Influence of cyclical development of the most significant foreign-trade partners on small open economy (VAR approach)

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Abstract. Small open economy is characterized by two basic attributes: significant share of foreign trade and negligible influence on world prices or interest rates. The Slovak Republic (SR) is a typical example of small open economy, as the openness of its economy is approx. 160% according to data of 2011 (defined as the share of total export and import of goods in GDP at current prices).
The main objective of this paper is to identify an influence of foreign factors on the domestic economy. The empirical approach VAR (vector autoregression) is applied for this purpose. Both domestic and foreign economies are represented by basic macroeconomic indicators - gross domestic product, inflation and interest rate and the foreign economy also by the exchange rate and oil price. The most significant foreign partners of the SR are selected according to their maximum contribution to the openness of the Slovak economy. To identify the vector autoregression (VAR), the Cholesky decomposition and structural restrictions are employed. The analysis of reactions of domestic macroeconomic indicators to foreign shocks is performed by means of impulse response functions. The analysis has confirmed that the development of significant foreign-trade partners has a strong influence on the development of the domestic economy.

Keywords: small open economy, model VAR, impulse response functions.

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AMS Classification: 91B84

1 Introduction

After the recent crisis the interest increased in studying macroeconomic fluctuations. In recent global world this issue is especially crucial for open economies. Small open economy is characterized by two main features. The first one is its active participation in international trade and the second is the neglected feedback reaction, i.e. the fact that the small open economy cannot significantly influence the world prices or interest rates.

The basic goal of this paper is to analyse the impact of fluctuations of foreign macroeconomic time series on a small open economy of the Slovak Republic (SR). The SR with its openness[2] of approx. 160% counts among the most open economies of the world. Considering this fact is assumed that the development of foreign environment has a significant impact on the Slovak economy and the foreign disturbances can have a stronger impact than domestic disturbances (in this respect the focus of this paper is mainly on the foreign disturbances). The knowledge of influence intensity of the main foreign factors can help also to reveal the main foreign factors of cyclical development for a small open economy.

In this respect, the empirical evidence is rather scarce in the case of Slovakia. E.g., there is a study of Elbourne and Haan [2] oriented on the monetary policy transmission of Central and Eastern European countries. Relating to the Slovakia's joining of the Euro area in January 2009, the research has been oriented mostly towards the investigation of euro area's influence on the Slovak economy, e.g. in [4]. However, the most important trading partners of Slovakia are also its neighbouring countries which are non-members of euro area. This fact suggests an idea to identify the most important foreign-trade partners of the Slovak Republic and to analyse which foreign shocks caused by the development of the most important trading partners are most significant for a small open economy.

In this paper, modelling of a small open economy uses an empirical VAR approach and first results are gained also from a structural VAR (SVAR) approach. SVAR models are popular in the analysis of sources of business cycle fluctuations, as in Blanchard [1]. According to the literature, the SVAR approach is better suited for small open economies rather than the more traditional identification methods of the VAR, e.g. the Cholesky

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[2] The openness of economy is defined as the share of total import and export of goods in gross domestic product at current prices.

decomposition. For example Elbourne and Haan [2] conclude that the structural VAR yields much better results than the Cholesky ordering, because it can capture more of the salient features of open economies. Cholesky decomposition VAR only allows one direction of contemporaneous causation, which can be a disadvantage in some cases. Both approaches are used for discussion of impulse response functions and identification of the most important business cycle factors.

The paper is organized as follows. Section 2 introduces the theoretical background for the selection of variables and identifies the most important foreign-trade partners of the Slovak economy. Section 3 contains the VAR and SVAR models and discusses their impulse response functions. Section 4 concludes with summary results.

