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The Nature and the Importance of Foreign Shocks in Slovak Economy: a block exogeneity VAR analysis

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Prohlášení

Prohlašuji, že jsem bakalářskou práci vypracoval samostatně a použil pouze uvedené prameny a literaturu.

V Praze dne 2.6.2008 ……..……..

Marek Rusnák

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Further, I wish to thank my mother, sisters and in particular, all of my friends for all their love, patience and support.

Abstract

This thesis provides the evidence about the nature and the relative importance of domestic and foreign shocks in Slovak economy. We estimate a seven variable Vector Autoregressions system with block exogeneity restriction. Using impulse response analysis, we examine the size and the persistence of the effects of the shocks on the economy. First, we estimate the effects of domestic monetary policy shock. Next, we turn our attention to the effects of foreign shocks. Further, we study the relative importance of foreign shocks in explaining the fluctuations in Slovak aggregate variables. The results indicate that the effects of monetary policy shocks in Slovakia are consistent with economic theory. Moreover, the foreign shocks seem to play an important role in explaining the variation of the Slovak macroeconomic variables, especially for the price level.

JEL classification: F41, E3, E52

Keywords: vector autoregressions, block exogeneity, small open economy, monetary policy shocks, external shocks

Abstrakt

Táto práca sa zaoberá dopadmi a dôležitosťou domácich a zahraničných šokov pre slovenskú ekonomiku. Odhadneme model vektorových autoregresií, kde pri identifikácii využívame takzvanú block exogeneity restriction. Analyzujeme veľkosť a perzistentnosť dopadov šokov na slovenskú ekonomiku. Budeme sa zaoberať domácimi a zahraničnými šokmi v monetárnej politike. Ďalej posúdime relatívnu dôležitosť zahraničných šokov pre slovenskú ekonomiku. Výsledky ukazujú, že dopady šokov v slovenskej monetárnej politike sú v súlade s ekonomickou teóriou. Okrem toho naznačujú, že zahraničné šoky hrajú dôležitú úlohu pri vysvetlení fluktuácii slovenských makroekonomických veličín, to platí obzvlášť pre cenovú hladinu.

JEL klasifikácia: F41, E3, E52

Kľúčové slová: vektorové autoregresie, block exogeneity, malá otvorená ekonomika, šoky v monetárnej politike, zahraničné šoky

Contents

1. Introduction

Over the past decades, countries are becoming more and more connected through the international trade. Naturally, with the deepening of economic interlinkages, it seems appropriate to suppose that economic environment and state of the economy in one country might possibly influence the happening in the neighbor countries, to a large extent.
Consequently, the proper knowledge about the transmission of foreign shocks is important for policymakers, especially in small open economy, such as Slovakia.

Slovakia is expected to join the European monetary union in January 2009. It might be of interest to study whether the monetary transmission in Slovakia operates similarly to Euro area countries. Moreover, understanding the role of euro zone shocks in the fluctuation of Slovak aggregate variables may help policymakers to react properly to unexpected fluctuations in domestic and foreign variables. Further, it may shed more light on the appropriateness of the decision to join the Eurozone.

Since the evidence on the effects of external shocks on the small open economies in Central and Eastern Europe is scarce, this thesis will attempt to contribute to the discussion, while focusing on the country, which hasn't been analyzed so far. More specifically, the thesis will examine mainly the effects of the foreign shocks on the Slovak economy.

The contribution of the thesis is twofold. First, the effects of domestic interest rate based monetary policy shocks in Slovakia were not explored in the existing empirical literature.[1] Therefore, we make use of Vector Autoregressions (VARs), which are standard empirical technique to analyse the effects of monetary policy on macroeconomic variables. By estimating VAR system, we investigate the monetary transmission in Slovak economy for the 1999-2006 period. Second, to our knowledge, there is no evidence about the effects of foreign shocks on Slovak economy. For that reason, we examine the interactions between Slovak and Euro area economies. We focus on the size and persistence of the domestic and foreign shocks in Slovakia. Furthermore, we assess the relative importance of foreign shocks in explaining the macroeconomic fluctuations of Slovak aggregate variables.

[1] The only study focusing on Slovakia is by Kuijs (2002) who estimates structural VAR with error correction mechanism for 1993-2000 period i.e. transformation period where fixed exchange rate arrangement and monetary aggregates targeting were in effect for most of the time. However, he finds no direct effect on prices or output. We investigate the interest rate based monetary policy and thus provide the up-to-date evidence on the monetary transmission in Slovakia.

To indicate the results in the thesis, our VAR model seems to be successful in identifying the domestic monetary policy shocks.[2] The responses appear to be in line with economic theory. Following the unexpected domestic monetary tightening the interest rate increases, the price level drops, the output decreases (although not significantly) and the nominal exchange rate appreciates. The effects are transitory and the typical domestic monetary policy shock seems to have no persistent effect on the economy.

Besides, the euro area monetary policy shocks affect the Slovak interest rate quickly and strongly. Furthermore, we find that the Slovak price level declines significantly and persistently in reaction to the unexpected euro area interest rate contraction. Additionally, the results suggest that foreign shocks are crucial in explaining the fluctuations of the Slovak price level. On the other hand, the fluctuations of the output are mainly due to domestic factors.

The thesis is organized as follows. Section 2 reviews the relevant VAR literature. Section 3 provides theoretical motivation for the topic. Next, section 4 describes the data used in estimation. Section 5 considers the estimation issues. Section 6 presents the empirical model while section 7 contains the results. Section 8 considers the robustness of the model. Finally, Section 9 concludes by summarizing the results.

[2] Monetary policy shocks are defined as changes in the interest rates not explained by the variables (and their lags) included in the system. For example, one plausible economic interpretation for monetary policy shock might be a shift in the preferences of the monetary authorities. For other interpretations, see Christiano et al. (1998).

2. Review of the literature

2.1. The Origins

The Vector autoregressions (VARs) modeling goes back to the pioneering work of Sims (1980) and his seminal paper named Macroeconomics and Reality. He reacts to the state of macroeconomic modeling in that period by critique of the large structural models and the "incredible restrictions" used. Adding more variables and equations to the models often did not result in improvements of the forecasting performance. In addition to the identification issues of the large structural models, another possible explanation for the poor performance was the fact that they did not allow for the dynamic interactions between the variables in the system. Sims addresses the issues by proposing the new technique – the vector autoregressions. Modeling the economy by the VAR system makes minimal identifying restrictions and takes all the variables as endogenous and this enables it to capture the rich dynamics present in relations of the macroeconomic variables. Since then, many researchers applied the technique. For instance, the VARs are especially popular in the study of the monetary transmission.[3]

Stock and Watson (2001) assess how well VARs address four main macroeconometric tasks – data description, forecasting, structural inference and policy analysis. In first two tasks they find VARs "powerful and reliable tools", but the latter two tasks are more difficult because of the "identification problem". As they point out, even though VARs have limitations in structural inference and policy analysis, so do the alternatives. Calibrated dynamic stochastic general equilibrium models do not fit the data well and in case of simple single equation models it is difficult to distinguish between correlation and causality.

However, the VAR methodology was subject to the criticism. The main reprimand is their atheoretical approach and ad hoc identification. More sharp critique of VARs is by Rudebusch (1998), where he points out several problems of the standard VAR reaction function such as a time invariant, linear structure, a restricted information set, the use of final, revised data and long distributed lags.

Further, Enders (2004) notes that, the early VAR modeling was in the spirit of minimal identifying restrictions and could be considered as atheoretical. No prior beliefs from the

[3] For the review of the monetary transmission research focused on U.S., see Christiano, Eichenbaum and Evans (1998) or Leeper et al. (1996).

economic theory were imposed. The only creative role for the applied econometrician was to choose the variables and select the appropriate lag. However, even the simplest identification technique, recursive (Choleski) approach, is sensitive to the ordering of variables. This type of identification invokes Wold causal chain. And because the residuals from VAR are often correlated, different orderings produce different results. This sensitivity to the ordering of variables is not the only problem of VARs.

2.2. Some puzzles in VAR literature applied to monetary transmission

In the vast empirical literature, the numerous counterintuitive results occurred. These findings, named as puzzles, are inconsistent with the economic theory and cast doubts on the ability of empirical research to identify the monetary shocks correctly.

Kim and Roubini (2000) identify the 4 types of anomalous findings, which were present in the empirical literature on the effects of monetary policy.

1. The liquidity puzzle

An observation, that a shock represented by the innovation in money is associated with increases in nominal interest rate, got the name the liquidity puzzle. Sims (1992) proposed the use of innovations in short term interest rates as indicators of change in monetary policy. However, one puzzle was just substituted by the other – the infamous price puzzle followed.

2. The price puzzle

Disreputable enough, at least for the macroeconometric profession, finding that a shock represented as interest rate hike results in increase in the price level was labeled as the price puzzle. Yet, readily after observing the price puzzle, Sims (1992) argued that the puzzle is caused by the model misspecification, more precisely, the lacking forward looking component in modeling the monetary authority reaction function. He suggested the use of commodity prices in order to overcome the price puzzle.[4]

Another approach to solve the puzzle was proposed by Sims and Zha (1995). They came with the idea of structural VAR modeling. Instead of using the recursive identification scheme, they employ the structural contemporaneous restrictions across different equations. Thus they are able to exploit the price data to capture inflationary expectations to overcome the puzzle.

[4] On the contrary, Coricelli et al. (2006) suggest that the only reason why commodity prices might help to solve the puzzle is that they are correlated with the US business cycle.

Since then the structural VAR modeling became usual approach in the study of the effects of monetary policy. Applied by, for instance, Kim (1999), Kim and Roubini (2000) and recently by Anzuini and Levy (2007).

From the different perspective, Barth and Ramey (2001) claim that the puzzle is the consequence of the prevailing supply (cost) channel of the monetary transmission mechanism.

Additionally, Giordani (2004a) derives explicitly how can the use of output without controlling for the potential output bias the estimates and thus possibly bring about the price puzzle. Hence he proves that omission of a measure of output gap can spuriously produce the puzzling result. Further, he argues that the commodity price index, traditionally included in VARs to solve the price puzzle, alleviates the puzzle mostly because it contains useful information about the output gap[5], not because it is a good predictor of future inflation (which it really is).

Finally, Castelnuovo and Surico (2006) find that the positive responses of prices to a monetary policy shock are historically limited. According to them the puzzling responses are only present in the periods when the reaction of a central bank to inflation was weak. They exemplify the pre Volcker period in the US and the period before the introduction of the inflation targeting in the UK.

3. The exchange rate puzzle

Another puzzling result is the observation that following the monetary contraction the currency value depreciates on impact.[6] Sims (1992) and Grilli and Roubini (1995) argued that once the price puzzle is explained, the exchange rate puzzle is explained as well.

Indeed, Kim and Roubini (2000) address the price and the exchange rate puzzle by employing the structural VAR to model the open economy. Their non-recursive identification scheme, which exploits the economic theory, is able to produce results that are consistent with broad set of theoretical models and shows no signs of puzzling anomalies. The main modification is that they allow the monetary authority to react to exchange rate movements.

[5] In the sense that commodity prices are correlated with the output gap.
[6] This is found mainly for the G7 countries. E.g. Sims (1992) observes that after the interest rate innovation for the France and Germany the large and persistent depreciation of the currency follows.

4. The forward discount puzzle

A positive interest rate differential on domestic assets is associated with persistent appreciations of the domestic currency. This is related to the "delayed overshooting" of exchange rates in VAR responses to interest rate shocks. This phenomenon is found by Eichenbaum and Evans (1995) and Grilli and Roubini (1995).

The puzzles, however, were fairly successfully solved mostly by structural VAR approach or including the appropriate variables.[7] And over the years, VARs have become one of the most employed tools in the empirical macroeconomic research.

2.3. Different identification schemes and VAR modifications

Since many different attitudes to the identification in VAR were mentioned, in this subsection we summarize the main approaches to the identification of the shocks in VAR systems.

In the first use of VAR, Sims (1980) identified the shocks using recursive approach. This approach decomposes the residuals in a triangular fashion i.e. the matrix relating the regression residuals and structural disturbances is a lower triangular. This approach is also called a Choleski decomposition. This scheme proved to be powerful for the study of monetary transmission in the U.S. (for an excellent survey, see Christiano et al., 1998)

Nevertheless, when modeling the small open economies by VAR, recursive identification seemed to be unsatisfactory. Therefore, to utilize the economic theory, the non-recursive identification was proposed. The matrix that identifies the relation between the structural disturbances and the reduced form residuals takes the general form. The individual equations are given an economic meaning e.g. money supply, money demand equations are modeled. Moreover, the price stickiness or adjustment cost assumptions are employed. This approach was suggested by Sims and Zha (1995)[8] and further developed by many authors, for example Cushman and Zha (1999). Only recently, this approach has begun to be used in the study of the fiscal shocks too, e.g. Blanchard and Perotti (2002).

Completely different way to identify the shocks is pursued by Blanchard and Quah (1989). By estimating bivariate VAR (real GNP and unemployment), they decompose real GNP into its

[7] To find out more about the solutions, see Kim and Roubini (2000).
[8] According to Enders (2004), the origins of the idea go back to Sims (1986) and Bernanke (1986).

temporary and permanent components and identify demand and supply side shocks. They do so by imposing the long run restrictions. Further, Clarida and Galí (1994) extend the approach by studying the sources of real-exchange rate fluctuations and identifying three structural shocks, demand, supply and money.

To address the issue of possible omitted variables bias, which can arise because of limited number of variables that can be included in the VAR systems, Bernanke et al. (2004) come up with the idea of Factor Augmented VARs. They argue that monetary policy authorities have much wider information set at their disposal, compared with just a few variables usually included in VARs. They suggest the use of factors to proxy for the plethora of series that central bankers look at when conducting the monetary policy. Recently, Borys and Horváth (2007) applied the FAVAR methodology on the Czech data.

Next, and very relevant to our study, Jarocinski (2006) correctly notes that estimation of the VARs for the post-communist countries, where only short samples are available results in estimates which are very sensitive to small changes in sample or specification and suffer from a high degree of uncertainty.[9] Therefore, he makes use of Bayesian estimation procedure, which combines the information across the countries. Bayesian VAR models were introduced by Litterman (1980). Since then, the technique has become quite popular.

One very attractive feature of Bayesian approach, as noted by Sims et al. (1990), is that it does not require special treatment of cases where unit roots are present in a time series model.[10] For instance, Kim and Roubini (2000) estimated their structural VAR from Bayesian perspective. Besides, Maćkowiak (2005, 2006 and 2007) uses almost solely the Bayesian inference. Furthermore, Canova (2005) and Jarocinski (2006) use Bayesian methodology and impose the so called sign restrictions in their papers.

2.4. Small Open Economy VAR modeling

Moving towards the focus of our study we will review the relevant literature. While most of the literature where the VAR are used focuses on study of the monetary transmission mechanism, the technique can be applied to the wider range of topics. The question of how

[9] Indeed, our sample is very short, and we experience the qualitative changes in estimates when changing the sample period.

[10] It is because the Bayesian inference is almost entirely based on the likelihood function, which has the same Gaussian (normal) shape regardless of the presence of unit roots or nonstationarities. Sims and Uhlig (1991) come to same conclusion.

the external shocks affect the small open economy can be addressed as well. Using the powerful tools of VAR analysis, it is possible to estimate the impact of the foreign shock, its size and the persistence. We might as well assess the importance of the external variables by studying how much variation in the home economy's fundamentals is explained by the external shocks. However, the empirical evidence on this topic is still relatively scarce, being overshadowed by the monetary transmission topic.

After all, the focus of researches is gradually turning into this direction. Indeed, it is documented by the studies of Cushman and Zha (1997), Kim (2001), Giordani(2004b), Canova (2005) and abundantly by Maćkowiak (2005, 2006 and 2007)

First, Cushman and Zha (1997) consider the interactions between the U.S. and Canadian economy, when identifying the Canadian monetary policy. Further, they utilize the block exogeneity restriction. The restriction exploits the assumption that the small economy cannot influence significantly the developments in the large economy. Nevertheless, they just account for the interactions by including the U.S. block into the system, and thus controlling for external shocks. Ultimately, they focus only on the assessment of domestic (Canadian) monetary shock, leaving the impact of U.S. shocks unstudied.

