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**How Important Are Foreign Shocks in Small Open Economy?
The Case of Slovakia**

By: Roman Horváth and Marek Rusnák

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How Important Are Foreign Shocks in Small Open Economy? The Case of Slovakia

Roman Horváth*
Czech National Bank
and Institute of Economic Studies, Charles University, Prague

Marek Rusnák
Institute of Economic Studies, Charles University, Prague

Abstract

In this paper, we provide evidence on the nature and the relative importance of domestic and foreign shocks in Slovak economy based on block-restriction vector autoregression model in 1999-2007. We document well-functioning monetary transmission mechanism in Slovakia. Subject to various sensitivity checks, we find that contractionary monetary policy shock has a temporary negative effect on the degree of economic activity and price level. We find that using output gap instead of GDP alleviates the price puzzle. In general, prices are driven mainly by foreign factors and the European Central Bank monetary policy shock on Slovak prices is more powerful than that of the National Bank of Slovakia. Slovak central bank interest rate policy seems to follow the ECB's interest rates. On the other hand, spectacular Slovak economic growth is primarily driven by domestic factors suggesting the positive role of recently undertaken Slovak economic reforms.

JEL Classification: E58, F41, F42.

Keywords: small open economy, foreign shocks, monetary policy, Slovakia, euro area.

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Corresponding author: roman.horvath@cnb.cz and roman.horvath@gmail.com

1. Introduction

How important are foreign shocks for small open economy? In this paper, we assess this question empirically using the data from one of the EU new members, Slovakia. More specifically, we estimate two-country VAR model and assess the relative importance of euro area shocks for Slovak economy.

Slovakia will join the euro area in January 2009 and therefore, it is of great interest to policy makers to understand how the euro area economy likely affects the developments in Slovak economy. However, existing empirical evidence in this respect is rather scant. For example, an authoritative survey of Coricelli et al. (2006) on monetary transmission in Central and Eastern Europe indicates that literature focused largely on the remaining Central European countries and rarely investigated the Slovak monetary transmission mechanism. In addition, existing VAR literature on Slovakia controls for the exogenous euro area variables, but an explicit examination of foreign shocks remains unexplored (Elbourne and Haan, 2006). This is a bit paradoxical, as Slovakia belongs among the most open countries in the world and foreign disturbances are likely to play an important role, possibly more important than many domestic disturbances. In this paper, we therefore aim to bridge this gap and investigate the relative importance of foreign shocks in Slovakia.

The paper is organized as follows. Section 2 reviews the relevant VAR literature. Section 3 provides a brief theoretical motivation. Next, section 4 introduces our small open economy VAR model. Section 5 presents the results. Concluding remarks are given in section 6. Appendix with additional results and data description follows.

2. Relevant Literature

In this section, we provide a brief review of small economy VAR modeling literature, e.g. we specifically focus on literature that estimate two-country VAR models and assess the nature of how foreign shocks hit domestic economy.

Cushman and Zha (1997) consider the interactions between the U.S. and Canadian economy for the identification of the Canadian monetary policy. They utilize the block exogeneity restriction, which exploits the assumption that the small economy cannot influence significantly the developments in the large economy. They argue that previous literature were unable to identify the monetary policy shock accurately, as it did not control for external factors explicitly.

Ultimately, they focus only on the assessment of domestic (Canadian) monetary shock, leaving the impact of U.S. monetary shocks unexplored. As compared to Cushman and Zha (1997), we also analyze how foreign monetary policy influence domestic economy (in our case how monetary policy of the ECB affects Slovak economy).

Kim (2001) studies the effects of US monetary policy shocks across non-US G7 countries. He finds that US monetary expansion has a positive spillover effect on output in these countries. In addition, expansion leads to a short run deterioration of the trade balance, but the balance improves persistently in the medium to long run. Contrary to previous literature that suggested non-US G7 countries monetary policy substantially follow the US monetary policy, Kim (2001) shows that after controlling for inflationary or supply shocks, the reaction of non-US monetary authorities to US monetary policy does not seem to be particularly strong with an exemption of Canada.

Next, Giordani (2004a) focuses on responses of a small open economy to foreign rather than to domestic shocks. He estimates the structural theoretical model from a class of New-Keynesian models and compares it with Bayesian VAR. As majority of other researchers in this stream of literature, he uses US – Canada pair in empirical estimation and finds that US shocks are a very important source of variation in all Canadian variables. He puts forward that foreign variables should figure prominently in both optimal and actual monetary policy rules.

Additionally, Canova (2005) gives evidence about the importance of the effects of the US monetary policy shocks on the Latin America economies, i.e. the countries that are strongly financially linked to the U.S. Interestingly, he finds no major difference between transmission of shocks in the countries with fixed exchange regime and economies with more flexible arrangements.

Maćkowiak (2006a) asks to what extent the macroeconomic variation is caused by external shocks in Central Europe. He examines Czech Republic, Poland and Hungary (note that he does not consider the remaining Central European country that is in center of attention in this paper – Slovakia). Using Germany as a proxy for external shocks, he sets up a model consisting of key macro variables from both Germany and the relevant small open economy. The main finding is that the sizeable amount of the variation in the variables is attributable to external shocks in these countries. He estimates that external shocks account for approximately 60-85 % of the variance

in price level. The corresponding estimate for the real output ranges from 25 to 50%. His results also indicate that German interest rate shocks account for around 50% of variation in Czech aggregate price level, it is about 2/3 in the case of Hungary of Poland.

Maćkowiak (2006b) investigates the impact of Japanese monetary shocks on macroeconomic variation in East Asia economies (i.e. the neighbors of Japan – Hong Kong, Korea, Malaysia, Philippines, Singapore and Thailand). Using Bayesian VAR he finds that Japanese monetary shocks account for only small fraction of the variance in real output, trade balances and exchange rates in East Asia. In particular, he finds no support evidence that expansionary Japan monetary policy shocks contributed to the Asian crisis. He shows also that net exports decrease after Japan’s monetary expansion, which is inconsistent with the so called “beggar thy neighbor” effects of monetary policy.

Finally, Maćkowiak (2007) estimates the structural VAR models with block exogeneity for 10 emerging markets from East Asia and Latin America. He finds that in a typical emerging market, external shocks account for approximately 50% of the variation in the exchange rate and the price level and 40% and 33% for variation in real output and short term interest rate, respectively. At the same time, he shows that US monetary policy shocks are less important for emerging markets as opposed to other external shocks, as they account for less than 10% of macroeconomic fluctuations on average. On the other hand, he notices that the price level and real output responses to US monetary policy tightening are actually larger than in the U.S itself.

3. Theoretical Motivation

The choice of variables for our empirical exercise can be motivated by New Keynesian models (Svensson (2000), Giordani (2004a), Galí & Gertler (2007) and Galí & Monacelli (2005)). In general, the model typically consists of an IS curve, a Philips curve and is closed by a monetary policy rule for setting a short-term interest rate. In open economies each equation may be augmented by the exchange rate and other foreign variables. We briefly present here a version of the small open economy model by Svensson (2000) extended by Giordani (2004a).

Small open economy such as Slovakia can be described by the following set of equations. First, partially forward looking pricing rule (Phillips curve) is typically assumed of the following form:

$$\pi_{t+1} = \alpha_{\pi} \pi_t + (1 - \alpha_{\pi}) E_t \pi_{t+2} + \alpha_x x_{t+1} + \alpha_q (q_t - q_{t-1}) + \varepsilon_{t+1}^{CP} \quad (1)$$

π_t denotes inflation, x_t is the output gap, defined as $x_t = y_t - y_t^N$, where y_t is log real GDP and y_t^N is log real potential output (this is modeled as an exogenous process); q_t is the log of real exchange rate. E_t is an expectations operator. ε_t^{CP} is a cost-push shock, $\varepsilon_t^{CP} \sim nid(0, \sigma_{CP}^2)$. The coefficients are assumed to be non-negative. The lags for monetary policy are brought in by $E_t \pi_{t+2}$. It is also supposed that exchange rate movements affect inflation with a lag.