2 Theoretical background and data selection

As the goal is to investigate the impact of foreign business cycle on the domestic business cyclical development, we concentrate on the transmission channels of country-specific shocks. It has been suggested that there are two different channels of international business transmission, as according to Lee [5]. That is, the foreign business cycle has an impact on the domestic economy through its export (through changes in export demand and through changes in terms of trade) and another channel is the financial market. The selected indicators correspond with these two channels. The export demand is contained in the gross domestic product of the trading partners and the changes in terms of trade are influenced by the price level of trading partners. The financial market can be characterized by the development of short term interest rate.

In this model, the Slovak economy is represented by the following basic macroeconomic indicators: real gross domestic product (*y*), inflation (*p*) and short-term interest rate (*r*). The foreign environment is represented by their foreign counterparts of the most important foreign-trade partners (*ys, ps, rs*). The most important foreign-trade partners of SR are identified on the basis of their ratio in the openness of the Slovak economy. The openness of economy is defined as the share of total export and import of goods in GDP at current prices. According to this definition, the following 8 countries of European Union are identified: Germany, Czech Republic, Italy, Austria, Poland, Hungary, France, and United Kingdom. These 8 countries constitute together approx. 63.4% of Slovakia's foreign trade of goods. Only half of these countries are also euro area members (Germany, Italy, Austria, and France).

In the case of open economies also the exchange rate can be included; in this case it is an aggregate exchange rate between Slovakia and the most important trading partners (*e1*). To cover the global economy the exchange rate of Euro to U.S. Dollar (*e2*) and the price of oil (*po*) are also included. The choice of data corresponds to the following economic relationships inspired by the New Keynesian models, e.g. in Horvath [4]: forward-looking pricing rule (1), IS/AD equation (2) and monetary policy rule for setting a short-term interest rate (3).

$$p_{t+1} = a_1 p_t + a_2 p_{t+2} + a_3 y_{t+1} + a_4 (e1_t - e1_{t-1}) + \varepsilon_{t+1} \tag{1}$$

$$y_{t+1} = b_1 y_t + b_2 y_{t+2} - b_3 (r_t - p_{t+1}) + b_4 ys_{t+1} + b_5 e1_{t+1} + \varepsilon_{t+1} \tag{2}$$

$$r_{t+1} = c_1 r_t + c_2 (d_1 y_{t+1} + d_2 \bar{p}_{t+1} + d_3 rs_{t+1} + d_4 ys_{t+1} + d_5 \overline{ps}_{t+1}) + \varepsilon_{t+1} \tag{3}$$

where ε_{t+1} stands for shocks with zero mean value and constant variance. All these equations characterize the relationships between selected variables and all equations can be extended to include also foreign variables like the price of oil and world exchange rate.

3 VAR vs. SVAR model

The starting point of the analysis is a vector autoregression (VAR) model which is free of any economic assumptions. All variables in model VAR are regarded as endogenous. VAR is a system where each variable is regressed on *k* of its own lags and on *k* lags of the other variables. Each equation in the VAR contains the same determining variables and this allows estimating the VAR using OLS method. The reduced form of model VAR in matrix notation is the following:

$$Y_t = A(L) Y_t + u_t \tag{4}$$

where Y_t denotes the *(n x 1)* vector of endogenous variables, *A(L)* denotes the matrix polynomials in the lag operator *L* and u_t is the *(k x 1)* vector of reduced-form errors. However, the estimated model cannot be directly used for the analysis of variables' behaviour in response to the various shocks, as the errors in u_t are correlated with each other. One possible way to solve this is using Cholesky decomposition to identify the underlying orthogonal

shocks. The structural shocks are derived from their reduced-form counterparts through the contemporaneous correlation matrix from the structural moving average representation. It means restrictions such that certain variables have no contemporaneous effect on the others. Cholesky decomposition may be atheoretical, but it implies a strict causal ordering of the variables in the VAR, e.g. the last positioned variable responds contemporaneously to all the other variables, but they do not respond contemporaneously to this variable. For the purpose of better economic interpretation of the impulse responses the economic theory can be included in the model and this leads to the model SVAR - structural vector autoregressions. The structural model SVAR is then given by:

$$\Omega Y_t = B(L)Y_t + e_t \tag{5}$$

The relations between (4) and (5) are the following: $A = \Omega^{-1}B$ and $u_t = \Omega^{-1}e_t$. When we want to express the endogenous variables in Y_t as a function of current and past reduced-form innovations u_t, the moving average representation of (4) is computed:

$$Y_t = C(L)u_t \tag{6}$$

where $C(L) = (I - A(L))^{-1}$. The matrix C can imply pointed restrictions on the system in the form of long-run restrictions.

