MUSE: Monetary Union and Slovak Economy Model

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Abstract

In this paper, we employ the Bayesian method together with the calibration approach to parameterise a medium-scale two-country dynamic stochastic general equilibrium model of Slovakia and the eurozone. Parameters controlling the steady state of the model are calibrated to match the ratios of a few selected variables to their empirical counterparts. The remaining parameters are estimated via the Bayesian method. Since Slovakia has been a Euro area member for only two years, we need the model to operate under two different monetary regimes – autonomous monetary policy regime and monetary union regime. This feature enables us to estimate the model parameters in the case of independent monetary policy and subsequently simulate impacts of various structural shocks on the Slovak economy as a part of the monetary union. At the end of the paper, we present the impulse-response functions of the model to selected structural shocks.

Keywords: *DSGE; two-country model; Bayesian methods; monetary union*

JEL Classification: C11, C51, D10, D58

1. Introduction

In January 2009, Slovakia joined the Euro area and the euro became its official currency. As a consequence, the National bank of Slovakia ceased to conduct an autonomous monetary policy, since the European Central Bank conducts monetary policy for the whole Euro area, including Slovakia. In this paper, we

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present theoretical foundations and simulation results of a new version of the Dynamic Stochastic General Equilibrium (DSGE) model for the Slovak economy and the rest of the Euro area. A novelty in the Slovakian context is that parameters of the model have been estimated for the first time by Bayesian technique. Data on the Slovak economy and on the rest of Euro area covering the period from 1997 to 2008 were used.

Within the Euro area, the Slovak economy is very small, less than 1% in terms of both GDP and population. Moreover, the foreign sector plays a very important role for the Slovak economy, with the export to GDP ratio standing at more than 80%. The most usual way of including the foreign sector is through a small open economy framework. In such a setting, the transmission of shocks is a one-way road – shocks from the large economy affect the small one, but shocks originating in the small country have no impact on the large one. The foreign sector is represented by a few exogenous variables and only shocks of these variables can be transmitted to the domestic economy. This approach has been used in a DSGE model for the Slovak economy by Zeman and Senaj (2009).

The National Bank of Slovakia, as a member of the Eurosystem, participates in policy discussions covering the entire Euro area. While its main objective is still to evaluate the effects of different policies and impacts of shocks on the Slovak economy, the Slovak central bank is now more interested in the evaluation of these effects on the whole Euro area. This motivation leads us to develop a two-country model in which countries form a monetary union. The Slovak economy represents one country and the rest of the Euro area represents the other country. Such a model allows us to analyze various scenarios relating to both regions in a unified framework.

There are several papers devoted to multi-country models. For example, Obstfeld and Rogoff (1995) develop a two-country model based on monopolistic competition and sticky nominal prices. Pytlarczyk (2005) presents a two-country DSGE model with one country representing the German economy and the other one the rest of Euro area. The structure of both economies is symmetrical and both countries form a monetary union. This setup enables an examination of how domestic as well as foreign shocks are transmitted in both regions and of their relative impact on both economies. A similar setup was used in the model of the Austrian economy developed by Breuss and Rabitsch (2009) and in the model at the Banco de Espana by Andres, Burriel and Estrada (2006) who augmented it with the housing and durable goods sectors. Large-scale models used in the IMF and the European Central Bank (ECB) are worth mentioning as well. The Global Economy Model (GEM) prepared by the IMF Research Department was published in 2004. The ECB staff regularly use the New Area Wide Model

(NAWM) (Chrisoffel, coenen and Warne, 2008) in the Macroeconomic Projection Exercise. Based on its predecessor, the Area Wide Model, the NAWN is a micro-founded open-economy model of the Euro area. It also underpins the Euro area and GLobal Economy model (EAGLE) developed by Gomes, Jacquinot, Pisani (2010) – which is a four-country model of the Euro area and the world economy and is intended to be used for policy analysis of economic relationships across regions of the Euro area and between Euro area countries and the world economy.

As a benchmark, we chose the Pytlarczyk model (2005). Our departures from the benchmark model include a different form of the investment adjustment cost function and the use of a general CES function instead of a Cobb-Douglas function to bundle differentiated intermediate goods. Furthermore, we have incorporated flexible utilisation of capital in the production process. In our framework, the Euro area only trades with Slovakia, which means that the Euro area region in the model represents almost a closed economy. As the Slovakia is a small open economy, the exchange rate played a crucial role in monetary policy before joining the Euro area. Therefore we include changes in the exchange rate inte the Taylor rule.

A complication of the modelling strategy is that we do not have a sample of data from the monetary union regime on which to estimate the model. Pytlarczyk (2005) framework has the advantage that we can easily switch between the autonomous monetary policy regime and monetary union regime. Therefore, we can use the data from the period prior to the euro adoption to estimate the model parameters. In DSGE models, it is assumed that a change in policy does not result in a change in parameter values, and thus we can switch the model to the monetary union regime.

The remainder of the paper is organised as follows. Section 2 presents the theoretical model. In section 3, we discuss the calibration process of parameters affecting the steady state and describe the data used for Bayesian estimation of the remaining parameters. Section 4 presents the impulse-response functions of the model to technology and monetary shocks. Our conclusions are presented in the last section.

2. The Model

As mentioned above, the economy consists of two countries: a home small economy (Slovakia) and a foreign large economy (rest of the Euro area). The normalised population of the overall economy is 1 with the home population equal to n and the foreign population equal to $1 - n$.

All real variables are expressed in terms of quantity per head. That is why equations containing a combination of home and foreign variables (e.g. market clearing condition) have to be properly adjusted. Foreign variables are denoted by an asterisk. In the next paragraphs, we will describe the home economy. The foreign economy has an identical structure.

2.1. Firms

Final Good Firms

There are three different types of final good firms that combine bundles of domestically produced intermediary goods with imported intermediary goods; the firms are differentiated according to the types of non-tradable final good they produce: a private consumption good, an investment good, and a government good. They operate in a perfectly competitive market.

The representative firm producing a private consumption good combines a bundle of domestic intermediary goods C_t^D and a bundle of imported intermediary goods M_t^C with CES technology

$$C_t = \left[\omega_c^{\frac{1}{\mu_c}} \left(C_t^D\right)^{\frac{\mu_c - 1}{\mu_c}} + \left(1 - \omega_c\right)^{\frac{1}{\mu_c}} \left(M_t^C\right)^{\frac{\mu_c - 1}{\mu_c}} \right]^{\frac{\mu_c}{\mu_c - 1}} \tag{1}$$

where

μ_c – the elasticity of substitution between domestic and imported intermediary goods,

ω_c – the share of domestic intermediary goods used in production.

