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THE SPILLOVERS OF U.S. MONETARY POLICY SHOCKS ON CESEE COUNTRIES: A GVAR ANALYSIS

Prelivanja šokova u monetarnoj politici SAD na CESEE zemlje – GVAR analiza

Abstract

This paper studies the effects of policy tightening by the Federal Reserve System (Fed) on Central, Eastern and Southeastern European (CESEE) countries. To this end, the Global Vector Autoregressive Model (GVAR) was estimated, capturing the interlinkages between the economies based on trade flows. The obtained results indicate that U.S. policy tightening can have non-negligible effects on the real activity and financial conditions in CESEE economies. While the short-term effects on relatively persistent inflation may be beneficial in some of these countries, the primary risk moving forward comes from the negative impacts on the real sector. These arise from the contraction in the U.S. and Eurozone economies, as well as spillovers leading to higher interest rates in CESEE countries. The negative effects are particularly pronounced in countries with a higher level of foreign currency liabilities.

Keywords: *international monetary spillover, GVAR, risk premium, monetary policy*

Sažetak

Ovaj rad analizira efekte zaoštravanja monetarne politike Sistema federalnih rezervi (Fed) na zemlje centralne, istočne i jugoistočne Evrope (CESEE). Za tu svrhu korišćen je Globalni vektorski autoregresivni model (GVAR) koji uzima u obzir i međusobnu povezanost ekonomija preko njihovih trgovinskih veza. Dobijeni rezultati ukazuju na to da zaoštravanje monetarne politike u SAD može imati osetne efekte na realnu ekonomsku aktivnost i finansijske uslove u zemljama CESEE. Dok bi efekti na trenutno prilično persistentnu inflaciju mogli biti povoljni u kratkom roku u nekim od posmatranih ekonomija, negativni efekti na realni sektor, do kojih dolazi usled smanjenja ekonomske aktivnosti u SAD i evrozoni i efekta prelivanja na rast kamatnih stopa u CESEE ekonomijama, predstavljaju primarni rizik u narednom periodu. Negativni efekti će biti izraženiji u finansijski osetljivijim zemljama, odnosno zemljama sa većim stepenom obaveza u inostranoj valuti.

Ključne reči: *međunarodni kanal transmisije monetarne politike, GVAR, premija rizika, monetarna politika*

Introduction

Over the past two and a half decades, the degree of trade and financial integration overall, and of emerging market economies (EM) in particular, has significantly increased. Higher integration of the global economy increased the potential that the impact of domestic shocks may spill over to other economies, especially if the shock originates in one of or several key advanced economies (AE). What is more, the deepening integration gave rise to views that financial conditions and growth worldwide may be driven by a global financial cycle, which in turn is largely driven by monetary policy conditions in the U.S., and Europe ([5], [28]). While the debate about the extent of monetary policy spillovers has a long history in international economics (being part of the Mundell-Fleming framework), changes in monetary policies in AE and volatile capital flows in and out of integrating emerging markets have brought the spillovers back to the forefront of the policy and academic debate in recent years.

The recently announced changes in the U.S. trade policy significantly increased the level of uncertainty on the global goods and financial markets. The uncertainty about the potential effects of the changes in the U.S. trade regime on the economy is associated with a less dovish policy stance from the Federal Reserve System over the last quarter of 2024 relative to what has been communicated earlier in the year. The inflationary pressures that may arise due to higher tariffs and trade barriers can lead to slower than expected U.S. monetary policy relaxation or even the need for increase in the policy rate. In both cases, the underlying policy shock would have the policy tightening character.

In this paper, we study the spillover effects of the U.S. monetary policy tightening on the key macro-financial indicators of the Central, Eastern and Southeastern Europe countries. The analysis can provide some guidance on the expected effects of potential changes in the policy stance in 2025, abstracting of course from the Lucas critique. The spillovers can arise through multiple channels discussed in the earlier literature (see e.g., [23], [15]) – impacting economic activity, inflation, risk premium, interest rates and exchange rates in small open markets.

We use the global vector autoregession (GVAR) framework to model the variables of interest. We collect quarterly data for key macro-financial variables (GDP, inflation, short-term interest rate, country risk premium, nominal exchange rate) for the U.S., Czech Republic, Hungary, Poland, Romania, Serbia and Turkey over the 2005 Q1 to 2023 Q4 period. We use the brent crude oil prices as the global (exogenous) variable in the system. To mitigate potential omitted drivers, we also collect data for the Eurozone and use it for both the construction of foreign variables in the GVAR system and in GVAR estimation, though we do not explicitly focus on the Eurozone results. The foreign variables are computed using total trade weights which include both export and import flows. The model is estimated using the standard set of cointegrating restrictions which correspond to long-term theoretical economic relationships. The reaction function of the CESEE countries' macro-financial conditions to the U.S. policy tightening shock was analyzed based on the Generalized Impulse Response Function (GIRF). The GVAR methodology, which explicitly takes into account interconnectedness between the economies based on the observed trade patterns, is well-suited for studying the problem of interest. Unlike traditional single equation or VAR models, which focus on a single economy in isolation, GVAR accounts for cross-country feedback effects, allowing a more comprehensive analysis of how policy innovations in one economy can reverberate across the global economic system. This is also in line with modern central banking practices which are increasingly taking into account developments in the international environment when making policy decisions.

The obtained results suggest that changes in U.S. trade policy in 2025, which could lead to explicit or implicit tightening of U.S. monetary policy, may have non-negligible effects on real activity and financial conditions in the CESEE economies. The estimated responses indicate that U.S. monetary policy tightening would spillover to an increase in local interest rates. In line with the previous empirical literature (see e.g., [1], [12], [14]), the estimated country responses display a certain degree of heterogeneity. The increase in local interest rates is more pronounced and persistent in Turkey, Serbia, and Romania, which is consistent with the estimated nominal exchange rate depreciation pressures and a rise in the country risk premium. Given the relatively higher share of foreign currency liabilities in these countries, there is a stronger incentive for monetary authorities to maintain higher interest rates to prevent capital outflows and mitigate the risk of currency depreciation.

