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Fed and ECB monetary policy spillovers to Emerging Market Economies

Małgorzata Walerych[1], Grzegorz Wesołowski *

Institute of Economics, Polish Academy of Sciences, Poland

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ABSTRACT

This paper presents evidence that the international spillovers of both Fed and ECB conventional monetary policies to Emerging Market Economies (EMEs) are global. The result comes from the panel Bayesian Vector Autoregressive (BVAR) model estimated for EMEs in which we control i.a. for foreign central banks' policy shocks. Furthermore, in the separate BVAR model for Central and Eastern European (CEE) countries we show that the ECB is the main foreign central bank for these economies — after controlling for its shocks, their Fed counterparts play a very moderate role in driving GDP and prices in CEE.

1. Introduction

Monetary policy in the United States (US) and the euro area (EA) is believed to impact not only domestic economies but also other countries. Since many of them are open to capital flows and their exchange rates float, changes in short-term interest rates by major central banks affect prices and trade globally, see, e.g. IMF (2007) or di Giovanni and Shambaugh (2008). This phenomenon has already received well-deserved attention separately in case of Fed and ECB policy spillovers to Emerging Market Economies (EMEs). Much less is known, however, about the relative importance of these two for international business cycles.

This paper aims to fill this gap and investigate conventional monetary policy spillovers of both the ECB and the Fed to EMEs. We focus on conventional monetary policy since, even though major central banks engaged in non-standard measures such as quantitative easing and forward guidance, they maintained the short-term interest rate as their main instrument, ready to be used when times normalize. In fact, by the end of 2018, Fed had already increased short-term rates in several steps. Therefore, it is important to understand how the main policy instruments of two major central banks spill over the boundaries. It is also worth to note that in our analysis we explicitly account for the role of expected policy changes by distinguishing between the impact of monetary policy shocks that have been anticipated by the markets and unanticipated monetary surprises. Thus, we go much beyond the standard approach that focuses solely on the latter.

The paper addresses two questions. First, given a well-established role of the Fed monetary policy for global business cycle, we investigate whether ECB shocks similarly spill over to EMEs. Second, given strong trade and financial linkages between Central and Eastern Europe (CEE) and the EA, we verify whether in this particular group of countries ECB spillovers are stronger than their Fed counterparts.

To this end we first derive unanticipated and anticipated policy changes in short-term interest rates in the EA and the US. Then, we estimate Fed and ECB monetary policy rules and use them to split fluctuations in unanticipated and anticipated policy rates

* Corresponding author.
E-mail addresses: m.j.skibinska@gmail.com (M. Walerych), g.wesolowski@uw.edu.pl (G. Wesołowski).

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into their systematic and shock components. We interpret the latter as the conventional monetary policy shocks and show that they intuitively and significantly affect their economies of origin. As the final step we estimate the panel Bayesian Vector Autoregressive (BVAR) models separately for two groups of countries: nine EMEs excluding CEE economies and three CEE countries. These two groups are homogeneous in a number of respects: they are small open economies, their trade is strongly linked to one of the advanced economies (either the US or the EA) and they have substantial financial linkages to the world financial system.

Our main finding is that the ECB conventional monetary policy spills over to EMEs even after excluding countries that are closely tied to the EA, i.e. CEE economies. This suggests that not only the Fed but also the ECB plays an important role for global business cycle. Second, we show that the ECB is the main foreign central bank for CEE — after controlling for its shocks, their Fed counterparts play a very moderate role in driving GDP and prices in economies that are tightly linked to the EA.

The paper is closely related to Vicondoa (2019) who investigated the propagation of Fed news (anticipated) and surprise (unanticipated) shocks to a set of EMEs. We add to the literature by focusing on the relative importance of Fed and ECB conventional policy spillovers. Furthermore, we propose the shock identification procedure that explicitly accounts for the effective lower bounds episodes. Finally, differently from the Vicondoa's 2019 work, we estimate panel BVAR models with hierarchical priors inspired from Jarociński (2010) instead of the classical panel model. Using Bayesian approach mitigates the problem of short data samples available for the analysed countries.