The bundle C_t^D comprises goods produced by domestic intermediary firms $i \in [0, n]$ while M_t^C comprises goods produced by foreign intermediary firms $i^* \in [n, 1]$

$$C_t^D = \left[\left(\frac{1}{n}\right)^{\frac{1}{\sigma_d}} \int_0^n \left(C_t^D(i)\right)^{\frac{\sigma_d - 1}{\sigma_d}} di \right]^{\frac{\sigma_d}{\sigma_d - 1}} \tag{2}$$

$$M_t^C = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\sigma_d^*}} \int_n^1 \left(M_t^C\left(i^*\right)\right)^{\frac{\sigma_d^* - 1}{\sigma_d^*}} di^* \right]^{\frac{\sigma_d^*}{\sigma_d^* - 1}} \tag{3}$$

σ_d, σ_d^* are elasticities of substitution between domestic and foreign intermediary goods, respectively.

Now given the composition of both bundles with prices P_t^D and P_t^{D*} respectively, firms combine these bundles in a way that minimises the total cost of production $P_t^D C_t^D + P_t^{D*} M_t^C$ subject to aggregation (1). This yields the following demand functions for the intermediary goods and price index:

$$C_t^D = \omega_c C_t \left(\frac{P_t^D}{P_t^C} \right)^{-\mu_c} \tag{4}$$

$$M_t^C = (1-\omega_c) C_t \left(\frac{P_t^{D*} S_t}{P_t^C} \right)^{-\mu_c} \tag{5}$$

where S_t is the nominal exchange rate expressed as an amount of home currency per unit of foreign currency (*SKK/EUR*), and the price of a unit of consumption good is:

$$P_t^C = \left[\omega_c \left(P_t^D \right)^{1-\mu_c} + (1-\omega_c) \left(S_t P_t^{D*} \right)^{1-\mu_c} \right]^{\frac{1}{1-\mu_c}} \tag{6}$$

In the home economy, there are also representative firms producing investment good I_t (by combining domestic bundle I_t^D with imported bundle M_t^I) and government good G_t (produced solely out of domestic intermediary goods), and there are similar firms in the foreign economy.

Intermediate Good Firms

There is a continuum of domestic intermediate good firms indexed by $i \in [0, n]$, each producing a differentiated good in a monopolistically competitive market. Firm *i* rents capital $u_t K_t(i)$ from households and hires a bundle of differentiated labour services $H_t(i)$ to produce a differentiated good $X_t(i)$ with Cobb-Douglas production technology

$$X_t(i) = \varepsilon_t^X \left(A_t H_t(i) \right)^{\alpha} \left(u_t K_t(i) \right)^{1-\alpha} \tag{7}$$

where u_t is the intensity of capital use, and bundle $H_t(i)$ combines household-specific varieties of labour in a monopolistically competitive market

$$H_t(i) = \left[\left(\frac{1}{n} \right)^{\frac{1}{\sigma_w}} \int_0^n \left(H_t(i,j) \right)^{\frac{\sigma_w - 1}{\sigma_w}} dj \right]^{\frac{\sigma_w}{\sigma_w - 1}} \tag{8}$$

where

σ_W – the elasticity of substitution between differentiated labour services,

ε_t^X – a transitory technology shock while,

A_t – a unit root technology shock that permanently effects labour productivity.

The growth rate ε_t^A of A_t defined by $\varepsilon_t^A \equiv A_t / A_{t-1}$ is a stationary process

$$\varepsilon_t^A = (1 - \rho_A) g^A + \rho_A \varepsilon_{t-1}^A + u_t^A \tag{9}$$

where g^A is a steady-state labour productivity growth rate. It is assumed that all real variables inherited this growth rate.[1] It is also assumed that a similar labour productivity shock in foreign economy A_t^* is co-integrated with A_t. The shock $\varepsilon_t^Z \equiv A_t / A_t^*$ is then a transitory one which measures the degree of asymmetry in the technological progress in both countries (Adolfson et al., 2007).

Given the rental rate of capital Z_t^{nom} and the aggregate wage index W_t^{nom}, firm *i* wants to minimise its total cost of production $Z_t^{nom} u_t K_t(i) + W_t^{nom} H_t(i)$ subject to (7). Defining $MC_t^{nom}(i)$ as a Lagrange multiplier associated with constraint (7), the first order conditions with respect to $K_t(i)$ and $H_t(i)$ lead to the following equations:

$$H_t(i) = \frac{\alpha}{1-\alpha} \frac{Z_t^{nom} u_t K_t(i)}{W_t^{nom}} \tag{10}$$

$$MC_t^{nom}(i) = \frac{1}{\varepsilon_t^X} \left(\frac{W_t^{nom}}{\alpha A_t} \right)^{\alpha} \left(\frac{Z_t^{nom}}{1-\alpha} \right)^{(1-\alpha)} \tag{11}$$

Note that the right-hand side of (11) is independent of index *i,* meaning that all firms have the same marginal cost.

[1] When solving the model all real variables are detrended.

Price Setting

Because intermediate firms produce differentiated goods in a monopolistically competitive market they have market power in setting their prices. Intermediate goods are tradable and we assume that there is no price discrimination between these goods being sold domestically and abroad. Hence LOOP holds for each good.

In order to accommodate inflation persistency observed in real data, we introduce sluggish price adjustment à la Calvo (1983). Let $P_t^D(i)$ be a price of intermediate good produced by firm *i*. In each period, a fraction $(1 - \tau_d)$ of randomly chosen firms is allowed to set their price to optimal value $P_t^{D,o}(i)$ while the remaining fraction τ_d of firms indexes their price to a combination of the inflation target and previous-period inflation

$$P_t^D(i) = P_{t-1}^D(i)\left(\Pi_{t-1}^C\right)^{\gamma_d}\left(\overline{\Pi}^C\right)^{(1-\gamma_d)} \tag{12}$$

where

$\Pi_t^C = P_t^C / P_{t-1}^C$ – the gross inflation rate,

$\overline{\Pi}^C$ – the gross steady-state inflation rate.

Firms set the same optimal price $P_t^{D,o}$ in period *t* keeping in mind that they may not be able to re-optimise in future. Thus firms select such price that maximises the present value of all future expected real profits achieved in periods when this price is just indexed but cannot be re-optimised. Such behaviour of firms leads to the following evolution of the aggregate price index P_t^D:

$$P_t^D = \left[\tau_d\left(\left(\overline{\Pi^C}\right)^{(1-\gamma_p)}\left(\Pi_{t-1}^C\right)^{\gamma_p} P_{t-1}^D\right)^{1-\sigma_d} + (1-\tau_d)\left(P_t^{D,o}\right)^{1-\sigma_d}\right]^{\frac{1}{1-\sigma_d}} \tag{13}$$

2.2. Households

There is a continuum of domestic households which, indexed[2] by $j \in [0, n]$,[3] obtain their utility from the level of consumption and from leisure. Each household *j* maximises its discounted lifetime utility at period *t* by choosing a level of real consumption $C_t(j)$, and real investment $I_t(j)$ that increases existing capital stock $K_t(j)$, the rate of capital utilisation $u_t(j)$, next period domestic bond holdings $B_{t+1}(j)$[4] and hours worked $H_t(j)$. Because each household provides differentiated labour, it has a market power in setting its wage $W_t(j)$ in a monopolistically competitive market.