IS/AD equation is modeled as:

$$x_{t+1} = \beta_x x_t + (1 - \beta_x) E_t x_{t+2} - \beta_i (i_t - E_t \pi_{t+1}) + \beta_x^* x_{t+1}^* + \beta_q E_t q_{t+1} + \varepsilon_{t+1}^{AD} \quad (2)$$

where i_t the monetary policy instrument (e.g. a short-term interest rate) and x_t^* is the foreign output gap. All coefficients are expected to be positive. ε_t^{AD} represents an aggregate demand shock, $\varepsilon_t^{AD} \sim nid(0, \sigma_{AD}^2)$. In Eq. (2), interest rate influences output with a lag.

The exchange rate follows uncovered interest parity:

$$(i_t - E_t \pi_{t+1}) - (i_t^* - E_t \pi_{t+1}^*) = q_{t+1|t} - q_t \quad (3)$$

Where π_t^* denotes foreign inflation rate. Monetary policy is characterized by a Taylor-type policy rule:

$$i_{t+1} = \rho_i i_t + (1 - \rho_i) (\gamma_x x_{t+1} + \gamma_\pi \bar{\pi}_{t+1} + \gamma_i i_{t+1}^* + \gamma_x^* x_{t+1}^* + \gamma_\pi^* \bar{\pi}_{t+1}^*) + \varepsilon_{t+1}^{MP} \quad (4)$$

On the whole, quite a general specification is assumed in a sense that the equations are extended to include also foreign variables.

Next, the rest of world can be modeled as closed economy by the Phillips curve, IS curve and Taylor rule.

$$\pi_{t+1}^* = \alpha_\pi^* \pi_t^* + (1 - \alpha_\pi^*) E_t \pi_{t+2}^* + \alpha_x^* x_{t+1}^* + \varepsilon_{t+1}^{CP*} \quad (5)$$

$$x_{t+1}^* = \beta_x^* x_t^* + (1 - \beta_x^*) E_t x_{t+2}^* - \beta_i^* (i_t^* - E_t \pi_{t+1}^*) + \varepsilon_{t+1}^{AD*} \quad (6)$$

$$i_{t+1}^* = \rho_i^* i_t^* + (1 - \rho_i^*) (\gamma_x^* x_{t+1}^* + \gamma_\pi^* \bar{\pi}_{t+1}^*) + \varepsilon_{t+1}^{MP*} \quad (7)$$

i_t^* denotes foreign monetary policy rate. The specification in the Eqs. 5-7 is less general than for small open economy Eqs. 1-3, as it is assumed that small open economy does not directly influence the fluctuations in large closed economy.

Consequently, the VAR model we estimate can be thought of as a reduced form of one specific model from the vintage of New-Keynesian models. The variables we include in the model are thus as follows: output gap, aggregate price level, interest rate and their foreign counterparts plus the bilateral nominal exchange rate.

4. Empirical Model – Small Open Economy VAR

Methodologically, we follow Sims et al. (1990) and estimate our VAR model in levels for the following reasons. First, it is sometimes difficult in small samples to determine whether a cointegrating relationship is present. Second, imposing the cointegrating restriction inappropriately could possibly lead to incorrect inference. On the top of that, Sims et al. (1990) claim that the usual practice of transforming the models to stationary form by difference or cointegrating operators whenever it appears likely that the data are integrated is often unnecessary.¹

In this section we present a seven variable VAR system to model the interactions between the euro area and Slovak economies.²

We begin with a general specification assuming the economy is described by a structural form equation, which is of a linear, stochastic dynamic form (omitting constant and other deterministic terms):

$$A(L)y(t) = \varepsilon(t),$$

Where $A(L)$ is an $m \times m$ matrix polynomial in the lag operator (with non-negative powers), $y(t)$ is an $m \times 1$ vector of observations, and $\varepsilon(t)$ is an $m \times 1$ vector of structural disturbances or shocks. $\varepsilon(t)$ is serially uncorrelated and $var(\varepsilon(t)) = \Lambda$ and Λ is a diagonal matrix, where diagonal elements are the variances of structural disturbances. In other words, we assume that structural disturbances are mutually uncorrelated. More formally, $E[\varepsilon(t)\varepsilon(t)' | y(t-s), s > 0] = I$, $E[\varepsilon(t) | y(t-s), s > 0] = 0$.

We divide the model into the euro area and Slovak block. Therefore, we have

¹ In a similar fashion, Stock and Watson (1998) put forward to exploit the additional information contained in levels of variables rather than their differences.

² Note that euro area is the Slovak main trading partner and it represents nearly 50% of the Slovakia's foreign trade share. During our sample period, Slovakia exhibited relatively stable macroeconomic environment with nearly double digit growth rates and inflation rate below 5%.

$$A(L) = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix}, \quad y(t) = \begin{bmatrix} y_1(t) \\ y_2(t) \end{bmatrix}, \quad \varepsilon(t) = \begin{bmatrix} \varepsilon_1(t) \\ \varepsilon_2(t) \end{bmatrix}.$$

The model contains m_t domestic variables in a small open (Slovak) economy vector $y_1(t)$ and m_2 variables exogenous to the small open economy in vector $y_2(t)$, i.e. the euro area variables. The dimension of $A_{ij}(L)$ is $m_i \times m_j$, $y_i(t)$ and $\varepsilon_i(t)$ each of dimension $m_i \times 1$.

The vector of Slovak variables consists of a measure of economic activity (output gap; GDP and industrial production gap for sensitivity analysis) (x_t^{SVK}), a measure of aggregate price level (p_t^{SVK}), the short term interest rate (i_t^{SVK}) and the exchange rate ($e_t^{SKK/EUR}$):

$$y_1(t)' = (x_t^{SVK} \quad p_t^{SVK} \quad i_t^{SVK} \quad e_t^{SKK/EUR})$$

The vector of foreign variables is comprised of a measure of the euro area economic activity (x_t^{EU}), euro area aggregate price level (p_t^{EU}) and the euro area short term interest rate (i_t^{EU}):

$$y_2(t)' = (x_t^{EU} \quad p_t^{EU} \quad i_t^{EU})$$

All variables except for the output gap and the interest rate are in log levels.

As Slovakia is a small economy, their shocks are unlikely to have significant effect on the euro area economy and therefore, we restrict accordingly the $A_{21}(L) = 0$. This is so-called block exogeneity restriction and it has been employed by the studies of small (open) economies before (e.g. Cushman and Zha, 1997, Mackowiak, 2006a). As claimed by Zha (1999), failing to impose the block exogeneity restrictions is not only economically unappealing but also may result in misleading conclusions.

In order to be able to carry out the estimation, we consider the corresponding reduced form:

$$y(t) = B(L)y(t-1) + u(t),$$

where $B(L)$ is a polynomial matrix in the lag operator and $\text{var}(u(t)) = \Sigma$. The structural innovations are recovered in a following way. We rewrite $A(L)$ as $A(L) = A_0 + A^0(L)$, where A_0 is the coefficient matrix on L^0 in $A(L)$ that means the contemporaneous coefficient matrix in the structural form. A_0 can be called the impact matrix. $A^0(L)$ is the coefficient matrix in $A(L)$ without contemporaneous coefficient A_0 . We can rewrite structural equation as $A_0 y(t) + A^0(L)y(t) = \varepsilon(t)$. After rearranging and premultiplying the equation by A_0^{-1} we get $y(t) = -A_0^{-1}A^0(L)y(t) + A_0^{-1}\varepsilon(t)$.

