Research Paper

ANALYSIS OF AN IMPACT OF MONETARY SHOCKS THROUGH POLICY RATE ON TWO EASTERN EUROPEAN ECONOMIES

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Abstract

In this paper we investigate the impact of monetary shocks in two Eastern European economies: Romania and Slovakia. We implement two structural VAR models to analyze the effect of the policy rate of the respective country on three economic variables: GDP growth rate, inflation and EUR/USD exchange rate. In Romania, we find that GDP growth reacts negatively to monetary shocks, while in Slovakia the response is oddly positive even though not significant. The reaction to inflation is negative for both countries and more pronounced for Romania. Thus, the integration in Eurozone of Slovakia could dampen the magnitude of its shocks.

1. Introduction

The Eurozone has been sharing a common monetary policy for the last 23 years, gathering 19 countries so far. Thus, it has attracted some Central and Eastern European countries in its zone, in particular: Estonia (2011), Latvia (2014), Lithuania (2015), Slovakia (2009) and Slovenia (2007). In this paper we focus on two economies: Romania and Slovakia.

Romania entered the European Union in 2007 while Slovakia in 2004. A main difference is that Slovakia adopted the Euro currency in 2009 whereas Romania uses its national currency: the Romanian leu (RON). The goal of this paper is to study the impact of monetary shocks between two Eastern European economies through the traditional main channel: monetary policy interest rate. We focus on the impact on two macroeconomics fundamentals: Gross Domestic Product (GDP) growth[1], inflation, as well as the exchange rate between the Euro and the U.S dollar (EUR/USD). We build two structural Vector Autoregressive models *(Sims, 1980),* one per country.

Euro (EUR) plays an important role as an international safe-haven currency, accounting for 20.7%[2] of the total global foreign exchange reserves in 2018. On top of that, it also plays an important role as a significant trading currency, as opposed to the Leu which is only used in Romania. Furthermore, Slovakia and Romania have similar historical background. Both were part of a communist regime before the 1990's and jumped in the economics transition bandwagon after. They share similar economic characteristics nowadays: a close GDP per capita (17.820 € against 12.510 € in 2021)[3], a comparable unemployment rate (5.9% against 6.6%)[4], both are low debt economies (63,10 % against 48,80 % for debt to GDP ratio in % of GDP in 2021)[5] and a low integration of their respective financial markets.

Our dataset starts from 2005 as the National Bank of Romania (NBR) adopted inflation targeting strategy and Slovakia began to abide by the convergence criteria and was included in the European Exchange rate Mechanism II (ERM II). The goal of this mechanism is to enable a country to reduce its exchange rate volatility and achieve monetary stability to adopt the common currency. Once a country enters the European Union, it is obliged to join the Eurozone in the long run. However, four economic convergence criteria must be met: an inflation rate which does not exceed 1.5%, a public deficit below 3% of GDP, a debt below 60% of GDP, long-term interest rates close to those of the best performers in the Eurozone and a participation for at least two years in the ERM II.

The literature regarding the analysis of the monetary policy transmission mechanism with VAR models applied on emerging markets of Central and Eastern Europe is still in infancy. The research on monetary shocks on these regions made so far using a VAR methodology focus either on individual countries such as Czech Republic *(Hurnil and Arnostova, 2005; Morgese, Horvath 2008)*, Poland *(Lyziak, Przystuba, Wrobel, 2008; Demchuk et al.,2012)* or Romania *(Andries, 2008; Antohi, Udrea and Braun, 2003)* or compares Central and Eastern European countries against other advanced European economies. *(Creel Levasseur, 2005; Héricourt, 2005; Elbourne and de Haan, 2006).*

We therefore aim to provide a first intuition on how the impact of monetary policy shocks differ in two economically similar Eastern European countries, where one has the Euro while the other its own currency. Our analysis is mainly based on the study of the impulse response functions from a structural VAR model. Impulse response functions have been a popular way to study the monetary policy transmission mechanism (*Eichenbaum and Evans, 1995*).