The utility function has the following form:

$$U_j = E_0 \sum_{t=0}^{\infty} \beta^t \left(\varepsilon_t^C \log\left(C_t(j) - hab \cdot C_{t-1}\right) - \frac{\left(H_t(j)\right)^{1+\nu}}{1+\nu} \right) \tag{14}$$

where

β – the discount factor, ν is the inverse of elasticity of labour supply,

ε_t^c – an exogenous consumption preference shock,

Hab – a parameter of external habit formation (Abel, 1990).

It means that utility depends positively on the difference between contemporaneous consumption and lagged aggregate consumption. This rigidity is introduced to the model in order to improve the persistency of responses of various variables to shocks. In optimising expression (14), household *j* faces the following budget constraint:

$$\begin{aligned} &P_t^C C_t(j) + P_t^I I_t(j) + \frac{B_{t+1}(j)}{R_t} + TAX_t(j) \le W_t^{nom}(j) H_t(j) + \\ &+ \left[Z_t^{nom} u_t(j) - \Gamma^u\left(u_t(j)\right) P_t^I \right] K_t(j) + B_t(j) + d_t(j) + TR_t(j) \end{aligned} \tag{15}$$

where

P_t^C and P_t^I – the prices of, respectively, a unit of consumption and the investment good,

$W_t^{nom}(j)$ – the nominal wage rate of household *j,*

Z_t^{nom} – the rental rate of effective capital rented to firms,

$\Gamma^u\left(u_t(j)\right)$ – the cost, in units of investment goods, of setting the utilisation rate to

$u_t(j)$, $d_t(j)$ – dividends paid by firms,

$TR_t(j)$ – transfers from government,

$TAX_t(j)$ – taxes paid by household *j.*

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[2] Indexation indicates household differentiation in terms of the unique labour each household provides to firms.

[3] The index of foreign households obtains values from [*n*, 1].

[4] In fact, the assumption of complete asset markets makes the existence of bonds redundant.

Thus the left-hand side of the inequality (15) represents household j expenditure and the right-hand side its income.

We follow (Christiano, Eichenbaum and Evans, 2005) and assume that the cost of setting the capital utilisation rate to $u_t(j)$ is given by

$$\Gamma_t^u \equiv \Gamma^u\left(u_t(j)\right) = \gamma_{u,1}(u_t(j)-1) + \frac{\gamma_{u,2}}{2}(u_t(j)-1)^2 \tag{16}$$

The accumulation of physical capital owned by household j evolves according to:

$$K_{t+1}(j) = (1-\delta)K_t(j) + \varepsilon_t^I\left(1-\Gamma^I\left(I_t(j)\Big/I_{t-1}(j)\right)\right)I_t(j) \tag{17}$$

where

δ – the physical capital depreciation rate,

ε_t^I – an investment specific technology shock and

Γ^I – the adjustment cost (Christiano, Eichenbaum and Evans, 2005) of converting investment into physical capital, which has the following form:

$$\Gamma_t^I \equiv \Gamma^I\left(I_t(j)\Big/I_{t-1}(j)\right) = \frac{\gamma_I}{2}\left(\frac{I_t}{I_{t-1}} - g^A\right)^2 \tag{18}$$

with $\gamma_I \geq 0$ and g^A denoting the trend growth rate of the technology process in the steady state. The positive adjustment cost gives the household an incentive to smooth investment.

The Lagrange multipliers associated with budget constraint (15) and capital law of motion (17) are, respectively, $\lambda_{1,t}(j)$ and $\lambda_{2,t}(j)$. The first-order conditions for maximising the household's lifetime utility (22) with respect to $C_t(j)$, $B_{t+1}(j)$, $K_{t+1}(j)$, $u_t(j)$ and $I_t(j)$ are the following Euler equations:

$$\lambda_{1,t} = \varepsilon_t^C\left(P_t^C\left(C_t - hab\cdot C_{t-1}\right)\right)^{-1} \tag{19}$$

$$\lambda_{1,t} = \beta R_t\,\lambda_{1,t+1} \tag{20}$$

$$\lambda_{2t}P_t^I = \beta\left[\lambda_{1,t+1}u_{t+1}Z_{t+1}^{nom} - \lambda_{1,t+1}\Gamma_{t+1}^u P_{t+1}^I + (1-\delta)\lambda_{2,t+1}P_{t+1}^I\right] \tag{21}$$

$$Z_t^{nom} = (\gamma_{u,1} + \gamma_{u,2}(u_t - 1))P_t^I \tag{22}$$

$$\lambda_{1,t} = \varepsilon_t^I\lambda_{2,t}\left[1-\Gamma_t^I + \gamma_I\frac{I_t}{I_{t-1}}\left(\frac{I_t}{I_{t-1}} - g^A\right)\right] + \beta\varepsilon_{t+1}^I\lambda_{2,t+1}\left(\frac{I_{t+1}}{I_t}\right)^2\pi_{t+1}^I\gamma_I\left(\frac{I_{t+1}}{I_t} - g^A\right) \tag{23}$$

Since all households make identical decisions in equilibrium, the index *j* in the equations (19) – (23) has been dropped.

Household *j* supplies differentiated labour $H_t(j)$ in a monopolistically competitive market i.e. it has a certain market power in setting its wage. It can negotiate a markup on labour cost. In order to emulate the wage adjustment rigidity that takes place in the real economy we introduce staggered wage setting á la Calvo (1983). A randomly chosen fraction $1-\tau_W$ of households can reset their nominal contracts $W_t^{nom,o}$ at period *t*, while wages of the remaining τ_W of households are adjusted to inflation according to the following indexation scheme:

$$W_t^{nom}(j) = \Pi_{t-1}^C W_{t-1}^{nom}(j) \tag{24}$$

Then the aggregate real wage index W_t evolves according to:

$$W_t = \left[(1-\tau_W)\left(W_t^o\right)^{(1-\sigma_w)} + \tau_W \left(\frac{\Pi_{t-1}^C}{\Pi_t^C} W_{t-1} \right)^{(1-\sigma_W)} \right]^{\frac{1}{1-\sigma_w}} \tag{25}$$

where

W_t^o – the real optimal wage defined by $W_t^o = W_t^{nom,o} \big/ P_t^C$.

