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Assessment of asymmetric effects on exchange market pressure: Empirical evidence from emerging countries

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ABSTRACT

In this study, structural vector autoregression (SVAR) models are used to analyze the asymmetric effects of external and internal economic factors on the exchange market pressure index (EMPI) in the Czech Republic, Iceland, Poland, and Russia. Along with the forecast error variance decompositions (FEVDs) of the SVAR models and slope-based asymmetry tests suggesting that there may be asymmetric effects on EMPI, impulse response functions (IRFs) of SVAR models for the Czech Republic and Poland indicated that improvements in the current account balance will reduce the exchange market pressure (EMP), whereas deterioration of the current account balance may create a more serious speculative attack potential in Iceland and Poland, due to the high ratio of debt to GDP. Changes in inflation may have significant asymmetric effects on the EMP; more precisely, it was found that high inflation and the interest rate environment will increase the pressure on the exchange rate in all four economies. My findings indicate that decreases in inflation rates did not reduce the EMPI in Iceland and Russia, whereas the decline in interest rates did not constitute the necessary environment for capital inflows in any of the four countries. It is also implied that, due to the changes in long-term interest rates, the formation of the expectation of depreciation of the home currency is easier than the formation of the expectation of appreciation. Furthermore, I reveal that credit conditions in the United States of America (USA) could affect global crisis expectations and thus have asymmetrical effects.

1. Introduction

In terms of analyzing the factors leading to variations in exchange rates, it has become critically important to study the role of international spillovers, especially after global financial crisis (GFC) and the quantitative easing policy of major central banks. In the post-crisis period, the implementation of economic policies both in developed and developing countries focused on improving their deteriorated macroeconomic economic conditions. Along with internal and external macroeconomic factors, the need for foreign funds and international capital flows has come the core of the analysis of exchange rate fluctuations, especially in developing countries. In this respect, it is critically important to understand the dynamics of the foreign exchange market to make more precise explanations about the effects of exchange rate changes in future periods. Herein, the exchange rate pressure index (EMPI) has been recognized as a leading indicator of the current state of the foreign exchange market and the future value of the exchange rate. According to Weymark (1995), exchange market pressure (EMP) measures the total excess demand for an exchange rate change that would have been required to remove this excess demand in the absence of foreign exchange intervention (FXI). Because FXIs and interest rate adjustments can be used as policy tools to decrease the EMP in developing countries, the definition of EMP has been modified. In particular, the EMPI can be defined as the summation of weighted changes in official reserves, nominal exchange rate,

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and interest rates (Jing, 2015). There have been many studies in the literature focusing on using different EMPI definitions and analyzing the macroeconomic and financial variables as determinants of the EMPI (Aizenman & Binici, 2016; Aizenman & Hutchison, 2012; Aizenman, Lee, & Sushko, 2012; Akram & Byrne, 2015; Feldkircher, Horvath, & Rusnak, 2014; Panday, 2015; Soe & Kakinaka, 2018). However, exchanges rates can interact with many domestic macroeconomic and financial variables, meaning that models analyzing the factors influencing EMP can be enhanced by the inclusion of domestic economic risk factors (Forbes, Hjortsoe, & Nenova, 2018). In this way, exogenous exchange rate shocks can be taken into consideration in the analysis of EMP. For this purpose, credit default swap (CDS) or the three-month LIBOR based on the US dollar minus three-month Treasury bill (TED spread), which is under the influence of both monetary and fiscal policy implementation, can be included in an empirical model as the main country risk indicators. Due to the spillover effects of the monetary policy of the US after the GFC, the inclusion of macroeconomic and financial variables of foreign countries in models examining the variations in exchange rates has also gained ground in the most recent scientific literature (Adler, Lama, & Medina, 2018; Belke & Fahrholz, 2018; Jordan, 2016).

In this paper, I will contribute to the existing literature by estimating SVAR models to determine the possible impacts of both external and internal economic factors on EMP in emerging countries with independently-floating currency regimes and capital control regimes classed as "Gate" countries by the IMF (Czech Republic, Iceland, Poland, and Russia), using quarterly data.[1] The countries under investigation also correspond to Banco Bilbao Vizcaya Argentaria's (BBVA) definition of EAGLE countries.[2] More specifically, I derive EMPI for the Czech Republic, Iceland, Poland and Russia following the methodology of Jing et al. (2015), and thus the roles of foreign reserves and interest rates are considered in the measurement of the index. With regard to an internal economic factor, consumer price inflation is included in the SVAR models to account for the inflation dynamics on EMPI through changes in exchange rate expectations. Current account/GDP is also employed as an internal factor, reflecting the need for foreign currency borrowing and to determine the EMP. In the empirical exercise, the monetary policy stances of the Czech Republic, Iceland, Poland, Russia and the United States of America (USA) are evaluated in terms of the difference between long-term interest rates of countries and the long-term interest rate of the US, since interest rate differences may become the driving force of the capital flows. Another contribution of this study is that TED spread for the US economy is contained in the SVAR models as an external economic factor with which to analyze the possible impacts of credit risk in the US economy, and more precisely to expose the consequences of the expectations of the US economy on EMPI. In this respect, the aims of this study are threefold: (i) to assign the proportion of the movements in the forecast errors of dependent variables, which are due to their own shocks and shocks to the other variables by estimating forecast error variance decompositions (FEVDs) of SVAR models; (ii) to trace the reactions of the dependent variables in the SVARs to shocks to each of the variables by estimating impulse response functions (IRFs), thus showing the possibility of asymmetry in terms of the coefficients of IRFs; and (iii) to specify the presence of asymmetry via slope-based tests. The main hypothesis of this paper tests whether changes in external and internal variables may have a considerable asymmetric impact on EMPI. Therefore, I intend to address the issue of what economic policies can be designed to reduce the EMP which in turn prevent capital outflows and maintain financial and economic stability in said countries.

2. Literature review

2.1. Derivation of the EMPI

Along with price stability, the objective of achieving financial stability has come to the fore of monetary policy due to the developments after the GFC; in this respect, it is important to reduce the volatility of exchange rates in developing countries that need financing with foreign currencies (Asteriou, Masatci, & Pılbeam, 2016; Bahmani-Oskooee & Gelan, 2018; Lin, Shi, & Ye, 2018). Reducing the volatility of the exchange rate will not only result in an increase in capital inflows, but will also reduce the uncertainties that the export sector of a developing country is exposed to, and trigger real economic activity (Audzei & Brázdik, 2018). Herein, the financial fragilities and thus the EMPI, as macroeconomic and financial developments may be considered an important indicator in reducing exchange rate volatility. In other words, reducing the volatility of exchange rates in developing countries may be related to the control of the factors that put pressure on the exchange rate.

Reducing the EMP can be related to central banks' aim of achieving financial stability; moreover, the interplay between EMP and macroeconomic and financial variables should be determined to formulate the optimal monetary policy. Given the significant impacts of exchange rate pass-through (ERPT) in emerging countries, inflation targeting (IT) policy seeks to meet the inflation target, while the central bank via its policy tools additionally attempts to reduce fluctuations in the exchange rate in line with its primary objective. Eventually, emphasis will be placed on alleviating the EMP, with the indirect aim of avoiding a potential currency crisis. In other words, reducing ERPT and ensuring price stability in this way is closely related to the diminishment in EMP. There have been many EMPI definitions in the scientific literature, while EMPI definition including foreign exchange reserves and nominal exchange rates

[1] The latest issue of the Annual Report on Exchange Arrangements and Exchange Restrictions by the IMF and Fernández, Klein, Rebucci, Schindler, and Uribe (2016) presents a yearly definition of the foreign exchange arrangements, exchange and trade systems, and capital controls of all IMF member countries. An Open country has virtually no capital controls on any asset category, a Wall country imposes persistently high controls across most asset categories, and a Gate country uses capital controls episodically. Due to the availability of data, quarterly data from 2003:01 to 2018:01 is used for the Czech Republic and Iceland, while empirical models for Russia and Poland employ quarterly data from 2004:01 to 2018:01.

[2] EAGLE countries are recognized as growth-leading economies, which are expected to trigger global growth in the next 10 years according to BBVA.

can generally be used to determine the value of EMPI (Feldkircher et al., 2014; Jing, 2015). However, the variables of the EMPI can be deflated by monetary aggregates, in line with Klaassen and Jager (2011) and Aizenman and Binici (2016). In this study, the variables of the EMPI are not deflated by monetary aggregates, while the interest rate of the home country is not included in EMPI because it is intended to estimate the effects of the monetary policies of the home country and the USA via changes in the differences in long-term interest rates on the EMPI. Consequently, and in contrast to Klaassen and Jager (2011), Akram and Byrne (2015), Jing (2015), and Aizenman and Binici (2016), who all include interest rates in their formulations of EMPI, changes in monetary policy stances are considered in terms of their direct impacts on nominal exchange rates and foreign exchange reserves, which in turn affect the value of the EMPI. On the basis of Jing (2015) EMPI formulation, I deducted the interest rates, hence in this study the EMPI is defined as the weighted average of exchange rate changes and foreign reserve losses for country i in period t. Thus, FXIs implemented by the central banks as a policy tool are considered by giving a certain weight to the loss of foreign exchange reserves in the index. Finally, the EMPI can be specified as in Eq. (1):

$$EMPI_{i,t} = \rho_{i1} \times \%\Delta ex_{i,t} - \rho_{i2} \times \%\Delta fr_{i,t} \tag{1}$$

where $i = 1, 2, ...,N$ and $t = 1, 2, ...,T$. $\%\Delta fr_{i,t}$ and $\%\Delta ex_{i,t}$ refer to the percentage changes in foreign reserves measured in foreign currency and exchange rates. ρ_{i1} and ρ_{i2} are the weights of the two components in country i. The two weights in Equation (1) can be computed based on the standard deviations of exchange rates ($\sigma_i(ex)$) and foreign reserves ($\sigma_i(fr)$) as below:[3]

$$\rho_{i1} = \frac{1/\sigma_i(ex)}{\left(1/\sigma_i(ex)\right) + \left(1/\sigma_i(fr)\right)},\ \rho_{i2} = \frac{1/\sigma_i(fr)}{\left(1/\sigma_i(ex)\right) + \left(1/\sigma_i(fr)\right)} \tag{2}$$

where $ex_{i,t}$and $fr_{i,t}$ are in levels in line with Jing (2015). In this respect, $fr_{i,t}$ is measured in USD, and the standard deviations of these variables are computed using quarterly data, since empirical models in this study employ quarterly data.[4] According to Equation (1), it can be suggested that depreciation/appreciation in the domestic currency against foreign currencies increases/decreases EMP. Conversely, it can be assumed that a decrease/increase in foreign exchange reserves raises/lowers EMP. Herein, it can also be inferred that the sign of foreign reserve is negative because the monetary policy authority decreases foreign reserves to protect the currency against depreciation. Unlike the industrial production index and consumer price index, the EMPI does not have a base year within Eq. (1). In this regard, the EMPI index can be interpreted as a currency crisis indicator. The EMPI takes values greater or lower than 0, and the probability of a foreign exchange crisis becomes stronger or weaker due to whether its value is greater or lower than 0. Within this framework, the volatility of components and weights assigned to them can be considered interrelated, because the dynamics of the market in the foreign exchange market result in FXI that will alter the level of foreign exchange reserves. However, no study has yet considered the interrelationships between the weights assigned in the EMPI formulas.

