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The Lithuanian block of the ECSB multi-country model

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Igor Vetlov *

The Lithuanian block of the ESCB multi-country model **

Abstract

This paper presents preliminary results of modelling the Lithuanian block of the ESCB Multi-Country Model, LT_MCM. The theoretical structure of the LT_MCM is in line with most current mainstream macro models, i.e. supply factors determine the long-run equilibrium, while output is demand determined in the short run. Starting with a brief overview of the common features and main building blocks of a typical MCM country model block, we report the preliminary results of estimation of the Lithuanian MCM block. To illustrate the main characteristics of the estimated model, some standard shocks are introduced in the model and the responses studied. Compared to other MCM country blocks, we find that the Lithuanian macro model is characterised by relatively large and rapid response to shocks. Model simulation reveals that, compared to domestic prices, GDP is more responsive to shocks in the short run, while investment on average is more volatile than private consumption. The latter findings are similar to those reported for other EU country macro models.

JEL Code: E10, E13, C5

Key Words: Macro Model, Lithuania

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Igor Vetlov

The Lithuanian block of the ESCB multi-country model

Tiivistelmä

Tutkimuksessa raportoidaan alustavasti EKPJ:n monimaamallin Liettua-osan tuloksista. Mallin teoreettinen rakenne on sopusointuinen suurimman osan kanssa muista valtavirtamakromalleista, eli tarjontatekijät määrittävät pitkän aikavälin tasapainon, kun taas lyhyellä aikavälillä kysyntä määrää tuotannon tason. Tutkimuksen alussa esitellään monimaamallin tyypillisen maaosan yhteiset piirteet ja keskeiset rakentumisainekset, ja sen jälkeen raportoidaan alustavia tuloksia mallin Liettua-osasta. Tutkimuksessa tarkastellaan joidenkin tavanomaisten sokkien vaikutusta mallin pääpiirteiden havainnollistamiseksi. Muihin monimaamallin maaosiin verrattuna Liettuan makromallin vasteet sokkeihin ovat melko suuria ja nopeita. Simuloinnit osoittavat, että BKT reagoi lyhyellä aikavälillä kotimaisia hintoja joustavammin, kun taas investoinnit ovat keskimäärin heilahtelevampia kuin yksityinen kulutus. Jälkimmäiset tulokset ovat samanlaisia kuin muissa EU-maiden makromalleissa.

Asiasanat: makromallit, Liettua

1 Introduction

As a new member of the European Union (EU) from May 1, 2004, Lithuania has effectively joined the EU policymaking process. Increasing participation in various economic-policy-related structures of the EU implies greater interest in developments in the Lithuanian economy. In this respect, Lithuania faces new challenges in conducting sound macroeconomic analysis, forecasting, and policy-option research.

Meeting these challenges requires, among other things, application of a formal macroeconomic model that captures the main features of the domestic economy. Unfortunately, the pool of macroeconomic models available for the Lithuanian economy today is rather scarce. Worse still, they poorly meet criteria for theoretical soundness, range of forecasted variables, etc. Thus, there is a need for building better models for the Lithuanian economy in line with current mainstream macro models.

The present paper is a contribution towards building such a model. In particular, it reports preliminary estimation and simulation results of the Lithuanian macro-econometric model, which features the basic structure of a typical country block of the European System of Central Banks (ESCB) Multi-Country Model (MCM). By construction, the ESCB-MCM is a set of country-model blocks comprising EMU participants. The MCM is being developed through cooperation between the ECB and the national central banks of the ESCB. Individual country blocks share similar statistical and theoretical properties to ensure comparability and interpretability of the simulation results. The MCM's short- and long-run features are also similar to those of the ECB's Area-Wide Model (AWM). The MCM thus stands as a multi-country counterpart to the AWM, which treats the euro area as a single country. Of course, both the MCM and the AWM can be used in forecasting and policy analysis. Several national central banks, including Austria, Ireland, Luxembourg and Spain, apply their MCM country blocks as an important – or even the main – tool for generating national forecasts and conducting policy analysis.

The choice of the prototype model for Lithuania was heavily influenced by several considerations related to numerous attractive characteristics of the MCM. First, the MCM accounts for behaviour of a sufficient number of macroeconomic variables for forecasting purposes. Second, extensive use of balancing equations in the model ensures consistency among macroeconomic indicators and stock-flow equilibrium. Third, the overall long-term

properties of the model are driven by behavioural equations largely derived from theoretical foundations. Fourth, the model is relatively simple, and thus transparent, which facilitates communication of the model results to non-modellers. Fifth, it has the scope for active fiscal policy via explicit application of fiscal policy rules, while assuming a passive monetary policy regime (i.e. making it broadly consistent with the main features of economic policymaking in Lithuania). Finally, having the Lithuanian block of the MCM at hand permits comparative analysis of the model results with other MCM country blocks. This is a matter of future exercise, of course, since the MCM modelling is an ongoing work. Official simulation results are presently available for only a few MCM country blocks.

While development of the Lithuanian MCM block (coded LT_MCM) is ongoing, several important findings from the current study are worthwhile highlighting here. In terms of estimated coefficients, we find on average relatively large values of the loading coefficients in the LT_MCM compared to other MCM country blocks. This finding is similar to those reported in previous papers on building structural macro models for the Lithuanian economy (Vetlov, 2004; Kuodis and Vetlov, 2002). In addition, the length of lag structure of the dynamic equations in the LT_MCM is much shorter than the average in this type of model. Altogether, this results in a relatively fast response and adjustment to shocks in the LT_MCM. The simulation of the model reveals that, compared to domestic prices, GDP is more responsive to shocks in the short run, while on average investment is more volatile than private consumption. The latter findings are similar to those reported for macro models of other EU countries.

The remainder of the paper is structured as follows: Section two makes a brief introduction into the basic structure of a typical MCM country block. The results of estimation of the Lithuanian MCM block, brief discussion of the baseline scenario and its underlying assumptions, and standard shock simulation results are presented in section three. The last section summarises the main findings and provides suggestions for further research.

2 The main features of the MCM country block

While several national country blocks are under construction, published descriptions are available for the French, Spanish and Irish MCM blocks.[1] Since all MCM country blocks have a similar structure, we can reasonably characterise the basic features of an MCM country block from these three country block overviews. In addition, due to similar modelling philosophy applied to the MCM and the AWM, it is instructive to consult the paper of Fagan et al. (2001), which includes an AWM description. In the following, we discuss the theoretical underpinnings of the MCM, highlight methodological issues of model estimation and simulation and provide an overview of main building blocks of the MCM that focuses on long-run relationships.

2.1 Theoretical underpinnings

From a theoretical standpoint, the design of MCM country blocks relies on a neo-classical Keynesian synthesis, i.e. aggregate supply governs long-run properties and aggregate demand factors determine short-run dynamics. The supply curve is vertical in the long run with the level of output governed by technology and population levels, both of which are exogenous. Aggregate demand can deviate from long-run output over the short run. Such deviations, or output gaps, trigger wage and price adjustments that bring the model into long-run equilibrium.

The goods market in the MCM is characterised by monopolistic competition. Facing a downward-sloping demand curve, firms set the price on their products as a mark-up over marginal unit-labour costs. The labour market is imperfectly competitive. Various market frictions (union bargaining power, income taxes, unemployment benefits, etc.) drive the wedge between marginal product of labour and real wage. Long-run unemployment is endogenous in the MCM. It is a function of labour productivity growth rate and labour market imperfections.

Consistent with a monetary union framework, national monetary policy is absent from MCM country blocks. The exchange rate and the short-term interest rate are treated

as exogenous variables. In this context, the enhanced emphasis on adjustments in the external and fiscal sectors ensures model stability.

In the current specification, a typical MCM country block is backward looking. The expectations enter the model implicitly through lagged values in the dynamic equations. Forward-looking elements might conceivably be introduced into the MCM.

There is high degree of ad hoc specification in the model. Although, the supply side is largely based on first-order conditions obtained from a representative firm's profit maximisation exercise, the equations of GDP expenditure components are largely postulated. Thus, we do not expect the model to give a fully consistent story about agent behaviour. In addition, while economic theory is used to define the long-run properties of the model, the short-run dynamics (or adjustment part) of the model are fully driven by the data.

Lastly, there is no account for the financial market behaviour in the MCM. The financial sector is treated as fully post recursive and not modelled in the MCM.

2.2 Estimation and simulation framework

The MCM country block is a highly aggregated representation of the economy, comprising on average about a hundred equations, of which roughly one-fifth are stochastic equations. The model is estimated on the basis of quarterly data typically spanning the period from 1980 to 2000 (or later date). Most MCM country blocks are built using the data, which complies with ESA95 methodology.

The behavioural part of the model is constructed employing the error-correction approach. Johansen's Full Information Likelihood Method (Johansen, 1988) and the two-step Engel-Granger procedure are widely applied. At the stage where long-run (co-integrating) relationships are estimated, a number of restrictions are imposed to account for theoretical priors. Restrictions based on economic theory are subject to statistical testing, i.e. restrictions are imposed only where supported by the data. The specification of short-run relationships is mainly determined by the statistical significance of the regressors and based on a general-to-specific approach.

[1] Boissay and Villetelle (2004), Estrada and Willman (2002) and McGuire and Ryan (2000), respectively.

The MCM is usually coded in TROLL, which is commonly used for simulation exercises at the ECB and European national central banks. However, since expectations in a typical MCM country block are modelled in a backward-looking fashion, other software (e.g. Eviews) is also adequate for simulation purposes.

2.3 Model structure

Aggregate supply

Aggregate supply is represented by a Cobb-Douglas production function with constant returns to scale and labour-augmenting technological progress. The latter is usually assumed to follow a time trend. The elasticity parameters of the production function are either estimated or approximated by the average wage-income share in the national accounts.

$$YER = KSR^{\beta} LNN^{(1-\beta)} A_0 e^{(1-\beta)\gamma TIME}, \quad [1]$$

where *YER* is real GDP, *KSR* is the real capital stock, *LNN* is employment, *TIME* is the time trend, β is the income share of capital and γ is the rate of technological progress.

The long-run equations for factor demand and the GDP deflator at factor cost are derived from the production function. Labour demand is obtained by inverting production, while the desired capital stock is determined by the equilibrium condition for the marginal product of capital and the marginal cost of capital. The latter follows from the first-order profit maximisation problem for a representative firm. The equilibrium GDP deflator at factor cost is determined as the mark-up over marginal labour costs. In a small, open economy, the size of the mark-up is usually allowed to vary in response to pressures from foreign competition. The latter can be approximated by the real exchange rate.

$$LSTAR = A_0^{-\frac{1}{1-\beta}} e^{-\gamma TIME} \left[YER(KSR)^{-\beta} \right]^{\frac{1}{1-\beta}}, \quad [2]$$

$$KSTAR = (\beta/\eta) YER\ (CC/YFD)^{-1}, \quad [3]$$

$$YDSTAR = \eta[(1-\beta)YER]^{-1} WUN\ LNN\ (1-TIX)^{-1}, \quad [4]$$

where *LSTAR* is the equilibrium level of employment, *KSTAR* is the equilibrium level of the capital stock, *YDSTAR* is the equilibrium level of the GDP deflator, η is the mark-up, *CC* is the nominal cost of capital, *YFD* is the GDP deflator at factor cost, *WUN* is compensation per employee and *TIX* is an indirect tax rate.

The nominal cost of capital is defined as the gross fixed capital formation deflator multiplied by the sum of real interest rate and the depreciation rate. The expected change in the price of the capital stock is usually approximated by a simple average of past price changes

$$CC = ITD\,(LTI - \mathrm{E}(\Delta ITD) + \delta), \qquad [5]$$

where *ITD* is the gross fixed capital formation deflator, *LTI* is the long-term nominal interest rate, δ is the rate of capital depreciation and E(ΔITD) is the expected change in the gross fixed capital formation deflator.

Supply-side equations [2]–[4] in combination with equation [5] set the steady-state level of the economy. The GDP deflator is the key price in the MCM. It adjusts to keep the labour income share at its long-run level.