Kim (2001) studies the effects of U.S. monetary policy shocks across non-U.S. G7 countries. He finds that U.S. monetary expansion has a positive spillover effect on output in studied countries. What is more, expansion leads to a short run deterioration of the trade balance, but the balance improves persistently in the medium to long run. Further, contrary to Grilli and Roubini (1995) suggestion that non-U.S. G7 countries monetary policy substantially follow the U.S. monetary policy, he shows that when one controls for inflationary or supply shocks, the reaction of non-U.S. monetary authorities endogenous to U.S. monetary policy seems not to be very strong.

Next, Giordani (2004b) 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[11] and compares it with empirical VAR, using Bayesian inference. He uses U.S. – Canada pair in empirical estimation and finds that U.S. shocks are a very important

[11] Specifically, he estimates the modified version of the model by Svensson (2000).

source of variation in all Canadian variables. His conclusion includes the advice that foreign variables should figure prominently in both optimal and actual policy rules.

Additionally, Canova (2005) gave evidence about the importance of the effects of the U.S. monetary policy shocks on the Latin America economies. He explains it by rather tight financial linkages with the U.S. economy, as opposed to explaining the transmission of shocks by the trade linkages. Interestingly, he founds no major difference in between transmission of shocks in countries with fixed exchange regime and economies with more flexible arrangements.[12]

Maćkowiak (2005) asks to what extent is the macroeconomic variation caused by external shocks. He examines Czech Republic, Poland and Hungary. Using Germany as a proxy for external shocks, he sets up a model consisting of key macro variables from both Germany and the particular small open economy country. He uses Bayesian inference and exploits block exogeneity assumption. The main finding of his paper is that the sizeable amount of the variation in the variables is attributable to external shocks. He estimates that external shocks account for approximately 60-85% of the variance in price level in the studied countries. The corresponding estimate for the real output is 25-50%. When considering the external monetary shock he also finds that interest rate shocks explain a sizeable fraction of the external shocks. He finds the remarkable similarity of the effects of euro area shocks in the Czech Republic, Poland and Hungary as in Germany.

More recently, Maćkowiak (2006) again studies the impact of Japanese monetary shocks on macroeconomic variation in East Asia economies (the neighbors of Japan – average of Hong Kong, Korea, Malaysia, Philippines, Singapore and Thailand). Using structural VAR estimated using Bayesian methodology he concludes that Japanese monetary shocks account for only small fraction of the variance in real output, trade balances and exchange rates in East Asia. Especially, 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.

[12] This finding could possibly allow us to include data prior to 1999, when Slovakia had a fixed exchange rate regime, but ultimately we study just the period after 1999. First, since it is a regime switch and thus we could be exposed to the so-called Lucas critique. Second, the Slovak economy was in a period of intense transformation from centrally planned economy to a market one.

Finally, Maćkowiak (2007) estimates 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 per cent 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 U.S. monetary policy shocks are not important for emerging markets as opposed to other kinds of external shocks, 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 U.S. monetary policy tightening are bigger than in the U.S. itself.

3. Theoretical Motivation

3.1. The small open economy

We feel that more open economies are prone to be more vulnerable to external shocks. Therefore, using the *Penn World Tables database* we set up a table with ten most open economies in the world and included some countries that we find interesting to take account of. A pure glance at the Table 1 shows that Slovakia belongs to the most open economies in the world. On the other hand, countries like Germany, China, U.S. and Japan are among the most closed economies.

Table 1: Openness

	Country	openness[13]
1.	Singapore	462.93
2.	Hong Kong	343.39
3.	Luxembourg	281.97
4.	Slovak Republic	186.78
5.	Estonia	184.14
6.	Maldives	181.72
7.	Hungary	179.98
8.	Czech Republic	179.23
9.	Ireland	176.67
10.	Belgium	173.99
34.	Korea, Republic of	95.46
40.	Canada	81.81
50.	Germany	76.57
56.	Poland	69.47
63.	United Kingdom	59.91
64.	France	57.47
67.	China	54.38
77.	United States	26.6
78.	Japan	23.42

Source: Penn World Tables 6.2 (http://pwt.econ.upenn.edu/)

Moreover, we also expect that the effects of one country on another should be most obvious in case of the main trading partners. Therefore we compile the Table 2, which report on the main trading partners of Slovakia.

[13] Values for 2004. Openness measured at constant prices. Defined as exports plus imports divided by the real GDP.

Table 2: Slovakia's Main Trading Partners in 2005

	Trade	Imports+Exports[14]	Share
	Total	53 230 217	100.00%
	EA12	23 933 902	44.96%
	Neighbors	16 036 264	30.13%
1	Germany	12 298 039	23.10%
2	Czech republic	7 159 589	13.45%
3	Russia	3 361 976	6.32%
4	Italy	3 008 738	5.65%
5	Austria	2 904 024	5.46%
6	Poland	2 739 082	5.15%
7	Hungary	2 513 265	4.72%
8	France	1 891 676	3.55%
9	United Kingdom	1 278 376	2.40%
10	Netherlands	1 251 120	2.35%
11	United States	1 188 407	2.23%
12	China	1 000 259	1.88%

Source: Slovak Statistical Office (http://www.statistics.sk)

When considering the individual countries the main trading partners are Germany, Czech Republic and Russia. Additionally, we find that the trade with the Euro area account for almost 45%. In a way, that justifies our decision to focus on Eurozone – Slovakia interactions.

Our hypothesis is that shocks originating from the Eurozone have significant impact on the Slovak macroeconomic variables in the short to medium run. We will look at the relative importance of the foreign shocks as opposed to domestic shocks. The contribution of the respective shock to the variation in the different time horizons will be examined. Next, we turn our attention to the question of the effects of the foreign monetary shock, represented by the innovation in the eurozone short term interest rate. We will assess the size, persistence and qualitative response of the Slovak aggregates to the foreign monetary contraction. Taking into consideration the results of the similar study by Maćkowiak (2005), where he estimates the effects of Germany's shocks on Czech Republic, Poland and Hungary, we expect that the effects should be similar for Slovakia as well.

3.2. Rationale for the choice of variables

The theoretical justification for the choice of variables is the vintage of New – Keynesian models exposed in, for example Svensson(2000), Galí & Gertler (2007) and Galí & Monacelli (2005).

[14] Values in thousand of euros.

We present here a version of the small open economy model by Svensson (2000), which was modified by Giordani (2004b).

In simple terms, the model consists of 3 basic equations: an IS curve, a Philips curve and a monetary policy rule for setting a short interest rate. In open economies each equation may be augmented by the exchange rate and foreign variables.

We very briefly describe the equations for the small open economy.

Partially forward looking pricing rule (Phillips curve):

$$\pi_{t+1} = \alpha_\pi \bar{\pi}_t + (1-\alpha_\pi)\pi_{t+2|t} + \alpha_x x_{t+1} + \alpha_q (q_t - q_{t-1}) + \varepsilon^{CP}_{t+1} \quad (1)$$

For any variable v, $v_{t+\tau|t}$ denotes $E_t v_{t+\tau}$. π_t is annualized quarterly CPI inflation, $\bar{\pi}_t$ is annual 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 (which is modeled as an exogenous process); q_t is the log real exchange rate. ε_t^{CP} is a cost-push shock, $\varepsilon_t^{CP} \sim nid(0, \sigma^2_{CP})$. We assume lags in the effects of monetary policy. Similarly, lagged pass-through of exchange rate changes is assumed.

IS/AD equation:

$$x_{t+1} = \beta_x x_t + (1-\beta_x) x_{t+2|t} - \beta_i (i_t - \pi_{t+1|t}) + \beta_{x^*} x^*_{t+1} + \beta_q q_{t+1|t} + \varepsilon^{AD}_{t+1} \quad (2)$$

where i_t the instrument of monetary policy (e.g. a short interest rate) and x_t^* is the foreign output gap. All coefficients are expected to be positive. ε_t^{AD} is an aggregate demand shock, $\varepsilon_t^{AD} \sim nid(0, \sigma^2_{AD})$. Interest rate movements affect output with a lag.

The exchange rate fulfills **uncovered interest parity:**

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

A Taylor-type policy rule:

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

where ε_t^{MP} is a monetary policy shock, $\varepsilon_t^{MP} \sim nid(0, \sigma^2_{MP})$.

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

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.
So the variables we include in the model are as follows: output gap, aggregate price level, interest rate and their foreign counterparts plus the bilateral exchange rate.

Contrary to the most of the literature, we do not include the money aggregate. First, money supply is not implied by the theoretical model. Second, we assume that the Slovak monetary authorities target the short term interest rate, so the money supply is simply adjusted with this objective. And finally, the ultimate reason not to include the money aggregate is that our model with 7 endogenous variables is already large by VAR modeling standards, so we prefer to conserve the degrees of freedom and estimate the model without money supply.[15]

[15] The inclusion of money aggregate would bring additional information about the money demand; however, the identification of money demand goes beyond the focus of our study.

4. The Data

In this section we describe the data we use in the estimation. The data are at the monthly frequency. We use monthly observations in order to maximize the number of observations. The drawback is that the measures of output – *the real GDP* and *the output gap*[16] are not available monthly, so they have to be interpolated.[17]

The sample is restricted to run from January 1999. There are two basic reasons for this. First, the Eurozone came into being on 1st January 1999, when euro was introduced and the responsibility for the monetary policy of the member states were put to the hands of 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.

The data span from 1999:1 – 2007:12. Consequently, we have 108 observations.
The data were obtained from the Eurostat database. We downloaded the measures of the *real GDP (seasonally adjusted, millions of national currency at 1995 prices)*. Next, the measures of price level were obtained – we opted for *Harmonized index of consumer prices (HICP).* Further, the *3-month money market interest rates* are used. Finally, we use monthly averages of *nominal EUR/SKK exchange rate*.

Additionally, for robustness analysis, we use the *industrial production index (seasonally adjusted) (Slovakia: 93666..BZF..., Eurozone: 16366..CZF...)* which was acquired from IMF International Financial Statistics Database (February 2008).

The plot of all series is available in the Appendix.

[16] We obtained the output gap by applying the Hodrick-Prescott filter on the log of real GDP (seasonally adjusted, quarterly frequency), with the λ=1600.
[17] Quadratic match average procedure was employed using Eviews.

5. Estimation Issues

There are a couple of problems associated with the estimation of the VAR system for Slovak economy. First, the data sample is shorter compared to the data available for industrialized countries such as the G7 members. The small sample causes estimates to be very sensitive to individual observations, as well as changes to the sample span or specification of the model. Moreover, due to short sample, high uncertainty is usually present. Ideally, the use of Bayesian inference would seem as appropriate. Nevertheless, such a technical estimation procedure goes beyond the scope of our thesis. Usual "approach" when not using Bayesian VARs for small samples, is to "let the data speak for themselves" and try to recover reasonable results for the available dataset.[18] Second issue in the estimation is the fact that the official central bank interest rates varied widely from market interest rates in the early days of Slovak money market. Figure 1 gives support for the claim.

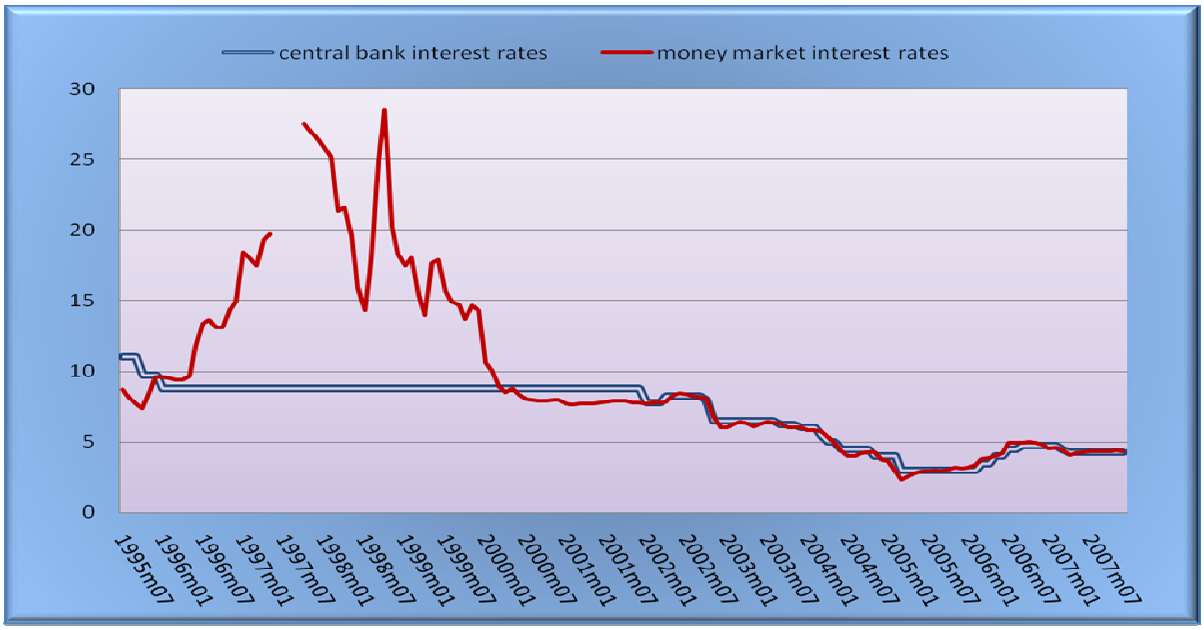

Figure 1: Official vs. Money Market interest rates[19] (Source: Eurostat)

Obviously, it was not until the end of 1999 that the two rates finally converged. This might be just the consequence of the fact that the central bank started to manage the money market by its instrument rate only in the beginning of 2000. In a different manner, Jarocinski (2006) offers also second explanation for the disaccord of the two rates in Slovakia. He suggests that it might be the big shocks in money demand which were not accommodated by the monetary

[18] Pursued for instance by Anzuini and Levy (2007).
[19] The Slovak money market was terminated during 29/5/1997 – 16/10/1997 period.

authorities that are responsible for the difference of the rates. Consequently, he as well as most other authors does not consider Slovakia in his study.[20]

Another problem we are facing in the estimation is the fact that Slovak economy is now, in its already post transformation period, experiencing an extraordinary growth. Indeed, this can be recognized easily from the Figure 2.

Figure 2: quarterly GDP growth (%) (Source: Eurostat)

Especially, the last two years have been really successful from the growth figures point of view. Unfortunately, the outstanding value of 14.3% growth in last quarter of 2007 brings on the problems from the estimation perspective.[21] The last observation clearly is the outlier in the sample. Indeed, when estimating our VAR system for the whole span 1999:1 – 2007:12, we observe counterintuitive impulse responses to euro area monetary policy shock.

What is more, taking account of the possibly biased inference in case we do not take account of potential output when using a measure of economic activity in the estimation (Giordani, 2004a) we prefer to include the output gap instead of GDP growth. Additionally, as pointed by Borys and Horváth (2007), the output gap gives more appropriate information about the degree of economic activity in the economy with dynamically changing potential output than

[20] Regardless, he considers Slovakia in robustness checks eventually.
[21] The explanation that the retailers arranged for supplies of cigarettes before the new year's tobacco tax increase appeared in the press. And according to revised data adjusted for the cigarette stockfiles, the growth in last quarter of 2007 was actually 9.7%. (Hospodárske noviny, 9 May 2008, http://ekonomika.hnonline.sk/c1-24649310-rast-hdp-v-prvom-kvartali-pravdepodobne-spomalil)

actual GDP growth does. Apparently, the potential of Slovak economy has been changing lately.

Unfortunately, the output gap is not observable. Therefore, we need to filter the (log) GDP series, in order to obtain the measure of output gap. We will employ Hodrick-Prescott (1981) filter. However, Hodrick-Prescott (HP) filter is not without flaws. As noted by Kočenda and Černý (2007), the HP filter often fails at the beginning and the end of the time series. To address this issue, we have decided to filter the quarterly real GDP (seasonally adjusted) series in the span 1998:1-2007:4 and estimate the baseline model only for the 1999:1-2006:12 period.[22] Additional rationale for doing so, is the presence of the outlier in 2007:4, which was mentioned earlier.

[22] The results for the whole period are presented in the sensitivity analysis section.