${}^t\varepsilon(t)$. The relationship between the reduced form residuals and the structural shocks is thus $u(t) = A_0^{-1} \varepsilon(t)$.

Clearly, there is an identification problem, as there are less parameters estimated in the reduced form VAR than in the structural form. In order to obtain a just identified system we need to impose $n(n-1)/2$ restrictions. The most straightforward approach to identification is so called Choleski recursive scheme. In the scheme matrix A_0^{-1} is a lower triangular.

Following Mojon and Peersman (2001), we order the variables in each block as follows: a measure of economic activity, price level, interest rate and the exchange rate (this variable only for Slovak block). Therefore, our recursive scheme is:

$$\begin{pmatrix} u_t^1 \\ u_t^2 \\ u_t^3 \\ u_t^4 \\ u_t^5 \\ u_t^6 \\ u_t^7 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ d_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ d_{31} & d_{32} & 1 & 0 & 0 & 0 & 0 \\ d_{41} & d_{42} & d_{43} & 1 & 0 & 0 & 0 \\ d_{51} & d_{52} & d_{53} & d_{54} & 1 & 0 & 0 \\ d_{61} & d_{62} & d_{63} & d_{64} & d_{65} & 1 & 0 \\ d_{71} & d_{72} & d_{73} & d_{74} & d_{75} & d_{76} & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_t^{x(eu)} \\ \varepsilon_t^{p(eu)} \\ \varepsilon_t^{i(eu)} \\ \varepsilon_t^{x(svk)} \\ \varepsilon_t^{p(svk)} \\ \varepsilon_t^{i(svk)} \\ \varepsilon_t^{e(skk/eur)} \end{pmatrix}$$

Obviously, while the above ordering is likely to be economically appealing, different ordering can produce different results. In consequence, we perform sensitivity analysis by changing the ordering of the variables to assess the robustness of our model; more on this below.

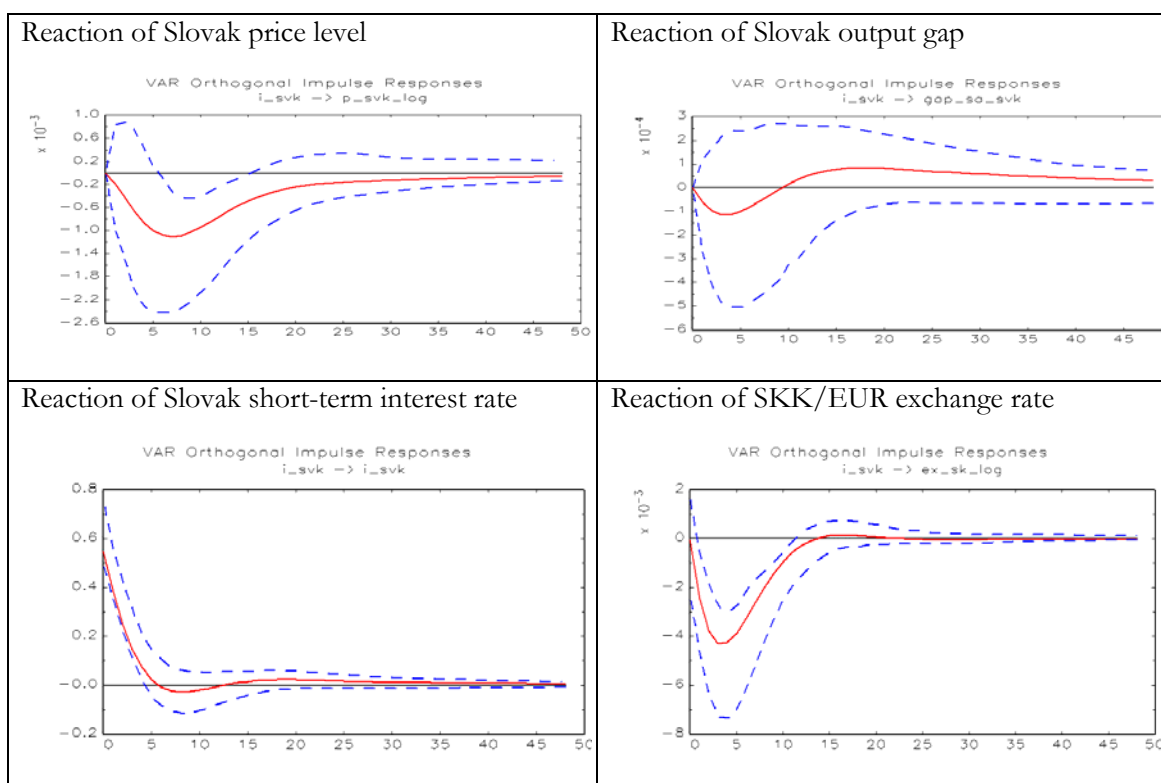
Several issues are noteworthy. The third equation could be viewed as the simplified version of the ECB reaction function and the shock to the third equation can be interpreted as the monetary policy shock. Analogously, the sixth equation can be understood as the reaction function of the National Bank of Slovakia (NBS). It assumes that Slovak central bank take into account in their monetary policy considerations not only the domestic output and prices, but may also react to the euro area fundamentals – output, prices as well as interest rate. Contemporaneous exchange rate is missing in the reaction function of the NBS in our baseline specification. However, as put forward by Calvo and Reinhart (2002), the monetary authorities in open economies are often very sensitive to exchange rate developments. As a result, we address this issue in our robustness analysis by using different identification scheme by ordering the policy instrument of NBS after

the exchange rate, so that the central bank may react contemporaneously to the exchange rate shocks.

5. Results

This section gives our results. First, the impulse responses assessing the magnitude and persistence of the reaction to the shock are presented. Next, the variance decompositions follow. We set the lag in our VAR model to 1, as suggested by the Schwarz information criterion. Given our data are monthly, we include seasonal dummies to assess the seasonality effects (however, we estimate also the VAR model without seasonal dummies and the results are largely unchanged). The impulse responses are accompanied by 95% confidence bands, which were bootstrapped using 250 replications according to Hall (1988).

Figure 1: Domestic monetary policy shock, impulse responses



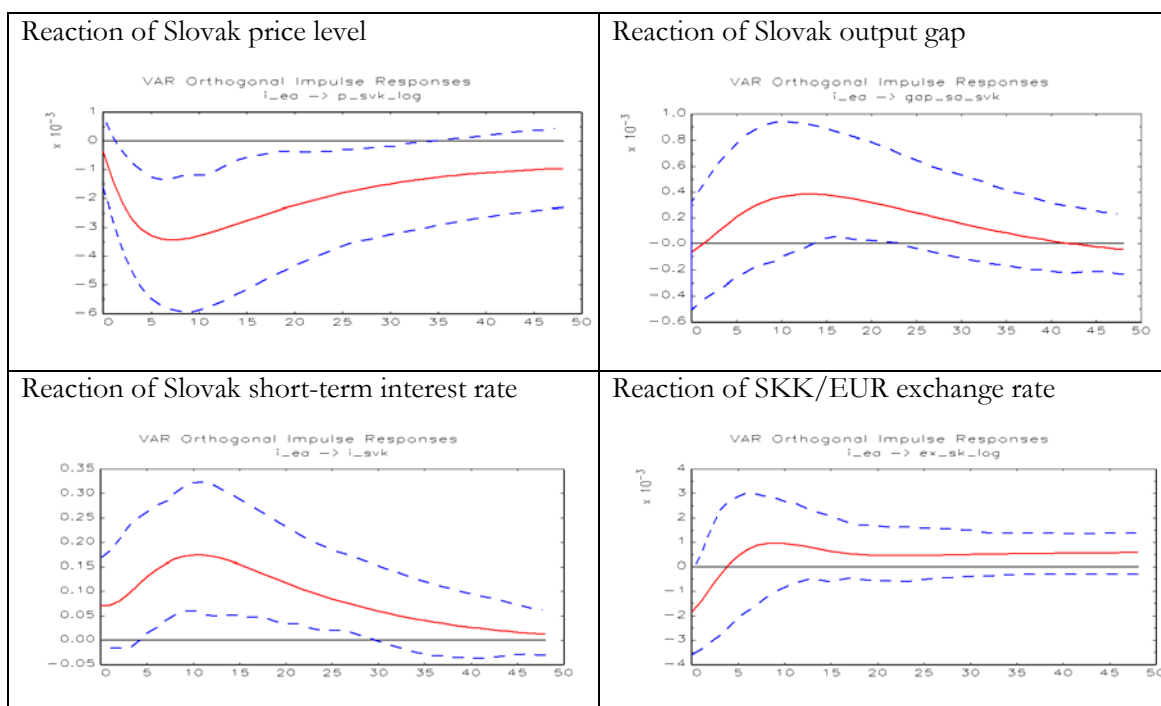
Note: The one-standard deviation shock; 95% confidence intervals bootstrapped by Hall (1988) method.

