Monetary policy and financial stability: empirical evidence from Central and Eastern European countries

Vasile Cocriș1 and Anca Elena Nucu2

Abstract

The international financial and economic crisis highlights that central banks should go beyond their traditional emphasis on low inflation to adopt an explicit goal of financial stability. Our paper addresses this highly topical issue of macro-prudential framework with the focus on effectiveness of monetary policy in affecting some financial stability indicators, in the experience of several Central and Eastern European countries during 2003M01-2012M06. Using a Structural Vector Autoregressive model and impulse response function, we analyze the impact of short-term interest rates upon industrial production, loan to deposit ratio for the banking system, stock prices and exchange rate (proxy variables for financial stability). We want to test if the interest rate is conducive to financial stability. Our empirical results show that the effectiveness of the short-term interest rate in affecting selected asset prices depends on monetary policy strategy. In the case of the Czech Republic, Hungary, Poland and Romania, the interest rate instrument used for inflation targeting is conducive to financial stability. Among countries with a fixed exchange rate regime, only in Bulgaria does transmission of the foreign interest rate impulse to domestic variables promote financial stability. Additionally, our results show that in Latvia and Lithuania adjustments to the monetary policy of the European Central Bank (ECB) are not in accordance with country-specific conditions. The paper contributes to a policy debate on the design of macro-prudential polices in the aftermath of the boom-bust cycle experienced by the Central and Eastern European countries in the second half of the last decade.

JEL classification codes:: E52, C58, G01
Key words: monetary policy, financial stability, Structural Vector Autoregressive model, CEE countries

1. Introduction

It has long been understood that monetary policy can enhance financial stability (IMF, 2012), but the international financial and economic crisis highlights that central banks should go beyond their traditional emphasis on low inflation and adopt an explicit goal of financial stability. Our paper addresses this highly topical issue of macro-prudential framework with the focus on effectiveness of short-term interest rates in affecting selected asset prices.

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The purpose of our paper is to investigate the implications of monetary policy on financial stability in the experience of several Central and Eastern European (CEE) countries, during 2003M01-2012M06. Using a Structural Vector Autoregressive model, we analyze the impact of the short term interest rate upon industrial production, loan to deposit ratio for the banking system, stock prices and exchange rate (proxy variables for financial stability). We want to test whether a monetary policy interest rate is conducive to financial stability.

The literature outlines that there is no widely accepted definition of financial stability or a standard measurement framework. As in Granville and Mallick (2009), we define financial stability in terms of changes in share prices, the exchange rate measured as local currency versus the single European currency and the bank loan-deposit ratio. We also examine the effect of monetary policy on the real sector, by including the industrial production index in the empirical model.

The motivation to address these issues is related to a niche revealed by the literature review. Although the monetary policy transmission mechanism in the candidate countries has been written about from the empirical standpoint, the studies are less numerous, and the results often contradictory due to the relatively short time series and the narrow set of variables. Thus, we aim to address this problem by considering different data series, extending the sampling and grouping the countries according to their monetary policy strategy. In addition, from the econometrical standpoint, the period under review represents a real challenge because we are dealing with structural breaks of the time series due to the macroeconomic impact of the crisis since 2007.

The paper is organized as follows. The next section briefly surveys the major contributions of the literature review. Section 3 lays out the data and the methodology used. Section 4 evaluates the empirical results. Section 5 concludes.

2. Literature review

Interest in analysis of the monetary policy transmission mechanism has increased in the last decade and the Vector Autoregressive (VAR) approach proposed by Sims (1980) has been extensively used in empirical research. The academic literature abounds in studies which analyze the impact of monetary policy on macroeconomic variables in the United States, Great Britain and the euro area using Vector Autoregressive methodology in its different variants (Structural Vector Autoregressive-SVAR, Vector Error Correction-VEC, Structural Vector Error Correction-SVEC) and impulse response analysis derived from these. Among the studies carried out on the example of Central and Eastern European countries, we recall those of Ganev et al. (2002), Elbourne and de Haan (2006), Coricelli, Egbert & MacDonald (2006) Anzuini and Levy (2007), Minea and Rault (2008), Gavin and Kemme (2009), Jareckiński (2010), Minea and Rault (2011), Pirovano (2011), Spulbár et al. (2012). The scarcity of studies is related to the difficulty of using econometrics for emerging countries. The possible causes could be:

- Lack of long data series. Performing an empirical analysis requires a large number of observations, with some frequency in order to draw conclusions. Currently, we are dealing with structural breaks in time series due to the macroeconomic impact of the crisis.
• Lack of comparability between data series on samples of countries.
• Administrative control of economic variables such as prices or interest rates. This takes into consideration that economic variables which are controlled by the authorities generate misleading results because empirical models “assume that the variables of interest are random” (see, for example, Botel, 2002).