Aggregate demand

Equations for GDP expenditure components describe the demand side of the economy. The model typically incorporates separate equations for private consumption, gross fixed capital formation, changes in inventory stocks, exports of goods and services, and imports of goods and services. Government consumption is treated as exogenous.

Over the long run, private consumption (*CSTAR*) is determined by real disposable income (*PYR*) and real wealth (*FWR*). Real disposable income is defined as the sum of wage compensation (*WIN*), government transfers to households (*TRN*) net of direct taxes (*TDN*) and other income (*OPN*), deflated by the private consumption deflator (*PCD*). The definition of real wealth assumes that households own all assets in the economy. This includes the stock of private capital, net foreign assets (*NFA*) and public debt (*GDN*).

$$CSTAR = \lambda_0\,(PYR)^{\lambda_1}\,(FWR)^{(1-\lambda_1)} \qquad [6]$$

$$PYR = (WIN + TRN + OPN - TDN) / PCD \qquad [7]$$

$$FWR = KSR + (GDN+NFA) / PCD. \quad [8]$$

Over the long run, the actual capital stock converges to its equilibrium level and the level of real investment (*ITR*) will eventually match capital depreciation adjusted for exogenous labour productivity growth so that the investment-to-capital-stock ratio converges to a constant[2]

$$ITR = KSTAR\ (\gamma+\delta)\ /(1+\gamma). \quad [9]$$

The stock of equilibrium inventory investment is assumed to be a fraction of the normal level of production (*YNR*), which depends negatively on the real interest rate

$$LSSTAR = \varphi_0 YNR^{\varphi_1}\ . \quad [10]$$

The equilibrium levels of exports (XSTAR) and imports (MSTAR) are postulated in standard forms. Real exports are related to the level of foreign demand (*WDR*) and the relative price, which is defined as the ratio of the domestic exports deflator (*XTD*) over a weighted average of the export prices of foreign trade partners (*CXD*), such that

$$XSTAR = WDR\ (XTD / CXD)^{-\theta_X}\ . \quad [11]$$

Equilibrium imports depend on the level of the composite expenditure variable and relative price. The composite expenditure variable (*WER*) is a weighted average of private consumption, investment, exports and government consumption. The relative price of imports is defined as a ratio of the import deflator (*MTD*) over the GDP deflator (*YED*)

$$MSTAR = WER\ (MTD / YED)^{-\theta_M}\ . \quad [12]$$

Prices and wages

This block of the model consists of equations describing the expenditure deflators and wages. The private consumption, public consumption and investment deflators (*PCD*, *GCD* and *ITD*, respectively) are modelled as weighted averages of the GDP deflator and the imports deflator. The deflator of changes in inventories is derived as a residual.

$$PCD = YED^{\mu_C} MTD^{(1-\mu_C)} \quad [13]$$

[2] Throughout the section, the population growth rate is assumed to be zero.

$$GCD = YED^{\mu_G} MTD^{(1-\mu_G)} \quad [14]$$

$$ITD = YED^{\mu_I} MTD^{(1-\mu_I)} \quad [15]$$

The wage equation states that the marginal product of labour derived from the production function determines real wages in the long run. In addition, a measurement of labour market tightness is introduced in an ad hoc manner to capture the impact of labour market conditions on real wages. The wage equation can also be augmented by the direct tax rate and the replacement rate, defined as a ratio of unemployment benefits over labour compensation

$$WUN/YED = (1-\beta)\ (YER / LNN)\ (LNN / LFN)^{\theta_U}\ , \quad [16]$$

where *LFN* is the labour force.

Fiscal block

Among the expenditure components of the government budget, only transfers to households and debt-interest payments are modelled explicitly. The main determinant of the former is the unemployment rate, while the latter is a function of the level of public debt and the interest rate. On the revenue side, tax revenues are related to the respective tax bases via exogenous effective tax rates. The exception is the effective tax rate on household income, which is assumed to be endogenous. It is defined as a calibrated fiscal policy rule that ensures long-run stability of the government-debt-to-GDP ratio. The direct tax rate exceeds the baseline direct tax rate when the actual debt-to-GDP ratio exceeds the targeted debt-to-GDP ratio (*GDNYEN*). The tax rate reaction is smoothed to the extent of the size of smoothness parameter κ. Thus,

$$TDX = TDXEXO + \kappa(TDX_{-1} - TDXEXO_{-1}) + (1-\kappa)(GDN_{-1}/YEN_{-1} - GDNYEN)\ , \quad [17]$$

where *TDX* is the effective direct tax rate paid by households, *TDXEXO* is the baseline effective direct tax rate, *GDN* is the general government's consolidated gross debt and *YEN* is nominal GDP.

External block

In addition to the foreign trade equations described above, the external block contains equations for net factor income and transfers from the rest of the world. Net factor income is determined by the stock of net foreign assets and the interest rate. Transfers from the rest of the world are defined as a fraction of GDP.

In a simplified MCM block, Willman and Estrada (2002) derive steady-state solutions for aggregate supply per capita and demand per capita. They show that aggregate supply per capita in its reduced form is positively related to the level of technological progress and the real exchange rate, and negatively related to the real interest rate. The fact that the supply curve has a positive slope with respect to the real exchange rate is due to the positive impact of real exchange rate appreciation on the capital stock via the user cost of capital. The aggregate demand per capita increases with the level of technological progress, real government consumption and accumulation of net foreign assets. It declines with increases in taxes and population. The impact of changes in real interest rate and real exchange rate on per capita demand has an ambiguous sign. The overall effect in the latter case depends on the relative strength of substitution and income effects. In particular, real exchange-rate appreciation has both positive and negative impacts on domestic demand via rise in purchasing power (income effect) and via deterioration of export competitiveness (substitution effect), respectively.

3 The MCM block for Lithuania

This section provides a brief overview of the macro model for Lithuania, the LT_MCM. As a caveat, the results reported below should by no means be considered final; rather they should be viewed as an interim report on ongoing modelling work. In the following two sub-sections, we discuss the empirical content of the basic structure, issues of data and estimation of the LT_MCM, as well as report simulation results for several standard shocks.

3.1 Empirical content of the LT_MCM

The LT_MCM has 121 variables: 92 endogenous variables, 18 exogenous variables, 10 dummy variables and a time trend. Roughly a third of the equations are estimated. Preliminary results of estimation of LT_MCM behavioural equations (including identities) are displayed in Annex 1. The estimated dynamic equations are supplemented with figures that show partial impulse-response analysis of an individual equation, namely, reaction of the endogenous variable to a permanent one-per-cent increase in one of the equation exogenous variables (or one percentage point in the case of rate variables). Annex 2 lists the variables used in the LT_MCM.

As mentioned above, we have tried to follow the basic structure of other MCM country blocks in the construction of the LT_MCM. The latter task was heavily burdened by substantial data problems. Most of the time series available for the Lithuanian economy start from the first quarter of 1995 and many required time series are unavailable, incomplete or inconsistent. Several critical quarterly time series (e.g. capital stock, household wealth and government accounts) were virtually created using information from relevant secondary data sets. The new time series were created in a consistent way to best serve the model purposes. As new data becomes available, the LT_MCM data set will be updated.

Nearly all behavioural equations in the LT_MCM are estimated using econometric techniques, which, given the severe data limitations, are limited to the Ordinary Least Squares (OLS) method. The cointegration relationships and the dynamic equations are estimated applying the two-step Engle-Granger procedure. For diagnostics criteria in specifying individual equations, the main emphasis is put on achieving non-correlated residuals, statistical significance of the explanatory variables (particularly in the case of dynamic equations) and a high coefficient of determination. Calibration of parameters has be performed where possible to tackle overshooting and excessive oscillation in endogenous variable responses. Again, as better data becomes available, the equations will be subject to re-estimation.

Supply side

The core of the supply side is the aggregate Cobb-Douglas production function. The capital stock is derived using the Perpetual Inventory Method. We assume that the capital-stock-

to-annual-GDP ratio in Lithuania was 1.4 at the beginning of 1995. This value is largely based on previous relevant estimates for the Lithuanian capital stock (Vetlov, 2003; Rõõm, 2001). The estimate of elasticities of the production function with respect to labour (1-β) is obtained from the national accounts after correcting the time series on labour compensation. As a result, the time series on compensation per employee used in the model is about 50% higher than the official data shows. The productivity parameters are estimated for given production function elasticity by OLS (see equation [1] in Annex 1). The point estimate of the gamma parameter implies about 5.1% annual growth in labour productivity, which is more than double the productivity growth rate estimated for euro-area countries. This is, however, consistent with the transitional period of the Lithuanian economy and a gradual convergence with EU income levels. Over the long term, we would also expect the productivity growth in Lithuania to converge with the EU average.

The empirical production function is used to derive equilibrium employment and the capital stock. To allow for an endogenous labour force response, we include an equation for labour supply. The latter captures the impacts on the labour supply from a decline in the working population represented by a linear trend and a discouraged worker effect from lower employment. The equilibrium GDP deflator at factor cost is modelled as a mark-up over the unit labour cost. The mark-up is endogenous in the LT_MCM (similar to the Spanish MCM block in Willman and Estrada, 2002) and a function of the real exchange rate defined as the GDP-deflator-to-import-deflator ratio.

Demand side

In the long run, real private wealth and disposable income determine private consumption. The unemployment rate is included into the dynamic equation to account for negative effects on private consumption from deteriorating labour market conditions. The behaviour of the real investment is governed by the changes in the desired capital of capital. In the short run, investment is positively related to real GDP growth and negatively to the rise in the user cost of capital. Changes in inventories are determined by the real interest rate and the normal level of output, which we proxy with the level of output that can be achieved using factors of production fixed at their level in the previous period. Export and import functions are modelled in a traditional fashion, relating both variables to their corresponding income and relative price indicators.

Price block

Domestic demand expenditure deflators are estimated as weighted averages of the key domestic price (GDP deflator) and the import deflator. Import and export deflators are directly linked to the effective price of foreign competitors expressed in the domestic currency. The foreign trade deflators are heavily influenced by the oil price due to the large share of oil-related products in Lithuania's foreign trade. Thus, the price of oil is included explicitly in the specification of a number of price equations to control for the distortionary effects of highly volatile price of this commodity. The wage equation is an important determinant of the long-term unemployment rate. In the current version of the LT_MCM, the consumption-deflator-based real wage is equal over the long run to the marginal product of labour adjusted for the unemployment rate and the generosity of the government benefit system as captured by the government-transfers-to-GDP ratio.

Fiscal block

In the model, total government revenue derives from four major sources: direct taxes, other direct taxes, indirect taxes and other government income. Tax revenues are endogenised by relating revenue categories to their respective tax bases. Aside from the direct tax rate, we assume exogenous tax rates (see below). The variable "other government income" is left exogenous. On the government expenditure side, we identify four categories: government transfers, interest payments on government debt, government current consumption expenditures and public investment. The last two expenditure variables are exogenous. Government interest expenditures related to public-debt servicing are directly linked to the outstanding stock of public debt. The amount of government transfers is modelled as a function of nominal GDP and the exogenous transfer rate.

Accumulated government budget balances are reflected in the development of government debt, which is part of private sector wealth. To rule out the option of continuously increasing or decreasing government debt, the fiscal policy rule is introduced into the model. The rule is that changes in the direct tax rate react to the deviation of the actual government-debt-to-GDP ratio from its predetermined baseline level. The fiscal rule in the LT_MCM is calibrated. Its parameters' values are similar to those in other MCM country blocks. There are, of course, other candidates for fiscal policy instruments than the

direct tax rate. For Lithuania, which has difficulties in controlling collection of tax revenues, it is often politically more expedient to reduce public consumption or investment when facing an increase in debt. In Lithuania's recent fiscal history, rapid consolidations of public finances have been accomplished predominately by cutting current and capital expenditures. Given this propensity, the fiscal policy rule in the LT_MCM should probably be revisited in the future.

External block

The external block summarises the current account balance and economy's accumulation of net foreign assets. The current account balance is defined as the sum of foreign trade balance, net factor income received from abroad and net transfers from abroad. The latter is assumed to be a fraction of nominal GDP, while the former is directly linked to the outstanding stock of net foreign assets. In long-run simulations, it is assumed that the interest rates paid on government debt and net foreign assets are equal. This assumption ensures a symmetric response from interest payments paid on government debt and net foreign assets.[3] Finally, the stock of net foreign assets is defined as the accumulation of positive and negative current account balances.