[1] In this paper we use the terms "GDP" or "GDP growth" interchangeably
[2] Statistics from the European Central Banks, available on https://www.ecb.europa.eu/stats/html/index.en.html
[3] Statistics from the European Central Banks, available on https://www.ecb.europa.eu/stats/html/index.en.html
[4] Statistics from the European Central Banks, available on https://www.ecb.europa.eu/stats/html/index.en.html
[5] Statistics from the European Central Banks, available on https://www.ecb.europa.eu/stats/html/index.en.html

2. Model

To analyze monetary shocks on economic variables, a Vector Autoregressive (VAR) model seems appropriate. More precisely, we use the structural VAR approach methodology to identify the shocks. It will enable us to compute impulse response functions and hence look at the magnitude and the persistence of the effect of the monetary policy shocks. We use the following model:

$$\begin{pmatrix} GDP_t^i \\ Inflation_t^i \\ Interest\ rate_t^i \\ Exchange\ rate_t^i \end{pmatrix} = C^i + \Phi^i(1) \times \begin{pmatrix} GDP_{t-1}^i \\ Inflation_{t-1}^i \\ Interest\ rate_{t-1}^i \\ Exchange\ rate_{t-1}^i \end{pmatrix} + B^i \times U_t^i \quad (1)$$

Where C^i is the constant of the respective model, B^i is a lower triangular matrix for country *i*, estimated by a Cholesky decomposition and U_t^i a vector of structural shocks occurring at date *t* for country *i*. Hence the error term is $\varepsilon_t^i = B^i \times U_t^i$. Setting B^i as a lower triangular matrix prevents a structural shock from affecting an endogenous variable contemporaneously. As it is a key feature of a SVAR model, we explain in more detail the reasons for such variable order and the assumptions about contemporary effects it implies in section 3b. The matrix $\Phi^i(1)$ contains the coefficients of the structural VAR with one lag for each country. The estimated coefficients for Romania and Slovakia are displayed in Table 5 and Table 6 respectively. The lag selection and the variables used are discussed in the next section.

3. Data and Methodology

Data

To analyze the impact of the monetary policy shocks, i.e., unexpected changes in interest rates, we use quarterly dataset of three variables that reflects some changes in the economy: Gross Domestic Product (GDP) growth, inflation rate, and the exchange rate between the Euro and the U.S. dollar (EUR/USD). Our dataset starts from the first quarter of 2005 to the last of 2021.

GDP reflects the health of an economy by measuring the value of the production of its goods and services. This is a reason why we implement the growth rate of GDP in our model, as it is an objective measure that can be easily compared across countries. As a proxy for inflation, we use the quarterly CPI index of each country. The CPI index captures the average changes in the prices of consumer goods and services purchased by households. For both GDP growth and CPI index, we use quarterly percentage change, standardized and seasonally adjusted data from the *National Institute of Statistics of Romania* and from the *Statistical Office of the Slovak Republic* for each country respectively. To measure the impact of monetary policy shocks on the Euro currency, we use the exchange rate between the Euro and the U.S. dollar (EUR/USD) from the *European Central Bank (ECB).*

To complement this data, we need a proxy for the monetary policy. As Slovakia is part of the Eurozone, we use the quarterly interest rate from the ECB of the main refinancing operations (MRO), which provide the bulk of liquidity to the banking system. Regarding Romania, we use the policy rate from its own national bank (NBR). This proxy captures the influence the national bank has on the economy, as it is a principal tool of a monetary policy. It represents the tightness or ease of the monetary policy.

All these variables are graphically exposed in Figure 1 and Figure 2.

Methodology

a) Lag selection

To choose the appropriate number of lags, we check four different criteria: Akaike's Information Criterion (AIC), Hannan-Quinn Criterion (HQ), Schwarz Criterion (SC) aka Bayesian Information Criterion (BIC) and

Akaike's Final Prediction Error Criterion (FPE). The results are displayed in Table 1. Regarding these, we decide to choose one lag for both countries. For Romania, it seems reasonable as both Hannan-Quinn Criterion (HQ) and Schwarz Criterion (SC) suggest it. Concerning Slovakia, Hannan-Quinn Criterion (HQ) and Akaike's Final Prediction Error Criterion (FPE) suggest two lags, while Schwarz Criterion (SC) advises one lag. We justify the choice of one lag for Slovakia to have two more comparable models and to avoid an overfitting specification which could imply additional estimation errors.