Figure 1 reports our baseline specification estimates on the effect of domestic monetary policy shock. After a monetary policy shock of one standard deviation (55 basis points), prices gradually decline and reach a bottom after approximately 6 months. In the period of 6-12 months after the shock, the log of prices is found to decrease by about 0.1 per cent on average. This result largely complies with Elbourne and Haan (2006), who find the peak price level response in Slovakia

after 5 months using somewhat shorter sample (1998-2004). Interestingly, the reaction is much faster than the response of prices in a neighboring country, the Czech Republic, which is found to have a bottom after approximately 12 months (Borys and Horváth, 2008).

Next, the response of output gap seems to be insignificant. This indicates that Slovak monetary policy likely plays a little role for the domestic output developments. Following the increase in Slovak interest rates, the exchange rate quickly appreciates. The nominal appreciation reaches its peak after 3-4 months with the maximum response of the log of exchange rate 0.43%. Elbourne and Haan (2006) report similar findings for the response of output and exchange rate, too.

Figure 2: Euro area monetary policy shock, impulse responses



Note: The one-standard deviation shock; 95% confidence intervals bootstrapped by Hall (1988) method.

Figure 2 presents our estimates on the response to the euro area monetary policy shock. The typical unexpected foreign monetary shock is 10 basis points.³ The Slovak monetary authority is found to react to the ECB monetary shock quite extensively and seem to follow its interest rate policy. The maximum response occurs after 14 months with the magnitude of about 15 basis points. This indicates that there is approximately one-to-one relationship between the interest

³ To compare, the typical interest rate shock for Slovakia is at roughly five times larger than for the euro area. This is in line with the results of Jarocinski (2006), i.e. that monetary shocks in central and eastern European countries are associated with larger interest rate movements than in western European countries. He puts forward that it is the consequence of higher output growth rates, inflation and interest rates in transforming countries that could generate higher variance of the shocks.

rate setting of ECB and NBS and that NBS follows ECB with a lag. The price level decline reaches its bottom (-0.34 %) after 6 months. The ECB's monetary policy shock thus seems to have actually a larger effect on the Slovak prices than the corresponding NBS monetary policy shock. In this respect, Parrado (2001) reports the effects of domestic and foreign monetary policy shock for Chile, but he does not find that foreign (U.S. in this case) monetary policy would be more powerful than domestic Chilean monetary policy in terms of domestic price developments. The response of output gap is positive reaching its peak after 10 months. The positive impact of the foreign monetary tightening on the Slovak output may reflect the depreciation of the Slovak currency, which could in turn boost the net exports or, more generally, aggregate demand and thus increase the output (Parrado, 2001, reports similar finding for Chile). Nevertheless, the estimates are surrounded by a certain degree of uncertainty. Finally, we find the reaction of the nominal exchange rate to ECB's monetary tightening insignificant.

Additionally, we investigate the relative importance of the external shocks via forecast errors variance decompositions from the estimated VAR. We are interested in the share of the variance in aggregate variables that can be attributed to the external vs. domestic shocks. Further, we assess the relative importance of monetary policy shock in explaining the variability of macroeconomic variables.

Table 1: Price level – domestic vs. foreign shocks, variance decomposition

| Horizon | Source of disturbance: | | | |
|---------|------------------------|---------------------------|-----------------|---------------------------|
| | external shocks | ECB monetary policy shock | domestic shocks | NBS monetary policy shock |
| 6 | 0.39 | 0.15 | 0.62 | 0.01 |
| 12 | 0.54 | 0.25 | 0.45 | 0.02 |
| 24 | 0.68 | 0.28 | 0.33 | 0.02 |
| 36 | 0.74 | 0.26 | 0.27 | 0.01 |
| 48 | 0.77 | 0.23 | 0.22 | 0.01 |

Note: The horizon is in the months. External and domestic shocks add to one.

Table 1 reports the variance decomposition for the Slovak price level. We find that external shocks become dominant source of price fluctuations after 12 months. In the long run, i.e. as assessed by four year horizon, the external shocks account nearly 80% in the Slovak price level variability. Interestingly, 23% of the Slovak price level fluctuations can be attributed to the euro area monetary policy disturbances. That result contrasts sharply when compared with the importance of domestic monetary policy shock, which accounts only for 1% of variance in the price level. For example, the corresponding estimate of Parrado (2001) is that Chilean monetary policy explains a little bit more than 10% of domestic price level variability in the long run.

In the light of the looming accession of Slovakia into the euro area, the finding that the external shocks account for the most of the variation in the price level and that the ECB monetary policy shocks are substantially more important in explaining the fluctuations of prices than the domestic monetary policy shocks might suggest that the Slovak decision to join the euro area is justifiable on these grounds. On the other hand, it is questionable whether the timing of ECB monetary shocks contributes to macroeconomic stability.

Maćkowiak (2006a) provides the corresponding estimates for other central European countries⁴ and finds that in Hungary and Poland 80% of the long run variance in aggregate price level can be accounted to external shocks. Interestingly, the corresponding estimate for the Czech Republic is a bit lower and accounts approximately only to 50%. Next, Giordani (2004a) estimates that around 40% of variation in Canadian inflation is due to foreign shocks.

Table 2: Output gap – domestic vs. foreign shocks, variance decomposition

| Horizon | Source of disturbance: | | | |
|---------|------------------------|---------------------------|-----------------|---------------------------|
| | external shocks | ECB monetary policy shock | domestic shocks | NBS monetary policy shock |
| 6 | 0.07 | 0.01 | 0.93 | 0.00 |
| 12 | 0.08 | 0.04 | 0.92 | 0.00 |
| 24 | 0.15 | 0.08 | 0.86 | 0.00 |
| 36 | 0.23 | 0.07 | 0.78 | 0.01 |
| 48 | 0.30 | 0.06 | 0.69 | 0.00 |

Note: The horizon is in the months. External and domestic shocks add to one.

Table 2 presents the results on the variance decomposition for output gap. Initially, we find that almost all of variance in output gap is explained by domestic factors. In the long run, the share of external shocks rises to 30%, where 6% of total variation is due to foreign monetary shock. Surprisingly, monetary policy shocks (both of the ECB and NBS) seem rather unimportant in explaining the output gap fluctuations. Contrary to the results for the price level, the variance decomposition of output gap fluctuations suggests that most of the growth of Slovak economy is driven by domestic factors. This could be a consequence of comprehensive structural reforms Slovakia has implemented recently (see Moore, 2005, on Slovak product and labor market reforms).