Our paper relates also to other works deriving and investigating monetary policy shocks. The first strand of research applies VAR models to identify structural monetary policy shocks with various properties, see, e.g. Caldara and Herbst (2019) and Jarociński (2010). Other papers, notably Gertler and Karadi (2015), Altavilla et al. (2019) and Swanson (2021), use high-frequency data on asset prices to derive policy surprise components around central banks' announcements of their decisions. Jarociński and Karadi (2020) combine the high-frequency identification with sign restrictions and show that news about central bank lowering rates may be contractionary information shock by affecting agents expectations about worsening economic outlook. The importance of central bank information shock is also documented by Nakamura and Steinsson (2018). Finally, Romer and Romer (2004) is a seminal contribution to the narrative approach to monetary policy shock identification.

Moving to spillover aspect of our research, we build on the rich literature that points to a strong impact of US short-term rates on the global economy, see e.g. Vicondoa (2019), Hanisch (2019), Dedola et al. (2017), Georgiadis (2016), di Giovanni and Shambaugh (2008), Maćkowiak (2007) or Canova (2005). There is also a number of papers that address ECB policy spillovers, such as, e.g. Potjagailo (2017), Babecká Kucharčuková et al. (2016) or Hájek and Horváth (2016). In case of CEE economies considered in some of these articles, we add to literature by investigating whether the ECB's policy spills over similarly to the Fed's. Our paper addresses this issue utilizing a consistent framework that accounts for both anticipated and unanticipated policy shocks of these two main central banks.

The rest of the paper is structured as follows. Section 2 explains how we model conventional policy in the US and the EA and derives monetary policy shocks. Section 3 describes the empirical model which we use to investigate policy spillovers to emerging countries and presents the main results of the paper. Section 4 concludes. The Appendix checks the robustness of our main findings to a number of specific modelling assumptions.

2. ECB and FED conventional monetary policy

Central banks are believed to have been actively steering private sector expectations about interest rates in recent decades (see Weidmann, 2018). This suggests that one should investigate the spillovers of not only contemporaneous conventional monetary policy surprises but also news shocks about the future monetary policy (Vicondoa, 2019). Therefore, in Section 2.1 we analyse anticipated changes in Fed and ECB short-term rates in order to assess the importance of expectations about future policy stance. In particular, we determine the horizon, for which market expectations are an useful predictor of future interest rates both for the Fed and the ECB.[2] Next, in Section 2.2 we discuss our shock identification procedure and present its results — conventional monetary policy shocks. In Section 2.3 we investigate whether and how the latter affect the EA and US economies.

2.1. Anticipated and unanticipated policy changes

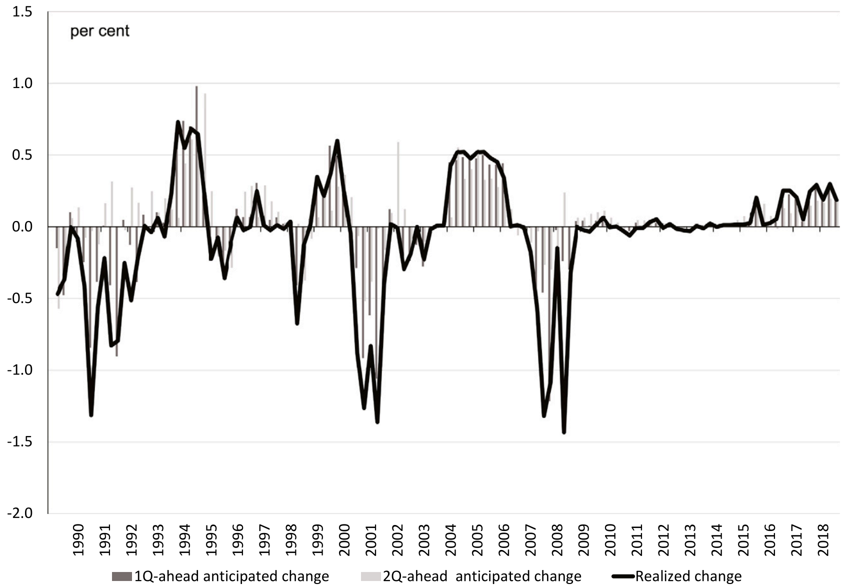
We define the anticipated changes in short-term interest rates from period $t-1+j$ to $t+j$ given the information from period $t-1$ as:

$$\Delta R^a_{t-1+j,t+j|t-1} = \mathbf{E}_{t-1}\left(R_{t+j} - R_{t-1+j}\right) \text{ for j} = 0, 1, 2... \tag{1}$$

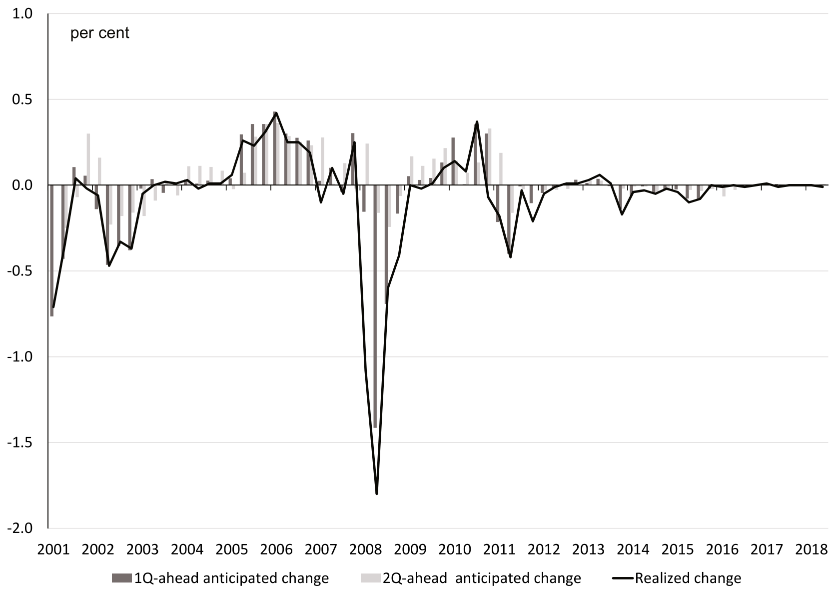
where E_{t-1} denotes the expectations conditional on the information available by the end of period $t-1$. In particular, one-quarter ahead anticipated movement in the interest rates is given by $\Delta R^a_{t-1,t|t-1} = \mathbf{E}_{t-1}\left(R_t - R_{t-1}\right)$ and the actual change by $\Delta R_{t-1,t} = R_t - R_{t-1}$. We define the unanticipated interest rate change as the difference between the actual and the anticipated interest rate movements:

$$\Delta R^u_t = R_t - \mathbf{E}_{t-1} R_t \tag{2}$$

[2] Note, that this is not the same as the verification of Expectation Hypothesis of the interest rates term structure. The latter concerns the question of unbiasedness of market expectations, while we impose stricter and more subjective criterion of predictive power.



(a) Fed rates



(b) ECB rates

Fig. 1. Anticipated and realized changes in Fed and ECB short-term rates.

The anticipated interest rate movements in periods $t, t+1, t+2...$ given information from period $t-1$ are calculated using the financial market expectations at the end of period $t-1$. In case of the ECB rates, we use financial market expectations derived from swap rates (3M1D, 6MD1, 9MD1), while for the Fed — 3-month averages of monthly Fed fund futures in the appropriate horizon. The data choice was determined by the availability of the specific instrument prices in Bloomberg. The actual rates are given by 3-month averages of 1-day interbank interest rates (EONIA and effective Fed Funds rate). Our data spans the period from 2001 Q4 to 2018 Q3 for the EA and 1990 Q1 to 2018 Q3 for the US.