3.1 Analysis of input data

The analysis is based on quarterly time series from the 1st quarter of 1998 to the 4th quarter of 2011, i.e. 56 observations. All variables in the model are not seasonally adjusted, but transformed into the form of year-on-year growth rates and this transformation removes the seasonality from original data. The data used for the Slovak republic are the following:

- real GDP (*y*) – at constant prices (chain-linked volumes with reference year 2005), mil. EUR, source: Eurostat;
- inflation (*dp*) – quarter-on-quarter changes in harmonized consumer price index (2005=100), source: Eurostat;
- short-term interest rate (*r*), 3-month interbank rate (%), source: OECD.

The most significant trading partners are represented by the following aggregates in the model:

- real GDP (*ys*) – at constant prices (chain-linked volumes with reference year 2005), mil. EUR, source: Eurostat;
- inflation (*dps*) – quarter-on-quarter change in harmonised consumer price index (2005=100), source: Eurostat;
- short-term interest rate (*rs*), 3-months interbank rate (%), source: OECD;
- exchange rate of SR towards the selected trading partners (*e1*) – average monthly nominal exchange rate of SKK/EUR until 31.12.2008 and EUR towards the foreign currency from 1.1.2009, sources: National Bank of Slovakia, Eurostat.

The global economy is characterized by the world exchange rate and price of oil:

- exchange rate EUR/USD (*e2*) – average monthly nominal exchange rate EUR/USD, source: National Bank of Slovakia and
- price of oil (*po*) – price of oil Brent in USD per barrel, source: U.S. Energy Information Administration.

To obtain unbiased estimates of VAR model, the input data are analysed on stationarity by means of Augmented Dickey-Fuller unit root test, all three variants of the test are given in the Table 1.

variable	trend+constant t-stat/sign.	const t-stat/sign.	none t-stat/sign.
y	-3.23(0.09)	**-3.25(0.02)**	-2.24(0.03)
dp	-6.40(0.00)	**-6.46(0.00)**	-6.52(0.00)
r	-4.61(0.00)	-4.59(0.00)	**-4.43(0.00)**
ys	-4.06(0.01)	**-2.90(0.05)**	-2.24(0.03)
dps	-3.38(0.06)	-4.34(0.00)	**-4.38(0.00)**
rs	-1.86(0.66)	-1.60(0.48)	**-1.76(0.07)**
e1	-2.26(0.45)	-2.32(0.17)	**-2.23(0.03)**
e2	-3.42(0.06)	-3.38(0.02)	**-3.23(0.00)**
po	-4.84(0.00)	**-4.90(0.00)**	-4.04(0.00)

Table 1 Testing unit root of variables in levels

The highlighted values are significant for the corresponding variables; trend was insignificant in all the tested time series. According to the results of the test all time series are stationary – I(O) at the significance level of 10%.

3.2 VAR model

VAR model in reduced form (4) is estimated for the vector of endogenous variables $Y_t=(y_t\ dp_t\ r_t\ ys_t\ dps_t\ rs_t\ e1_t\ e2_t\ po_t)$. Regarding the relatively short time series the lag length is set to 2. This lag is verified by the Akaike criterion suitable to use in the cases the model is the best approximation in the information-theoretical sense, as mentioned in [3]. The estimated VAR is stable and its residuals contain no autocorrelation, no heteroskedasticity, however, the normality of residuals is questionable according to the Jarque-Berra test.

