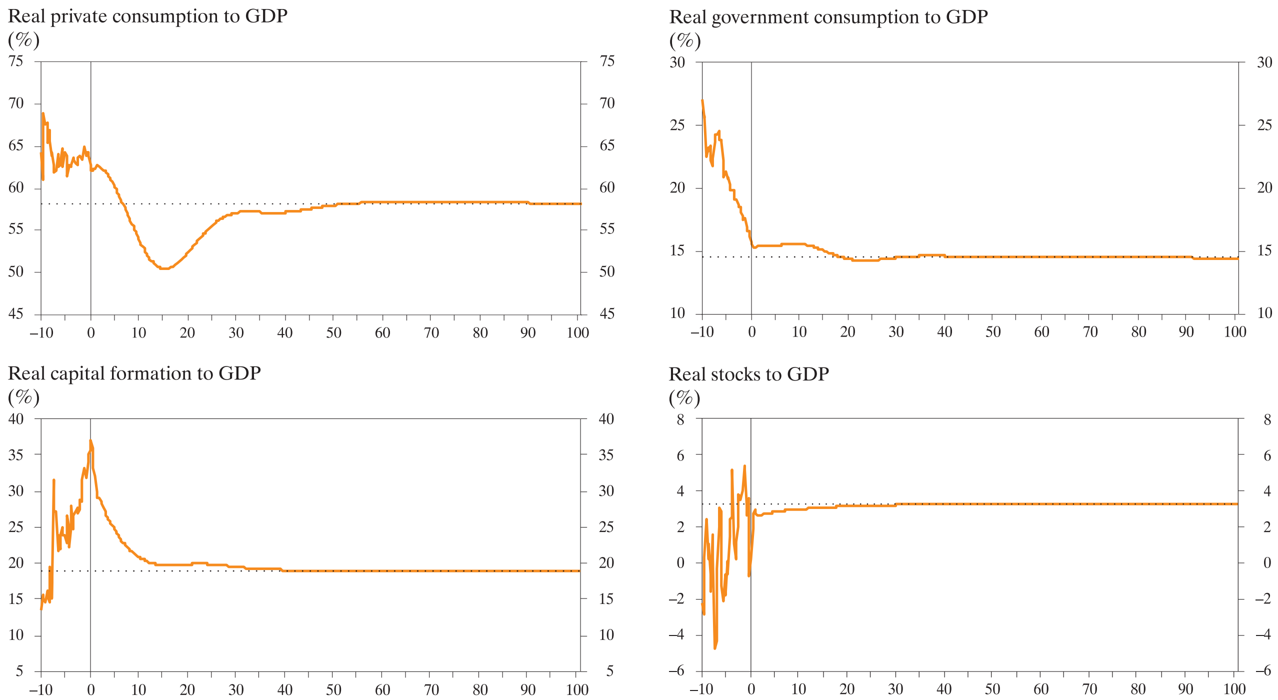
3. BASELINE SCENARIO

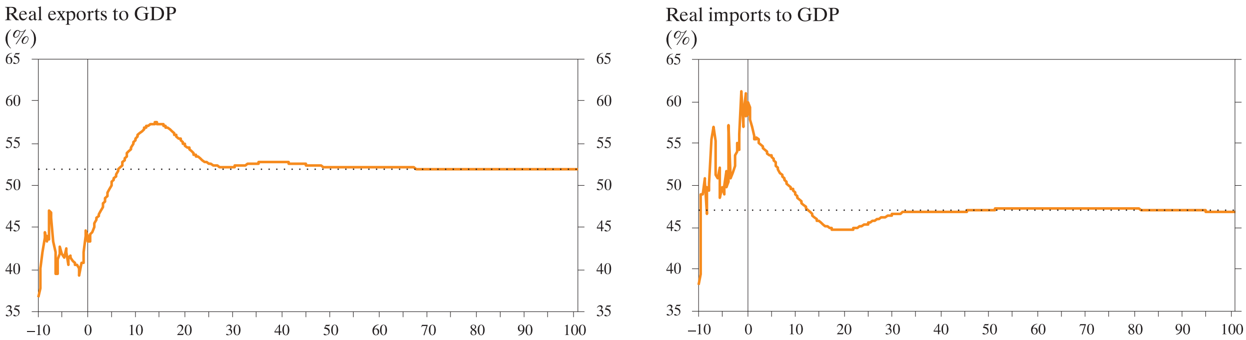
The aim of this section is to present the long-run properties of the model. The long-run solution cannot be viewed as a forecast of the Latvian economy for the reasons mentioned in section 2.1; therefore, this is just a technical exercise with the aim to check the convergence to the stable path in the long run and the plausibility of the ratios obtained.

The steady state of the model is obtained using several assumptions of exogenous variables; for simplicity, the exchange rates and interest rates are fixed at the level of the last observation, the growth rates of all real variables are set equal to $\hat{\gamma}+\hat{n}$, but the growth in price indices is equal to $\hat{\pi}$. To limit the government budget deficit to a specific target, the fiscal rule has been switched on. We simulated the model over a long-term horizon (100 years) until it reached a stable, balanced growth path.

According to the results obtained (see Chart 3.1), the steady state ratio of real consumption to GDP is equal to 58.1%, slightly below the values observed in 1995–2004. The ratio of the real government consumption to GDP decreases and converges to the level of 14.5%, as its growth rate is significantly below the GDP growth at the beginning of the simulation period.

Chart 3.1
Long-term structure of GDP





The capital formation ratio to GDP at the steady state (19.0%) is significantly lower than in the sample period; it can be explained by the current capital formation process, while in the future there will be no need for capital replacement in such a large amount.

The share of real exports in total GDP keeps increasing (reaching 51.9%), and it could be explained only by the real exchange rate dynamics because the growth rate of the world demand also is equal to $\hat{\gamma}+\hat{n}$. Both the positive unemployment gap and the negative output gap at the beginning of the simulation period reduce domestic prices and improve Latvia's competitiveness in external markets.

Despite the increasing share of real exports, the steady state ratio of real imports to GDP is slightly lower than the in-sample value, stabilising at 47.0%. Although the increase of real exports positively affects real imports due to a large import component in Latvian exports, the significant drop in the investment ratio offsets this effect.

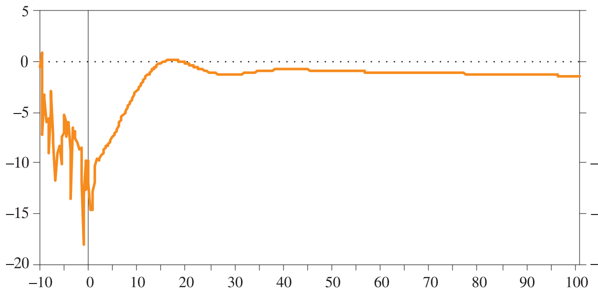
The output and unemployment gaps are closed in the steady state (see Chart 3.2), and it is ensured via the wage-price adjustment mechanism: when the output and employment gaps differ from zero it immediately affects the ratio between the domestic and world prices, adjusting the real GDP to its potential level through changes in real exports and imports. The Chart shows somewhat high volatility of cyclical nature for the output and employment gaps over a relatively long period of time. According to G. Fenz and M. Spitzer (5), this effect could be produced by the absence of monetary rule and the fact that the nominal interest rates are exogenous and kept constant in simulation exercises.

Chart 3.2
Output gap and unemployment gap

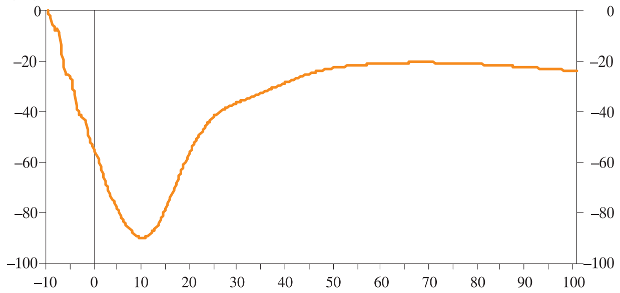
Under a fixed exchange rate regime, there is no mechanism to adjust the current account balance to zero; therefore, the current account balance in the long run is slightly negative and sustained at 1.4% of GDP (see Chart 3.3). As a result, the net foreign asset ratio to GDP is also negative and stabilises at around 24% of GDP.

Chart 3.3
Current account and net foreign assets

Current account balance to GDP
(%)



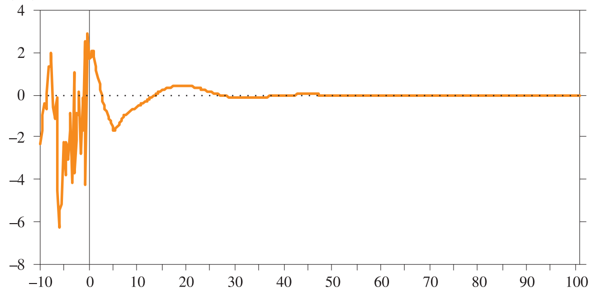
Net foreign assets to GDP
(%)



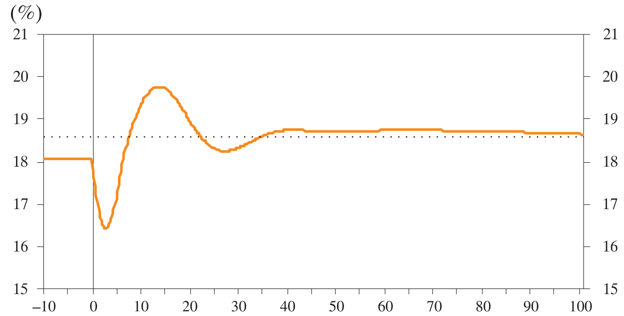
The fiscal rule ensures that the government budget balance achieves the target, which is equal to zero (see Chart 3.4), i.e. no deficit is permitted in the long run. In the event of a deficit, the fiscal rule gradually increases the direct taxes in the model to compensate for the growing expenses, and, vice versa, in the event of a government profit the direct taxes decrease. In the model, the effective direct tax rate converges to 18.6% in the long run compared to the in-sample value of 18.1% in the model.

