ANALYSIS OF THE MONETARY POLICY TRANSMISSION INTO CEEs COUNTRIES. A VAR APPROACH

Ph.D. Student Patricia Amalia MERCEA (HANDRO)
University of Craiova, Romania
E-mail: patricia.handro@yahoo.com

Abstract*: Understanding how real economy adjust to the exchange rate fluctuations enables us to anticipate the effects on inflation, capital market, exports, as well as the monetary policy responses. This study examines the extent of the exchange rate pass-through to the real economy (consumer price index, industrial production, capital market, exports, interest rate) in Bulgaria, Czech Republic, Poland, Romania, and Hungary over the 2008M01-2019M08 period. A Vector Autoregressive analysis using impulse-response functions supported the results for the short term and found a lower degree of passthrough for the exchange rate shocks for all CEE countries. The results of its econometric analysis show that the degree of the exchange rate pass-through is incomplete. The conclusion is that exchange rate remains an important instrument for monetary policy in these economies.*

Keywords*: exchange rate pass-through, vector autoregression, Cholesky decomposition, impulse response function.*
JEL Classifications*: E31, E52, E58, C32.*

1. Introduction

The quantification of the magnitude of exchange rate variation transmission in the real economy represents an extremely important element for the elaboration of economic policies in a small and open economy as it is the case of the central and eastern European states.

The impact of the exchange rate variation on the economy can be measured by the exchange rate pass-through (ERPT), which shows how much the price level changes (and possibly other macroeconomic variables (such as real GDP, industrial output), respond to a change by 1% of the exchange rate. When the passage is equal to one, the exchange rate shock is completely transferred to the price level for example. On the other hand, a zero change implies that the level of domestic prices is independent of the exchange rate. The magnitude and speed of this transmission depend on different determinants, such as the expectations of the economic subjects regarding the evolution of the exchange rate, or the internal demand conditions.

The mechanism of transmitting for depreciation of exchange rate to inflation and increasing production in a small open economy is assumed to operate through direct and indirect effects. In the beginning, the prices of imported final goods are rising, which increases the production costs of domestic producers. Depending on the ERPT size, the price level also increases. In addition to these direct effects, domestic production becomes less expensive than foreign production due to real depreciation, and external demand for domestic goods gradually increases. In response, both the trade balance and domestic production are balanced, and, under these improved conditions, the economy creates premises for more jobs and greater salaries. The magnitude of the exchange rate pass-through receive even a supplementary relevance for monetary policy when the exchange rate is used as an additional unconventional monetary policy tool when short-term interest rates are truncated by the zero-lower limit.

Another mechanism that could be involved in transmitting changes of the exchange rate on the internal rate of inflation, affecting even goods that are not directly sensitive to the exchange rate changes, is represented by the so-called - second-round effects through the inflationary expectations of the economic subjects.

By virtue of exchange rate theories, exchange rates matter because they influence long-term interest rates. A highly valued domestic currency is associated with reduced

long-term risk premiums, while a national currency that suffers from a sharp depreciation is associated with significantly increased risk premiums. Even for a central bank that is not afraid of financial stability, these variations in long-term rates matter for the conditions of the aggregate demand. When financial stability issues are considered, the impact of the exchange rate is even greater. External loans from banks and foreign capital markets increase the exposure in foreign currency, which is further increased with domestic loans denominated in foreign currency.

The exchange rate appreciation tends to reduce inflation, but it fuels debt accumulation by weakening financial conditions, raising vulnerabilities in the medium term. As the risks of financial stability also entail risks for longer-term price stability, this mechanism imposes on central banks in emerging economies a trade-off between short-term and medium-term actions, both for production stability and for price stability.

The economies of Central and Eastern Europe have a number of particular characteristics of the transmission mechanism compared with the old Member States, such as: less developed financial systems, which could result in a weaker effect of autonomous monetary policy on the economy; additional difficulties in anchoring inflation expectations, which can lead to price responses with a larger time lag; higher inflation rate, which complicate the mechanism of monetary policy transmission (because in an inflationary environment, agents adjust their prices more frequently and as such, a lower price rigidity can be identified in these countries compared to more developed economies); the prevalence of the exchange rate channel over the other two traditional channels of the monetary policy transmission mechanism (the interest rate and the credit rate channel); technological and productivity differences; gaps in the level of research and development. Furthermore capital flows are higher than in the euro area, but these capital inflows are also extremely volatile and capital controls have been eliminated; foreign direct investments in these states are large relative to the euro area but there were real appreciations of the exchange rate; notwithstanding the effects of Balassa-Samuelson, inflation has decreased after joining the European Union but shows an upward trend in the current period; the CEECs start from a per capita income (at the purchasing power parity) in half compared to the euro area; therefore, the context in which these states conduct their monetary policy is different compared to other emerging or developed economies.

Ensuring macro-stability, as these economies recovers from the gap with the European economies, was a major challenge after joining the European Union, which also meant the capital account liberalization. In the context of intensification of the international transactions with goods and services, as an effect of the phenomenon of globalization, the degree of openness of CEECs quantified as a share in GDP of exports and imports of goods and services has increased substantially. Of the CEECs countries, Romania recorded the fastest growth rate since the global financial crisis started (but the main growth factor continued to be consumer demand, driven by stimulating conditions, increase in wages and employment, as well as relaxation measures in the fiscal-budgetary sphere). Romania instead recorded one of the highest levels of inflation in EU. As a large part of domestic demand is covered by imports, its increase has led to a deepening of the current account deficit. Even though this level was financed entirely through stable capital flows, the trend in recent years of twin deficits is worrying, given that most EU countries have recorded either current account surpluses or decreasing deficits. Maintaining a sustained trend of GDP growth was thus affected by the accumulation of macroeconomic deficits that were amplified by the increasing openness of the economy towards the outside but especially by the pro-cyclical fiscal policies, factors that amplify the pressure exerted on the exchange rate.