Monetary and exchange rate policy in the LT_MCM

Consistent with other MCM blocks and reflecting Lithuania's currency board framework, there is no independent national monetary policy in the LT_ MCM. The short-term interest rate and exchange rate are exogenous in the model. The long-term interest rate is specified in line with term structure behaviour. While an exogenous nominal interest rate potentially invites unstable dynamics, it is important to remember that we are dealing with a small, open economy characterised by strong adjustment in the external sector. The endogenous real interest rate may also result in excessive cyclical adjustment paths. In such instances, as pointed out by Willman and Estrada (2002), the specification of inflation expectations can be crucial. To preserve the backward-looking nature of the model, we thus allow for greater inertia in inflation expectations. In the current version of the LT_MCM, inflation expectations are defined as a simple arithmetic average of annual change in investment deflator over the current and three previous quarters.

Finally, before discussing the simulation properties of LT_MCM, it is important to emphasise that we find on average relatively large values for the loading coefficients compared to other MCM blocks. In addition, the length of lag structure of the dynamic equations in the LT_MCM is much shorter than the average for such models. Overall, this results in relatively fast response and adjustment to shocks.

3.2 Baseline scenario

A baseline scenario is developed to analyse steady-state properties and simulate various shocks. In building the baseline scenario, we make several important assumptions. First, population growth is assumed to be zero, implying that, in the steady state, the real variables (including exogenous domestic and foreign variables) will grow at the rate of exogenous technological progress. The latter is constant: approximately 5.1% per annum. We also assume a zero foreign inflation rate. The short-term nominal interest rate is fixed at the level of last observation. In addition, when estimating the baseline values, the fiscal policy rule is invoked. These assumptions, although simplistic, are sufficient to uncover the main properties of the model. It goes without saying that more realistic assumptions must be put in place for actual forecasting purposes.

Table 1 reports the historical average and steady state shares of capital stock and aggregate demand components in GDP. The capital-to-GDP ratio is nearly unchanged in the steady state relative to its historical value: around 1.5 of annual GDP. Among demand expenditures in the simulated steady state, a significant decline relative to the historical average is recorded for private consumption, while openness of the economy increases. The lower steady-state share of private consumption can be attributed to a higher steady-state tax rate (Table 3), lower labour share (Table 2) and lower private wealth (Table 2) relative to historical averages. The export share of GDP in the steady state rises for two reasons. First, we assume relatively high exogenous rate of foreign demand growth, i.e. the same rate as exogenous technological growth rate in Lithuania. Second, relatively high unemployment rate results in deteriorating terms of trade caused by downward pressures on domestic prices. Imports in the steady state are higher relative to the historical average due to the significant role of re-exports in the model.

[3] For further discussion on this issue, see Willman and Estrada (2002).

Table 1. Steady-state ratios as a percentage of real quarterly GDP.

	KSR	PCR	ITR	SCR	GCR	XTR	MTR
1995 - 2003 2 q	580	61.9	19.8	1.2	22.4	49.3	54.6
Steady state (2100 4 q)	620	49.5	20.2	0.8	24.7	74.3	69.5

Table 2. Steady-state ratios as a percentage of nominal quarterly GDP.

	GLN	GDN	FWN	WIN	NFA	CAN
1995 - 2002 2 q	-3.3	93.9	545.9	56.7	-104.2	-8.8
Steady state (2100 4 q)	-1.9	148.2	237.3	52.9	-531.0	-6.7

Table 3. Steady-state rates, % (except ETA mark-up).

	INFA	URX	STI	LTI	TDX	ETA
1995 - 2002 2 q	5.0	13.1	15.5	11.2	25.9	1.0
Steady state (2100 4 q)	0.0	18.5	7.3	6.8	29.0	1.1

In Table 2, a sustainable level of government fiscal budget balance (i.e. consistent with stable government-debt-to-GDP ratio) is a deficit of around 2%. Government debt stabilises at a level of 37% of annual GDP. Insufficient domestic savings result in relatively higher borrowing from abroad. In a steady state, net foreign assets decline until they stabilise at a level of about –130% of annual GDP.

Given our assumption about a stable foreign price level, domestic inflation is zero in the steady state (Table 3). Long-run unemployment stabilises at a relatively high level. This feature of the steady state is not satisfactory and calls for improving specification of the wage-price block. However, as this result will probably not affect the impulse-response analysis substantially, we retain this specification in conducting the shock simulation below. The steady-state long-term nominal interest rate is set at 6.8, implying a real interest rate of the same magnitude (due to zero steady-state inflation) and approximately

0.5-percentage points in the time premium. Stabilisation of such high government debt levels requires a relatively high direct tax rate. Its steady-state level is almost three percentage points above the historically observed level. The steady-state mark-up implies a ten-percentage-point wedge between the GDP price and marginal costs. This is higher than the historical average, which is estimated at a zero rate.

3.3 Shock analysis of the LT_MCM

To illustrate the simulation properties of the LT_MCM, we discuss the response of the model's main variables to the following shocks:

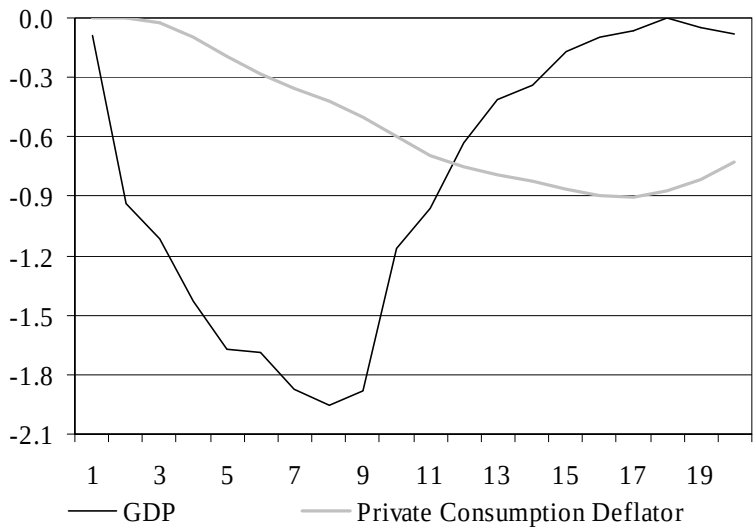
- A transitory interest-rate shock,
- A permanent government-consumption shock,
- A transitory exchange-rate shock,
- A transitory world-demand shock, and
- A permanent labour-supply shock.

The transitory interest-rate shock is defined as an unanticipated increase in the short-term interest rate by 100 basis points over eight quarters with a subsequent return to the baseline level. The exchange rate and all foreign variables are assumed constant. Given the currency board constraint, the interest-rate shock described above can be loosely interpreted as a risk-premium shock. The government-consumption shock is represented by a permanent 1% increase in real government consumption. The transitory exchange-rate shock is defined as a 1% appreciation of the euro over five years. As the price of oil is conventionally quoted in US dollars, the price of oil expressed in domestic currency is reduced by euro appreciation against the US dollar. The nominal interest rate is held constant. The transitory world-demand shock is a 1% increase in the real world imports over five years. Finally, the labour-supply shock is defined as a permanent increase in the labour supply by 1%. In all simulations, the fiscal policy rule is enabled. The basic tables summarising the model response to the shocks described above appear in Annex 3. Here, we only present figures illustrating GDP and price responses to the considered shocks.

Transitory interest-rate shock

An increase in the nominal interest rate has two straightforward effects. First, the user cost of capital will rise, precipitating a sharp decline in the desired capital stock and lowering investment demand. Second, there will be a decline in the accumulation of inventories. Lower domestic demand brings about lower apparent productivity that results in reduced nominal wages. To accommodate lower output, employment falls in the short run, leading to lower disposable income of households and a decline in private consumption. Exports rise slowly, reacting to increased competitiveness caused by falling domestic prices. Falling prices and a declining demand for imports, however, cause improvement in the current account balance, which helps stabilise the economy. Following the interest shock, prices react slowly and do not decline substantially until the second year. Their maximum accumulated decline is reached in the fourth year. There is also a transitory worsening in the government budget balance and an increase in government debt. To stabilise government debt, the direct tax is temporarily raised. Overall, the accumulated GDP decline in the second year is 1.8%. In subsequent years, the real economy moves back to the baseline level. Aggregate expenditure reaction decomposition reveals the largest contribution to the GDP decline stems from domestic demand (particularly investment). Although employment declines relative to the capital stock in the short run, after three years the capital-to-employment ratio has fallen below the baseline, reflecting the supply-factor-substitution effect.

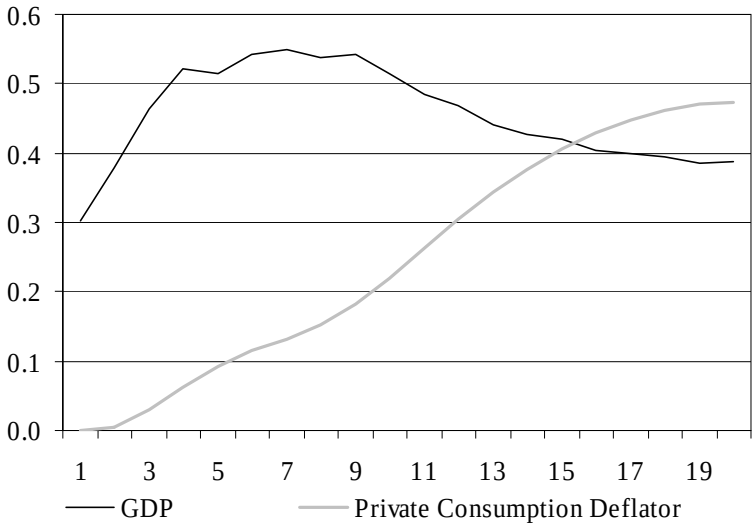
Figure 10. Response of GDP and private consumption deflator to an interest-rate shock.



Permanent government-consumption shock

The rise in government consumption triggers an overall rise in domestic demand. In the short run, employment rises to accommodate higher GDP. The economic expansion also boosts real wages. The latter, combined with higher employment, contributes to a rise in the disposable income of households, and thereby higher private consumption. The current account balance starts to deteriorate already in the first year due to higher imports. Higher domestic prices result in real appreciation. In response to the latter the decline in exports gathers strength over several years and causes further widening of the current account deficit. Overall, the short- and medium-run government expenditure multiplier is above unity due to the constant nominal interest rate assumption.

Figure 11. Response of GDP and private consumption deflator to a government-consumption shock.

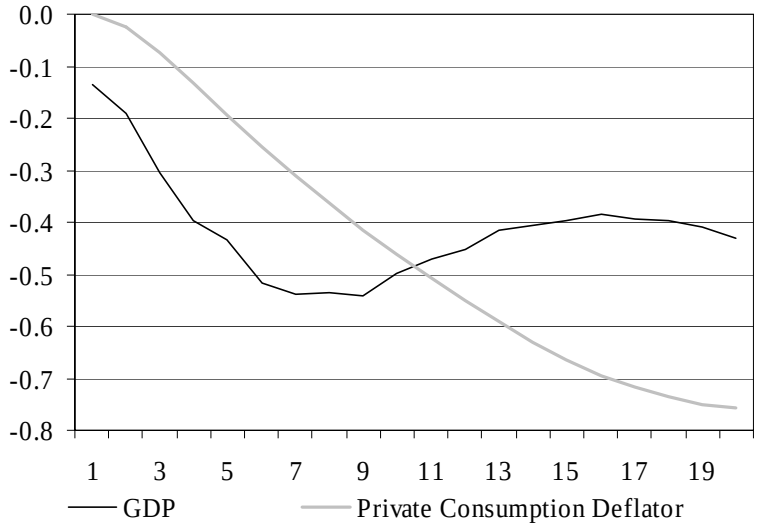


In a new equilibrium, the capital-to-labour ratio rises because labour has become a relatively more expensive production factor. Also, direct taxes are raised relative to baseline to stabilise the debt-to-GDP ratio. Accumulated deficits lead to lower private sector wealth, which in turn pushes private consumption (and GDP) slightly below the baseline.