Ganev et al. (2002), using Granger causality and impulse response analysis, on the example of CEE countries, find evidence that the exchange rate channel is stronger and more stable than the interest rate channel. Anzuini and Levy (2007) examine, empirically, the effects of monetary policy shocks in the Czech Republic, Hungary and Poland, using a Vector Autoregressive (VAR) model. Their results state that in all countries macroeconomic variables react in line with economic theory: an increase by one percentage point in the interest rate leads to a persistent and significant decline in industrial production, causes an appreciation in the exchange rate and a significant decline, after one year, of the consumer price index. Thus, Anzuini and Levy (2007) find no evidence of counter-intuitive effects of monetary policy shocks.

Elbourne and de Haan (2006), using the Structural VAR methodology, examine to what extent the monetary policy transmission mechanism is related to indicators of financial structure, in the experience of ten countries from Central and Eastern Europe. The variables under consideration (industrial production, consumer prices, exchange rates) react according to economic theory in all countries analyzed, but with differences in the magnitude of the impact and shock persistence. Unlike Anzuini and Levy (2007), Elbourne and de Haan (2006) find a counter-intuitive response: following an increase in industrial production due to monetary policy shock in Romania. The counter-intuitive results obtained for the candidate countries are due, mainly, to small VAR models, typically four variables (see, for example, Balabanov and Brüggemann, 2012).

Jarocinski (2010) performed a comparative impulse response analysis to monetary policy shocks on the example of the euro area countries before EMU (Finland, France, Italy, Portugal and Spain) and new EU member states in CEE (the Czech Republic, Hungary, Poland and Slovenia) and finds that responses of macroeconomic variables to monetary policy shocks in the new Member States are broadly similar to those in the euro area countries.

Spulbăr et al. (2012), using a Bayesian Vector Autoregressive Model on Romanian experience over the past ten years reveal that the exchange rate remains an important mechanism which significantly affects real economic variables and “output puzzle” and “price puzzle” effects do not appear after a positive interest rate shock.

The presence of a particular monetary system in Bulgaria has attracted the attention of researchers. Minea and Rault (2008), using estimations based on the SVAR, analyze the impact of the European Central Bank (ECB) interest rate on four Bulgarian monetary aggregates and find that both the domestic interest rate and broad money M3 follow key interest rate dynamics only in the medium and long term, therefore confirming the endogeneity of the main financial variables under the currency board. In a related line of research, the same authors, Minea and Rault (2011) assess the impact of the ECB and FED interest rate on Bulgarian monetary variables using generalized impulse response functions. They find that ECB mon-
etary policy shocks are more rapidly absorbed and have a less significant impact on domestic variables compared with FED interest rate shocks.

Much less, however, has been written about the optimal monetary instrument to maintain financial stability. In the literature, this topic is currently at the centre of academic debate. Goodhart et al. (2011) assess the choice between adopting a monetary base or an interest rate setting instrument for prudential purposes. The authors suggest that the interest rate instrument is preferable, since during times of panic or financial crisis the central bank automatically satisfies the increased demand for money. A recent strand of literature focuses on central banks’ practice of smoothing the interest-rate (Giorgio and Rotondi, 2011) in order to promote financial stability. The authors conclude that an interest rate smoothing policy can enhance financial stability, but also gives rise to indirect effects that lower financial stability (Smith and Egteren, 2005). To the best of our knowledge, none of these studies was conducted on the example of CEE countries.

In conclusion, as observed, the academic literature provides no consensus on the sign and size of responses by macroeconomic variables after a monetary policy shock in CEE countries. Also, the role of the interest rate in promoting financial stability is currently at the centre of academic debate.