To analyse the reaction of domestic economy to foreign shocks the Cholesky decomposition is used. The ordering of variables is proposed on the basis of Granger causality test. Table 2 presents the significance levels at which the hypothesis can be rejected about the uselessness of other endogenous variable to explain the variance of particular variable. With the exception of domestic interest rate the results suggest that all other variables can be explained with this bunch of variables.

y	dp	R	ys	dps	rs	e1	e2	po
0.00	0.01	0.63	0.00	0.02	0.00	0.10	0.06	0.08

Table 2 Results of Granger causality test

The variables are ordered as follows: *(r e1 po e2 dps rs ys dp* y). The impulse response functions follow the effect of shock from one period on innovations of selected time series. The impulses influence the other endogenous variables also indirectly through the dynamic structure of lags in VAR model. The effect of common component is assigned to the first variable in the order.

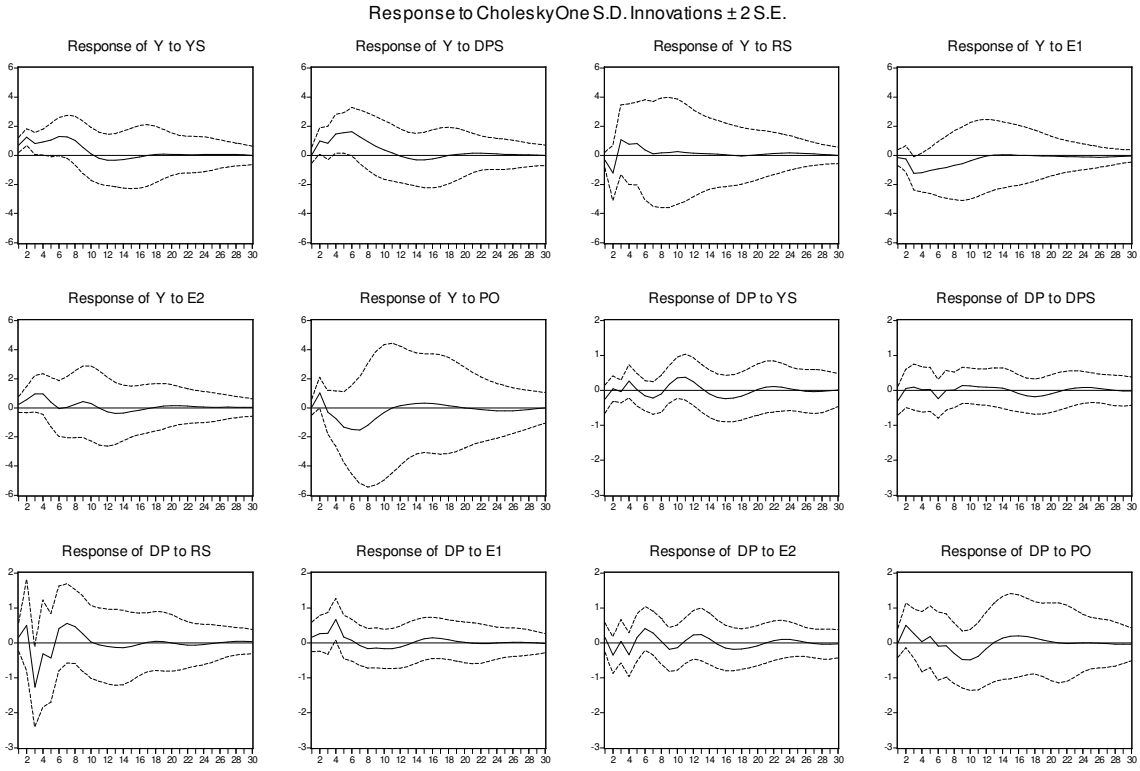

Figure 1 Impulse response functions from Cholesky VAR

Figure 1 contains the impulse response functions for two domestic variables – GDP and inflation (regarding the results of Granger causality test the impact on the interest rate is not analysed). The impact of six following foreign shocks is analysed: foreign demand shock represented by increasing economic activity in trading partners (*ys*), foreign price level (*dps*), foreign interest rate shock (*rs*), two exchange rate shocks - exchange rate of Slovakia vs. trading partners (*e1*) and world exchange rate (*e2*), and supply shock – the development of price of oil at world market (*po*). Each shock simulates a 1% change in standard deviation of innovation. The strong