Inflation dynamics in response to the U.S. monetary policy innovation also exhibit a heterogeneous pattern. Inflation slows down in Romania in the first year following the shock, but the effect is not persistent and becomes statistically insignificant after two years. In Hungary, Poland, and Turkey, prices do not respond significantly, while the shock has a negative and more persistent effect on inflation in the Czech Republic and Serbia. While the short-run effects on now relatively persistent inflation may be beneficial for some CESEE countries, the estimated negative effects on the real output represent the primary risk going forward. The expected increase in the risk premium and potential depreciation pressures may necessitate a monetary policy response and a tightening of domestic financial conditions could lead to additional, second-round negative effects on real output, discussed in [11].

The remainder of the paper is structured as follows: The next section outlines relevant literature. The following section sets the conceptual framework. The subsequent section presents the data and variable construction. The results and their discussion are provided before the concluding section.

Literature Review

This paper is related to a rapidly growing empirical literature that studies the global spillovers of policy innovations in advanced economies. The dominant position of the United States and Eurozone in global trade and finance implies significant potential for spillovers which can propagate through several channels, including exchange rates, capital flows, trade linkages, and financial markets. Theoretical framework for small open economies' responses to external monetary shocks is well established in the literature (see e.g., [23]). [15] show that in response to a rise in foreign interest rates in advanced economies, primary the U.S., small open economies typically experience higher domestic interest rates, a decline in foreign reserves (associated with central bank interventions), exchange rate depreciation, lower inflation, and reduced GDP growth.

One strand of the literature focuses on the identification of the transmission mechanisms through which the spillovers can occur. One of the key channels is the exchange rate, where policy actions, such as policy rate tightening in the AE can lead to currency depreciation in other economies, which in turn impacts trade flows and inflation through traditional competitiveness and pass-through channels (see [6]). The exchange rate changes are closely connected with changes in capital flows dynamics, where changes in interest rates or risk sentiment can induce significant, and often sudden, shifts in cross-border capital flows, affecting local asset prices and exchange rates. Furthermore, monetary policy changes in major economies can affect global demand conditions through trade linkages, leading to changes in output and inflation in trading partner countries (see e.g., [7]). The findings are empirically confirmed by [19], who document strong and heterogeneous spillover effects from U.S. interest rate hikes, leading to declining output growth, increased inflationary pressures, and exchange rate depreciation in emerging markets, particularly when accompanied by heightened policy uncertainty. [20] also show that increasing domestic interest rates as a response to monetary tightening in the US is consistent with the fact that tighter U.S. monetary policy leads to capital outflows from emerging markets, while a higher emerging market policy rate, concurrent with a higher federal funds rate, can reduce outflows. [3] emphasized the increasing importance of the financial channel in transmitting monetary policy spillovers, arguing that globalization has amplified all three channels, though their net effects remain an empirical question. Similarly, [22] provide evidence that monetary policy shifts in advanced economies generate uncertainty spillovers across financial markets, influencing business cycle fluctuations in emerging markets.

Another strand of the literature focuses on studying the heterogeneity in the spillover magnitude across the countries, which can be associated with the degree of financial and trade openness, exchange rate regimes, and overall structure of the economy. [1] demonstrate that spillovers are more pronounced in economies with higher trade openness and greater financial integration. [14] finds that U.S. monetary policy exerts significant output spillovers on other economies, sometimes exceeding its domestic effects. The extent of these spillovers depends on factors such as a country's trade and financial integration, de jure financial openness, exchange rate regime, financial market development, labor market flexibility, industry structure, and participation in global value chains. [12] analyze the effects of contractionary U.S. monetary policy on financial conditions, industrial production, and consumer prices in emerging markets, concluding that economies with greater vulnerabilities experience stronger responses to U.S. monetary shocks. Similarly, [16] highlights that the nature of the Federal Reserve's monetary policy response matters: spillovers tend to be larger when the Fed tightens policy to combat inflation rather than when it reacts to economic growth.

The challenges faced by monetary policymakers in economies with flexible exchange rates have gained increasing attention following the work of [8] and [28] (see also [30] for new era challenges). These studies analyze the trade-offs involved in international monetary transmission, particularly in economies where external debt is predominantly denominated in foreign currency. In such cases, a rise in the U.S. interest rate leads to domestic currency depreciation, which stimulates exports but also exacerbates balance sheet vulnerabilities by increasing the domestic-currency value of foreign-denominated debt. As a result, even economies with flexible exchange rates may experience constraints on their monetary autonomy, as central banks must balance the objectives of stabilizing economic activity and mitigating financial stability risks. This also gives rise to the importance of policy coordination. [15], among others, emphasize how coordinated global monetary policy actions can reduce adverse spillovers, particularly in times of economic crises.

The literature on spillovers to CESEE countries has expanded more recently as these economies have become increasingly integrated into the global financial system. Early studies, such as [21], studied the sensitivity of CESEE economies to external monetary policy shocks, emphasizing the role of global financial integration and capital markets. Not surprisingly, multiple studies, such as [27], finds strong spillovers of European Central Bank (ECB)'s monetary policy innovations on both, countries which were in the process of joining the Eurozone as well as those, such as the Czech Republic and Poland, which maintained independent exchange rate regime.

The empirical studies for CESEE countries generally confirm the earlier findings on the key transmission channels and cross-country heterogeneity in responses. [17] showed that the U.S. monetary policy shocks can have strong effect on the currencies of CESEE economies, particularly those with floating exchange rates. The fluctuations in exchange rates directly affect trade balances and inflation, with the pass-through effect often being more pronounced in economies with higher external trade exposure. Similarly, [2] show the importance of the capital flows channel, where changes in interest rates in advanced economies tend to impact the foreign direct investment (FDI) and portfolio investment flows to CESEE markets. [4] suggest that countries with higher financial integration and reliance on foreign capital, such as Hungary and the Baltic states, are more sensitive to spillovers from global monetary policy, particularly with respect to interest rate changes and asset price movements. On the other hand, countries with more independent monetary policies, such as the Czech Republic, are to some degree insulated from global monetary policy but still experience indirect effects through trade and investment channels.