2.3. Real Exchange Rate and the Terms of Trade

Households in both countries buy domestic riskless bonds to insure against adverse shocks. We assume that these bonds are tradable without restriction between home and foreign households (financial markets are complete) and thus that there exists perfect risk-sharing across countries. Then, combining (19) with a similar equation in the foreign country (Gomes, Jacquinot and Pisani, 2010), we can derive a relationship between the real exchange rate and the marginal utilities of consumption of the consumers in the two countries:

$$\frac{S_t P_t^{C*}}{P_t^C} \equiv S_t^{real} = \kappa \frac{\varepsilon_t^{C*} U'\left(C_t^*\right)}{\varepsilon_t^C U'\left(C_t\right)} = \kappa \frac{\varepsilon_t^{C*}\left(C_t^* - hab^* \cdot C_{t-1}^*\right)^{-1}}{\varepsilon_t^C \left(C_t - hab \cdot C_{t-1}\right)^{-1}} \tag{26}$$

Knowing the composition of consumption baskets (1) and (1*) we can find a relationship between the real exchange rate and the terms of trade $T_t = \frac{S_t P_t^{D*}}{P_t^D}$ defined as the price of foreign goods in terms of home goods:

$$S_t^{real} = \frac{\left(\omega_c^* T_t^{1-\mu_c^*} + \left(1-\omega_c^*\right)\right)^{\frac{1}{1-\mu_c^*}}}{\left(\omega_c + \left(1-\omega_c\right) T_t^{1-\mu_c}\right)^{\frac{1}{1-\mu_c}}} \tag{27}$$

Due to different shares of domestic goods in the home and foreign consumption baskets and to the potential difference between elasticities μ_c and μ_c^*, the real exchange rate deviates from the purchasing power parity (PPP) rule (deviates from 1) even though the law of one price (LOOP) holds for intermediary goods.

2.4. Fiscal and Monetary Authority

The fiscal authority runs a balanced budget in each period. It collects lump-sum taxes TAX_t and uses the tax revenue to purchase government goods G_t and to finance social transfers to households TR_t :

$$P_t^D G_t + TR_t = TAX_t \tag{28}$$

Government expenditure G_t is assumed to be an exogenous process that evolves according to

$$G_t = \rho_g G_{t-1} + (1-\rho_g)\overline{G} + u_t^G \tag{29}$$

where

$\overline{G}$ – a constant fraction of total output at steady state.

In order to stabilise inflation, output and the exchange rate in the domestic economy, the monetary authority adjust the short-term nominal interest rate in each period according to Taylor rule:

$$R_t = \left(1-\rho_R\right)\overline{R} + \rho_R R_{t-1} + $$
$$+ \left(1-\rho_R\right)\left[\phi_\pi \left(\frac{\Pi_t^C}{\overline{\Pi^C}} - \Pi_t^{\text{target}}\right) + \phi_x \left(\frac{X_t}{\overline{X}} - 1\right) + \phi_s \left(\Delta S_t - 1\right)\right] + u_t^R \tag{30}$$

where

R_t	– the gross nominal interest rate,
ΔS_t	– stands for the change of exchange rate,
$\overline{R}$, $\overline{\Pi^C}$ and $\overline{X}$	– steady state values of the respective variables,
u_t^R	– an *i.i.d.* monetary policy shock,
Π_t^{target}	– a time varying inflation target, which follows AR(1) process.

The monetary authority in foreign country sets the nominal interest rate R_t^* independently using a different Taylor rule reacting on inflation and output only.

$$R_t^* = \left(1-\rho_R^*\right)\overline{R^*} + \rho_R^* R_{t-1}^* + \left(1-\rho_R^*\right)\left[\phi_\pi^*\left(\frac{\Pi_t^{C*}}{\overline{\Pi^{C*}}} - \Pi_t^{\text{target*}}\right) + \phi_x^*\left(\frac{X_t^*}{\overline{X^*}} - 1\right)\right] + u_t^{R*} \quad (31)$$

2.5. Market Clearing Conditions

The aggregate output of home intermediary goods is:

$$X_t = \int_0^n X_t(i)\,di = C_t^D + I_t^D + G_t + \frac{1-n}{n}\left(M_t^{C*} + M_t^{I*}\right) \quad (32)$$

where

M_t^{C*} and M_t^{I*} – exported bundles of home intermediary goods used for the production of foreign consumption and investment goods,[5] respectively.

The aggregate output of foreign intermediary goods is:

$$X_t^* = \int_n^1 X_t^*\left(i^*\right)di^* = C_t^{D*} + I_t^{D*} + G_t^* + \frac{n}{1-n}\left(M_t^C + M_t^I\right) \quad (33)$$

2.6. Regime Switch

So far, we have assumed that both countries have their own currencies, with S_t being the nominal exchange rate. Every equation derived in previous paragraphs (except (26) and (27)) has its asterisked counterpart valid in the foreign country. These equations form the model of an economy comprising two countries with autonomous monetary policies.

However, this model can be easily switched to a regime with a common currency, i.e. to a currency union.

[5] X_t is expressed "per head of population n", while X_t^* is expressed "per head of population $(1 - n)$".

In the currency union there is one monetary authority that sets interest rate for both countries according to the following Taylor rule:

$$R_t^{EMU} = \left(1-\rho_R^{EMU}\right)\overline{R}^{EMU} + \rho_R^{EMU} R_{t-1}^{EMU} + \\ +\left(1-\rho_R^{EMU}\right)\left[\phi_\pi^{EMU}\left(\frac{\Pi_t^{C,EMU}}{\overline{\Pi}^{C,EMU}}\right) + \phi_x^{EMU}\left(\frac{X_t^{EMU}}{\overline{X}^{EMU}} - 1\right)\right] + u_t^{R,EMU} \tag{34}$$

where

$\Pi_t^{C,EMU}$ and X_t^{EMU} – Euro area wide weighted averages of inflation and output, respectively.

Hence two different Taylor rules (30) and (31) are replaced with the rule (34). Also, in a flexible exchange rate setting we have two different Euler equations giving the price of a riskless bond in each country, obtained by combination of (19), (20) and (19)*, (20)*, respectively. In the currency union, these bonds' prices are equal and one Euler equation becomes redundant.

As the number of variables is not changed by switching from one regime to the other, the two equations that are dropped have to be replaced. The model for the currency union is extended by the dynamic equation for the terms of trade:

$$\frac{T_t}{T_{t-1}} = \frac{\Pi_t^{D*}}{\Pi_t^D} \tag{35}$$

and the nominal interest rate:

$$R_t = R_t^* \tag{36}$$

In the currency union, financial market completeness guarantees the validity of UIP, which together with (36) implies that, the nominal exchange rate S_t stays constant over time.

3. Parameterisation of the Model

The process of parameterisation of the model consists of two steps. First, we calibrate parameters that determine the non-stochastic steady state of the model. In the second step, we estimate the remaining structural parameters and standard deviations of the shocks by a Bayesian method. Because steady state assumptions of the model[6] are not fully in line with the observed data, we decided to calibrate a subset of parameters instead of estimating them. Especially in the beginning of our sample, investment and government expenditure shares of output follow a downward trend. For this reason, we calibrate the steady state on a shorter period, from 2005 to 2008. The details on parameterisation come in the sections following the description of the data used in the estimation.

3.1. Data

In the estimation, we use the following set of six variables for each country: real GDP (X), real consumption (C), real investment (I), real compensation (W), short-term nominal interest rate (R), and GDP deflator (p). On top of that, the exchange rate (SKK/EURO) is employed.

We also use government expenditures to estimate the autoregressive process of the corresponding variable in the model. All variables come from the Eurostat database, are seasonally adjusted, and are expressed in per capita terms. The length of the period in the model is one quarter. We further assume that the Euro area consists of twelve countries[7] over the whole sample, although the actual composition changed several times.