2.2. Previous studies examining the EMPI

The studies mentioned in the previous section refer to differences in definitions of EMPI, and it is also important to determine the macroeconomic and financial factors that may affect the index. Investigations that examine the effects of monetary policy implementation and inflation dynamics are at the forefront in this regard, because monetary policy authorities seek to stabilize fluctuations in exchange rates. For instance, Feldkircher et al. (2014) has revealed the crucial role played by price stability in explaining changes in EMPI through the use of a data set covering 149 countries and 58 indicators. According to their Bayesian-type model, Feldkircher et al. (2014) also indicated that the currencies of countries that experienced higher inflation prior to the GFC were more significantly affected in times of stress. The approach by Panday (2015) focused on a single country; more precisely, the effects of monetary policy on EMP in the case of Nepal was analyzed. Panday (2015) constructed a theoretical monetary model of EMP and employed a recently developed estimation technique, impulse indicator saturation. In association with the general specification of EMPI, Panday (2015) attempted to explain the variation in nominal exchange rates by foreign exchange reserves, foreign prices, domestic credit volume and domestic GDP. It was revealed that a contractionary monetary policy led to the decrease in the EMPI, while this finding contrasts with the EMPI specification of Jing (2015), indicating that an increase in interest rates raises the EMP. The relevant finding of Panday (2015) can be interpreted as the expansion in domestic credit resulting in an increase in foreign currency demand; on the other hand, Jing (2015) assumes that the EMP can be related to a joint process with foreign exchange reserve loss and an increase in interest rates. Most recently, Soe and Kakinaka (2018) constituted their analysis based on the assumption that the IT regime would reduce ERPT, so analyzed whether IT is related to the variability in the EMP and its components in 101 developing countries. Soe and Kakinaka (2018) found that the IT regime helped to stabilize EMP and decreased the volatility of changes in international reserves.

Alongside the specification in line with Jing (2015), the EMPI can also be defined by the inclusion of FXIs and relative values of

[3] The calculation of weights can influence the value of the EMPI, while the method developed by Kaminsky and Reinhart (1999) can also be used to calculate the weights found in Eq. (2). More specifically, the weights are computed as $\rho_{i1} = 1$ and $\rho_{i2} = \frac{\sigma_i(ex)}{\sigma_i(fr)}$ by Kaminsky and Reinhart (1999); however, the index is driven by the least volatile component in the corresponding method. Eq. (2) is used for the determination of the weights in this study; thus the dynamics of each variable belonging to the previous are taken into account.

[4] The samples used to compute standard deviations for each country cover quarterly data going back two years. The EMPIs computed with alternative sample periods do not exhibit a high amount of change in the estimation results of the SVARs, supporting the robustness of SVAR estimations.

components with respect to a country. Consideration of FXIs indicates that a fully free-floating exchange rate regime cannot be consistent, even in countries with capital regimes in the "Open" class according to the International Monetary Fund (IMF). On the other hand, the inclusion of relative values of components implies that capital movements (which may lead to changes in the indices) may be associated with a single country. In this respect, Akram and Byrne (2015) examined the relationship between exchange market and financial liberalization in terms of EMP and capital controls. By using a panel of forty countries, the additional determinants of EMPI were defined as: current account openness, real exchange rate, IT regime, reserve import ratio, monetary aggregates, remittances and growth in real income. Akram and Byrne (2015) obtained results showing that capital account openness may be an important determinant correlating with exchange market indicators in emerging and developed countries. According to the findings of Akram and Byrne (2015), differences in the effects of capital account openness for advanced and emerging market economies might be associated with the depth and development of the financial sector. Akram and Byrne (2015) also revealed that capital controls were less relevant in times of acute market stress, possibly due to their slow-moving nature.

The aforementioned studies imply that the capital regime plays a decisive role in the EMPI, and especially that the developments in foreign trade balance that determine the financing needs of developing countries can be deemed a factor that applies pressure to the exchange rate. On the other hand, the use of capital control as a policy tool may mitigate the possible impacts of foreign and global factors on EMPI; liabilities in foreign currency can also provide critical in terms of the effects on EMPI. In this respect, some studies have stressed the role of foreign liabilities and capital controls. For instance, Aizenman et al. (2012) investigation can be regarded as a pioneering approach because the role of international capital flows and trade was analyzed for emerging markets (EMs) during the 2000s. By using regression techniques, Aizenman et al. (2012) found that capital outflows and deleveraging were the main factors leading to an increase in EMPI during the global financial crisis. It was also shown that greater FDI inflows (greater portfolio debt) prior to the crisis were associated with a lower (higher) crisis EMPI. Using a similar approach, Aizenman and Hutchison (2012) focused on how the global financial crisis emanating from the USA was transmitted to emerging markets using regression analysis. Accordingly, it was suggested that the situation of high external portfolio liabilities exceeding international reserves could lead to a significant rise in EMPI and thus high exchange rate depreciation. Most recently, Aizenman and Binici (2016) studied the effects of internal and external global factors on the EMP for both OECD countries and emerging market countries before and after the global financial crisis. They also enhanced their analysis by exploring whether capital controls can be used as efficient tools to ward-off pressure on exchange rates. By using dynamic panel data models, Aizenman and Binici (2016) found that short-term gross portfolio inflows and outflows were crucial factors of EMP in emerging markets. More specifically, Aizenman and Binici (2016) stressed that capital controls could be an efficient tool to reduce EMP depending on the institutional quality.

As the role of possible asymmetry in the exchange rate passes through to prices, EMPI can also react with different magnitudes to the same amount of increase and decrease in domestic, foreign and global factors. More specifically, ignoring the role of asymmetry in terms of the impacts of macroeconomic and financial variables of exchange rate dynamics can cause inaccurate macroeconomic outcomes for policy makers. In this study, the role of asymmetry both in the short and long run is considered in terms of the analysis of dynamics of EMPI in some emerging countries.

3. Methodology of analysis

3.1. Empirical model

In this study, SVAR models were used to analyze the impacts of current account balance, consumer price inflation, long-term interest rate difference and TED spread for the US economy and EMPI for the Czech Republic, Iceland, Poland and Russia. Like all VAR-type models, the VAR model written in Eq. (3) constitutes a base for the derivation of the SVAR Blanchard-Quah model pioneered by Blanchard and Quah (1989).

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + B_0 exg_t + \ldots + B_q exg_{t-q} + CD_t + u_t \tag{3}$$

where p and $q$are the lag lengths of the endogenous and exogenous variables of the VAR model. y_t includes the endogenous/dependent variables of the VAR model, thus $y_t = (y_{1t}, \ldots, y_{Kt})'$ corresponds to a vector including K endogenous variables. Additionally, $exg_t = (exg_{1t}, \ldots, exg_{Mt})'$ refers to vector containing Melements. In this framework, intercept and linear trend terms and dummy variables are included in the vector D_t, and A_j, $B_j$and$C$are the parameter matrices of the VAR (p) model. Finally, u_t is an unobservable white noise process with positive covariance matrix $E(u_t, u_t') = \Sigma_u$ (JMulTi Help System Manual, 2008).

On the other hand, IRFs that detect the responsiveness of dependent variables in the VAR to shocks to each of the variables for the following periods, can be useful in terms of the analysis of transmission mechanism. In order to specify the IRFs, moving average representation of the stationary y_t process below can be employed:

$$y_t = \Phi_0 u_t + \Phi_1 u_{t-1} + \Phi_2 u_{t-2} + \ldots, \tag{4}$$

where $(k \times k)$ identity matrix $(I_K) = \Phi_0$ and the matrices Φ_s referring to the coefficients of the IRFs ($s = 1, 2, \ldots$) can be estimated as:

$$\Phi_s = \sum_{j=1}^{s} \Phi_{s-j} A_j, \tag{5}$$

More specifically, the (i, j)th elements of Φ_s correspond to the expected response of $y_{i,t+s}$ to a unit change in y_{jt} holding constant all past values ofy_t. The innovation u_{it} computes the change iny_{it}, given $\{y_{t-1}, y_{t-2}, \ldots\}$. In this respect, the $u_t$variables are 1-step ahead

forecast errors and these impulse responses refer to the forecast error impulse responses (Breitung, Brüggemann, & Lütkepohl, 2007, p. 166). Similarly, the impulse response matrices can be estimated for non-stationary processes, while total long run effects can be expressed as:

$$\Phi = \sum_{s=0}^{\infty} \Phi_s = (I_k - A_1 - ... - A_p)^{-1} \tag{6}$$

If the components of u_t may be instantaneously correlated, a Cholesky decomposition of the covariance matrix $\Sigma_u$is employed to orthogonalize the innovations of the VAR(p). Denoting by Ba lower triangular matrix such that $\Sigma_u = \mathrm{BB}'$, $\varepsilon_t = \mathrm{B}^{-1}u_t$ represents the orthogonalized shocks that based on an one standard deviation shock. Accordingly, the model in (4) can be modified as in (8) for the stationary case.

$$y_t = \Psi_0\varepsilon_t + \Psi_1\varepsilon_{t-1} + ..., \tag{7}$$

where $\Psi_i = \Phi_i\mathrm{B}$ ($i = 0,1,2,\ldots$), $\Psi_0 = \mathrm{B}$ is lower triangular. In this model, an ε or one standard deviation shock in the first variable may have an instantaneous influence on all variables of the VAR(p) model, whereas a shock in the second variable does not have an instantaneous effect on y_{1t} but only on the other variables (JMulTi Help System Manual, 2008). Within this context, the SVAR Blanchard-Quah model exposes the long run effects of shocks by placing restrictions. Identification of the shocks in IRFs can also be made by putting restrictions on the Aand Bmatrices of the SVAR model:

$$\mathrm{A}y_t = A_1^* y_{t-1} + ... + A_p^* y_{t-p} + \mathrm{B}\varepsilon_t \tag{8}$$

In (8), ε_t denotes $(K \times 1)$vector of structural shocks having a covariance matrix $\mathrm{E}(\varepsilon_t\varepsilon_t')=\Sigma_\varepsilon$, which is also specified as an identity matrix. The residuals of SVAR model in (8) are represented by $\mathrm{B}\varepsilon_t$, while structural shocks are instantaneously uncorrelated. Within this framework, SVAR model can be written in three types, an Amodel, where B= I_K, a Bmodel, where A= I_K, and a general AB model, where restrictions can be placed on both matrices. Similarly, IRFs of every type of SVAR model can be obtained from the Eqs. (3)–(8) with $\Psi_j = \Phi_j\mathrm{A}^{-1}\mathrm{B}$ (Breitung et al., 2007, p. 162–167). However, in the SVAR Blanchard-Quah model A= I_K and the matrix of long run impacts, $(I_K - A_1 - \cdots A_p)^{-1}\mathrm{B}$ is assumed to be lower-triangular. Estimation of SVAR Blanchard-Quah is implemented by a Choleski decomposition of the matrix $(I_K - \widehat{A}_1 - \cdots \widehat{A}_p)^{-1}\widehat{\Sigma}_u(I_K - \widehat{A}'_1 - \cdots - \widehat{A}'_p)^{-1}$, where a hat corresponds to a reduced form estimate (JMulTi Help System Manual, 2008).