The results from this paper contribute to empirical literature by providing one of the handful studies that include measures of country risk premium as one of the endogenous variables in the GVAR system, thereby capturing one of the main spillover transmission channels discussed in theoretical literature. In addition, by using the updated sample which included the most recent period of policy tightening across the globe, the results can be useful for approximating the expected effects of potential policy changes in 2025 and the required policy response in CESEE countries.

Methodology Framework

The GVAR methodology has gained significant attention since the work of [24], who investigated the spillover effects of aggregate supply and demand shocks in the United States on the global economy while accounting for the interconnectedness of various economies. The methodology was specifically designed to address the challenges associated with the high dimensionality of models that attempt to analyze the world economy, which comprises numerous individual countries. By incorporating both domestic and foreign economic variables, the GVAR provides a useful framework for studying potential spillovers of the policy changes in one economy on the other.

The GVAR methodology assumes that there are $N+1$ countries (regions) denoted by $i = 0,1,..., N$, where 0 denotes the reference country (in this paper, it will be the U.S.). Dynamics of macro-financial variables of interest are modeled through VARX model which includes local variables (country-specific variables), foreign variables specific to a particular country (country-specific foreign variables) as well as global variables which are weakly exogeneous to all countries in the system. Each country-specific foreign variable is created as a weighted average of that variable for all other countries in the sample, where the weight assigned to a country j corresponds to the share of trade between the countries i and j in the total trade of country i with all other countries in the model (see [24]).

In particular, the VARX*(1,1) model for country i (ignoring higher order lags) can be represented by the following expression:

$$x_{it} = a_{i0} + a_{i1}\, t + \Phi_i\, x_{i,t-1} + \Lambda_{i0}\, x^*_{i,t} + \Lambda_{i1}\, x^*_{i,t-1} + \Psi_i\, \theta_t + u_{i,t}\,,\ i=0,1,\dots N \text{ and } t=1,2,..T \qquad (1)$$

where: $x_{i,t}$ is the vector of dimensionality $k_i x1$ which contains domestic variables;

$x^*_{i,t}$ is the vector of dimensionality $k^*_i x1$ which contains foreign variables specific for country i;

$$x^*_{i,t} = \Sigma^N_{j=0}\, \omega_{ij}\, x_{jt} \qquad (2)$$

the weights ω_{ii} satisfy $\omega_{ii} = 0$, and $\Sigma^N_{j=0}\, \omega_{ij} = 1$;

θ_t is the vector of global variables;

and $u_{i,t}$ is the vector of dimensionality $k_i x1$ with shocks specific for every country i which are assumed to be serially uncorrelated with expected value of 0 and non-singular covariance matrix.

The equilibrium error correction representation of the VARX* (1,1) model can be written as:

$$\Delta x_{it} = c_{i0} - \alpha_i \beta'_i\, [z_{i,t-1} - \gamma_i\, (t-1)] + \Lambda_{i0}\, x^*_{i,t} + \Psi_i\, \Delta\theta_t + \Gamma_i\, \Delta z_{i,t-1} + u_{i,t} \qquad (3)$$

where $z_{i,t-1} = (x_{i,t} x^*_{i,t})'$, α_i is a $k_i \times r_i$ matrix of rank r_i,and β_i is a $(k_i + k^*_i) \times r_i$ matrix of rank r_i.

To estimate the cointegrating vector we impose several well-known theoretical restrictions discussed in more detail in the following section.

The conventional GVAR (see [24]) estimates each individual country model under the assumption of weak exogeneity of foreign and global variables, i.e., it is assumed that each economy except the reference country can be viewed as a small open economy whose impact on the global economy is negligible. The assumption is plausible in our case as we focus on the CESEE countries whose impact on the reference (the U.S.) economy is negligible. The maximum likelihood tests of the weak exogeneity of foreign variables hypothesis indicate that this assumption is indeed met in our sample. In addition, we include the data for Eurozone in the model to avoid heavily biasing trade weights for the construction of foreign variables and to allow for the indirect propagation of the U.S. shocks to CESEE countries via reaction of the Eurozone macro-financial conditions. Once the individual models are estimated, they are combined to obtain a solution of the global model. The obtained models are used to track the spillover of shocks in different variables through impulse response function analysis.

Following [10] and [24], the shock propagation is analyzed using the generalized impulse response function (GIRF). The generalized impulse responses are invariant with respect to the order of variables and countries in the GVAR model, which is of particular importance in the case of macroeconomic systems, since identifying the order of countries and variables can be challenging based on the theoretical restrictions. Namely, in the case of the GIRF, a shock is assumed in only one element, e.g., j-th element in u_t, corresponding to the l-th variable in the i-th country using the historical error distribution. The generalized impulse response function is given by the following expression:

$$GIz{:}\varepsilon_{il}\,(n,\sqrt{(\sigma_{ii,ll}}, I_{t-1}) =$$
$$E(z_{t+n}|\varepsilon_{ilt} = \sqrt{(\sigma_{ii,ll}}, I_{t-1}) - \mathrm{E}(z_{t+n}|I_{t-1}) \quad (4)$$

where $I_{t-1} = (z_t, z_{t-n}, \ldots)$ represents the model's information set at time *t-1*. Assuming that underlying structural shock ε_t has a multivariate normal distribution, the effect of a shock of one standard error at time *t* on the expected values of *z* at time *t* + *n* will be given by: $\psi_j(n) = \frac{1}{\sqrt{\sigma_{ii,ll,}}} F^n G^{-1} \Sigma s_j, \quad n = 0,1,2, \ldots N$

Data and Variables

We collect data for gross domestic product (GDP), inflation rate, short-term interest rate, dollar nominal exchange rate and Emerging market bond index (EMBI), a common proxy for the country risk premium, over the period from 2005 Q1 to 2023 Q4 for the USA, the Eurozone, the Czech Republic, Hungary, Poland, Romania, Serbia and Turkey. The selection of CESEE countries is based on data availability of a consistent series of EMBI indices as well as on the prevailing exchange rate regime.