In both Poland and the Czech Republic or Bulgaria, the balance of foreign trade has constant surplus and the current account balance has been positive in recent years. In Hungary, fiscal policy has remained cautious, leading to a decrease in the debt rate as a percentage of GDP and a decrease in foreign debt to reduce the external vulnerability of the economy.

In the first part of the article, we intend to develop a model able to analyze the exchange rate transmission mechanism for the Central and Eastern European Countries: Bulgaria, Czech Republic, Poland, Romania and Hungary and, based on the theoretical framework that governs exchange rate, supplying details regarding the evolution of the real economy response on those shocks. In the second part of the article we offer a quantitative assessment of the magnitude of transmission of real exchange rate changes in the variation of different variables: prices, stock exchange, exports, output, interest rate in CEEC over a horizon of two years.

2. Literature review

While in the case of the advanced economies there are numerous specialized studies that analyze the mentioned above aspects, in case of the emerging economies of CEECs there is a significantly smaller number of such works. Many studies show that the exchange rate pass-through to inflation in many Emerging Economies has decreased considerably in recent times although it often remains larger than in Advances Economies. The decline in exchange rate pass-through to prices is one of the important consequences of the inflation targeting regime adoption since the 1990s Edwards (2006) or Mishkin și Schmidt-Hebbel (2007). Jašová *et al.* (2016)provide an exhaustive study about ERPT before and after the GFC for advanced and emerging economies. The authors note that the Indicator differs over time for both advanced and emerging economies; it also estimates a stable evolution of the indicator in the case of advanced economies, and a decrease in its magnitude in emerging economies argued by reducing inflation rates and second round effect. Özyurt (2016) estimates the magnitude of ERPT in the euro area and finds that it decreased significantly from 0.3 to 0.11 in 2011, when interest rates reached the lower zero limit.

In the case of the Czech Republic, Franta *et al*. (2014), conclude that at the lower zero limit, the exchange rate has a greater impact than in normal times. Franta *et al*. (2014) argue that in the case of small and open economies the use of successive interventions on the exchange rate in order to accelerate economic growth and circumvent the zero lower limit (especially when the central bank does not face severe disruptions of on the financial markets) is quit useless. Providing liquidity through quantitative easing would also have minor effects. Another option would be negative interest rates. Although recent experience shows that interest rates can be set below zero, Franta *et al.* (2014) consider that the Czech National Bank appreciated that the uncertainty generated by these unconventional instruments could have major adverse effects on the economy and ultimately opted for the exchange rate commitment. The exchange rate floor proved to be extremely effective.

In normal times, the central bank may not be willing to accept higher inflation, especially for inflation targeting. Therefore, the increase in the monetary policy rate and the impact of the initial depreciation of the national currency on the economy decreases. However, a diametral situation appears at the lower zero limits, when the central bank wants to increase inflation to combat deflation spiral and, in the case of low inflation expectations, it fights to increase these expectations. In this situation, the monetary authority maintains the nominal interest rate unchanged, and the initial depreciation results in a higher domestic price level and stimulation of economic activity.

Also in the case of the Czech Republic, Baxa and Sextorad (2019) manage to surprise by a Time Varying Parameter-Vector Autoregressive model (TVP-VAR) with stochastic volatility the magnitude of the ERPT in the variation of the different financial variables (taking into consideration that the influence of the interest rate in monetary policy transmission was limited by the commitment applied to the exchange rate). Baxa and Sextorad (2019 p.7) provide supplementary explanation about short run an long run pass-through: "the short-run pass-through is defined as the value of impulse response functions at a given point in time, while the cumulative value of the impulse responses measures the long-run pass-through". The authors note a limited effect of the exchange rate commitment on inflation (this being rather influenced by the structural changes in the Czech economy and not by the temporary effect of the exogenous shocks induced by the introduction of the exchange rate ceiling. On the other hand, the ERPT transmission of production has increased over time, with some possibility of maximum towards the end of the sample.

In the case of Romania Stoian and Murărașu (2015), evaluates the transmission of the changes of the nominal exchange rate in the variation of the different price indices in the Romanian economy (the variation of three price categories: import prices, industrial production prices and consumer prices). The authors use a variety of econometric models in comparison: regression with time-varying coefficients, the Error Correction Model (ECM) and Autoregressive Vectors (VAR) for a sample of data with monthly and quarterly frequency in the period 2000-2014. Regarding the estimation of VAR models, several subsamples, with movable windows, and threshold variables are used to identify possible asymmetric effects on ERPT and the variables used are: CPI inflation rate and CORE2 inflation rate, industrial production prices, international price of Brent oil, the deflator of imports and the real GDP deviation from its potential level as a proxy for inflationary pressures from the real economy. Stoian and Murărașu (2015, p.7) also offer a definition in ERPT in Romanian: "The transmission of the nominal exchange rate changes in the variation of the different price indices can be defined as the percentage change of the internal price level caused by a one point change. percentage of nominal exchange rate". Also here, the authors argue that the value of the indicator presents significant transmission disproportionalities both economically and statistically, determined by the sign and the amplitude of the nominal exchange rate volatility, the inflation rate, as well as specific periods of time (Stoian and Murărașu). , 2015, p.7). The conclusion of the study is that the magnitude of ERPT in Romania has decreased.

Arratibel and Michaelis's (2014) study uses a Bayesian VAR model with time-varying parameters, developed by Primiceri (2005), to analyze whether the reaction of production and prices to interest rate and exchange rate shocks changed by - over time (1996-2011) in the Polish economy. Empirical results show that production seems more receptive to a shock in the interest rate at the beginning of the sample - since 2000, the absorption of this shock has become less costly in terms of production, despite fluctuations since the beginning of the Great Financial Crisis from 2008-2009. The shock of the exchange rate also has an effect that varies over time on production. From 1996 to 2000, the production seems to decrease, while for the periods between 2000 and 2008 the shock of the exchange rate has a significant positive effect on the industrial production. Consumer prices seem more sensitive to a shock in the interest rate in the first half of the sample, when Poland experienced high inflation. The impact of the exchange rate shock on prices seems to decrease slightly.