6. The Empirical model

6.1. The VAR in levels

Visual inspection of the plots of the series reveals that there are some nonstationarities present in the variables used for the estimation. The textbook approach would induce us to get rid of the nonstationarity, either by differencing or by modeling the cointegrating relationship. Nevertheless, we will take the advice of Sims et al. (1990) and estimate the VAR system in levels. The majority of empirical literature takes this approach. The reasons are as follows. First, in small samples, it is difficult to determine whether a cointegrating relationship is present. Second, imposing the cointegrating restriction inappropriately could possibly lead to incorrect inference. Finally, 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.[23]

All in all, because we are primarily concerned with the short term effects of the shocks on other variables in the system, and we are not so much interested in the structure of the cointegration, we will assume the cointegration between the variables in levels only implicitly, without explicitly modeling it.

6.2. The VAR model

In this section we present a seven variable VAR system to model the Euro area and Slovakia economies and their interactions.

We begin with a general specification. We assume 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. Hence we assume that structural disturbances are mutually uncorrelated. Formally,

$$E[\varepsilon(t)\varepsilon(t)' \mid y(t-s), s > 0] = I,$$

$$E[\varepsilon(t) \mid y(t-s), s > 0] = 0$$

[23] In the same fashion, Stock and Watson (1988) give advice to exploit the additional information contained in levels of variables rather then their differences.

6.3. The Baseline specification

We divide the model into a Slovak and a Euro area block. So we have,

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

The model contains m_1 domestic variables in a small open economy vector $y_1(t)$and m_2 variables external to the small open economy in vector $y_2(t)$. 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, industrial production) (x_t^{SVK}), a measure of price level (p_t^{SVK}), the short term interest rate (i_t^{SVK}) and the exchange rate ($e_t^{SKK/EUR}$):

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

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

$$y_2(t)' = \left(x_t^{EA} \quad p_t^{EA} \quad i_t^{EA} \right)$$

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

6.4. Imposing the block exogeneity restriction

Since we assume that Slovakia is a small economy and therefore we do not expect that the shocks originating from Slovak economy would have any significant effects on the euro area economy, we restrict the $A_{21}(L) = 0$. This, so called block exogeneity restriction has been employed by the studies of small (open) economies before.[24] Further advantage is that it reduces the number of parameters needed to be estimated. Besided, as claimed by Zha (1999), failing to impose the block exogeneity restrictions is not only economically unappealing but also may result in misleading conclusions.

[24] For example, by Cushman and Zha (1997) and more recently by Mackowiak (2005)

6.5. Identification Issues

In order to be able to carry out the estimation[25], we consider the reduced form:

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

where $B(L)$ is a polynomial matrix in the lag operator and $var(u(t)) = \Sigma$.

Since the residuals from the estimated reduced form VAR are composed of structural shocks, we need to recover the structural innovations.

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.

And $A^0(L)$ is the coefficient matrix in $A(L)$ without contemporaneous coefficient A_0.

We can rewrite structural equation as

$$A_0y(t) + A^0(L)y(t) = \varepsilon(t)$$

After rearranging and premultiplying the equation by A_0^{-1} we get

$$y(t) = - A_0^{-1}A^0(L)y(t) + A_0^{-1}\varepsilon(t)$$

So we see, that the relationship between the reduced form residuals and the structural shocks is

$$u(t) = A_0^{-1}\, \varepsilon(t)$$

Since there are less parameters estimated in reduced form VAR than in structural form, we are facing the so called identification problem. In order to obtain a just identified system we need to impose n x (n-1)/2 restrictions.

The most straightforward approach to identification is so called Choleski recursive scheme.[26] In the scheme, matrix A_0^{-1} is a lower triangular.

[25] As known from basic econometric courses and indeed, as noted in Enders (2004) standard estimation techniques require that the regressors be uncorrelated with the error term.

[26] When using this recursive identification scheme the ordering of the variables matters, and usually different orderings produce different results (especially in case of substantial crosscorrelation between reduced form residuals). To assess the robustness of our model, we later check how sensitive our results are to the change in the ordering of the variables.

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

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

By using this scheme we assume that the shock to the first equation affects all variables in the same period but the shocks to other equations do not affect first variable (output gap) contemporaneously. The second variable (price level) is affected contemporaneously by the first variable only, and so on.

The third equation could be viewed as the simplified version of the ECB reaction function. Therefore, the shock to the third equation can be seen as the monetary policy shock.

Similarly, the sixth equation can be interpreted as the reaction function of the National Bank of Slovakia. It assumes that Slovak central bank authorities take into account not only the Slovak output and price level figures but consider the euro zone fundamentals – output, prices, interest rate as well, when deciding on the interest rate settings.

One, potentially crucial, shortcoming of the scheme is that it does not account for the fact that Slovak monetary authorities look at the contemporaneous values of the exchange rate. This might be inappropriate assumption, since Slovakia is a small open economy. And as shown by Calvo and Reinhart (2000), the monetary authorities in open economies are very sensitive to exchange rate developments. We will address this issue in the sensitivity analysis section by using different identification scheme (we will order the policy instrument of NBS after the exchange rate, so that the central bank can react contemporaneously to the exchange rate shocks).

7. The Results

In the section we present the results from estimated VAR.[27] Due to reasons explained in the estimation issues section[28], we present the results for the 1999:1-2006:12 period.

First, we show the impulse response functions. By using impulse responses we can trace the dynamic effects of the particular shock on the other variables in the system. The impulse responses are accompanied by 95% confidence bands, which were bootstrapped using 250 replications according to Hall (1988).

Second, we present the variance decompositions. The forecast error variance decomposition tells us the proportion of the variability in a series that is due to its own shock as opposed to shocks to the other variables.

We estimated the model, using one lag, which was suggested by the Schwarz Bayes information criterion.[29] We include the complete set of seasonal dummies in all estimations in order to capture any additional seasonality effects.

7.1. The effects of Slovak monetary policy shocks

First, in order to get an idea about the monetary transmission mechanism of Slovak economy, we will investigate the responses of a domestic monetary policy shock. More precisely, we are interested in the effects of unexpected one standard deviation interest rate increase.

[27] All the estimations in this section were performed using statistical package JMulTi.
[28] Especially, because of the end-point bias of the HP filter and the outlier in Slovak output series.
[29] We set the maximum lag order equal to 6. When taking account of the small sample we have at disposal, higher order would be implausible due to degrees of freedom considerations. We are aware that the reduced form residuals might not be serially uncorrelated, but again given the short sample, we opted for preserving as many degrees of freedom as possible rather than eliminating completely the autocorrelation of residuals.

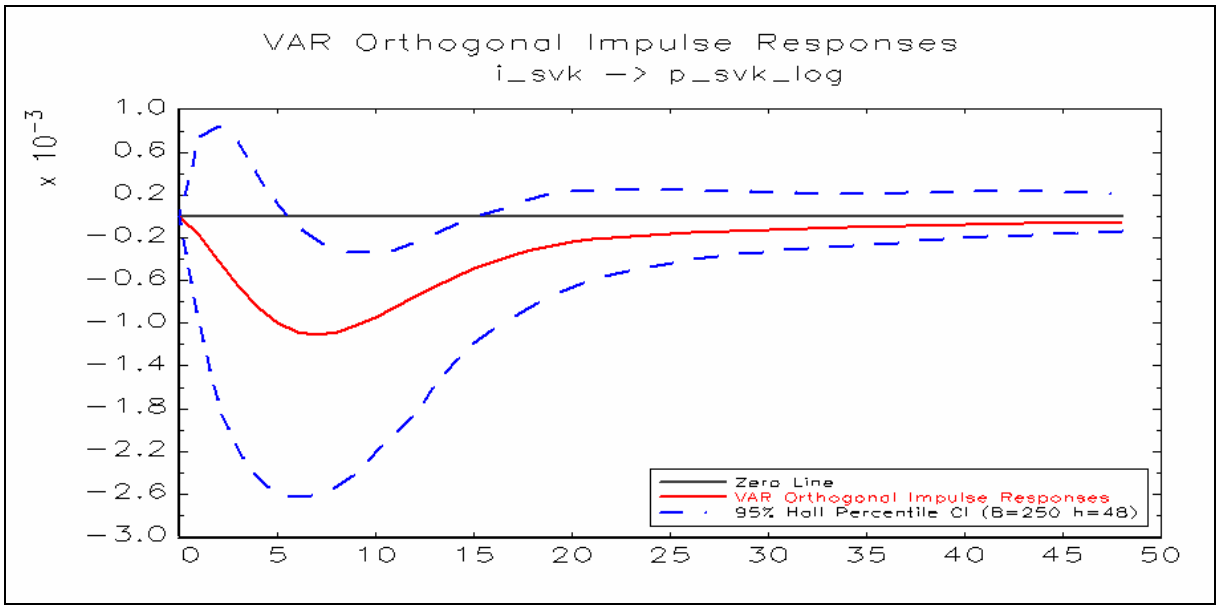

Figure 3: The reaction of the price level to domestic monetary shock

After a monetary policy shock of one standard deviation (54.65 basis points), prices decline gradually. They reach a bottom after approximately 6 months. In the period of 6 to 12 months after the shock, the log of prices decreased by 0.1 per cent on average. The decline becomes significant after 6 months. Prices gradually rise again to its pre shock level. The drop becomes insignificant after 16 months. The long run effect on the prices level is estimated to be zero. Interestingly, the reaction is much faster than the response of prices in Czech Republic, which is found by Borys and Horváth (2007). They obtain the maximum response after approximately 12 months.

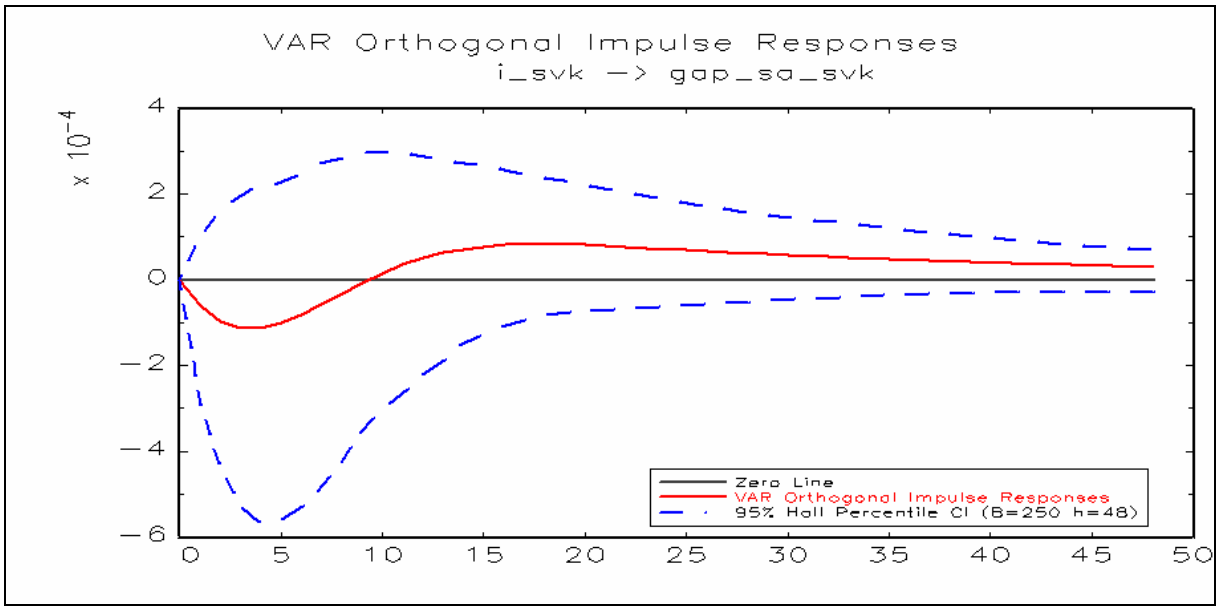

Figure 4: The reaction of the output gap to domestic monetary shock

Next, we turn our attention to the response of the output gap. We observe the swift drop, with the maximum response in the first 6 months with magnitude of -0.0001%. Surprisingly, the response seems to become positive gradually. However, the response is surrounded by quite large uncertainty – the confidence intervals easily contain the zero line. The response to the shock is insignificant for the whole forecasted period. The shock seems not to have any effect in the long run.

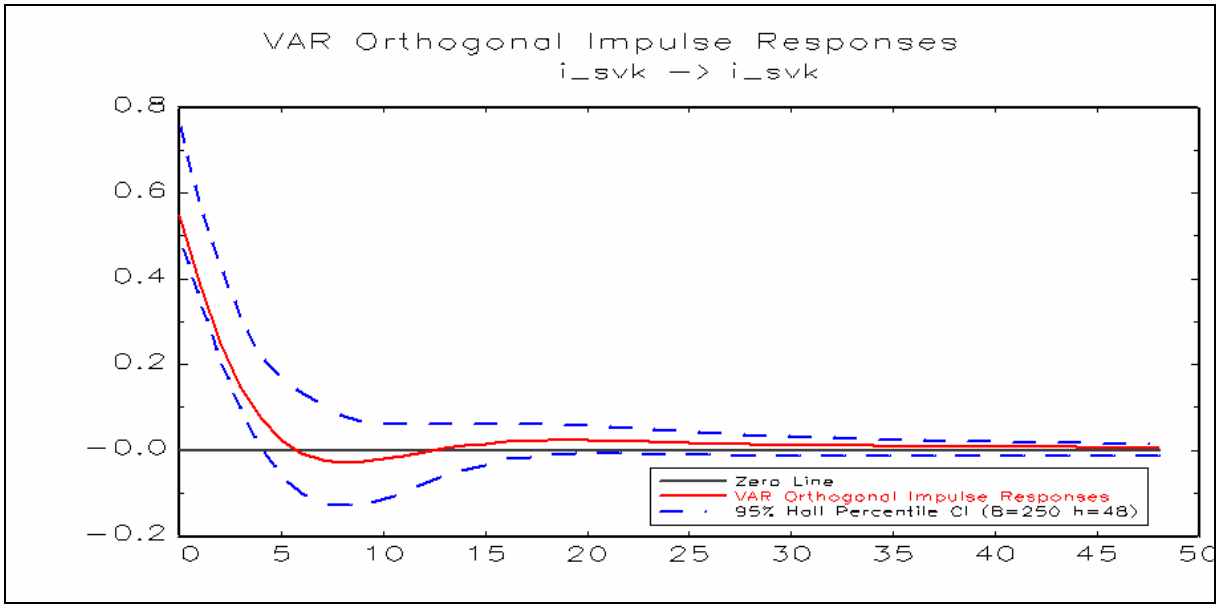

Figure 5: The reaction of the interest rate to domestic monetary shock

In Figure 5, we see that the persistence of the interest rate shock appear to die out swiftly. The response of monetary shock with the size of one standard deviation (54.65 basis points) becomes insignificant after 5 months.

