

IMPULSE-RESPONSE ANALYSIS OF MONETARY POLICY – VISEGÁD GROUP COUNTRIES CASE

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Abstract

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In this paper, we focus on comparability of monetary policies of Visegrád group countries (V4). Main objective of central banks function in V4 countries lies in maintaining price stability. For this purpose, inflation targeting regime is realized in a medium-term focus in V4, which means that there is a certain lag between monetary policy operation and its influence on an inflation target. Central bank does not have a direct impact on its ultimate goals. Therefore, any monetary policy analysis and assumption of its effectiveness comes out from an essential existence of a working transmission mechanism. Thus, changes in settings of monetary policy instruments have to be able to inflict causal changes on intermediary markets and via these markets on target markets. This situation can be modeled by the vector autoregressive (VAR) model with suitable variables. Our main task is to compare a relationship between VAR model responses to predefined impulses for all V4 pairs. We use calibration technique for this purpose. Specifically, we will utilize one-dimensional calibration model with a linear calibration function for deriving unknown parameters. Moreover, we will test a significance of estimated parameters. We distinguish between model parameters for before-crisis- and during-crisis-data, because we suppose that financial crisis affects VAR model parameters significantly. Different responses in each country can mean the inability of the common monetary policy for V4 at present.

calibration, financial crisis, impulse-response analysis, inflation targeting, monetary policy, VAR model

This paper focuses on implications of the current financial crisis within the framework of the monetary policy of four Central European countries. Monetary transmission depends on monetary policy, but also on a structure of economy. Financial crisis is able to affect both of these phenomena. The article studies changes in transmission channel using impulse-response analysis.

The inflation targeting strategies have been gradually adopted in the world in the 1990s after an unsuccessful “Volcker Experiment” period that came out from a monetarist idea of price level proportional growth to a money supply growth. Instability of money multiplier and unstable velocity of money circulation pointed out to an unclear applicability of rigorous “equation of exchange”, respectively to an unclear link between monetary aggregates and price inflation rate. The

monetary aggregates were excluded from monetary policy decision making. Nevertheless a monetarist argument, that inflation is always a monetary phenomenon, has stayed valid. A principle of neutrality of money in long-term is accepted generally as well as an assumption that central bank can contribute to an improvement of an economy growth potential only through maintaining a stable price environment. But a monetary policy operational criterion has become a short-term interest rate in relation to an inflation forecast in a mainstream economics.

Czech National Bank (ČNB) implemented the inflation targeting strategy as the first from V4 members in 1998. National Bank of Poland (NBP) followed in 1999. Since 2001 the inflation targeting has been utilized in Hungarian National Bank (MNB). National Bank of Slovakia (NBS) has worked

under inflation targeting regime since 2005. The European Central Bank (ECB) took over its mission in 2009.

An essential precondition for effective monetary policy is an existence of functional transmission mechanism. There is not an exact consensus about its behaviour. Transmission mechanism is a process, in which a change in settings of monetary policy instruments works via changes of intermediary markets on final changes in economy, particularly in inflation with variously long lags. There are several possible channels of transmission mechanism. Traditionally, interest rate channel, credit channel and exchange rate channel are referred. In the interest rate channel a value of the base interest rate of central bank impacts on short-term interest rates of inter-banking market. In accordance with it, commercial banks set up their deposit and credit rates. Investment behaviour and a demand for goods and services are influenced in this way. This view is stemming from an idea of money exogeneity, where central bank determines behaviour of commercial banks and public. Contrary to that, Post-Keynesians refer to an endogeneity of money. They believe that an aggregate demand does not fall down with an ascending price level. According to them an amount of money in circulation is set by demand for money and is not determined by central bank exogenously. Although Post-Keynesians presumption of the broad exogenous money has been accepted by mainstream economics after the “monetarist experiment”, a hypothesis of the lead role of central banks still dominates the economic paradigm.