3.2. The role of asymmetry in Macroeconomic models

The time series of various economic variables may have asymmetry. More specifically, it can be stated that the pass-through of cost increases to prices is greater than that of cost decreases. Although there exists a wide body of literature on asymmetries in the dynamics of prices, the role of asymmetry has also been prevalent in analyses of the effects of oil prices on macroeconomic and financial variables. For instance, Kilian and Vigfusson (2011) made a major contribution to the literature in terms of asymmetry through studying the effects of oil prices on gross domestic product (GDP). In particular, Kilian and Vigfusson (2011) departed from linear, symmetric and asymmetric data generating processes by estimating the IRFs of the asymmetric VAR model presented below.[5]

$$x_t = b_{10} + \sum_{i=1}^{p} b_{11,i}x_{t-i} + \sum_{i=1}^{p} b_{12,i}y_{t-i} + \varepsilon_{1,t} \tag{9}$$

$$y_t = b_{20} + \sum_{i=1}^{p} b_{21,i}x_{t-i} + \sum_{i=1}^{p} b_{22,i}y_{t-i} + \sum_{i=1}^{r} g_{21,i}x_{t-i}^{+} + \varepsilon_{1,t} \tag{10}$$

where $i = 1, ...,p$ and p is the lag order of both equations. Equation (9) is a linear VAR model examining the impacts of x_t on y_t, whereas Equation (10) incorporates the effects of both x_t and the censored variable (x_t^+) on y_t. In this respect, the dynamic responses of y_t to positive and negative changes inx_t can be computed. Accordingly, Kilian and Vigfusson (2011) performed slope-based and IRF-based tests; however, their nonlinear VAR model identification, including two variables (oil prices and GDP), can be accepted as a factor limiting the mechanism of macroeconomic interactions. These authors' methodology constitutes a basis upon which to derive a nonlinear VAR (p) in terms of the effects of asymmetry on the relationship between variables. In this context, Ülke and Berument (2016) defined their set of equations incorporating both censored variables and the nonlinear VAR model as:

$$s_t = b_{10} + \sum_{k=1}^{p} b_{11,k}s_{t-k} + \sum_{k=1}^{p} b_{12,k}\lambda_{t-k} + \varepsilon_{1,t} \tag{11}$$

$$\lambda_t = b_{20} + \sum_{k=1}^{p} b_{21,k}s_{t-k} + \sum_{k=1}^{p} b_{22,k}\lambda_{t-k} + \sum_{k=1}^{p} g_{21,k}s_{t-k}^{+} + \varepsilon_{2,t} \tag{12}$$

[5] The data generation process (DGP) of x_t can both be assumed as symmetric and asymmetric with the regression model $x_t = \alpha_1 + \varepsilon_{1,t}$. Thus, the replacement of negative values of $x_t$with zero leads to the specification of a censored variable x_t^+. The censored variable can be defined as: $x_t^+ = \begin{cases} x_t & x_t > 0 \\ 0 & x_t \leqslant 0 \end{cases}$.

where $k = 1, ...,p$ and p refers to the lag order. s_t denotes the variable which its possible asymmetric impacts are investigated. Additionally, $\lambda_t$vector includes variables that can be under the influence of s_t. Equation (11) is a linear symmetric model with s_t, while equation (12) includes both s_t and censored variable of s_t^+. The term s_t^+ stands for positive changes and it can be assumed that; $s_t^+ = \begin{cases} s_t & s_t > 0 \\ 0 & s_t \leqslant 0 \end{cases}$. In this framework, b_{10} and b_{20} in (9) and (10) corresponds to the vector of intercept and dummy variables, respectively. The coefficients of the s_t change are contained in b_{12} and b_{22}vectors. g_{21} comprises the vector of the coefficient of the censored variable and finally $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are the residual vectors of (11) and (12). In a similar approach, Kang, Ratti, and Vespignani (2017) followed the methodology of Kilian and Vigfusson (2011) and estimated VAR model impulse responses to trace the effects of positive/negative shocks to economic policy uncertainty on oil prices.

The approach developed by Hatemi-J (2014) can also be used at the point of considering asymmetric effects in VAR-type models. In this framework, this approach first requires the variables to be decomposed into cumulative positive and negative sums in accordance with Hatemi-J (2012) and Hatemi-J and El-Khatib (2016).[6] Relationships that are assumed to be economically valid between the variables decomposed in line with Hatemi-J and El-Khatib (2016) are included as variables in the vector of VAR-type models. Therefore, even if the VAR model is used, the theoretical assumptions will be incorporated into the model process. Thus, the use of SVAR models will lead to both examining asymmetric effects via positive and negative sums, as well as considering the restrictions imposed by the theoretical assumptions in the estimation process. Based on $y_t = (y_{1t}, y_{2t})'$, the vectors $y_{1t}^+ = (y_{1t}^+, y_{2t}^+)$ and $y_{1t}^+ = (y_{1t}^+, y_{2t}^+)$can be formed. Thus, IRF and FEVD analysis can be performed within the 2-variable VAR model below:

$$y_t^+ = v + A_1 y_{t-1}^+ + ...+A_p y_{t-1}^+ + u_t^+ \tag{13}$$

$$y_t^- = vv + AA_1 y_{t-1}^- + ...+AA_p y_{t-1}^- + u_t^- \tag{14}$$

where y_t^+ and y_t^- represent the 2×1 vector of variables and constant terms of the model are contained in 2×1 vectors v and vv. For simplicity, trend and exogenous variables are ignored in (13) and (14), in contrast to the basic specification of the SVAR model in (3).

3.3. Identification of SVAR model

As for the empirical exercise, I depart from the asymmetric causality approach of Hatemi-J (2012) to analyze the impacts of macroeconomic and financial factors on EMPI for the Czech Republic, Iceland, Poland and Russia. Thus, the variables were decomposed into cumulative positive and negative sums; however, I adopted a VAR model including more than two variables. For both cases, the EMPI ($empi_t^{cze}$, $empi_t^{ice}$, $empi_t^{pol}$, $empi_t^{rus}$), inflation referring to the percentage change in consumer price index (2010 = 100) over the previous period of the current year (ifl_t^{cze}, ifl_t^{ice}, ifl_t^{pol}, ifl_t^{rus}), the difference between the long-term interest rates of countries under investigation and the long-term interest rate of the US ($lird_t^{cze}$, $lird_t^{ice}$, $lird_t^{pol}$, $lird_t^{rus}$), current account balance as % of GDP (cur_t^{cze}, cur_t^{ice}, cur_t^{pol}, cur_t^{rus}) and TED spread for the US economy (ted_t^{us}) are used. Within this framework, vectors including variables decomposing according to cumulative positive and negative sums approach of Hatemi-J (2012) and Hatemi-J and El-Khatib (2016) were used to investigate the impacts on EMPI via IRFs and FEVDs in line with Hatemi-J (2014) and Nouira, Amor, and Rault (2018). On the other hand, structural changes may have occurred for the Czech Republic, Iceland, Poland and Russia in terms of the relations between EMPI and other variables of the SVAR model after the GFC. More precisely, structural breaks can be detected in the related series, while I found different years causing structural breaks in the dynamics of the time-series included in my empirical exercise. Considering that there are non-linearities in terms of the relationship between the variables I investigated, and no common specific break data are found for all variables, two SVAR models are estimated with quarterly data: Model 1 includes variables in the cumulative positive format, while Model 2 has variables in the cumulative negative format.

The ordering of the variables in the SVAR models for the Czech Republic, Iceland, Poland, and Russia is $empi_t$, cur_t, ifl_t, $lird_t$, ted_t, implying that changes in the EMPI affect the value of exchange rates, which in turn influence international competitiveness and current account balance. Accordingly, I assume that changes in real economic activity influence inflation and, thus, long-term interest rates. Within the Cholesky decomposition, it is assumed that all these developments influence the credit risk proxied by the TED spread. Although Cholesky is a short-term restriction, long-term restrictions are also considered within the relevant matrix in this study. Derivation of SVAR Blanchard-Quah is made by a Choleski decomposition in accordance with Breitung et al. (2007); however, the identification of my empirical analysis is reflected on the matrix in (15). Herein, it is assumed that EMPI responds to the current account balance (% of GDP), consumer price inflation, and the difference between long-term interest rates and the TED spread for the US economy in the short run. More specifically, this assumption can be interpreted to show that the EMPI may not be under the influence of the other variables in the model in the long run. In this context, it can be inferred that the purchasing power parity (PPP) condition may be consistent in the long run, whereas macroeconomic and financial factors can influence EMP both in the short and medium run. Nevertheless, the ordering of the variables in line with the Cholesky decomposition also allows for the formation of the matrix in (15). On the other hand, ordering of the remaining variables (current account balance [% of GDP], inflation, and the difference between long-term interest rates and the TED spread) are selected arbitrarily in the Blanchard-Quah type SVAR models for the Czech Republic, Iceland, Poland, and Russia. According to the alternative ordering of variables, the impulse response and FEVD analysis results do not exhibit a high amount of change, and thus the robustness of SVAR estimations based on the vector $(empi_t, cur_t, ifl_t, lird_t, ted_t)'$ is verified. Restrictions can be imposed on matrix A, which contains the long-term relationship between

[6] For the derivation of the cumulative sums, see Hatemi-J (2012) and Hatemi-J and El-Khatib (2016).

variables as below:

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 \\ a_{41} & a_{42} & a_{43} & 1 \end{pmatrix} \tag{15}$$

4. Empirical data and analysis

4.1. Empirical data

In order to select the appropriate type of econometric model and thus obtain significant estimation results, unit root properties of the time series should be determined. In this respect, the Lumsdaine-Papell unit root test, allowing for two breaks in the intercept, the trend or both at unknown locations is employed. The same test was also performed with more than three breaks and the robustness of test results are verified. Furthermore, the Zivot-Andrews and Lee-Strazicich unit root tests with multiple break tests are in line with the Lumsdaine-Papell unit root test for the model variables.