⁴ We are aware that comparisons have to be interpreted with caution since different studies use different estimation and identification techniques. Nevertheless, we provide the estimates at least for a rough comparison.

Our findings comply with Maćkowiak (2006a), who finds that the external shocks explain 30% of long run variation in economic activity for the Czech Republic and Poland and only 13% for Hungary. On the other, Giordani (2004a) estimates that approximately 70% of fluctuations in Canadian output in the long run are due to foreign (U.S.) shocks. Likewise, the corresponding estimate of Cushman and Zha (1997) is 75%. Del Negro and Obiols-Hums (2001) attribute about 75-85% of the variance in the Mexican output to external shocks. In general, this piece of evidence suggest that output in central European small open economies is driven more by domestic factors, as compared to other small open economies such as Canada and Mexico. This might be a consequence of transition of former centrally planned economies into market-oriented economies that were accompanied by large domestic structural reforms.

Table 3: Interest rate - domestic vs. foreign shocks, variance decomposition

| Horizon | Source of disturbance: | | | |
|---------|------------------------|---------------------------|-----------------|---------------------------|
| | external shocks | ECB monetary policy shock | domestic shocks | NBS monetary policy shock |
| 6 | 0.13 | 0.05 | 0.87 | 0.51 |
| 12 | 0.25 | 0.14 | 0.75 | 0.33 |
| 24 | 0.32 | 0.21 | 0.68 | 0.25 |
| 36 | 0.36 | 0.20 | 0.64 | 0.22 |
| 48 | 0.41 | 0.19 | 0.60 | 0.20 |

Note: The horizon is in the months. External and domestic shocks add to one.

Next, Table 3 gives our results on the variance decomposition for Slovak interest rates. We find that the most of the variance is explained by the domestic factors. Initially, most of them are due to domestic monetary disturbances. Over time, the external shocks gain importance. In the long run, 60% of the fluctuations in interest rate are explained by domestic shocks, while remaining 40% is due to external shocks. This is largely in line with empirical evidence on other emerging economies, see Maćkowiak (2007). The results also point to importance of ECB interest rates for Slovak monetary policy, as 20% of variation in Slovak interest rates is attributable to the ECB interest rates.

Table 4: Exchange rate - domestic vs. foreign shocks, variance decomposition

| Horizon | Source of disturbance: | | | |
|---------|------------------------|---------------------------|-----------------|---------------------------|
| | External shocks | ECB monetary policy shock | domestic shocks | NBS monetary policy shock |
| 6 | 0.16 | 0.02 | 0.84 | 0.20 |
| 12 | 0.23 | 0.03 | 0.77 | 0.22 |
| 24 | 0.30 | 0.03 | 0.71 | 0.20 |
| 36 | 0.34 | 0.03 | 0.66 | 0.19 |
| 48 | 0.40 | 0.04 | 0.60 | 0.17 |

Note: The horizon is in the months. External and domestic shocks add to one.

Finally, we investigate the sources of fluctuations in exchange rate in Table 4. In first 6 months external shocks explain only 16% of the variability. However, over time the fraction of variation that can be attributed to the external shocks rise to 40% in 4 years horizon. Interestingly, foreign monetary policy shocks explain only 3% of variation on average, while domestic monetary policy accounts for almost 20%.

Next, we carry out a number of sensitivity checks, i.e. the sensitivity of results to different identification scheme and to two different measures of economic activity. The corresponding results are available in the Appendix. In general, the sensitivity analysis supports our findings presented in the main text.

First, we change ordering of our variables in a way to allow the contemporaneous effect of exchange rate on domestic monetary policy similarly to as in Kim and Roubini (2000) and present the impulse responses to domestic and foreign monetary policy shock. The results largely confirm findings of our baseline specification. Second, we employ two different measures of economic activity – log of real GDP and the (HP filtered) industrial production gap.

We would like to note that our preferred measure of economic activity is output gap that we use in our baseline specification. First, real GDP as the measure of the degree of economic activity for central bank might be problematic, as the potential output growth accelerated in Slovakia during the sample period (OECD, 2007). Due to potential output growth acceleration, actual GDP growth does not give an accurate picture about demand pressures to which central bank may want to react. Second, industrial production is known to vary considerably from month to month and represent only a certain share of GDP.

The results seem to support our aforementioned considerations. The impulse responses are less precisely estimated and we observe price puzzle. This complies with Giordani (2004b), who shows that using the output gap instead of GDP growth alleviates the price puzzle. Nevertheless, the results with industrial production gap are largely in line with our baseline specification. Additionally, we also consider the robustness of the variance decomposition results. On the whole, the estimates confirm our baseline specification, to a large extent (variance decomposition results are available upon request).

6. Concluding remarks

In this paper, we estimate a small open economy VAR model for Slovakia and assess the importance of domestic vis-à-vis foreign shocks. The VAR model consists of two blocks – Slovak block and the euro area block and it is assumed that euro area variables affect the Slovak variables, but not *vice versa*.

We document a well-functioning monetary transmission mechanism in Slovakia. Following the unexpected domestic monetary tightening the price level drops (thus, there is no price puzzle), the output decreases and the nominal exchange rate appreciates. Notably, we find hump-shaped reaction of the Slovak price level to the euro area monetary policy shock. The ECB's monetary policy shock thus seems to have actually a larger effect on the Slovak prices than the corresponding NBS monetary policy shock. In general, the results suggest that foreign shocks are crucial in explaining the fluctuations of the Slovak price level. We find that the external shocks explain nearly 80% of variation in the aggregate Slovak price level in the long run. Moreover, about 23% of the fluctuations are attributed to foreign (ECB) monetary policy shock. On the other hand, we find rather small role for domestic monetary policy shocks in explaining the variation in the price level.

Next, the Slovak monetary authority is found to react to the ECB monetary shock quite extensively and seem to follow its interest rate policy. The results indicate that there is approximately one-to-one relationship between the interest rate setting of ECB and NBS and that NBS follows ECB with a lag.

The fluctuations in Slovak output are mainly due to domestic factors and contribute to about 70% in the variation. This may reflect the positive role that Slovak economic reforms, which aimed to increase product and labor market flexibility, played for domestic economic growth. Next, we find that monetary policy (either of ECB or National Bank of Slovakia) explain small part of variation in Slovak output. Additional finding of this paper is that using output gap instead of GDP alleviates the price puzzle.

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Appendix

Data Description

The data are available at the monthly frequency from January 1999 - December 2007 (108 observations). The source of data is Eurostat and IMF International Financial Statistics Database. The beginning of sample is restricted to January 1999 for two following reasons. First, the euro area came into being on 1st January 1999, when euro was introduced and the responsibility for the monetary policy of the member states were transferred to the European Central Bank. Second, the National bank of Slovakia abandoned the fixed exchange rate regime in October 1998 and the price stability successively became the main goal of the monetary policy. We restrict the end of sample to December 2006, because of end-point bias of HP filter that we use to construct the output gap.

Output gap – the difference between seasonally adjusted real GDP and potential output, as estimated by the Hodrick-Prescott filter with a smoothing parameter of 1600, is interpolated from the quarterly to monthly values by quadratic match procedure. Note that different interpolation techniques affect the resulting estimates rather marginally. Data were downloaded for the sample period 1999-2007 and 2007 observations were excluded to take end-point bias of Hodrick-Prescott filter into account. For sensitivity analysis, we use industrial production index, which was downloaded from IMF International Financial Statistics Database (*Slovakia: 93666..BZF...*, *Eurozone: 16366..CZF...*).

