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FED vs. ECB: Which matters most for Visegrad economies? Evidence from a Bayesian VAR model

Monika Junicke, Vincenzo Merella

Monika Junicke (*corresponding author*, email: monika.junicke@vse.cz), International Research Centre, Prague University of Economics and Business, Prague, Czech Republic

Vincenzo Merella (emails: vincenzo.merella@vse.cz, merella@unica.it), International Research Centre, Prague University of Economics and Business, Prague, Czech Republic; Department of Economics and Business Sciences, University of Cagliari, Cagliari, Italy

Abstract

This paper employs a VAR model with economically meaningful structural restrictions to examine how monetary policy shocks originating from the FED and the ECB influence macroeconomic variables in Central European economies, specifically the Visegrad Group (V4). We investigate whether US monetary policy shocks impact the V4 independently or primarily through Germany. Our results indicate that US monetary policy shocks significantly affect V4 macroeconomic variables, at times equalling or surpassing the influence exerted by their European counterparts, even after accounting for indirect effects transmitted through Germany. Additionally, our findings highlight the dominance of the income absorption effect, leading to output contractions in these small open economies.

Keywords: Monetary policy, Federal Reserve System, European Central Bank, Visegrad Group, structural restrictions, monetary policy shocks

JEL Classification: E52, F41, P24

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1. Introduction

There is considerable empirical evidence suggesting that monetary policy shocks originating from large economies have a significant impact on key economic indicators in small open economies (SOEs). Historically, research has predominantly focused on the effects of monetary policy in major economies such as the US and Germany, recognising their extensive trade and financial linkages worldwide. For instance, Canova (2005) highlights the substantial influence of US Federal Reserve (FED) monetary shocks on Latin American economies, while Mackowiak (2007) identifies similar effects on emerging markets in Southeast Asia and Latin America, illustrating the global reach of FED monetary policy.

Central European economies, particularly those within the Visegrad Group (V4) comprising the Czech Republic, Hungary, Poland, and the Slovak Republic, provide an interesting context for further exploration of this phenomenon. Traditionally, Germany has been considered the main economic influencer within this region, given its dominant role as a trading partner for the V4 countries. Previous studies, such as Anzuini and Levy (2007) and Mackowiak (2006), support this perspective by demonstrating that German Bundesbank and (later) European Central Bank (ECB) monetary policy shocks significantly influence macroeconomic outcomes in the V4 countries.

However, recent literature emphasizes the need to broaden this view by considering the direct and indirect influences of FED monetary policy. Ilzetzki and Jin (2021) illustrate how US economic shocks propagate globally, suggesting evolving dynamics that may directly affect SOEs, such as those in the V4 group. Furthermore, Han (2023) expands this understanding by detailing the impact of FED monetary policy on emerging markets, specifically through channels such as foreign direct investment and trade credit. Based on these considerations, we investigate whether the effect of a FED monetary policy shock on V4 countries is quantitatively comparable to the one generated by the ECB.

Germany is the main trading partner of the V4 countries, accounting for almost one-third of their exports. This relationship is quantitatively asymmetric, characterising the V4 as SOEs relative to Germany. Likewise, Germany can be considered an SOE relative to the US, since the US is an important export partner for Germany, accounting for a 7% share, but not vice versa. Our goal is to assess the extent to which movements in key macroeconomic variables in the V4 countries are driven by FED monetary policy shocks or their ECB counterparts, and how much of the former might be due to changes in German aggregate demand in response to the US shocks. We show that ECB shocks are not necessarily the main source of V4 variations: even after controlling for the impact of FED shocks on V4 countries through

Germany, the magnitudes of the effects of shocks originating from the two monetary institutions on V4 variables are at least comparable.

To examine whether ECB or FED monetary policy shocks most significantly influence V4 macro variables, we construct three different estimations. The first two exercises align with the existing literature and estimate the influence of either an ECB or a FED monetary policy shock on a set of key V4 economic indicators. These estimations suggest that FED and ECB shocks impact the V4 macro variables heterogeneously, yet their economic significance is remarkably similar. However, one may argue that the impact of FED monetary policy could be generated, at least partially, by the effect that the FED shock exercises on German economic indicators, which in turn would have a significant impact on the V4 variables via their strong economic linkages. The third estimation controls for such a potential indirect channel by simultaneously considering two large economies, Germany and the US, where it is assumed that Germany is open towards the US but closed towards the V4 economies. The objective is to investigate how much of a monetary policy shock generated by the FED is merely absorbed by Germany and how much is instead directly transmitted to the V4. As a result, one may expect that the effect of the FED shock is significantly weaker than the one generated by the ECB. But the estimation suggests otherwise: even if we control for the US impact through Germany, the magnitudes of the two effects on the V4 variables are comparable.

A vast literature analyses exogenous disturbances generated at home or abroad and their impact on other macroeconomic variables. Several studies, including Uhlig (2005) and Canova and Gambetti (2003), investigate FED monetary policy shocks and their impact on US macroeconomic variables. Similarly, Kim (1999) studies the effects of domestic shocks in individual G7 countries, and Kim (2001a) investigates their influence on the trade balance in other European countries such as France, the UK, and Italy, using German and US interest rates as proxies for a worldwide short-term interest rate. Kim (2001b) analyses the effect of the FED's monetary policy on the exchange rate and foreign trade balances of other G6 countries. He shows that an expansionary monetary policy shock generates positive spillover effects.

Methodologically, Structural Vector Autoregressions (SVARs) remain central to this field because of their flexibility and robust identification strategies. Kilian and Lütkepohl (2017) provide a comprehensive analysis of SVAR methodologies, outlining both their theoretical foundations and their empirical implementations. Sign restrictions in SVARs, critically evaluated by Fry and Pagan (2011) and further refined by Baumeister and Hamilton (2015), have become a valuable tool for accurately identifying and interpreting monetary policy shocks. Furthermore, recent advances in Bayesian VAR modelling, detailed by Banbura, Giannone, and Reichlin (2010) and expanded upon by Carriero, Clark, and Marcellino (2015), allow researchers to effectively manage large datasets while maintaining model accuracy and predictive reliability.

Our study contributes to the literature by employing a Bayesian VAR with economically interpretable structural restrictions and zero restrictions on lags, explicitly addressing whether FED monetary policy shocks significantly influence the V4 economies, independently or through Germany. In doing so, we clarify not only the relative importance of FED and ECB monetary policy shocks but also the underlying transmission mechanisms affecting these economies. In this paper, the long-term zero restrictions for SOE are based on findings from Cushman and Zha (1995), Kim and Roubini (2000), and Kim (1999). Sign restrictions are implemented similarly to Canova (2005) and Scholl and Uhlig (2005), employing the algorithm proposed by Rubio-Ramirez, Waggoner, and Zha (2010). Finally, we impose the prior in our model using artificial observations, following the work of Banbura, Giannone, and Reichlin (2010).

The structure of this paper is as follows. Section 2 gives more details about the model adopted for the estimations. Section 3 describes the structural analysis for each country, including the description of the data and the results (impulse response functions, forecast error variance decomposition, and historical decomposition). Finally, Section 4 concludes.

2. Methodology

To estimate the impact of foreign monetary policy on the V4 economic variables, we use the structural vector autoregressive model (SVAR)

$$Y_t = BX_t + \boldsymbol{D_t} + A\boldsymbol{e_t} \tag{1}$$

where D_t is a set of dummy variables indicating the EU membership status and the exchange rate regime of the V4 country under consideration.[1] The orthogonal white noise vector D_t abides by the relationship $\epsilon_t = A\boldsymbol{e_t}$, with an identity variance-covariance matrix given by:

$$E[e_t e_s'] = I_m \text{ if } t = s;\ E[e_t e_s'] = 0 \text{ if } t = s \tag{2}$$

1 Specifically, $\boldsymbol{D_t}$ is a 1 × 2 vector. The first element takes the value 1 in $\boldsymbol{t}$ if the V4 country is an EU member; the second if the country's exchange rate regime is under commitment or, in the case of the Slovak Republic, when it is part of the Eurozone.