b) Ordering of variables

One of the main assumptions we must formulate when using a SVAR model is the ordering of the variables. In our model, we assume that the exchange rate does not contemporaneously affect the three other variables, as to say GDP growth, inflation, and interest rate. Consequently, we put the exchange rate in the last row of our vector of variables (see equation 1). According to existing literature (*Blanchard and Quah, 1989*), we use the following order for the three remaining variables: GDP growth, interest rate, and inflation. By doing so, we first assume that the inflation does not contemporaneously affect both policy interest rate and GDP growth and, second that the interest rate has no contemporaneous effect on the GDP growth.

c) Stationarity

In this section, we discuss the stationarity of our data. Using nonstationary data when estimating a VAR model could be misleading, as several biases arise. Indeed, coefficients shrink towards zero and problems of spurious regression take place. We therefore run two non-stationarity tests and one stationarity test for our variables. Thanks to these three tests, we claim that the GDP growth is stationary in our dataset. However, the tests indicate that inflation rate, interest rate and exchange rate are not stationary *(result not shown)*. We therefore detrend both inflation and exchange rate to get closer to stationarity, by taking the first difference. Regarding the interest rate, we start from the premise that this is a boundary variable that cannot go from minus infinity to plus infinity, and we therefore do not transform it. One justification is that we hence keep its fluctuations and obtain better impulse response functions. After having made these necessary transformations, we compute again the same tests performed previously.

The first non-stationarity test we compute is the Augmented Dickey-Fuller (ADF) test which states whether the null hypothesis of a unit root can be rejected or not. The results are summarized in Table 2. As we want to reject the null hypothesis, we seek for small p-values. We observe that the p-values of GDP growth for both countries are 0.01. As obtained before, we could then reject the null hypothesis that GDP growth is not stationary at a confidence interval of 99%. We can apply same conclusions for inflation rate and exchange rate since we obtain identical results. We run a second non-stationarity test: Phillips-Perron Test for Unit Roots. The results are shown in Table 3 and consistent with the ADF test. For further evidence, we also compute Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, for which the null hypothesis states that the variables are stationary. Results are displayed in Table 4. According to this test, we never reject the null hypothesis, which indicates that all our variables are stationary.

4. Results and Discussion

a) Theoretical considerations

This section is meant to present the results of our research with the support mainly of our impulse response functions. Before analyzing our results, it is useful to briefly describe the theoretical transmission mechanism of monetary policy shocks. First, an increase of the monetary policy rate should decrease investments due to more expensive borrowing for economic agents. Thus, a decrease in growth rate of GDP is expected since it is more expensive for firms to finance their investments while households reduce their consumption. Moreover, a decrease in inflation is expected as the economy slows down. We also expect to see a rise in the interest rate after an increase in inflation, as one of the main roles of a central bank is to stabilize prices. Finally, the impact of an increase in the monetary policy rate of the NBR on exchange rate (EUR/USD) should be intuitively neutral for Romania since it does not use this currency. Regarding Slovakia, if the ECB monetary policy rate increases, the Euro is expected to appreciate. Indeed, a high interest rate will attract more foreign investment to the respective country, which will increase the demand for the currency in question.

b) Transmission mechanisms and countries comparison

If we analyze the impulse response functions of an unexpected contractionary monetary policy shock, i.e., a sudden increase in the policy rate, we can notice a long-lasting decline in Romanian GDP growth rate reaching a maximum after two quarters (Figure 3). The monetary shock seems to be quite significant for this country. However, a shock of monetary policy rate in Slovakia (Figure 4) leads oddly to a sustainable increase in growth rate of its GDP, reaching its maximum after two quarters. However, the result is not significant.

Then, if we analyze the impact of monetary policy shocks on inflation, both countries tend to react negatively on it, confirming our first economic intuition. Their impulse response functions are quite significant and reach their maximum after two quarters in both countries while maintaining a long-lasting negative effect on inflation in the long term. However, inflation in Romania seems to react more strongly than in Slovakia.

Now, if we analyze the impact of a monetary policy shock on exchange rate (EUR/USD), we notice surprising results. For Romania, if its monetary interest rate increases, the Euro will appreciate with a significant effect. Regarding Slovakia, which is in reality the fact for the entire Eurozone, if ECB monetary policy rate increases, the Euro will slightly appreciate but the effect is globally insignificant. Therefore, our results found for exchange rate are against our main assumptions, or at least not significant and nearly zero. It suggests a probable weakness of our model in predicting the response of the exchange rate. This may be due to the lack of stationarity of the interest rate at the beginning of our sample.

c) Robustness check

To check the robustness of our both VAR models, we first test their stability. If they are not stable, the confidence intervals of our impulse response functions cannot be built. We find that all roots of both VAR models are within the unit circle. Therefore, these VAR models are considered stable.