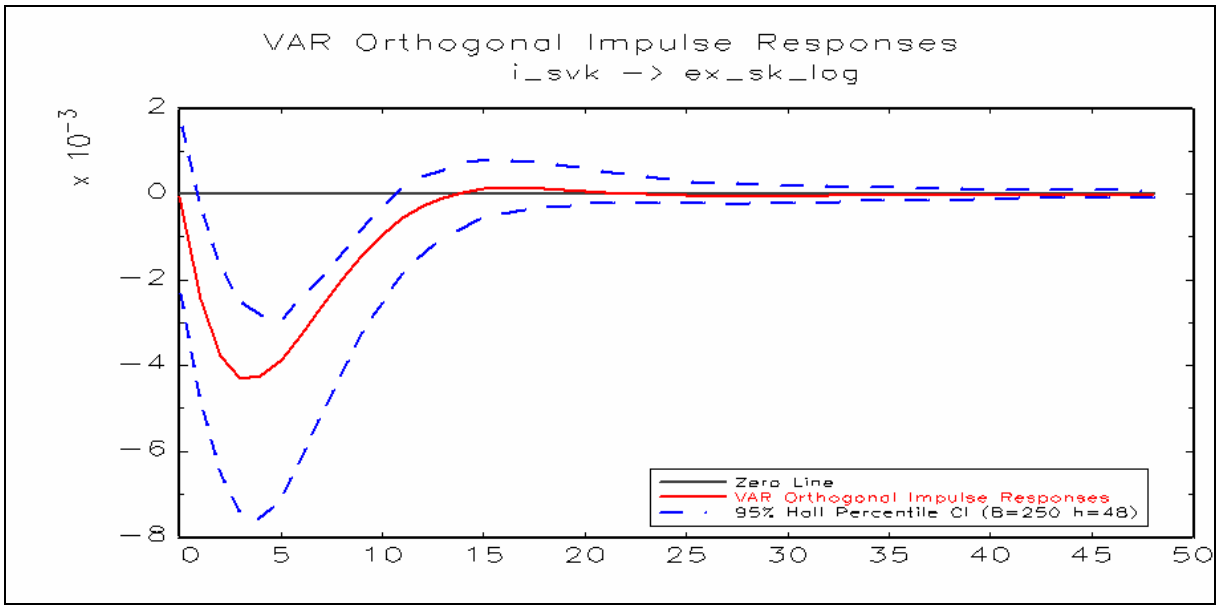

Figure 6: The reaction of the nominal exchange rate to domestic monetary shock

Finally, the last response to the monetary tightening we study is the reaction of the nominal exchange rate. Following the increase in Slovak interest rates, the exchange rate appreciates quickly and significantly. The nominal appreciation reaches its peak after 3-4 months with the maximum response of the log of exchange rate 0.43%. Over time, the path of response goes back to its original level and becomes insignificant after approximately 11 months.

7.2. The effects of foreign monetary policy shocks

In this subsection, we analyze the effects of the foreign monetary tightening. The foreign monetary policy shock is proxied by an unexpected ECB interest rate hike. We will study its impact on the Slovak macroeconomic variables.

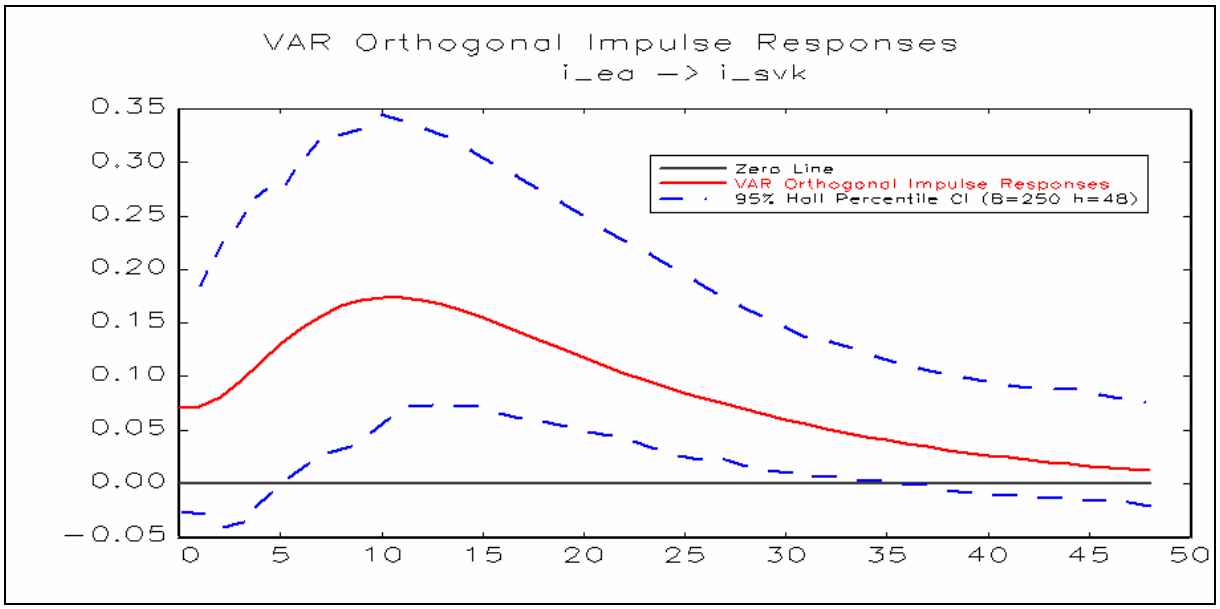

Figure 7: The reaction of the domestic interest rate to foreign monetary shock

We start our study of the transmission of an unexpected foreign monetary tightening by looking at the response of domestic interest rate. The typical unexpected foreign monetary shock is 10.21 basis points.[30] Following the foreign monetary tightening, the domestic interest rate rise on impact by 7.1 basis points. The Slovak monetary authorities seem to react to the foreign monetary shock with a lag. The maximum response seems to occur after 14 months with the magnitude of 17.39 basis points. The response becomes significant after 6 months. Afterwards, the response declines and becomes insignificant. We observe no persistent effect on domestic interest rates.

[30] To compare, the typical interest rate shock for Slovakia is at roughly 5 times bigger (54.65 basis points) than for Eurozone. This is in line with finding of Jarocinski (2006) that monetary shocks in central and eastern European countries are associated with larger interest rate movements than in western european countries. He explains that it is just the consequence of higher output growth rates, inflation and interest rates in transforming countries that could generate the higher variance of the shocks.

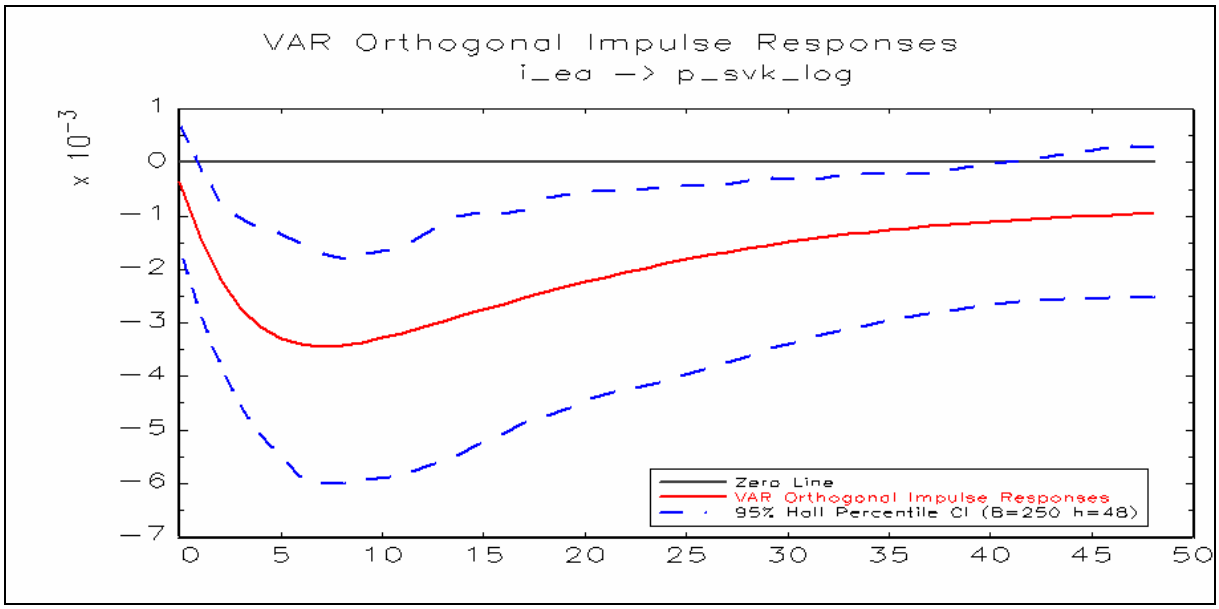

Figure 8: The reaction of the domestic price level to foreign monetary shock

Next, the effect of unexpected monetary tightening on the price level is investigated. The prices decline immediately. The drop is -0.04% at impact. The price level decline reaches its bottom (-0.34%) after 6 months. The response is significant for almost whole forecasted period. On the whole, the prices decline persistently with the drop being at roughly 0.1% after 4 years.

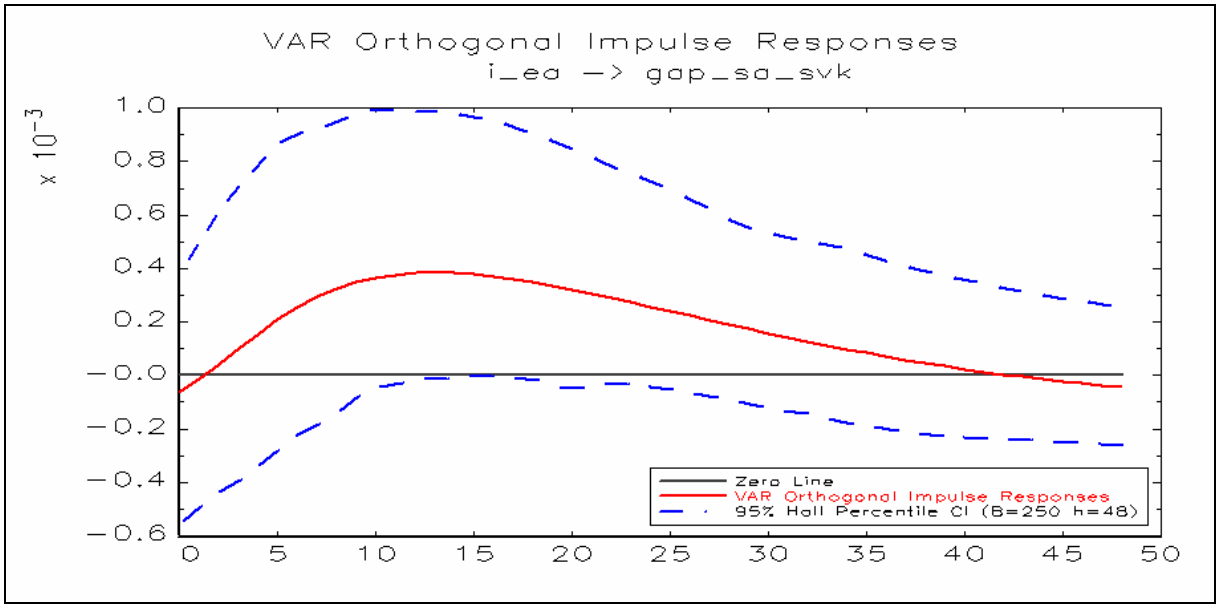

Figure 9: The reaction of the domestic output gap to foreign monetary shock

Figure 9 shows the reaction of the Slovak output gap. The response is initially negative, but surprisingly becomes positive quickly, reaching its peak after 10 months. Nevertheless, the

estimates are surrounded by a high degree of uncertainty. The bottom line is that the response of output to monetary tightening is insignificant.

The positive impact of the foreign monetary tightening on the Slovak output might be explained by the depreciation of the Slovak currency, which could in turn boost the net exports and thus increase the output. We cannot confirm this hypothesis, since the responses of output as well as the response of the exchange rate (as can be seen from the next figure) are not statistically significant.

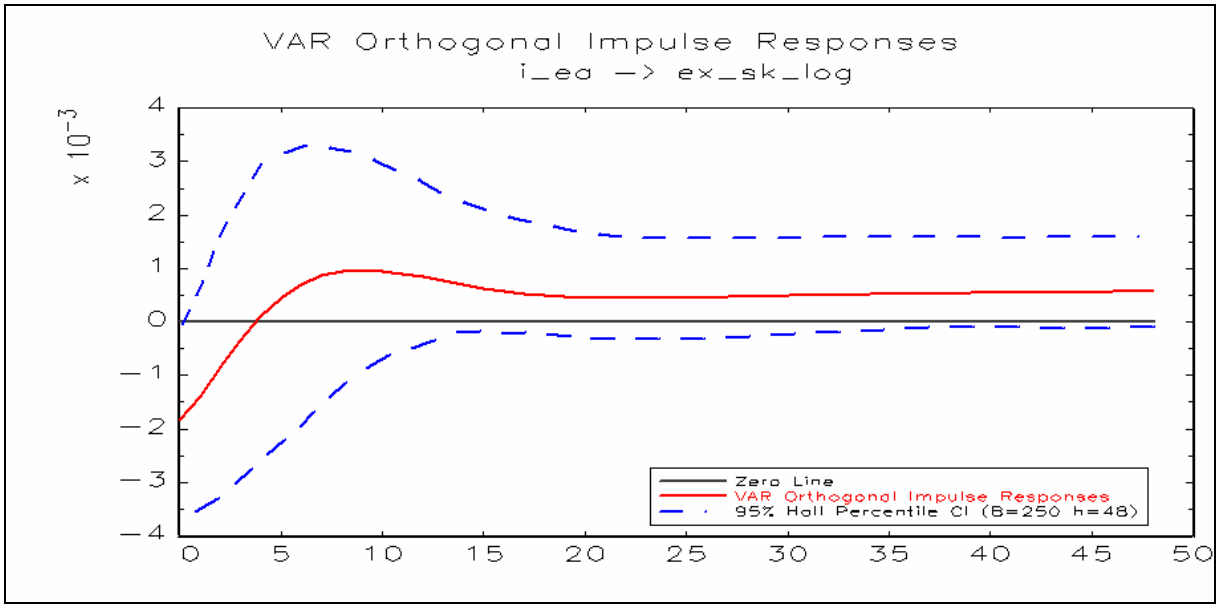

Figure 10: The reaction of the exchange rate to foreign monetary shock

Finally, we look at the reaction of the nominal exchange rate. The expected effect from the foreign interest rate hike is the depreciation of the nominal interest rate. However, after the foreign monetary tightening, the nominal exchange rate appreciates (-0.18% on impact). Nevertheless, the exchange rate depreciates eventually. The response is insignificant for the whole period.

7.3. Monetary transmission in Euro zone

Just to make the picture complete, we present the effects of eurozone monetary policy shock on the Eurozone economy.