We orthogonalise the shocks by using restrictions derived from an economic interpretation of the model, following Canova (2007). It follows that:

$$E[Ae_t e_t' A'] = AA' = \Sigma \tag{3}$$

In the contemporaneous period, the sign restrictions are implemented in such a way that the model is consistent with economic theory, mainly to avoid a misspecification of the monetary policy shock that, if positive, should lead to a contemporaneous increase in interest rate and a contemporaneous fall in output and inflation. In this respect, we follow an algorithm provided by Ramirez *et al.* (2010) to compute a structural impact matrix $\widetilde{\mathbf{A}}$; so, we can write:

$$\Sigma = AQQ'A';\ \Sigma = \widetilde{\mathbf{A}}\widetilde{\mathbf{A}}' \tag{4}$$

Matrix $\widetilde{\mathbf{A}}$ must satisfy the sign restrictions set out below and $\epsilon_t = \widetilde{\mathbf{A}}\boldsymbol{e_t}$ must still hold. Furthermore, we impose contemporaneous zero-value restrictions to ensure that the SOE does not contemporaneously influence the large economy. The dots correspond to freely estimated parameters.[2] The identification schemes are outlined in Appendix B.

In addition to contemporaneous restrictions, we impose restrictions on lagged variables. Note that the model can be divided into two parts: an $m_1 \times 1$ vector of the foreign large economy variables (Y_t^*), and a complementary $(m - m_1) \times 1$ vector of domestic SOE variables (Y_t^{V4}).

$$Y_t = \begin{pmatrix} Y_t^* \\ Y_t^{V4} \end{pmatrix}, \epsilon_t = \begin{pmatrix} \epsilon_t^* \\ \epsilon_t^{V4} \end{pmatrix} \tag{5}$$

Therefore, matrix $\boldsymbol{B}(j), j = 1, \dots, p$, can be rewritten as:

$$\boldsymbol{B}(j) = \begin{pmatrix} B_{11}(j) & B_{12}(j) \\ B_{21}(j) & B_{22}(j) \end{pmatrix} \tag{6}$$

Following Cushman and Zha (1995), we impose zero restrictions on the prior beliefs in matrix $\boldsymbol{B}_{12}(j)$, whose $(m - m_1) \times m_1$ coefficients govern the impact of domestic SOE variables on the variables in the large economy.

In the whole system, only the foreign monetary policy shock is of our interest. Impulse-response functions, forecast error variance decompositions (FEVDs), and historical decompositions are calculated through matrix $\widetilde{\mathbf{A}}$, which is estimated using the Bayesian method with Gibbs sampling. It is worth mentioning that matrix $\widetilde{\mathbf{A}}$ is not unique. That is, it is possible to find different matrices that satisfy the sign restrictions. We deal with this

2 For a critical survey on contemporaneous restrictions, see Fry and Pagan (2011).

issue by drawing many matrices and choosing the one closest to the median. We then use the selected matrix $\widetilde{\mathbf{A}}$ in our analysis.

We incorporate a prior belief with zero restrictions, and thus, we opt for an independent normal inverse Wishart prior. Technically, we impose this prior by following Banbura *et al.* (2008) and incorporating additional artificial data. For more details about the priors, we refer to Appendix C. To carry out the Bayesian inference, we use a Gibbs sampling procedure, which is a posterior Markov chain Monte Carlo (MCMC) simulation mechanism. We iterate the Gibbs algorithm 500,000 times to produce draws for B and Σ. Each iteration requires sampling from the conditional posterior distribution, which, after the burn-in draws are discarded (specifically, the first 95% iterations), converges to the marginal distribution. Samples from the beginning of the chain are discarded to remove the influence of starting values. Once draws from the posterior distribution are obtained, we implement a structural analysis to ensure that the sign restrictions hold.

3. Empirical Analysis and Results

As representatives of the SOE, we select the four Visegrad countries, namely the Czech Republic, Hungary, Poland, and the Slovak Republic. These countries have similar characteristics and development paths following the collapse of their Soviet-imposed regimes. They all initially experienced rapid GDP growth and, over the last three decades, developed from being classified as emerging markets to fully industrialised parts of the European Union. We use a small-scale model with three domestic variables for each country, namely GDP growth, CPI inflation, and the exchange rate between the currencies of the large economy (euro or US dollar) and the relevant V4 country (Czech Koruna, Hungarian Forint, Polish Zloty, or Slovak Koruna).[3] The time series are quarterly, seasonally adjusted, and expressed in the year-on-year first difference of the logarithm values. The data are sourced from Macrobond and the FRED database, as described in Appendix A. Given the quarterly data, both the Akaike and Swarz criteria confirm that the two-lag VAR estimation fits best.

3 The Slovak Republic joined the Eurozone in January 2009. We exploit this fact by letting the Slovak Koruna be a separate currency, pegged to the euro since then. With the use of a dedicated dummy variable, our modelling choice counterfactually shows what would happen if the Slovak Republic kept its monetary sovereignty, allowing for an impulse response comparison with the other V4 currencies (see Figures 1-3 below). Analogously, a dummy variable is also used for the Czech Republic's exchange rate commitment from November 2013 to April 2017.

Regressions are conducted separately for each country over the period 1996-2019 in combination with either US or German variables, or both.[4] More precisely, we run three groups of estimations. First, we estimate the impact of an ECB monetary shock on SOE macroeconomic variables. This estimation is parallel to that of Mackowiak (2006), who claims that since Germany is by far the most important trade partner for all the countries included in the estimation (with export shares ranging from 25% to 30%), ECB monetary policy innovation should play an important role for the V4 countries. Second, we compare this impact with the direct effect of a FED monetary policy shock. The goal here is to assess the impact of US-generated shocks on V4 markets. Finally, the third group of estimations analyses the influence of a FED monetary shock on V4, controlling for Germany. Specifically, we estimate the model including Germany as an SOE relative to the US and as a large economy relative to the V4. Then, we produce the results of the model after setting the coefficients that link the German and V4 economic indicators to zero. As a result, we counterfactually prevent FED shocks from propagating to SOEs through the influence they exert on German macroeconomic variables, thus identifying the direct effect of shocks in isolation.

Henceforth, the three estimations are, in short, referred to as: 1) direct ECB monetary shock (ECB_V4); 2) direct FED monetary shock (FED_V4); and 3) FED monetary shock with control for German variables (FED_DE_V4).

The impulse responses for the three groups of estimations are given by the median reaction over 12 periods of the domestic variables to a one-standard-deviation point increase in the interest rate of the large economy.[5] They are displayed in a posterior 68% band, extracting the 16th and 84th percentiles of the simulated impulse response distribution. The impulse response functions for the estimations are presented in Figures 1–3. The patterns are overall similar for the three estimation groups: The monetary shock generated abroad is generally followed by a decrease in CPI inflation and a depreciation of the domestic currency in all V4 countries. However, the impact on GDP growth is ambiguous.

4 We end the estimation period in 2019 Q4 to avoid distorting the model, which is designed around market-driven cyclical dynamics, with the COVID-19 crisis. Unlike standard recessions, the "Great Lockdown" arose from public health policy rather than market forces and thus constitutes an atypical Keynesian supply shock, simultaneously disrupting supply and depressing demand (Guerrieri *et al.,* 2022; Gopinath, 2020), that deviates fundamentally from the transmission mechanisms underlying US- and euro-area monetary shocks.

5 Our VAR-based identification follows standard practice, but we acknowledge high-frequency approaches that identify exogenous monetary policy surprises, such as Jarociński and Karadi (2020), which offer complementary insights using intraday data.

The impulse responses in Figure 1 show the effects of an ECB monetary policy shock on key macroeconomic variables in the V4 countries. The immediate reaction is a slight depreciation of domestic currencies, followed by modest and delayed GDP responses, though the effect is not statistically significant. In the cases of the Czech Republic, Poland, and Hungary, output initially declines after one quarter, reflecting the dominant income absorption effect: weaker demand from the euro area reduces exports, and the exchange rate depreciation only partially offsets this drop. After approximately three quarters, the expenditure switching effect becomes more visible, particularly in the Czech Republic and Poland, where external exposure to Germany is stronger. In the Slovak Republic, which shares the euro and thus lacks an exchange rate channel, the income absorption effect is immediate and not counteracted, resulting in a temporary decline in output.