The sample starts at the second quarter of 1997 and ends at the fourth quarter of 2008. With Slovakia having been a member of the Euro area since the beginning of 2009, the last observation in the sample is the last quarter of autonomous monetary policy in the country.

3.2. Calibration of the Coefficients

The parameters that determine the non-stochastic steady state take values such that the ratios of a few selected model variables correspond to their empirical counterparts. In particular, we match the ratios of investment, government, and net exports to output. The following Table 1 presents the steady state properties of the model.

T a b l e 1

Steady State Ratios

Country\variable	I/X	C/X	Im/X	ImI/X	ImC/X	G/X	TB/X	n
SK	0.22	0.55	0.26	0.10	0.16	0.18	0.00	0.01
EA	0.20	0.60	0.003	0.001	0.003	0.20	0.00	0.99

Note: The abbreviations X, I, C, Im, ImI, ImC, G, TB, n stand for output, investment, consumption, import, import of investment goods, import of consumption goods, government expenditures, trade balance, size of the economy.

Source: Authors' calculation.

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[6] The balanced growth incorporated in the model implies that shares of consumption, investment, government spending and net exports in output are constant.

[7] The following countries are assumed to form the Euro area: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain.

Since Slovakia has been a transition country, the empirical ratios that we aim to match are not steady. For example, investment and government expenditures as shares of output in real terms tend to decline over the sample period, while net exports improve. Moreover, GDP per capita in Slovakia is well below the Euro area GDP per capita, while investment share in output is higher in Slovakia. We set the investment to GDP ratio in Slovakia and in the Euro area to 22% and 20%, respectively. The government size is 18% in Slovakia and 20% in the Euro area.

Regarding international trade flows, it is sufficient to specify the size of trade and the trade balance of one country. Naturally, we primarily focus on Slovakia. In order to obtain the specification of the trade, some necessary adjustments to the data need to be made.

In the actual data, a substantial part of imported goods is used as an input in the output production of export sectors. In the model, however, all imports are consumed domestically. There is empirical evidence that about 60% of all Slovak imports enter the production process of the exporting sectors. We assume that Slovakia exchanges its entire trade volume with the Euro area. Thus we set the Slovak imports to GDP ratio at 26%. As for the trade balance, we make a simplifying assumption and set this variable at zero.

Along with the total imports of both countries, we need to specify the share of imported investment and consumption goods. Of total Slovak imports, investment goods represent 40% (10% share in GDP) and consumption goods 60% (16% share in GDP). The small size of Slovakia compared to the Euro area means that the Euro area is more or less a closed economy. We assume that Slovakia exports substantially fewer investment goods than consumption goods. Thus, in the Euro area, the investment share of imports is only 19% while the consumption share reaches 81%.

The balanced growth assumption adopted in the model requires that the two countries share the long-term technological progress. To meet this assumption we set the technological growth rate in both countries in line with (Pytlarczyk, 2005), at 1.6% p.a., even though the average growth rate of the Slovak GDP is considerably higher than the growth rate of the Euro area GDP.

The size of Slovakia in the modelled world is 1% whereas the size of the Euro area is 99%. The set of parameters that we fix symmetrically across the two regions include: labour share in production α, depreciation rate δ, discount factor β, and intratemporal elasticities of substitution between the domestic and imported bundles of investment and consumption goods μ_C, μ_I, σ_w and ν. We present the values of all calibrated parameters in the Table 2.

Table 2

Calibrated Parameters

Parameter	SK	EAA	Description
Households			
hab	0.64	0.70	degree of habit persistence
β	0.998	0.998	subjective discount factor
δ	0.02	0.02	depreciation rate of capital
v	2	2	inverse of the Frisch elasticity of labour supply
n	0.01	0.99	country size
Intermediate-good firms			
α	0.7	0.7	share of labour income in production
g^A	1.004	1.004	steady state growth
Distributors			
ω_C	0.638	0.997	home bias in production of final consumption goods
ω_I	0.441	0.998	home bias in production of final investment goods
μ_I	2	2	price elasticity of demand for investment goods
μ_C	2	2	price elasticity of demand for consumption goods
Adjustment costs			
$\gamma_{u,2}$	0.26	0.02	parameter of capital utilisation cost function
σ_d	6.0	3.7	elasticity of substitution between differentiated intermediate goods
σ_w	6	6	elasticity of substitution between labour services

Source: Authors' calculation.

3.3. Bayesian Estimation of the Parameters

The Bayesian approach is widely used as an estimation tool when working with DSGE models, with such approach proposed by a clutch of recent books and papers (Almeida, 2009; Canova, 2007; Cristoffel, Coenen and Warne, 2008; Schorfeide, 2000; Smets and Wouters, 2007).

The novelty of this paper is that we estimate selected parameters of the model by Bayesian method. To our knowledge, the parameters describing the Slovak economy have not so far been estimated via Bayesian approach.

Using this approach, we estimate 47 parameters of the model, for example, coefficients describing the monetary policy, wage and price setting, and adjustment cost. These parameters, stacked in vector θ, do not affect steady state! Moreover, the parameters calibrating the structural shocks, e.g. autoregressive coefficients and standard errors, are estimated for both countries.

Bayes' theorem tells us that posterior distribution $p\left(\theta \middle| Y^{data}\right)$ can be obtained from prior beliefs about parameter values, summarised in prior distribution $p(\theta)$, and from information on empirical data and suggested model structure, summarised in the likelihood function $p\left(Y^{data} \middle| \theta\right)$. The mathematical representation of the Bayes' rule is as follows:

$$p\left(\theta \middle| Y^{data}\right) = \frac{p\left(Y^{data} \middle| \theta\right) p(\theta)}{p\left(Y^{data}\right)} \tag{37}$$

Since, $p(Y^{data})$ is constant with respect to θ, then it can be rewritten as follows:

$$p\left(\theta \middle| Y^{data}\right) \propto p\left(Y^{data} \middle| \theta\right) p(\theta) \tag{38}$$

Posterior distribution can be evaluated for any given value of θ. But, in general, the whole distribution of $p\left(\theta \middle| Y^{data}\right)$ is unknown.

Therefore, the Metropolis-Hastings (H-M) algorithm is used to approximate the posterior distribution. The M-H algorithm belongs to the group of Markov Chain Monte Carlo (MCMC) methods. The basic aim is quite straightforward – to produce a Markov chain with desired ergodic distribution, the distribution in our case being equal to $p\left(\theta \middle| Y^{data}\right)$. Consequently, after a large number of steps, the state of the chain is used as a sample from posterior distribution.

One of the shortcomings of the Bayesian approach is that the shape of likelihood, and consequently the shape of posterior distribution, are sensitive to the selection of observables. The paper by Guerron-Quintana (2010) provides evidence of this sensitivity. He estimates the same model on different subsets of observables in which some observable is missing. He claims that, depending on the dataset, the point estimates of habit formation range from 0.7 to 0.97. This paper concludes that point estimates are influenced more by the omission of some observables than by the choice of the shorter sample.