As shown in Table 1, the Lumsdaine-Papell unit root test results indicated that the variables of Models 1 and 2 became stationary at first-differences and the possibility of a cointegration relationship between the variables of SVAR Models 1 and 2 for the Czech Republic, Iceland, Poland and Russia may exist. In this study, I followed the approach of Hatemi-J (2014) and decomposed variables cumulative sums in line with Hatemi-J (2012) and Hatemi-J and El-Khatib (2016) to understand the interplay between variables. However, no co-integration relationship was found for all cases based on the vector specification as; $(empi_t^p, cur_t^p, ifl_t^p, lird_t^p, ted_t^p)'$ and $(empi_t^n, cur_t^n, ifl_t^n, lird_t^n, ted_t^n)'$ with the help of Johansen cointegration test.[7]

Lumsdaine-Papell unit root tests have demonstrated that each variable may differ in terms of structural breakdown data. In this regard, Bai-Perron tests have also confirmed that there can be multiple and different structural breaks for the model variables,[8] although their results are not presented here to save space. Therefore, I did not divide the full sample into particular sub-samples, and the nonlinear VAR and SVAR models for each country were estimated using the full sample for each country. Nevertheless, analyzing the macroeconomic developments that may result in breaks in model variables can prove useful through revealing the overall economic course of the Czech Republic, Iceland, Poland and Russia. For both model variables of the Czech Republic, 2005, 2006 and 2007 were identified as the years in which breaks occurred. According to the suggested break dates in Table 1, it can additionally be said that the GFC and a slump in demand within the EU and government austerity measures represented major factors with lagged impacts on model variables. The government's reform program in 2014 constituted a factor that resulted in breaks in the country's macroeconomic variables. In terms of the models' variables of Poland, another Visegrad country, similar break dates were identified using the Lumsdaine-Papell unit root tests. It should be noted that Poland is also an open country, and represents the sixth largest economy in Europe. Thus, it can be said that the expansionist fiscal policies applied in order to overcome the negative effects of the GFC caused breaks in the models' variables. More precisely, it can be argued that the break dates for the macroeconomic variables of the Czech Republic were affected by external developments, whereas in Poland both internal and external macroeconomic developments caused such breaks. A further member of the Eastern Bloc, Russia, has undergone significant changes since the collapse of the Soviet Union, moving from a centrally planned economy toward a more market-based system. In this respect, economic reforms in the 1990s privatized the majority of industries, albeit not in the energy, transportation, banking, and defense-related sectors. Such developments should be recognized as crucial factors that explain the break dates before the GFC in the model variables of Russia. Similar economic reforms can be considered effective in the Czech Republic and Poland, while Russia has been vulnerable to boom and bust cycles in global commodity prices as a commodity exporter. Falling oil prices, international sanctions, and structural limitations may also help explain the breaks in 2015 and 2018 for the model variables of Russia. The economic characteristics of Iceland differ significantly from the other countries investigated here. Indeed, Iceland combines a capitalist structure and free-market principles with an extensive welfare system over multiple decades. The privatization of the banking sector in the early 2000s stimulated increased borrowing in foreign currencies from foreign markets, possibly explaining the structural breaks prior to the GFC. Alongside the effects of the GFC, the collapse of Iceland's financial sector, economic policies aimed at stabilizing the krona, capital controls, tight fiscal policies to control inflation, and polices to restructure the financial sector can also be considered factors that caused breaks in the models' variables for Iceland.

4.2. Empirical analysis

In this study, I estimated SVAR models for the Czech Republic, Iceland, Poland and Russia to expose the future dynamics of EMPI under the influence of current account balance (% of GDP), consumer price inflation, the difference between these countries' long-

[7] Johansen cointegration is an approach that is sensitive to lag length, while the results of the test are not presented to save space. On the other hand, they can be provided upon request.

[8] The Lumsdaine-Papell unit root test results additionally indicate that there can be different break dates for each variable at levels and at first-differences. These dates may correspond to the GFC, quantitative easing polices of major central banks, and internal macroeconomic developments. Nevertheless, economic dynamics at that time were not discussed in order to avoid exceeding the aims of the study.

Table 1
Lumsdaine-Papell Unit Root Test Results.

Variables	Test statistic	Number of lagged differences	Suggested break date	Variables	Test statistic	Number of lagged differences	Suggested break date
$empi_t^{p,cze}$	−3.8806	1	2005:04 2008:04	$empi_t^{p,ice}$	−6.1109	2	2006:04 2013:03
$\Delta empi_t^{p,cze}$	−10.4932	0	2005:03 2008:01	$\Delta empi_t^{p,ice}$	−11.2608	0	2006:04 2009:02
$empi_t^{n,cze}$	−4.5430	0	2005:02 2007:04	$empi_t^{n,ice}$	−5.9192	0	2006:03 2013:04
$\Delta empi_t^{n,cze}$	−6.7510	0	2009:01 2015:01	$\Delta empi_t^{n,ice}$	−9.8872	0	2006:02 2009:03
$cur_t^{p,cze}$	−6.9506	0	2008:02 2011:02	$cur_t^{p,ice}$	−5.0649	5	2008:03 2012:02
$\Delta cur_t^{p,cze}$	−6.1174	7	2005:04 2012:02	$\Delta cur_t^{p,ice}$	−6.0893	4	2007:02 2010:03
$cur_t^{n,cze}$	−8.0145	0	2008:03 2011:02	$cur_t^{n,ice}$	−7.2840	1	2007:03 2010:01
$\Delta cur_t^{n,cze}$	−9.4752	1	2010:01 2012:03	$\Delta cur_t^{n,ice}$	−12.2333	0	2007:03 2010:04
$ifl_t^{p,cze}$	−3.5139	4	2006:04 2013:04	$ifl_t^{p,ice}$	−6.0903	2	2008:01 2010:03
$\Delta ifl_t^{p,cze}$	−6.2576	4	2006:04 2015:03	$\Delta ifl_t^{p,ice}$	−11.7355	0	2003:03 2008:01
$ifl_t^{n,cze}$	−3.8841	1	2008:01 2013:04	$ifl_t^{n,ice}$	−5.8148	10	2008:04 2014:04
$\Delta ifl_t^{n,cze}$	−12.8954	0	2008:01 2012:01	$\Delta ifl_t^{n,ice}$	−12.3508	0	2003:04 2008:02
$lird_t^{p,cze}$	−5.0508	1	2005:02 2007:02	$lird_t^{p,ice}$	−6.1779	0	2006:02 2009:01
$\Delta lird_t^{p,cze}$	−8.2552	0	2006:02 2013:03	$\Delta lird_t^{p,ice}$	−8.0690	1	2008:01 2011:01
$lird_t^{n,cze}$	−4.4357	2	2007:03 2014:03	$lird_t^{n,ice}$	−5.0475	1	2003:03 2008:03
$\Delta lird_t^{n,cze}$	−17.4086	1	2007:03 2015:03	$\Delta lird_t^{n,ice}$	−7.8967	1	2006:03 2013:03
$empi_t^{p,pol}$	−3.7607	0	2008:01 2014:02	$empi_t^{p,rus}$	−6.5686	0	2000:04 2018:01
$\Delta empi_t^{p,pol}$	−9.0094	0	2008:01 2014:02	$\Delta empi_t^{p,rus}$	−9.3310	1	2007:02 2014:02
$empi_t^{n,pol}$	2.4511	0	2005:01, 2015:03	$empi_t^{n,rus}$	−6.8284	0	2003:03 2015:01
$\Delta empi_t^{n,pol}$	−0.2338	0	2004:04 2015:03	$\Delta empi_t^{n,rus}$	−10.6447	0	2009:01 2015:01
$cur_t^{p,pol}$	−5.5514	0	2007:01 2015:03	$cur_t^{p,rus}$	−5.0308	0	2009:02 2012:01
$\Delta cur_t^{p,pol}$	−10.3913	0	2008:04 2015:03	$\Delta cur_t^{p,rus}$	−8.7494	0	2009:01 2014:01
$cur_t^{n,pol}$	−3.7876	0	2011:04 2015:04	$cur_t^{n,rus}$	−5.6716	0	2006:03 2008:03
$\Delta cur_t^{n,pol}$	−10.4481	0	2007:02 2011:03	$\Delta cur_t^{n,rus}$	−5.8034	3	2006:03 2015:04
$ifl_t^{p,pol}$	−4.9207	6	2010:03 2014:01	$ifl_t^{p,rus}$	−4.2036	4	2004:04 2012:03
$\Delta ifl_t^{p,pol}$	−6.8417	3	2012:02 2014:04	$\Delta ifl_t^{p,rus}$	−6.6584	10	2006:04 2014:03
$ifl_t^{n,pol}$	−5.5882	4	2007:03 2014:02	$ifl_t^{n,rus}$	−4.7364	4	2005:01 2012:01
$\Delta lcpi_t^{n,pol}$	−9.3568	4	2004:04 2015:03	$\Delta ifl_t^{n,rus}$	−9.5053	1	2008:02 2015:01
$lird_t^{p,pol}$	−5.9525	4	2004:03 2007:03	$lird_t^{p,rus}$	−3.4729	3	2010:01 2013:01
$\Delta lird_t^{p,pol}$	−7.3872	4	2007:02 2012:03	$\Delta lird_t^{p,rus}$	−31.1174	0	2003:01 2015:03
$lird_t^{n,pol}$	−4.9984	0	2005:02 2012:03	$lird_t^{n,rus}$	−5.6058	1	2008:02 2015:02
$\Delta lird_t^{n,pol}$	−6.5068	10	2007:03 2015:01	$\Delta lird_t^{n,rus}$	−7.2342	0	2009:01 2015:03
ted_t^p	−4.6486	0	2003:02 2005:03	ted_t^n	−5.6782	2	2004:03 2010:04
Δted_t^p	−11.2516	0	2005:04 2008:02	Δted_t^n	−18.4574	2	2008:03 2014:02

Note: The lag orders used in the ADF tests are selected by the Schwarz Criterion (SC).

term interest rates and those of the USA, and the TED spread for the US economy. The SC suggested a lag length of 1 for the two SVAR models of the Czech Republic and Iceland, with the time series vectors $(empi_t^p, cur_t^p, ifl_t^p, lird_t^p, ted_t^p)'$ and $(empi_t^n, cur_t^n, ifl_t^n, lird_t^n, ted_t^n)'$, respectively.[9] Lag lengths of 2 and 4 are imposed by the SC for Models 1 and Model 2 with the time-series vectors of Poland and Russia. SVAR Models 1 and 2 for the Czech Republic and Iceland are estimated using quarterly data from 2003:01 to 2018:01; due to availability of data, models include quarterly data from 2004:01 to 2018:01 for Russia and Poland, respectively.