Many authors concern with rightfulness of inflation targeting itself primarily within Post-Keynesians or Hayek's arguments, e. g. Hlaváč & Munzi (2011). Regardless this issue, there is indisputably a necessity of the existence of the functioning transmission mechanism for feasible central bank monetary policy. Therefore, many authors deal with a modelling of this mechanism for various world economies. Papers concerning this problem for countries in Central Europe are for example Burian & Brčák (2012) and Krušec (2011). However, these studies work with standard techniques and do not reflect potential changes in the value of the model parameters with time progress. There are only few studies, which deal with structure modification: recently Darvas (2012) has investigated modifications caused by transition to the inflation targeting strategy and by entering the European Union; alternatively Lyziak *et al.* (2011) have modelled changes in Polish monetary transmission.

The aim of the present paper is to complement the above efforts and to study current changes in transmission mechanism more thoroughly. There is a supposition that financial and subsequent economic crisis could have an impact on force of monetary policy. Toward this end, we try to find out whether responses of inflation rate to changes of key interest rate have been transformed during

crisis. Modelling for similar V4 economies can demonstrate a generality of such changes or their local conditionality.

VAR model is used for obtaining responses to predefined impulses. This approach is a common method for analyses of monetary policy impact on economic variables. This approach is appropriate because it works with lags and central banks derive their decisions from an expected future inflation rate. Moreover it will be able to determine the causality between monetary policy and real indicators. From the essence of the data, high VAR model orders are required. Therefore linear restrictions on parameters are set to eliminate statistically insignificant ones. This should help us to improve stability and prediction power of the model.

Further technique used in this paper is a one-dimensional linear calibration model. It aims at two sets of data, when both are burdened with random errors. As a result we obtain a function, which relates data from the first set to the data from the second set; another finding is possible – such that there is no meaningful relation between both datasets. Even though the calibration methodology is designed for real measurements primarily, it is possible to use it for selected parts of economic problems (see Myšková & Hampel, 2012b).

MATERIAL AND METHODS

For all countries in our paper – Czech Republic, Poland, Hungary and Slovakia – three indicators were included: inflation, interbank interest rate and central bank key interest rate. Our sample data include monthly observations in the period from the January 2002 to the August 2012 for Czech Republic and Hungary and to the July 2012 for Poland and Slovakia. It was not possible to use quarterly indicators, for example Gross domestic product, because available number of observations would not be sufficient for an accurate analysis of during-crisis period.

First variable used is P, an inflation rate as an increase in consumer price index (CPI) compared with the corresponding month of preceding year. Data sources were national statistical offices. Next included variable is IR, 3 month interbank interest rate taken from national central banks. In Slovakia there was a transition from BRIBOR to EURIBOR on January 2009. Last variable is BR, central bank base rate from an identical source. In Slovakia it was National Bank of Slovakia key rate until the end of 2008 and rate of ECB since the time. We set the same breakpoint for all datasets as the October 2008. In this time the Chow test (Chow, 1960) detects structural change in inflation progress for all V4 countries. In the further text, we will use the following notation: the term “before crisis” means period before the October 2008 and the term “during crisis” means period after the October 2008.

VAR model is used for modelling of the multivariate time series consisting of P, IR and BR. It is a special case of VARMA model, what is an analogy of Box-Jenkins ARMA model. Detailed description of this approach is given for example in Lütkepohl (2006), Lütkepohl & Krätzig (2009). To obtain stationarity, what is an important condition for using of this model, we difference all the univariate time series; another possibility is outlined for example in Neubauer (2008). Such an approach should lead to description of inner relations in data; not to relating external characteristics as a common trend. We want to describe long-term dependencies in the multivariate time series. It requires high order of the VAR model, what causes an overparametrization usually. Hence we use sequential elimination of regressors strategy (see Brügemann & Lütkepohl, 2001) what helped us to obtain statistically significant parameters in VAR matrices (zeros otherwise) only. This approach improves numerical performance of the VAR model estimation as well.

With estimated parameter matrices it is relatively easy to calculate responses of particular variables to impulse or “random shock” in one of them. These responses, precisely defined for example in Lütkepohl & Krätzig (2009), seem to be useful tool for exploration of VAR variables interaction. They can be compared visually or their characteristics (lag, maximum, minimum, spread, duration, area) can be calculated, as we do. Moreover, for pairwise comparison of responses we can use linear calibration technique, because both impulse responses can be formulated as measurements with random error.