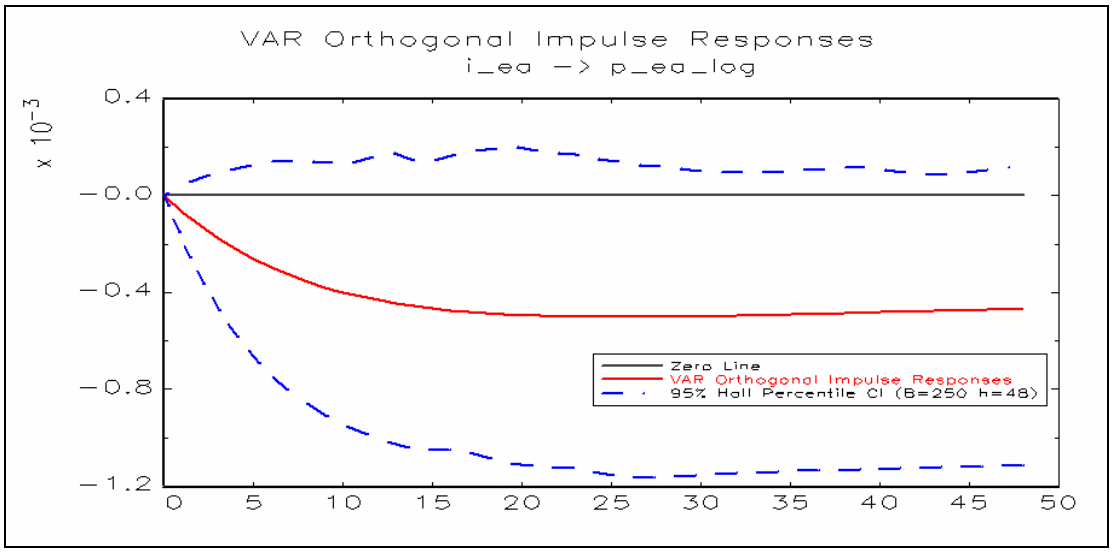

Figure 11: The reaction of the eurozone prices to eurozone monetary shock

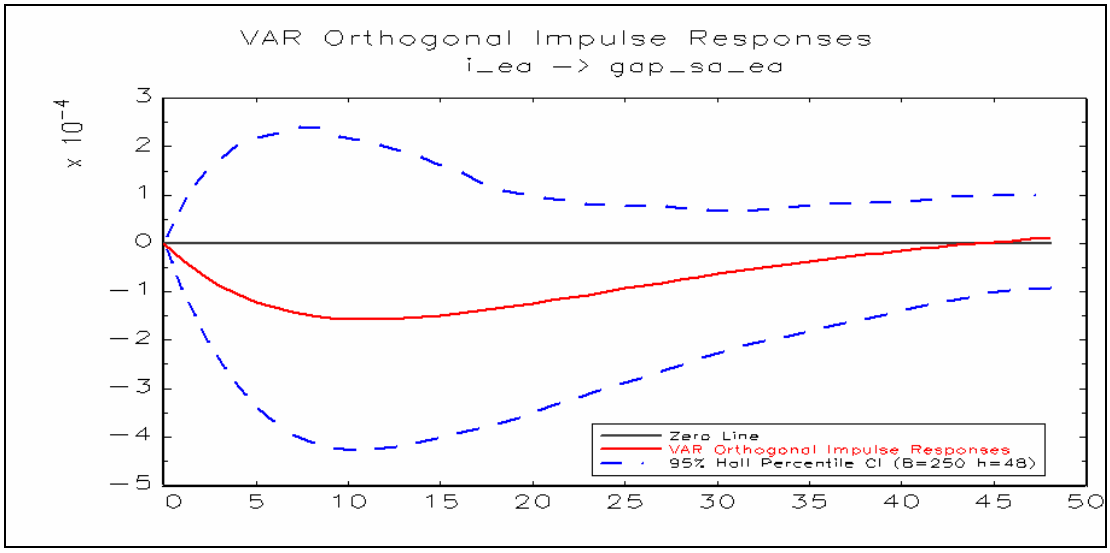

Figure 12: The reaction of the eurozone output gap to eurozone monetary shock

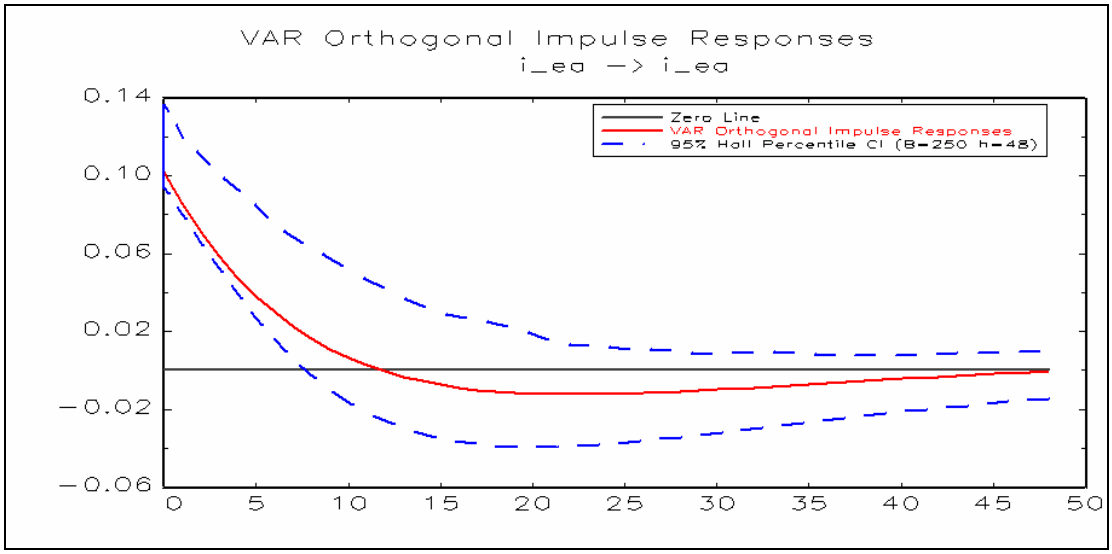

Figure 13: The reaction of the eurozone interest rate to eurozone monetary shock

On the whole, the reaction of eurozone variables is consistent with the economic theory. However, the responses of prices and output gap are insignificant. Probably, it is just the consequence of the fact that we included only 3 eurozone variables into the model and were working with the short sample.

Further and more comprehensive evidence on the Euro area monetary transmission can be found in a paper by Peersman and Smets (2001).

7.4. The importance of foreign shocks

In this section, we investigate the relative importance of the external shocks. We do so by looking at the 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 the variables.

Table 3: the fraction of the variance in price level due to the shocks

	source of disturbance:			
Horizon	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	0.32	0.01

In Table 3, we report the share of the variance in the Slovak price level that can be explained by the external and domestic shocks. We find that external shocks become dominant source of price fluctuations after 12 months. In the long run, i.e. in a four year horizon the external shocks jointly account for 77% in the price level variability. What is more, 23% of the fluctuations can be attributed to the unpredicted eurozone 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.

In the light of the looming accession of Slovakia into Eurozone, 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 the prices than the domestic monetary policy shocks might suggest that the decision to join the European monetary union is justifiable from this point of view.

Next, we compare our results with the estimates for other central European countries provided by Maćkowiak (2005).[31] Similarly, he finds that in Hungary and Poland 70% of the long run variance in aggregate price level can be accounted to external shocks. Interestingly, the corresponding estimate for the Czech Republic is only 35%. Comparably, Giordani (2004b) estimates that around 40% of variation in Canadian inflation is due to foreign shocks.

Table 4: the fraction of the variance in output gap due to the shocks

	Source of disturbance:			
Horizon	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

As regards the fluctuations in output gap, Table 4 shed more light on the issue. Initially, we find that almost all of variance in output gap is explained by domestic fluctuations. After a year only 8% of the variation in the output gap can be attributed to the external shocks. But in four years horizon, the share of external shocks rises to 30%, where 6% of total variation is due to foreign monetary shock. Surprisingly, the domestic monetary policy shocks seem 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 led by domestic factors. It could be the structural reforms and the car industry investments are responsible for the growth.

Our findings are similar to the study of Maćkowiak (2005), 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 (2004b) estimates that approximately 70% of fluctuations in Canadian output in the long run is due to foreign (U.S.) shocks. Likewise, the corresponding estimate of Cushman and Zha (1997) is 75%.

[31] Comparisons have to be perceived with caution since different studies use different estimation and identification techniques. Nevertheless, we provide the estimates at least for a rough comparison.

Table 5: the fraction of the variance in interest rate due to the shocks

	Source of disturbance:			
Horizon	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	0.40	0.19	0.60	0.20

Next, in Table 5: the fraction of the variance in interest rate due to the shocks we look at the forecast error variance decompositions of interest rate. We find that the most of the variance is explained by the domestic shocks. Naturally, most of them is due to domestic monetary disturbances. Over time, the external shocks are becoming more important. In the long run, 60% of the fluctuations in interest rate is explained by domestic shocks, while approximately 40% is due to external shocks.

Table 6: the fraction of the variance in exchange rate due to the shocks

	source of disturbance:			
Horizon	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

Finally, we investigate the sources of fluctuations in exchange rate. 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 20 on average.

8. Sensitivity analysis

In this section, we investigate the robustness of the model. We check how results change when using different sample period, different identification scheme and different measures of economic activity. We present here the impulse responses for the different specifications.[32]

8.1. Robustness over time

Since we are working with really short sample, our possibilities to estimate the model over different periods are limited. We present the impulse response functions for the whole period 1999:1-2007:12.

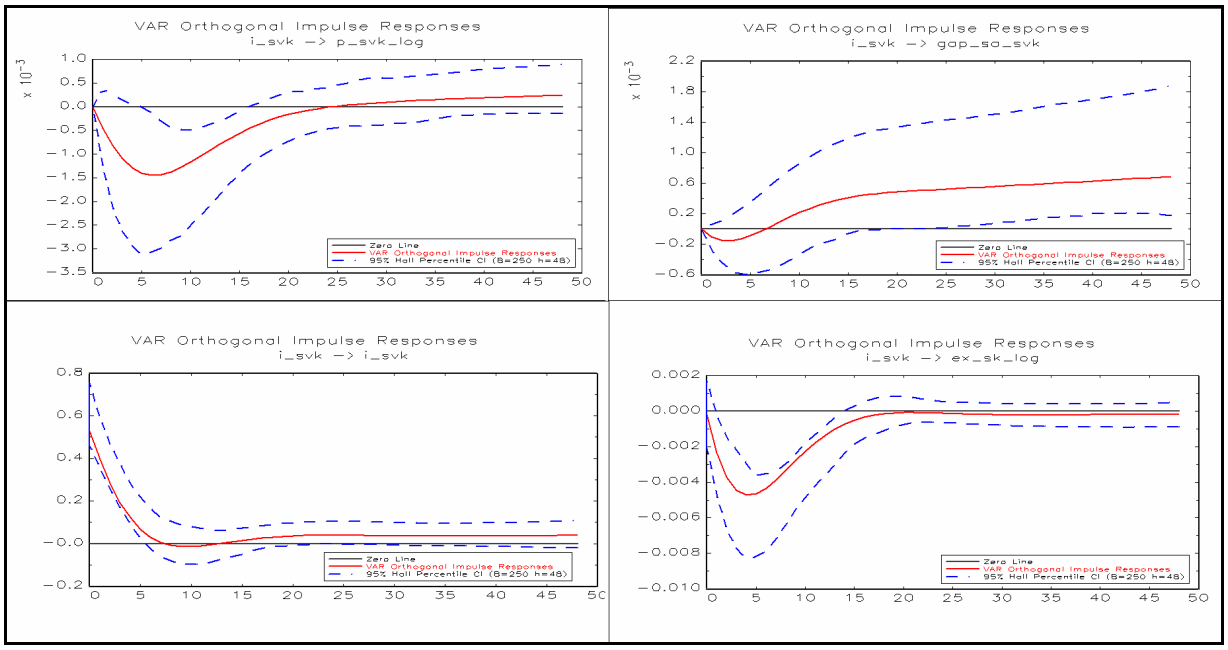

Figure 14: responses to domestic monetary shock

Figure 14 shows the impulse responses of Slovak variables to the domestic monetary tightening. The responses are more or less similar to those in the baseline model, except for the reaction of output gap. The additional difference is that we observe a greater degree of uncertainty.

[32] Additionally, we also considered the robustness of the variance decompositions results. On the whole, the estimates were not substantially different from the baseline model estimation. The only exception is the model with the log of industrial production, where quite an important fraction of the variation in the economic activity is attributed to the foreign price level disturbances (41%).

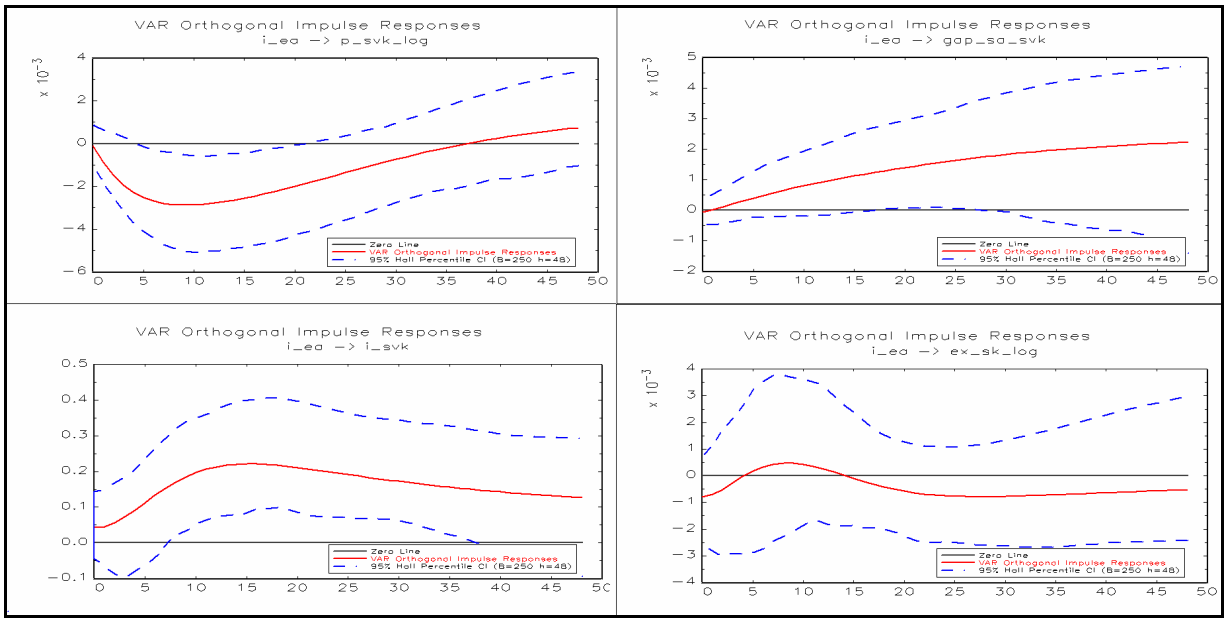

Figure 15: responses to foreign monetary shock

Again, responses are broadly similar to the original model. However, when looking at the responses to foreign monetary contraction, we notice that the responses are explosive. We are not able to obtain a stable set of impulse responses.[33] This might be the consequence of the problems mentioned in the estimation issues section.

8.2. Robustness over different identification schemes[34]

Kim and Roubini (2000) suggest that when considering the small open economy it is reasonable to use an identification scheme that allows for a contemporaneous response of central bank to exchange rate shocks. It is the consequence of the natural assumption that monetary authorities in small open economies care also about the effects of exchange rate depreciation on the prices and thus might respond by rising the interest rate. To take account of this, we reorder the variables in the system so that the Slovak interest rate is the last.[35]

[33] Indeed, one of the modulus of the eigenvalues of the reverse characteristic polynomial is less than one (0.9897), which suggest that the instability is present.
[34] We reestimate the baseline model i.e. for the 1999:1 – 2006:12 period.
[35] By ordering the interest rate variable as the last, we are not able to obtain the impact effect of monetary policy shock on the exchange rate.