Prices – Harmonized index of consumer prices (HICP)

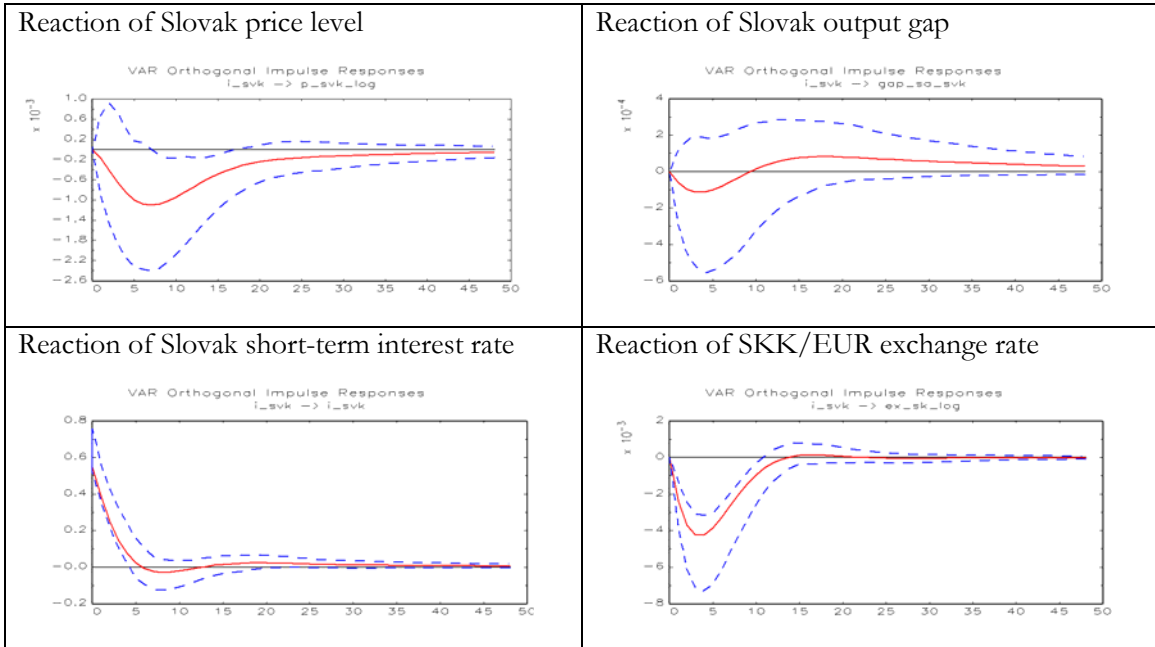
Interest rate – 3-month money market interest rates

Exchange rate – monthly average of SKK/EUR exchange rate

Sensitivity Analysis

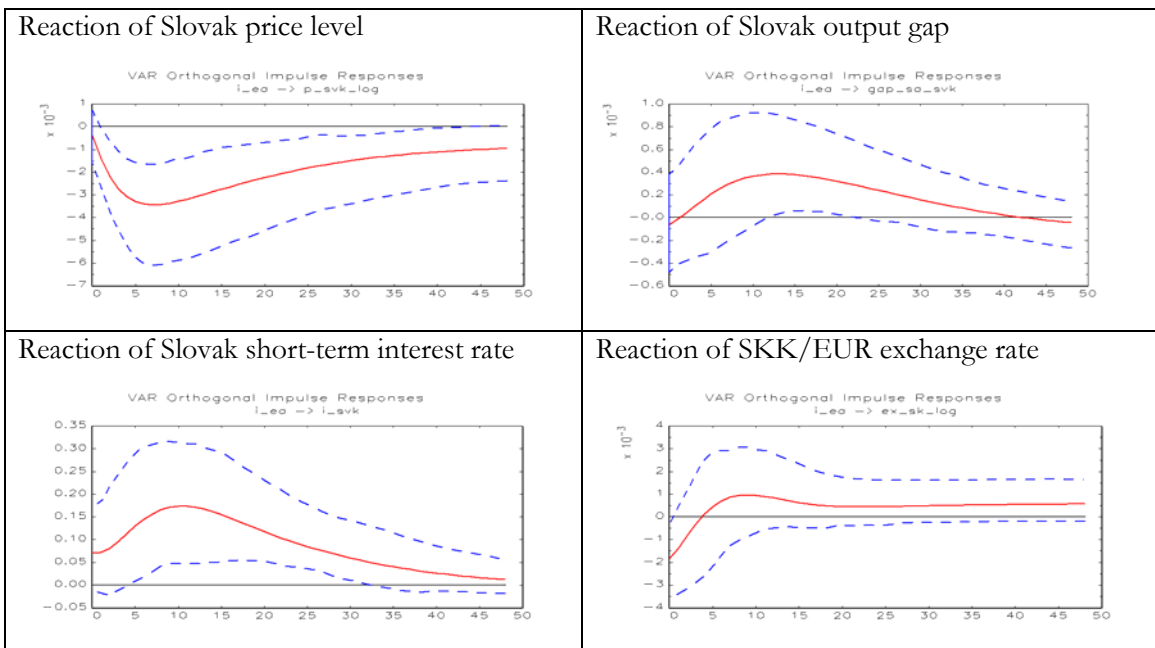
Different identification scheme - Allowing for contemporaneous effect of exchange rate on domestic monetary policy

Figure 3 – Domestic monetary policy shock, impulse responses



Note: The one-standard deviation shock; 95% confidence intervals bootstrapped by Hall (1988) method.

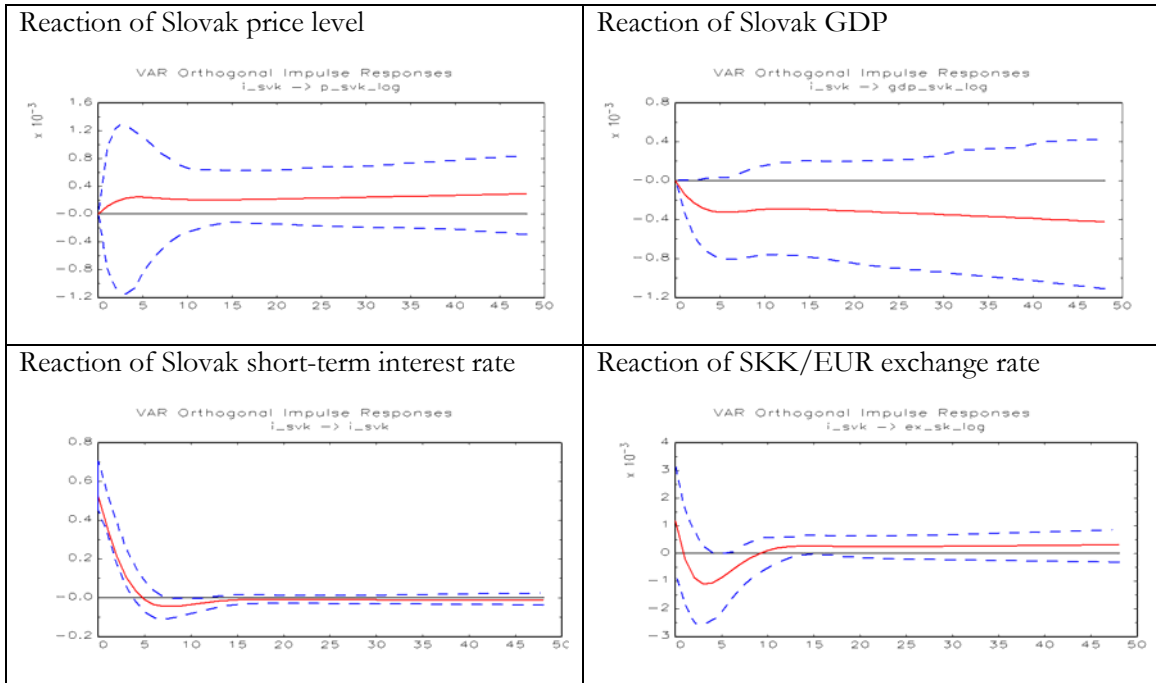
Figure 4 – Foreign monetary policy shock, impulse responses



Note: The one-standard deviation shock; 95% confidence intervals bootstrapped by Hall (1988) method.