Data for GDP and inflation is collected from Eurostat, while three-month interbank interest rates, foreign exchange rates, EMBI and Brent crude oil price are collected from Bloomberg.

Vector x_{it} contains the following domestic variables that are included in the model: y_{it} (gross domestic product), $\Delta p_{i,t}$ (inflation rate), r^S_{it} (short term interest rate), $embi_{it}$ (EMBI risk premium), e_{it} (nominal exchange rate vs dollar).

In a general case, when, for country *i* data is available for all abovementioned variables, vector $x_{it} = (y_{it}, \Delta p_{i,t}, r^S_{it}, embi_{it}, e_{it})$ represents the vector of domestic variables, while vector $x^*_{it} = (y^*_{it}, \Delta p^*_{i,t}, r^{S*}_{it}, embi^*_{it}, e^*_{it})$ represents the foreign variables vector specific for country *i*.

The variables are defined in the following way:

y_{it} – the logarithm of real GDP: $y_{it} = \ln\left(\frac{GDP_{i,t,2010=100}}{GDPdeflator_{i,t,2010=100}}\right)$

$\Delta p_{i,t}$ inflation rate: $\Delta p_{i,t} = p_{i,t} - p_{i,t-1}$, where $p_{i,t} = \ln(CPI_{i,t})$

r^S_{it} short term interest rates – the three month interbank interest rate transformed in line with [24]: $r^S_{it} = 0{,}25\ln\left(1 + \frac{R^S_{i,t,}}{100}\right)$ where R^S_{it} stands for annualized short term interest rates.

$embi_{it}$ the logarithm of EMBI index: $embi_{it} = \ln(EMBI_{i,t})$

$e_{it} = \ln(E_{i,t})$ – the logarithm of nominal exchange rate with respect to dollar, defined such that increase in the nominal exchange rate implies stands its appreciation:

After defining domestic variables, the next step is to define the foreign variables specific to each country using weights that reflect trade relations. Corresponding foreign variables that relate to each individual country $x^*_{it} = (y^*_{it}, p^*_{i,t}, r^{S*}_{it}, embi^*_{it}, e^*_{it})$ are calculated using the generic formula:

$$x^*_{it} = \sum_{j=0}^{N} \omega_{i,j} x_{i,t}$$

The weights used in calculation of foreign variables, $\omega_{i,j}$ are defined as the share of country j in the total trade (imports + exports) of country i. The own weight, $\omega_{ii} = 0$ and the weights sum to 1. When calculating the weights, positive weights were assigned only to those countries for which there is available data for a specific variable, so that the weights always add up to 1. For example, since the variable $embi_{it}$ does not exist for the Czech Republic, while it does exist for example for Serbia, when calculating $embi^*_{it}$ for Serbia, the Czech Republic was assigned a weight of 0, while when calculating the variable e^*_{it} for Serbia, the Czech Republic, for which data on the nominal exchange rate exists, was assigned a weight corresponding to the sum of imports and exports from Serbia to the Czech Republic in relation to total imports and exports of Serbia. The weights are calculated based on data on total trade between the countries in the sample. Imports and exports data are taken from the World Integrated Trade Solutions portal and cover the full sample period from 2005 to 2023. In the case of the reference economy, i.e., the United States, the domestic variable $e_{it} = 0$, since this variable will be defined through foreign variables, as the weighted average of the exchange rates of other countries against the dollar.

Empirical Model Results

This section presents the results of empirical analysis. We first focus on preliminary steps in estimation and then present the estimates of the main results.

The preliminary steps include testing the order of integration of model variables, determination of the VARX*(p,q) order and testing of the number of cointegrating vector restrictions. Reduced rank estimator of the GVAR models is based on the assumption that all endogenous and exogenous variables included in the model have exactly one unit root (see [24]). This implies testing the order of integration of the included variables as the first step in the analysis. We used the standard ADF test, as well as the WS test, which is based on weighted symmetric estimates of the ADF type (see [29]). The Schwartz Bayesian (SBC) criterion was used in determining the number of terms to include in both tests. The macro-financial variables we study are typically found to be integrated of order 1 (I(1)) in the literature, which is also indicated by the majority of the results of the unit root tests we run. The results of the unit root tests (Table 1) indicate that at the 5% significance level, we can conclude that all variables have exactly one unit root, except for the inflation variable, which is found to be stationary.

The VARX*(p,q) order, i.e., the number of lagged domestic (p) and foreign variables (q) included in the model, is determined using the Akaike information criteria. In determining which foreign variables are included in the individual country specification, we follow the approach outlined in [24] which looks at the country's position in the global economy. In the equation for the U.S., therefore, the CESEE interest rates were excluded from the set of foreign variables. On the other hand, in equations for CESEE countries all foreign variables are included. Oil prices as a global variable are included in all country specifications. Finally, the selection of deterministic components included in each country's equation is based on the results of the maximum likelihood test as in [29]. Details of the procedure are described in Section A.10 of [29].