Transitory exchange-rate shock

A 1% appreciation of the euro results in an approximately 0.6% nominal effective appreciation of the domestic currency. The shock quickly feeds in to increase the foreign trade deflators. Although the trade balance initially deteriorates, export prices in the medium term decline in excess of the exchange-rate appreciation, resulting in improvement in the foreign trade balance. GDP declines by 0.5% at most by the second year, mainly due to lower private consumption and investment. Private consumption reacts to lower disposable income triggered by the drop in employment and real wages, as well as the increase in direct taxes. Investment adjusts downward, following the decrease in the desired capital stock. Prices gradually decline over five years with the overall decline in excess of the effective exchange-rate appreciation. The latter is partly the result of the assumed contemporaneous drop in oil prices, expressed in domestic currency.

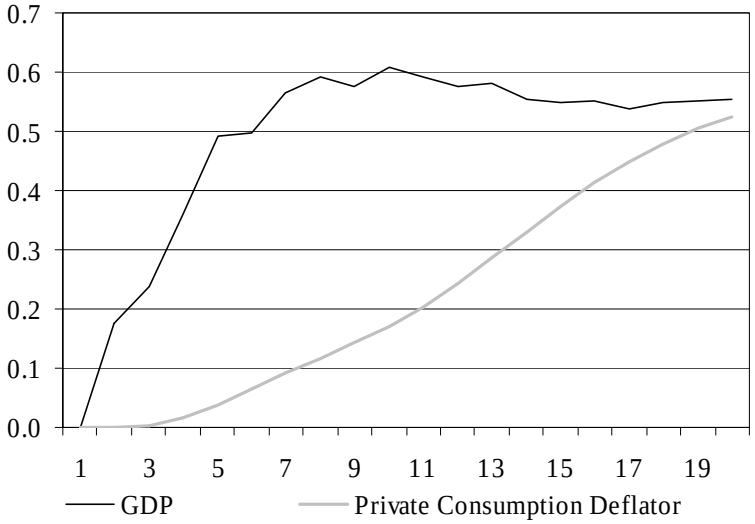
Figure 12. GDP and private consumption deflator responses to a nominal exchange-rate shock.



The short- and medium-run impact of a positive world-demand shock on domestic demand is somewhat similar to the above case of fiscal expansion. The main difference is that the government's fiscal position improves and the government-debt-to-GDP ratio declines to bring about a temporary reduction in direct tax rate. In addition, there is a temporary improvement in the trade balance caused by a rapid increase in exports following the

world-demand shock. Of course, strong domestic demand and real appreciation will eventually result in rising imports and reduce the current account surplus.

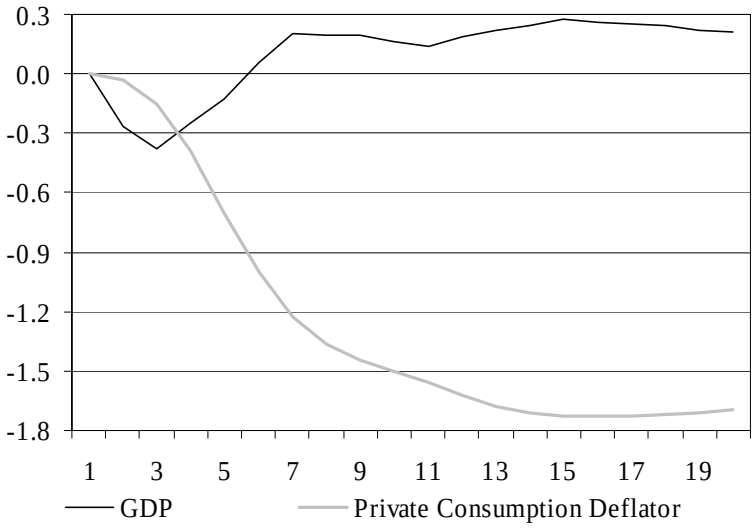
Figure 13. Responses of GDP and private consumption deflator to a world-demand shock.



Permanent labour-supply shock

An increase in the supply of labour has a negative impact on GDP in the short run. In the medium term, it results in an output level above the baseline. In the first year, overall GDP declines due to lower domestic demand. In particular, private consumption falls as a reaction to lower real wages caused by a rising unemployment rate. Employment is still above the baseline, but insufficient to prevent a reduction in the disposable income of households. The direct tax rate also increases as the fiscal authorities attempt to stabilise the government-debt-to-GDP ratio. Lower investment reflects the general deterioration of the macroeconomic environment and the fact that, during a large decline in real wages, capital becomes a relatively more expensive factor of production. High unemployment also puts strong downward pressure on domestic prices, leading to a substantial fall in export prices and a significant improvement in the competitiveness of Lithuanian exports. The surge in the foreign trade surplus starting from the second year is sufficient to reverse the initial negative GDP response. As a result, the medium-term output response to the positive labour-supply shock is positive, while prices are significantly below the baseline level.

Figure 14. Responses of GDP and private consumption deflator to a labour-supply shock.



4 Conclusions

The modelling results presented in the paper are intermediate as the model development is a continuous process. This current macro model for the Lithuanian economy only provides rough approximations. The parameters of the model are largely determined by the statistical estimation and given severe data problems (short time series, errors in data, etc) are subject to great uncertainty. This effectively implies that the results presented in the study should be treated with caution. Having said this, we would nevertheless like to highlight some of the important observations from estimation and simulation of the LT_MCM.

In terms of estimated coefficients, we find on average relatively large values of the loading coefficients in the LT_MCM compared to other MCM country blocks. This finding is similar to those reported in previous papers on building structural macro models of the Lithuanian economy (Vetlov, 2004; Kuodis and Vetlov, 2002). Furthermore, the length of lag structure of the dynamic equations in the LT_MCM is much shorter than the average for such models, and results in relatively fast response and adjustment to shocks. This outcome is largely expected due to high volatility of the historical data used to

estimate the model. At the same time we find some similarities between the LT_MCM model simulation results and those from other MCM country blocks. Specifically, the simulation of the model reveals that GDP is more responsive to shocks over the short run than domestic prices. Also, we find that among aggregate demand expenditures, investment is relatively more volatile than private consumption. The latter is broadly in agreement with findings of several other EU country models reported in Angeloni et al. (2002) and Van Els et al. (2001).

The following modelling issues deserve further attention. We need to build a satisfactory baseline scenario for the LT_MCM with more realistic steady-state levels (ratios for a growing economy). This is necessary to be able to use of the model in forecasting and to introduce forward-looking behaviour into the model. Forward-looking elements can be introduced into inflation expectations and definition of the permanent disposable income of households. In addition, to construct a plausible medium- and long-run scenario, we need to make several assumptions regarding the rate of convergence of Lithuanian labour productivity growth to the EU average. Explicit treatment of the risk premium in the domestic nominal interest rate could significantly enrich the model and improve on model's overall empirical plausibility. Finally, updating the model database with newer observations will improve coefficient estimates and allow a much-needed revision of the estimated equations.

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Annex 1: Summary of equations in the LT_MCM

1. Long-run model

1.1. Supply side

Production function

LOG(YER) = 0.36*LOG(KSR) + (1-0.36)*LOG(LNN)+ LOG(143.03) + (1-0.36)*0.0128*TIME [1]

(463.15) (14.537)

R^2=0.923; DW=0.75; S.E.=0.02960; Estimation period: 1995q1 – 2002q4;

BETA=0.36; ALPHA=143.03; GAMMA=0.0128.

Equilibrium level of capital stock (KSTAR)

LOG(KSTAR)=LOG(YER) -LOG(ALPHA) + (1-BETA)*(LOG(BETA/(1-BETA))+LOG(WUN)
- LOG(CC1) – GAMMA*TIME) [2]

Equilibrium level of employment (LSTAR)

LOG(LSTAR) = - (1/(1-BETA))*LOG(ALPHA) – GAMMA*TIME+ (1/(1-BETA))*LOG(YER)
-(BETA/(1-BETA))*LOG(KSR) [3]

Equilibrium level of labour force (FSTAR)

LOG(FSTAR)=0.331+0.589*LOG(LNN)-0.0014*TREND-0.031*D022 [4]

(9.642) (7.951) (-4.318) (-4.804)

R^2=0.956; DW=0.51; S.E.=0.00903; Estimation period: 1995q1 – 2002q4;

Equilibrium level of GDP expenditure deflator (YDSTAR)

LOG(YED*(1-TIX))= LOG(ETA)-LOG(1-BETA)-LOG(YER/LNN)+LOG(WUN) [5]

LOG(ETA) = -0.071+0.083*D011- (0.196571053/(1-0.196571053))*LOG(YED*(1-TIX)/MTD) [6]

(-7.358) (7.317) (9.229)

R^2=0.978; DW=1.89; S.E.=0.01968; Estimation period: 1995q1 – 2002q4

1.2. Demand side

Equilibrium level of private consumption (CSTAR)

LOG(CSTAR) = -0.819+0.299*LOG(FWR) + (1-0.299)*LOG(PYR)+0.056*D992 [7]

(-11.92) (8.787) (5.292)

R^2=0.963; DW=2.41; S.E.=0.01982; Estimation period: 1995q2 – 2002q2

Equilibrium level of exports (XSTAR)

LOG(XSTAR) =LOG(WDR)-LOG((XTD*PEI^(-0.182))/CXD)+0.043*TREND-0.465*DRC

(21.93) (-11.91)

+8.049 [8]

(425.6)

R^2=0.954; DW=2.07; S.E.=0.04535; Estimation period: 1995q1 – 2003q1

Equilibrium level of imports (MSTAR)

LOG(MSTAR) = 0.047+LOG(WER)-0.315*LOG(MTD*(PEI^(-0.095))/YED) [9]

(7.035) (-8.913)

R^2=0.979; DW=1.23; S.E.=0.03321; Estimation period: 1995q1 – 2003q2

Equilibrium level of stock of inventories (LSSTAR)

LOG(LSSTAR) = -0.953+0.0179*TREND+LOG(YNR)-0.630*(STI/400-LOG(YED/YED(-1))) [10]
(-61.17) (26.86) (-2.220)

R^2=0.986; DW=2.01; S.E.=0.024793; Estimation period: 1997q1 – 2003q1

1.3. Prices

Equilibrium level of compensation per employee (WSTAR)

LOG(WSTAR) = LOG(PCD)+LOG(1-BETA)+LOG(PROD)-0.596-LOG(LFN/LNN) [11]
(-6.806)

+5.766*LOG(1+TRX)
(6.618)

R^2=0.983; DW=1.34; S.E.=0.034777; Estimation period: 1995q1 – 2002q2

Equilibrium level of private consumption deflator (PCDSTAR)

LOG(PCDSTAR) = 0.0183+0.84*LOG(YED) + (1-0.84)*LOG(MTD) [12]
(3.93) (30.47)

R^2=0.950; DW=1.05; S.E.=0.024793; Estimation period: 1995q1 – 2003q2

Equilibrium level of public consumption deflator (GCDSTAR)

LOG(GCDSTAR) = -0.099+LOG(YED)+0.031*LOG(TREND)+0.095*D984 [13]

(-5.685) (4.816) (2.972)

R^2=0.965; DW=1.35; S.E.=0.03155; Estimation period: 1995q1 – 2003q2

Equilibrium level of investment deflator (ITDSTAR)

LOG(ITDSTAR) = 0.017+0.263*LOG(YED) + (1-0.263)*(LOG(MTD)-0.137*LOG(PEI))

(2.979) (10.78) (-6.28)

+0.086*D971 [14]

(3.971)

R^2=0.806; DW=1.46; S.E.=0.02135; Estimation period: 1995q1 – 2003q2

Equilibrium level of export deflator (XDSTAR)

LOG(XDSTAR) = -0.011+0.526*LOG(CXD)+0.183*LOG(PEI)+(1-0.526-0.183)*LOG(YED) [15]

(-2.08) (26.44) (13.61)

R^2=0.882; DW=1.39; S.E.=0.01954; Estimation period: 1995q1 – 2003q1

Equilibrium level of import deflator (MDSTAR)