Then, we could check the absence of autocorrelation of errors by computing the Portmanteau autocorrelation test. For both models, we notice a presence of serial autocorrelation as we reject the null hypothesis (stating the absence of serial autocorrelation) with a p-value lower than 0.01 for a number of lags up to 10 (*results not shown*). However, when we test for 10 lags the impulse response functions provide approximately the same results except that they are more wobbling.

Finally, we test the robustness of our models by inverting the order of the exchange rate and the interest rate. In fact, by setting the exchange rate before the interest rate induces the assumption that the interest rate is contemporaneously affected by the exchange rate, i.e., each central bank responds directly to changes in the exchange rate (EUR/USD). However, we don't notice a sizeable change in our results *(result not shown*).

d) Variance decomposition and Granger causality

The fluctuations of the endogenous variables come from the shocks U_t^i. We compute the variance decomposition to identify the shares of the fluctuations of our endogenous variables that result from the different structural shocks. We focus on the variance decomposition regarding the interest rate. Concerning Romania, we found that 0.028% of the variance of the GDP growth comes from an interest rate shock, after two periods. Moreover, it explains only 0.19% of the variance of inflation growth rate after two quarters. But surprisingly, such shock accounts for 6.8% of the variance of EUR/USD exchange rate and until 21% after 10 quarters suggesting a long-term co-movement between Romanian monetary policy rates and the main international exchange rate (EUR/USD). This result does not seem consistent with empirical evidence and existing literature.

Regarding Slovakia, it indicates similarly that a shock of a monetary policy rate explains a small part of the variance of GDP growth (between 1% and 0.3% during the first four quarters). Moreover, it explains only 0.04% of the variance of inflation growth rate after two quarters. Concerning the exchange rate, the fluctuation that results from an interest rate shock is nearly zero. That suggests a noticeable disconnection between exchange rate and its fundamentals in the Eurozone (Phenomenon known as *exchange rate disconnect*[6] in the literature). The results of the variance decomposition are displayed in Table 8.

The examination of the Granger causality (Table 7) for the estimated models reveals no causality between nearly all variables. However, we can reject the null hypothesis for two Granger causality tests in Slovakia. At a significant level of 10%, we can reject the hypothesis that the inflation and the interest rate does not granger cause the GDP growth.

5. Conclusion

In this paper, we analyze the monetary policy transmission mechanism for two Eastern European countries with different currencies on three target variables using a structural VAR model. As main results, we find a negative response to GDP growth rate of monetary policy shocks for Romania but a positive one for Slovakia. Confirming the economic intuition, the impact of an increase in the monetary policy rate on inflation is negative for both countries and is more pronounced for Romania. The results seem to be more surprising for the exchange rate. Indeed, if the Romanian monetary policy rate increases, the Euro appreciates against the dollar in a significant way as opposed to the non-significant impact of ECB interest rate shocks on EUR/USD exchange rate. Thus, the slight effects of ECB monetary shocks on Slovakia's economic fundamentals can come from the relatively small size of this country relative to the Eurozone. But in general, thanks to the variance decomposition analysis, we notice the low magnitude of these effects from an empirical point of view no matter whether the effect is significant or not.

Furthermore, the non-stationarity of our data at the beginning of our sample (especially interest rates) is an issue to address. This might have misled some results as well as the presence of serial autocorrelation which could be solved with a VEC model in future research. Moreover, several things can be implemented to improve the robustness of our results. First, including more Central and Eastern European countries (e.g., Poland, Hungary, Czech Republic, Slovenia) in our sample could enhance the reliability of our results. Secondly, we could either set the exchange rate as an exogeneous variable in both models or replace the EUR/USD exchange rate by the RON/USD one in the VAR model related to Romania to capture the dynamics of its national currency. Finally, we could add economic variables in our VAR model e.g., unemployment rate or trade openness, to assess the impact of monetary shock on an extended bunch of economic outcomes. We leave these suggestions to future research.