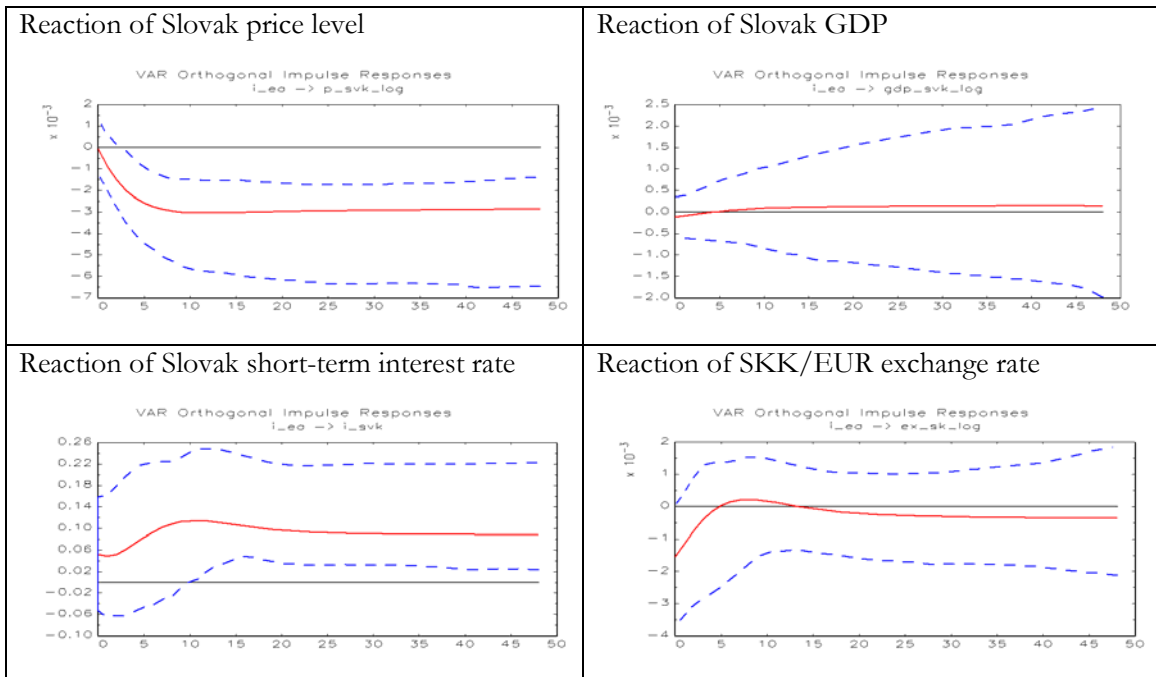
Two different measures of economic activity

Figure 5 – Domestic monetary policy shock, impulse responses, log of real GDP



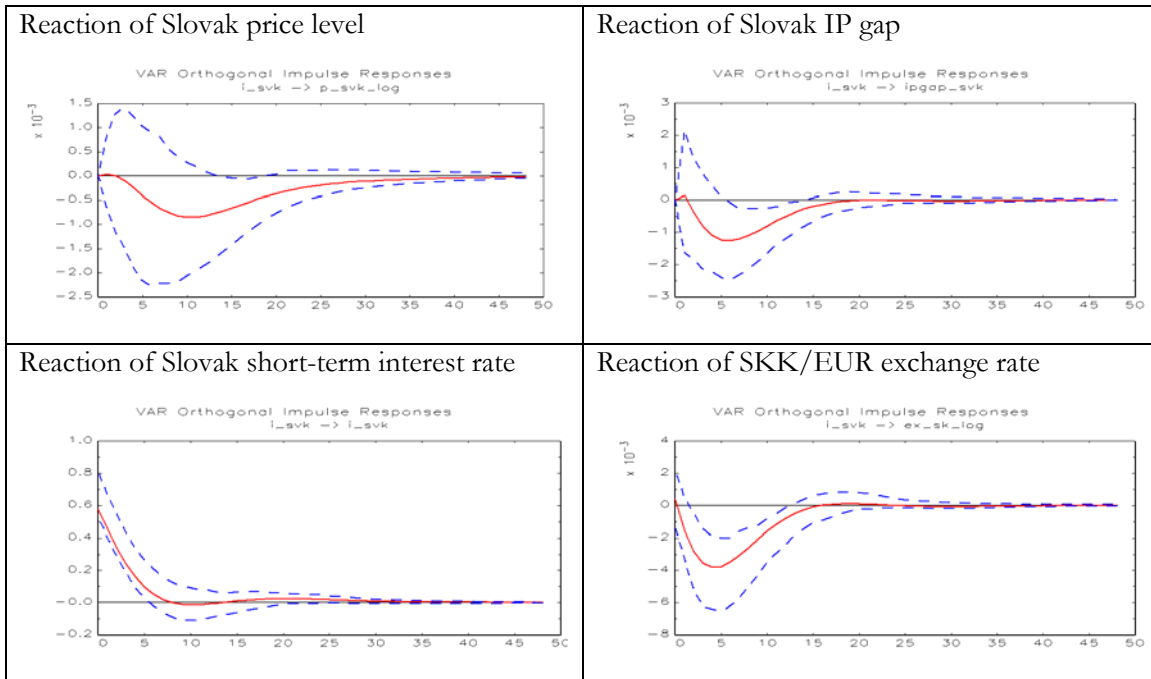
Note: The one-standard deviation shock; 95% confidence intervals bootstrapped by Hall (1988) method.

Figure 6 – Foreign monetary policy shock, impulse responses, log of real GDP



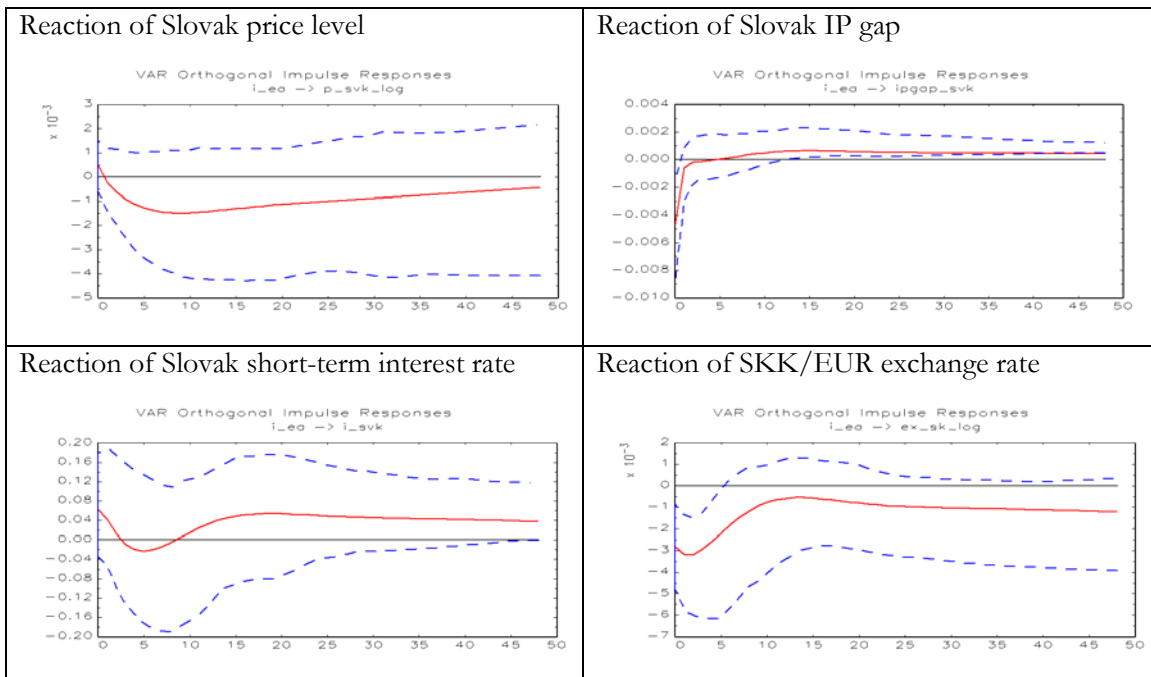
Note: The one-standard deviation shock; 95% confidence intervals bootstrapped by Hall (1988) method.