Chart 3.4
Government budget and direct tax effective rate

Government budget balance to GDP
(%)



Direct tax effective rate
(%)



4. SIMULATIONS

To illustrate the simulation properties of the LMM, we present the response of the model's main variables to the following standard shocks:

– transitory interest rate shock (over a 2-year period);
– permanent exchange rate shock;
– permanent oil price shock;
– permanent world demand shock;
– permanent government consumption shock.

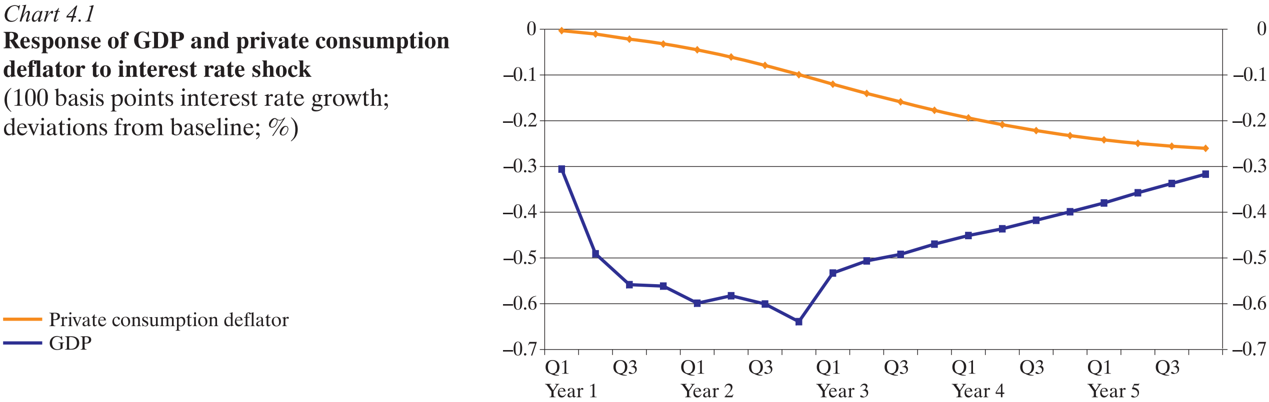
The transitory interest rate shock is a monetary policy shock when the short-term nominal interest rate is shifted by 100 basis points for 2 years. As Latvia has joined the ERM II and the lats is fixed to the euro, the monetary policy shock could be interpreted as an increase of the short-term interest rate by the ECB. The permanent exchange rate shock is the depreciation of the lats by 1% against all other currencies. The permanent oil price shock is defined as an oil price rise by 10% in US dollar terms. The permanent world demand shock is the strengthening of real imports of trading partners by 1%, and, finally, the permanent government consumption shock is expressed as an increase in government real consumption by 1% of GDP. Summary tables of the model response to these shocks are presented in Appendix 4.

The simulation results will be compared, where possible, with those obtained in other MCM blocks.

4.1 Monetary policy shock

Before the description of the results, some comments on the implementation of a shock should be made. The reaction of long-term interest rates to the monetary policy shock is usually rather weak in euro area country models. The standard response of the long-term interest rate is 0.163 in the first year and only 0.063 in the second (see 12; 4; 2; 5). However, this weak reaction is not supported by the Latvian empirical data (see Chart 4.1). According to our estimates (see the backward-looking equation for the long-term interest rate in Appendix 3), the response of the long-term interest rate to the monetary policy shock in the first and in the second year is almost one to one – 0.90 and 0.93, respectively.

Chart 4.1
Response of GDP and private consumption deflator to interest rate shock
(100 basis points interest rate growth; deviations from baseline; %)



It is worth pointing out that the initial responses of the LMM to the monetary policy shock were extremely strong due to a very high and implausible elasticity of interest rates on investment in the short run (0.44). Therefore, we had to calibrate the short-term interest rate elasticity to 0.25, which is similar to the results obtained by the Estonian and Lithuanian models (see 14; 7).

As the exchange rate does not react to domestic interest rate changes (because of the fixed exchange rate regime), the main effect of the shock translates into the real side through investment, thus rising costs of capital and hence also reducing output. According to the results of the estimated dynamic equation of investment, the reaction of investment to interest rate changes is fast and relatively strong; therefore, the maximum effect of the increased interest rate is achieved in the first year when the real investment shrinks by 2.8% and output is reduced by 0.5%. Later, the effect persists also due to declining consumption.

A little smaller output reduces employment (only by 0.2% in the first year), leading to a decrease in productivity and nominal wages, and translating into declining imports. As exports are stable because of a sustained external demand, lower imports improve the current account balance. The impact of interest rate changes on domestic activity is rather instantaneous, and, with interest rates returning to their initial level after a two-year period, the impact dies out rather quickly as well.

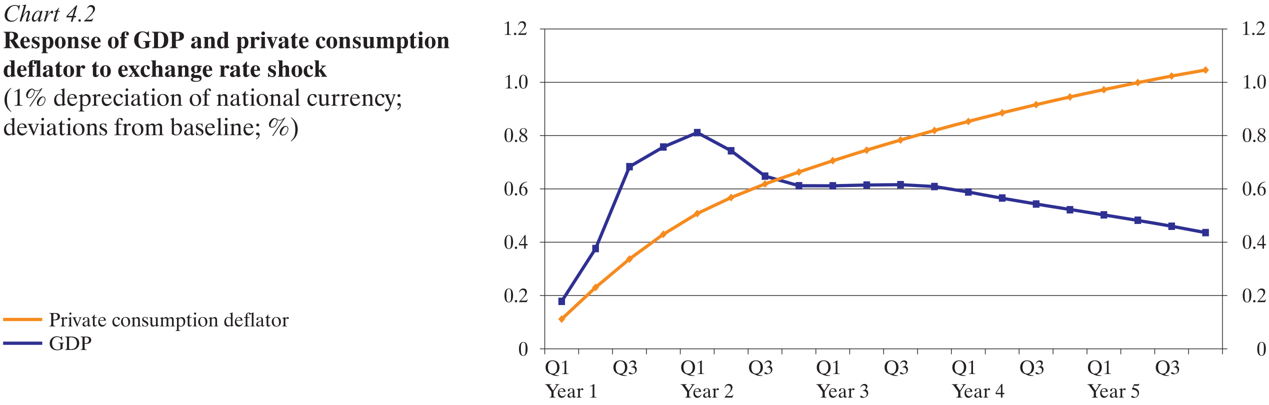
The effect on domestic prices is rather weak and becomes pronounced at a slower pace. Initially, the shock decreases consumer prices only slightly, with the effect becoming stronger in upcoming years due to a weaker domestic demand. However, it is still small – up to 0.25% in the fifth year, that is not surprising due to the openness of the Latvian economy.

Comparing the simulation obtained with responses of other country blocks of the MCM, we concluded that the reaction of consumer prices and GDP in the LMM is stronger than in the euro area country models. This can be explained by a higher share of investment in GDP. The Estonian model displays a similar GDP response, with a significantly weaker reaction of prices. Finally, the Lithuanian block of MCM shows much stronger reaction of both GDP (maximum – 1.8% in the second year) and consumer prices (0.8 % in the fifth year).

4.2 Exchange rate shock

The decrease in the value of the lats against all other currencies has an immediate and significant impact on both the import and export deflators (see Chart 4.2). The pass-through to domestic prices is moderate in the short run, causing only a 0.3% increase in consumer prices during the first year; it is more pronounced in the upcoming years, with consumer prices rising by 1.0% in the fifth year after the shock. Moreover, the exchange rate shock determines a 1.3% higher GDP deflator in the fifth year because of a stronger domestic demand.

Chart 4.2
Response of GDP and private consumption deflator to exchange rate shock
(1% depreciation of national currency; deviations from baseline; %)



As nominal interest rates are exogenous in the model, higher domestic prices mean the lowering of the real interest rate; therefore, depreciation of the lats causes a fast and strong expansion of domestic investment. Although this effect is clear from the technical point of view, its plausibility is questionable. One of the potential ways to solve this problem is smoothing the user cost of capital that will prevent an excessive response of investment during the simulation exercise (similar to D. Sideris and N. Zonzilos in the Greek block of MCM (11)). On the other hand, smoothing will dampen and postpone the excessive response but not eliminate the problem completely.