[6] Meese and Rogoff (1983)

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APPENDIX

A.1 Tables

Table 1: Lag Selection

	Romania	Slovakia
AIC(n)	3	10
HQ(n)	1	2
SC(n)	1	1
FPE(n)	3	2

Notes: The entries are the number of lags suggested by each of the four criteria; Akaike Information Criterion (AIC), Hannan- Quinn Criterion (HQ), Schwarz Criterion (SC) aka Bayesian Information Criterion (BIC), and Akaike's Final Prediction Error Criterion (FPE).

Table 2: Augmented Dickey-Fuller Test

	GDP	Inflation	Interest Rate	EUR-USD
Romania	0.01	0.01	0.773	0.01
Slovakia	0.01	0.01	0.534	0.01

Notes: Each entry is the p-value, for the column variable of the economy, of the Augmented Dickey-Fuller (ADF) test for the null hypothesis that the series has unit root (i.e., is non-stationary).

Table 3: Phillips-Perron Test for Unit Roots

	GDP	Inflation	Interest Rate	EUR-USD
Romania	0.01	0.01	0.404	0.01
Slovakia	0.01	0.01	0.690	0.01

Notes: Each entry is the p-value, for the column variable of the economy, of the Phillips-Perron Test for Unit Roots. P-value = 0.01 means p-value ≤ 0.01

Table 4: Kwiatkowski-Phillips-Schmidt-Shin Test

	GDP	Inflation	Interest Rate	EUR-USD
Romania	0.1	0.1	0.1	0.1
Slovakia	0.1	0.1	0.1	0.1

Notes: Each entry is the p-value, for the column variable of the economy, of the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test under the null hypothesis of non-stationarity. P-value = 0.1 means p-value ≥ 0.1

Table 5: VAR Estimates - Romania

	(1) GDP	(2) Inflation	(3) Interest Rate	(4) Exchange rate
GDP	0.127 (0.126)	0.007 (0.018)	0.059 (0.046)	0.171 (0.362)
Inflation	-0.812 (0.759)	-0.498** (0.110)	-0.325 (0.046)	-0.018 (2.178)
Interest Rate	-0.040 (0.119)	-0.024 (0.017)	0.869*** (0.043)	0.643* (0.342)
Exchange Rate	-0.004 (0.029)	0.002 (0.004)	0.017 (0.010)	0.785*** (0.082)
Constant	0.014 (0.032)	-0.001 (0.005)	-0.017 (0.002)	0.236** (0.092)
Observations	67	67	67	67
R^2	0.036	0.269	0.940	0.807
R^2 adjusted	-0.027	0.222	0.936	0.795
F Statistic (df = 4)	0.572	5.707***	242.024***	64.944***

Notes: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05. The table shows the coefficients from the structural VAR estimation, for which the order is GDP, inflation, interest rate and exchange rate and which include 1 lag for each variable.

Table 6: VAR Estimates - Slovakia

	(1) GDP	(2) Inflation	(3) Interest Rate	(4) Exchange rate
GDP	-0.120 (0.123)	-0.009 (0.009)	0.023 (0.017)	-0.221 (0-318)
Inflation	3.083** (1.512)	-0.417*** (0.114)	0.209 (0.205)	9.332** (3.913)
Interest Rate	0.306* (0.177)	-0.013 (0.013)	0.969*** (0.024)	0.582 (0.459)
Exchange Rate	0.032 (0.047)	-0.001 (0.004)	0.004 (0.006)	0.001 (0.120)
Constant	0.005 (0.003)	0.0004 (0.0003)	-0.0003 (0.0005)	-0.009 (0.009)
Observations	67	67	67	67
R^2	0.118	0.197	0.966	0.109
R^2 adjusted	0.061	0.145	0.964	0.051
F Statistic (df = 4)	2.081*	3.802***	439.946***	1.890

Notes: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05. The table shows the coefficients from the structural VAR estimation, for which the order is GDP, inflation, interest rate and exchange rate and which include 1 lag for each variable.