Darvas (2013), compares the transmission mechanism of monetary policy and its effect on the main macroeconomic variables for the Czech Republic, Hungary, and Poland with the euro area. As these three states have undergone changes in monetary policy and

currency regimes changes as well as large structural transformations in the economy (moving from the centralized economy to the free market economy), it is necessary to use an analysis that involves variables (drift) parameters precisely for capture all these changes. Thus, through the modeling of TVP-VAR, it is found that the effect of a monetary shock to the production has evolved over time. The model estimates that at the last observation of the sample studied, respectively in the last quarter of 2011, the monetary policy in the case of Poland was the most effective recording performance similar to the transmission in the euro area. However, we discuss various factors that may contribute to the differentiation in the monetary transmissions specific to these states, such as the structure of the financial systems (less developed), the rigidity of the labor market, the structure of the industry, the exchange rate regime, the credibility of the monetary policy and the commercial openness as the fundamental factors that diminish the efficiency of the domestic monetary policy.

3. Methodology and data

The estimation is made by using monthly data for the period 2008M01-2019M08 (excepting Bulgaria where the data span includes the interval 2008M01-2018M07 due to some missing data for interest rate in Bloomberg). The data series come from the databases of the Eurostat, Bloomberg, as well as Bruegel dataset (available at: <http://www.bruegel.org) and include: actual real effective exchange rate, industrial production prices - total industry, exports, imports, stock exchange indexes (SOFIX BUX PX WIG10 BET) , inflation rate and interest rate (SOFIBOR BUBOR PRIBOR WIBOR ROBOR). The unit value index of imports is calculated by Eurostat on a monthly basis, using the values expressed in million euros of foreign EU trade in goods and services partners, and provides, together with fluctuations in the nominal exchange rate, information about developments in imported inflation.

The first five mentioned indicators have been replaced with the annual value index (the monthly data has been transformed in year on year monthly variation using formula: 100* current value/t-1 value) and renamed: reer_growth for real exchange rate variation, y for industrial production rate, nx for commercial balance (exports minus imports), and stock_growth for stock exchange indexes yields variation. The last two variables are a series of indicators calculated as effective measures: inflation rate (noted infl) and interest rate (noted r).

The model uses a recursive identification scheme, the variables being ordered, from the most exogenous to the most endogenous, depending on the contemporary influences that exist between them, as described below:

infl « y « nx « reer_growth » stock_growth » r

The number of lags (here two lags) of the VAR model in a reduced form and with level variables is chosen according to the Akaike informational criterion, to preserve the number of degrees of freedom. Johansen cointegration tests, performed to assess the existence of some long-term equilibrium relationships between the analyzed variables, indicate a single relationship of cointegration.

From the analysis of the fundamental statistical properties of the data (the main statistic for CEECs countries are presented in Appendix1), we observe that the values of the distribution parameters for the six variables selected for each analyzed state suggests that there were events that pushed upward and downward the data distribution mode, removing them, for a period ,from the normal distribution. But we have an attractor, an

area of concentration of variables even though the values of the Jarque-Bera test (well above the zero value) clearly reject the normal distribution.

From the preliminary stage of our analysis, if we evaluate the comparative evolution of the REER_GROWTH indicator, for the five CEECs, we observe in the case of the average, which is also the simplest estimator of the central tendency, it takes negative values in all the CEE countries studied, except Bulgaria. These values can be explained by the currency regime adopted in these states: (controlled floating and free-floating) for Romania, the Czech Republic, Poland and Hungary and in the case of Bulgaria, by the extreme fixed currency regime option such as the monetary council.

For the median, which is a robust indicator of the data distribution center, less sensitive to the effects induced by the existence of extreme values or outliers compared to the average we also find positive values for Bulgaria, respectively negative for the other analyzed states. Although the values of the Jarque-Bera test show no normal distribution, the values of the median, as well as the coefficients of asymmetry indicate the existence of an attractor in data and that the shocks involved in the variables tend to balance in the long term, these following a trajectory similar to the normal distribution.

The minimum and maximum levels allow the time series to be included in the evolution thresholds for the observation period. Thus, in the case of Bulgaria we have evolutions in the range [-5,785: 6,116], for the Czech Republic [-10,008: 9,745], for Poland [-11,101: 17,940], Romania [-11,536: 8,779], and Hungary [-13,731: 17,613]. We notice lower values of real exchange rate variation in the fixed regime and larger amplitudes for the floating regimes, with maximum values for Poland where the foreign exchange regime is one of free-floating.

From the analysis of the standard deviation of the data for the 5 CEE countries analyzed, which is also the simplest form of volatility measurement, we also note here, the maximum value in the case of Poland (6,818) where a free-float regime has been operating since 2000, respectively the minimum values (1,497) are found in the case of Bulgaria where, since 1997, the exchange rate regime is an extreme variant of fixed exchange rate (currency board) and the monetary policy strategy adopted is that of targeting the exchange rate.

In order to estimate the transmission coefficient of exchange rate changes in the variation of prices and other financial variables, as modeling procedure we used for estimation the model based on Autoregressive Vectors proposed by Sims (1980) that capitalizes on the advantage of a higher frequency of the available data series (in this case, monthly frequency).Another reason why we chose a VAR model proposed by Sims (1980) is that this analytical method is one of the most commonly used in modeling and forecasting the transmission mechanism of monetary policy, in particular of aggregate macroeconomic variables and monetary policy shocks (Gorgi, Koopman and Schaumburg, 2017). Fry and Pagan (2005) argue that these models offer the best combination of database-based models and those that describe economic theory.