The GVAR methodology allows for introduction of the long-run relationships that are consistent with economic theory with the goal of providing additional theoretical underpinnings to the otherwise fully reduced-form model (see e.g. [29]). In addition, [26] have shown that individual VARX* models can be derived as a solution to a DSGE model, where the long-run relationships of the overidentified equations can be tested and, if valid, introduced as constraints. In line with the literature and variables included in the empirical model, which are: $x_{it} = (y_{it}, \Delta p_{i,t}, r^S_{it}, embi_{it}, e_{it})$ $x^*_{it} = (y^*_{it}, \Delta p^*_{i,t}, r^{S*}_{it}, embi^*_{it}, e^*_{it})$, we test the following theoretical relationships:

Fisher's equation, i.e., the stationarity of the real interest rate:

$$r^S_{it} - \Delta p_{i,t} \sim I(0)$$

Uncovered interest rate parity:

$$r^S_{it} - r^{S*}_{it} \sim I(0)$$

Stationarity of the real exchange rate:

$$e_{it} - \Delta p_{i,t} + \Delta p^*_{i,t} \sim I(0)$$

Table 1: Unit root test results

Domestic Variables	Critical Value	USA	EURO	ROMANIA	CZECH	HUNGARY	POLAND	SERBIA	TURKEY
interest rate (with trend)	-3.45	-1.258	-1.933	-1.507	-1.586	0.290	-2.775	-5.537	-2.966
interest rate (no trend)	-2.89	-1.939	-2.000	-1.710	-1.882	-1.013	-2.389	-1.191	-2.946
interest rate (first difference)	-2.89	**-2.896**	-3.443	-5.012	-3.402	-3.143	-4.344	-6.136	-4.604
foreign exchange rate (with trend)	-3.45		**-3.962**	**-4.229**	-2.748	**-4.024**	**-4.681**	-3.305	0.007
foreign exchange rate (no trend)	-2.89		-1.370	-0.594	-1.939	-0.082	-1.022	-0.972	3.273
foreign exchange (first difference)	-2.89		**-6.307**	**-6.804**	**-6.765**	**-6.870**	-6.962	-6.414	-6.495
embi (with trend)	-3.45					-2.791	-3.127	-3.548	-3.567
embi (no trend)	-2.89					-2.747	-2.690	-2.900	-2.298
embi (first difference	-2.89					**-6.270**	-6.120	-7.191	-6.639
gdp (with trend)	-3.45	-2.254	-2.692	-2.592	-2.570	-1.560	-2.942	-1.746	-2.381
gdp (no trend)	-2.89	0.280	-1.046	-0.940	-1.246	0.175	-1.056	-0.682	-0.178
gdp (first difference	-2.89	**-7.059**	**-7.150**	**-6.874**	**-6.225**	**-6.710**	-5.829	-6.330	-6.503
inflation (with trend)	-3.45	**-7.381**	-3.452	**-3.720**	**-5.564**	-0.583	-1.461	**-4.434**	**-4.404**
inflation (no trend)	-2.89	**-7.381**	**-3.300**	**-3.805**	**-5.287**	-0.580	-1.113	**-4.297**	**-3.595**
inflation (first difference	-2.89	**-12.09**	**-8.478**	**-9.875**	**-9.557**	**-8.619**	-9.965	-7.649	-8.138

Source: Authors' calculations

Note: The table reports the results of the ADF test for the presence of unit root. The values in bold imply that the null hypothesis is rejected at the 5% significance level.

Long-term constraints were introduced into individual VARX* models and the results from the maximum likelihood test justify the validity of the introduced cointegrating vector restrictions. Given the importance that the introduction of long-term constraints may have on the model estimates, we complement the results from the statistical tests with the analysis of the persistence profiles.

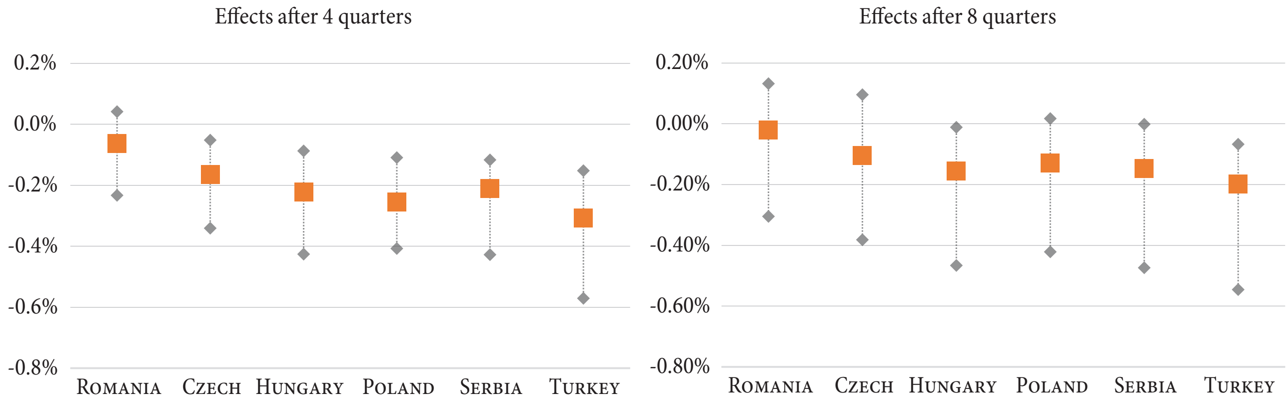
The persistence profile shows the speed at which long-term relationships converge towards an equilibrium state following the shock. The persistence profiles (PP) were introduced by [25] with the aim of studying the effects of systemic shocks on the dynamics of long-run relationships. PPs refer to the time profiles of the effects of systemic shocks or shocks specific to certain variables related to cointegration relationships and provide visual evidence regarding the empirical validity of long-run relationships. At the moment of the shock, PP has a value of 1 and should converge to a value of 0 as time approaches infinity (see [25]). If the rate of convergence to the cointegration relationships turns out to be very slow, then this is an important indicator that the given cointegration vector is incorrectly specified, which may be a consequence of the fact that the number of cointegration vectors is not well specified or if long-term identification restrictions are imposed that are not supported by the data. See [25] for a discussion of PP in cointegration VAR models and [10] for the implementation of PPs in GVAR.