3. Methodology and data

In order to analyze the role of interest rate policy in contributing to financial stability, we follow the standard literature and apply a Structural Vector Autoregressive model on the experience of several CEE countries: Bulgaria, the Czech Republic, Hungary, Latvia, Lithuania, Poland and Romania. Therefore, we have chosen the states from Central and Eastern Europe which joined the EU in 2004 and 2007, but which are not members of the Euro Zone.

3.1. Methodology

Our point of departure is a K-dimensional stationary, stable VAR(p) process with the following form:

\[ Y_t = \nu + A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + u_t, \quad (1) \]

where \( Y_t \) is a (K*1) vector of endogenous variables, \( \nu \) is a (K*1) vectors of intercepts, \( A_p \) are the (K*K) fixed VAR coefficient matrices and \( u_t = (u_{1t}, \ldots, u_{kt})' \) is an unobservable error term, with the usual properties:

\[ E[u_t] = 0 \quad (2) \]

\[ E[u_t u_s'] = \Sigma_u (\text{time invariant variance-covariance matrix}) \quad (3) \]

\[ E[u_t u_s'] = 0, \forall t \neq s. \quad (4) \]

K is the number of variables.

Given the trending properties of the time series, we employ information criteria to select the lag length of the VAR, including a constant and a deterministic trend. We select the lag length
according to the Akaike Info Criterion (AIC) and Final Prediction Error (FPE). Our analysis employs a reduced-form specification of the relationship between the variables, based on the sequential elimination algorithm- Top-Down (TD) procedure which starts from the last regressor in the equation and checks whether deleting it improves the criterion value and so on (Lutkepohl, 2004). For the VAR specifications, we conduct a series of diagnostic tests. We test against autocorrelation, nonnormality and ARCH effects in the VAR residuals.

Since the purpose of our empirical analysis is to evaluate the response of financial variables to a monetary policy shock, we explain the methodology of the impulse response analysis in the following. Monetary policy shock is the only shock identified here. The correlations of the error term may indicate that a shock in one variable is likely to be accompanied by a shock in another variable. Therefore, we assume that structural shocks are orthogonal, which means that the covariance matrix of the VAR residuals conveys information about the coefficients of the contemporaneous relationships between endogenous variables, as in Jarociński (2010). The relationship between reduced-form disturbances \( u_t \) and structural shocks \( \varepsilon_t \) is as follows:

\[
u_t = B^* \varepsilon_t, \quad (5)\]

with the following structure in the case of the Czech Republic, Hungary, Poland, Romania:

\[
\begin{pmatrix}
  u_{tp} \\
  u_{irs} \\
  u_{ldr} \\
  u_{sp} \\
  u_{er}
\end{pmatrix}
= 
\begin{pmatrix}
  b_{11} & 0 & 0 & 0 & 0 \\
  b_{21} & b_{22} & 0 & 0 & 0 \\
  b_{31} & b_{32} & b_{33} & 0 & 0 \\
  b_{41} & b_{42} & b_{43} & b_{44} & 0 \\
  b_{51} & b_{52} & b_{53} & b_{54} & b_{55}
\end{pmatrix}
\begin{pmatrix}
  \varepsilon_{tp} \\
  \varepsilon_{irs} \\
  \varepsilon_{ldr} \\
  \varepsilon_{sp} \\
  \varepsilon_{er}
\end{pmatrix}
= \begin{pmatrix}
  \varepsilon_{tp} \\
  \varepsilon_{irs} \\
  \varepsilon_{ldr} \\
  \varepsilon_{sp} \\
  \varepsilon_{er}
\end{pmatrix}
\]

industrial production innovation
short term interest rate innovation
loan to deposit ratio innovation
stock prices innovation
exchange rate innovation

respectively for Bulgaria, Latvia and Lithuania

\[
\begin{pmatrix}
  u_{tp} \\
  u_{LIBOR} \\
  u_{ldr} \\
  u_{sp}
\end{pmatrix}
= 
\begin{pmatrix}
  b_{11} & 0 & 0 & 0 \\
  b_{21} & b_{22} & 0 & 0 \\
  b_{31} & b_{32} & b_{33} & 0 \\
  b_{41} & b_{42} & b_{43} & b_{44}
\end{pmatrix}
\varepsilon_{LIBOR}
= \begin{pmatrix}
  \varepsilon_{tp} \\
  \varepsilon_{LIBOR} \\
  \varepsilon_{ldr} \\
  \varepsilon_{sp}
\end{pmatrix}
= \begin{pmatrix}
  \varepsilon_{tp} \\
  \varepsilon_{LIBOR} \\
  \varepsilon_{ldr} \\
  \varepsilon_{sp}
\end{pmatrix}
\]