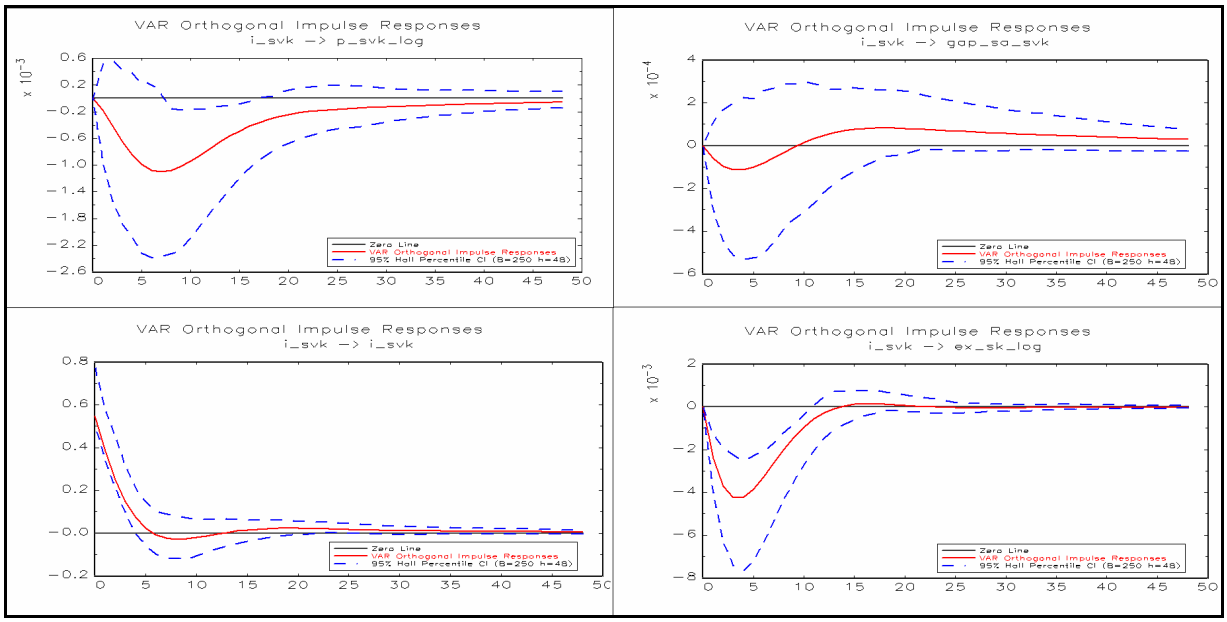

Figure 16: policy instrument last - responses to domestic monetary shock

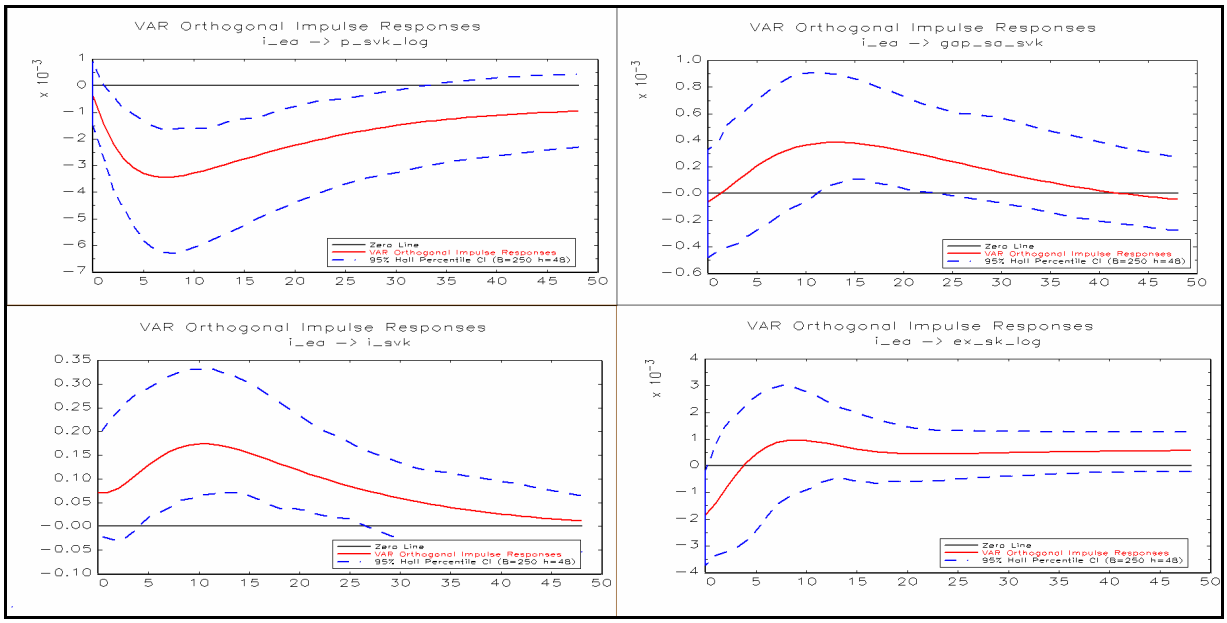

Figure 17: policy instrument last - responses to foreign monetary policy shock

As obvious from Figures 16-17, the responses have not significantly changed compared to the baseline specification. Only the reaction of the output gap seems to have changed. The unexpected foreign interest rate increase seems to have positive and slightly significant impact on the output gap.

8.3. Robustness over different economic activity measures

In this subsection, we check how sensitive the model is to different measures of economic activity. We employ successively the log of real GDP, output gap obtained from industrial

production index[36] and log of industrial production index. We estimate the baseline model for the 1999:1 – 2006:12 period, as the whole span leads to instable impulse responses.

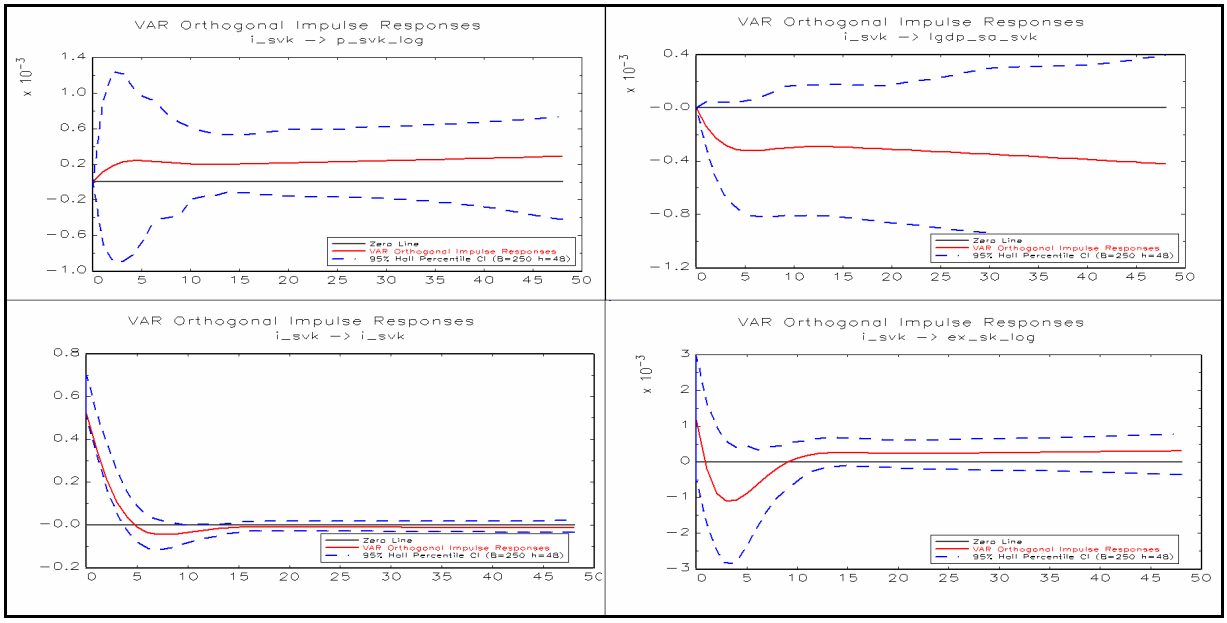

Figure 18: real GDP - responses to domestic monetary shock

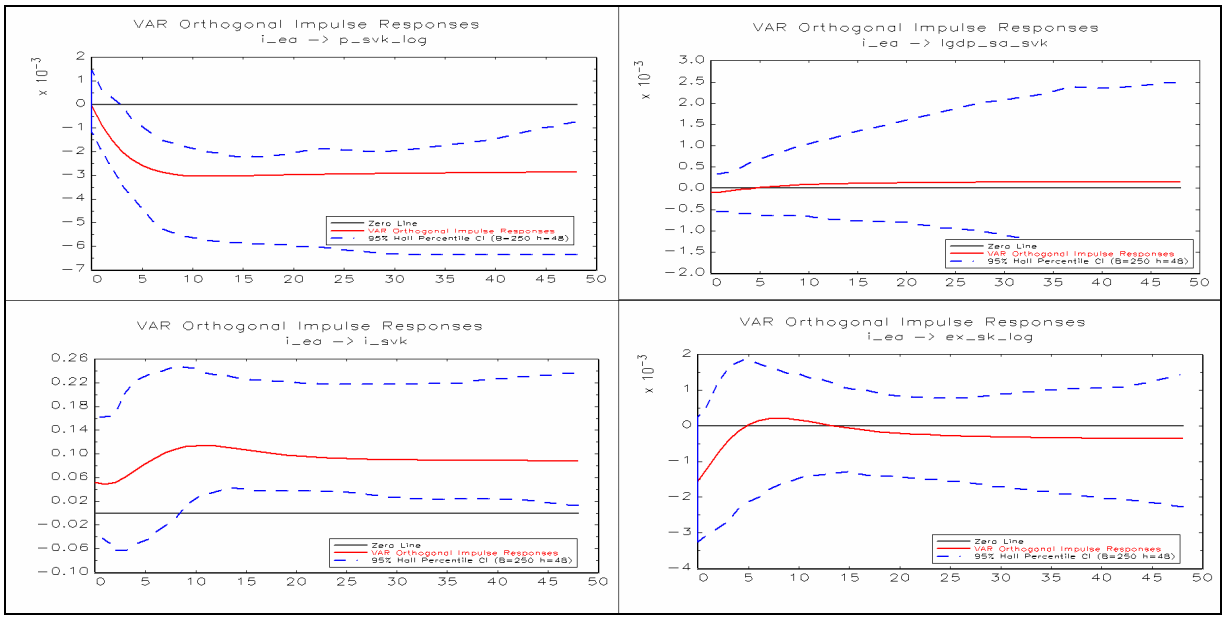

Figure 19: real GDP - responses to foreign monetary shock

As can be seen from figures 18-19, when following the common practice of estimating a VAR including output, but not the output gap or potential output we obtain the price puzzle. Interestingly, this is exactly what Giordani (2004a) predicts for such a specification.

[36] We used the HP filter with λ=14400, according to Kočenda and Černý (2007) this value is suggested when filtering data with the monthly frequency.

The rest of impulse responses for the model with the log of real GDP are qualitatively the same as for the baseline specification. Nevertheless, we the confidence bands are much wider.

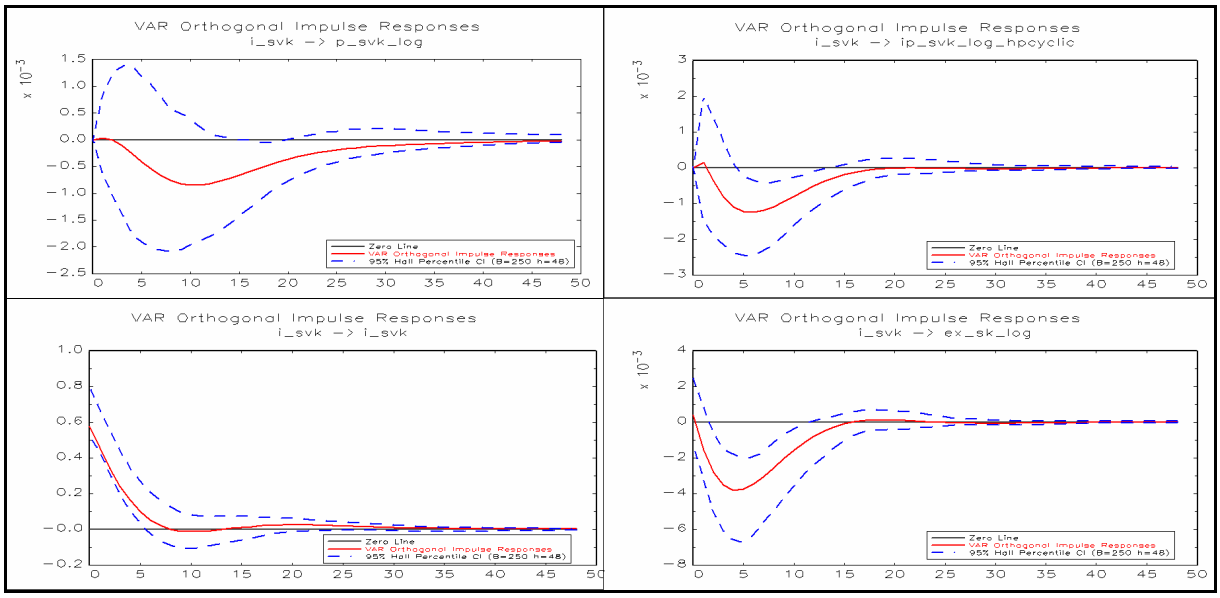

Figure 20: IP gap - responses to domestic monetary shock

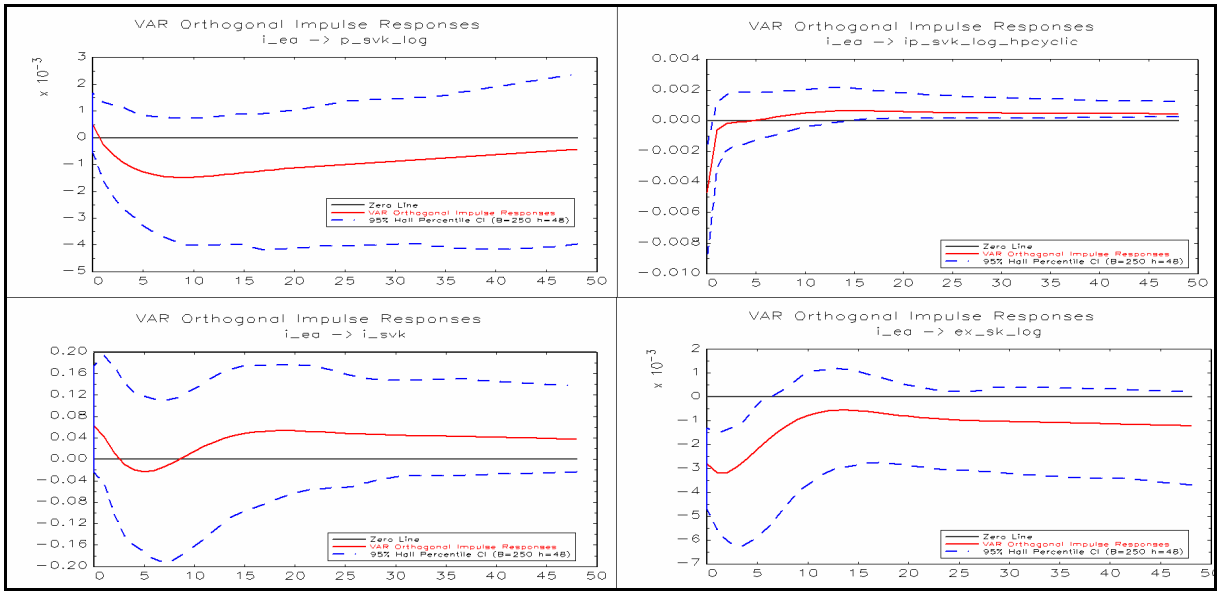

Figure 21: IP gap - responses to foreign monetary shock

To check the sensitivity of the model to the use of interpolated data, we estimate the model with the output gap obtained from industrial production data which are available monthly. From Figures 20-21 we see that, the responses are again comparable to those for the baseline model. Still, the response of the IP gap to the foreign monetary shock is little bit different. Following the impact (significant) decline, IP gap increase swiftly reaching positive values and is marginally significant for the rest of the forecast horizon.