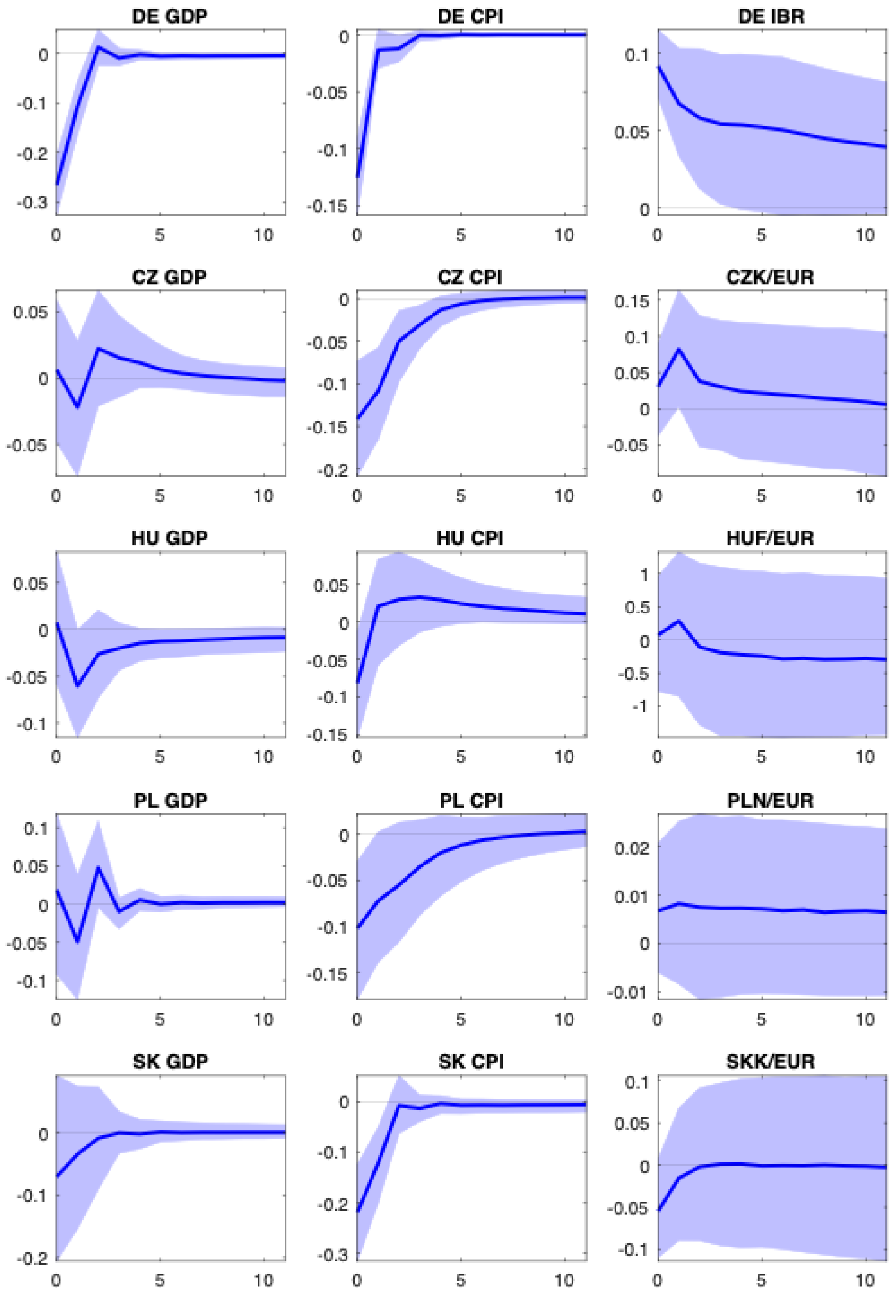
CPI inflation exhibits a more consistent reaction across countries. Except for Hungary, all V4 countries experience a significant immediate drop in inflation following the ECB rate hike, with effects gradually dissipating over time.

Figure 2 illustrates the transmission of a US monetary policy shock to the V4 economies causing immediate and consistent depreciation of domestic currencies against the US dollar. In terms of output, all countries except Poland exhibit a significant decline in GDP, indicating that the income absorption effect dominates over the expenditure switching channel. The timing and intensity of the response differ: the Czech Republic shows a delayed but more pronounced drop in output, while the Slovak Republic and Hungary experience an immediate decline followed by a gradual recovery. Poland's output appears largely unaffected, likely reflecting its more diversified economy and relatively weaker direct exposure to the global monetary change.

CPI responses are less uniform and generally weaker. Most countries exhibit a modest, though significant expect for Hungary, drop in inflation immediately after the shock, followed by a return toward baseline and, in some cases, a slight increase, consistent with the pass-through effects of a weaker domestic currency.

Our results show that, perhaps surprisingly, changes in global monetary policy (represented by the United States) have a greater impact on V4 economies in real terms than those originating from the euro area. However, estimating the effect of US monetary shocks directly on V4 countries raises questions regarding the transmission mechanism. Introducing Germany as an intermediary makes economic sense, given its dominant role in regional trade and financial linkages.

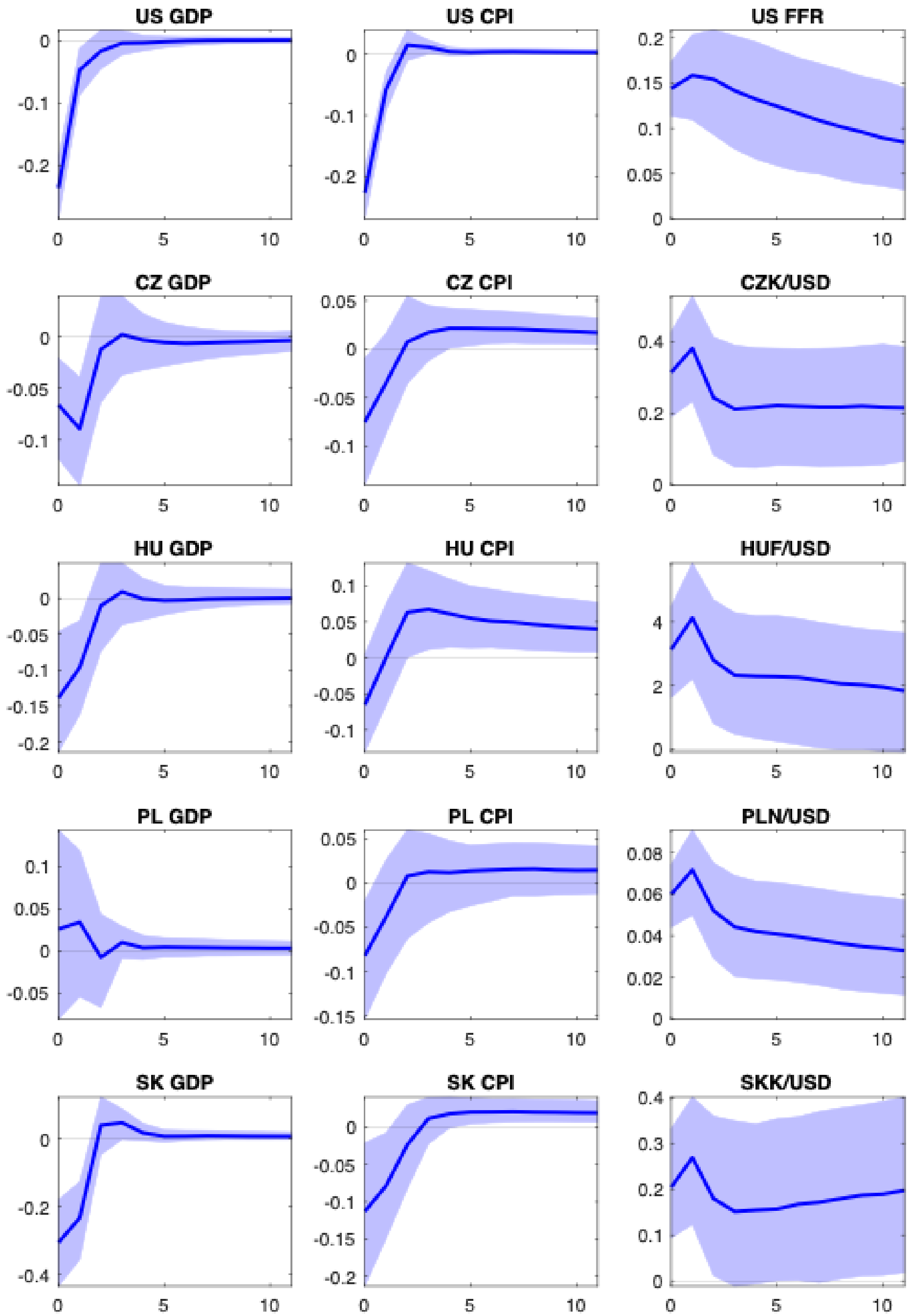
Figure 1: Dynamic effect of an ECB monetary shock on V4 macroeconomic variables



Note: The figure displays impulse response functions (IRFs) showing the median response of GDP growth, CPI inflation, and exchange rates in Visegrad countries (Czech Republic, Hungary, Poland, and Slovak Republic) to a one standard deviation contractionary monetary policy shock originating from the European Central Bank (ECB). Shaded bands represent 68% posterior intervals (16th and 84th percentiles). GDP growth, inflation, and exchange rates are represented as percentage logarithmic deviations ($\log(X_{t+1}/X_t) \times 100$); exchange rate not produced for the Slovak Republic, since it is a Eurozone member).