LOG(MTD) = 0.405*LOG(CMD)+0.095*LOG(PEI)+0.023-0.038*D991 [16]

(5.242) (7.349) (2.279) (-3.608)

R^2=0.852; DW=1.24; S.E.=0.01535; Estimation period: 1995q1 – 2003q1

2. Dynamic model

2.1. Demand side

Dynamic equation for private consumption (PCR)

DLOG(PCR) = 0.068*D(D992) – LOG(PCR(-1)/CSTAR(-1)) + 0.175*DLOG(FWR)

(4.466) (1.933)

+0.420*DLOG(PYR)-1.217*D(URX/100) [17]

(5.671) (-2.956)

R^2=0.745; DW=2.0 S.E.=0.01372 Estimation period: 1995q3 – 2002q2

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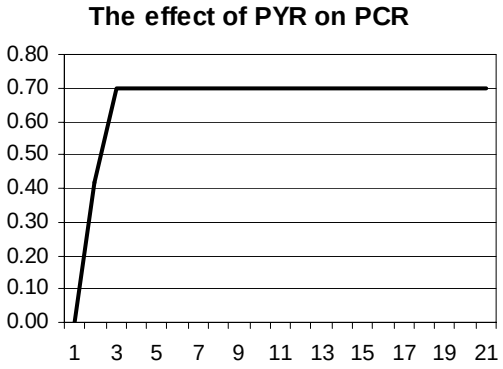
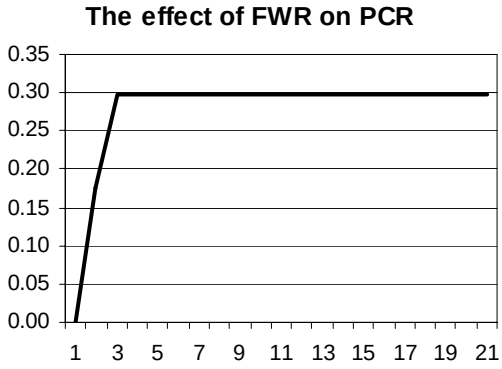
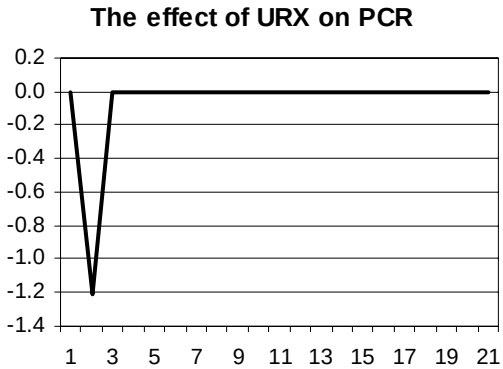






Dynamic equation for investment (ITR)

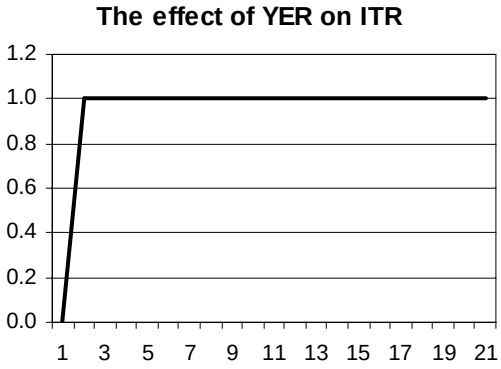
DLOG(ITR) = -0.198*LOG(((1+GAMMA)*ITR(-1))/(KSTAR(-1)*(0.02+GAMMA)))

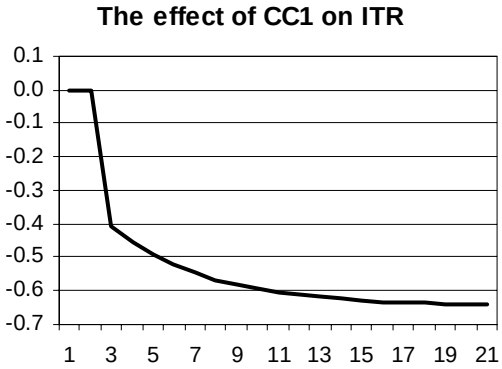
(-3.265)

+DLOG(YER)-0.282*DLOG(CC1(-1))+0.145*DIN1+0.139*DIN2 [18]

(-2.945) (4.654) (4.606)

R^2=0.779; DW=1.95; S.E.=0.04246; Estimation period: 1997q2 – 2003q1 8





Dynamic equation for changes in inventories (SCR)

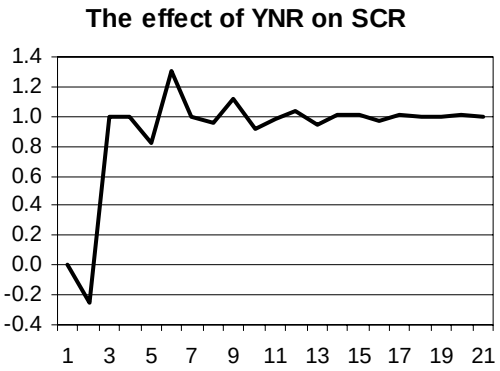
D(SCR) =-(SCR(-1)-D(LSSTAR(-1))) + 0.119*(D(SALE(-3))-D(YNR(-3)))

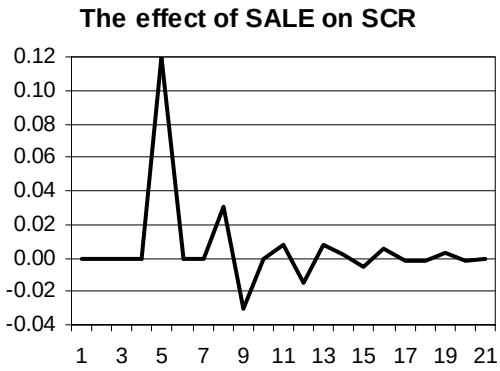
(1.509)

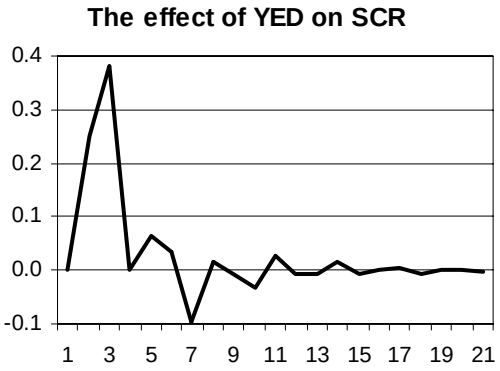
-0.250*D((STI/400-LOG(YED/YED(-1)))*YNR)+0.253*D(SCR(-3)) [19]

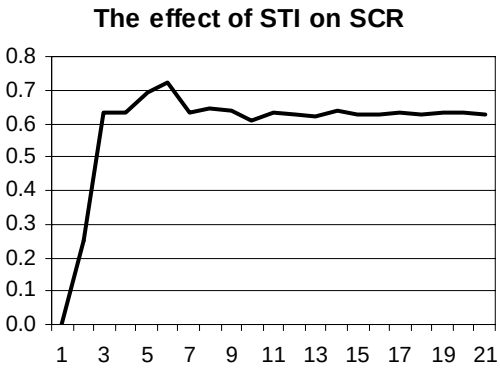
(-1.533) (1.846)

R^2=0.592; DW=2.49; S.E.=166.302; Estimation period: 1997q3 – 2003q1









Dynamic equation for exports (XTR)

DLOG(XTR) =0.058*D(TREND)-0.534*LOG(XTR(-1)/XSTAR(-1))-0.370*DLOG(XTR(-1))

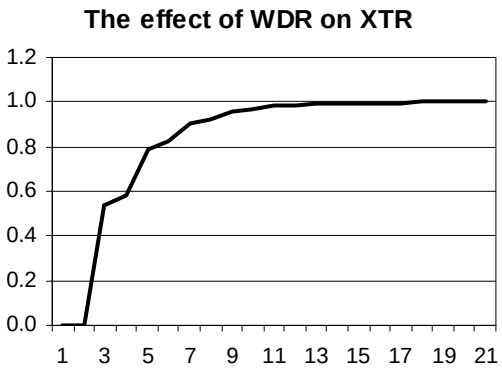
(5.864) (-2.764) (-2.631)

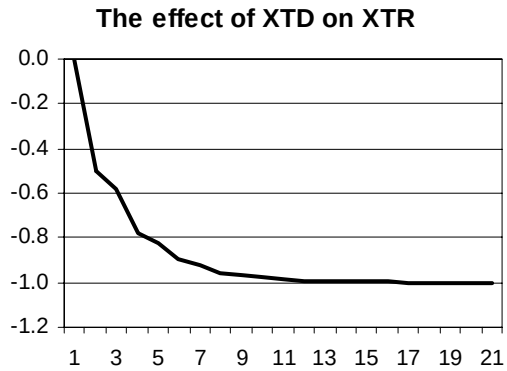
-0.5*DLOG((XTD*PEI^(-0.18))/CXD)-0.643*D(DRC) [20]

(-5.691)

R^2=0.600 DW=2.3; S.E.=0.04093 Estimation period: 1995q3 – 2003q1

8; 5





Dynamic equation for imports (MTR)

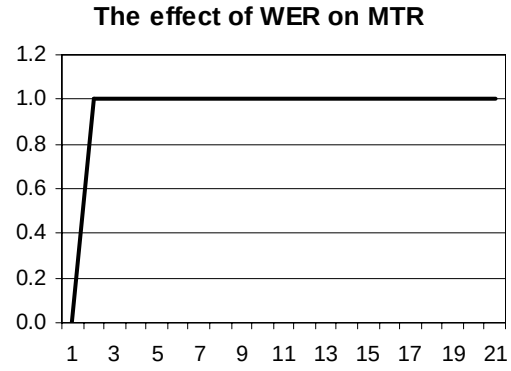
DLOG(MTR) = -0.631*(LOG(MTR(-1)/MSTAR(-1))) -0.204*DLOG(MTD*(PEI^(-0.095))/YED)

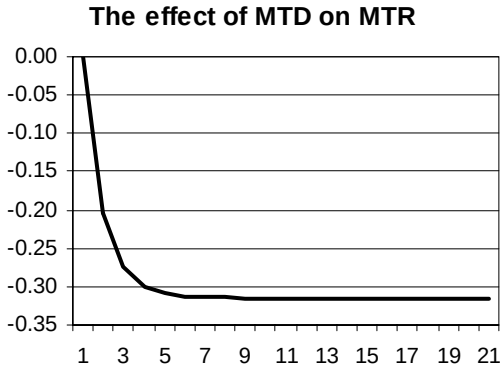
(-3.865) (-1.420)

+DLOG(WER) [21]

R^2=0.743 DW=1.8 S.E.=0.03064 Estimation period: 1995q2 – 2003q2

4; 7; 6





2.2.Labour market

Dynamic equation for employment (LNN)

DLOG(LNN) = -0.092*LOG(LNN(-1)/LSTAR(-1))+0.108*DLOG(YER/KSR)

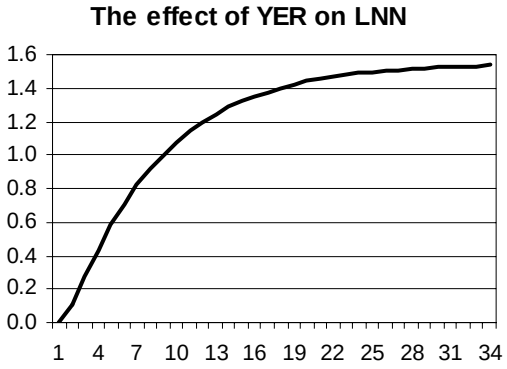
(-5.487) (3.922)