In the proposed VAR model for the analysis of CEECs states, each variable is predicted as a linear function of the variable from the previous period, plus the effects from the previous period of the other variables that build the model: it is assumed that each variable at time t is estimated through changes of the other variables. (including through its own variation) compared to the previous moment of time (t -1). In addition to a set of parameters, the VAR model is composed of autoregressive effects, which indicates, on the one hand, the level to which a variable is estimated by its evolution over a previous period, (the dependent variable is modeled according to its own observations) and, on the other hand, effects with time-lag (hysteresis), caused by changes of the other variables from a previous moment (eng. cross-lagged). By the Cholesky decomposition, the assumptions

that are taken into account are, for example, that a shock in the real exchange rate (negative evolutions represent the depreciation of the real exchange rate while positive values constitute appreciation) simultaneously affects only the stock market and the interest on monetary policy and with time lag exports, output, and consumer prices.

For the VAR model, we will have six simultaneous equations that reflect the link between the actual real exchange rate (reer_growth), inflation (inflation), industrial production (y), trade balance (nx), the financial market, exposed by the dynamics of the stock indexes of each state (stock_growth), respectively the money market represented by the evolution of the interbank interest rate, monthly series (r). In order to track the effect of the exchange rate fluctuation in the change of the real economy variables, we use a vector of the following macroeconomic and financial variables.

$$\{reer\_growth, inflation, y, nx, stock\_growth, r\},$$

Although the arguments for including the external sector are well-founded in the literature, the differences between VAR models and without blocking foreign variables are not great. Borys *et al.* (2009) regarding the linear VAR model, the shock of monetary policies can be well-identified without affecting the results and without the input of external variables.

$$Reer\_growth_t = A_1 + \sum_{j=1}^{j=p} B_{1j} reer\_growth_{t-j} + \sum_{j=1}^{j=p} C1_j infl_{t-j} + \sum_{j=1}^{j=p} D1_j Y_{t-j}$$

$$+ \sum_{j=1}^{j=p} E_{1j} NX_{t-j} + \sum_{j=1}^{j=p} F_{1j} Stock\_growth_{t-j} + \sum_{j=1}^{j=p} G_{1j} R_{t-j} + u_{1t} \quad (1)$$

$$Infl = A_1 + \sum_{j=1}^{j=p} B_{1j} Reer\_growth_{t-j} + \sum_{j=1}^{j=p} C_{1j} Infl_{t-j} + \sum_{j=1}^{j=p} D_{1j} Y_{t-j} + \sum_{j=1}^{j=p} E_{1j} NX_{t-j}$$

$$+ \sum_{j=1}^{j=p} F_{1j} Stock\_growth_{t-j} + \sum_{j=1}^{j=p} G_{1j} R_{t-j} + u_{1t} \quad (2)$$

$$Y = A_3 + \sum_{j=1}^{j=p} B_{3j} Reer\_growth_{t-j} + \sum_{j=1}^{j=p} C_{3j} Infl_{t-j} + \sum_{j=1}^{j=p} D_{3j} Y_{t-j} + \sum_{j=1}^{j=p} E_{3j} NX_{t-j} +$$

$$\sum_{j=1}^{j=p} F_{3j} Stock\_growth_{t-j} + \sum_{j=1}^{j=p} G_{3j} R_{t-j} + u_{3t} \quad (3)$$

$$NX = A_4 + \sum_{j=1}^{j=p} B_{4j} Reer\_growth_{t-j} + \sum_{j=1}^{j=p} C_{4j} Infl_{t-j} + \sum_{j=1}^{j=p} D_{4j} Y_{t-j} + \sum_{j=1}^{j=p} E_{4j} NX_{t-j} +$$

$$\sum_{j=1}^{j=p} F_{4j} Stock\_growth_{t-j} + \sum_{j=1}^{j=p} G_{4j} R_{t-j} + u_{4t} \quad (4)$$

$$Stock\_growth = A_5 + \sum_{j=1}^{j=p} B_{5j} Reer\_growth_{t-j} + \sum_{j=1}^{j=p} C_{5j} Infl_{t-j} + \sum_{j=1}^{j=p} D_{5j} Y_{t-j} +$$

$$\sum_{j=1}^{j=p} E_{5j} NX_{t-j} + \sum_{j=1}^{j=p} F_{5j} Stock\_growth_{t-j} + \sum_{j=1}^{j=p} G_{5j} R_{t-j} + u_{5t} \quad (5)$$

$$R = A_6 + \sum_{j=1}^{j=p} B_{6j} Reer\_growth_{t-j} + \sum_{j=1}^{j=p} C_{6j} Infl_{t-j} + \sum_{j=1}^{j=p} D_{6j} Y_{t-j} + \sum_{j=1}^{j=p} E_{6j} NX_{t-j} +$$

$$\sum_{j=1}^{j=p} F_{6j} Stock\_growth_{t-j} + \sum_{j=1}^{j=p} G_{6j} R_{t-j} + u_{6t} \quad (6)$$

Source: We applied the original model proposed by Sims (1980) using our own variables

Where u_t is the term error, or impulse (innovations or shocks) in VAR language.
The matrix form of the equation can be written:

$$AY_t = BY_{t-1} + CX_t + D\varepsilon_t$$

Where: matrix A comprises all the coefficients that present the contemporary links between the variables, the matrix B is assigned the coefficients for the time-lag variables, and the matrix C treats the coefficients that describe the links between the explanatory and the dependent variables. The matrix D is a diagonal matrix and the vector ε assumes the values of the residual random variable. By multiplying the VAR system by the inverse of matrix A, we obtain the relation:

$$Yt = (A)^{-1}By_{t-1} + (A)^{-1}\,CX_t + (A)^{-1}D_{\varepsilon t} \quad (8)$$

The equation can be rewritten as follows:

$$VAR\left(reer_{growtht}\right) = \alpha\left(reer_{growtht-1}\right) + \beta\begin{pmatrix} y_{t-1} \\ nx_{t-1} \\ reer_{growtht-1} \\ stock_{growtht-1} \\ r_{t-1} \end{pmatrix} + \mu_t \quad (9)$$

The vector of the exogenous variables (cause) includes the six variables of interest, considered in the analysis, respectively: the inflation rate (inflation), the variation of the annualized industrial production, the dynamics of the annualized trade balance (nx), the annualized variation of the real exchange rate (reer), the dynamics annualized stock indexes (stock_growth) and the evolution of the interbank interest rate (r), all six variables being presented at time t for each central and eastern European countries mentioned. The vector of the endogenous variables includes the estimated values of the exchange rate as a conjugate effect of the exchange rate values from the previous period and of the other variables considered in the analysis, all six variables being presented at time t for each CEE state.