In Figure A1 in the Appendix, it can be seen that all persistence profiles display a trajectory aligned with stable behavior, i.e. after the shock, they tend to converge towards a zero value. In contrast, the persistence profiles of the basic model which does not include any restrictions display non-converging behavior (Figure A2). The results from both statistical tests and persistence profiles analysis indicate that the introduction of the long-run restrictions is supported by the data and contributed to achieving model stability.

Next, we present the estimates of the generalized impulse responses. For each country/variable pair, we focus on the relatively moderate-run responses corresponding to the first eight quarters (two years) following the shock. This aligns with our goal of understanding the short and mid-term effects of policy tightening shocks. To keep the number of figures manageable and for easy comparability, we display the cumulative response of all country-level variables after one (left panel) and two years (right panel) rather than displaying all quarterly responses for each country/variable pair in the separate figures. Figures 1-5 display the responses of CESEE macro-financial variables to one standard deviation innovation in U.S. federal funds rate, which corresponds to approximately fifty basis points. In each figure, the square denotes the estimated response of the given variables, while the upper and lower diamond indicate the width of the 90% bootstrap confidence band.

Figure 1 displays the response of output in SEE countries to one standard deviation policy tightening shock by the Fed. The results imply statistically significant effect on the real activity across the CESEE countries after one year, except Romania for which the response is not statistically significant. The shock has a stronger effect

Figure 1: The response of output to the U.S. policy shock



Source: Authors' calculations

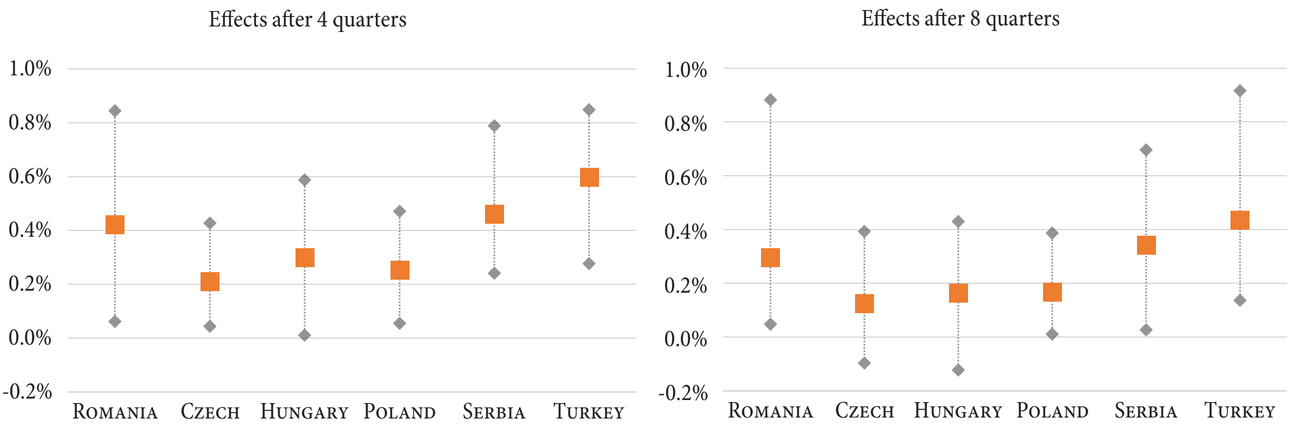
Note: The figure reports the response of output after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line.

after one year and the impact tends to die out slowly over the subsequent year. In line with the earlier literature, we observe a certain degree of heterogeneity in responses which tends to be stronger in the case of Turkey and Poland initially, and Turkey, Hungary and Serbia after two years, relative to other economies. Nevertheless, the same obtained sign of the country responses exhibit is in line with [18] who emphasized the similarity in the business cycles dynamics in Serbia and neighboring countries.

The impulse response functions presented in Figure 2 indicate that the U.S. monetary policy tightening would spillover to increase in local interest rates in the short run, as all responses are statistically significant. The effect is again the strongest for Turkey, followed by Romania and Serbia, countries with a relatively higher share of foreign currency liabilities. In such economies, there may be stronger pressure on the monetary policy authorities to keep interest rates at a higher level in order to prevent capital outflows and potential effects on currency depreciation. The obtained results are broadly in line with studies conducted in the earlier period [9] and [13] who observed the existence of a transmission mechanism in short-term interest rates, i.e. that the increase in the Fed interest rate by 1 s.e. (around 0.4%) is accompanied by an increase in the short-term interest rates of other CESEE countries.

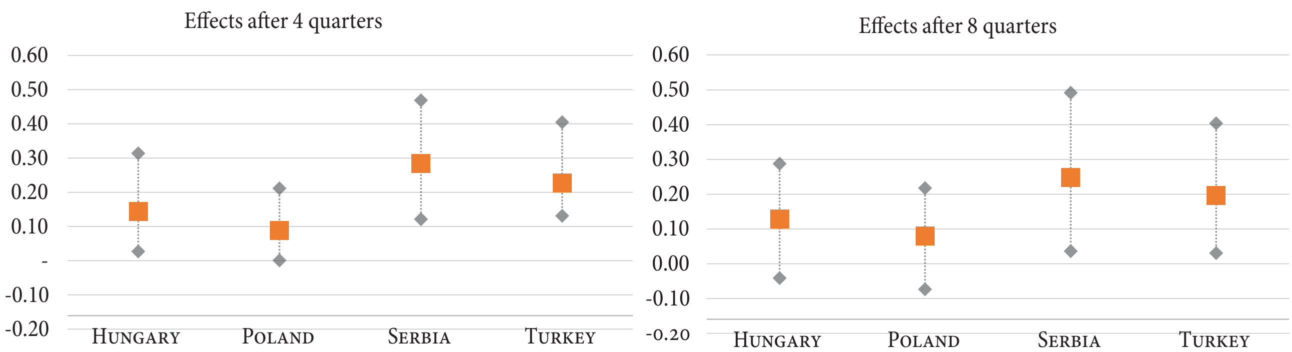
The estimated response of domestic interest rates is in line with the estimated responses of country risk premium, measured by EMBI index for countries with sufficient data availability (Figure 3). The EMBI index increases over the first four quarters for Turkey, Serbia, and to some extent Hungary and begins a slow reversion to the pre-shock level in the second year, while remaining elevated relative to the pre-shock level. The estimated spike in risk premium in turn is aligned with an observed response in domestic interest rates which serves to mitigate potential capital outflows.