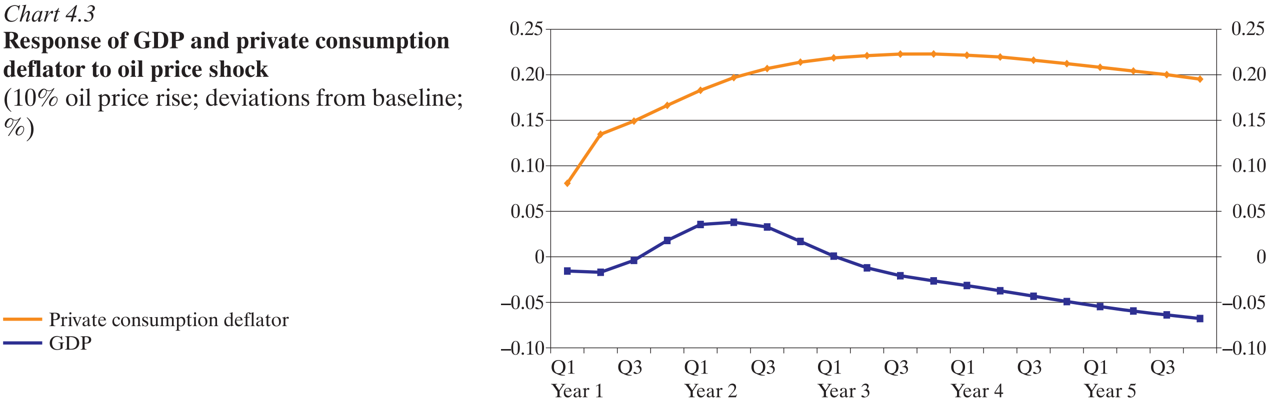
An effect of the exchange rate on the real side occurs through the improvement of exporters' competitiveness and higher real exports. The reaction of real GDP to an exchange rate shock is rather prompt, achieving its maximum in the second year (up by 0.7%), but a decrease in further years is determined by the growth of real imports.

In the case of an exchange rate shock, the reaction of the Lithuanian block of MCM is less pronounced: for GDP, it achieves the maximum in the second year (0.5%), but for consumer prices the reaction is only 0.7% in the fifth year. Also the reaction of French and Greek models to the exchange rate shock turns out to be weaker. The strong reaction of the LMM is determined by the small size and high-degree openness of Latvia's economy.

4.3 Oil price shock

An oil price shock leads to increasing domestic prices, both through direct channels (i.e. rising import prices) and the second-round effects, although the magnitude of the latter appears to be rather limited (see Chart 4.3). As the oil price does not enter the supply side of the model, the shock does not affect the level of potential output.

Chart 4.3
Response of GDP and private consumption deflator to oil price shock
(10% oil price rise; deviations from baseline; %)



The oil price pass-through to domestic prices is similar to the exchange rate shock, but in this case the shock influences the price of a single imported commodity that plays an important part in private consumption and production. The oil price significantly influences all domestic prices; the response grows gradually and achieves 0.2% for consumer prices and 0.1% point for the GDP deflator in the fifth year after the shock. The second-round effect is determined by a decrease in labour productivity and further growth in the domestic price indices.

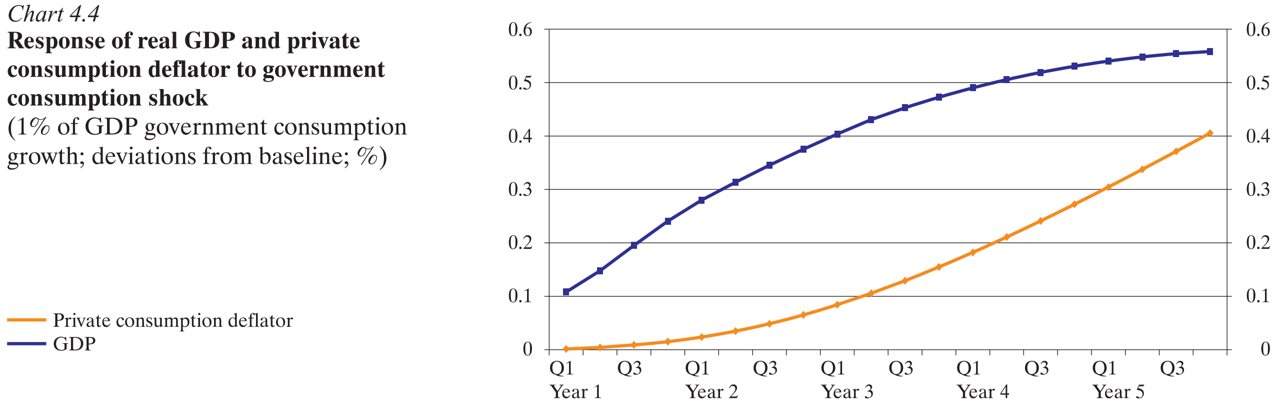
Unexpectedly, real GDP reacts positively to the oil price shock during the first two years, reflecting a short-term rise in investment (as it was discussed above, a price jump means a decrease in the real interest rate and cost of capital). However, over a period that exceeds two years, higher oil prices have a negative impact on the output and domestic demand (private consumption declines by 0.2%, whereas GDP and investment both fall by 0.1% in the fifth year) under the impact of diminishing real wealth and real consumption of households. As concerns external trade, reduced economic activity leads to a lower demand for imports, whereas real exports are shrinking due to an increase in domestic prices (the shock is designed in such a way that higher oil prices do not lead to an increase in world prices P^W).

Compared to other MCMs, the LMM records low responses to the oil price shock, which are comparable to the GDP reaction in the Greek model, whereas the response of consumer prices in the Estonian model is even weaker. Modest responses in the LMM can be partly explained by a relatively low share of fuel in the total consumer basket.

4.4 Foreign demand shock

The external demand shock has a significant impact on the country's overall economic activity and translates into a stronger domestic demand (see Chart 4.4).

Chart 4.4
Response of real GDP and private consumption deflator to government consumption shock
(1% of GDP government consumption growth; deviations from baseline; %)



At first, the external shock directly pushes up the volume of exports by 0.9% in the first two years (this effect diminishes in later years due to higher domestic prices and a deteriorating competitiveness). The growth in exports determines an increase in investment, consumption and labour productivity, and causes a decline in unemployment rate, with the effect on GDP reaching 0.6% in the fifth year after the external demand shock. However, due to the strong interconnection of exports, investment and imports, the strengthening of foreign demand has a positive marginal impact on the net trade position only in two years' time.

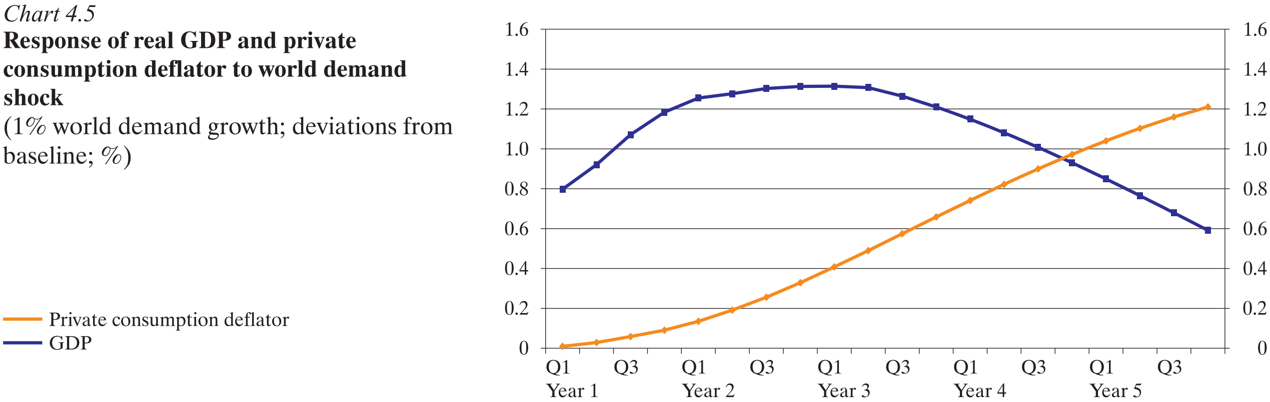
Overall, the effect of the foreign demand shock on the economic activity appears to be of significant magnitude, reflecting the small size and high degree of openness of the country. The impact of the foreign demand shock on prices, on the other hand, is rather weak, with the consumption deflator rising only by 0.4% in the fifth year.

It should be noted that due to the high openness of Latvia's economy, the results of the LMM are close to those recorded for the Lithuanian and Estonian models but exceed the reaction of the French, Greek and Austrian models.

4.5 Fiscal policy shock

An increase in the government consumption boosts domestic demand, thus making a positive contribution to GDP (higher by 0.7% in the fifth year) and raising all components of the domestic demand (see Chart 4.5). The fiscal expansion provides an overall direct stimulus to production, consumption and investment. Since employment is inelastic, additional output indicates higher productivity and wages, with the latter rising at a faster pace. The growing tax revenues as a result of expanding economic activity ensure that deterioration in fiscal deficit occurs at a slower pace than the initial increase in the government consumption.

Chart 4.5
Response of real GDP and private consumption deflator to world demand shock
(1% world demand growth; deviations from baseline; %)



Larger investment and stronger private and government consumption lead to expanding imports; at the same time, the effect of these factors on exports is negative because the external demand remains unchanged, while domestic prices rise. High elasticity of the demand for imports implies that fiscal loosening translates into a rising volume of imports and deteriorating trade balance.

The influence on prices becomes visible at a slower pace, with the demand pressure and growing unit labour costs caused by higher government consumption pushing consumer prices up by 1.1% in the fifth year after the fiscal shock occurs.