To identify the SVAR Blanchard-Quah models estimated in the empirical exercise, the number of bootstrap replications was selected as 2000 and the seed 2 was used to compute the coefficients of the matrix with long-term restrictions and for the

[9] Previous studies using the cumulative sums approach in VAR-type models (Hatemi-J, 2014; Nouira et al., 2018) have failed to consider the unit root properties of the time series. Such an approach is congruent with Granger and Yoon (2002), who assumed hidden cointegration in VAR models with integrated variables at levels.

performance of impulse response analysis.[10] On this basis, contemporaneous and long-term matrices were estimated, and impulse response and FEVD analyses were performed. The number of forecast periods was selected as 36, while the Efron Bootstrap Percentage Confidence Interval used was 0.95 in the implementation of the impulse response exercise. Forecast horizon of forecast errors of the EMPI is also 36 to analyze impacts of the past values of EMPI and other variables of relevant SVAR models. On the other hand, the robustness of my empirical findings is substantially verified when other EMPI specifications are included in the empirical exercise.

Alternatively, the role of asymmetric effects in relationships between variables can be studied by employing methods other than the examination of coefficients of IRFs in the SVAR model.[11] For instance, the approach developed by Kilian and Vigfusson (2011) is contingent on the nonlinear VAR model framework, and can be utilized to consider the role of asymmetry. In this respect, the censored variables approach is first used to generate the vector required to estimate the nonlinear VAR models, and so variables that can cause asymmetric impacts on the EMPI are discussed. Consequently, slope-based tests were performed for the countries under investigation. More specifically, the lag lengths of nonlinear VAR models that constitute a basis for Mork (1989) test for each case were suggested as 1 with the SC criterion.

4.2.1. Test of asymmetry via Slope-Based tests

In this study, the estimated coefficients of the IRFs were traced for the following periods to understand the asymmetric effects of the possible relationship between the variables, and to interpret the role of asymmetry on EMPI. More precisely, the differences between the effects of the shocks in the variables decomposed according to the positive and negative cumulative totals sums were determined, and any existence of an asymmetric relationship was sought. The IRFs used in 4.2.3. included multiple variables, and the SVAR Blanchard-Quah models were estimated using the vectors $(empi_t^p, cur_t^p, ifl_t^p, lird_t^p, ted_t^p)'$ and $(empi_t^n, cur_t^n, ifl_t^n, lird_t^n, ted_t^n)'$, respectively. However, first the asymmetric effects to which the EMPI may be subject were interpreted in line with the censored variables approach developed by Kilian and Vigfusson (2011). Given that their approach is based on the two-variable nonlinear VAR model, potential asymmetric effects on the EMPI can be evaluated via a limited empirical framework. Therefore, in contrast to the approach taken in 4.2.3. (for example), the effects of cur_t on $empi_t$ were explored without taking into account ifl_t, $lird_t$, ted_t in the nonlinear VAR model (see Table 2).[12]

As a result of the slope-based asymmetry tests performed for the Czech Republic, Iceland, Poland and Russia, it can generally be accepted that there can be no asymmetric effects of cur_t, ifl_t, $lird_t$and ted_t on $empi_t$. In this respect, it can be asserted that the inverse effect of the increase and decrease in variables on the EMPI may be the same as the absolute value. However, some exceptional results were obtained via Mork's test. Indeed, the interest rate differential in Iceland, current account in Russia, and TED spread in Poland were all far lower than five percent. Herein, it is necessary to estimate SVAR-based FEVDs and IRFs for the entire sample in order to ascertain whether the results support the slope asymmetry-based estimates. As for the estimation of SVAR models, the prerequisite constraints displayed in Eq. (15) are based on assumptions derived from economic theory. The validity of these assumptions was also evaluated by taking asymmetry into consideration in the estimation process of SVARs. Consequently, it is apparent that the EMPI of all four countries may be subject to the asymmetric effects of internal and external economic factors.

4.2.1.1. Results of FEVD analysis. In this study, two types of SVAR models were estimated and FEVD analysis was used to determine the proportion of movements in the forecast errors of dependent variables in terms of their own shocks and shocks to other variables. In this respect, SVAR Model 1 contains only those variables that are decomposed according to the positive cumulative sums approach. Model 2 includes variables that are decomposed by the negative cumulative sums approach. As shown in Table 3, FEVDs indicate that variations in the EMPI are mainly led by their own shocks up to the following thirty-sixth month, accounting for more than 50% of the 36-step forecast error variance of itself. Moreover, it was found for Iceland that approximately 70% of the 36-step forecast error variance of EMPI is explained by its own shocks. Within the framework of Model 1, the finding that the increase in $empi_t^p$ is mainly explained by its own past values reveals that the dynamics of the foreign exchange rate market and the level of the foreign exchange reserves of the 4 countries can be accepted as crucial factors. More specifically, it can be suggested that a possible FXI policy, which is used to stabilize the exchange rate, should be implemented in such a way that the foreign exchange reserves will not be lower than the critical level in the Czech Republic, Iceland, Poland and Russia. Thus, it can be asserted for the four countries that the FXI policy can significantly increase the value of EMPI in the following periods when the relevant policy is implemented without incorporating the level of foreign exchange reserves. Similarly, it can be argued that the implementation of a monetary policy that would increase the foreign exchange reserves or the macroeconomic developments in this direction will play an important role in explaining the shocks that might occur in the decline in the EMPI.

On the other hand, regardless of the level of foreign exchange reserves of the country, foreign exchange demand may change, and the increase in the demand for foreign exchange will often be considered within the scope of portfolio diversification of investors in the financial market. FEVD analysis performed within Models 1 and 2 implied that the loss and gain of foreign currencies of the

[10] Lütkepohl, Markus Krätzig, and Boreiko (2006) have advocated the selection of a few thousand replications, even though this may result in substantial waiting times. The model could not be calculated for replication numbers greater than 2000, while the robustness of model results for different seed values have been confirmed.

[11] Although the identification of the SVAR is related to orthogonal shocks, existing studies have interpreted their results in terms of the effects of one model variable on another.

[12] Following Killian and Vigfusson (2011), the variables included in the nonlinear models are at levels. This method also helps make comparisons with the SVAR model.

Table 2
Slope-Based Asymmetry Test.

	Czech Republic		Iceland	
	Mork's Test of Symmetric Coefficients	p-Value	Mork's Test of Symmetric Coefficients	p-Value
cur_t	1.95994	0.09762697	0.27709	0.89294332
ifl_t	0.32688	0.86009677	0.49072	0.74258346
$lird_t$	1.38286	0.23697988	3.18512	0.01261593
ted_t	1.68087	0.15124167	1.54026	0.18743917
	Poland		Russia	
	Mork's Test of Symmetric Coefficients	p-Value	Mork's Test of Symmetric Coefficients	p-Value
cur_t	0.52421	0.71795230	4.13682	0.00236622
ifl_t	2.05260	0.08416849	1.31432	0.26190222
$lird_t$	2.17150	0.06944559	1.15594	0.32812392
ted_t	5.06534	0.00044343	2.35844	0.05112640

Table 3
FEVDs of the EMPI (positive progressions).

	Czech Republic					Iceland				
Forecast Horizon	$empi_t^p$	cur_t^p	ifl_t^p	$lird_t^p$	ted_t^p	$empi_t^p$	cur_t^p	ifl_t^p	$lird_t^p$	ted_t^p
1	0.03	0.75	0.03	0.1	0.09	0.28	0.15	0.3	0.05	0.17
12	0.08	0.6	0.18	0.1	0.04	0.64	0.17	0.1	0.07	0.02
24	0.33	0.38	0.16	0.1	0.03	0.7	0.16	0.07	0.06	0.01
36	0.53	0.23	0.12	0.1	0.02	0.7	0.16	0.07	0.06	0.01
	Poland					Russia				
h	$empi_t^p$	cur_t^p	ifl_t^p	$lird_t^p$	ted_t^p	$empi_t^p$	cur_t^p	ifl_t^p	$lird_t^p$	ted_t^p
1	0.01	0.3	0.43	0.22	0.04	0.33	0.18	0.33	0.12	0.04
12	0.16	0.61	0.12	0.08	0.03	0.54	0.16	0.15	0.11	0.04
24	0.4	0.44	0.09	0.05	0.02	0.56	0.16	0.14	0.11	0.03
36	0.58	0.3	0.06	0.04	0.02	0.58	0.16	0.13	0.1	0.03

domestic currency of the Czech Republic, Iceland, Poland and Russia would have a considerable impact on the EMPI. Herein, it can be said that it is necessary to determine what factors may cause to speculative attack on exchange rate within the context of financial crisis models. Therefore, Models 1 and 2 have included other macroeconomic variables that could change foreign exchange supply and demand.

The results of FEVD analysis revealed that the changes in the current account balance to GDP ratio played a key role in explaining the increase and decrease in the EMPI for all cases. The weight of the current account balance to GDP ratio variable in the explanation of the fluctuations occurring in the increase in $empi_t^p$ has the lowest values for Iceland and Russia. Similar results were obtained for Model 2, and it was found that the share in the current account balance was higher in the Czech Republic and Poland in the explanation of decreases in the EMPI. Accordingly, the FEVD results of Models 1 and 2 indicated that the current account balance (the main determinant of a country's external resource need) will increase or decrease the country's foreign currency debt, and this phenomenon will in turn increase or decrease the likelihood of speculative attack considering the level of foreign exchange reserves. On the other hand, although FEVDs do not show the direction of impact on the variables, it can be stated that the weights obtained from the FEVDs of Models 1 and 2 (0.16 and 0.14) did not provide sufficient evidence that the current account balance of Russia had asymmetric impacts on EMPI.

As a reflection of the changes in the current account balance, foreign direct investments and portfolio flows can be assumed to be changing. More specifically, the inflow/outflow of funds to a country affect the value of the EMPI via changes in foreign exchange market dynamics, regardless of the real level of the exchange rate. Additionally, it can be argued that the inflation dynamics of the country will produce results on the EMPI by changing the expectations of the exchange rate in line with the PPP condition. The results of FEVD analysis based on Model 1 showed that the increase in inflation rate would overvalue the nominal exchange rate, leading to an increase in the depreciation expectations in nominal exchange rates. Thus, it can be inferred that inflation would have a considerable role in explaining the variations in $empi_t^p$. FEVD analysis of Model 2 also showed that the decrease in inflation might play a significant role in reducing the EMPI, while, in terms of explaining the variations in the $empi_t^n$, ifl_t^n has the highest weight in Russia up to the following 36 quarter (see Table 4).