Table 7: Granger Causality - Romania and Slovakia

Null Hypothesis	Romania		Slovakia	
	F-statistic	P-value	F-statistic	P-value
GDP does not Granger cause Inflation	0.2012	0.6553	1.5318	0.2204
GDP does not Granger cause Monetary Policy Rate	1.5259	0.2212	1.6354	0.2056
GDP does not Granger cause Exchange Rate	0.1257	0.7241	0.3978	0.5305
Inflation does not Granger cause GDP	1.1012	0.2980	3.7973	0.0558
Inflation does not Granger cause Monetary Policy Rate	1.1052	0.2971	0.8342	0.3645
Inflation does not Granger cause Exchange Rate	0.0001	0.9822	5.4891	0.0223
Monetary Policy Rate does not Granger cause GDP	0.3358	0.5643	2.9480	0.0908
Monetary Policy Rate does not Granger cause Inflation	2.1330	0.1491	1.1435	0.2890
Monetary Policy Rate does not Granger cause Exchange Rate	3.5302	0.0648	0.7828	0.3797
Exchange Rate does not Granger cause GDP	0.2221	0.6390	0.6452	0.4249
Exchange Rate does not Granger cause Inflation	0.4665	0.4971	0.1366	0.7130
Exchange Rate does not Granger cause Monetary Policy Rate	3.0861	0.08375	0.3578	0.5519

Notes: For all the granger causality tests, we use an order of 1. If the p-value is less than a certain significance level, then we can reject the null hypothesis and state that we have sufficient evidence to say that *x* Granger-causes y.

Table 8: Variance decomposition with respect to the monetary policy rate

	Romania			Slovakia		
Lag	GDP	Inflation	Exchange Rate	GDP	Inflation	Exchange rate
1	0.000000	0.000000	6.838042	0.000000	0.000000	0.005702
2	0.028746	0.190102	8.891061	0.148936	0.042880	0.083173
3	0.043884	0.207612	10.916300	0.233320	0.070083	0.131436
4	0.064189	0.266476	12.856591	0.319833	0.096470	0.148327
5	0.079581	0.294443	14.644480	0.402172	0.122177	0.181588
6	0.094834	0.326295	16.259862	0.479734	0.146289	0.212913
7	0.107833	0.348819	17.695150	0.553296	0.169220	0.242703
8	0.119734	0.369603	18.958120	0.622882	0.190932	0.270898
9	0.130176	0.386436	20.061565	0.688768	0.211516	0.297625
10	0.139510	0.401240	21.021705	0.751141	0.231023	0.322951

Notes: Variance decomposition of GDP growth / inflation / exchange rate in Romania and Slovakia with respect to the monetary policy rate of the respective country. The numbers displayed in this table show the contribution in percentage of an interest rate shock for the respective endogenous variable. For instance, 0.043% of the variance of the GDP in period 3 comes from an interest rate shock.