The review of LMM results leads to the conclusion that the reaction of GDP is broadly in line with other MCM blocks, while that of consumer prices differs, exceeding the reaction of the French model and being significantly lower than in the Greek model.

CONCLUSIONS

The paper presents the analysis of the current state of Latvia's Macroeconomic Model, explaining the underpinning theoretical principles, reporting the main equations of the supply, demand, price and external blocks, as well as discussing the baseline scenario and policy simulations obtained. This model is the first attempt to build a structural macroeconomic model for the Latvian economy using a structure close to that of the AWM and MCMs; it is likewise a step towards a more intense use of the econometric approach in economic analysis and forecasting.

The equations of the model fit the data reasonably well despite such data problems as short time series, omissions and recent data revisions. In order to ensure an appropriate adjustment to the long run equilibrium and to include some expert knowledge about functioning of the economy, some of the equations were constrained and coefficients were calibrated. The main results of the baseline scenario and standard simulations are plausible and confirm that we are on the right way of building the macroeconomic model.

Nonetheless, the work on the model is still in progress and the paper can be considered only an interim report. The availability of new data as well as further structural changes in the economy during the convergence process will require the re-estimation of the model in the future. Moreover, the model captures only a backward-looking behaviour, but the accession to the EU has revealed the importance of the impact of forward-looking expectations on macroeconomics. Therefore, the inclusion of forward-looking expectations is one of the possible improvements to the model that will result in a more accurate forecasting and policy analysis.

APPENDICES

Appendix 1
Mathematical Derivations

A1.1 Supply side of the model

The supply side of the model is derived solving the firm's profit maximisation problem:

$$\begin{cases} \Pi(Y_i) \xrightarrow[L_i, K_i]{} \max \\ \Pi(Y_i) = P_i Y_i - wL_i - cK_i \\ Y_i = Y\left(\dfrac{P}{P_i}\right)^{\varepsilon} \\ Y_i = AK_i^{\beta}\left(e^{\gamma t}L_i\right)^{1-\beta} \end{cases} \quad [1.3]$$

where Y_i is the production of the firm i, L_i is the labour force used at the firm, K_i is the capital stock of the firm, P_i is the price of goods produced by the firm, Y is the aggregate supply of generic goods, P is the price of the generic consumption goods, ε is the elasticity of the demand for goods produced by the firm i to its relative price, γ denotes the exogenous growth rate of technological progress, β is the elasticity of production factors, w is the nominal wage level, and c is the nominal cost of capital and by definition $c = P(r + \delta)$ where r is the real rate of interest but δ is the physical depreciation rate of capital.

$$\Pi(Y_i) = P_i Y_i - wL_i - cK_i = P\left(\frac{Y}{Y_i}\right)^{\frac{1}{\varepsilon}} Y_i - wL_i - cK_i = \\ = PY^{\frac{1}{\varepsilon}}\left(AK_i^{\beta}\left(e^{\gamma t}L_i\right)^{1-\beta}\right)^{\frac{\varepsilon-1}{\varepsilon}} - wL_i - cK_i \quad [A1.1].$$

First order conditions are:

$$\frac{\partial \Pi}{\partial K_i} = PY^{\frac{1}{\varepsilon}}\left(A\left(e^{\gamma t}L_i\right)^{1-\beta}\right)^{\frac{\varepsilon-1}{\varepsilon}} \beta\left(\frac{\varepsilon-1}{\varepsilon}\right) K_i^{\beta\left(\frac{\varepsilon-1}{\varepsilon}\right)-1} - c = 0 \quad [A1.2],$$

$$\frac{\partial \Pi}{\partial L_i} = PY^{\frac{1}{\varepsilon}}\left(AK_i^{\beta}e^{\gamma t(1-\beta)}\right)^{\frac{\varepsilon-1}{\varepsilon}} (1-\beta)\left(\frac{\varepsilon-1}{\varepsilon}\right) L_i^{(1-\beta)\left(\frac{\varepsilon-1}{\varepsilon}\right)-1} - w = 0 \quad [A1.3].$$

Using the assumption of symmetric equilibrium $\left(P_i = P, Y_i = Y, L_i = L, K_i = K \quad \forall i\right)$, we get:

$$Y = AK^{\beta}\left(e^{\gamma t}L\right)^{1-\beta} \quad [A1.4],$$

$$\frac{\partial \Pi}{\partial K_i} = PAe^{\gamma t(1-\beta)}\left(\frac{L}{K}\right)^{1-\beta} \beta\left(\frac{\varepsilon-1}{\varepsilon}\right) - c = 0 \quad [A1.5],$$

$$\frac{\partial\Pi}{\partial L_i} = PAe^{\gamma t(1-\beta)}\left(\frac{K}{L}\right)^{\beta}(1-\beta)\left(\frac{\varepsilon-1}{\varepsilon}\right) - w = 0 \qquad [A1.6].$$

After rearranging equation [A1.4], we get:

$$L = e^{-\gamma t}\left(\frac{Y}{AK^{\beta}}\right)^{\frac{1}{1-\beta}} \qquad [A1.7].$$

From equation [A1.6], we derive:

$$\frac{w}{P} = Ae^{\gamma t(1-\beta)}\left(\frac{K}{L}\right)^{\beta}(1-\beta)\left(\frac{\varepsilon-1}{\varepsilon}\right) \qquad [A1.8].$$

Using equation [A1.4], we get:

$$\frac{w}{P} = \frac{(1-\beta)(\varepsilon-1)}{\varepsilon}\frac{Y}{L} \qquad [A1.9].$$

From equation [A1.5], we obtain:

$$K = \left(\frac{PA\left(e^{\gamma t}L\right)^{1-\beta}\beta}{c}\left(\frac{\varepsilon-1}{\varepsilon}\right)\right)^{-\frac{1}{\beta-1}} \qquad [A1.10].$$

Using equations [A1.9] and [A1.7], we get:

$$\frac{K}{L} = \frac{w\beta}{c(1-\beta)} \qquad [A1.11],$$

$$K = \frac{Y}{Ae^{(1-\beta)\gamma t}}\left(\frac{\beta w}{(1-\beta)P(r+\delta)}\right)^{1-\beta} \qquad [A1.12].$$

Equations [A1.7], [A1.9] and [A1.12] form the supply side of the model:

$$\begin{cases} L = e^{-\gamma t}\left(\dfrac{Y}{AK^{\beta}}\right)^{\frac{1}{1-\beta}} \\ K = \dfrac{Y}{Ae^{(1-\beta)\gamma t}}\left(\dfrac{\beta w}{(1-\beta)P(r+\delta)}\right)^{1-\beta} \\ \dfrac{w}{P} = \dfrac{(1-\beta)(\varepsilon-1)}{\varepsilon}\dfrac{Y}{L} \end{cases} \qquad [1.4].$$

A1.2 Calibration of parameters of supply side equations

From equation [A1.11], we obtain:

$$\beta = \frac{cK}{wL + cK} = \frac{(r+\delta)K}{\frac{w}{P}L + (r+\delta)K} \qquad [A2.1].$$

From equation [A1.9], we get:

$$\varepsilon = \frac{PY(1-\beta)}{PY(1-\beta) - wL} \qquad [A2.2].$$

Using equation [A2.1], we get:

$$\varepsilon = \frac{PY}{PY - wL - cK} \qquad [A2.3].$$

Using equation [A1.4], we obtain:

$$A = \frac{Y}{K^{\beta}\left(e^{\gamma t}L\right)^{1-\beta}} \qquad [A2.4].$$

After rearranging equation [A1.4], we obtain:

$$e^{\gamma t} = \left(\frac{1}{A}\frac{Y}{L}\left(\frac{L}{K}\right)^{\beta}\right)^{\frac{1}{1-\beta}} \qquad [A2.5],$$

and taking the first difference of logarithms, we get:

$$\gamma = \frac{\Delta \log\left(\frac{Y}{L}\right) - \beta\Delta \log\left(\frac{K}{L}\right)}{1-\beta} \qquad [A2.6].$$

A1.3 Intermediate target for investment

We can derive the intermediate target for investment from the standard capital accumulation equation

$$K = (1-\delta)K_{-1} + I \qquad [1.22]$$

where I is the investment.