industrial production innovation
LIBOR innovation
loan to deposit ratio innovation
stock prices innovation

where B is a lower triangular matrix obtained from a Cholesky decomposition of the covariance matrix \( \Sigma_u \), such that \( BB' = \Sigma_u \) and \( \varepsilon_{LIBOR} \) represent the monetary policy shock. The present model with \( u_t = B^* \varepsilon_t \) and \( \varepsilon_t \sim (0, I_k) \) is a B-model and K(K − 1)/2 restrictions have to be imposed to identify B. We obtain these restrictions from a “timing scheme” for the shocks. In this paper, we assume a recursive transmission scheme under the following two assumptions:

- the industrial production index does not respond immediately to monetary policy shock;
- a monetary policy shock may have an immediate impact on the loan to deposit ratio, index prices and exchange rate.

Restricting B to be a lower triangular matrix ensures that the first component of \( \varepsilon_t \), \( \varepsilon_{1t} \), can have an instantaneous impact on all equations, where \( \varepsilon_{1t} \) cannot affect the first equation instantaneously but only all the others, and so on. Hence, the recursive structure implies the required K(K-1)/2 zero restrictions.
Taking into consideration that the effects of shocks are easily seen in terms of moving average representation:

\[ y_t = \Phi_0 u_t + \Phi_1 u_{t-1} + \Phi_2 u_{t-2} + \ldots \]  

we obtain the following form:

\[ y_t = \omega_0 \varepsilon_t + \omega_1 \varepsilon_{t-1} + \ldots \]  

where \( \omega_i = \Phi_i B \), \( \omega_0 = B \). \( \Phi_i B \) are the matrices of impulse response function.

### 3.2. Data

The short-term interest rate represents the instrument of monetary policy in our empirical research.

The economic and financial crisis has determined central banks to pay greater attention to financial stability because a stable financial system provides necessary conditions for robust implementation of an efficient monetary policy. Therefore, we have considered one proxy variable for major markets which conceal risks that may affect the stability of the domestic financial system, as follows:

- loan to deposit ratio as a proxy for the banking system;
- stock index as a proxy for the capital market;
- exchange rate measured by local currency versus the euro as a proxy for the foreign exchange market.

Industrial production is our proxy for economic growth.

The datasets used in the empirical analysis depend on the monetary policy strategy of the countries from the sample. Therefore, for the Czech Republic (CZ), Hungary (HU), Poland (PO) and Romania (RO), countries operating under an inflation targeting regime, we estimate a five-dimensional Structural Vector Autoregressive Model with: log of industrial production index, 3 months short term interest rate, loan to deposit ratio, log of stock prices and log of exchange rate measured as local currency versus the euro. The loan to deposit ratio is computed as follows: Loans granted to clients (gross value) / Deposits from clients*100.

For Bulgaria (BG), Latvia (LV) and Lithuania (LT), countries operating under a fixed exchange rate regime, we also estimate a four-dimensional Structural Vector Autoregressive Model with: log of industrial production index, 3 months EUR LIBOR interest rate, loan to deposit ratio for the banking system and log of stock prices. Taking into consideration that changes in Bulgarian, Latvian and Lithuanian monetary variables are non discretionary-decided, we consider that shocks come from the ECB refinancing interest rate. However, in line with other studies (see, for example, Minea and Rault, 2008) that emphasize the fact that changes in ECB interest rate are too rare to produce a sufficient amount of variability, we consider the 3 month LIBOR EUR interest rate as an exogenous variable. Moreover, figure 1 illustrates the evolution in accordance with LIBOR and the ECB refinancing interest rate during January 2003-June 2012.
Figure 1 Evolution of 3 month LIBOR EUR interest rate and ECB refinancing interest rate (%), January 2003-June 2012

Source: Datastream Thomson Reuters

In addition, the currency board strategy implies that the exchange rate of BGN, LTL and LTV against the euro is constant, so that from an empirical standpoint the analysis has no coherent interpretation. Therefore, we dropped out the exchange rate from the VAR specification for Bulgaria, Latvia and Lithuania. Also, given the insignificant role of the domestic interest rate in the loan market (high euroisation) in these countries one may consider dropping the domestic interest rate from a VAR country.