We use one-dimensional linear calibration model with linear calibration function for derivation of unknown line parameters. Magnitude of the measurement error corresponds to the variance estimate obtained from the VAR model. We suppose that the first impulse response is realization of n -dimensional normal random vector X with mean value μ and covariance matrix $\sigma_x^2 V_n$ and the second

impulse response is realization of n -dimensional normal random vector Y with mean value v and covariance matrix $\sigma_y^2 V_n$, where V_n is diagonal matrix with values on the diagonal 2, 1, 1/2, 1/3, ..., 2/($n-1$). Calibration function, in our case in the form

$$v = a1_n + b\mu \quad (1)$$

(nonlinear due to a product of unknown parameters b and μ), describes relationship between real values. After the Taylor series expansion around initial values μ_0 and b_0 we get linear model

$$\begin{pmatrix} X - \mu_0 \\ Y \end{pmatrix} \sim N \left(\begin{pmatrix} \delta\mu \\ v \end{pmatrix}, \begin{pmatrix} \sigma_x^2 V_n & 0 \\ 0 & \sigma_y^2 V_n \end{pmatrix} \right)$$

with constrains

$$0 = (1_n, \mu_0) \begin{pmatrix} a \\ b \end{pmatrix} + (b_0 I_n, -I_n) \begin{pmatrix} \delta\mu \\ v \end{pmatrix},$$

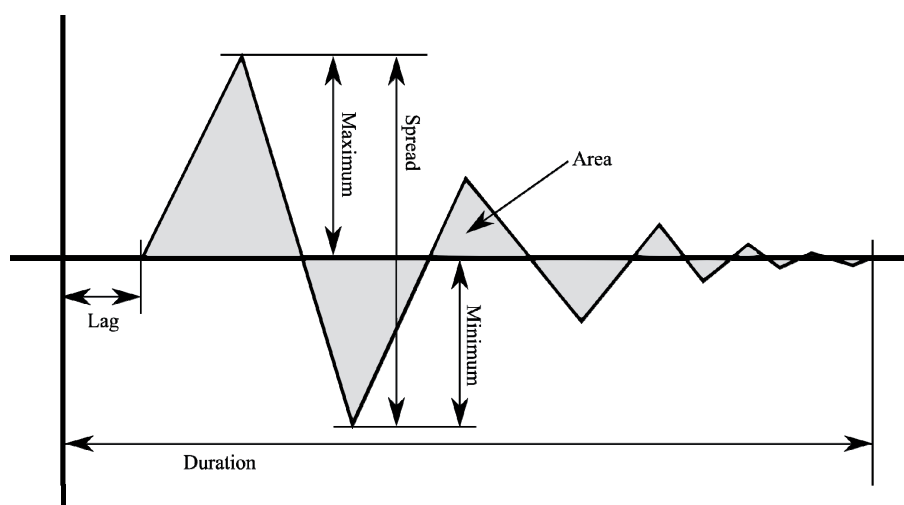
where $\delta\mu = \mu - \mu_0$. Further details can be found in Myšková (2011, 2012a).

VAR parameters estimation was carried out in the software JMulTi 4.24. Impulse-responses, their characteristics and calibration require programing of proper functions in computational system Matlab R2012b.

RESULTS AND DISCUSSION

We will compare responses of selected variables to impulse in one of them in a visual way, but beside this, we wish to compare them more objectively using numerical characteristics.

These are “Lag” – delay between impulse and response; “Duration” – duration of the response, the last moment when the absolute value of the response is greater than constant 0.01; “Maximum” – maximum of the response; “Minimum” – minimum of the response; “Spread” is equal to difference



1: Measured characteristics of particular responses

Maximum – Minimum; “Area” – sum of areas between the responses curve and x -axis. Illustration of the characteristics is given in Fig. 1. The characteristics were measured using own automated procedures realized in Matlab computational system, responses of IR to BR impulses are summarized in Tab. I; responses of P to BR or IR impulses are summarized in Tab. II.