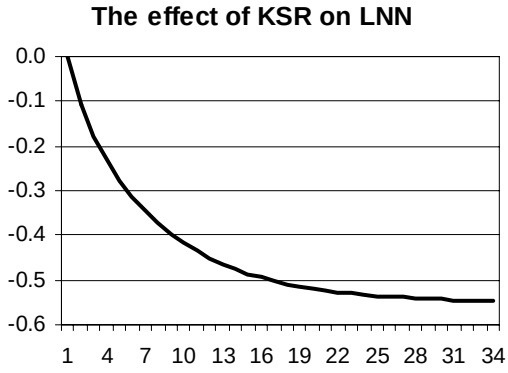
+0.273*DLOG(LNN(-1))-0.021*DLN+0.345*DLOG(LFN) [22]

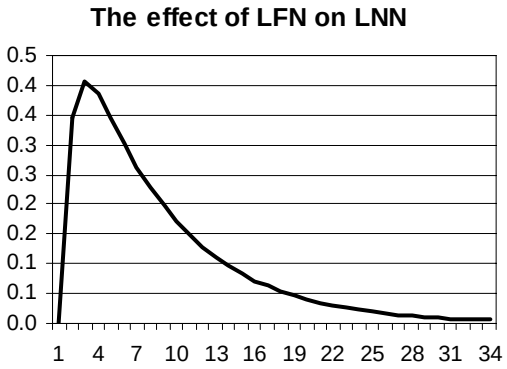
(3.937) (-6.644) (5.11)

R^2=0.842 DW=1.9 S.E.=0.00362 Estimation period: 1995q2 – 2002q4

0; 5; 9;





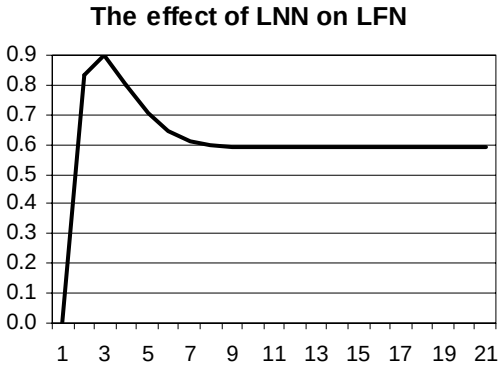


Dynamic equation for labour supply (LFN)

DLOG(LFN) = -0.370*LOG(LFN(-1)/FSTAR(-1))+0.191*DLOG(LFN(-1))+0.835*DLOG(LNN)
(-3.382) (2.406) (9.166)

-0.027*D(D022) [23]
(-5.601)

R^2=0.819; DW=1.47; S.E.=0.00470; Estimation period: 1995q3 – 2002q4



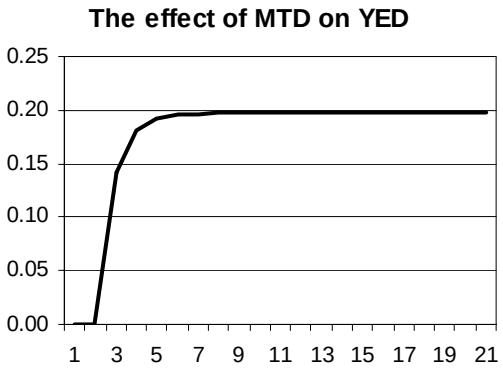
2.4. Prices

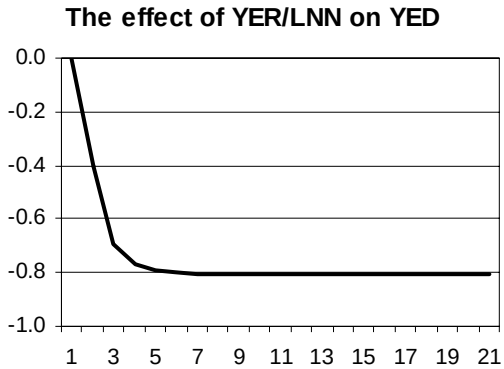
Dynamic equation for GDP deflator (YED)

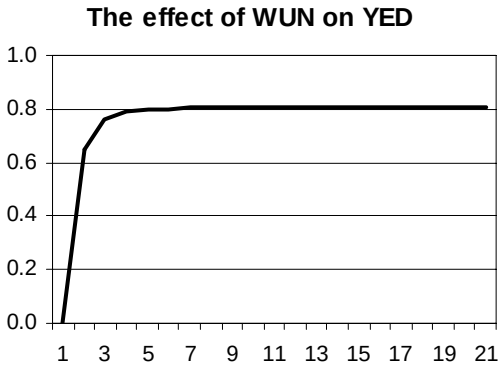
DLOG(YED*(1-TIX)) = -0.721*(LOG(YED(-1)/YDSTAR(-1))) +0.65*DLOG(WUN)
(-5.003)

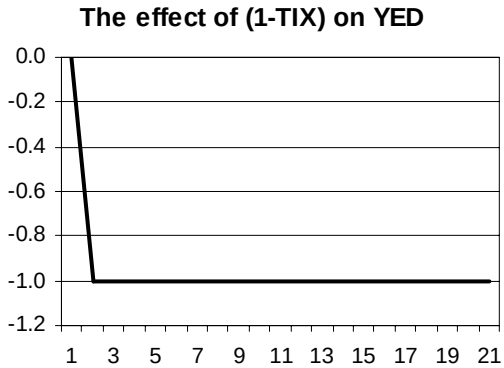
- 0.405*DLOG(YER/LNN)+0.029*D(D011)
(-3.444) (1.435) [24]

R^2=0.703; DW=1.87; S.E.=0.01770; Estimation period: 1995q2 – 2002q4









Dynamic equation for compensation per employee (WUN)

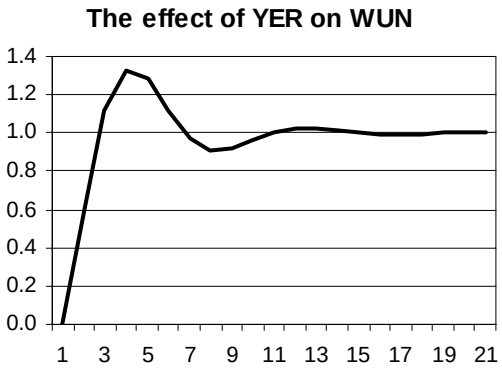
DLOG(WUN) = -0.490*(LOG(WUN(-1)/WSTAR(-1)))+0.598*DLOG(PROD)

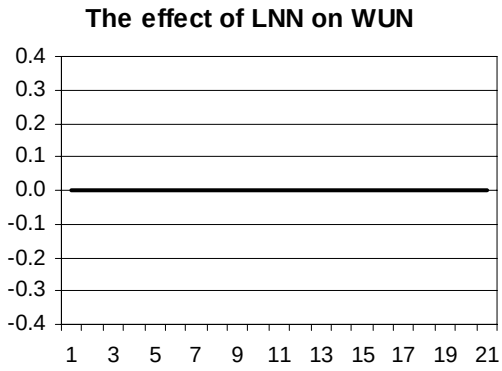
(-3.761) (5.138)

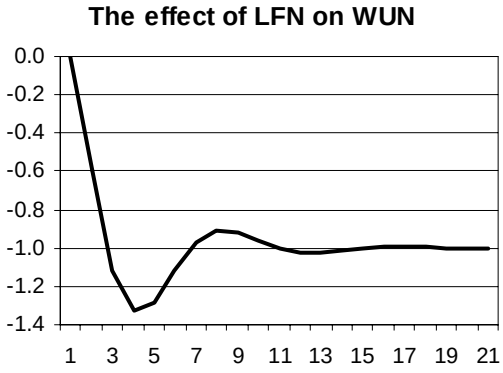
+0.534*DLOG(WUN(-1))+0.415*DLOG(PCD)+2.436*DLOG(1+TRX)-0.598*DLOG(LFN/LNN) [25]

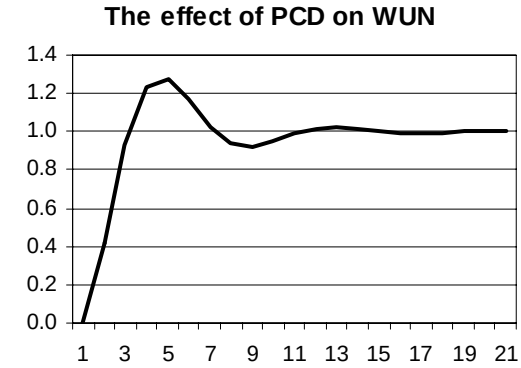
(5.407) (2.466) (4.224) (-1.415)

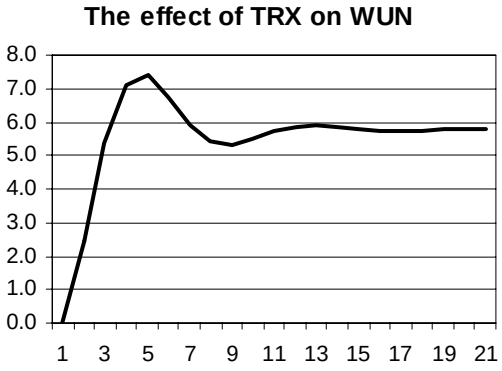
R^2=0.683; DW=2.65; S.E.=0.016626; Estimation period: 1995q3 – 2002q2











Dynamic equation for private consumption deflator (PCD)

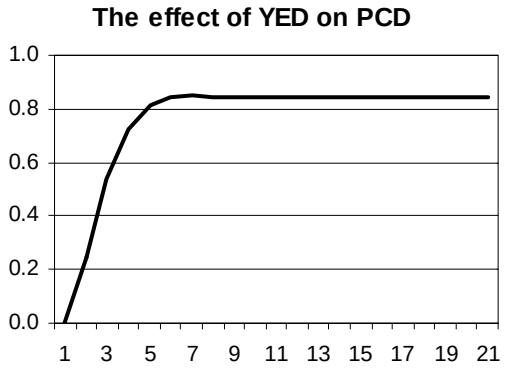
DLOG(PCD) =-0.399*LOG(PCD(-1)/PCDSTAR(-1))+0.249*DLOG(YED)

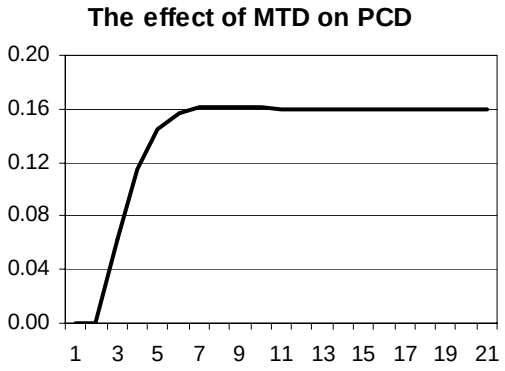
(-4.103) (3.905)

+0.23*DLOG(PCD(-1)) [26]

R^2=0.652; DW=1.7 S.E.=0.00779 Estimation period: 1996q2 – 2003q2

1; 9





Dynamic equation for public consumption deflator (GCD)

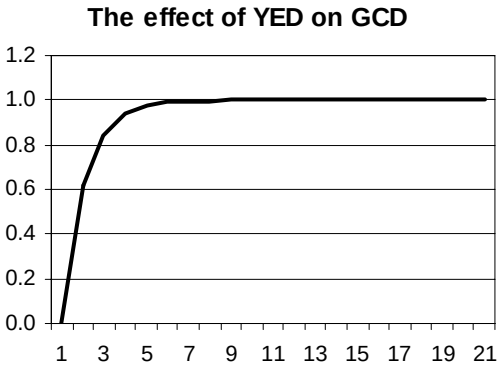
DLOG(GCD) = -0.593*LOG(GCD(-1)/GCDSTAR(-1)) + 0.616*DLOG(YED)

(-3.477) (3.033)

+0.064*DLOG(TREND)+0.081*D(D984) [27]

(1.570) (3.829)

R^2=0.576; DW=2.16; S.E.=0.02842; Estimation period: 1995q2 – 2003q2



Dynamic equation for investment deflator (ITD)