In line with Jarocinski (2010), we have not included monetary aggregates in the baseline model. It is assumed that central banks target short-term interest rates and adjust monetary aggregates accordingly with this objective.

Monthly time series data ranging from 2003M01 to 2012M06 have been used, therefore giving a total of 114 observations. The start of the estimation sample is governed by data availability. All series are obtained from Datastream Thomson Reuters. The choice of frequency was motivated by the necessity for accurate estimates, but this requires use of industrial production instead of GDP per capita detrended, which is reported quarterly. We focus on monthly instead of quarterly frequency because the number of observations in the second case would simply not be enough to perform a structural analysis, as the error bands would be very large and results non-informative.

We define the variables as follows: LIBOR_EUR_3M- 3 month LIBOR EUR interest rate, irs- short term interest rate, log_ip- log of industrial production index, ldr- loan to deposit ratio for the banking system, log_er- log of exchange rate measured as local currency per EUR, log_sp- log of stock prices.

We would like to deal with economies for which the exchange rate arrangements do not change in the estimation, because this fact represents an attempt to minimize the effects of parameter inconsistency that one would expect when estimating over multiple regimes (see, for example, Elbourne and de Haan, 2006). However, the Czech Republic and Hungary have modified the exchange rate regime in the period analyzed, according to the International
Monetary Fund classification. Moreover, in less industrialized economies, it is not clearly specified how the exchange rate regime affects transmission of a monetary shock.

The current economic crisis could represent a structural break in data. Taking a look at the evolution of the time series, we observe the fact that the behavior of variables has changed since 2008, after Lehman Brothers’ bankruptcy. Moreover, Chow tests yield robust results concerning structural breaks. In order to check whether the structural analysis is still valid for the whole sample, we have compared impulse responses of different subsamples (i.e. 2003M01-2008M07, 2008M08-2012M06) and we find that the patterns remain unchanged. In line with other studies (see, for example, Gerke et al., 2008) we conclude that the whole sample remains adequate for empirical research.

4. Empirical results

The unit root analysis, according to Augmented Dickey-Fuller (ADF) and Philips-Perron tests, indicates that the unit root hypothesis cannot be rejected for all the time series considered and that all of them can be characterized as integrated of the order of 1, I(1).

The AIC and FPE suggest two lagged differences for the Czech Republic, Hungary, Poland, Romania and Bulgaria, and respectively, three lagged differences for Latvia and Lithuania.

We present the country impulse response functions in the order of country grouped by the degree of nominal exchange rate flexibility.

Figure 2 plots the responses of financial variables in the Czech Republic to a monetary policy shock. Our empirical results show that after a monetary policy shock via the interest rate, all the variables react in line with economic theory: the industrial production index decreases by roughly 0.08%, after 8 months, the loan to deposit ratio declines and also stock prices drop down. All these effects are statistically significant and the shock has transitory effects, being absorbed after 40-50 periods ahead. In the short run, the local currency appreciates against the single European currency under the impact of a monetary policy shock, but this effect is not statistically significant. Anzuini and Levy (2007), applying a VAR model on the Czech example between July 1997 and January 2002, find that industrial production decreases and the nominal exchange rate measured as local currency versus the U.S. dollar appreciates after a monetary policy shock. The inverse relationship between the interest rate and industrial production is also confirmed by Jarocinsky (2010) and Elbourne and de Haan (2006). In line with our results, Pirovano (2010), using a SVAR model with short-term restrictions, finds that the stock index drops by 0.017, after 8 months, under a restrictive monetary policy shock.
Figure 2 Responses of financial variables in the Czech Republic to an interest rate shock together with a 95% Hall bootstrap confidence interval based on 1,000 replications.

Response of LOG_IP to IRS

Response of IRS to IRS

Response of LDR to IRS

Response of LOG_SP to IRS

Response of LOG_ER to IRS
In Figure 3, the responses of Hungarian macroeconomic variables to an interest rate shock are plotted. As in the case of the Czech Republic, the industrial production index follows a downward trend and the effect is statistically significant. Also, the central forecast for the loan to deposit ratio and stock prices is negative. In the short run, the national currency appreciates against the euro, but the error bands are again quite wide. The negative co-movement between the interest rate and the industrial production index is also confirmed by Jarocinski (2010) and Elbourne and de Haan (2006). Regarding evolution of the stock market index, our empirical results are in line with Pirovano’s study (2010) which confirms the negative relation between this variable and the interest rate.