Source: Authors' own elaboration

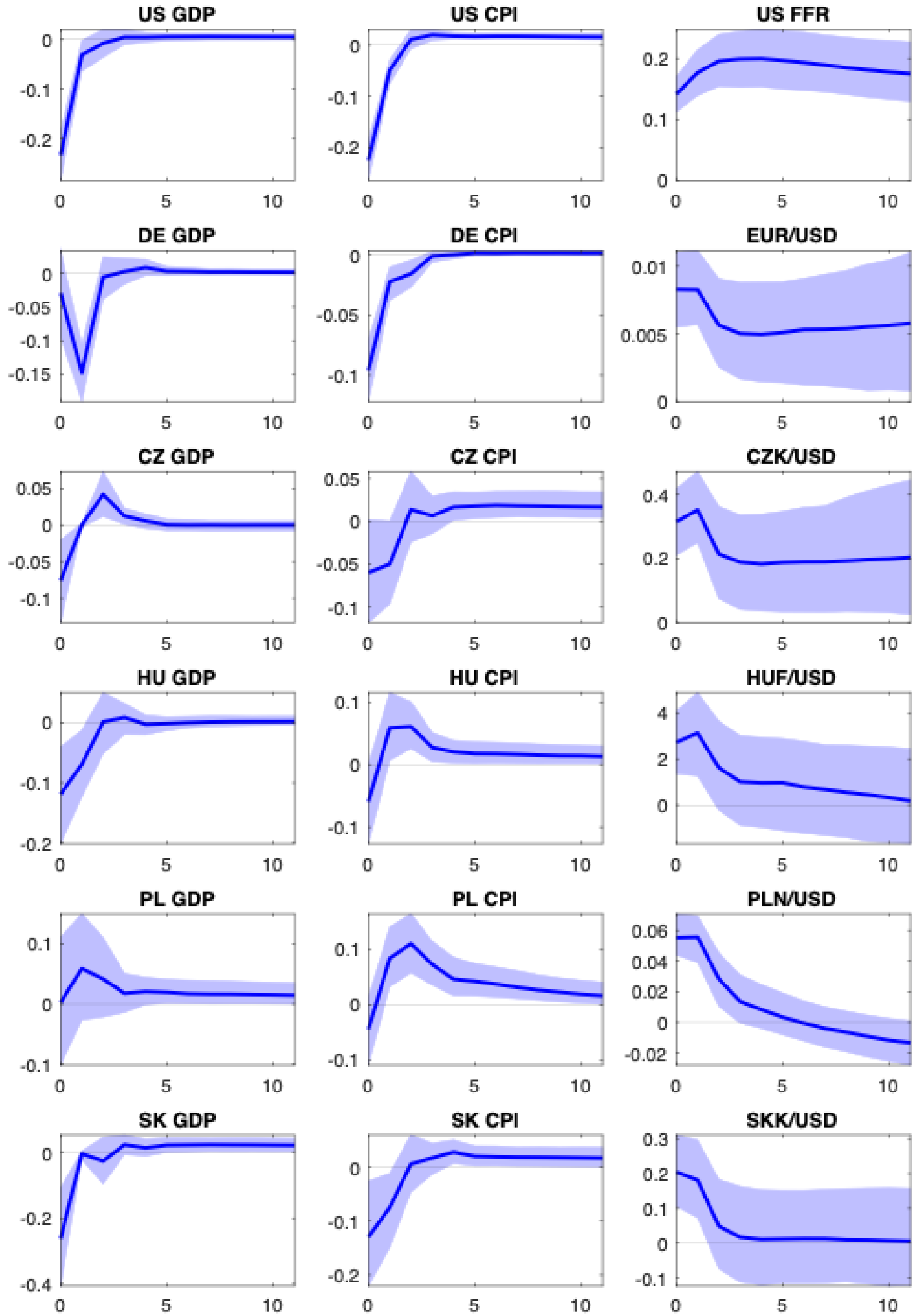
Figure 2: Dynamic effect of a FED monetary shock on V4 macroeconomic variables



Note: The figure displays impulse response functions (IRFs) showing the median response of GDP growth, CPI inflation, and exchange rates in Visegrad countries (Czech Republic, Hungary, Poland, and Slovak Republic) to a one standard deviation contractionary monetary policy shock originating from the US Federal Reserve (FED). Shaded bands represent 68% posterior intervals (16th and 84th percentiles). GDP growth, inflation, and exchange rates are represented as percentage logarithmic deviations ($\log(X_{t+1}/X_t) \times 100$).

Source: Authors' own elaboration

Figure 3: Dynamic effect of a FED shock on German and V4 macroeconomic variables



Note: The figure displays impulse response functions (IRFs) showing the median response of GDP growth, CPI inflation, and exchange rates in Germany and Visegrad countries (Czech Republic, Hungary, Poland, and Slovak Republic) to a one standard deviation contractionary monetary policy shock originating from the US Federal Reserve (FED). Shaded bands represent 68% posterior intervals (16th and 84th percentiles). GDP growth, inflation, and exchange rates are represented as percentage logarithmic deviations ($\log(X_{t+1}/X_t) \times 100$).

Source: Authors' own elaboration

Figure 3 illustrates the impulse responses to a monetary policy shock originating in the United States, capturing its transmission through Germany and subsequently to the V4 economies. The model structure is described in Appendix B. The responses suggest that an unanticipated increase in the Federal Funds Rate (FFR) leads to a significant depreciation of all currencies, more pronounced than in the case of the ECB shock and in line with the direct impact of the FED shock shown in Figures 1 and 2, respectively. The Czech Republic and Hungary both experience a marked decline in GDP, followed by a relatively quick recovery after about three periods.

The Polish economy continues to exhibit a mild increase, like the pattern observed in Figure 2, but also shows greater volatility. In contrast to the ECB shock, Slovak output declines significantly in the initial periods.

As for consumer prices, only Germany and Slovakia show a clear drop in CPI following the shock. In the remaining countries, the initial CPI response is more ambiguous, but over time, the depreciation-induced rise in import prices leads to gradually increasing inflation.

To summarise, our analysis yields three main findings. First, a contractionary US monetary policy shock causes a significant decline in output across most V4 countries, whereas the effect of ECB tightening on GDP is generally not statistically significant.[6] Second, exchange rate depreciation is more pronounced and persistent following a US shock than an ECB shock. Third, ECB shocks tend to cause a significant decline in CPI in the initial periods. This effect is insignificant in the case of FED shocks. More importantly, a comparison between Figures 1 and 3 shows that controlling for Germany as an indirect channel of transmission of a FED shock do not alter significantly the impact of the latter on the V4 macro variables.

6 While contractionary monetary shocks in the large economy (either the euro area or the United States) are followed by a depreciation of the SOE exchange rate, this response is consistently statistically significant only in the case of US monetary tightening. This asymmetry reflects the empirical pattern that UIP holds more robustly vis-à-vis the US dollar than the euro, especially in the case of Poland and Hungary (see, *e.g.*, Pietrych, 2021; Dąbrowski and Janus, 2024).

Table 1: FEVDs for CPI inflation

ECB_V4				
	CZ CPI	**HU CPI**	**PL CPI**	**SK CPI**
1	4.40	1.42	0.65	0.71
4	8.56	1.80	1.36	3.70
12	10.3	6.42	3.62	8.56
FED_V4				
	CZ CPI	**HU CPI**	**PL CPI**	**SK CPI**
1	0.97	0.52	0.51	0.66
4	4.86	1.75	1.76	3.50
12	12.1	10.3	11.3	6.33
FED_DE_V4				
	CZ CPI	**HU CPI**	**PL CPI**	**SK CPI**
1	1.12	0.52	0.48	0.63
4	5.01	2.00	1.88	2.96
12	6.83	4.80	2.98	3.94

Note: The table presents median forecast error variance decompositions (FEVDs) showing the percentage of the forecast variance in CPI inflation explained by monetary policy shocks originating from the US Federal Reserve (FED) and the European Central Bank (ECB), across short-run (1 quarter), medium-run (4 quarters), and long-run horizons (12 quarters). Results are reported for three estimation models: direct FED shocks (FED_V4), direct ECB shocks (ECB_V4), and FED shocks controlling for German variables (FED_DE_V4).