Figure 2: The response of short-term interest rates to the U.S. policy shock



Source: Authors' calculations
Note: The figure reports the response of short-term interest rates after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line.

Figure 3: The response of EMBI index to the U.S. policy shock



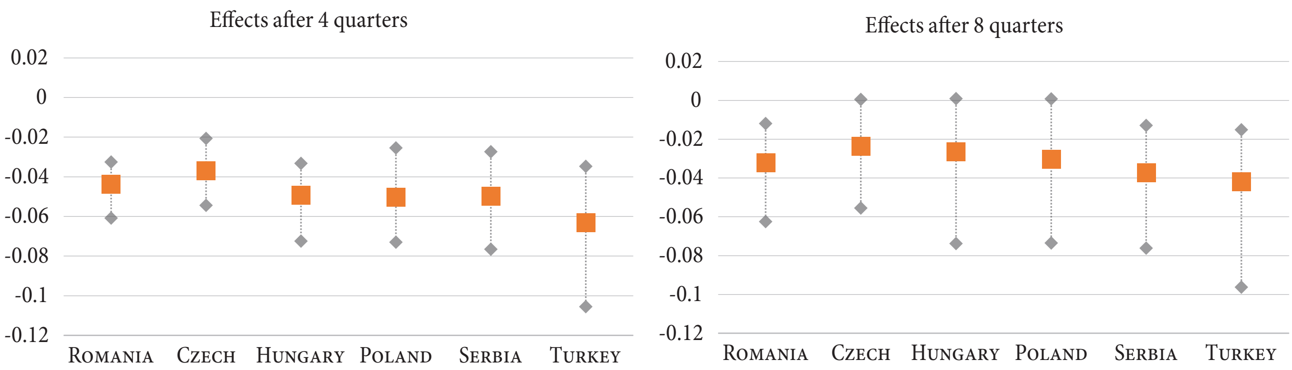
Source: Authors' calculations
Note: The figure reports the response of EMBI index after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line.

In line with elevated risk-premium pressures and potential rebalancing of global investors' portfolios, i.e., the withdrawal of capital from riskier markets and investments in US securities, which offer a better risk-adjusted return, all CESEE countries exhibit a depreciation of the local currency against the dollar in the first year following the shock (Figure 4). The Turkish lira displays the strongest depreciation over the first year, with slight gains in the second year following the shock. In contrast, the shock effects are not persistent for currencies of CEE countries, which tend to revert to pre-shock levels as the estimated responses in the second year are not statistically significant.

Inflation dynamics in response to the shock exhibit a more heterogeneous pattern (Figure 5). Inflation slows down in Romania in the first year following the shock, and the effect is not persistent and becomes statistically insignificant after two years. Prices do not respond in a statistically significant manner in Hungary, Poland, and Turkey. The lack of response in the latter is likely driven by strong domestic inflationary pressures which lead to the fact that changes in the global financial environment have a limited direct effect on the inflation path. The shock has negative and more persistent effect on inflation in the Czech Republic and Serbia. The results for the former are likely to reflect stronger ties with the Eurozone economies, which also exhibit a drop in inflation following the U.S. monetary policy tightening and lead to inflation spillovers. The results for Serbia are likely to reflect relatively stronger tightening of the domestic monetary policy that we see in the interest rate responses and smaller level of the pass-through of the depreciation in the dollar foreign exchange rate relative to the movements in the exchange rate versus euro.

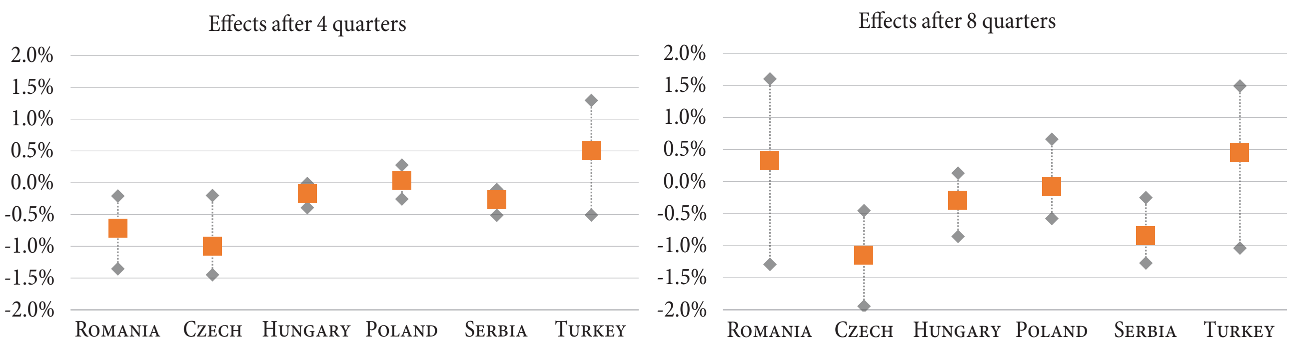
Overall, the results are indicative of the fact that changes in the U.S. trade policy in 2025 which may give rise to explicit or implicit tightening in the U.S. monetary policy may have non-negligible effects on the real activity

Figure 4: The response of the dollar foreign exchange rate to the U.S. policy shock



Source: Authors' calculations
Note: The figure reports the response of dollar foreign exchange rate after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line

Figure 5: The response of inflation rate to the U.S. policy shock



Source: Authors' calculations
Note: The figure reports the response of inflation rate after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line.

and financial conditions in the CESEE economies. While the effects on now relatively persistent inflation may be beneficial in the short run in some of these countries, the negative effects on the real sector present the primary risk going forward. The expected increase in the risk premium and potential depreciation pressures may require a monetary policy response and tightening of domestic financial conditions which in turn can lead to second round negative effects on the real output.