**Figure 3** Responses of financial variables in Hungary to an interest rate shock together with a 95% Hall bootstrap confidence interval based on 1 000 replications

**Note:** Vertical axis - deviation from the baseline scenario, horizontal axis - number of months after the shock

**Source:** own estimates based on JMulTi
Response of IRS to IRS

Response of LDR to IRS

Response of LOG_SP to IRS

Response of LOG_ER to IRS

Note: Vertical axis - deviation from the baseline scenario, horizontal axis - number of months after the shock

Source: own estimates based on JMulTi
Figure 4 plots the responses of financial variables in Poland to a monetary policy shock. As we can see from the figure, under an unexpected increase in the short term interest rate, all the variables move in the expected direction: the industrial production index falls, the loan to deposit ratio decreases, the Polish stock market index loses about 0.7%, and the local currency appreciates against the EUR in the short run. Our results are in line with those of Jarocinski (2010) and Pirovano (2010).

**Figure 4** Responses of financial variables in Poland to an interest rate shock together with a 95% Hall bootstrap confidence interval based on 1 000 replications

Response of LOG_IP to IRS

Response of IRS to IRS

Response of LDR to IRS
Figure 5 plots the responses of financial variables in Romania to a monetary policy shock via the interest rate. Thus, our empirical results show that a positive monetary policy shock leads to a decrease in the industrial production index, the stock index and the loan to deposit ratio as in the case of previous countries. Also, in the short run the local currency appreciates, the pattern of response is similar to the Czech Republic. Unlike our results, Elbourne and de Haan (2006) find a positive relationship between industrial production and the interest rate using a SVAR model with data spanning the period 1998M06-2004M06, the authors’ explanation being the high level of inflation experienced by our country in that period. Albulescu (2010) using a regression model over the period January 2003-August 2008 finds that ROBID 3 months is not an efficient instrument of the central bank in order to correct imbalances related to evolution of asset prices. The difference from our results is due to the methodology used and period tested, as well. We can also say that we are witnessing a consolidation of the interest rate, as an instrument of monetary policy transmission in Romania, which is a fulcrum for an inflation targeting strategy (see, for example, Spulbăr et al., 2012).
Figure 5 Responses of financial variables in Romania to an interest rate shock together with a 95% Hall bootstrap confidence interval based on 1 000 replications

Response of LOG_IP to IRS

Response of IRS to IRS

Response of LDR to IRS

Response of LOG_SP to IRS
Figure 6 plots the responses of domestic variables in Bulgaria to a shock in the LIBOR EUR interest rate together with a 95% Hall bootstrap confidence interval based on 1000 replications. We note that, in the short run, the industrial production index responds counter-intuitively, but in the long run, the central forecast is negative and statistically significant. An ECB monetary policy shock via the interest rate drives down the loan to deposit ratio and share prices but the effects are only marginally significant.

Figure 6 Responses of financial variables in Bulgaria to a shock in the LIBOR EUR interest rate together with a 95% Hall bootstrap confidence interval based on 1 000 replications

Response of LOG_IP to LIBOR

Response of LIBOR to LIBOR
The impulse response analysis (figure 7) highlights a counter-intuitively and statistically significant response of the loan to deposit ratio for the banking system in Latvia after an ECB monetary policy shock. All the other variables react in line with economic textbooks.

**Figure 7** Responses of financial variables in Latvia to a shock in the LIBOR EUR interest rate together with a 95% Hall bootstrap confidence interval based on 1 000 replications

**Note:** Vertical axis - deviation from the baseline scenario, horizontal axis - number of months after the shock

**Source:** own estimates based on JMulTi
Figure 8 plots the responses of domestic variables in Lithuania to a shock in the LIBOR EUR interest rate together with a 95% Hall bootstrap confidence interval based on 1000 replications. The responses of Lithuanian indicators are similar to those of Latvia. We also note a counter-intuitive response of the loan to deposit ratio which increases by 6% after roughly 15 periods. Unlike our results, Elbourne and de Haan (2006) find a negative relationship between the interest rate and industrial production, but statistically insignificant.
Figure 8 Responses of financial variables in Lithuania to a shock in the LIBOR EUR interest rate together with a 95% Hall bootstrap confidence interval based on 1 000 replications.