A.2 Figures

Figure 1: Descriptive statistics - Romania

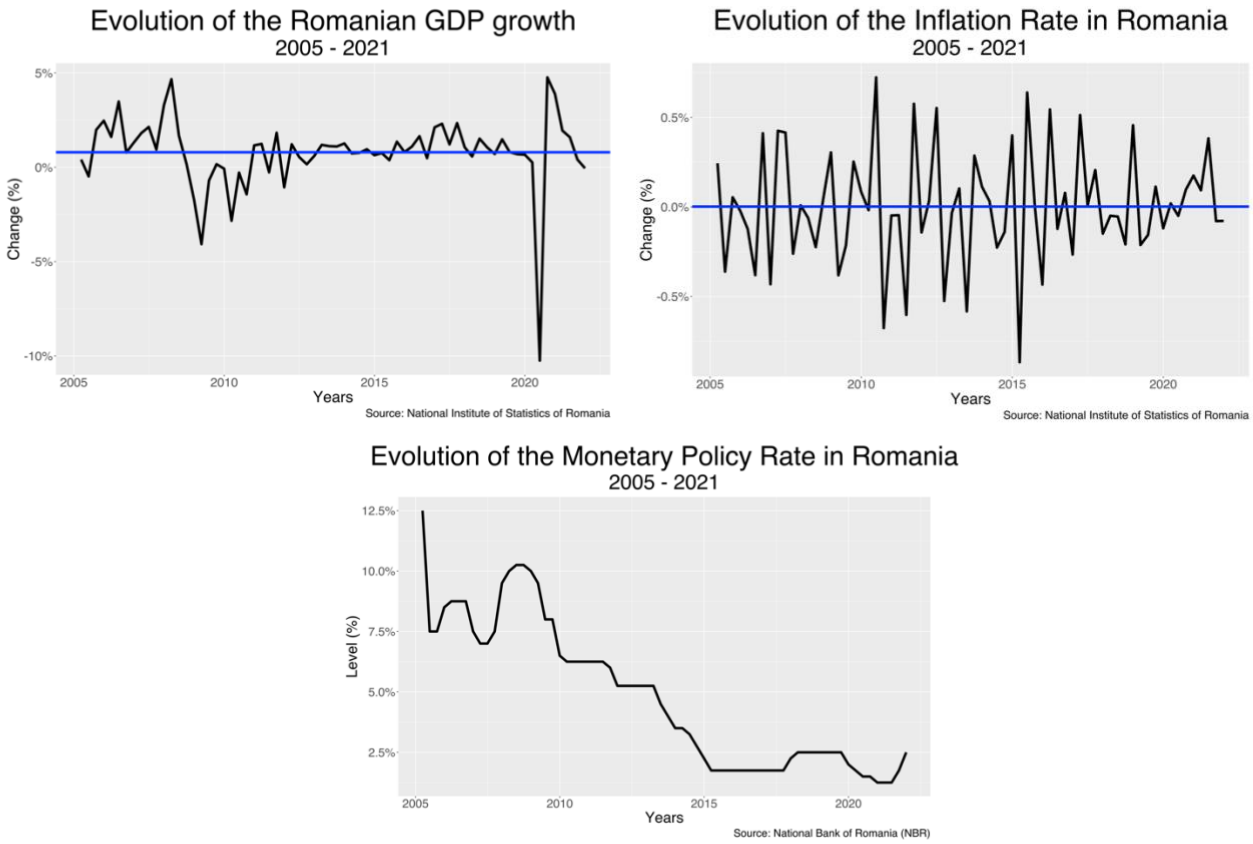

Figure 2: Descriptive statistics - Slovakia