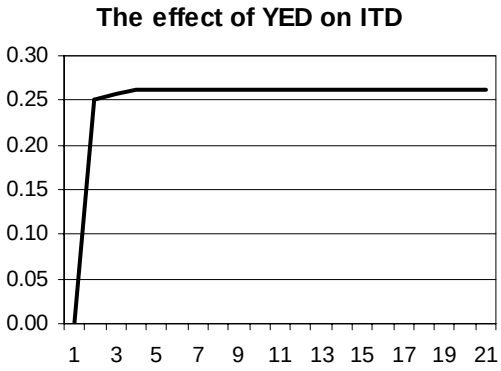
DLOG(ITD) = -0.662*LOG(ITD(-1)/ITDSTAR(-1)) + 0.522*DLOG(MTD*PEI^(-0.137))

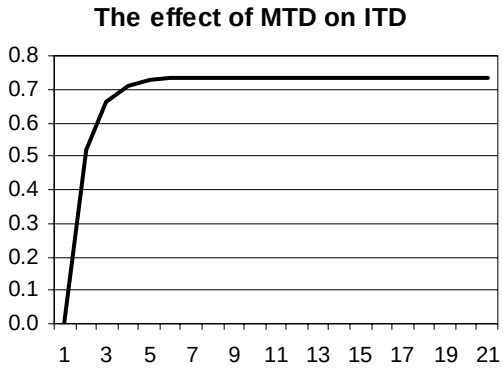
(-3.796) (2.836)

+0.25*DLOG(YED)+0.067*D(D971) [28]

(4.698)

R^2=0.583; DW=2.02; S.E.=0.01934 Estimation period: 1995q2 – 2003q2; 8;





Dynamic equation for export deflator (XTD)

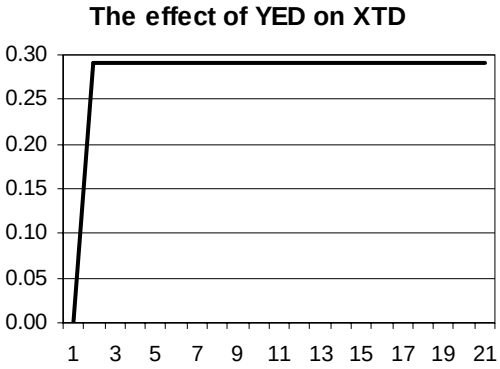
DLOG(XTD) = -0.649*LOG(XTD(-1)/XDSTAR(-1)) +0.082*DLOG(PEI)+0.29*DLOG(YED)

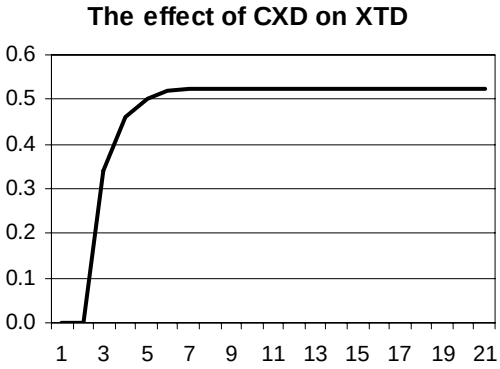
(-5.377) (4.306)

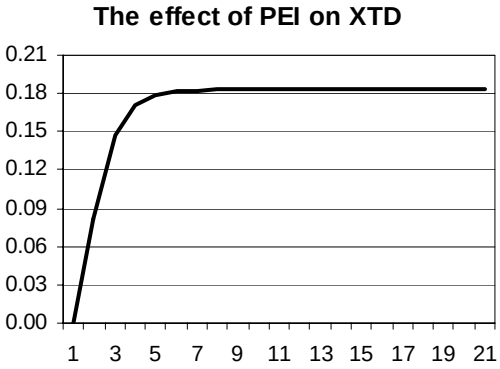
+0.396*DLOG(MTD)+0.345*DLOG(MTD(-1)) [29]

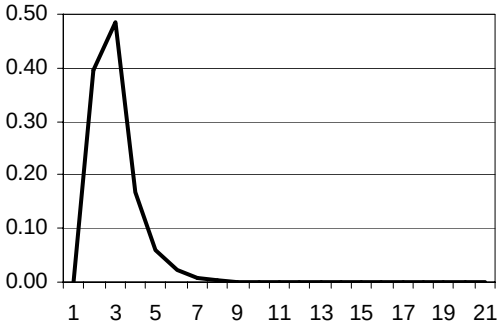
(3.237) (3.274)

R^2=0.851; DW=1.88; S.E.=0.01189 Estimation period: 1995q3 – 2003q2; 0;









Dynamic equation for import deflator (MTD)

DLOG(MTD) = -0.619*LOG(MTD(-1)/MDSTAR(-1)) +0.077*DLOG(PEI)+0.197*DLOG(CMD)

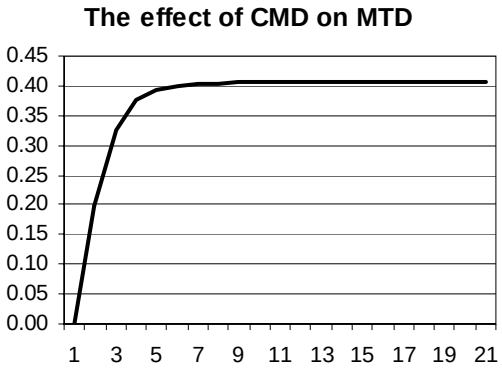
(-3.75) (3.960) (1.483)

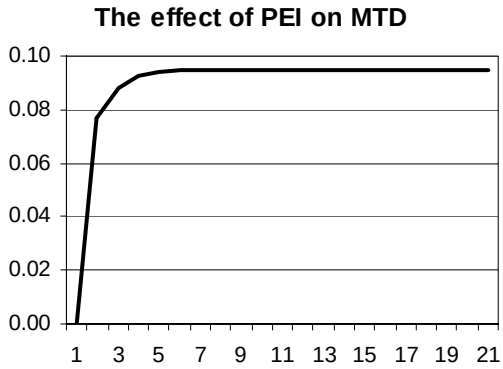
-0.038*D(D991) [30]

(-2.752)

R^2=0.549 DW=1.8 S.E.=0.01363 Estimation period: 1995q2 – 2003q1

3; 3; 4





2.5. Fiscal policy rule

TDX =TDXEXO+0.9*(TDX(-1)-TDXEXO(-1))+0.01*(GDN(-1)/YEN(-1)-GDNYEN(-1)) [31]

3. Identities and definitions

LNT = (1 - 0.01 * URT) * LFN

LOG(YFT) = LOG(ALPHA) + BETA * LOG(KSR) + (1 - BETA) * (GAMMA * TIME + LOG(LNT))

YGA = YER / YFT

FWN = GDN(-1) + NFA(-1) + (KSR - KGR) * OID

FWR = FWN / PCD

PCN = PCR * PCD

GCN = GCR * GCD

CC1 = ITD * (LTI + 8 - INFE) / 400

KSR = KSR(-1) * (1 - 0.02) + ITR(-1)

KGR = KGR(-1) * (1 - 0.02) + GIR(-1)

OIR = ITR - GIR

OIN = OIR * OID

GIN = GIR * GID

ITN = ITR * ITD

LOG(YNR) = LOG(ALPHA) + BETA * LOG(KSR(-1)) + (1 - BETA) * (GAMMA * TIME + LOG(LNN(-1)))

SALE = PCR + XTR

CMD = CMUD * EXR

CXD = CXUD * EXR

XTN = XTR * XTD

WER = 0.2 * (PCR + GCR) + 0.1 * (ITR + SCR) + 0.70 * XTR

ULC = WIN / YER

MTN = MTR * MTD

YER = PCR + GCR + ITR + SCR + XTR - MTR + ZER

YEN = YER * YED

SZN = YEN - PCN - GCN - ITN - XTN + MTN

UNN = LFN - LNN

URX = 100 * (LFN - LNN) / LFN

PROD = YER / LNN

WIN = WUN * LNN

YFD = YED * (1 - TIX)

OID = ITD

GID = ITD

INFE = 100 * (((ITD / ITD(-4) - 1) + (ITD(-1) / ITD(-5) - 1) + (ITD(-2) / ITD(-6) - 1) + (ITD(-3) / ITD(-7) - 1)) / 4)

INFQ = 100 * (PCD - PCD(-1)) / PCD(-1)

INFA = 100 * (PCD - PCD(-4)) / PCD(-4)

GON = YEN - WIN - TIN - ZIN

PYN = WIN + TRN + OPN - TDN

PYR = PYN / PCD

TRN = TRX * YEN

OPN = 0.9 * (GON)

PSN = PYN - PCN

PLN = PSN - OIN

GYN = TDN + ODN + TIN + OGN - TRN - INN

TDNBAS = WIN

TDN = TDX * TDNBAS

ODN = ODX * YEN

TINBAS = YEN

TIN = TIX * TINBAS

INN = 0.015 * GDN(-1)

GSN = GYN - GCN

GLN = GSN - GIN

SGLN = SGLN(-1) + GLN

GDN = - SGLN

OLN = CAN - PLN - GLN

OYN = GON + NFN + TWN + INN - (ODN + OGN + OPN)

BTN = XTN - MTN

CAN = XTN - MTN + NFN + TWN

NFN = 0.015 * NFA(-1)

TWN = 0.02 * YEN

SCAN = SCAN(-1) + CAN

NFA = NFA(-1) + CAN + ZNFA

LTI = LTI(-1) + (STI - STI(-1))

Annex 2: Alphabetical list of variables in the LT_MCM

CODE	DESCRIPTION
BTN	Foreign trade balance
CAN	Current account
CC1	User cost of capital 1
CMD	External competitor price on the import side in domestic currency
CMUD	External competitor price on the import side in USD
CSTAR	Equilibrium level of private consumption
CXD	External competitor price on the export side in domestic currency
CXUD	External competitor price on the export side in USD
D011	Step dummy variable, 1 from 2001q1, 0 otherwise
D022	Step dummy variable, 1 from 2002q2, 0 otherwise
D971	Impulse dummy variable, 1997q1=1, 0 otherwise
D984	Impulse dummy variable, 1998q4=1, 0 otherwise
D991	Impulse dummy variable, 1999q1=1, 0 otherwise
D992	Step dummy variable, 1 from 1999q2, 0 otherwise
DIN1	Impulse dummy variable, 1998q2=1, 1998q2=1, 0 otherwise
DIN2	Impulse dummy variable, 2001q4=1, 2002q1=-1, 0 otherwise
DLN	Impulse dummy variable, 1998q1=1, 0 otherwise
DRC	Step dummy variable, 1998q3=0.2, 1998q4=0.4, 1999q1=0.6, 1999q2=0.8, 1 from 1999q3, 0 otherwise
ETA	Mark-up
EXR	Domestic currency and US dollar nominal exchange rate
FSTAR	Equilibrium level of labour force
FWN	Nominal private financial wealth
FWR	Real private financial wealth
GCD	Public consumption deflator, 2000=1
GCDSTAR	Equilibrium level of public consumption deflator
GCN	Nominal public consumption
GCR	Real public consumption
GDN	Nominal government debt

GDNYEN	Baseline government debt to GDP ratio
GID	Public investment deflator, 2000=1
GIN	Nominal public investment
GIR	Real public investment
GLN	Government net lending
GON	Nominal gross operating surplus and mixed income
GSN	Government gross savings
GYN	Government nominal disposable income
INFA	Annual inflation (based on private consumption deflator)
INFE	Expected inflation (based on private investment deflator)
INFQ	Quarterly inflation (based on private consumption deflator)
INN	Government expenditures on interest payments
ITD	Investment deflator, 2000=1
ITDSTAR	Equilibrium level of investment deflator
ITN	Nominal gross fixed capital formation (investment)
ITR	Real gross fixed capital formation
KGR	Real capital stock in public sector
KSR	Real capital stock
KSTAR	Desired capital stock
LFN	Labour force
LNN	Employment
LNT	Potential level of employment
LSSTAR	Equilibrium level of stock of real inventories
LSTAR	Accumulated stock of real inventories
LTI	Nominal long-term (over 1year) bank lending interest rate
MDSTAR	Equilibrium level of import deflator
MSTAR	Equilibrium level of real import
MTD	Import deflator, 2000=1
MTN	Nominal imports of goods and services
MTR	Real import
NFA	Net foreign assets
NFN	Net factor income from the rest of the world