Response of LOG_IP to LIBOR

Response of LIBOR to LIBOR

Response of LDR to LIBOR
We observe that our empirical results differ according to monetary policy strategy in place and, therefore, we prefer to draw conclusions based on this criterion, as follows:

- countries operating under an inflation targeting regime (the Czech Republic, Hungary, Poland and Romania);
- countries operating under a fixed exchange rate regime based on a currency board (Bulgaria, Lithuania) or fluctuation band (Latvia).

Table 1 Responses of financial variables to a monetary policy shock in the Czech Republic, Hungary, Poland and Romania (2003: M01 2012: M06)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Czech Rep (CZ)</th>
<th>Hungary (HU)</th>
<th>Poland (PO)</th>
<th>Romania (RO)</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial production index</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>-</td>
</tr>
<tr>
<td>Loan to deposit ratio</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>-</td>
</tr>
<tr>
<td>Stock prices</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>-</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>*</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: - negative response, * statistically significant response at 5% level
Source: own estimates based on JMulTi

From the perspective of financial stability, our empirical results highlight the following:

- There is a statistically significant inverse relationship between the interest rate and stock prices in the Czech Republic, Hungary, Poland and Romania (table 1), which means that the interest rate represents an efficient instrument of intervention in order to correct evolution of asset prices.
- Since stock markets in the Czech Republic, Hungary, Poland and Romania are sensitive to unexpected changes in interest rates, a good alternative for investors would be to rely on interest rate forecasts to make investment decisions in the Czech, Hungarian, Polish and Romanian capital markets.
• There is an inverse relationship between the interest rate and the loan to deposit ratio for the banking system in the Czech Republic, Poland and Romania (table 1). This means that the interest rate represents an efficient instrument of the central bank in order to prevent excessive borrowing by households and economic agents. A credit boom which is not accompanied by an increase in the level of deposits (which reflects confidence in the national currency) indicates a potential imbalance in the financial system and the fact that households and companies face the problem of informational asymmetry.

• There is an inverse relationship between the exchange rate and the interest rate in all countries analyzed, irrespective of their exchange rate regime (free floating or managed floating).

• The sensitivity of the exchange rate to interest rate evolution shows that the exchange rate regime is in compliance with use of inflation targets as a nominal anchor for monetary policy.

From the perspective of monetary policy, our empirical results highlight the following:

• Responses of macroeconomic variables to a monetary policy shock are similar in the Czech Republic, Hungary, Poland and Romania. The differences between countries consist in the number of periods (months) after the shock when these effects occur and in the persistence of the shocks.

• The differences between countries analyzed concerning the magnitude and persistence of shocks show that it is not appropriate to formulate general monetary policy decisions.

• All the macroeconomic variables move in the expected direction after a monetary policy shock. Therefore, we subscribe to Jarocinski (2010) who states that “we need to go beyond the simple rule that monetary policy is less effective in less financially developed countries”. Economic and financial integration has reshaped the frameworks and transmission channels of monetary policy in emerging market economies (Mihaljek, 2011).

Empirical analysis shows that an inflation targeting strategy under a free or managed floating exchange rate is suitable for promoting financial stability.

Table 2 Responses of financial variables to ECB monetary policy shock in Bulgaria, Latvia and Lithuania (2003: M01 2012: M06)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Country</th>
<th></th>
<th></th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BG</td>
<td>LV</td>
<td>LT</td>
</tr>
<tr>
<td>Industrial production index</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Loan to deposit ratio</td>
<td></td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Stock prices</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: - negative response, + positive response, * statistically significant response at 5% level

Source: own estimates based on JMulTi

The empirical results obtained for countries operating under a fixed exchange rate regime highlight the following:
In Bulgaria, after an ECB monetary policy shock all the variables react in line with economic theory.

A counterintuitive response of the loan to deposit ratio for the banking system in Latvia and Lithuania. Liquidity is not a constraint for banking systems whose loan/deposit ratio is under or near 100%. From this perspective, the Baltic countries are not in a comfortable position (see figure 2).