impact on the domestic economic activity was proved for all analysed shocks; however, the strongest fluctuation was caused by the shock in foreign price level, where the positive peak was achieved after one and half year. The faster reaction of increasing domestic GDP resulted from the foreign demand shock and supply shock – it was recorded already in the second quarter. On the other hand, the negative fluctuations in GDP could be explained with the increased price of oil and increased foreign interest rate. The responses for domestic inflation to foreign shocks show that inflation is not much dependent on the foreign environment. According to the results the highest impact can be assigned to the foreign interest rate where the increase in interest rate caused the decrease in domestic inflation.

3.3 SVAR model

The long-run restrictions imposed on the matrix C are needed for the structural model to be identified. The long-run effect of the proposed shocks on the endogenous variables is given by:

$$\begin{pmatrix} po_t \\ e2_t \\ e1_t \\ rs_t \\ dps_t \\ ys_t \\ r_t \\ dp_t \\ y_t \end{pmatrix} = \begin{pmatrix} C_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & C_{22} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ C_{31} & C_{32} & C_{33} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & C_{43} & C_{44} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{55} & 0 & 0 & 0 & 0 \\ C_{61} & 0 & 0 & C_{64} & C_{65} & C_{66} & 0 & 0 & 0 \\ 0 & C_{72} & 0 & C_{74} & C_{75} & C_{76} & C_{77} & 0 & 0 \\ 0 & 0 & C_{83} & 0 & 0 & C_{86} & C_{87} & C_{88} & 0 \\ C_{91} & C_{92} & C_{93} & 0 & 0 & C_{96} & C_{97} & C_{11} & C_{99} \end{pmatrix} \begin{pmatrix} u_t^{po} \\ u_t^{e2} \\ u_t^{e1} \\ u_t^{rs} \\ u_t^{dps} \\ u_t^{ys} \\ u_t^{r} \\ u_t^{dp} \\ u_t^{y} \end{pmatrix}$$

The restrictions on the foreign variables are imposed according to the correlations of original variables (if the pairwise correlation between variables is below 0.1, the restriction is set to 0) and the restrictions on the domestic variables are set according to the theoretical background – the domestic variables includes the shocks of all variables contained in the equations (1), (2), (3); two insignificant parameters were restricted to 0.