Figure 7 – Domestic monetary policy shock, impulse responses, industrial production gap



Note: The one-standard deviation shock; 95% confidence intervals bootstrapped by Hall (1988) method.

Figure 8 – Foreign monetary policy shock, impulse responses, industrial production gap



Note: The one-standard deviation shock; 95% confidence intervals bootstrapped by Hall (1988) method.

Figure 9 -Slovak variables, plot of the series

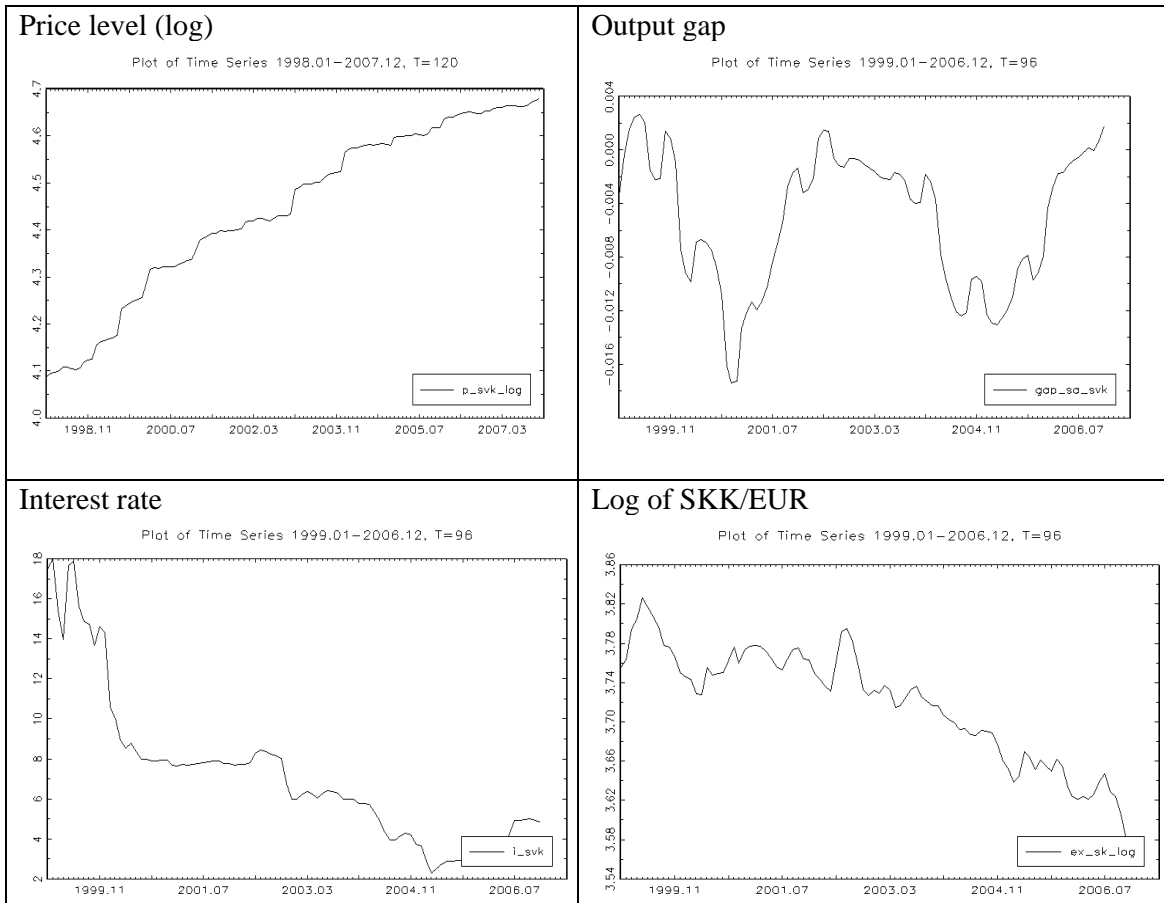
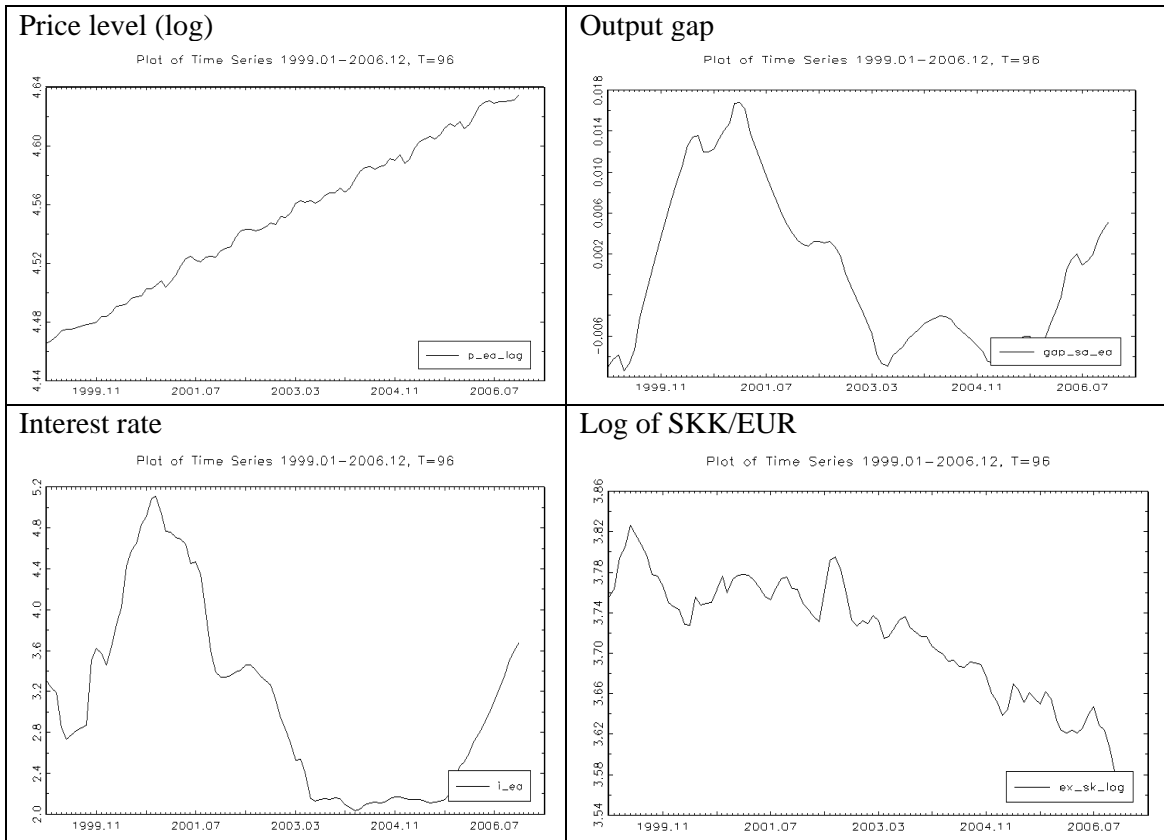


Figure 10 – Euro area variables, plot of the series



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