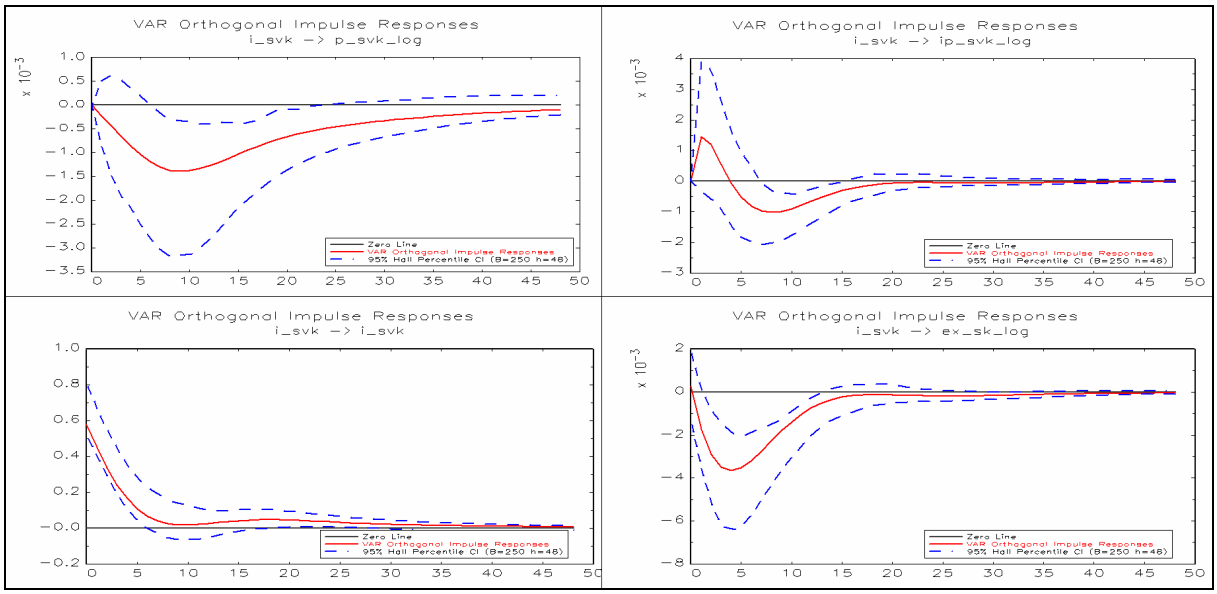

Figure 22: industrial production - responses to domestic interest rate shock

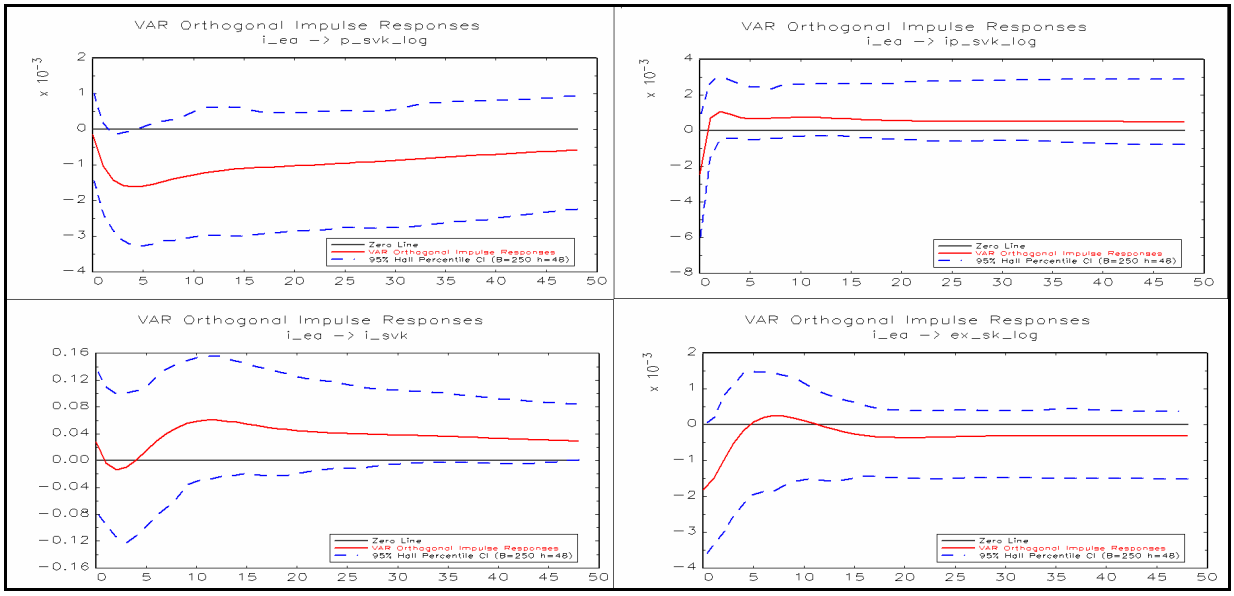

Figure 23: industrial production - responses to foreign monetary shock

After all, we use log of industrial production index to use the series, which was not modified by interpolation or filtering. Figures 22-23 show that again responses are qualitatively similar for almost all the variables. Yet, only the responses of industrial production to both domestic and foreign monetary policy shocks are somehow counterintuitive. The industrial production reacts to the domestic monetary tightening by sharp, though insignificant increase and only gradually declines.[37] The reaction to the foreign interest rate shock is persistent, but insignificant increase.

[37] Jarocinski (2006) considers Slovakia in the robustness analysis in his study of monetary policy shocks. Similarly, he finds that output reacts positively.

9. Conclusion

In this thesis, we estimated an open economy seven variable VAR model for Slovak economy with block exogeneity restriction. Using the main macroeconomic aggregates, we attempted to fill the gap in the empirical literature and provide the evidence about the nature and the importance of domestic and foreign shocks in Slovak economy.

On the whole, we found that the monetary transmission in Slovakia is in line with the expected effects of a monetary tightening. The domestic monetary policy shock is associated with an increase in interest rates, a decline in the price level, a transitory fall (or no real effects) on economic activity and the nominal exchange rate appreciation. Especially, by using the output gap we are able avoid the puzzling results (i.e. we find no evidence of the price puzzle or the exchange rate puzzle). Notably, these results are obtained without more advanced identification techniques such as non-recursive identification scheme in structural VARs, which goes beyond the scope of our thesis.

Next, we investigated the transmission of euro zone monetary policy shock. The main finding is that euro area monetary policy shock seems to have significant and persistent effect on the Slovak price level. The eurozone monetary policy shock affects the short term interest rates quickly and strongly. The response of economic activity and the nominal exchange rate to the foreign monetary tightening is uncertain.

Finally, the results indicate that major fraction of fluctuations in the Slovak price level is attributable to foreign shocks. We find that the external shocks explain almost 77% of variation in the aggregate price level in the long run. Moreover, almost 23% of the fluctuation is due to foreign monetary policy shocks. Surprisingly, we find a rather limited role of domestic monetary policy shocks in explaining the variation in the price level. On the other hand, most of the variation in the output seems to be due to domestic factors.

All in all, the results are robust to various changes in the specification and confirm the hypothesis about the importance of the foreign shocks for Slovak economy, especially for the price level. Our conclusions are similar to findings for other small open economies, particularly, the results of Maćkowiak (2005) for the Czech Republic, Poland and Hungary and Giordani (2004b) for Canada.