Source: Authors' own calculations

Tables 1–2 present the median results of the FEVDs for forecast horizons of 1 quarter (referred to as the short run), 4 quarters (1 year, the medium run), and 12 quarters (3 years, the long run). Although the contribution of an ECB shock is generally higher in the short run, the impact of a FED shock after three years tends to outgrow the influence of an ECB shock, particularly regarding V4 domestic inflation.

Table 1 compares the FEVDs for the CPI inflation in the three groups of estimates and shows that an ECB monetary policy shock explains more of the CPI inflation for all countries than its US counterpart in the short run. The difference is large, especially for the Czech Republic. Generally, in the long run, a FED monetary shock accounts for 6% to 12% of the variability of CPI inflation. An ECB shock mostly explains Czech (over 10% after three years) and, in the long run, Slovakian inflation (over 8%).

Table 2: FEVDs for GDP growth

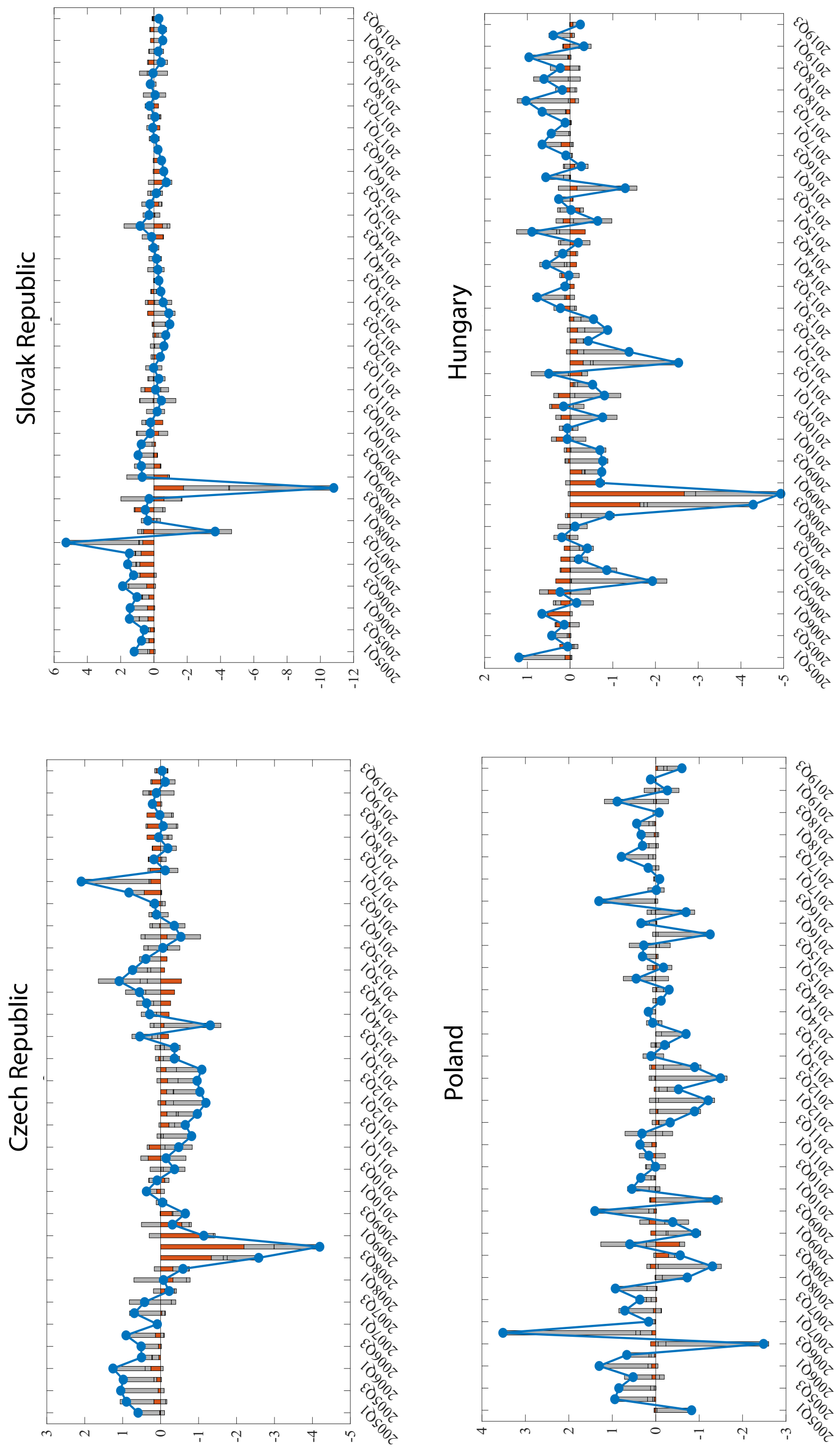
ECB_V4				
	CZ GDP	**HU GDP**	**PL GDP**	**SK GDP**
1	15.7	17.6	0.57	11.3
4	17.0	18.3	1.99	15.9
12	21.9	24.2	2.54	17.3
FED_V4				
	CZ GDP	**HU GDP**	**PL GDP**	**SK GDP**
1	9.91	9.19	4.35	0.45
4	18.8	15.1	5.39	14.1
12	19.3	15.8	5.94	14.7
FED_DE_V4				
	CZ GDP	**HU GDP**	**PL GDP**	**SK GDP**
1	10.7	10.1	3.42	0.43
4	11.0	12.8	4.84	1.13
12	11.3	13.1	6.43	1.94

Note: The table presents median forecast error variance decompositions (FEVDs) showing the percentage of the forecast variance in GDP growth explained by monetary policy shocks originating from the US Federal Reserve (FED) and the European Central Bank (ECB), across short-run (1 quarter), medium-run (4 quarters), and long-run horizons (12 quarters). Results are reported for three estimation models: direct FED shocks (FED_V4), direct ECB shocks (ECB_V4), and FED shocks controlling for German variables (FED_DE_V4).

Source: Authors' own calculations

Table 2 shows that a sizeable fraction of the variation in real GDP growth can be attributed to external monetary policy shocks, except for Poland, for which it is significantly lower than the rest of the V4. The FED generates a relatively higher variation in Polish GDP when controlling for Germany. The remaining V4 countries are generally more exposed to the shocks originating from the ECB in the long run. In general, exogenous monetary shocks explain a larger fraction of GDP growth variations than CPI inflation at all horizons.

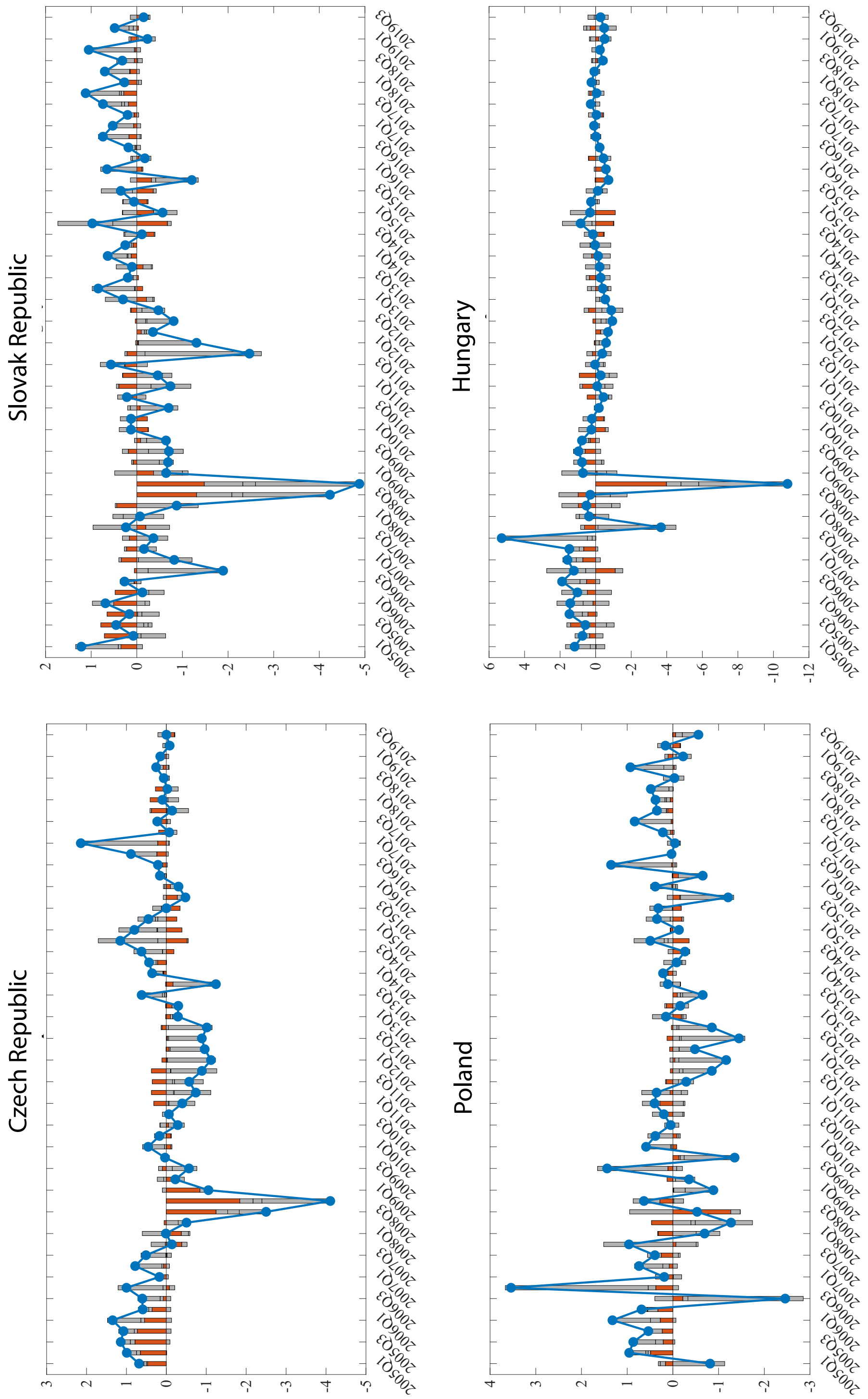
Figure 4: Contribution of an ECB monetary policy shock to V4 GDP Growth