In the case of our model, a monetary policy shock is identified by standard Cholesky decomposition (decomposition of positive Hermitian symmetric matrices into two conjugate matrices). Impulse response functions are required to quantify the magnitude of ERPT. Their determination requires the recovery of structural shocks from shocks of the VAR model in the reduced form, marked with the symbol, applying the Cholesky decomposition:

$$\begin{pmatrix} \varepsilon t\ infl \\ \varepsilon ty \\ \varepsilon t\ nx \\ \varepsilon t\ reer_{growth} \\ \varepsilon t\ stock_{growth} \\ \varepsilon t\ r \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a11 & 1 & 0 & 0 & 0 & 0 \\ a11 & a11 & 1 & 0 & 0 & 0 \\ a13 & a13 & a33 & 1 & 0 & 0 \\ a14 & a14 & a34 & a44 & 1 & 0 \\ a15 & a15 & a35 & a45 & a55 & 1 \end{pmatrix} + \begin{pmatrix} \mu t\ infl \\ \mu t\ y \\ \mu t\ nx \\ \mu t\ reer_{growth} \\ \mu t\ stock_{growth} \\ \mu t\ r \end{pmatrix} \quad (10)$$

The use of Cholesky decomposition implies the restriction that a shock of the exchange rate influences only the stock exchange and monetary policy interest, and with a time lag, exports, industrial production, and inflation.

4. Results and comments

The main virtue of the VAR model is its ability to provide impulse response functions for the variable of interest, the variance decomposition, and the decomposition of the shocks. The estimated responses to a unitary depreciation of the REER are shown in Figure 1, while Table 1 shows detailed average responses of real economy to exchange rate variation for 24 month time horizons (i.e. price level, industrial production rate, trade balance, interest rate, stock exchange yield, and exchange rate) for entire sample of CEECs. The resulting transfer period is quite fast: more than half of the transfers: to output, exports and real exchange rate takes place in the first six, eight months after a unit depreciation of the exchange rate. In addition, ERPT is almost completed after one year for those indicators. Consumer price response and interest rate responses to exchange rate shocks seem to be more persistent (about 24 months). In addition, the effect of the exchange rate variation on the price level is incomplete (a 1% depreciation leads to a less than proportional increase in the price level).

The interesting results values for the transfer of exchange rate variation on consumer prices take place for Czech Republic where there was applied an exchange rate floor[1].

After three months of decrease, the response of the price level sharply increases and reach positive values. The other countries from our sample have only negatives responses. Relating the exchange rate pass-through production, in Bulgaria the output seems to respond better to the real exchange rate shocks. Although the contribution of external shocks may be significant, the results show that transmission of exchange rate variation on inflation is low and has long-term implications. The discrepancy between the effects on output and those on inflation can be easily explained by a flattened Phillips curve (which implies that the dynamics of production growth and inflation has become increasingly independent of each other)

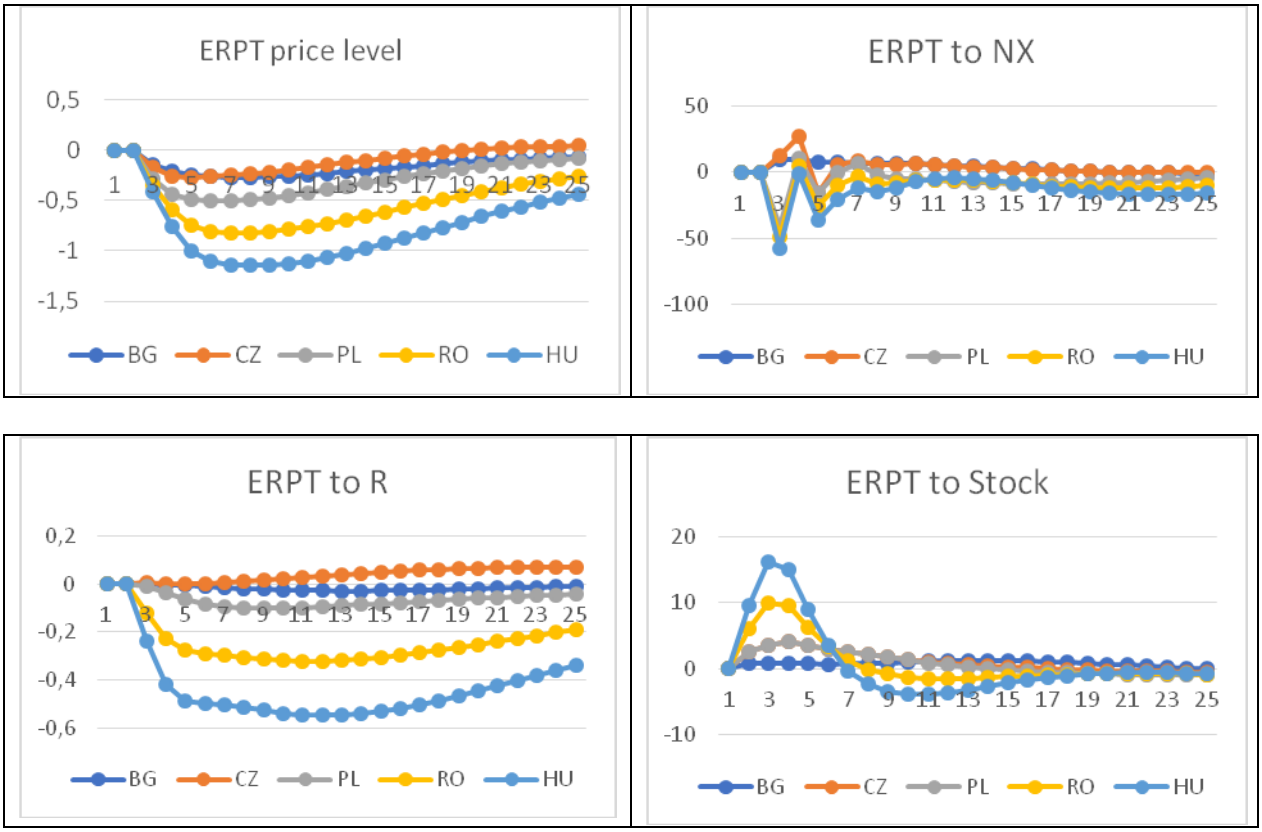
The response of exports to exchange rate shocks, are more consistent in Czech Republic, Poland, and Hungary. This effect can be attributed to the long-term changes in the Czech, Polish and Hungarian economies, which include increasing internationalization of production and participation in the global value chains. In these three states, monetary policy is also the most efficient, recording performance similar with the euro area transmission. However, we discuss various factors that may contribute to the differentiation in the monetary transmissions specific to these states, such as the structure of the financial systems (less developed), the rigidity of the labor market, the structure of the industry, the exchange rate regime, the credibility of the monetary policy and the commercial opening as the fundamental factors that diminishes the efficiency of the domestic monetary policy.