When estimating the model we use 13 observables. In order to build a link between our model and the empirical data, the model was extended by the following measurement equations:

T a b l e 3

Measurement Equations

Slovakia	Euro area
$X_t^{obs} / X_{t-1}^{obs} = X_t / X_{t-1} * \varepsilon_t^A + \varepsilon_t^{me\_X}$	$X_t^{*obs} / X_{t-1}^{*obs} = X_t^* / X_{t-1}^* * \varepsilon_t^{A*} + \varepsilon_t^{me\_X*}$
$C_t^{obs} / C_{t-1}^{obs} = C_t / C_{t-1} * \varepsilon_t^A + \varepsilon_t^{me\_C}$	$C_t^{*obs} / C_{t-1}^{*obs} = C_t^* / C_{t-1}^* * \varepsilon_t^{A*} + \varepsilon_t^{me\_C*}$
$I_t^{obs} / I_{t-1}^{obs} = I_t / I_{t-1} * \varepsilon_t^A + \varepsilon_t^{me\_I}$	$I_t^{*obs} / I_{t-1}^{*obs} = I_t^* / I_{t-1}^* * \varepsilon_t^{A*} + \varepsilon_t^{me\_I*}$
$W_t^{obs} / W_{t-1}^{obs} = W_t / W_{t-1} * \varepsilon_t^A + \varepsilon_t^{me\_W}$	$W_t^{*obs} / W_{t-1}^{*obs} = W_t^* / W_{t-1}^* * \varepsilon_t^{A*} + \varepsilon_t^{me\_W*}$
$p_t^{d,obs} / p_{t-1}^{d,obs} = p_t^d / \overline{p}^d$	$p_t^{d*,obs} / p_{t-1}^{d*,obs} = p_t^{*d} / \overline{p}^{*d}$
$R_t^{obs} / R_{t-1}^{obs} = R_t^4 / R_{t-1}^4$	$R_t^{*obs} / R_{t-1}^{*obs} = R_t^{*4} / R_{t-1}^{*4}$
$S_t^{obs} / S_{t-1}^{obs} = \Delta S_t$	

Source: Authors' calculation.

The left-hand side of the measurement equations stands for the observables labelled with superscript *obs*. Eight equations are supplemented with measurement errors (ε_t^{me}). Combining the empirical data and the model structure with the help of a Kalman filter, the likelihood function can be computed.

According to the Bayes rule, the posterior is equal to likelihood times prior, where the priors represent additional information added to the estimation procedure. Thus, priors can be seen as the researcher belief about structural parameters. Fernández-Villaverde (2010) argues that tighter priors are the better option if the model is to be used for policy analysis. By contrast, looser priors (e.g. uniform priors) are the preferred option if the model is to be used for pure research. Loose priors let the likelihood dominate the posterior. Since our model is assumed to be used for policy simulation, we prefer tighter priors with reasonable standard deviation.

When setting the priors in this paper, four types of probability distribution were used. In the case of the parameters constrained between 0 and 1, the Beta distribution is employed. The prior for parameter of investment adjustment cost is set as a Gamma distribution. Normal distribution is used for two parameters in the Taylor rule, namely response to the output gap and response to the deviation of inflation from its steady state value. Finally, Inverse-gamma distribution is used for standard deviations of the structural shocks. The particular type of distribution, its mean, and the standard deviation for each parameter is shown in Table 4 in the Appendix.

Using a Metropolis-Hastings algorithm, we generated 500 000 draws from the posterior. This procedure was repeated with two different Markov chains. The posterior characteristics – such as median, mean, mode and confidence intervals – are reported in Table 4 in the appendix. In the following part, we discuss the estimated means of the parameters in short.

In the case of price and wage adjustments, the estimated parameters for the Slovak economy are different to those obtained for the Euro area. In Slovakia, the probability of no wage change is around 0.26, while in the Euro area it is estimated at 0.65. Another difference is price flexibility. According to the estimated fraction of firms that are not allowed to set optimal prices in the current quarter, we can conclude that prices in Slovakia are more flexible than those in the Euro area. The estimated values are 0.6 and 0.9 in Slovakia and the Euro area, respectively. This implies shorter average price contract duration of 2.5 quarters in Slovakia.

The degree of price indexation is rather comparable in both countries and ranges from 0.36 to 0.38.

T a b l e 4
Priors and Posterior of Parameters

		Prior		Posterior		
Parameter	Distr.	Mean	s. d.	Mode	Mean	s. d.
Slovakia						
Adjustment costs						
Parameter of investment adj. cost	Gamma	4.00	2.00	3.95	4.98	3.53
Wage and price setting						
Price indexation	Beta	0.50	0.10	0.36	0.36	0.09
Probability of no price change	Beta	0.60	0.01	0.60	0.60	0.01
Probability of no wage change	Beta	0.50	0.10	0.25	0.26	0.03
Taylor rule						
Interest rate smoothing	Beta	0.75	0.10	0.81	0.78	0.04
Resp. to inflation	Normal	1.80	0.40	2.22	2.25	0.33
Resp. to output growth	Normal	0.20	0.10	0.19	0.20	0.08
Resp. to exchange rate	Beta	0.60	0.10	0.52	0.53	0.10
Autoregressive coefficients						
Preference shock	Beta	0.70	0.20	0.63	0.66	0.18
Investment shock	Beta	0.60	0.20	0.42	0.31	0.49
Covariance stationary technology shock	Beta	0.50	0.10	0.39	0.37	0.11
Technology growth shock	Beta	0.60	0.10	0.54	0.55	0.09
Asymmetric technology innovation	Beta	0.75	0.10	0.88	0.83	0.03
UIP shock	Beta	0.70	0.20	0.40	0.41	0.11
Time-varying inflation target	Beta	0.70	0.20	0.93	0.81	0.07
Standard deviations						
Preference shock	Gamma $^{-1}$	0.10	inf	0.035	0.034	0.005
Investment shock	Gamma $^{-1}$	0.20	inf	0.089	0.151	0.061
Covariance stationary technology shock	Gamma $^{-1}$	0.04	inf	0.064	0.067	0.009
Monetary shock	Gamma $^{-1}$	0.04	inf	0.010	0.011	0.002
Technology growth shock	Gamma $^{-1}$	0.02	inf	0.004	0.004	0.001
Asymmetric technology innovation	Gamma $^{-1}$	0.01	inf	0.002	0.003	0.000
UIP shock	Gamma $^{-1}$	0.01	inf	0.024	0.025	0.003
Time-varying inflation target	Gamma $^{-1}$	0.01	inf	0.004	0.005	0.001
Measurement error (output)	Gamma $^{-1}$	0.01	inf	0.016	0.017	0.005
Measurement error (consumption)	Gamma $^{-1}$	0.01	inf	0.005	0.006	0.002
Measurement error (investment)	Gamma $^{-1}$	0.02	inf	0.035	0.025	0.020
Measurement error (wages)	Gamma $^{-1}$	0.01	inf	0.017	0.017	0.002
Euro area						
Adjustment costs						
Parameter of investment adj. cost	Gamma	4.00	2.00	4.18	5.22	1.44
Wage and price setting						
Price indexation	Beta	0.60	0.10	0.36	0.38	0.08
Probability of no price change	Beta	0.75	0.10	0.90	0.90	0.01
Probability of no wage change	Beta	0.65	0.01	0.65	0.65	0.01
Taylor rule						
Interest rate smoothing	Beta	0.90	0.05	0.91	0.91	0.02
Resp. to inflation	Normal	1.70	0.10	1.69	1.70	0.10
Resp. to output growth	Normal	0.20	0.01	0.20	0.20	0.01
Autoregressive coefficients						
Preference shock	Beta	0.70	0.10	0.72	0.70	0.11
Investment shock	Beta	0.70	0.10	0.72	0.67	0.09
Covariance stationary technology shock	Beta	0.70	0.10	0.39	0.40	0.09
Time-varying inflation target	Beta	0.20	0.10	0.17	0.20	0.10
Standard deviations						
Preference shock	Gamma $^{-1}$	0.01	inf	0.004	0.005	0.001
Investment shock	Gamma $^{-1}$	0.02	inf	0.012	0.017	0.006
Covariance stationary technology shock	Gamma $^{-1}$	0.02	inf	0.115	0.112	0.020
Monetary shock	Gamma $^{-1}$	0.00	inf	0.001	0.001	0.000
Measurement error (output)	Gamma $^{-1}$	0.01	inf	0.003	0.003	0.000
Measurement error (consumption)	Gamma $^{-1}$	0.01	inf	0.003	0.003	0.000
Measurement error (investment)	Gamma $^{-1}$	0.01	inf	0.016	0.016	0.002
Measurement error (wages)	Gamma $^{-1}$	0.01	inf	0.003	0.004	0.001
Time-varying inflation target	Gamma $^{-1}$	0.01	inf	0.003	0.004	0.001