Table 1
R^2 statistics for regression of $\Delta R_{t-1,t}$ on $\Delta R^a_{t-1,t|t-1-j}$.

	$j=0$	$j=1$	$j=2$
United States	0.81	0.19	0.03
Euro area	0.82	0.12	0.01

Table 2
Estimates of Taylor rule parameters.

Response to:	Formula	ECB	Fed
lagged interest rate	$\hat{\gamma}_r$	0.94	0.93
inflation	$\frac{\hat{\gamma}_\pi}{1-\hat{\gamma}_r}$	1.18	1.84
output growth	$\frac{\hat{\gamma}_y}{1-\hat{\gamma}_r}$	1.31	1.40
unemployment	$\frac{\hat{\gamma}_u}{1-\hat{\gamma}_r}$	−0.22	−1.17

Fig. 1 shows that the conventional belief that the monetary policy is well-predicted by financial markets is confirmed in the short term, both for the ECB and the Fed. While the realized changes in the interest rates are in line with the changes anticipated one quarter ahead, they are less so for predictions two quarters in advance. In order to formally show how well the anticipated interest rates movements predict the actual changes in conventional monetary policy, we estimate a series of OLS regressions of $\Delta R_{t-1,t}$ on $\Delta R^a_{t-1,t|t-1-j}$, see Table 1. We assume that the latter are the good predictors of the former if they explain more than 10% of their volatility. Under this threshold, the conventional policy is well-predicted two quarters in advance, both for the US and the EA. Thus, in our further empirical analysis, we consider two-quarter ahead anticipations for movements in the interest rates.

2.2. Conventional monetary policy shocks

Both unanticipated and anticipated short-term interest rate changes may reflect either macroeconomic developments to which conventional policy reacts in a systematic way or deviations from such response. In order to differentiate between these two cases and to extract policy shocks we assume that each central bank follows a standard Taylor rule that explicitly accounts for the effective lower bound (ELB):

$$R_t = \begin{cases} \gamma_r R_{t-1} + \gamma_y y_t + \gamma_\pi \pi_t + \gamma_u u_t + \epsilon_t & \text{for } \gamma_r R_{t-1} + \gamma_y y_t + \gamma_\pi \pi_t + \gamma_u u_t + \epsilon_t > \text{ELB} \\ \text{ELB} + \eta_t & \text{otherwise} \end{cases} \tag{3}$$

where y_t stands for GDP growth in period t, π_t – inflation rate, u_t – unemployment rate, ϵ_t denotes interest rate deviation from a typical (historical average) level, while η_t – minor fluctuations of average quarterly interest rates from the ELB level driven, e.g. by the liquidity conditions in the interbank market. While setting the rule, we explicitly account for the ELB case since it was an important policy constraint in the considered period. We assume ELB levels for the ECB and the Fed at the historically lowest values of their policy rates, i.e. −0.5% for the ECB (the lowest level of the deposit rate) and 0.125% for the Fed (the centre of the corridor for the targeted federal funds rate). Consequently, in our sample the ELB was binding only in the US for 7 years (from 2009 Q1 to 2015 Q4).

We estimate Taylor rules both for the US and the EA using the longest available quarterly data series that comprise short-term interest rates, GDP, inflation and unemployment. For the EA we apply the data from the Area-Wide Model database (Fagan et al., 2001) with the Eurostat data and obtain time series spanning the period from 1970 Q1 to 2012 Q4. For the US we utilize the Fred data that goes from 1960 Q3 to 2008 Q4. We do not include recent years when the interest rate volatility was very low by historical standards i.a. due to the ELB period. Nevertheless, as we show in Appendix, the resulting parameter estimates are robust to a number of sample choices.

Table 2 presents the estimates of the Taylor rules parameters. Both central bank rules exhibit similar level of persistence. At the same time, the Fed turns out to be more responsive to developments in prices and in the real economy, in particular to unemployment which is what one might expect given Fed's dual mandate.