By using equation for the desired level of capital [A1.12] and taking into account that in the steady state the real GDP growth is determined by productivity and demographical developments $Y^{*} = Y^{*}_{-1}(1+\hat{\gamma}+\hat{n})$, but the real wage growth depends on productivity improvement $\left(\frac{w}{P}\right)^{*} = \left(\frac{w}{P}\right)^{*}_{-1}(1+\hat{\gamma})$, we get:

$$I = \frac{Y}{Ae^{(1-\beta)\gamma t}}\left(\frac{\beta w}{(1-\beta)P(r+\delta)}\right)^{1-\beta} - (1-\delta)\frac{Y_{-1}}{Ae^{(1-\beta)\gamma(t-1)}}\left(\frac{\beta w_{-1}}{(1-\beta)P_{-1}(r+\delta)}\right)^{1-\beta} =$$

$$= \left(1 - \left(\frac{(1-\delta)}{e^{-(1-\beta)\gamma}(1+\gamma+n)}\right)\left(\frac{1}{1+\gamma}\right)^{1-\beta}\right)K \qquad \text{[A3.1].}$$

As $e^{(1-\beta)\gamma} \approx (1+\gamma)^{1-\beta}$ for small γ,

$$I = \left(1 - \left(\frac{(1-\delta)}{(1+\gamma+n)}\right)\right)K = \left(\frac{\gamma+n+\delta}{1+\gamma+n}\right)K \qquad \text{[A3.2].}$$

Consequently, the intermediate target for investment is

$$\log(I^*) = \log\left(\frac{\hat{\gamma}+\hat{n}+\hat{\delta}}{1+\hat{\gamma}+\hat{n}}\right) + \log(K^*) \qquad \text{[1.23].}$$

Appendix 2
List of Variables

Endogenous variables

Symbol	Description
CAN	Current account balance
CMD	Competitors' import price in domestic currency
CORE	CPI excluding fuel and administered prices
CORESTAR	Intermediate target of CPI excluding fuel and administered prices
CXD	Competitors' export price in domestic currency
FUEL	Domestic fuel prices
FUELSTAR	Intermediate target of domestic fuel prices
FWN	Nominal private financial wealth
FWR	Real private financial wealth
GCD	Government consumption deflator
GCDSTAR	Intermediate target of government consumption deflator
GCN	Nominal government consumption
GDN	Government net debt
GEN	Nominal government expenditures (total)
GIN	Real gross fixed capital formation in public sector
GLN	Government net lending
GON	Nominal gross operating surplus and mixed income
GSN	Government gross savings
GYN	Government nominal disposable income
INN	Government expenditures on interest payments
INNSTAR	Intermediate target of government expenditures on interest payments
IPN	Nominal gross fixed capital formation in private sector
IPR	Real gross fixed capital formation in private sector
ITD	Gross fixed capital formation deflator
ITDSTAR	Intermediate target of gross fixed capital formation deflator
ITN	Nominal gross fixed capital formation
ITR	Real gross fixed capital formation
ITRSTAR	Intermediate target of real gross fixed capital formation
KGR	Real capital stock in public sector
KPR	Real capital stock in private sector
KSR	Total real capital stock
KSRSTAR	Intermediate target of total real capital stock
LFN	Labour force
LFNSTAR	Intermediate target of labour force
LNN	Employment

Symbol	**Description**
LNNSTAR	Intermediate target of employment
LNT	Potential level of employment
LTI	Long-term nominal interest rate (annual)
LTR	Real long-term interest rate (quarterly)
MTD	Imports of goods and services deflator
MTDSTAR	Intermediate target of imports of goods and services deflator
MTN	Nominal imports of goods and services
MTR	Real imports of goods and services
MTRSTAR	Intermediate target of real imports of goods and services
NAIRU	NAIRU unemployment rate
NFA	Net foreign assets
NFN	Net foreign income from the rest of the world
NFNSTAR	Intermediate target of net foreign income from the rest of the world
OGN	Other government net revenue
OGNSTAR	Intermediate target of other government net revenue
OPN	Other personal income
PCD	Private consumption deflator
PCN	Nominal private consumption
PCR	Real private consumption
PCRSTAR	Intermediate target of real private consumption
PEI	Brent oil prices (in lats)
PYN	Households' nominal disposable income
PYR	Households' real disposable income
SCD	Changes in inventories (deflator)
SCN	Changes in inventories (nominal)
SCR	Changes in inventories (real)
SCRSTAR	Intermediate target of changes in inventories (real)
TDN	Direct taxes including social security contributions
TDNSTAR	Intermediate target of direct taxes
TDX	Effective direct tax rate
TIN	Indirect taxes net of subsidies
TINSTAR	Intermediate target of indirect taxes net of subsidies
TRN	Total transfers from government
TRNSTAR	Intermediate target of total transfers from government
TWN	Net transfers from the rest of the world
TWNSTAR	Intermediate target of net transfers from the rest of the world
URX	Unemployment rate
WER	Weighted import demand indicator
WIN	Total compensation to employees
WUN	Nominal compensation per employee

Symbol	Description
WUR	Real compensation per employee
WURSTAR	Intermediate target of real compensation per employee
XTD	Exports of goods and services deflator
XTDSTAR	Intermediate target of export of goods and services deflator
XTN	Nominal exports of goods and services
XTR	Real exports of goods and services
XTRSTAR	Intermediate target of real exports of goods and services
YED	GDP deflator
YEN	Nominal GDP
YER	Real GDP
YFT	Potential GDP
YGA	Output gap

Exogenous variables

Symbol	Description
CMUD	Competitors' import price in foreign currency
CXUD	Competitors' export price in foreign currency
EXR	Nominal effective exchange rate of lats
GCR	Real government consumption
GIR	Real gross fixed capital formation in public sector
OIL	Brent oil prices (in US dollars)
PA	Prices regulated by administrative means
STI	Short-term nominal interest rate (annual)
USD	US dollar nominal exchange rate to lats
WDR	Real effective import of Latvia's major trade partners
ZBOP	Net errors and omissions in balance of payments

Dummy variables and time trend

Symbol	Description
D0001	Impulse dummy variable, 1 in Q1 2000, 0 otherwise
D0101	Impulse dummy variable, 1 in Q1 2001, 0 otherwise
D0102_0202	Impulse dummy variable, 1 in Q2 2001–Q2 2002, 0 otherwise
D0201	Impulse dummy variable, 1 in Q1 2002, 0 otherwise
D0401	Impulse dummy variable, 1 in Q1 2004, 0 otherwise
D0404	Impulse dummy variable, 1 in Q4 2004, 0 otherwise
D0502	Impulse dummy variable, 1 in Q2 2005, 0 otherwise
D9501_9904	Impulse dummy variable, 1 in Q1 1995–Q4 1999, 0 otherwise

Symbol	**Description**
D9601	Impulse dummy variable, 1 in Q1 1996, 0 otherwise
D9701	Impulse dummy variable, 1 in Q1 1997, 0 otherwise
D9704	Impulse dummy variable, 1 in Q4 1997, 0 otherwise
D9801_0104	Impulse dummy variable, 1 in Q1 1998–Q4 2001, 0 otherwise
D9801_9904	Impulse dummy variable, 1 in Q1 1998–Q4 1999, 0 otherwise
D9801	Impulse dummy variable, 1 in Q1 1998, 0 otherwise
D9803	Impulse dummy variable, 1 in Q3 1998, 0 otherwise
D9901	Impulse dummy variable, 1 in Q1 1999, 0 otherwise
DD0001	Step dummy variable, 1 from Q1 2000, 0 otherwise
DD0201	Step dummy variable, 1 from Q1 2002, 0 otherwise
DD0301	Step dummy variable, 1 from Q1 2003, 0 otherwise
DD0401	Step dummy variable, 1 from Q1 2004, 0 otherwise
DD0402	Step dummy variable, 1 from Q2 2004, 0 otherwise
DD9601	Step dummy variable, 1 from Q1 1996, 0 otherwise
DD9602	Step dummy variable, 1 from Q2 1996, 0 otherwise
DD9701	Step dummy variable, 1 from Q1 1997, 0 otherwise
DD9801	Step dummy variable, 1 from Q1 1998, 0 otherwise
DD9803	Step dummy variable, 1 from Q3 1998, 0 otherwise
DD9901	Step dummy variable, 1 from Q1 1999, 0 otherwise
TREND	Linear trend, 1 in Q1 1990

Appendix 3
LMM Equations

(see Appendix 2 for the description of variables)

Supply side

Potential output

$$\log(YFT) = \log(\hat{A}) + (1 - \hat{\beta}) * \log(LNT) + \hat{\beta} * \log(KSR) + \hat{\gamma} * (1 - \hat{\beta}) * TREND$$

$\hat{A} = 55.700$
$\hat{\beta} = 0.325$
$\hat{\gamma} = 0.0101$

Capital stock

$$\log(KSRSTAR) = \log((WUN * \hat{\beta} / ((1 - \hat{\beta}) * YED * (LTR + \hat{\delta}^{total}))) \wedge (1 - \hat{\beta}) *$$

$$* YER / (\hat{A} * EXP(TREND * \hat{\gamma} * (1 - \hat{\beta})))) +$$

$$+ \underset{(6.926)}{0.429} - \underset{(-7.029)}{15.739} / TREND - \underset{(-4.822)}{0.211} * DD0401$$

$R^2 = 0.926$
$\hat{A} = 55.700$
$\hat{\beta} = 0.325$
$\hat{\gamma} = 0.0101$
$\hat{\delta}^{total} = 0.0250$

Labour force

$$\log(LFNSTAR) = 0.150 + \underset{(16.076)}{\hat{n}} * TREND + \underset{(5.743)}{1.488} / TREND + \underset{(11.572)}{0.195} * DD0001 -$$

$$- \underset{(-12.385)}{9.173} * DD0001 / TREND$$

$R^2 = 0.919$
$\hat{n} = -0.00152$

$$\Delta\log(LFN) = - \underset{(-5.757)}{0.900} * \log(LFN(-1) / LFNSTAR(-1)) -$$

$$- \underset{(-3.240)}{0.0256} * D0001 - \underset{(-2.042)}{0.0164} * D0201$$

$R^2 = 0.515$

Employment

$$\log(\text{LNNSTAR}) = (\log(\text{YER}) - \hat{\beta} * \log(\text{KSR}) - \log(\hat{A}) - \hat{\gamma} * (1 - \hat{\beta}) * \text{TREND}) / (1 - \hat{\beta})$$