The results presented should be analyzed taking into consideration two caveats. First, the empirical model does not explicitly take into account foreign exchange market interventions which may affect the propagation of the shock to some of the observed variables. This is because, for all countries in the sample (except Serbia), consistent data on foreign exchange market interventions was not available. The interventions are thus implicitly contained in the results through the movement of the exchange rate variables, which may, to some extent, drive the obtained exchange rate responses. Introducing foreign exchange market interventions as a separate variable in the model is the basis for future research on this topic. Second, the estimation period included the zero lower bound period in the U.S., as well as the period of unconventional monetary policy measures in the U.S., Eurozone and some of the CESEE countries. We control for this by including additional country-specific dummy variables for the identified periods of active unconventional policy measures. The obtained results with modified empirical specification are qualitatively similar to the ones presented in the paper, providing some robustness against model misspecification. However, more explicit control for the effects of unconventional monetary policy measures warrants further research.

Concluding Remarks

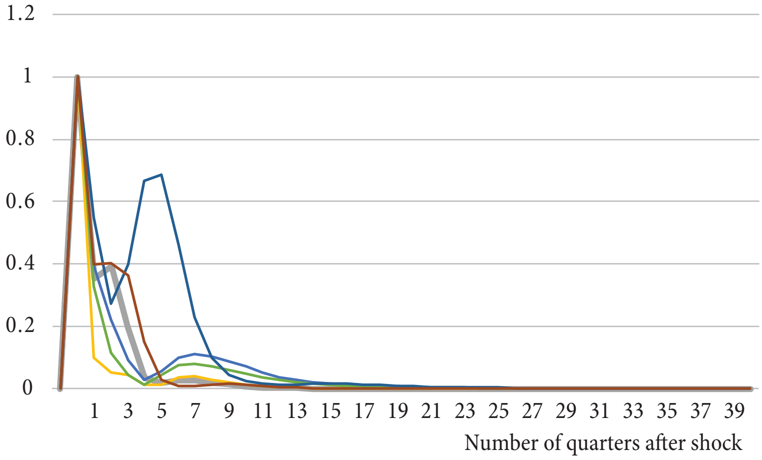
The deepening integration of the CESEE countries into the global trade and financial system led to potentially increasing exposure of these economies to global monetary policy spillovers. In this paper, we analyzed the extent to which monetary policy tightening by the Fed tends to spillover to the real sector and financial markets in the CESEE economies. We used the GVAR modelling framework to explicitly control for the interconnectedness between the economies in relation to their trade flows and enable that the propagation of the monetary policy shocks in the U.S. can realize through multiple channels discussed in the previous theoretical literature. We explicitly added the country risk premium as an endogenous variable in the system to control for the effects that policy tightening in the United States may have on the capital markets of CESEE countries (capital outflows) and, consequently, on the interest rate and exchange rate movements in these countries.

The results indicate that changes in U.S. trade policy in 2025, which may lead to explicit or implicit tightening in the U.S. monetary policy, could have non-negligible effects on real activity and financial conditions in the CESEE economies. The estimated responses suggest that the U.S. monetary policy tightening would spillover to increase in local interest rates. The increase in local rates is more pronounced and persistent in Turkey, Serbia, and Romania, consistent with the relatively larger share of foreign currency liabilities in these economies and correspondingly estimated nominal exchange rate depreciation and a rise in country risk premium. Inflation dynamics in response to the U.S. monetary policy innovation also exhibit a heterogeneous pattern. Inflation slows down in Romania in the first year following the shock, but the effect is not persistent and becomes statistically insignificant after two years. Prices do not respond in a statistically significant manner in Hungary, Poland and Turkey, while the shock has a negative and more persistent effect on inflation in the Czech Republic and Serbia.

The estimated negative effect on real output in all CESEE economies, however, represents a primary risk going forward. Moreover, the estimated increase in the risk premium and potential depreciation pressures may necessitate a monetary policy response and tightening of domestic financial conditions can have additional, second-round negative effects on real output.

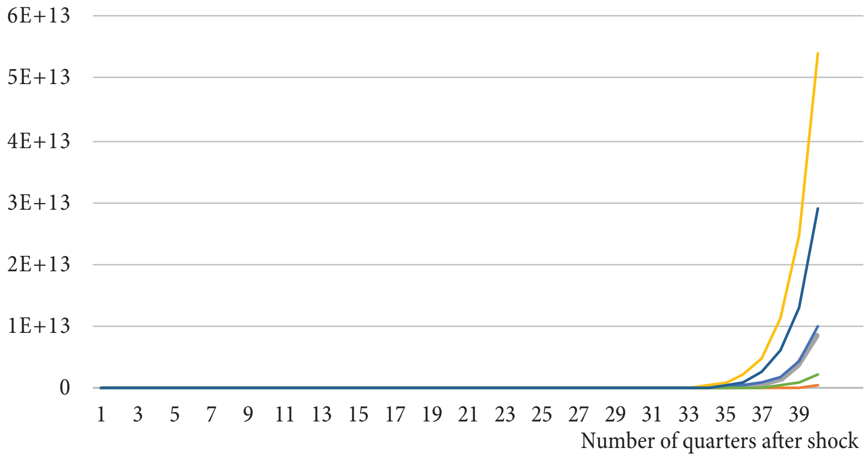
Appendix

Figure A1: Persistence profiles: Model with overidentifying long-run restrictions



Source: Authors' calculations
Note: The figure reports the persistence profiles of the response of cointegrating relationships to the system wide shock in a model with overidentifying long-run restrictions.

Figure A2: Persistence profiles: Unrestricted model



Source: Authors' calculations
Note: The figure reports the persistence profiles of the response of cointegrating relationships to the system wide shock in an unrestricted model.

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