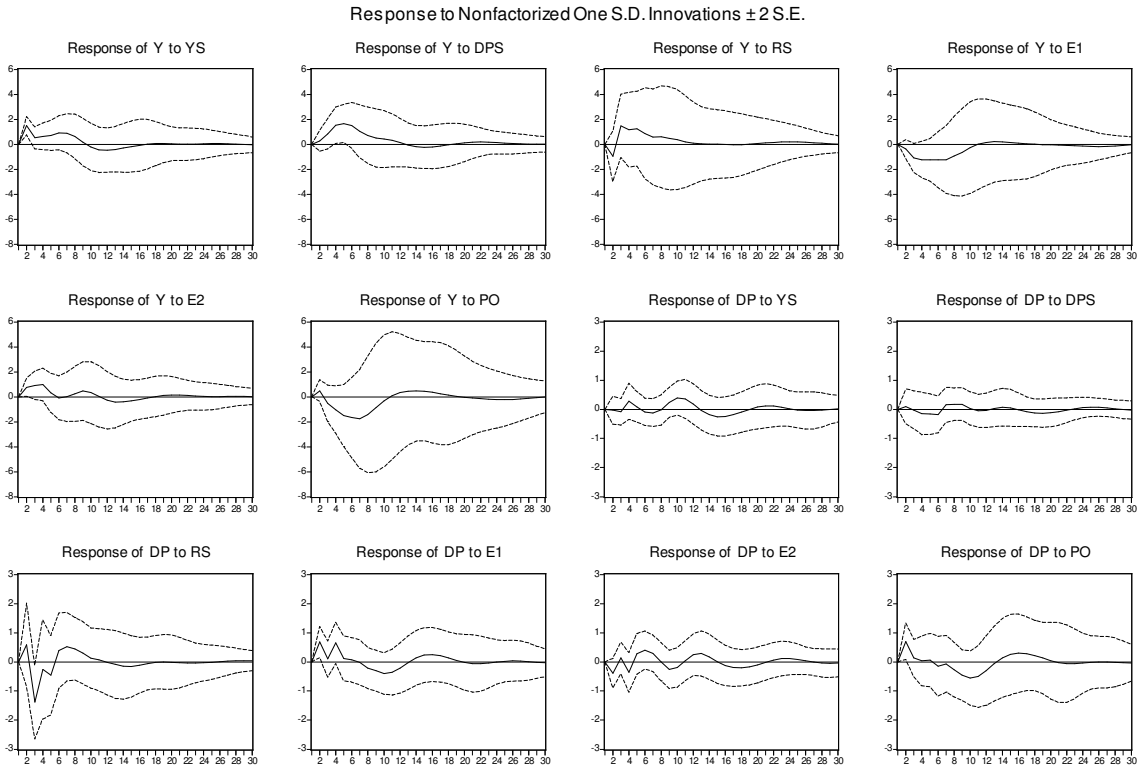

Figure 2 Impulse response functions from SVAR

The model identifies 9 structural shocks, but to be consistent with the assumption of a small open economy, domestic shocks are not allowed to affect the world variables. All parameters of the estimated SVAR are significant and the model is used to analyse the responses of domestic real GDP and inflation to the foreign shocks (Figure 2). At the first glance the results are similar to those from the Cholesky VAR, the highest responses are obtained from the same sources of shocks. Anyway, there are some differences discussed in the last section.

4 Summary results

The analysis of fluctuations of domestic macroeconomic indicators has confirmed the strong impact of foreign shocks coming from the main trading partners, especially on the domestic economic activity. The responses of Slovak indicators are summarized in the Table 3. However, some of the results coming from Cholesky VAR have not to be in compliance with the economic theory, so the model should be adjusted in this respect. The preliminary SVAR model suggests the opposite effects of shocks e.g. in the case of foreign interest rate shock and price of oil shock upon GDP. The domestic inflation responses essentially only to the foreign interest rate shock which causes the decrease in inflation.

shock	peak VAR	timing VAR	average VAR	peak SVAR	timing SVAR	average SVAR
Response of y						
u_t^{ys}	1.25	2	0.27	1.49	2	0.14
u_t^{dps}	1.65	6	0.33	1.66	5	0.30
u_t^{rs}	-1.33	2	0.08	1.49	3	0.25
u_t^{e1}	-1.45	5	-0.34	-1.24	5	-0.28
u_t^{e2}	0.87	3	0.09	1.00	4	0.11
u_t^{po}	1.06	2	-0.10	-1.76	7	-0.25
Response of dp						
u_t^{ys}	0.38	11	0.00	0.39	10	0.02
u_t^{dps}	-0.27	1	-0.01	0.18	9	0.00
u_t^{rs}	-1.26	3	0.00	-1.38	3	-0.01
u_t^{e1}	0.67	4	0.04	0.69	2	0.03
u_t^{e2}	0.41	6	0.01	0.40	6	0.00
u_t^{po}	-0.41	10	-0.02	0.70	2	-0.01

Table 3 Summary of responses for real GDP and inflation

Considering the preliminary version of the presented SVAR model further research should be oriented on the more detailed analysis of economic relations between the macroeconomic variables.

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