$\hat{A} = 55.700$
$\hat{\beta} = 0.325$
$\hat{\gamma} = 0.0101$

$$\Delta\log(\text{LNN}) = n - \underset{(3.3166)}{0.356} * (\hat{\gamma} + \hat{n}) + 0.356 * \Delta\log(\text{YER}) -$$

$$- \underset{(1.046)}{0.0680} * \log(\text{LNN}(-1) / \text{LNNSTAR}(-1)) - \underset{(-2.939)}{0.0290} * \text{D0001} + \underset{(2.330)}{0.0222} * \text{D0101}$$

$R^2 = 0.404$
$\hat{\gamma} = 0.0101$
$\hat{n} = -0.00152$

$$\text{NAIRU} = u^{NAIRU} + \underset{(417.504)}{0.959} * (\text{NAIRU}(-1) - u^{NAIRU})$$

$R^2 = 0.999$
$u^{NAIRU} = 9$

Real compensation per employee

$$\log(\text{WURSTAR}) = \log((1 - \hat{\beta}) * (\hat{\varepsilon} - 1) / \hat{\varepsilon}) + \log(\text{YER} / \text{LNN}) -$$

$$- \underset{(-8.576)}{0.322} + \underset{(9.233)}{7.774} / \text{TREND} + \underset{(6.737)}{0.134} * \text{DD9701}$$

$R^2 = 0.962$
$\hat{\beta} = 0.325$
$\hat{\varepsilon} = 2.643$

Nominal compensation per employee

$$\Delta\log(\text{WUN} / \text{PCD}) = (1 - \underset{(2.483)}{0.437}) * \hat{\gamma} + 0.437 * \Delta\log(\text{YER}(-1) / \text{LNN}(-1)) -$$

$$- \underset{(-4.927)}{0.593} * \Delta\log(\text{PCD} / \text{YED}) - \underset{(-1.412)}{0.122} * (\log(\text{WUN}(-1) / \text{YED}(-1)) - \log(\text{WURSTAR}(-1))) +$$

$$+ \theta^U * \log(\text{LNN} / \text{LNT}) - \underset{(-3.841)}{0.0595} * \text{D9601} + \underset{(5.529)}{0.0891} * \text{D9701} - \underset{(-2.584)}{0.0383} * \text{D0101}$$

$R^2 = 0.632$
$\hat{\gamma} = 0.0101$
$\theta^U = 0.0250$

GDP expenditure deflator

$$\Delta\log(YED) = (1 - \underset{(2.871)}{0.421} - 0.164) * \hat{\pi} + 0.421 * \Delta\log(MTD) +$$

$$+ \underset{(1.561)}{0.164} * \Delta\log(WUN(-3) * LNN(-3) / YER(-3)) + \theta^{GAP} * YGA -$$

$$- \underset{(-0.691)}{0.0658} * (\log(YED(-1) / WUN(-1)) + \log(WURSTAR(-1))) +$$

$$+ \underset{(4.022)}{0.0632} * D9601 - \underset{(-3.331)}{0.0536} * D9701 + \underset{(3.001)}{0.0513} * D9901$$

$R^2 = 0.487$
$\hat{\pi} = 0.00509$
$\theta^{GAP} = 0.100$

Demand side

Private consumption

$$\log(PCRSTAR) = \underset{(-4.214)}{-0.316} + \underset{(17.580)}{0.874} * \log(PYR) + (1 - 0.874) * \log(FWR) - \underset{(-5.810)}{0.0768} * DD9901$$

$R^2 = 0.971$

$$\Delta\log(PCR) = \underset{(3.256)}{0.284} * \Delta\log(PYR) + \underset{(2.180)}{0.106} * \Delta\log(FWR) -$$

$$- \underset{(-2.127)}{0.242} * \log(PCR(-1) / PCRSTAR(-1)) + \underset{(5.551)}{0.107} * D9601 + \underset{(3.735)}{0.0719} * D9701$$

$R^2 = 0.554$

Investment

$$\log(ITRSTAR) = \log(((\hat{\gamma} + \hat{n} + \hat{\delta}^{total}) / (1 + \hat{\gamma} + \hat{n})) * KSRSTAR)$$

$\hat{\gamma} = 0.0101$
$\hat{\delta}^{total} = 0.0250$
$\hat{n} = -0.00152$

$$\Delta\log(ITR / YER) = -0.250 * \Delta\log(LTR + \hat{\delta}^{total}) -$$

$$- \underset{(-0.886)}{0.0286} * \log(ITR(-1) / ITRSTAR(-1)) + \underset{(7.813)}{0.735} * D9801$$

$R^2 = 0.631$
$\hat{\delta}^{total} = 0.0250$

Exports

$$\log(XTRSTAR) = 6.649 + \log(WDR) + \theta^{XP} * \log(XTD / CXD) -$$
(173.008)

$$- 17.566 / TREND - 0.0312 * DD9803 + 0.0464 * DD0402$$
(–17.992) (–1.722) (3.171)

$R^2 = 0.984$
$\theta^{XP} = -1.000$

$$\Delta\log(XTR) = 0.805 * \Delta\log(WDR) - 0.579 * \Delta\log(XTD / CSD)$$
(4.115) (–4.079)

$$- 0.509 * \log(XTD(-1) / XTDSTAR(-1)) + 0.556 / TREND - 0.0769 * D9803$$
(–3.233) (2.802) (–3.450)

$R^2 = 0.594$

Imports

$$\log(MTRSTAR) = -0.184 + \log(WER) + \theta^{MP} * \log(MTD / YED)$$
(–23.946)

$R^2 = 0.967$
$\theta^{MP} = -0.5$

$$\Delta\log(MTR) = 1.483 * \Delta\log(WER) - 0.340 * \Delta\log(MTD / YED) -$$
(11.342) (–2.582)

$$- 0.161 * \log(MTR(-1) / MTRSTAR(-1)) - 0.0869 * D9901$$
(–1.666) (–2.867)

$R^2 = 0.790$

Changes in inventories

$$SCRSTAR = 0.0332 * YER - 828.272 / TREND$$
(4.479) (–2.629)

$R^2 = 0.240$

$$\Delta(SCR) = 0.273 * \Delta(SCR(-1)) - 0.637 * (SCR(-1) - SCRSTAR(-1)) + 36.336 * D0401$$
(1.699) (–4.239) (1.633)

$R^2 = 0.339$

Price block

Core inflation index

$$\log(CORESTAR) = \underset{(-15.698)}{-0.133} + \underset{(12.347)}{0.747} * \log(YED) + (1 - 0.747) * \log(MTD) +$$

$$+ \underset{(17.549)}{5.849} / TREND + \underset{(2.874)}{0.0225} * D0102\_0202$$

$R^2 = 0.971$

$$\Delta\log(CORE) = \underset{(3.362)}{0.474} * \Delta\log(CORE(-1)) + \underset{(2.288)}{0.148} * \Delta\log(YED) +$$

$$+ \underset{(2.434)}{0.110} * \Delta\log(MTD) - \underset{(-1.867)}{0.189} * \log(CORE(-1) / CORESTAR(-1))$$

$R^2 = 0.445$

Government consumption deflator

$$\log(GCDSTAR) = \underset{(1.728)}{0.0839} + \underset{(4.675)}{0.923} * \log(YED) + (1 - 0.923) * \log(MTD) -$$

$$- \underset{(-2.659)}{4.173} / TREND + \underset{(4.304)}{0.107} * DD0101$$

$R^2 = 0.955$

$$\Delta\log(GCD) = \underset{(4.044)}{1.027} * \Delta\log(YED(-1)) -$$

$$- \underset{(-4.248)}{0.561} * \log(GCD(-1) / GCDSTAR(-1)) + \underset{(1.839)}{0.0668} * D9701$$

$R^2 = 0.546$

Investment deflator

$$\log(ITDSTAR) = \underset{(-1.679)}{-0.0215} + \underset{(3.806)}{0.673} * \log(YED) + (1 - 0.673) * \log(MTD) -$$

$$- \underset{(-5.576)}{0.121} * DD0301$$

$R^2 = 0.648$

$$\Delta\log(ITD) = \underset{(2.854)}{0.336} * \Delta\log(ITD(-1)) + \underset{(2.948)}{0.668} * \Delta\log(YED(-2)) -$$

$$- \underset{(-5.012)}{0.546} * \log(ITD(-1) / ITDSTAR(-1)) - \underset{(-5.778)}{0.192} * D9801$$

$R^2 = 0.613$

Export deflator

$$\log(XTDSTAR) = \underset{(4.182)}{0.159} + \underset{(5.720)}{0.461} * \log(YED) + (1 - 0.461) * \log(CXD) -$$

$$- \underset{(-3.658)}{6.637} / TREND$$

$R^2 = 0.948$

$$\Delta\log(XTD) = \underset{(1.966)}{0.286} * \Delta\log(XTD(-1)) + \underset{(3.627)}{0.476} * \Delta\log(YED) + \underset{(1.876)}{0.252} * \Delta\log(CXD) -$$

$$- \underset{(-2.128)}{0.248} * \log(XTD(-1) / XTDSTAR(-1))$$

$R^2 = 0.295$

Import deflator

$$\log(MTDSTAR) = \underset{(4.215)}{0.293} + \underset{(55.599)}{0.978} * \log(CMD) + (1 - 0.978) * \log(PEI) -$$

$$- \underset{(-23.191)}{16.933} / TREND$$

$R^2 = 0.956$

$$\Delta\log(MTD) = \underset{(5.537)}{0.727} * \Delta\log(CMD) - \underset{(-2.588)}{0.400} * \log(M\_PI\_SA(-1) / M\_PI\_STAR(-1)) +$$

$$+ \underset{(2.617)}{0.0666} * D0001$$

$R^2 = 0.445$

Fuel prices

$$\log(FUELSTAR) = \underset{(-11.639)}{-0.670} + \underset{(10.861)}{0.201} * \log(PEI) + (1 - 0.201) * \Delta\log(YED) -$$

$$- \underset{(-7.204)}{0.117} * DD9602 + \underset{(2.293)}{0.0668} * DD9701 + \underset{(8.798)}{0.107} * DD9801 + \underset{(4.273)}{0.0642} * DD0402$$