There is a negative initial response of inflation to monetary shock in all countries before crisis (Fig. 2, right graph). This is in accordance with theoretical model, in which inflation also reacts negatively to a monetary shock. However, a positive initial response of inflation is detected in Slovakia during crisis (Fig. 3, right graph). In this respect, we can discuss not only influences of the crisis, but also an entrance of Slovakia to EMU in 2009, when a change

of monetary policy instruments could cause dissimilar reactions of real indicators.

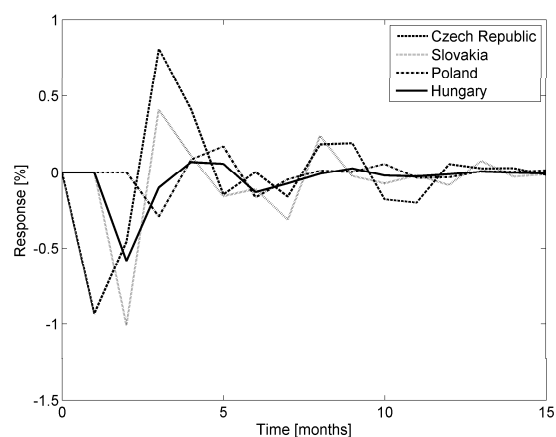
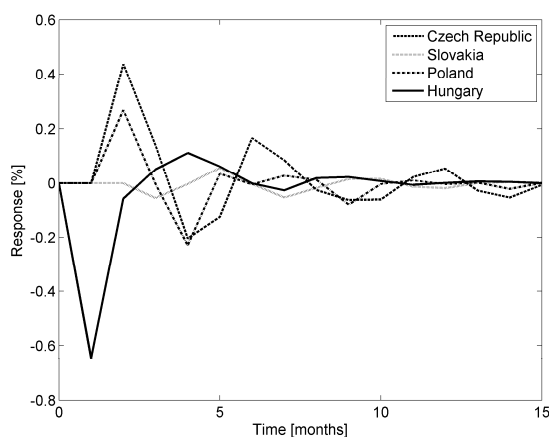
We found that restrictive (i.e. positive) monetary impulse has positive effect on interbank interest rate in the Czech Republic and Poland before crisis period (Fig. 2, left graph), which coincides with theoretical model again. But initial response is negative in Hungary and Slovakia. Similarly, there is even bigger negative response in Hungary during crisis. In this respect, we can discuss a low credibility of monetary policy in Hungary – despite of the implementation of the inflation targeting strategy in 2001 there had been still preserved crawling peg devaluation until 2008, when a free floating exchange rate was adopted. Moreover, a big share of foreign currency loans can be a substantial factor in ineffectiveness of monetary policy in Hungary,

I: Characteristics of IR responses to impulse in BR

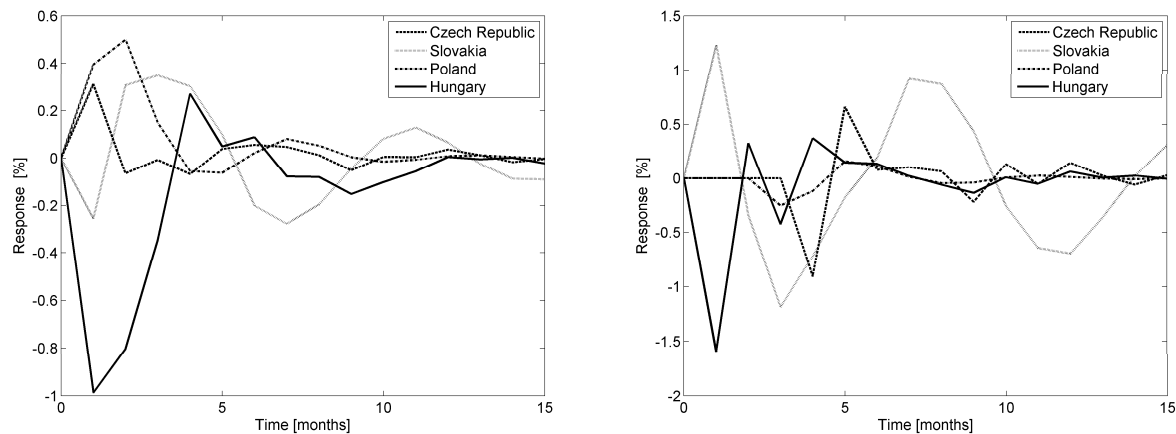
		Maximum	Minimum	Spread	Duration	Lag	Area
CZ	before	0.438	-0.204	0.642	21	2	1.364
	during	0.312	-0.068	0.380	17	1	0.548
HU	before	0.112	-0.647	0.759	9	1	0.663
	during	0.272	-0.988	1.260	19	1	2.482
PL	before	0.268	-0.229	0.497	14	2	0.661
	during	0.501	-0.063	0.564	13	1	1.118
SK	before	0.057	-0.056	0.113	12	3	0.249
	during	0.350	-0.278	0.628	23	1	2.354