ODN	Other direct taxes
ODX	Other direct tax rate
OGN	Other government income
OID	Private investment deflator, 2000=1
OIN	Nominal private investment
OIR	Real private investment
OLN	Other private sector net lending
OPN	Other personal income
OYN	Other private sector nominal disposable income
PCD	Private consumption deflator, 2000=1
PCDSTAR	Equilibrium level of private consumption deflator
PCN	Nominal private consumption
PCR	Real private consumption
PEI	Oil price in domestic currency, 2000=1
PLN	Personal net lending
PROD	Labour productivity
PSN	Personal sector savings
PYN	Households' nominal disposable income
PYR	Households' real disposable income
SALE	Indicator of the sales of storable goods
SCAN	Accumulated current account balances
SCR	Real changes in inventories
SGLN	Accumulated government net lending
STI	Nominal short-term (up to 1 year) bank lending interest rate
SZN	Statistical discrepancy and changes in inventories in nominal GDP by expenditure approach
TDN	Direct taxes including social security contributions
TDNBAS	Tax base for the direct taxes
TDX	Effective direct tax rate
TDXEXO	Baseline direct tax rate
TIME	Time trend, 1995q1=1
TIN	Indirect taxes net of subsidies

TINBAS	Tax base for the indirect taxes
TIX	Effective indirect tax rate
TRN	Total transfers to households
TRX	Effective transfer rate
TWN	Other transfers from the rest of the world
UNN	Number of unemployed
URT	Natural rate of unemployment
URX	Unemployment rate
WDR	Real effective import of Lithuania's major foreign trade partners in domestic currency
WER	Import demand indicator
WIN	Nominal labour compensation
WSTAR	Equilibrium level of compensation per employee
WUN	Compensation per employee
XDSTAR	Equilibrium level of export deflator
XSTAR	Equilibrium level of real export
XTD	Export deflator, 2000=1
XTN	Nominal exports of goods and services
XTR	Real export
YDSTAR	Equilibrium level of GDP deflator
YED	GDP deflator, 2000=1
YEN	Nominal GDP by expenditure approach
YER	Real GDP by expenditure approach
YFT	Potential GDP
YGA	Rate of capacity utilisation
YNR	Normal level of production
ZER	Statistical discrepancy in real GDP by expenditure approach
ZIN	Statistical discrepancy in nominal GDP by income approach
ZNFA	Errors and omissions in balance of payments

Note: Variables in bold are treated as exogenous in the model.

Annex 3: LT_MCM simulation results

Table A7. Model response to transitory interest-rate shock.

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	-0.03	-0.31	-0.64	-0.84	-0.83
GDP deflator	-0.09	-0.48	-0.87	-1.05	-0.89
ULC	-0.07	-0.66	-1.19	-1.28	-1.04
Compensation per employee	-0.65	-1.14	-0.79	-0.87	-1.14
Productivity	-0.58	-0.49	0.41	0.41	-0.10
Export deflator	-0.03	-0.14	-0.26	-0.31	-0.26
Import deflator	0.00	0.00	0.00	0.00	0.00
GDP and Components	*Levels, percentage deviations from baseline*				
GDP	-0.89	-1.80	-1.16	-0.25	-0.05
Consumption	-0.63	-1.71	-1.64	-0.87	-0.55
Investment	-3.13	-5.82	-3.67	-1.44	-0.87
Government consumption	0.00	0.00	0.00	0.00	0.00
Exports	0.01	0.10	0.21	0.28	0.28
Imports	-0.21	-0.52	-0.47	-0.28	-0.19
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	-0.96	-2.08	-1.60	-0.74	-0.47
Inventories	-0.08	-0.15	-0.03	0.10	0.09
Trade balance	0.16	0.43	0.47	0.39	0.32
Labour Market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	-0.32	-1.32	-1.56	-0.66	0.05
Unemployment rate	0.04	0.25	0.49	0.40	0.12

Household Accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	-0.97	-2.02	-1.52	-0.63	-0.30
Saving rate	-0.23	-0.21	0.09	0.16	0.17
Fiscal Ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	0.09	0.23	0.25	0.24	0.22
Total expenditure	0.27	0.56	0.41	0.15	0.06
Budget deficit	-0.17	-0.33	-0.15	0.09	0.16
Government debt	1.59	4.36	4.78	3.49	2.27
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	1.00	1.00	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 (euro)	0.00	0.00	0.00	0.00	0.00
Commodity prices (euro)	0.00	0.00	0.00	0.00	0.00

Table A8. Model response to permanent government-consumption shock.

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	0.02	0.12	0.24	0.39	0.46
GDP deflator	0.06	0.18	0.35	0.50	0.56
ULC	0.07	0.24	0.46	0.63	0.70
Compensation per employee	0.30	0.27	0.34	0.47	0.58
Productivity	0.23	0.02	-0.12	-0.16	-0.12
Export deflator	0.02	0.05	0.10	0.15	0.16
Import deflator	0.00	0.00	0.00	0.00	0.00
GDP and Components	*Levels, percentage deviations from baseline*				
GDP	0.42	0.54	0.50	0.42	0.39
Consumption	0.32	0.53	0.59	0.55	0.53
Investment	0.46	0.74	0.75	0.76	0.75
Government consumption	1.00	1.00	1.00	1.00	1.00
Exports	-0.01	-0.04	-0.08	-0.13	-0.16
Imports	0.14	0.20	0.23	0.24	0.24
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	0.50	0.66	0.69	0.68	0.67
Inventories	0.03	0.04	0.02	0.00	-0.01
Trade balance	-0.11	-0.17	-0.21	-0.25	-0.27
Labour Market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	0.19	0.51	0.62	0.58	0.51
Unemployment rate	-0.02	-0.11	-0.19	-0.20	-0.19

Household Accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	0.45	0.59	0.60	0.51	0.44
Saving rate	0.09	0.04	0.01	-0.03	-0.06
Fiscal Ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	-0.04	-0.05	-0.05	-0.05	-0.03
Total expenditure	0.12	0.09	0.09	0.12	0.14
Budget deficit	-0.16	-0.14	-0.15	-0.17	-0.17
Government debt	-0.20	0.06	0.44	0.95	1.53
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 (euro)	0.00	0.00	0.00	0.00	0.00
Commodity prices (euro)	0.00	0.00	0.00	0.00	0.00

Table A9. Model response to transitory exchange-rate shock.

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	-0.06	-0.28	-0.48	-0.64	-0.74
GDP deflator	-0.09	-0.35	-0.58	-0.75	-0.83
ULC	-0.06	-0.39	-0.66	-0.86	-0.95
Compensation per employee	-0.21	-0.49	-0.59	-0.74	-0.90
Productivity	-0.15	-0.11	0.07	0.12	0.05
Export deflator	-0.45	-0.61	-0.67	-0.72	-0.74
Import deflator	-0.28	-0.34	-0.34	-0.34	-0.34
GDP and Components	*Levels, percentage deviations from baseline*				
GDP	-0.26	-0.51	-0.49	-0.40	-0.41
Consumption	-0.26	-0.64	-0.77	-0.81	-0.89
Investment	-0.33	-1.02	-1.00	-0.84	-0.85
Government consumption	0.00	0.00	0.00	0.00	0.00
Exports	-0.24	-0.19	-0.14	-0.08	-0.05
Imports	-0.20	-0.30	-0.35	-0.37	-0.38
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	-0.20	-0.54	-0.61	-0.59	-0.64
Inventories	-0.03	-0.04	-0.03	0.00	0.00
Trade balance	-0.03	0.07	0.14	0.19	0.23
Labour Market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	-0.10	-0.40	-0.56	-0.52	-0.46
Unemployment rate	0.01	0.08	0.16	0.18	0.17

Household Accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	-0.30	-0.60	-0.63	-0.57	-0.59
Saving rate	-0.03	0.03	0.10	0.16	0.21
Fiscal Ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	0.04	0.09	0.12	0.14	0.17
Total expenditure	0.08	0.17	0.17	0.15	0.15
Budget deficit	-0.04	-0.08	-0.05	-0.01	0.02
Government debt	0.53	1.43	1.88	1.97	1.94
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	-0.60	-0.60	-0.60	-0.60	-0.60
Foreign prices (euro)	-0.60	-0.60	-0.60	-0.60	-0.60
Commodity prices (euro)	-1.00	-1.00	-1.00	-1.00	-1.00

Table A10. Model response to transitory world-demand shock.

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	0.01	0.08	0.19	0.35	0.49
GDP deflator	0.02	0.13	0.27	0.48	0.62
ULC	0.01	0.18	0.37	0.61	0.78
Compensation per employee	0.14	0.33	0.33	0.47	0.64
Productivity	0.13	0.15	-0.04	-0.14	-0.13
Export deflator	0.00	0.04	0.08	0.14	0.18
Import deflator	0.00	0.00	0.00	0.00	0.00
GDP and Components	*Levels, percentage deviations from baseline*				
GDP	0.19	0.54	0.59	0.56	0.55
Consumption	0.13	0.49	0.64	0.72	0.79
Investment	0.21	0.67	0.83	0.88	0.96
Government consumption	0.00	0.00	0.00	0.00	0.00
Exports	0.47	0.88	0.92	0.88	0.83
Imports	0.38	0.79	0.89	0.94	0.96
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	0.11	0.39	0.50	0.56	0.61
Inventories	0.01	0.06	0.04	0.01	0.00
Trade balance	0.08	0.09	0.05	-0.01	-0.06
Labour Market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	0.06	0.39	0.63	0.69	0.68
Unemployment rate	-0.01	-0.07	-0.16	-0.22	-0.23

Household Accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	0.21	0.60	0.71	0.75	0.76
Saving rate	0.05	0.08	0.04	0.02	-0.02
Fiscal Ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	-0.02	-0.06	-0.09	-0.13	-0.16
Total expenditure	-0.06	-0.16	-0.19	-0.19	-0.19
Budget deficit	0.04	0.10	0.09	0.07	0.04
Government debt	-0.33	-1.21	-1.77	-2.20	-2.43
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 (euro)	0.00	0.00	0.00	0.00	0.00
Commodity prices (euro)	0.00	0.00	0.00	0.00	0.00

Table A11. Model response to permanent labour-supply shock.

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from baseline*				
Consumption deflator	-0.14	-1.07	-1.53	-1.71	-1.71
GDP deflator	-0.38	-1.59	-1.90	-2.06	-2.02
ULC	-0.49	-2.06	-2.37	-2.55	-2.50
Compensation per employee	-0.88	-2.24	-2.53	-2.74	-2.83
Productivity	-0.39	-0.18	-0.16	-0.20	-0.34
Export deflator	-0.11	-0.47	-0.56	-0.60	-0.59
Import deflator	0.00	0.00	0.00	0.00	0.00
GDP and Components	*Levels, percentage deviations from baseline*				
GDP	-0.22	0.08	0.17	0.25	0.23
Consumption	-0.48	-0.34	-0.14	-0.18	-0.23
Investment	-0.31	-1.10	-1.62	-1.37	-1.31
Government consumption	0.00	0.00	0.00	0.00	0.00
Exports	0.06	0.35	0.51	0.59	0.60
Imports	-0.13	-0.28	-0.28	-0.28	-0.28
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*				
Domestic demand	-0.31	-0.40	-0.40	-0.37	-0.39
Inventories	-0.05	0.04	0.02	0.01	0.01
Trade balance	0.13	0.44	0.55	0.61	0.61
Labour Market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*				
Total employment	0.17	0.26	0.33	0.45	0.57
Unemployment rate	0.36	0.72	0.72	0.69	0.65

Household Accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*				
Disposable income	-0.45	-0.43	-0.23	-0.14	-0.12
Saving rate	0.02	-0.06	-0.06	0.03	0.08
Fiscal Ratios	*Percentage of GDP, absolute deviations from baseline*				
Total receipts	0.04	0.09	0.14	0.16	0.15
Total expenditure	0.10	0.08	0.04	0.00	-0.01
Budget deficit	-0.07	0.01	0.10	0.15	0.16
Government debt	0.90	2.19	2.05	1.53	0.79
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 (euro)	0.00	0.00	0.00	0.00	0.00
Commodity prices (euro)	0.00	0.00	0.00	0.00	0.00

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