Figure 9. Evolution of the loan/deposit ratio in Latvia and Lithuania during 2006-2012 (%)

Overall, the empirical results show that, in Latvia and Lithuania, countries which lost their monetary policy autonomy, adjustments in ECB monetary policy are not in accordance with country specific conditions. Moreover, our results provide some insights that when the interest rate is not controlled by the National Central Bank, households and economic agents face the problem of informational asymmetry. In this case, in the absence of a discretionary response from the central bank, preventive intervention would be more suitable, according to Albulescu (2010). We subscribe to measures proposed by this author, in order to monitor the development of asset prices, namely: strengthening supervision and regulation, respectively, reducing informational asymmetry. Among countries with a fixed exchange rate regime, only in Bulgaria is the transmission of the foreign interest rate impulse to the domestic variables conducive to financial stability. The impact of ECB monetary policy shock on Bulgarian macroeconomic variables is similar to countries which follow an inflation targeting strategy.

There are three main caveats of our analysis:

- The empirical results may be flawed by national differences in the definition of the loan portfolio for the banking system.
- The residuals are not normally distributed in the case of Bulgaria, Hungary, Romania.
- The small number of variables included in our stylized models. The impact of a monetary policy shock can be analyzed only for the variables included in the model, which are, generally, only a small fraction of the variables of interest for policymakers and researchers implicitly.

Our results are robust to different specifications. First, changing the order of variables does not affect the results. Secondly, the inclusion of dummy variables in order to account for
changes in exchange rate regimes provides similar impulse response functions, but with larger confidence intervals.

5. Conclusions

Using a Structural Vector Autoregressive methodology and impulse response function, with data ranging from 2003M01 to 2012M06, we have analyzed the effectiveness of the short term interest rate in affecting selected asset prices.

Our empirical results differ according to monetary policy strategy in place. Therefore, the main findings regarding the safeguarding of financial stability in CEE countries operating under inflation targeting strategy (the Czech Republic, Poland, Hungary, Romania) are:

- The interest rate represents an efficient instrument of intervention in order to correct the evolution of asset prices and a good alternative for investors would be to rely on interest rate forecasts to make investment decisions in the Czech, Hungarian, Polish and Romanian capital markets.
- The interest rate represents an efficient instrument of the central bank in order to prevent excessive borrowing by households and economic agents.
- The sensitivity of the exchange rate to interest rate evolution shows that the exchange rate regime is in compliance with use of inflation targets as a nominal anchor for monetary policy.

On the other hand, the main findings regarding monetary policy in CEE inflation targeting countries are:

- Responses of macroeconomic variables are similar in the Czech Republic, Hungary, Poland and Romania. The differences between countries consist in the number of periods (months) after the shock when these effects occur and in the persistence of the shocks.
- Differences between the countries analyzed concerning the magnitude and persistence of shocks show that it is not appropriate to formulate general monetary policy decisions.

Our empirical analysis shows that an inflation targeting strategy under a free or managed floating exchange rate is suitable for promoting financial stability.

Among countries with a fixed exchange rate regime, only in Bulgaria is transmission of the foreign interest rate impulse to domestic variables conducive to financial stability. The impact of ECB monetary policy shock on Bulgarian macroeconomic variables is similar to countries which follow an inflation targeting strategy. In the case of Latvia and Lithuania, adjustments in ECB monetary policy are not in accordance with country specific conditions, the loan to deposit ratio responds counter-intuitively to an unexpected increase in LIBOR.

Our contribution relative to the previous literature is twofold: an empirical exploration based on a structural VAR methodology applied to a number of CEE countries grouped by the degree of nominal exchange rate flexibility and a policy debate on the design of macro-prudential polices in the aftermath of the boom-bust cycle experienced by CEE countries in the second half of the last decade.
The paper is useful to those involved in central bank activity, because it assesses the effective transmission of monetary policy impulses via the interest rate, as an instrument, on several macroeconomic variables, proxies for financial stability. Moreover, the paper contributes to the policy debate on the design of macro-prudential polices in the aftermath of the boom-bust cycle experienced by CEE countries in the second half of the last decade.

Further research is called for. Since the VAR models yield problems with respect to a limitation to the size of the system, a first development should be to apply a Factor Augmented VAR (FAVAR) in order to consider a very large data set for estimation as in Balabanova and Brüggemann (2012). A second development should be to conduct counterfactual scenarios using the estimated models in order to better demonstrate the effectiveness of the interest rate in dealing with financial instabilities.

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