Note. Historical decomposition of GDP growth rates in V4 economies showing the contribution (in percentage points) of European Central Bank (ECB) monetary policy shocks from 2005 to 2012. The blue line indicates detrended GDP growth rates, and red bars represent the contributions of ECB shocks.

Source: Authors' own elaboration

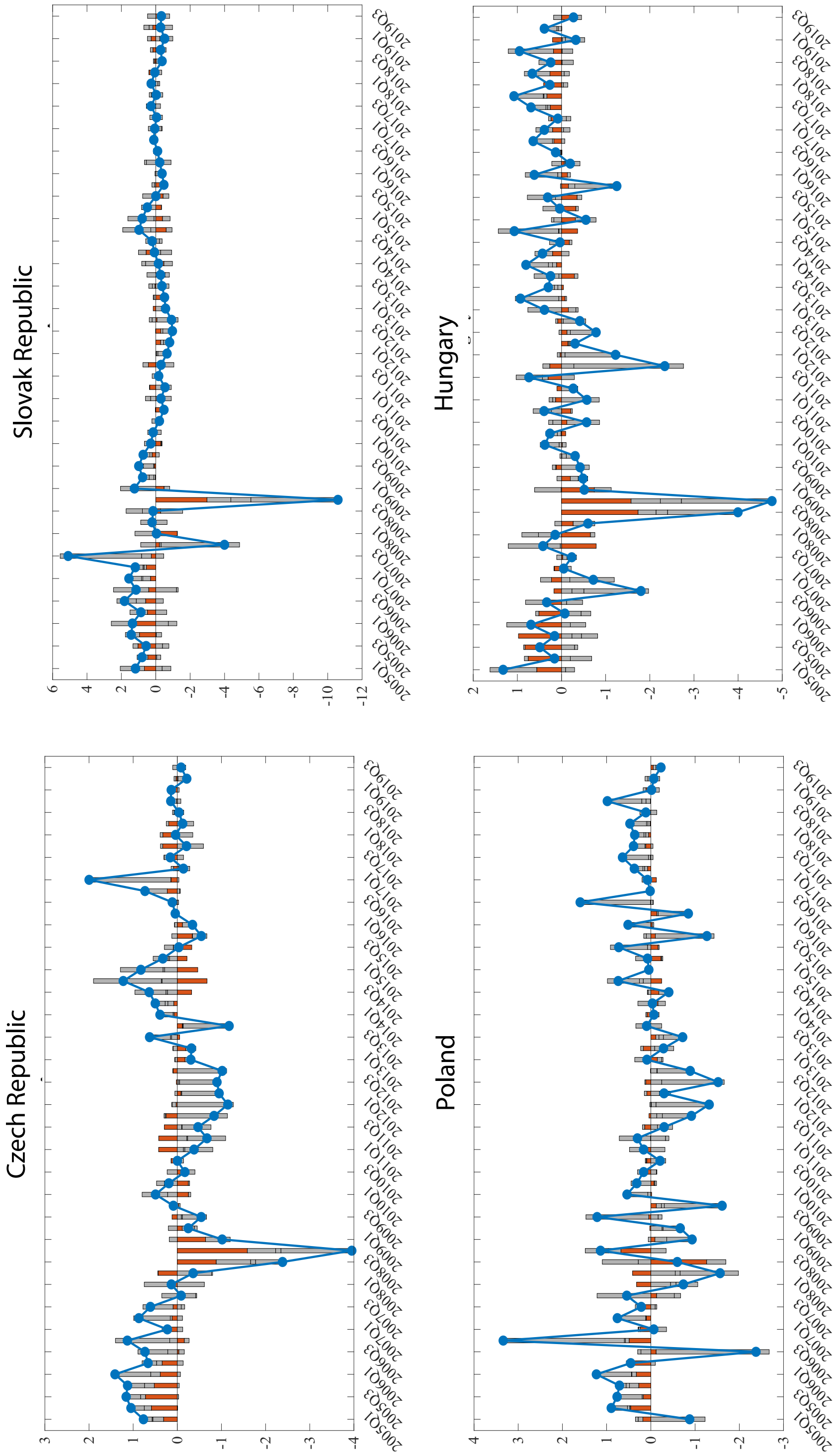
Figure 5: Contribution of a FED monetary policy shock to V4 GDP Growth



Note. Historical decomposition of GDP growth rates in V4 economies showing the contribution (in percentage points) of US Federal Reserve (FED) monetary policy shocks from 2005 to 2012. The blue line indicates detrended GDP growth rates, and red bars represent the contributions of FED shocks.

Source: Authors' own elaboration

Figure 6: Contribution of a FED monetary policy shock to German and V4 GDP Growth



Note: Historical decomposition of GDP growth rates in Germany and V4 economies showing the contribution (in percentage points) of US Federal Reserve (FED) monetary policy shocks from 2005 to 2012. The blue line indicates detrended GDP growth rates, the red bars the contributions of FED shocks.

Source: Authors' own elaboration

What would happen in the absence of any shock other than those generated by monetary policy? The historical decomposition shows the contribution of the monetary policy shock to the endogenous variables and, therefore, the overall effects of the exogenous monetary policy shock in specific periods. Figures 4–6 show the detrended GDP growth (represented by the blue line) and its decomposition in the structural shocks to the data, where the red (dark) bars measure the contribution of the monetary policy shock for the estimated model for the period 2005–2019 for each of the three groups of estimates. Inspecting these figures reveal that a FED monetary shock plays a more significant role in explaining the GDP growth in Poland. For the rest of the SOEs in the sample, the FED and ECB shock yield comparable influences in determining the output growth. Although the contributions of the exogenous monetary policy shocks are relatively small, there are some subperiods, for instance during the recession, in which they are substantial. Furthermore, the effects of the two shocks at times differ significantly. For example, the early expansionary phase in the Czech Republic and Poland was driven by a FED shock. Similar, though weaker, instances are also noticeable in the GDP innovation of the other countries.

4. Conclusions

This study investigates the impact of a FED monetary policy shock on countries of the Visegrad Group, namely the Czech Republic, Hungary, Poland and the Slovak Republic, using a structural vector autoregressive (SVAR) methodology. The SVAR process is identified using two types of restriction. We impose sign restrictions to ensure that a contractionary monetary policy shock in the large economy causes a decrease both in its inflation and output, and zero restrictions on the channels feeding back from the small open economy to the large economy to guarantee that the economic variables of the former have no influence on those of the latter. In our last estimation, we also impose zero restrictions on the channels linking German and V4 macro variables, to isolate the direct effect of a FED monetary policy shock on those European SOEs.

An important implication of our study is the quantifiable impact of FED monetary policy shocks on V4 economies, which appear to match or even exceed those stemming from ECB monetary policy, even after controlling for indirect effects mediated through Germany. This suggests that FED policy decisions play a crucial role in shaping macroeconomic dynamics within central European economies, independently of their stronger trade ties with Germany.