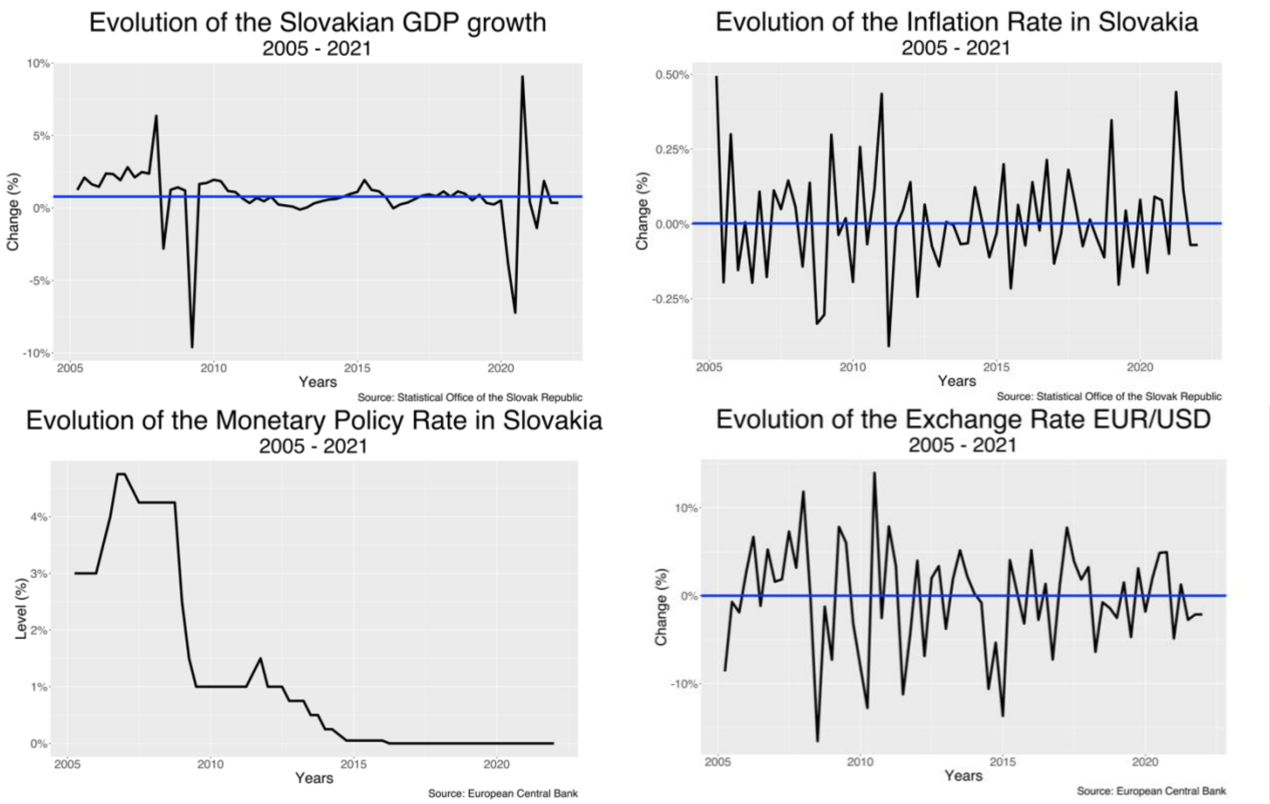

Figure 3: Impulse response functions - Romania

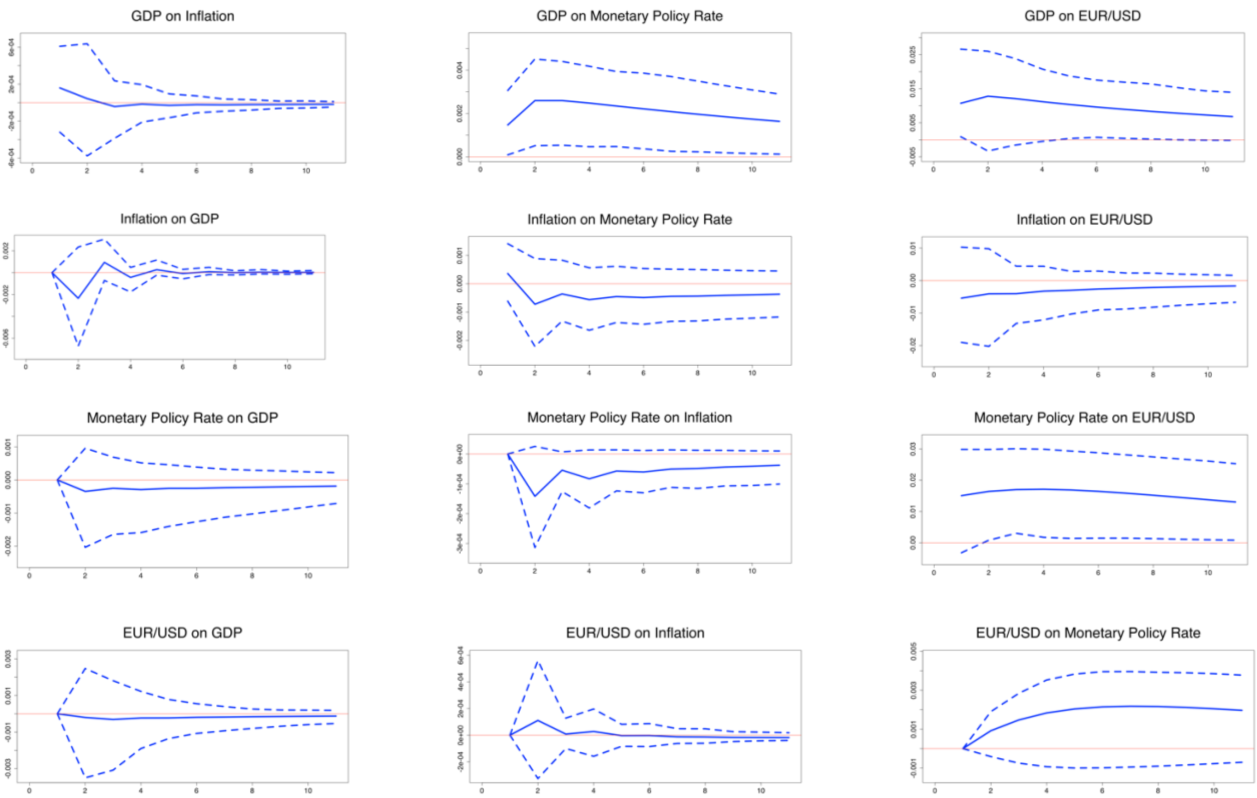

Figure 4: Impulse response functions - Slovakia