The FEVD analysis conducted with Models 1 and 2 revealed that the increase and decrease in Russia's inflation rate had a major effect on the EMPI. On the other hand, the effect of capital flows on the EMPI remained low compared to the PPP relationship. Nevertheless, FEVDs based on Models 1 and 2 indicated that long-term interest rates can have a considerable impact on variations in the EMPI in the Czech Republic and Russia. However, the result of the slope-based test indicating that there is asymmetry in terms of

Table 4
FEVDs of the EMPI (negative progressions).

	Czech Republic					Iceland				
Forecast Horizon	$empi_t^n$	cur_t^n	ifl_t^n	$lird_t^n$	ted_t^n	$empi_t^n$	cur_t^n	ifl_t^n	$lird_t^n$	ted_t^n
1	0.06	0.86	0.08	0	0	0	0.25	0.22	0.42	0.11
12	0.07	0.74	0.08	0.1	0.01	0.44	0.27	0.1	0.15	0.04
24	0.3	0.5	0.09	0.1	0.01	0.72	0.13	0.05	0.07	0.03
36	0.51	0.32	0.09	0.07	0.01	0.82	0.08	0.03	0.04	0.03
	Poland					Russia				
h	$empi_t^n$	cur_t^n	ifl_t^n	$lird_t^n$	ted_t^n	$empi_t^n$	cur_t^n	ifl_t^n	$lird_t^n$	ted_t^n
1	0.49	0.3	0.11	0.08	0.02	0.12	0.35	0.14	0.19	0.2
12	0.53	0.3	0.1	0.06	0.01	0.47	0.22	0.13	0.11	0.07
24	0.53	0.3	0.1	0.06	0.01	0.58	0.17	0.13	0.09	0.03
36	0.53	0.3	0.1	0.06	0.01	0.64	0.14	0.12	0.08	0.02

the effects of the long-term interest rate differential of Iceland on the EMPI was not fully supported by the FEVDs. More specifically, I obtained results showing that the weights were close to one another (0.06 and 0.04) based on Models 1 and 2, respectively. Accordingly, it can be proposed that the increase/decrease in long-term interest rates may decrease/increase the EMPI value by increasing/decreasing capital inflows in all four countries examined. In addition to the relevant channel in question, the uncovered interest rate parity (UIP) condition may be valid and the increase/decrease in the domestic interest rates will increase/decrease the EMPI by raising/lowering the expectation of depreciation of home currency. FEVD analysis implies that all of the channels explained above may be valid for the interest rate, and the clarification of possible channels is made by the impulse response analysis. The FEVDs of Models 1 and 2 also showed that through demonstrating the credit risk and liquidity abundance for the US economy, ted_t cannot produce a strong transmission channel to $empi_t$. Moreover, the result of Mork's test (indicating that there was asymmetry in the slope in terms of the impacts of U.S. credit risk on the EMPI for Poland) was not fully confirmed due to the weights of 0.02 and 0.01 found on the basis of Models 1 and 2. Although it has been acknowledged that the developments in the US economy have spread to the emerging countries, my findings suggest that the probability of contagion of financial crises over the credit risk of the US economy may be lower in the following periods due to the fact that the Czech Republic, Iceland, Poland and Russia have mostly high economic and financial linkages relations with the European countries.

4.2.1.2. Results of impulse response analysis. According to the impulse response analysis, it was found that the positive shocks in $cur_t^{p,cze}$ and $cur_t^{p,pol}$ variables (reflecting the improvements in current account balance with respect to the GDP) would decrease the values of $empi_t^{p,cze}$ and $empi_t^{p,pol}$for the following periods. The relevant effect was found to be valid in the longer term for Poland, which showed that the Polish economy was more sensitive and had a more lasting positive response to improvements in the current account balance. Although the Czech Republic's exports comprise approximately 80% of its GDP, and this makes its economy vulnerable to changes in external demand, it can be said that Poland's liberal economic policies and its status as the sixth largest economy in Europe have caused its exchange market to have a high level of integration with positive external macroeconomic developments. On the other hand, it was found that the improvement in current account balance in Iceland and Russia could not significantly affect the $empi_t^p$. Therefore, the improvement in the current account balance in Iceland and Russia will not be enough to compensate for the problem of foreign currency financing in the country. It can also be stated that this situation will not fully reduce the EMPI and that the severity of foreign currency demand in these two countries is related to the level of the country's foreign currency debt and country risk. The deterioration in the current account balance of the four countries examined will also have negative impacts, most notably increasing the $empi_t^n$. Furthermore, it has been shown that the long-term effect will persist in the Czech Republic and Russia. In this respect, it can be said that the result of Mork's test (i.e., the existence of asymmetry in the slope for the effects of the current account balance on the EMPI for Russia) was confirmed by the IRFs based on Models 1 and 2. As a result, it can be argued that a deterioration in the current account balance creates greater potential for speculative attack in Iceland and Poland than in the Czech Republic and Russia. This finding can be interpreted by the fact that the ratio of debt to GDP was more than 50% in Iceland and Poland, thereby increasing the risk of speculative attack (see Figs. 1–4).

Impulse response analysis implied that the shocks in ifl_t^p might cause to an increase in $empi_t^p$ for each 4 countries. Additionally, it was found that the decline in inflation rate in Iceland and Russia would not be sufficient to reduce the EMPI. Accordingly, impulse response analysis revealed that, especially in Iceland and Russia, the relationship between inflation and the EMPI could be exposed to asymmetric impacts. For the Czech Republic and Poland, the coefficients of the IRFs based on Models 1 and 2 may indicate the presence of symmetry in the relationship between the inflation and EMPI. However, there are some differences between the coefficients of IRFs predicted for the Czech Republic and Poland within SVAR Models 1 and 2. Thus, it can be said that the decrease in inflation rate in all 4 countries may not be enough to reduce the value of the EMPI by making a significant contribution to macroeconomic stability. IRFs examining the possible asymmetric effects of the current account balance and inflation rate shocks on the EMPI indicated that both variables have asymmetric effects; this issue is more dominant in Iceland and Russia (see Figs. 1–4).

On the other hand, as a result of the impulse response analysis, it can be implied that the increase in the long-term interest rates of

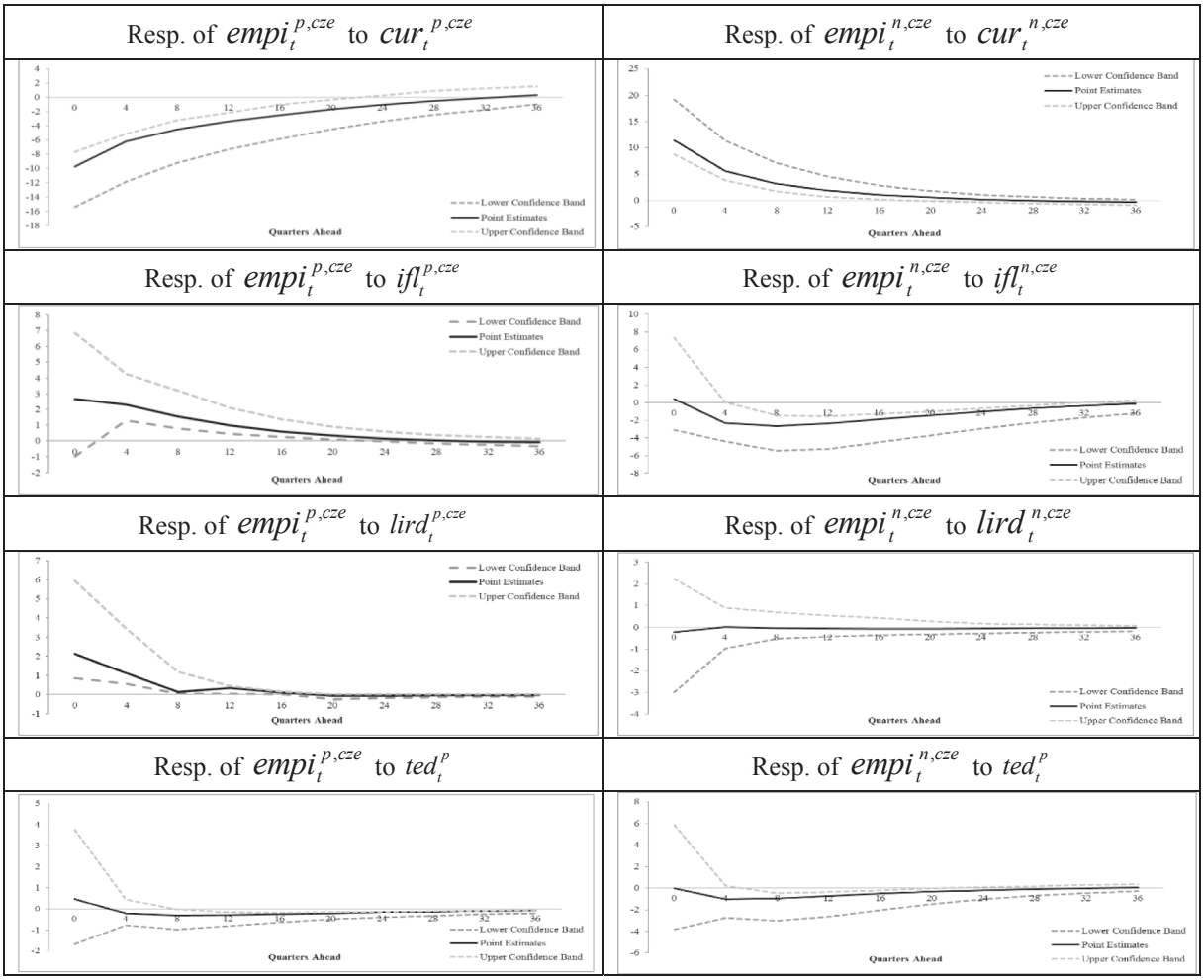

Fig. 1. Responses of EMPI to Shocks in the Variables of Models 1 and 2 for the Czech Republic.

the Czech Republic, Iceland, Poland and Russia with respect to the US would increase $empi_t^p$. Additionally, it was revealed that the impacts of $lird_t^p$ on $empi_t^p$ is relatively short-lived in Poland. Because the share of the export sector in GDP is more than 40% in the Poland, the relevant finding can be interpreted to show that long-term interest rates cannot be a key factor influencing real economic activity, and thus they have limited impacts on macroeconomic expectations and EMP. In this respect, it can be asserted that an increase in interest rates will not reduce the value of the EMPI by raising the capital inflows to the country. The results of the impulse response analysis indicate that the UIP condition can be valid. Indeed, the increase in interest rates may constitute a triggering base for the expectation of exchange rate depreciation, in turn leading to an increase in the value of EMPIs in the Czech Republic, Iceland, Poland, and Russia. However, it can be assumed that increased interest rates will accelerate capital inflows from abroad and decrease the EMPI in line with the Mundell-Fleming model. Thus, from the short-lived response of EMPI to the positive long-term interest rate differential in Poland it can be interpreted that the UIP condition and the Mundell-Fleming model have opposite effects, hence the increasing impact on $empi_t^p$ may be limited. Moreover, in the case of Poland, greater capital inflows may improve the existing investment stock and macroeconomic expectations, in turn leading to a short-lived effect on $empi_t^p$. The IRFs of SVAR Model 2 are also estimated to detect the asymmetric effects of $lird_t$ in this study; accordingly, it was revealed that the decrease in $lird_t^n$ did not produce statistically significant results in the $empi_t^n$ of the countries under investigation, except for Poland where $empi_t^{n,pol}$ decreases significantly after the following 24th period. More specifically, the result of Mork's test for Iceland in terms of the impacts of $lird_t$ on $empi_t$ was supported because $lird_t^n$ did not produce statistically significant results in the $empi_t^n$ (see Figs. 1–4).