$R^2 = 0.985$

$$\Delta\log(FUEL) = \underset{(4.983)}{0.159} * \Delta\log(PEI) + \underset{(2.264)}{0.0731} * \Delta\log(PEI(-1)) -$$

$$- \underset{(-3.014)}{0.182} * \log(FUEL(-1) / FUELSTAR(-1)) + \underset{(2.818)}{0.0638} * D9701 + \underset{(2.910)}{0.0682} * D9801$$

$R^2 = 0.608$

Fiscal block

Government expenditures – transfers

$$\log(TRNSTAR) = \underset{(-78.020)}{-2.085} + \log(YEN) + \underset{(4.654)}{0.201} * D9801\_0201$$

$R^2 = 0.884$

$$\Delta\log(TRN) = \underset{(1.590)}{0.808} * \Delta\log(YEN(-2)) - \underset{(-3.338)}{0.534} * \log(TRN(-1) / TRNSTAR(-1))$$

$R^2 = 0.214$

Government expenditures – interest payments

$$INNSTAR = \underset{(-1.295)}{-2.927} + \underset{(5.515)}{0.439} * GDN(-1) * LTI / 4 + \underset{(5.248)}{6.772} * DD9601$$

$R^2 = 0.508$

$$\Delta(INNSTAR) = \underset{(1.956)}{0.0198} * \Delta(GDN(-1)) - \underset{(-3.378)}{0.625} * (INN(-1) - INNSTAR(-1))$$

$R^2 = 0.318$

Government revenues – direct taxes

$$TDNSTAR = TDX * YEN + \underset{(9.220)}{0.0215} * D9501\_0001 * YEN$$

$R^2 = 0.985$

$$TDX = TDX(-1) - k * GLN(-1) / YEN(-1)$$

$k = 0.100$

$$\Delta\log(TDN) = \underset{(6.105)}{0.635} * \Delta\log(YEN) - \underset{(-3.283)}{0.381} * \log(TDN(-1) / TDNSTAR(-1)) +$$

$$+ \underset{(3.746)}{0.0996} * D9701$$

$R^2 = 0.265$

Government revenues – indirect taxes

$$\log(TINSTAR) = \underset{(-90.760)}{-2.239} + \log(YEN) + \underset{(5.873)}{4.995} / TREND + \underset{(4.473)}{0.0897} * D9801\_0001$$

$R^2 = 0.972$

$$\Delta\log(TIN) = \underset{(3.756)}{0.721} * \Delta\log(YEN(-2)) - \underset{(-2.101)}{0.310} * \log(TIN(-1) / TINSTAR(-1))$$

$R^2 = 0.119$

Government revenues – other

$$\log(OGNSTAR) = \underset{(-80.690)}{-3.126} + \log(YEN) + \underset{(3.086)}{0.316} * DD0401$$

$R^2 = 0.782$

$$\Delta\log(OGN) = \underset{(1.763)}{1.446} * \Delta\log(YEN) - \underset{(-4.416)}{0.629} * \log(OGN(-1) / OGNSTAR(-1)) -$$

$$- \underset{(-2.190)}{0.478} * D9901$$

$R^2 = 0.457$

External block

Net external income

$$NFNSTAR = \underset{(2.599)}{0.0106} * YEN + \underset{(5.164)}{0.748} * NFA(-1) * LTI / 4 + \underset{(2.270)}{15.044} * DD0001$$

$R^2 = 0.463$

$$\Delta(NFN) = \underset{(2.450)}{0.0287} * \Delta(NFA(-1)) - \underset{(-3.531)}{0.455} * (NFN(-1) - NFNSTAR(-1)) + \underset{(5.198)}{49.186} * D0502$$

$R^2 = 0.523$

Net current transfers

$$TWNSTAR = \underset{(7.140)}{0.0132} * YEN + \underset{(3.874)}{0.0150} * DD0201 * YEN + \underset{(5.053)}{0.0193} * DD0301 * YEN$$

$R^2 = 0.913$

$$\Delta(TWN) = -\underset{(-11.766)}{1.328} * (TWN(-1) - TWNSTAR(-1)) + \underset{(2.776)}{17.978} * D0201 + \underset{(5.629)}{38.394} * D0404$$

$R^2 = 0.862$

Interest rates

$$\Delta LTI = \underset{(14.752)}{0.799} * \Delta STI + \underset{(0.923)}{0.0553} * \Delta STI(-1) - \underset{(-3.654)}{0.533} * (LTI(-1) - STI(-1) - \underset{(18.372)}{4.818})$$

$R^2 = 0.858$

Identities

YGA = YER / YFT
YER = PCR + GCR + ITR + SCR + XTR – MTR
YEN = YER * YED
PCN = PCR * PCD
GCN = GCR * GCD
ITN = ITR * ITD
XTN = XTR * XTD
MTN = MTR * MTD
SCN = YEN – PCN – GCN – ITN – XTN + MTN
SCD = SCN / SCR
PCD = CORE * $(1 - w^E - w^A)$ + FUEL * w^E + PA * w^A
URX = 100 – 100 * (LNN / LFN)
KPR = KSR – KGR
KSR = $(1 - \delta^{total})$ * KSR(–1) + ITR
KGR = $(1 - \delta^{gov})$ * KGR(–1) + GIR
WUR = WUN / YED
LTR = ((1 + LTI) / (ITD / ITD(–4))) ^ 0.25 – 1
IPR = ITR – GIR
GIN = GIR * ITD
IPN = IPR * ITD
GLN = GSN – GIN
GSN = GYN – GCN
GYN = TDN + TIN + OGN – TRN – INN
WER = 0.3 * (PCR + GCR) + 0.5 * (ITR + SCR) + 0.6 * XTR
WIN = LNN * WUN
PYN = WIN + TRN + OPN – TDN
OPN = 0.9 * GON
GON = YEN – WIN – TIN
PYR = PYN / PCD
NFA = NFA(–1) + CAN + ZBOP
CAN = XTD – MTD + NFN + TWN
FWN = KPR(–1) * ITD + NFA(–1) + GDN(–1)
FWR = FWN / PCD
GDN = GDN(–1) – GLN
LNT = LFN * (1 – NAIRU / 100)
CMD = CMUD / EXR
CXD = CXUD / EXR
PEI = OIL / USD

Appendix 4
Simulation Results

Model response to interest rate shock (100 basis points interest rate growth)

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	–0.02	–0.07	–0.15	–0.21	–0.25
GDP deflator	–0.06	–0.17	–0.29	–0.37	–0.41
ULC	0.10	–0.10	–0.31	–0.41	–0.45
Compensation per employee	–0.18	–0.38	–0.51	–0.57	–0.61
Productivity	–0.28	–0.28	–0.19	–0.17	–0.16
Export deflator	–0.03	–0.10	–0.17	–0.21	–0.23
Import deflator	0.00	0.00	0.00	0.00	0.00
GDP and components	*Levels, percentage deviations from baseline*				
GDP	–0.48	–0.61	–0.50	–0.43	–0.35
Private consumption	–0.26	–0.57	–0.73	–0.75	–0.70
Investment	–2.78	–2.63	–1.39	–1.14	–0.97
Government consumption	0.00	0.00	0.00	0.00	0.00
Exports	0.03	0.08	0.15	0.20	0.22
Imports	–1.09	–0.90	–0.51	–0.46	–0.42
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	–1.12	–1.13	–0.84	–0.76	–0.67
Changes in inventories	–0.01	–0.02	–0.02	–0.01	–0.01
Net exports	0.65	0.54	0.36	0.35	0.33
Labour market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	–0.20	–0.32	–0.31	–0.26	–0.19
Unemployment rate	0.19	0.29	0.28	0.23	0.17
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	–0.55	–0.76	–0.74	–0.72	–0.65
Saving rate	–0.23	–0.14	–0.01	0.03	0.04
Fiscal ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	0.04	0.04	0.07	0.11	0.11
Total expenditure	0.15	0.18	0.13	0.11	0.10
Budget surplus	–0.10	–0.13	–0.06	–0.01	0.01
Government debt	0.46	1.02	1.31	1.33	1.22
Financial variables	*Percentage points, absolute deviations from baseline*				
Short-term interest rates	1.00	1.00	0.00	0.00	0.00
Long-term interest rates	0.90	0.93	0.04	0.00	0.00
Foreign demand	*Levels, percentage deviations from baseline*				
World demand	0.00	0.00	0.00	0.00	0.00
Foreign prices	*Levels, percentage deviations from baseline*				
Effective exchange rate	0.00	0.00	0.00	0.00	0.00
Foreign prices (EUR)	0.00	0.00	0.00	0.00	0.00
Price of oil (USD)	0.00	0.00	0.00	0.00	0.00