The expectations about the interest rate in period $t+j$ conditional on information available by the end of period $t-1$ can be then expressed as follows:

$$\mathbb{E}_{t-1} R_{t+j} = \begin{cases} \mathbb{E}_{t-1}\left[\hat{\gamma}_r R_{t+j-1} + \hat{\gamma}_y y_{t+j} + \hat{\gamma}_\pi \pi_{t+j} + \hat{\gamma}_u u_{t+j} + \epsilon_{t+j}\right] & \text{for } \mathbb{E}_{t-1} R_{t+j} > \text{ELB} \\ \text{ELB} + \mathbb{E}_{t-1}\eta_{t+j} & \text{otherwise} \end{cases} \tag{4}$$

It is important to note that we assume that parameters in the Taylor rules are fixed, i.e. in contrast to Vicondoa (2019) we do not estimate them for each j but we assume that the central bank follows one policy rule. Thus, while building their expectations about future interest rates, agents use the historical values of Taylor rule parameters, which are presented in Table 2.

Using the above definitions, we define anticipated i-period ahead ($s^a_{t,t+i}$) and unanticipated (s^u_t) shocks in the following way:

$$s^a_{t,t+i} = \begin{cases} \mathbb{E}_{t-1}\left(\epsilon_{t+i} - \epsilon_{t+i-1}\right) & \text{for } \mathbb{E}_{t-1}R_{t+j} > \text{ELB for } j = i-1, i \\ \mathbb{E}_{t-1}\epsilon_{t+i} - \mathbb{E}_{t-1}\eta_{t+i-1} & \text{for } \mathbb{E}_{t-1}R_{t+i} > \text{ELB and } \mathbb{E}_{t-1}R_{t+i-1} \leq \text{ELB} \\ \mathbb{E}_{t-1}\eta_{t+i} - \mathbb{E}_{t-1}\epsilon_{t+i-1} & \text{for } \mathbb{E}_{t-1}R_{t+i} \leq \text{ELB and } \mathbb{E}_{t-1}R_{t+i-1} > \text{ELB} \\ \mathbb{E}_{t-1}\left(\eta_{t+i} - \eta_{t+i-1}\right) & \text{for } \mathbb{E}_{t-1}R_{t+j} \leq \text{ELB for } j = i-1, i \end{cases} \tag{5}$$

$$s^u_t = \begin{cases} \epsilon_t - \mathbb{E}_{t-1}\left(\epsilon_t\right) & \text{for } \mathbb{E}_{t-1}R_t > \text{ELB and } R_t > \text{ELB} \\ \epsilon_t - \mathbb{E}_{t-1}\eta_t & \text{for } \mathbb{E}_{t-1}R_t \leq \text{ELB and } R_t > \text{ELB} \\ \mathbb{E}_{t-1}\eta_t - \epsilon_t & \text{for } \mathbb{E}_{t-1}R_t > \text{ELB and } R_t \leq \text{ELB} \\ \eta_t - \mathbb{E}_{t-1}\eta_t & \text{for } \mathbb{E}_{t-1}R_t \leq \text{ELB and } R_t \leq \text{ELB} \end{cases} \tag{6}$$

We calculate shocks using survey data on expected GDP, inflation and unemployment. In case of the US, we utilize expectations from Survey of Professional Forecasters of the Federal Reserve Bank of Philadelphia. In turn, for the EA we use Thomson Reuters Economic Indicator Polls. Taking parameters in the Taylor rules as given, we calculate ϵ_{t+j} and η_{t+1} using Eq. (4). Then, using Eq. (5) and (6) we obtain series of Fed and ECB policy shocks.