Source: Authors' calculation.

The estimated Taylor rule for the Euro area has a very important degree of inertia. The degree of interest rate smoothing is slightly higher than 0.9. The remaining two Taylor rule parameters have different interpretations. On one hand, there is significant sensitivity to consumer price inflation – the estimated weight is around 1.7. On the other hand, sensitivity to the output gap is relatively low, at 0.2. In Slovakia, the interest rate smoothing is also important. However, it is lower than in the eurozone – 0.78. Response to inflation is also high and estimated response to the output gap has the same level. The exchange rate plays an important role when setting the Slovak interest rates. The estimated coefficient on response to exchange rate is 0.53.

4. Impulse-response Functions

In this section, we comment on the reactions of a few selected model variables to two different shocks: temporary technology shock and monetary policy shock. For each shock, we report the impulse-response functions in the monetary union regime as this is now the relevant policy regime in Slovakia.[8] We assume that the change of the monetary policy regime did not change the structural parameters of the technology and preferences.[9] The only difference is that we adopt the Taylor rule of the Euro area for both regions of the model. The parameters of the Euro area did not change at all.

The assumption that structural parameters of DSGE models are invariant to policy interventions has been a crucial feature of these models. This assumption, together with micro-foundation of the models make them suitable framework for policy discussion and analysis that avoids the Lucas critique. However, as these models have been becoming more and more sophisticated and vector of parameters becoming still larger, the time-invariance of structural parameters began to be questioned. There is a growing body of research indicating that structural parameters are time varying, especially in case of a major policy change (e.g. exchange rate targeting vs. inflation targeting or floating exchange rate regime vs. currency union). The modelling of time-varying parameters is handled in two ways.

One approach assumes that a structural change is anticipated by rational agents who shift their expectations accordingly and this leads to time-drifting structural

[8] For extended report on the impulse-response function see working paper No. 1/2010 of the National Bank of Slovakia Working Paper Series (Senaj, Vyskrabka and Zeman, 2010). Here we report only impulse-response functions for common monetary policy. The working paper also includes the IRFs for autonomous monetary policy.

[9] There is some evidence that the deep parameters of DSGE models may not be structural in the sense of Lucas critique that these parameters are invariant to policy changes (Fernández-Villaverde and Rubio-Ramírez, 2007). However, it is not possible to estimate the model on the common monetary regime due to the lack of data.

parameters. Parameters are assumed to follow autoregressive processes, which are then estimated by Bayesian techniques. This approach is used in Fernández-Villaverde and Rubio-Ramírez (2007) where authors offer compelling proof of changing parameters in the Fed's behavior after Volcker's appointment.

In the other approach data is divided into two subsamples – before and after a policy change and it is tested if there are significant differences in the inference results. This method has been used e.g. in Clarida, Galí and Gertler (2000) and in the case of two-country model of currency union in Breuss and Rabitsch (2009). This approach, to the contrary of the first one implies that agents are unable to forecast the change in policy.

Both methods require rather large samples in order the results obtained were reliable. Due to the lack of data, especially after adopting the common currency, we have adopted the assumption of invariant parameters.

4.1. Technology Shock

The technology shock is implemented as a temporary, yet persistent,[10] improvement in the production technology. The size of the initial shock is 1%.

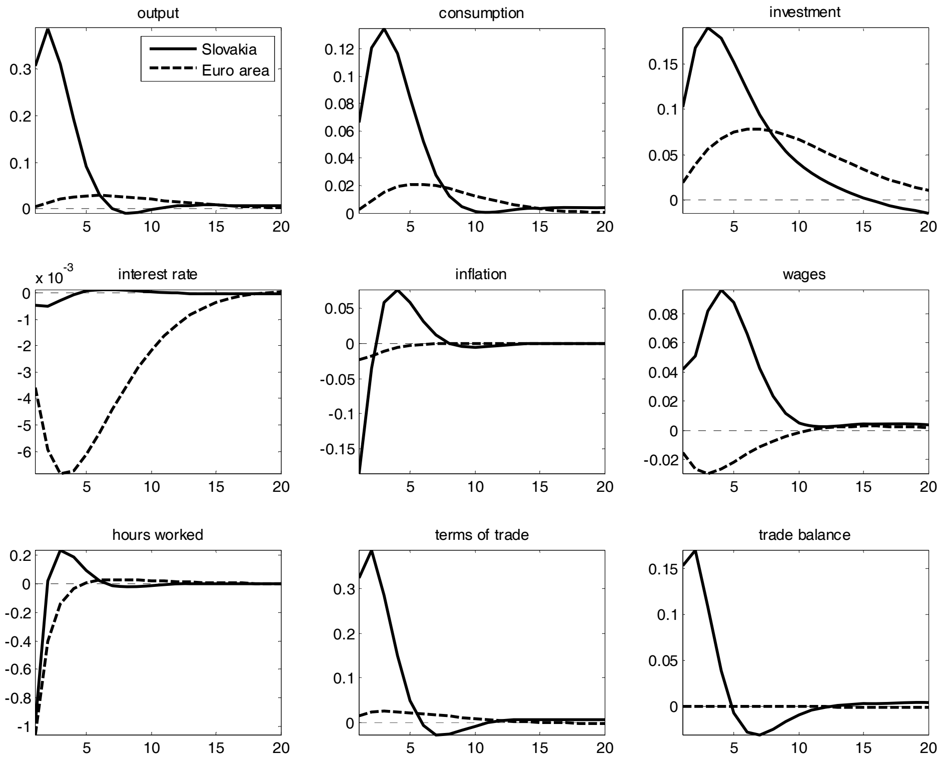
After the positive shock to the factor of productivity, marginal costs fall and households demand more consumption, investment, and are less willing to work. Real wages do not change significantly. Due to the expected higher lifetime income, consumers tend to immediately increase their consumption, and the higher return on capital motivates them to invest more. Higher consumption makes leisure less expensive, hence households decrease their supply of labour initially. However, as the positive impact of technology is only temporary, households increase their labour supply when the shock fades away. In fact, the labour supply even exceeds the steady state level of labour for a few periods. The positive wealth effect is also reinforced by the positive substitution effect, since prices decrease while interest rates do not adjust enough and real rates thus decline. Households therefore prefer early consumption. Lower production prices improve the competitiveness of the economy, which appears as an improvement in the terms of trade and leads domestic consumers to switch away from imported goods and replace them with domestic production. Due to imperfect substitution of foreign products for domestic ones, expansion in aggregate consumption and investment is below expansion in output (these arguments refer to Slovakia as the Euro area is essentially a closed economy).