II: Characteristics of P responses to impulse in BR or IR respectively

		Maximum	Minimum	Spread	Duration	Lag	Area	BR/IR
CZ	before	0.809	-0.933	1.742	25	1	2.959	BR
	during	0.660	-0.909	1.569	29	4	2.070	IR
HU	before	0.069	-0.583	0.652	12	2	1.032	BR
	during	0.372	-1.594	1.966	17	1	1.900	BR
PL	before	0.171	-0.292	0.462	16	3	0.765	BR
	during	0.158	-0.254	0.412	12	3	0.724	BR
SK	before	0.410	-1.010	1.420	19	2	2.156	BR
	during	1.230	-1.187	2.417	37	1	8.413	BR



2: Responses of IR to BR impulses (left graph), responses of P to BR impulses (right graph); dataset before financial crisis



3: Responses of IR to BR impulses (left graph), responses of P to BR impulses – for the Czech Republic response of P to IR – (right graph), dataset during financial crisis

III: Calibration of IR responses to impulse in BR and calibration of P responses to impulse in BR (IR for the Czech Republic during the crisis) for all countries. We omit the results of calibration of response of IR to BR for Slovakia, because they are unsystematic (denoted by the symbol “x”).

		Response of IR to BR impulse						Response of P to BR (IR) impulse					
		before crisis			during crisis			before crisis			during crisis		
		SK	PL	HU	SK	PL	HU	SK	PL	HU	SK	PL	HU
CZ	a	x	-0.010	-0.020	-0.457	0.034	-0.063	-0.038	-0.014	-0.038	-0.015	-0.007	-0.052
	b	x	0.546	-0.166	68.094	1.306	-3.262	0.607	-0.116	0.114	2.269	0.172	-1.300
SK	a		x	x		0.054	-0.115		-0.017	-0.019		-0.007	-0.064
	b		x	x		0.078	0.013		-0.109	0.429		0.046	-0.338
PL	a			-0.022			-0.005			-0.030			0.015
	b			-0.706			-2.027			0.942			8.958

because changes in a setting of central bank base rate cannot directly influence interest rates of foreign loans.

Regarding responses of IR to BR for particular countries before crisis (Fig. 2, left graph), there is an obvious similar development in the Czech Republic and Poland (a reaction within a meaning of a curve shape) with more powerful positive reaction of the Czech Republic. Fig. 2 (right) says that the Czech Republic and Poland have a similar development of responses of P to BR (a reaction within a meaning of a curve shape), but a response in Poland is delayed by two periods and the deviation is lower than the CR's is. A slow equilibrium restoring is typical for the Czech Republic and Poland. Hungary and Slovakia have bigger negative deviations than the positive (i.e. influence on decrease of inflation prevails the influence on its increase).

Responses of IR to BR react immediately on monetary shock in the Czech Republic and Poland during crisis, contrary to one period delayed response before crisis (see Fig. 3, left graph). The Czech Republic has lower response to a shock during crisis compared with the before-crisis one, Poland has an opposite effect, i.e. stronger response during crisis. There is no meaningful response of P to BR in the Czech Republic; there the role

of BR is replaced by IR. Regarding response of P to BR, or to IR, we can see the same response in the Czech Republic both during crisis and before crisis but delayed by three terms (see Fig. 3, right graph). Impulse response of IR in Poland stays almost identical during crisis. Hungary and Slovakia response without delay and they have bigger deviations during crisis. However, in Slovakia the initial response of inflation is strongly positive, then the inflation sharply falls down and after that it oscillates for at least 18 months remarkably.