Fig. 2 presents estimated conventional monetary policy shocks in the US and the EA. Their sign and size do not necessary coincide with their counterparts in anticipated and unanticipated interest rate changes presented in Fig. 1 since the latter may result from conventional policy responses to changing macroeconomic conditions approximated by the Taylor rule. In particular, years 2007 and 2008 saw strong interest rate drops in both large economies. This notwithstanding, some of the anticipated decreases in short-term rate were too small given how severely economic outlook deteriorated at that time. Therefore, anticipated shocks were contractionary (positive).

On the other hand, small shocks after 2010 reflect broadly stable interest rates in the US and the EA in this period. This coincidence results from the central banks' forward-looking communication that steered well agents' expectations as well as from our identification procedure that explicitly accounts for the ELB period in the US. Our finding for this particular episode is somewhat in contrast to results from other monetary policy shock identification schemes in the literature that often find relatively higher volatility of conventional policy shocks at that time.

Nevertheless, unanticipated shocks, i.e. the ones that are the closest to the standard policy surprises, are in general in line with their counterparts obtained in other papers and the ones that could be inferred from the historical narrative. In particular, in case of the US, unanticipated surprises are strongly accommodative in the first half of 2001 when the Fed eased monetary policy amidst the end of the dot-com bubble and geopolitical uncertainty. This is consistent with corresponding Fed surprises derived by Swanson (2021) and Jarociński and Karadi (2020) that are also strongly accommodative in this period. Similarly, in both 2007q4 and 2008q1 unanticipated negative surprises are in line with their counterparts in Swanson (2021). Overall, the correlation between US unanticipated shocks and the ones obtained by Swanson (2021) is 0.47 pointing to a strong comovement of these two series.

As far as the euro unanticipated shocks are concerned, they also seem to correctly indicate the monetary policy stance. First, from 2003 to 2006 unanticipated shocks are hardly volatile reflecting relative economic stability and associated monetary policy predictability. This pattern is in line with Altavilla et al. (2019) timing shock that is also relatively stable in this period. Furthermore, accommodative (negative) unanticipated surprises from 2008q4 to 2011q4 are in line with relatively low values taken by timing shocks from Altavilla et al. (2019) and surprise policy shocks from Jarociński and Karadi (2020).

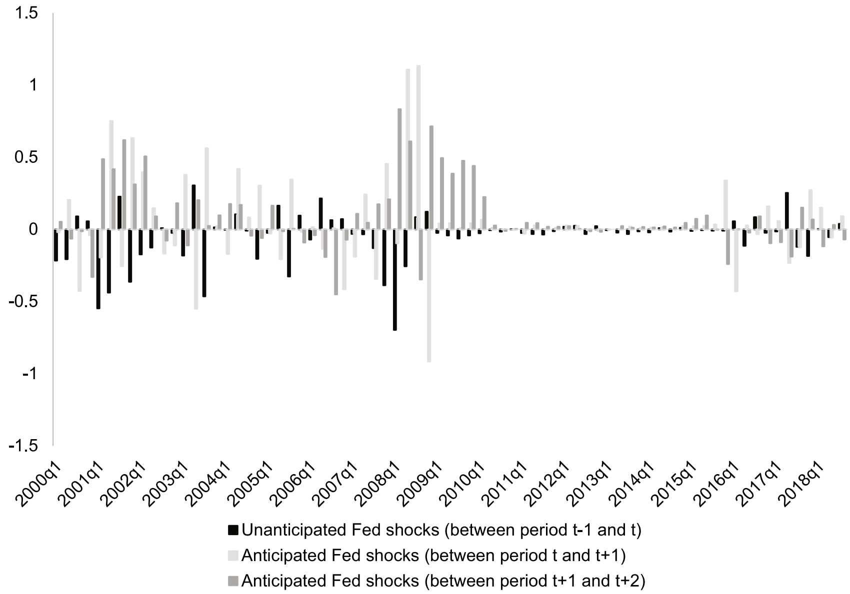
Overall, we conclude that the identified shocks fit in the narrative about the monetary policy stance in the US and the EA since 2000 and are broadly in line with what other authors find. Nevertheless, they also have some particular unique features that make the analysis of their impact on EMEs interesting.