In this study, the effects of the FED interest rate policy on the EMPI in the Czech Republic, Iceland, Poland and Russia are also incorporated. The interest rate policy of the FED reflects the course in the US economy, and due to the increasing/decreasing policy interest rates, the US long-term interest rates contained in the $lird_t$ variable are supposed to increase/decrease and the interest difference decreases/increases. With the help of the SVAR models' IRFs, the impacts of changes in credit risk in the US on EMP in the Czech Republic, Iceland, Poland, and Russia are also examined. Within this framework, the effects of interest rate changes in the credit market were considered indirectly. Impulse response analysis implies that positive variations in TED spread in the US would

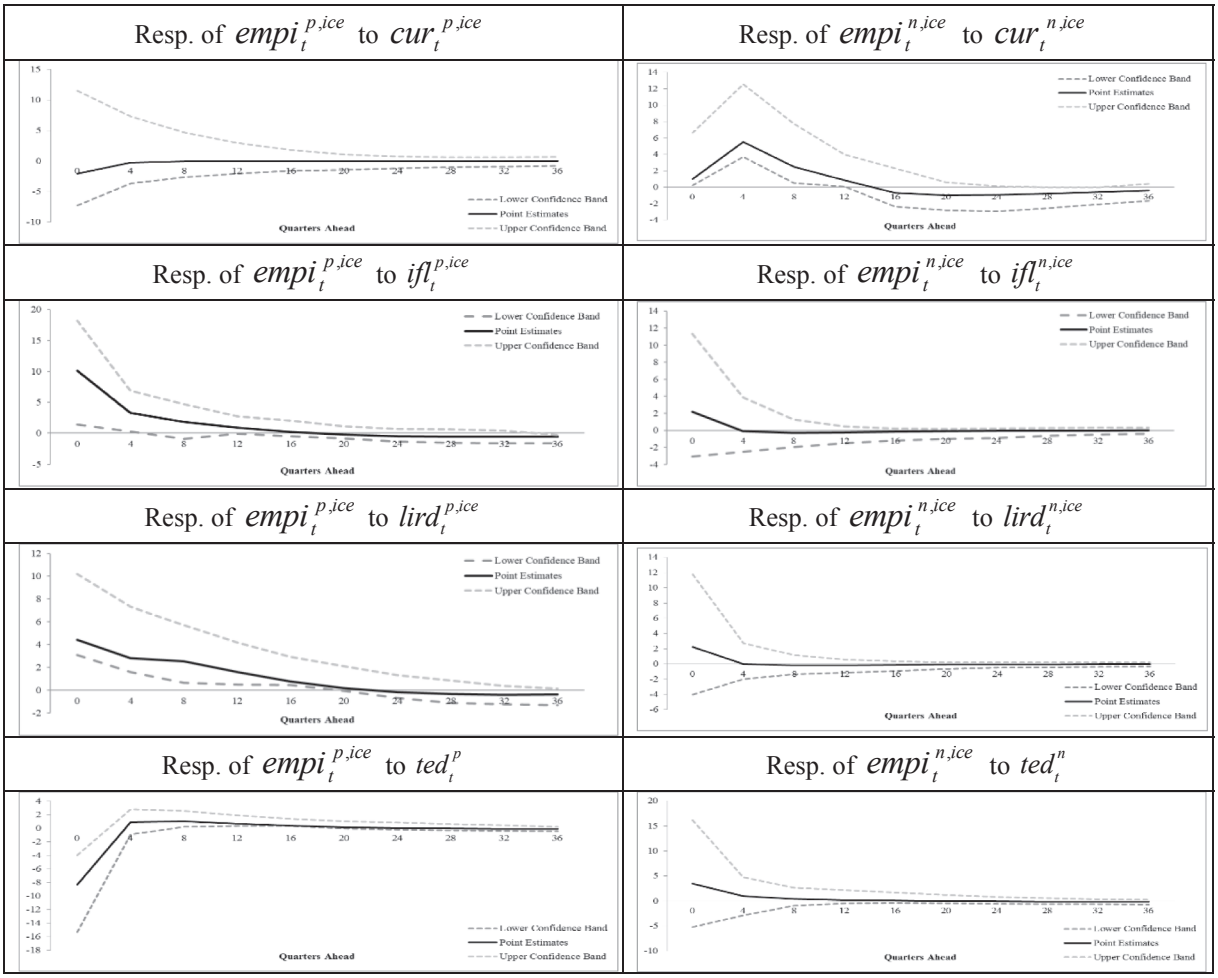

Fig. 2. Responses of EMPI to Shocks in the Variables of Models 1 and 2 for Iceland.

cause an increase in $empi_t^{p,pol}$; thus, it can be argued that an increase in credit risk in the US would strengthen the capital outflows of the Polish economy. On the other hand, although the increase in the TED spread in the US can be recognized as a factor for global economic slowdown and increase the demand on safe-haven assets, negative developments in credit conditions in the US may also reduce capital outflows and have a decelerating impact on the $empi_t^p$ in the Czech Republic, Iceland, and Russia, albeit only for certain periods. Of the countries examined, it was revealed that Poland is the most vulnerable to changes in credit conditions in the USA, and would relatedly be most severely affected by negative developments in the US credit market. Thus, the fact that Poland has the sixth largest economy in the EU, and enjoys a close relationship with the EU and the USA in terms of foreign trade volume, can be interpreted as negative factors that render the country more susceptible to global risks.

The relevant implication is supported by the impulse response analysis of Model 2, which shows that the negative variations in TED spread in the US could lead to a decline in $empi_t^n$ for the Czech Republic, Poland, and Russia. In other words, it can be argued that lower credit risk in the USA will reduce the EMPI due to positive expectations for the world economy, and thus capital inflows to the Czech Republic, Poland and Russia, which are also classified as developing countries. Accordingly, the result of Mork's test indicating asymmetry in the slope for the effects of TED spread on the EMPI for Poland was partly confirmed by the IRFs based on Models 1 and 2. Certainly, the coefficients of the IRFs based Models 1 and 2 do not presence of a strong asymmetric effect on the relevant relation (see Figs. 1–4).

5. Conclusions

In this study, FEVD analysis was performed based on SVAR models to determine the role of macroeconomic and financial factors on the EMPI. In this context, it was found that the past values of EMPI increase have a significant weight, explaining the variations in $empi_t^p$ for the Czech Republic, Iceland, Poland and Russia. Similarly, in the explanation of possible fluctuations in the variable corresponding to the decrease in the EMPI, which is expressed as $empi_t^n$, it was found that the historical values of the relevant variable have a significant share in all 4 countries. Thus, the determination of the effects of fluctuations in the foreign exchange reserve level of the country and dynamics of exchange rate market of each country is underlined in terms of the definition of the EMPI used in this

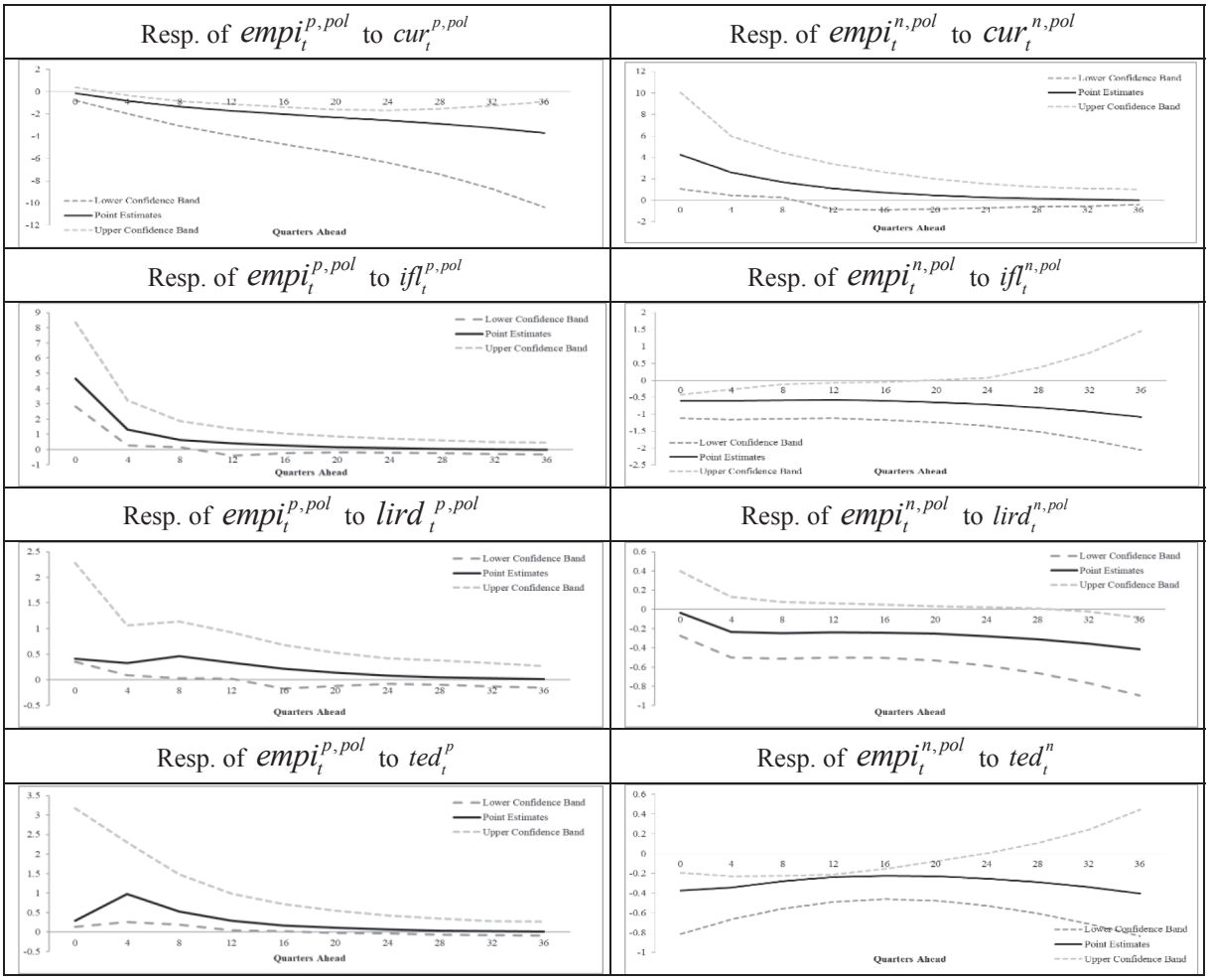

Fig. 3. Responses of EMPI to Shocks in the Variables of Models 1 and 2 for Poland.