The response of the interest rate to exchange rate shocks seems to have different results in Czech Republic, compared with the others CEECs countries (the interest rate was

[1] the exchange rate floor was applied between November 2013 - April 2017, set at 17 CZK / EUR; the exchange rate depreciated immediately by 7%, from 15.5 to 17.5 CZK / EUR. At that time, the goal was to use the exchange rate as an additional unconventional tool to increase the effectiveness of monetary policy when nominal interest rates were lowered to the zero lower limits, while the inflation rate was well below the 1% target, in particular. to break the deflationary spiral. However, contrary to forecasts, the commitment became credible in 2015 and the rise in inflation materialized at the end of 2016, about a year later than expected

constrained by the zero-lower bound. Hungarian and Czech stock exchange respond more intensive to the real exchange rate variation. The results could be justified by the refuge of investors affected by the depreciation of the nominal exchange rate in financial markets.

Figure 1. Exchange rate pass-through for CEECs



5. Conclusion

The results suggest that the importance of exchange rate shocks is fundamentally time dependent. Therefore, there is a loss of information when using standard linear models, which are, on average, time-consuming. The main conclusions underline the importance of the exchange rate channel, it significantly influencing the evolution of the real economic variables. We note that the response of the exchange rate to the shocks of domestic demand and supply weakened during the analyzed period and that the magnitude of the transmission of the real exchange rate volatility in the variation of the price index decreased. We identified transmission coefficients below zero both in the case of prices, as well as in the case of industrial production and other variables. The paper highlights the existence of significant asymmetries as well from the statistical point of view, as well as economically, of the analyzed transmission process, according to the sign and magnitude of the changes of the real exchange rate, as well as in the case of specific periods of time. An important conclusion that emerges from this study is that, over time, the magnitude of transmission of real exchange rate changes in the variation of the consumer price index and in the interest rate volatility in all 5 CEECs has decreased.