Although hypothetical period of the most efficient transmission is 12–18 months in literature, our results do not confirm this hypothesis. We found that an inflation response to monetary shock appears within 1 to 3 months and returns to its stable state after 9 to 23 months. Interest rate reacts within 1 to 4 months; shock persists during 12 to 37 months. This relatively low lag orders do not correspond with a “neoclassical” theory, but they are in accordance with findings of other recent studies for V4 countries (e.g. Krušec 2011; Darvas 2012). Now we would like to decide whether two impulse responses are equal or not. We expect that if two impulse responses are equal we can describe their relationship as a linear function with a slope parameter b equal to one and

a shift parameter a equal to zero, see (1). Results are summarized in Tab. III.

Results can be interpreted in the following way: response of IR to BR impulse is relatively similar in the Czech Republic and Poland before and during the crisis. When exploring response of P to BR impulse, before crisis we can see similarities between Poland and Hungary, and between Slovakia and the Czech Republic. During the crisis, there are no visible similarities at all.

CONCLUSIONS

There is an ongoing debate whether it is convenient to implement common monetary policy for V4 or not, and what consequences it could bring. It is possible to solve this issue by compiling VAR models for transmission mechanisms of V4 countries and subsequent comparing particular responses to monetary shocks. If the responses differ, an implementation of common monetary policy will lead to unpredictable oscillations and to unintentional effects in economies. Furthermore,

monetary policy could be substantially negatively affected by a crisis in economy by a lowering its effectiveness and unanticipated impacts. Crisis can destabilize structure of economy. Therefore, we executed a comparison of the monetary policy effects for before-crisis and during-crisis period.

We are able to find similarities in impulse responses at least for the Czech Republic and Poland before crisis. But each economy reacts differently during crisis. Slovakia has very slow fading down a shock during crisis. Moreover, an unexpected positive initial response of inflation to restrictive monetary shock becomes evident in Slovakia during crisis. Here, it is necessary to mention an entrance of Slovakia to EMU, which probably has brought substantial different effects of ECB's instruments to Slovak indicators. There are higher negative deviations of inflation in Hungary both during and before crisis. But responses of interbank interest rate are negative, which is an unexpected impact of the monetary policy. We can discuss low monetary policy credibility in Hungary in this respect.

SUMMARY

Present paper investigates similarities in effects of monetary policies on interest rates and inflation in four Central European economies – the Czech Republic, Hungary, Poland and Slovakia. It studies also implications of current financial crisis, because monetary transmission depends on a method of monetary policy and a structure of economy. Financial crisis can affect both of these features. An impulse-response analysis given by the vector autoregression models with a linear restriction of parameters is used for this research. A calibration technique is applied for an exact comparison of resemblance between responses. Responses to monetary shocks are investigated. Central banks currently use the inflation targeting strategy for achieving their ultimate goal in price level. Within IT regime changes in central bank base rate should be able to affect interbank interest rates. These rates are expected to affect the inflation via intermediary markets. Our results point out that in some cases the calibration function parameters have been substantially changed during crisis with a changing of the shapes and characteristics of impulse-response functions. We found a negative initial response of inflation to monetary shock in all countries in period before crisis. However, the causality turned over to a unexpected (positive) direction in Slovakia during crisis, appearing with its entrance to the European Monetary Union. A response of interbank interest rate to central bank base rate was positive in all countries with the exception of Hungary and Slovakia during crisis. A low credibility of Hungarian monetary policy can be one potential cause. Calibration functions show similarities only for responses of interest rate to monetary shock in Poland and the Czech Republic before crisis. Responses of inflation to monetary shock are comparable in Poland and Hungary, and in the Czech Republic and Slovakia before crisis. Any resemblances were not found for during-crisis period. Discovered dissimilarities within monetary policy effects in particular countries give evidence of the probable inconvenience of implementation common monetary policy in Visegrád Four in the present. Common policy would, under the conditions of diametrical differences of each transmission channel, lead to the unintended and unanticipated impacts on economies, what has probably happen in Slovakia.

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