Appendix

A.1 The plots of the series

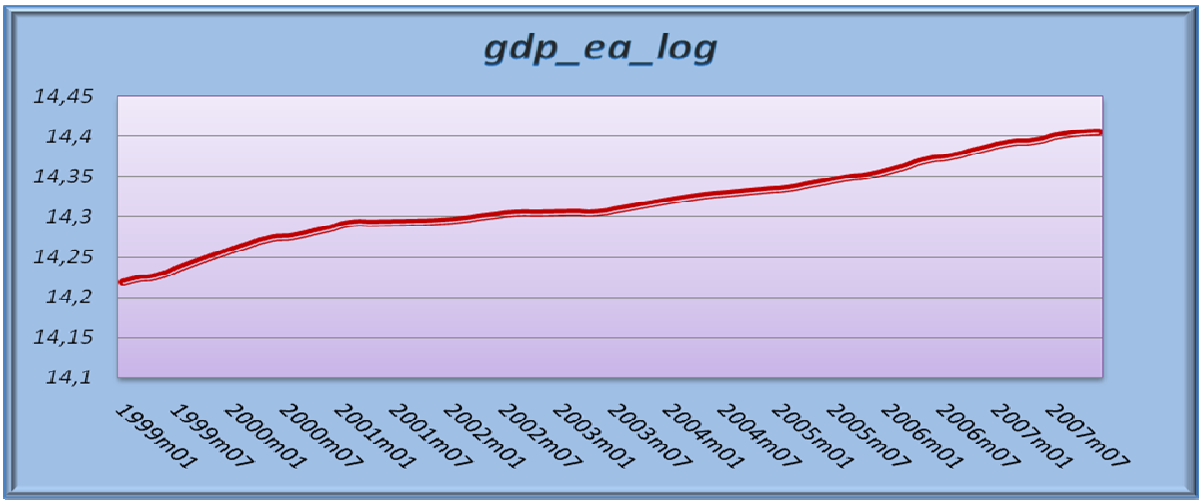

Figure 24: log of Euro zone GDP

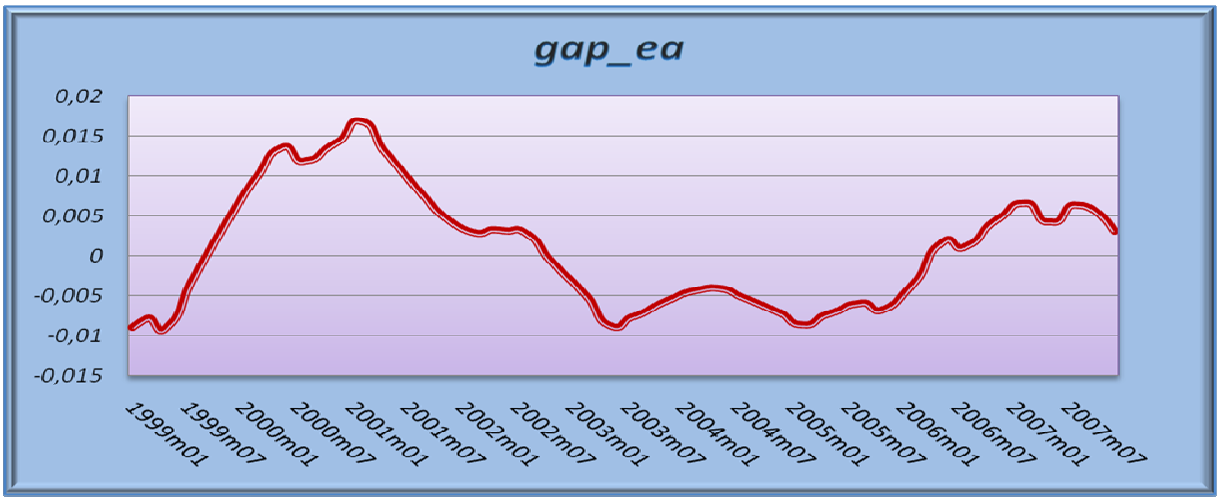

Figure 25: Euro zone output gap

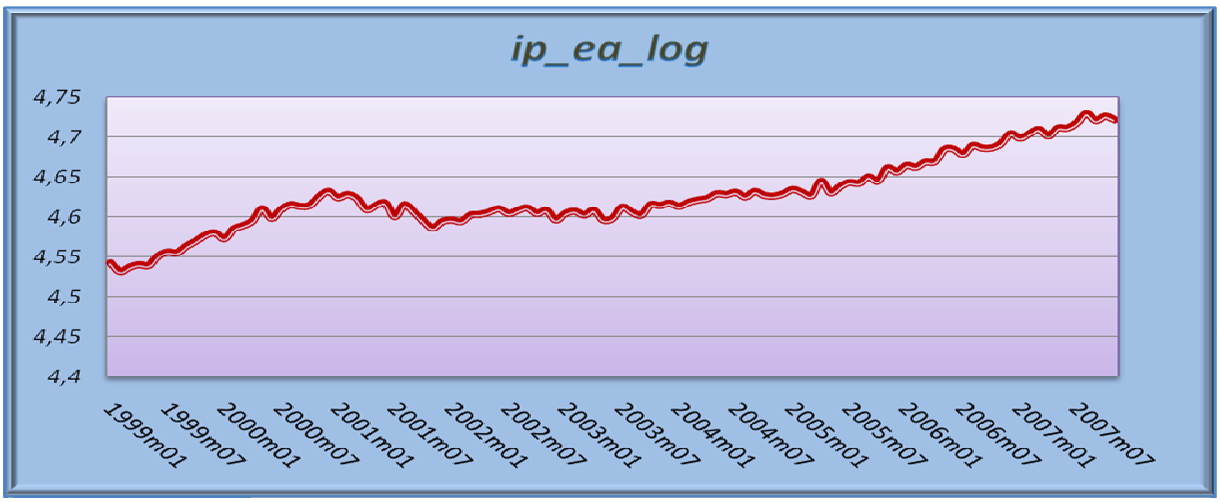

Figure 26: log of Euro zone industrial production

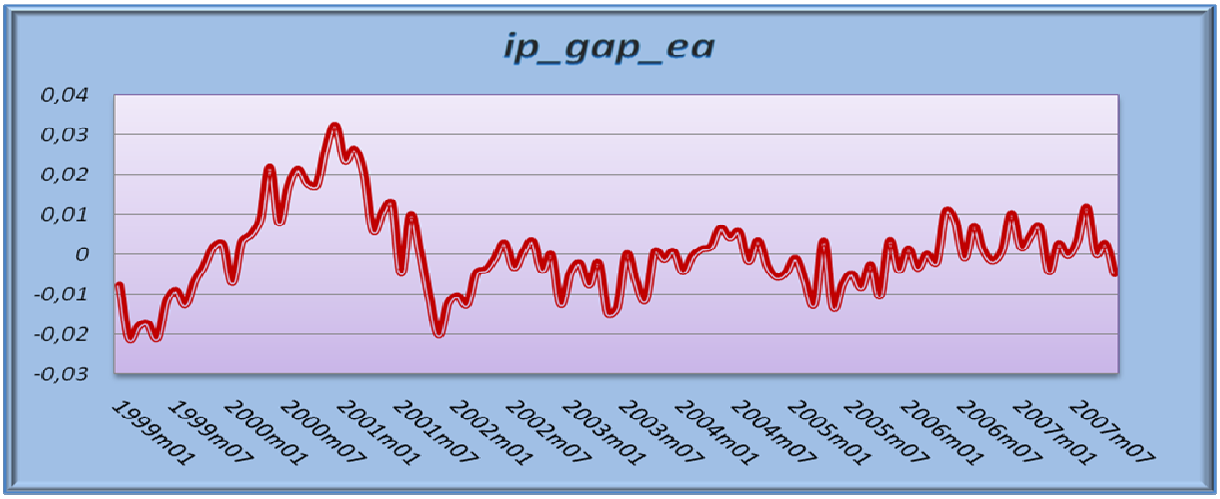

Figure 27: Euro zone output gap obtained from industrial production index

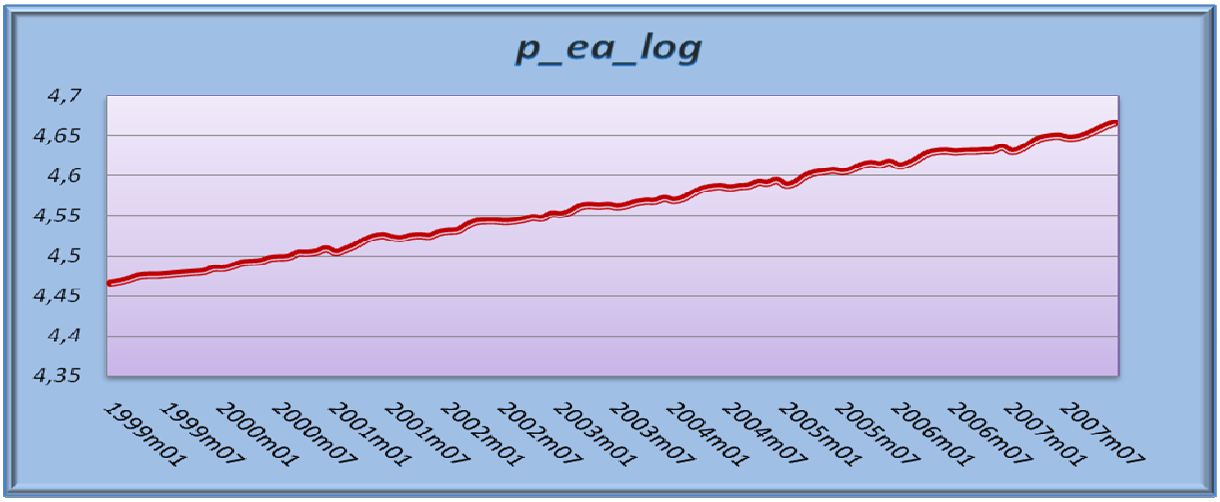

Figure 28: log of Euro zone prices

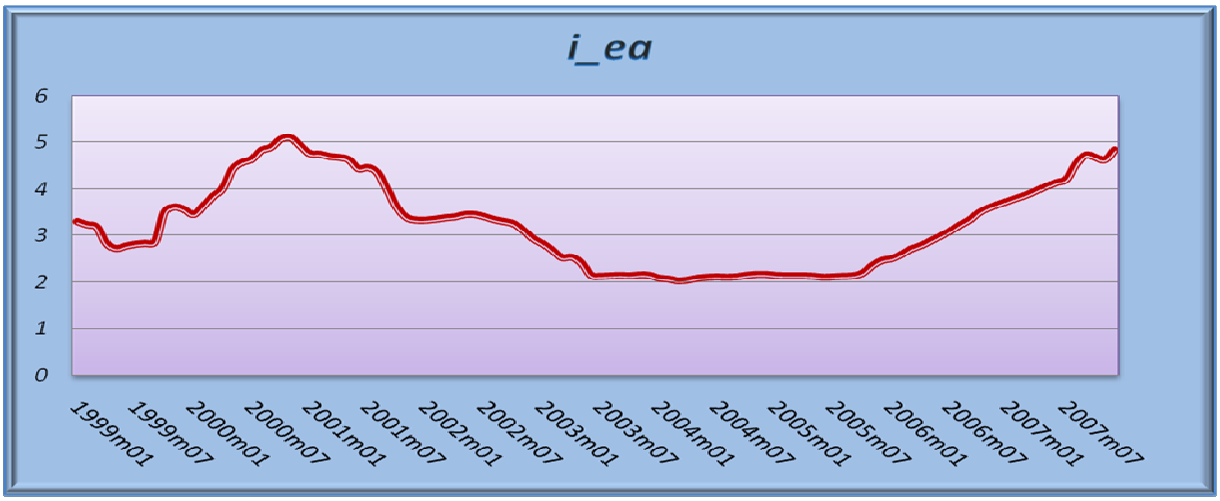

Figure 29: EURIBOR – 3 months money market interest rate

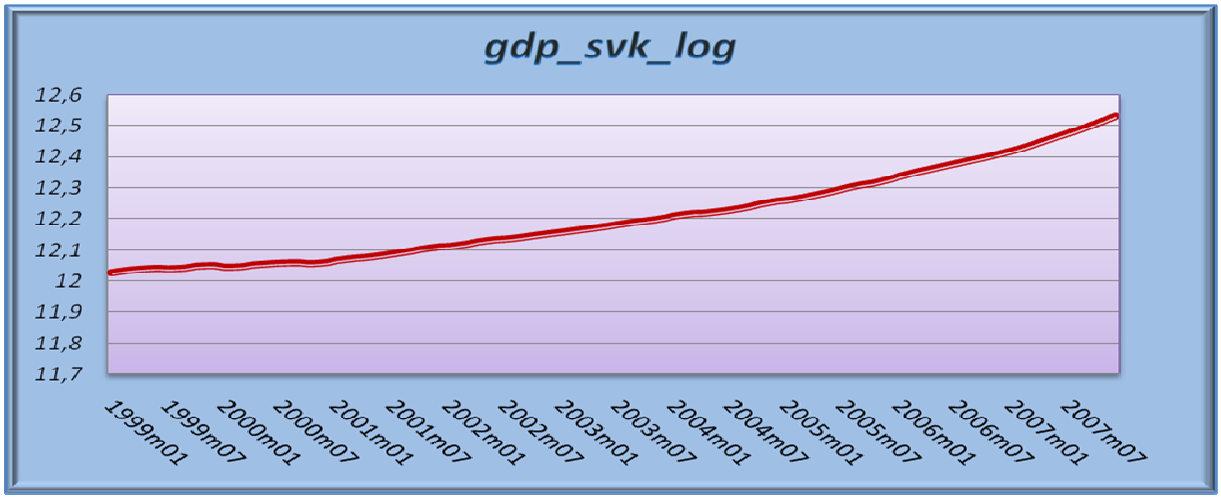

Figure 30: log of Slovak GDP

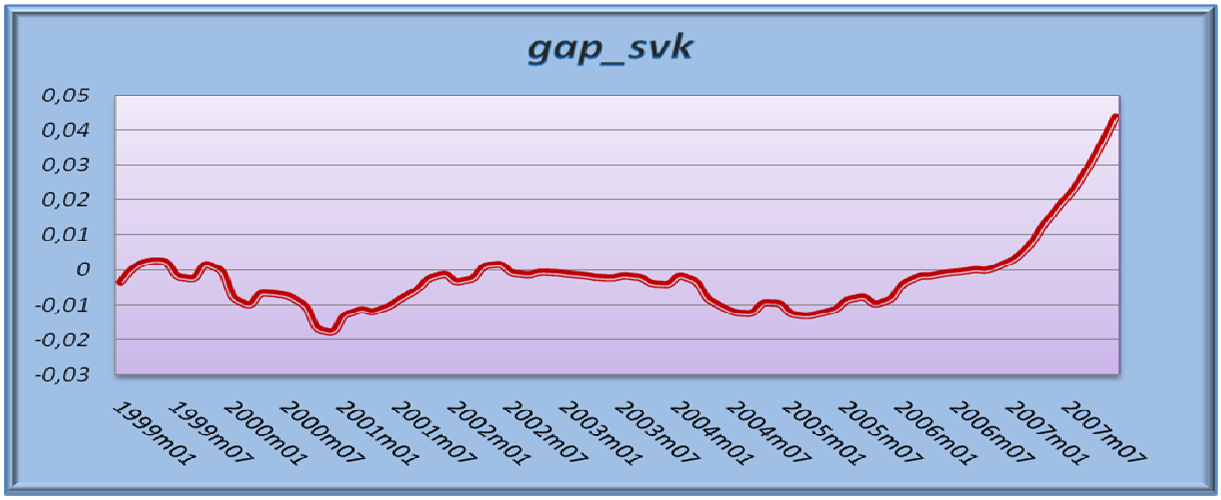

Figure 31: Slovak output gap

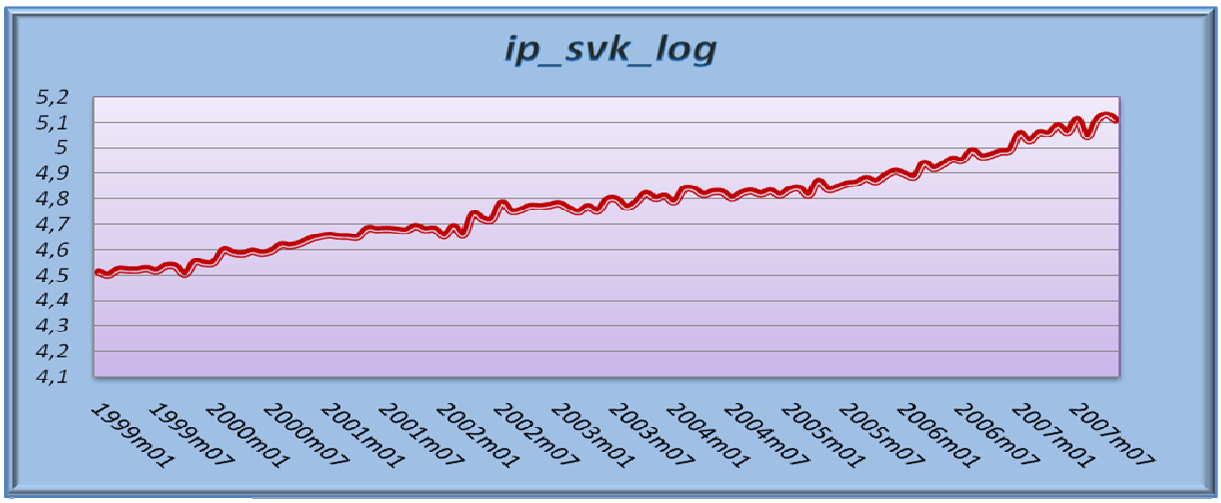

Figure 32: log of Slovak industrial production

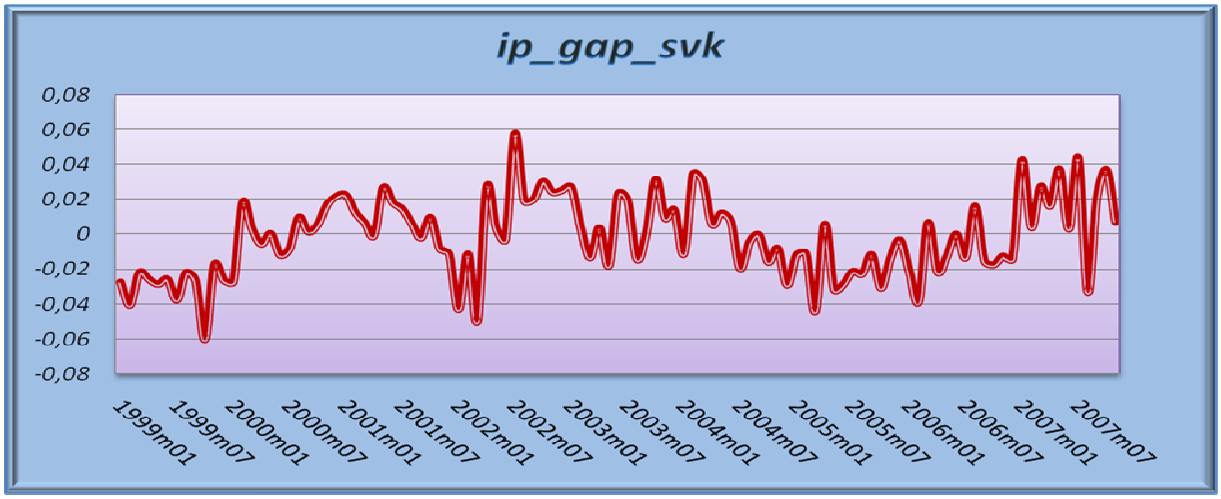

Figure 33: Slovak output gap obtained from industrial production

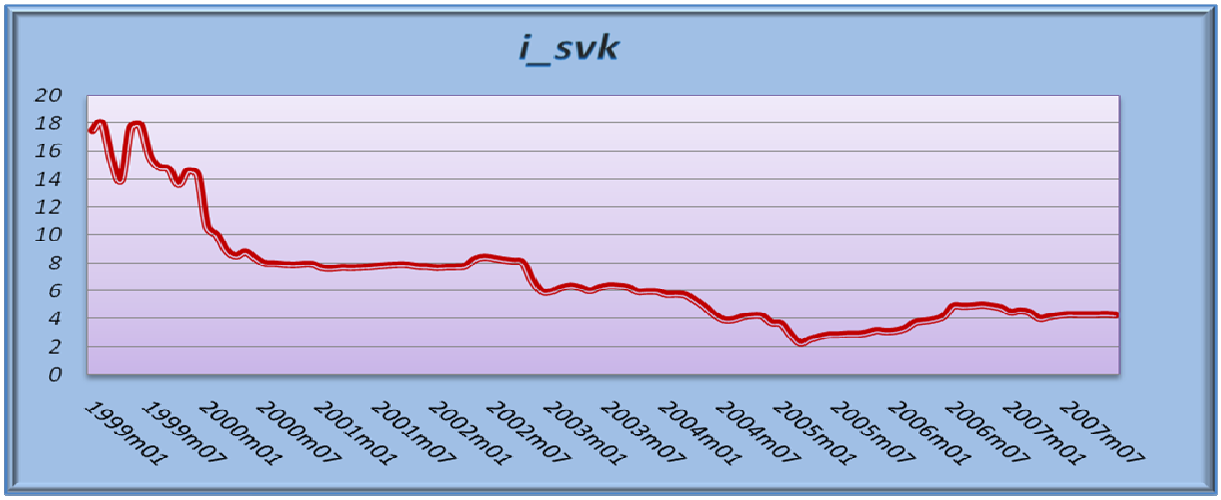

Figure 34: BRIBOR - 3 months money market interest rate

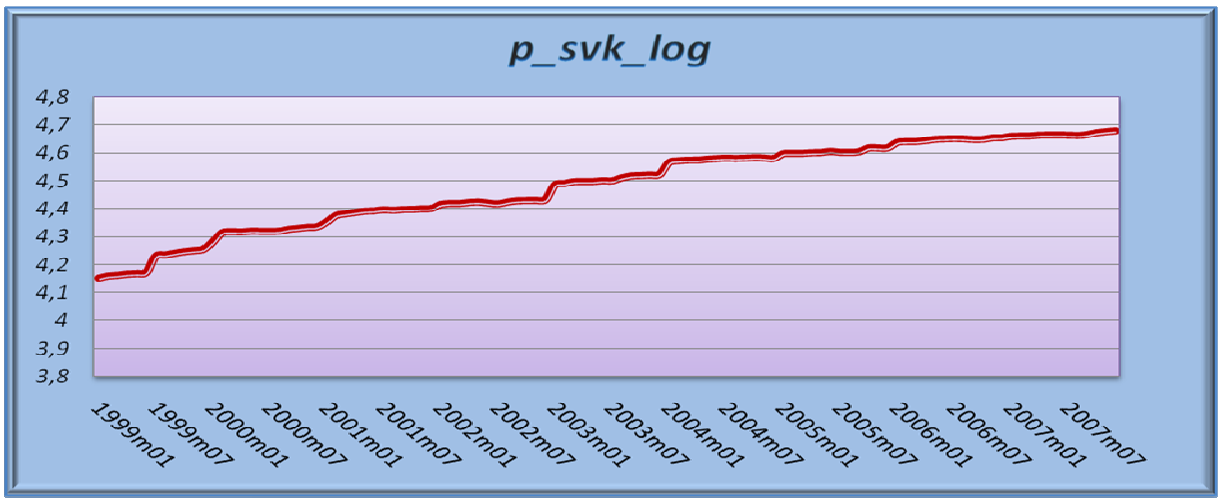

Figure 35: log of Slovak prices

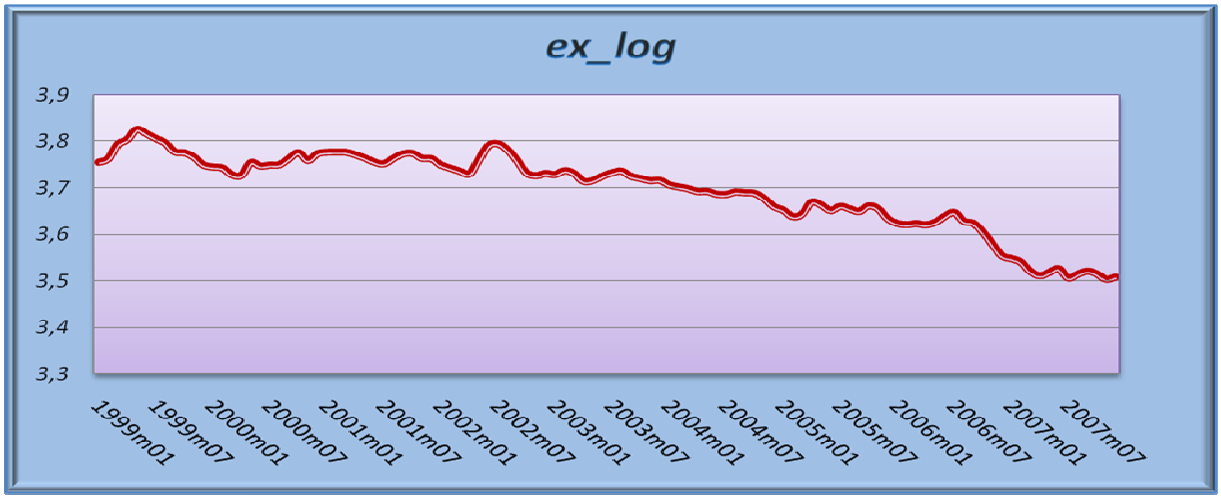

Figure 36: log of nominal exchange rate

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Akademický rok 2007/2008

TEZE BAKALÁŘSKÉ PRÁCE

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Garant studijního programu Vám dle zákona č. 111/1998 Sb. o vysokých školách a Studijního a zkušebního řádu UK v Praze určuje následující bakalářskou práci

Předpokládaný název BP:

The Effects of External Shocks on Slovak Economy

Charakteristika tématu, současný stav poznání, případné zvláštní metody zpracování tématu:

The aim of this work will be to discuss the importance of external shocks to small open economy, such as Slovakia. First, the work will seek to answer the question of how much of variation in macroeconomic variables in Slovakia can be attributed to external shocks (e.g. changes in exchange rates, foreign prices). Second, it will attempt to analyze the size and persistence of external shocks on the economy. The analysis will be conducted using tools of vector autoregressions (VAR) technique - variance decomposition and impulse response function.

Struktura BP:

1. Introduction
2. Survey of Literature
3. The Empirical Model
    3.1 Data
    3.2 Identification
    3.3 Results
4. Conclusion

Seznam základních pramenů a odborné literatury:

Enders, W. (1995): Applied Econometric Time Series, John Wiley & Sons, Inc., New York, USA

Ivanov and Kilian (2005): A Practitioner Guide to Lag Order Selection for VAR Impulse Response Analysis, Studies in Non-linear Dynamics & Econometrics, pp. 1219-1219

Mackowiak, B. (2005): How much of the Macroeconomic Variation in Eastern Europe is Attributable to External Shocks?, SFB 649 Discussion Papers, Humboldt University, Berlin, Germany.

Stock and Watson (2001): Vector Autoregressions, Journal of Economic Perspectives, pp. 101-115

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Termín odevzdání:	červen 2008