Table 1 Exchange Rate Pass-Through (Linear VAR with Exogenous Variables) CEECs

Variables	Country	M01	M02	M03	M04	M05	M06	M07	M08	M09	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24
INFL	BG	0	-0.14271	-0.21161	-0.2497	-0.26664	-0.27283	-0.27128	-0.26495	-0.25513	-0.24293	-0.22911	-0.21428	-0.19892	-0.18343	-0.16813	-0.15325	-0.13897	-0.12545	-0.11277	-0.101	-0.09017	-0.08028	-0.07132	-0.06327
	CZ	0	-0.03014	-0.04913	-0.02471	0.002628	0.019333	0.035207	0.046076	0.058154	0.070201	0.080068	0.089136	0.097328	0.104212	0.109911	0.114248	0.117225	0.118885	0.11925	0.118416	0.116497	0.113613	0.109911	0.105536
	PL	0.000000	-0.1153	-0.17372	-0.22145	-0.24102	-0.24954	-0.25444	-0.25581	-0.25395	-0.25032	-0.2444	-0.23691	-0.22824	-0.21873	-0.20868	-0.19833	-0.18784	-0.17736	-0.16697	-0.15678	-0.14686	-0.13725	-0.12801	-0.11917
	RO	0	-0.06026	-0.16107	-0.25555	-0.29872	-0.31989	-0.32805	-0.33387	-0.33704	-0.33817	-0.3365	-0.33224	-0.32547	-0.31655	-0.30576	-0.29348	-0.28004	-0.2658	-0.25107	-0.23616	-0.2213	-0.20671	-0.19254	-0.17892
	HU	0	-0.06026	-0.16107	-0.25555	-0.29872	-0.31989	-0.32805	-0.33387	-0.33704	-0.33817	-0.3365	-0.33224	-0.32547	-0.31655	-0.30576	-0.29348	-0.28004	-0.2658	-0.25107	-0.23616	-0.2213	-0.20671	-0.19254	-0.17892
y	BG	-0.24309	-0.45206	-0.87981	-1.02231	-1.14089	-1.13331	-1.07417	-0.96607	-0.83157	-0.68373	-0.53213	-0.3849	-0.24682	-0.12162	-0.01125	0.083215	0.161602	0.224334	0.272287	0.306652	0.328815	0.340274	0.342561	0.33719
	CZ	0.427122	0.090842	0.087665	0.088725	0.078541	0.17897	0.205502	0.159188	0.130992	0.086576	0.033688	-0.0211	-0.07904	-0.13458	-0.18664	-0.23523	-0.27832	-0.31591	-0.34771	-0.37347	-0.39335	-0.40755	-0.4163	-0.42002
	PL	-0.59566	-0.40539	-0.39004	-0.18247	-0.13001	-0.06935	-0.05219	-0.02702	-0.00563	0.011123	0.026989	0.041173	0.049964	0.055342	0.058105	0.058541	0.056970	0.053813	0.049349	0.043897	0.037776	0.031251	0.024537	0.017834
	RO	0.578966	-0.25556	0.129642	0.045636	0.165332	0.084968	0.050343	-0.01559	-0.05046	-0.08014	-0.09367	-0.10046	-0.09958	-0.09487	-0.08723	-0.07853	-0.06957	-0.06117	-0.05368	-0.04732	-0.04211	-0.03797	-0.03477	-0.03234
	HU	0.578966	-0.25556	0.129642	0.045636	0.165332	0.084968	0.050343	-0.01559	-0.05046	-0.08014	-0.09367	-0.10046	-0.09958	-0.09487	-0.08723	-0.07853	-0.06957	-0.06117	-0.05368	-0.04732	-0.04211	-0.03797	-0.03477	-0.03234
NX	BG	0	9.046452	9.105645	7.637571	7.914364	7.029114	6.974042	6.484782	6.085994	5.52859	4.920039	4.261162	3.583432	2.914467	2.271732	1.67265	1.126885	0.641676	0.220113	-0.13715	-0.4317	-0.66674	-0.84661	-0.97647
	CZ	0	3.117814	17.76833	-23.3238	-2.16017	1.621374	-1.71505	-1.03687	0.099703	-0.27563	0.019844	-0.23739	-0.12066	-0.12814	-0.19533	-0.17498	-0.12822	-0.10497	-0.03852	0.030303	0.111214	0.19755	0.286893	0.376111
	PL	0.000000	-53.2214	-16.0241	6.351811	-5.54904	-2.44085	-7.69879	-10.2769	-10.9932	-11.7415	-12.0015	-11.991	-11.9527	-11.7169	-11.3611	-10.8501	-10.2012	-9.44472	-8.59907	-7.68289	-6.71586	-5.71497	-4.69798	-3.68121
	RO	0	-8.1175	-5.87027	-10.1835	-10.2133	-8.99679	-6.11609	-3.4031	-1.08599	0.457832	1.322975	1.556443	1.305433	0.692385	-0.14848	-1.10607	-2.08515	-3.01477	-3.8444	-4.54324	-5.09623	-5.50103	-5.76451	-5.89986
	HU	0	-8.1175	-5.87027	-10.1835	-10.2133	-8.99679	-6.11609	-3.4031	-1.08599	0.457832	1.322975	1.556443	1.305433	0.692385	-0.14848	-1.10607	-2.08515	-3.01477	-3.8444	-4.54324	-5.09623	-5.50103	-5.76451	-5.89986
R	BG	0	-0.00194	-0.00348	-0.0063	-0.01011	-0.01437	-0.0185	-0.02218	-0.02516	-0.02735	-0.02875	-0.02938	-0.02933	-0.02868	-0.02756	-0.02605	-0.02426	-0.02228	-0.0202	-0.01809	-0.016	-0.01399	-0.01209	-0.01032
	CZ	0	0.004797	0.001678	0.006768	0.012457	0.021035	0.030436	0.039866	0.048458	0.056308	0.063205	0.069082	0.073924	0.077782	0.08074	0.082885	0.084311	0.085116	0.085392	0.085225	0.084692	0.083863	0.082797	0.081546
	PL	0.000000	-0.01085	-0.035	-0.06423	-0.08676	-0.10046	-0.11022	-0.11739	-0.12312	-0.12719	-0.12979	-0.13128	-0.13192	-0.13184	-0.13118	-0.13004	-0.12854	-0.12677	-0.12481	-0.1227	-0.12048	-0.11821	-0.11591	-0.11362
	RO	0	-0.11543	-0.19109	-0.2118	-0.20673	-0.20511	-0.20773	-0.21358	-0.21906	-0.22335	-0.22588	-0.22674	-0.22593	-0.22355	-0.21972	-0.2146	-0.20839	-0.20127	-0.19343	-0.18507	-0.17634	-0.16742	-0.15842	-0.14946
	HU	0	-0.11543	-0.19109	-0.2118	-0.20673	-0.20511	-0.20773	-0.21358	-0.21906	-0.22335	-0.22588	-0.22674	-0.22593	-0.22355	-0.21972	-0.2146	-0.20839	-0.20127	-0.19343	-0.18507	-0.17634	-0.16742	-0.15842	-0.14946
STOCK_GROWTH	BG	0.888422	0.923321	0.814585	0.753441	0.721841	0.745767	0.820096	0.923265	1.037544	1.141655	1.221893	1.268459	1.277269	1.248147	1.184053	1.089951	0.971933	0.836526	0.690166	0.538843	0.387868	0.241746	0.104127	-0.02219
	CZ	1.709354	2.589042	3.278712	2.835425	2.317789	1.800944	1.298701	0.844314	0.38115	-0.03065	-0.35746	-0.61768	-0.8116	-0.94312	-1.0211	-1.05162	-1.04367	-1.00503	-0.94246	-0.86249	-0.77059	-0.67137	-0.56876	-0.46587
	PL	3.984606	4.689251	3.334154	2.257323	1.328860	0.659743	0.392580	0.130986	-0.04183	-0.18639	-0.3012	-0.38806	-0.44987	-0.49389	-0.52348	-0.5429	-0.55384	-0.55809	-0.55662	-0.55007	-0.53893	-0.52363	-0.50449	-0.48185
	RO	3.44002	6.358895	5.450841	2.672172	0.231678	-1.39978	-2.24474	-2.58516	-2.59341	-2.4021	-2.09018	-1.72213	-1.34312	-0.98614	-0.67098	-0.40799	-0.19994	-0.04468	0.063196	0.130765	0.165778	0.175844	0.167943	0.14812
	HU	3.44002	6.358895	5.450841	2.672172	0.231678	-1.39978	-2.24474	-2.58516	-2.59341	-2.4021	-2.09018	-1.72213	-1.34312	-0.98614	-0.67098	-0.40799	-0.19994	-0.04468	0.063196	0.130765	0.165778	0.175844	0.167943	0.14812
REER_GROWTH	BG	0.788808	0.801022	0.720364	0.574958	0.43024	0.294296	0.178216	0.081417	0.002871	-0.05975	-0.10888	-0.14661	-0.17484	-0.19509	-0.20869	-0.21671	-0.22009	-0.21962	-0.21599	-0.20982	-0.20163	-0.1919	-0.18105	-0.16943
	CZ	1.606183	1.728705	1.545419	1.413584	1.260857	1.087911	0.938882	0.8089	0.69209	0.585812	0.492067	0.412138	0.34332	0.284097	0.234062	0.191908	0.15653	0.126997	0.102423	0.082034	0.06515	0.051181	0.03964	0.030106
	PL	1.972234	2.518644	2.038447	1.365199	0.868730	0.579926	0.397931	0.285602	0.192218	0.118999	0.060132	0.013805	-0.02112	-0.04591	-0.06346	-0.07592	-0.08483	-0.09102	-0.09508	-0.09743	-0.09837	-0.09811	-0.0968	-0.09451
	RO	1.467723	1.5701	1.15297	0.753291	0.453783	0.255794	0.108039	-0.00266	-0.08685	-0.14661	-0.18666	-0.21078	-0.22312	-0.22688	-0.22473	-0.21866	-0.21022	-0.20048	-0.19023	-0.17995	-0.16997	-0.16044	-0.15142	-0.14292
	HU	1.467723	1.5701	1.15297	0.753291	0.453783	0.255794	0.108039	-0.00266	-0.08685	-0.14661	-0.18666	-0.21078	-0.22312	-0.22688	-0.22473	-0.21866	-0.21022	-0.20048	-0.19023	-0.17995	-0.16997	-0.16044	-0.15142	-0.14292