study. In this framework, it can be argued that the value nominal exchange rate will affect the financial fragility in the Czech Republic, Iceland, Poland and Russia that are indebted in foreign currency and will have consequences on the possibility of speculative attack. The finding that past values in the EMPI are high in explaining the variations in EMPI for the future periods implies the importance of the currency risk of economic agents as well as the possible consequences of the speculative attack, which may occur depending on the level of foreign exchange reserves.

The results of FEVD analysis performed for all 4 countries revealed that developments in the current account balance were the second most important factor in explaining fluctuations in the EMPI. It can also be said that due to the developments in current account balance, the need for external financing varies considerably in the Czech Republic, Iceland, Poland and Russia. Accordingly, the possibility of speculative attack in the countries under investigation, which may occur by considering the level of foreign exchange reserves, increases or decreases. Additionally, FEVD results showed that the difference between long-term interest rates of the 4 countries and that of the US was found to be relatively low, but $lird_t$ has a considerable weight. It was also found by the FEVD analysis that the inflation rate, which is another variable that can affect the EMPI through changes in the nominal exchange rate in terms of the PPP condition, is of minor importance in explaining the changes in the EMP for all countries.

On the other hand, based on SVAR Models 1 and 2, impulse response analysis was conducted to determine whether asymmetric effects on the EMPI were present. Accordingly, it was found that improvements in the current account balance in the Czech Republic, Iceland, Poland, and Russia could reduce EMP. More specifically, it was revealed that the developed export sectors of the Czech Republic and Poland with respect to Iceland and Russia, and the degree of openness of both economies, led the countries' currency markets to have a high level of integration with positive external macroeconomic developments. In line with theoretical expectations, IRFs also showed that deterioration in the current account balance increased the foreign currency needs of the country and increased the pressure on exchange rates. For instance, the findings of this study stress that a deterioration of the current account balance creates a more serious speculative attack potential in Iceland and Poland with respect to the Czech Republic and Russia, due to the high ratio of debt to GDP.

However, the IRFs of SVAR Models 1 and 2 suggest that the improvement and deterioration of the current account balance have differing coefficients as absolute values. This emphasizes the fact that the current account balance may have asymmetric effects on

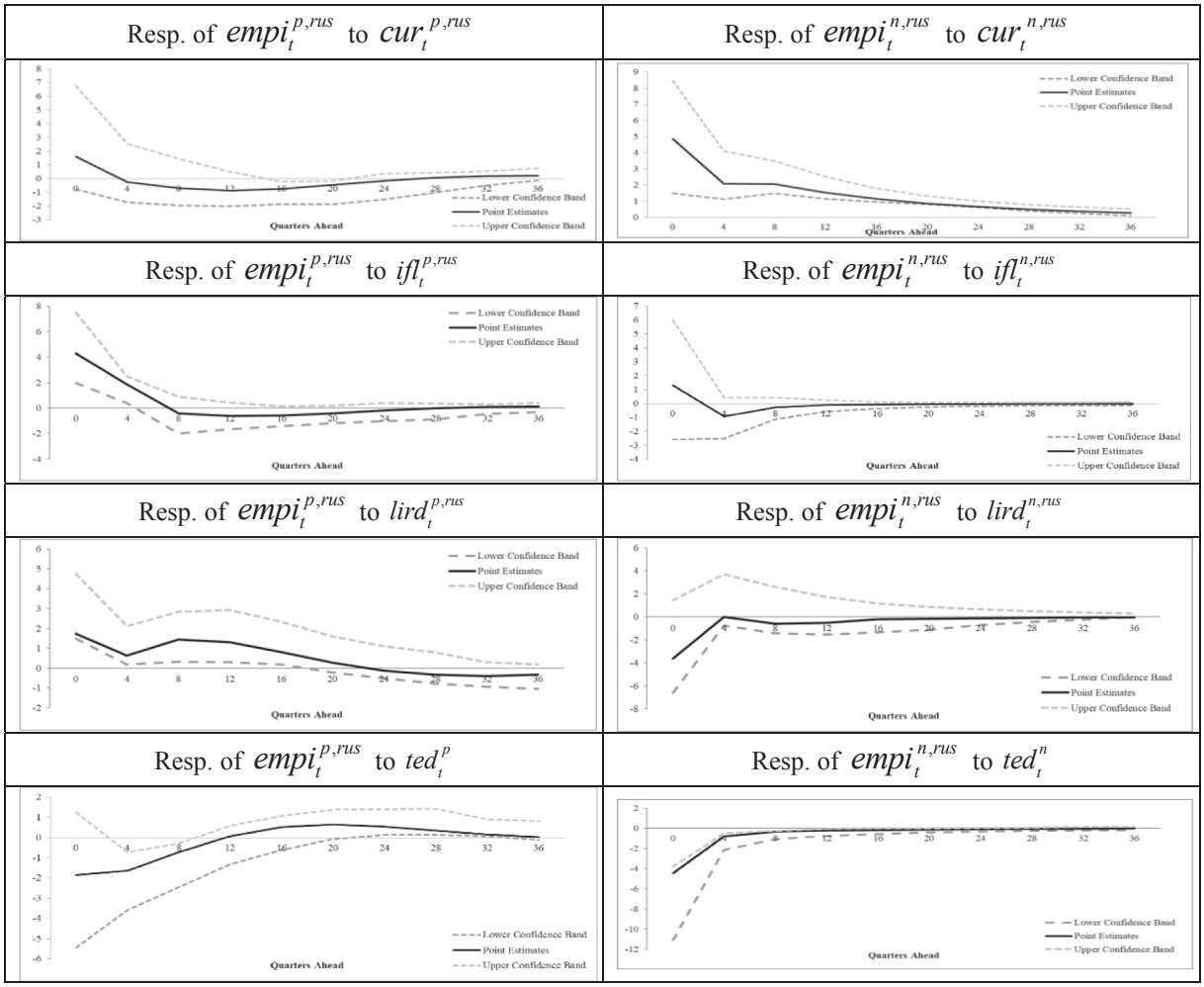

Fig. 4. Responses of EMPI to Shocks in the Variables of Models 1 and 2 for Russia.

the EMPI of the countries investigated here. Similarly, the increases and decreases in inflation rate will not be evaluated as symmetric in terms of increasing and decreasing the value of EMPI. It was detected that the raising effect of the increase in inflation rate on EMPI was higher and more persistent than the lowering effect of the increase in inflation rate on EMPI in the Czech Republic, Iceland, Poland and Russia. This finding highlighted that the increase in inflation rate had a considerable potential for speculative attack and financial crisis, but the decrease in inflation rate did not decrease the possibility of speculative and financial crises. Additionally, the results of the impulse-response analysis revealed that the increase in the long-term interest rate would increase the value of the EMPI in all 4 countries. Herein, it can be said that raising interest rates in these four countries with respect to the US will give rise to capital outflows to the country, which in turn will depreciate the nominal exchange rate and increase the value of the EMPI. Although the existence of the UIP condition is supported, the impulse response analysis shows that the decrease in long-term interest rate difference does not influence the value of the EMPI in the Czech Republic, Iceland, Poland, and Russia. Thus, it is stressed that the formation of the expectation of depreciation of the home currency is easier than the formation of the expectation of appreciation due to changes in long-term interest rates.

The FEVD analysis revealed that TED spread did not have a major impact on variations in the EMPI. These results can be interpreted as that the transmission effects of U.S. monetary conditions to the Czech Republic, Iceland, Poland, and Russia primarily operate via changes in FED's balance sheet size and bond interest rates, as confirmed by the important role played by long-term interest rate differences for the value of the EMPI relative to the TED spread. Additionally, IRFs demonstrated that the TED spread, which reflects the credit risk of the US economy and which has a transmission potential to the global economy, will create asymmetric effects on the EMPI in the Czech Republic, Iceland, Poland, and Russia. Given that the TED spread in the USA permits inferences about credit risks to be drawn in this country, it was suggested by the IRFs that high credit risk here would instigate capital outflows, especially from Poland. Consequently, it can be said that the size of the Polish economy and the level of financial development stimulated Poland's superior level of integration with the world economy relative to the Czech Republic, Iceland and Russia. More specifically, it can be inferred that Poland is more subject to global credit risk due to the country's economic and financial

linkages with the EU and the USA. For instance, the fact that Poland's foreign trade with Europe's three largest economies (Germany, France and Italy) was approximately 132 billion dollars by the end of 2016 according to the United Nations database supports the relevant inference of the study. The asymmetric effects were also valid for the TED variable; in other words, IRFs revealed that the reduction in credit risk in the USA provided the necessary environment for capital inflows to the Czech Republic, Poland, and Russia.

Herein, it should be noted that Russia is not a small emerging country like the Czech Republic, Iceland, and Poland, and Russia is heavily dependent on commodity prices. This makes the Russian economy vulnerable to the boom and bust cycles of global economy, while geopolitical risks can also trigger negative developments in the economy, as they did in 2015. In line with the approach of Kilian and Vigfusson (2011), the asymmetric effects on EMPIs were also evaluated via slope-based tests. Accordingly, similarly to IRFs based on the SVAR model, it was found that there can be asymmetric relationships between variables. Although it is generally revealed that the EMPI cannot be affected at the same rate by the improvement and deterioration of internal and external macroeconomic and financial conditions, the investigation of asymmetric impacts within enhanced quantitative models incorporating economic relations was highlighted as producing significant results for policy makers.

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