Our results show that output in the V4 countries tends to decline significantly in response to a contractionary US monetary shock, while the effect of ECB tightening is generally weaker and not statistically significant. The exchange rate response is also more pronounced and persistent in the case of US shocks, with V4 currencies exhibiting greater and more sustained weakening against the dollar than against the euro. As for inflation, ECB shocks tend to trigger an immediate decline in consumer prices, whereas FED shocks show a more muted initial effect, with inflationary pressures emerging only gradually in later periods. These patterns highlight the sensitivity of small open economies to global monetary conditions and underline the importance of distinguishing between regional and global sources of shocks in empirical analysis. Our findings support the dominance of the income absorption effect, as described in the Dornbusch–Mundell–Fleming (DMF) framework, for FED shocks, suggesting that monetary contractions abroad negatively affect output in SOEs primarily through a decline in foreign demand. This outcome aligns with previous empirical evidence from Kim (2001), who demonstrated that expansionary FED monetary policy shocks have positive spillover effects on G6 countries and is consistent with theoretical insights from Betts and Devereux (1999), which emphasise the central role of currency invoicing in shaping international transmission mechanisms.

In contrast, previous work by Junicke (2019), employing a DSGE approach, suggested a more pronounced expenditure switching effect, which could hinder the impact of ECB shocks. Our findings underscore the critical role of exchange rate regimes and central bank policy frameworks in determining economic outcomes. Specifically, our results imply that SOEs with strict exchange rate targets or pegs to a large economy's currency are more likely to experience dominant income absorption effects (although these may not necessarily imply a significant variation in output growth), while those that allow flexible currency adjustments can experience notable expenditure switching effects.

In our estimates, identification relies heavily on the variation caused by the Great Recession that occurred from late 2007 to mid-2009. From this perspective, it would be interesting to investigate whether the variability generated by the 2020–2023 COVID pandemic detects similar patterns of influence of FED and ECB monetary policy shocks on the same key economic indicators of the V4 countries. We leave this task to future research.

The insights gained from this analysis also highlight other promising avenues for future research. Examining in more detail the role of currency invoicing practices could clarify their influence on monetary transmission channels and macroeconomic stability. Furthermore, exploring how different exchange rate policy frameworks modulate these international transmission mechanisms could further enrich our understanding of the effectiveness of monetary policy in open economies. Finally, embedding the UIP analysis for the V4 in a framework allowing for different responses to ECB and FED monetary shocks is a promising future research line, especially in view of the evidence that UIP failures are state-dependent and time-varying (Cuestas *et al*., 2017; Jiang *et al*., 2013).

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Appendices

Appendix A

We opt for a parsimonious model and restrain the number of variables, focussing on the movement in key macroeconomic variables such as CPI inflation and GDP growth.

Macrobond was a source for the following data:

- As an indicator of monetary policy shock:
  - US money market rate – federal funds rate (USI60B),
  - Day-to-day money market rate monthly average (BDSU0101R).
- Exchange rates, as percentage logarithm values
  - German Mark (later, EUR) to US$ (USWGMRK),
  - Czech Koruna to US$ (USCZECK),
  - Hungarian Forint to US$ (USHUNGF),
  - Polish Zloty to US$ (USPOLZL),
  - Slovak Koruna to US$ (SXUSDSP).

The FRED database was used as a source for the following time series:

- As a measure of aggregate price level, seasonally adjusted and in the year-on-year first difference of the logarithm values:
  - Consumer Price Index of All Items in the United States (USACPIALLQINMEI),
  - Consumer Price Index of All Items in Germany (DEUCPIALLQINMEI),
  - Consumer Price Index: All Items for the Czech Republic (CZECPIALLMINMEI),
  - Consumer Price Index: All Items for Hungary (HUNCPIALLMINMEI),
  - Consumer Price Index: All Items for Poland (POLCPIALLMINMEI),
  - Consumer Price Index: All Items for the Slovak Republic (SVKCPIALLQINMEI).
- As a measure of real GDP activity, seasonally adjusted and in the year-on-year first difference of the logarithm values:
  - Real Gross Domestic Product in the US (GDPC96),
  - Current Price Gross Domestic Product in Germany (DEUGDPNQDSMEI),
  - GDP Implicit Price Deflator in Germany (DEUGDPDEFQISMEI),
  - Current Price Gross Domestic Product in the Czech Republic (CZEGDPNQDSMEI),
  - GDP Implicit Price Deflator in the Czech Republic (CZEGDPDEFQISMEI),
  - Current Price Gross Domestic Product in Hungary (HUNGDPNQDSMEI),
  - GDP Implicit Price Deflator in Hungary (HUNGDPDEFQISMEI),
  - Current Price Gross Domestic Product in Poland (POLGDPNQDSMEI),
  - GDP Implicit Price Deflator in Poland (POLGDPDEFQISMEI),
  - Current Price Gross Domestic Product in the Slovak Republic (SVKGDPNQDSMEI),
  - GDP Implicit Price Deflator in the Slovak Republic (SVKGDPDEFQISMEI).

Appendix B

We restrict the model by imposing specific signs and zero values in such a way that the identification scheme for a model with two countries takes the form:

$$\begin{pmatrix} \epsilon\{IR^*\} \\ \epsilon\{\Delta GDP^*\} \\ \epsilon\{\Delta CPI^*\} \\ \epsilon\{\Delta GDP^{V4}\} \\ \epsilon\{\Delta CPI^{V4}\} \\ \epsilon\{XR^{V4}\} \end{pmatrix} = \begin{pmatrix} + & \cdot & \cdot & 0 & 0 & 0 \\ - & \cdot & \cdot & 0 & 0 & 0 \\ - & \cdot & \cdot & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{pmatrix} \begin{pmatrix} e\{IR^*\} \\ e\{\Delta GDP^*\} \\ e\{\Delta CPI^*\} \\ e\{\Delta GDP^{V4}\} \\ e\{\Delta CPI^{V4}\} \\ e\{XR^{V4}\} \end{pmatrix} \tag{7}$$

The vector $\boldsymbol{a_j} \in R^m$ is called an impulse vector if there is some matrix $\widetilde{\mathbf{A}}$ such that $\widetilde{\mathbf{A}}\widetilde{\mathbf{A}}' = \Sigma$ holds and $\boldsymbol{a_j}$ is the *j*-th column of $\widetilde{\mathbf{A}}$. The impulse vector yields the instantaneous impulse response of all variables to the structural shock associated with that vector and, in our specification needs to have the following signs: $a_{11} > 0$, $a_{21} < 0$, $a_{31} < 0$. In other words, the sign restrictions on large economy variables ensure that positive shocks in the interest rate imply a fall in GDP growth and inflation in the US. The impulse responses for the rest of the variables remain unrestricted in sign.

The identification is completed by using zero restrictions on contem-poraneous structural parameters to ensure that the SOE does not influence the large economy contemporaneously. The dots correspond to freely estimated parameters.[7]

Following (4), some prior coefficients B_0 are restricted to zero on lags. The prior for the coefficient matrix $\mathbf{B}(j)$ has therefore the form:

$$\mathbf{B_0}(j) = \begin{pmatrix} B_{11}^0(j) & 0 \\ B_{21}^0(j) & B_{22}^0(j) \end{pmatrix} \tag{8}$$

and incorporates the belief that the coefficients of matrix $B_{21}^0(j)$ for all $j = 1, \dots, p$ are close to zero. To ensure that these restrictions are also fulfilled for the posterior, so that the appropriate parameters stay close to zero, we set the elements of the prior variance $\mathbf{H}$ matrix belonging to these coefficients very close to zero. For the remaining coefficients, regarding the first lag $j = 1$, the prior mean on its lag is set equal to 0.95, *e.g.*, the diagonals of matrices $B_{11}(1)$, $B_{22}(1)$, and $B_{33}(1)$ equal 0.95. All other elements of matrix $\mathbf{B}(1)$ are set to zero. $\widetilde{\boldsymbol{C}}$ is a zero vector and $B(j), j = 2, \dots, p$ a zero matrix. The elements of the prior variance $\mathbf{H}$ correspond to all the coefficients except those for $B_{12}(j)$, $B_{13}(j)$,

[7] For a critical survey on contemporanous restrictions, see Fry and Pagan (2011).

and $B_{23}(j)$, which are set to be sufficiently large (hence these coefficients are mainly determined within the model). To summarise, $\mathbf{H}$ is
a $\big(m \times (m \times p + 1)\big) \times \big(m \times (m \times p + 1)\big)$ diagonal matrix, with near-zero elements for coefficients which are believed to be zero, and large elements for the remaining coefficients.