Source: author contribution based on the analyzes performed in Eviews 11 and Excel

Table 2. Main statistics for CEECs countries

BULGARIA	REER_GROWTH	Y	INFL	R	NX	STOCK_GROWTH
Mean	0,054	0,791	1,093	1,915	18,611	514,911
Median	0,011	3,638	1,600	0,810	-10,800	455,550
Maximum	6,116	13,553	14,700	7,170	353,300	1419,560
Minimum	-5,785	-16,116	-1,500	-0,118	-340,800	164,710
Std. Dev.	1,497	9,050	3,814	1,179	111,985	117,566
Skewness	0,105	-1,637	1,669	0,970	0,001	1,151
Kurtosis	1,349	5,671	5,719	1,757	3,364	3,364
Jarque - Bera	54540,81	4,981	98,391	149,561	4,966	180,316
Probability	0,000	0,081	0,000	0,000	0,083	0,000

CEHIA	REER_GROWTH	Y	INFL	R	NX	STOCK_GROWTH
Mean	-0,194	1,771	1,919	1,110	11,911	0,004
Median	-0,114	4,610	1,700	1,040	9,100	0,174
Maximum	9,745	15,544	7,900	4,510	814,300	77,671
Minimum	-10,008	-11,711	-0,500	0,180	-801,100	-59,074
Std. Dev.	4,131	7,111	1,745	1,078	178,731	19,451
Skewness	0,117	-1,643	1,469	1,441	-0,109	0,119
Kurtosis	1,859	6,175	5,301	4,455	3,374	5,941
Jarque - Bera	1,116	115,747	81,31	61,36	1,004	47,539
Probability	0,569	0,000	0,000	0,000	0,605	0,000

POLONIA	REER_GROWTH	Y	INFL	R	NX	STOCK_GROWTH
Mean	-1,441	4,949	1,931	3,119	185,581	1,401
Median	-0,510	5,370	1,700	1,710	311,650	0,047
Maximum	17,940	15,417	4,600	6,850	1185,400	65,069
Minimum	-11,101	-13,554	-1,300	1,650	-877,900	-53,114
Std. Dev.	6,818	4,913	1,757	1,550	399,913	11,016
Skewness	-0,756	-0,914	-0,005	0,581	0,0945	0,345
Kurtosis	4,943	5,067	1,665	1,141	3,114	3,670
Jarque - Bera	31,479	41,010	10,393	11,116	0,460	4,941

Probability	0,000	0,000	0,005	0,001	0,794	0,084
ROMÂNIA	REER_GROWTH	Y	INFL	R	NX	STOCK_GROWTH
Mean	-0,788	4,661	4,639	4,639	40,178	8,961
Median	-0,565	4,401	3,140	3,140	-39,800	9,033
Maximum	8,779	10,098	15,910	15,910	1008,600	180,571
Minimum	-11,536	-17,774	0,500	0,500	-419,700	-74,487
Std. Dev.	4,314	6,191	3,840	3,840	177,53	31,311
Skewness	-0,133	-0,665	1,113	1,113	1,810	1,877
Kurtosis	1,195	4,695	3,537	3,537	6,343	11,411
Jarque - Bera	1,194	14,769	31,160	31,160	119,305	547,738
Probability	0,000	0,000	0,000	0,000	0,000	0,000
UNGARIA	REER_GROWT	Y	INFL	R	NX	STOCK_GROWTH
Mean	-1,316	1,897	1,940	3,896	16,147	10,574
Median	-1,856	3,947	3,000	3,170	11,150	6,970
Maximum	17,613	17,489	7,400	11,870	415,800	118,983
Minimum	-13,731	-17,070	-1,400	0,010	-381,400	-56,640
Std. Dev.	5,337	8,144	1,141	3,153	176,381	17,738
Skewness	0,581	-1,811	0,015	0,353	0,161	0,919
Kurtosis	4,113	6,711	1,059	1,865	1,351	5,778
Jarque - Bera	13,819	144,707	5,180	10,411	1,801	59,599
Probability	0,000	0,000	0,075	0,005	0,146	0,000

Source: author contribution based on the analyzes performed in Eviews 11

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