Overall, in Slovakia these effects result in output rising by about 0.4% shortly after the shock hits the economy. The open economy dimension amplifies the

[10] The autoregressive coefficient of the shock process is equal to 0.36 for Slovakia and 0.40 for the Euro area.

positive effects when net exports become the main driving force of the output gains. Consumer inflation declines by about 0.15 percentage point (p. p.) initially. In the Euro area the reactions reach lower magnitudes. During the second year after the shock, output is about 0.1% above its steady state and consumer inflation is about 0.1% below its target. Monetary policy in response to developments in the economy only negligibly loosens its stance.

F i g u r e 1
Technology Shock



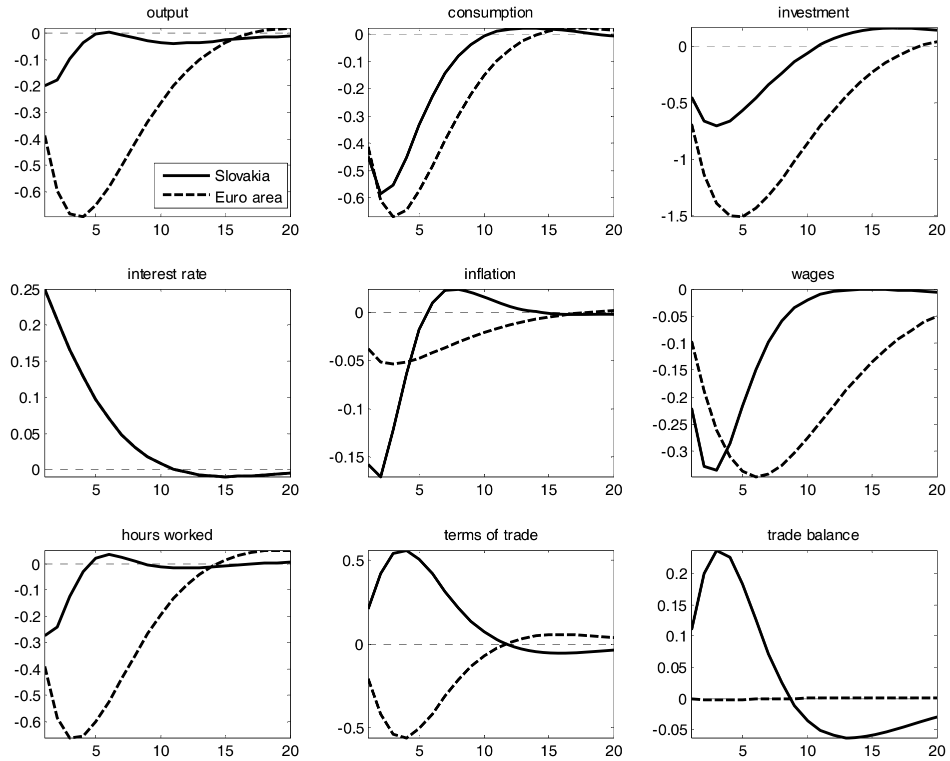
Note: The variables present a reaction to a shock originating in the same country as the reported variable – for instance the Euro area output responds to the technology shock originating in the Euro area while the Slovak output responds to the technology shock originating in Slovakia.

Source: Authors' calculation.

4.2. Monetary Policy Shock

The monetary policy shock represents an unexpected 100 basis point (in annualised terms) tightening of the common union-wide interest rate. Unlike with the previous simulation there is no inertia in the shock. The path of the interest rate from the second period on is purely an endogenous reaction of the rate to developments in the economy. An important difference in the setup of this simulation is that, in this case, the shock hits both regions in the model in line with the monetary union definition.

Figure 2
Monetary Policy Shock



Note: The variables present a reaction to a shock in common monetary policy.
Source: Authors' calculation.

The tightening of the monetary policy results in a higher cost of borrowing and in households postponing consumption. In order to meet lower demand, firms reduce labour. The resulting fall in output leads to lower marginal productivity of factors of production, which in turn means lower return on capital. As a consequence households cut investment and thus further decrease output. The structure of the economies is such that terms of trade initially improve in Slovakia and the positive effect of the net exports thus reduces the impact on output. Consumer inflation responds more aggressively in Slovakia than in the Euro area.

The maximum impact on output is about 0.2% in Slovakia. Consumption and investment are affected more than output, which is due to positive effect of the net exports. Consumer inflation slows by about 0.12 p. p. In the Euro area output is almost 0.7% below its steady state when investment is hit more heavily. Inflation adjusts gradually and the maximum impact, about 0.05 p. p., arrives after three quarters.

Conclusions

In this paper, we have described a two-country DSGE model suitable for policy analysis of the Slovak economy as a part of the Euro area. There are several standard features incorporated in the model, such as external habit formation, investment adjustment costs, sticky prices and wages, and flexible capital utilisation. The model allows switching between two types of monetary regimes. In one regime, the model can be specified for two countries that each have an autonomous monetary policy; in the other regime, the two countries constitute the Euro area with a common monetary policy.

The possibility of regime switching is a very practical tool especially for countries that have joined a monetary union in recent history, as is the case with Slovakia. Utilising this type of model and quarterly data covering the years 1997 to 2008, we have estimated selected parameters of the model. The parameterisation of the model consisted of two steps. Firstly, all parameters controlling the steady state were determined. Here, the aim was to match the deep ratios (such as the ratios of investment, government, and trade to output) determined by the model and computed from the empirical dataset. Secondly, the remaining structural parameters and all parameters describing the structural shocks were estimated via the Bayesian method.

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