Model response to exchange rate shock (1% depreciation of national currency)

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	0.28	0.59	0.76	0.90	1.01
GDP deflator	0.43	0.72	0.97	1.16	1.31
ULC	0.21	0.69	1.00	1.23	1.39
Compensation per employee	0.50	0.98	1.17	1.34	1.46
Productivity	0.29	0.29	0.17	0.11	0.06
Export deflator	0.63	0.88	1.01	1.11	1.18
Import deflator	0.85	0.98	1.00	1.00	1.00
GDP and components	*Levels, percentage deviations from baseline*				
GDP	0.50	0.70	0.61	0.55	0.47
Private consumption	0.34	0.72	0.80	0.86	0.85
Investment	1.74	1.79	1.24	1.14	1.01
Government consumption	0.00	0.00	0.00	0.00	0.00
Exports	0.31	0.15	0.02	–0.09	–0.17
Imports	0.77	0.66	0.46	0.45	0.44
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	0.80	0.98	0.84	0.82	0.77
Changes in inventories	0.01	0.03	0.02	0.02	0.02
Net exports	–0.31	–0.30	–0.25	–0.29	–0.32
Labour market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	0.21	0.42	0.45	0.45	0.41
Unemployment rate	–0.19	–0.38	–0.40	–0.40	–0.36
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	0.71	0.89	0.90	0.94	0.92
Saving rate	0.28	0.14	0.08	0.06	0.05
Fiscal ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	–0.08	–0.03	–0.07	–0.09	–0.11
Total expenditure	–0.15	–0.13	–0.14	–0.14	–0.13
Budget surplus	0.07	0.10	0.08	0.05	0.02
Government debt	–0.55	–1.03	–1.35	–1.53	–1.57
Financial variables	*Percentage points, absolute deviations from baseline*				
Short-term interest rates	0.00	0.00	0.00	0.00	0.00
Long-term interest rates	0.00	0.00	0.00	0.00	0.00
Foreign demand	*Levels, percentage deviations from baseline*				
World demand	0.00	0.00	0.00	0.00	0.00
Foreign prices	*Levels, percentage deviations from baseline*				
Effective exchange rate	1.00	1.00	1.00	1.00	1.00
Foreign prices (EUR)	0.00	0.00	0.00	0.00	0.00
Price of oil (USD)	0.00	0.00	0.00	0.00	0.00

Model response to oil price shock (10% oil price rise)

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	0.13	0.20	0.22	0.22	0.20
GDP deflator	0.04	0.11	0.12	0.11	0.08
ULC	0.07	0.12	0.14	0.12	0.09
Compensation per employee	0.07	0.14	0.14	0.11	0.08
Productivity	0.00	0.02	–0.01	–0.01	–0.01
Export deflator	0.02	0.07	0.07	0.06	0.04
Import deflator	0.10	0.20	0.21	0.21	0.21
GDP and components	*Levels, percentage deviations from baseline*				
GDP	0.00	0.03	–0.01	–0.04	–0.06
Private consumption	–0.05	–0.04	–0.08	–0.13	–0.17
Investment	0.07	0.29	0.03	–0.01	–0.06
Government consumption	0.00	0.00	0.00	0.00	0.00
Exports	–0.02	–0.06	–0.07	–0.06	–0.05
Imports	–0.03	0.00	–0.11	–0.13	–0.16
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	–0.01	0.06	–0.04	–0.08	–0.12
Inventories	0.00	0.00	0.00	0.00	0.00
Trade balance	0.01	–0.03	0.03	0.04	0.06
Labour market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	0.00	0.01	–0.01	–0.03	–0.05
Unemployment rate	0.00	–0.01	0.01	0.03	0.05
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	–0.09	–0.05	–0.12	–0.15	–0.19
Saving rate	–0.03	–0.01	–0.03	–0.02	–0.01
Fiscal ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	–0.01	0.00	0.00	0.00	0.01
Total expenditure	0.00	0.00	0.01	0.01	0.02
Budget surplus	0.00	0.00	0.00	–0.01	–0.01
Government debt	–0.01	–0.04	–0.02	0.01	0.07
Financial variables	*Percentage points, absolute deviations from baseline*				
Short-term interest rates	0.00	0.00	0.00	0.00	0.00
Long-term interest rates	0.00	0.00	0.00	0.00	0.00
Foreign demand	*Levels, percentage deviations from baseline*				
World demand	0.00	0.00	0.00	0.00	0.00
Foreign prices	*Levels, percentage deviations from baseline*				
Effective exchange rate	0.00	0.00	0.00	0.00	0.00
Foreign prices (EUR)	0.00	0.00	0.00	0.00	0.00
Price of oil (USD)	10.00	10.00	10.00	10.00	10.00

Model response to world demand shock (1% world demand growth)

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	0.01	0.04	0.12	0.23	0.35
GDP deflator	0.03	0.11	0.26	0.45	0.66
ULC	–0.03	0.06	0.23	0.45	0.68
Compensation per employee	0.06	0.20	0.37	0.56	0.76
Productivity	0.10	0.14	0.14	0.11	0.08
Export deflator	0.02	0.07	0.15	0.26	0.37
Import deflator	0.00	0.00	0.00	0.00	0.00
GDP and components	*Levels, percentage deviations from baseline*				
GDP	0.17	0.33	0.44	0.51	0.55
Private consumption	0.09	0.28	0.49	0.70	0.90
Investment	0.21	0.45	0.67	0.81	0.90
Government consumption	0.00	0.00	0.00	0.00	0.00
Exports	0.90	0.94	0.87	0.76	0.65
Imports	0.60	0.75	0.86	0.95	1.04
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	0.13	0.31	0.49	0.64	0.77
Changes in inventories	0.00	0.01	0.01	0.02	0.02
Net exports	0.04	0.01	–0.06	–0.15	–0.24
Labour market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	0.08	0.19	0.30	0.40	0.47
Unemployment rate	–0.07	–0.17	–0.27	–0.35	–0.41
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	0.20	0.43	0.63	0.82	0.97
Saving rate	0.08	0.11	0.11	0.09	0.06
Fiscal ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	–0.02	–0.02	–0.04	–0.07	–0.09
Total expenditure	–0.05	–0.08	–0.11	–0.14	–0.16
Budget surplus	0.03	0.06	0.07	0.07	0.06
Government debt	–0.15	–0.40	–0.69	–0.99	–1.25
Financial variables	*Percentage points, absolute deviations from baseline*				
Short-term interest rates	0.00	0.00	0.00	0.00	0.00
Long-term interest rates	0.00	0.00	0.00	0.00	0.00
Foreign demand	*Levels, percentage deviations from baseline*				
World demand	1.00	1.00	1.00	1.00	1.00
Foreign prices	*Levels, percentage deviations from baseline*				
Effective exchange rate	0.00	0.00	0.00	0.00	0.00
Foreign prices (EUR)	0.00	0.00	0.00	0.00	0.00
Price of oil (USD)	0.00	0.00	0.00	0.00	0.00

Model response to government consumption shock (1% of GDP government consumption growth)

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	0.05	0.23	0.53	0.86	1.13
GDP deflator	0.17	0.57	1.09	1.57	1.92
ULC	–0.15	0.46	1.14	1.75	2.16
Compensation per employee	0.39	0.94	1.40	1.77	1.99
Productivity	0.55	0.47	0.26	0.02	–0.17
Export deflator	0.10	0.33	0.63	0.89	1.07
Import deflator	0.00	0.00	0.00	0.00	0.00
GDP and components	*Levels, percentage deviations from baseline*				
GDP	0.99	1.29	1.27	1.04	0.72
Private consumption	0.55	1.09	1.24	1.12	0.83
Investment	1.23	1.90	2.19	1.90	1.48
Government consumption	6.42	6.45	6.44	6.45	6.47
Exports	–0.07	–0.28	–0.57	–0.83	–1.02
Imports	1.30	1.55	1.59	1.43	1.25
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	1.76	2.24	2.37	2.18	1.87
Changes in inventories	0.02	0.04	0.04	0.04	0.03
Net exports	–0.79	–0.99	–1.14	–1.18	–1.18
Labour market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	0.45	0.81	1.01	1.03	0.89
Unemployment rate	–0.41	–0.74	–0.91	–0.91	–0.78
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	1.13	1.31	1.16	0.84	0.45
Saving rate	0.44	0.17	–0.06	–0.21	–0.29
Fiscal ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	–0.05	0.25	0.54	0.73	0.84
Total expenditure	0.91	0.90	0.91	0.95	1.02
Budget surplus	–0.96	–0.64	–0.37	–0.23	–0.17
Government debt	1.89	4.54	5.89	6.54	6.90
Financial variables	*Percentage points, absolute deviations from baseline*				
Short-term interest rates	0.00	0.00	0.00	0.00	0.00
Long-term interest rates	0.00	0.00	0.00	0.00	0.00
Foreign demand	*Levels, percentage deviations from baseline*				
World demand	0.00	0.00	0.00	0.00	0.00
Foreign prices	*Levels, percentage deviations from baseline*				
Effective exchange rate	0.00	0.00	0.00	0.00	0.00
Foreign prices (EUR)	0.00	0.00	0.00	0.00	0.00
Price of oil (USD)	0.00	0.00	0.00	0.00	0.00

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