In the case of three countries, *e.g.*, the US, Germany, and a (domestic) V4 country like the Czech Republic, the matrix $B(j)$ can be written as:

$$B_0(j) = \begin{pmatrix} B_{11}(j) & 0 & 0 \\ B_{21}(j) & B_{22}(j) & 0 \\ B_{31}(j) & B_{32}(j) & B_{33}(j) \end{pmatrix} \tag{9}$$

where $B_{12}(j)$, $B_{13}(j)$, and $B_{23}(j)$ are zero matrices with $m \times (m \times p + 1)$ parameters, meaning that V4 variables have no impact on the German or the US economy, and where $B_{31}(j)$ and $B_{32}(j)$ respectively measure the direct influence of US and German variables on the V4. The first row represents the US economy.

The identification scheme has the form:

$$\begin{pmatrix} \epsilon\{FFR^{US}\} \\ \epsilon\{\Delta GDP^{US}\} \\ \epsilon\{\Delta CPI^{US}\} \\ \epsilon\{\Delta GDP^{G}\} \\ \epsilon\{\Delta CPI^{G}\} \\ \epsilon\{\Delta XR^{G}\} \\ \epsilon\{\Delta GDP^{V4}\} \\ \epsilon\{\Delta CPI^{V4}\} \\ \epsilon\{XR^{V4}\} \end{pmatrix} = \begin{pmatrix} + & \cdot & \cdot & 0 & 0 & 0 & 0 & 0 & 0 \\ - & \cdot & \cdot & 0 & 0 & 0 & 0 & 0 & 0 \\ - & \cdot & \cdot & 0 & 0 & 0 & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & 0 & 0 & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & 0 & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{pmatrix} \begin{pmatrix} e\{FFR^{US}\} \\ e\{\Delta GDP^{US}\} \\ e\{\Delta CPI^{US}\} \\ e\{\Delta GDP^{G}\} \\ e\{\Delta CPI^{G}\} \\ e\{\Delta XR^{G}\} \\ e\{\Delta GDP^{V4}\} \\ e\{\Delta CPI^{V4}\} \\ e\{XR^{V4}\} \end{pmatrix} \tag{10}$$

For $VAR(2)$, the model has the form:

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + C + \epsilon_t \tag{11}$$

The prior mean for $\boldsymbol{vec(B_0)}$ is set to be equal 0.95 for coefficients on own first lags and zero on all other remaining coefficients. The $VAR(2)$ model under the prior can be written as:

$$\begin{pmatrix}\mathbf{Y_t^{US}}\\ \mathbf{Y_t^{G}}\\ \mathbf{Y_t^{V4}}\end{pmatrix}=\begin{pmatrix}diag(0.95) & 0 & 0\\ 0 & diag(0.95) & 0\\ 0 & 0 & diag(0.95)\end{pmatrix}\begin{pmatrix}Y_{t-1}^{US}\\ Y_{t-1}^{G}\\ Y_{t-1}^{V4}\end{pmatrix}$$
$$+\begin{pmatrix}0 & 0 & 0\\ 0 & 0 & 0\\ 0 & 0 & 0\end{pmatrix}\begin{pmatrix}Y_{t-2}^{US}\\ Y_{t-2}^{G}\\ Y_{t-2}^{V4}\end{pmatrix}+\begin{pmatrix}0\\ 0\\ 0\end{pmatrix}+\begin{pmatrix}\epsilon_t^1\\ \epsilon_t^2\\ \epsilon_t^3\end{pmatrix} \tag{12}$$

where $\mathbf{Y_t^{US}}$ is a 3×3 matrix of US variables (namely, the interest rate, GDP growth, and CPI inflation), and $\mathbf{Y_t^{G}}$ and $\mathbf{Y_t^{V4}}$ are respectively 3×3 matrices of German and V4 variables (namely, the GDP growth, CPI inflation, and nominal exchange rate).

With nine endogenous variables, the prior variance matrix $\mathbf{H}$ is a 171×171 diagonal matrix, where the diagonal elements are set close to zero for coefficients restricted to zero and large for the remaining coefficients. In particular, concerning the part of the matrix $\mathbf{H}$ corresponding to matrix $\mathbf{B}(j), j = 1{,}2$ as in (5), the elements are all given a very high value except for those corresponding to $B_{12}(j)$, $B_{13}(j)$, and $B_{23}(j)$, which are set very low to impose the prior strictly.

Appendix C

The Bayesian estimation combines a subjective prior with sample information. It is based on the Bayes theorem, which states that posterior distribution ∝ likelihood × prior distribution.

The likelihood function is taken from the OLS estimation of the data sample. Equivalently, it can be written as:

$$R(\boldsymbol{vec}(\boldsymbol{B})\backslash\Sigma, Y_t) \propto F(Y_t\backslash\boldsymbol{vec}(\boldsymbol{B}), \Sigma) \times P(\boldsymbol{vec}(\boldsymbol{B}), \Sigma) \tag{13}$$

The posterior distribution $R(\boldsymbol{vec}(\boldsymbol{B})\backslash\Sigma, Y_t)$ is proportional to the product of the prior distribution $P(\boldsymbol{vec}(\boldsymbol{B}), \Sigma)$ and the sample distribution given by the likelihood function $F(Y_t\backslash\boldsymbol{vec}(\boldsymbol{B}), \Sigma)$. The vector $\boldsymbol{vec}(\boldsymbol{B})$ is a matrix of regressors $\mathbf{B}$ in vector form, and Σ the variance-covariance matrix. Because we incorporate a prior belief with zero restrictions, we opt for an independent normal inverse Wishart prior.

It can be assumed, given the nature of the data, that the matrix of coefficients B is normally distributed:

$$P\big(vec(B)\big) \sim N(vec(B_0), H) \tag{14}$$

where $\boldsymbol{vec}(\boldsymbol{B_0})$ is the $\big(m \times (m \times p + 1)\big) \times 1$ vector of prior means for the elements of matrix $\mathbf{B}$. The matrix $\mathbf{H}$ is a $\big(m \times (m \times p + 1)\big) \times \big(m \times (m \times p + 1)\big)$ diagonal matrix, whose elements are the prior variances for each corresponding coefficient from matrix $\mathbf{B_0}$. As discussed earlier, we impose the strong prior belief that the elements of matrices $B_{12}(j)$, $B_{13}(j)$, and $B_{23}(j)$ equal zero. Therefore, the prior variances of the corresponding elements in matrix $\mathbf{H}$ are set to be very low.

Following Zellner (1971), the conjugate prior for a positive definite variance-covariance matrix is an Inverse Wishart prior:

$$P(\Sigma) \sim IW(\bar{S}, \alpha) \tag{15}$$

with the prior scale matrix $\boldsymbol{\bar{S}}$ and prior degrees of freedom α.

Given the fact that the conjugate prior on $\mathbf{B}$ is normally distributed, it can be shown that the posterior distribution of the coefficients, conditional on the variance-covariance matrix, is given by:

$$R(\boldsymbol{vec}(\boldsymbol{B}) \backslash \Sigma, Y_t) \sim N(M^*, V^*) \tag{16}$$

where M^* and V^* are the mean and the variance of this normal distribution, respectively. As shown in Kadiyala and Karlsson (1997), the mean and the variance of the conditional posterior distribution are respectively given by:

$$M^* = (H^{-1} + \Sigma^{-1} \otimes X_t' X_t)^{-1} \times (H^{-1} \boldsymbol{vec}(\boldsymbol{B_0}) + \Sigma^{-1} \otimes X_t' Y_t) \tag{17}$$

$$V^* = (H^{-1} + \Sigma^{-1} \otimes X_t' X_t)^{-1} \tag{18}$$

Note that M^* is a weighted average of the prior mean $\boldsymbol{vec}(\boldsymbol{B_0})$ and the OLS estimator, given by $X_t' Y_t$, weighted by the reciprocal of the corresponding variance-covariance matrices. The smaller the values of matrix $\mathbf{H}$ elements, the higher the weight on the prior relative to the conditional posterior estimates. In the case where there are no beliefs about the prior, that is, the values of matrix $\mathbf{H}$ elements are very large, then the posterior estimates are identical to the maximum likelihood estimator.

Given the prior in Equation (7), the posterior distribution for Σ conditional on □ is Inverse Wishart

$$R(\Sigma \backslash \boldsymbol{vec}(\boldsymbol{B}), Y_t) \sim IW(\bar{\Sigma}, T + \alpha) \tag{19}$$