2.3. US and EA responses to monetary shocks

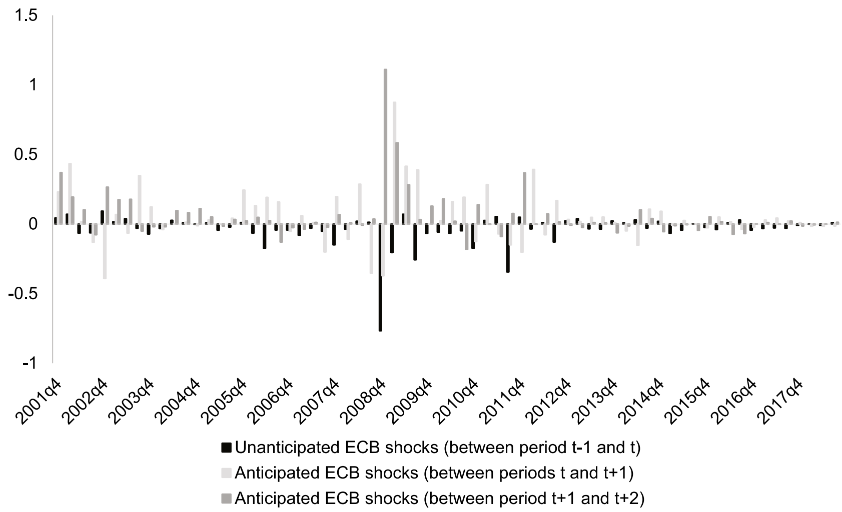
Before assessing how monetary policy shocks in the US and the EA propagate to the emerging economies, we investigate their impact on domestic business cycles. This step serves as an additional validation test for shocks that we computed in Section 2.2 and allows us to better understand their transmission. To this end, we estimate two BVAR models with Minnesota priors, one for the US and one for the EA, in which endogenous variables comprise of GDP, prices and interest rate spreads. In our estimations, we include as the exogenous variables both unanticipated and anticipated domestic monetary policy shocks, oil prices and the linear trend. In the model for the EA the set of exogenous variables contains additionally US GDP to control for the foreign economic activity and VIX index as an indicator of market uncertainty.[3]

GDP in the model is measured as the log of seasonally adjusted real GDP. As a measure of prices, we use the log of HICP for the EA and the log of CPI for the US. In order to capture tensions in financial markets, the set of our endogenous variables includes the interest rate spreads: BAA corporate spread in the model for the US and the difference between 10-year government bond yields of Italy and Germany in the model for the EA. The EA variables are taken from Eurostat and their US counterparts come from Fred.

[3] Adding VIX to the US BVAR model results in the model instability and hence this index is not included in the baseline specification.



(a) Fed shocks



(b) ECB shocks

Fig. 2. Conventional monetary policy shocks.

Using the Deviance Information Criterion (DIC) (see Spiegelhalter et al., 2002), we set the number of lags included in the model to two. The posterior distributions of the model coefficients are approximated using Gibbs sampler. From the generated sequence of 110 000 draws, the first 10 000 replications are dropped. In order to ensure that the draws used to simulate posterior distributions are not autocorrelated, only every 100th draw is kept. Therefore, the final estimates are based on 1000 Gibbs replications.

Fig. 3 depicts the 16th, 50th and 84th percentiles of the posterior distributions of the impulse responses to the 1 p.p. contractionary unanticipated and anticipated conventional monetary policy shocks in the US and the EA. The responses of output and prices are mostly negative, in line with the common sense and the results from previous studies (see, e.g. Maćkowiak, 2007; Jarociński, 2010). The only exception is the one-period ahead Fed anticipated shock which resembles the central bank information shock described in Jarociński and Karadi (2020) and leads to higher output and price level. The intuitive and statistically significant responses assure us that our identification strategy brings about reasonable shock estimates.

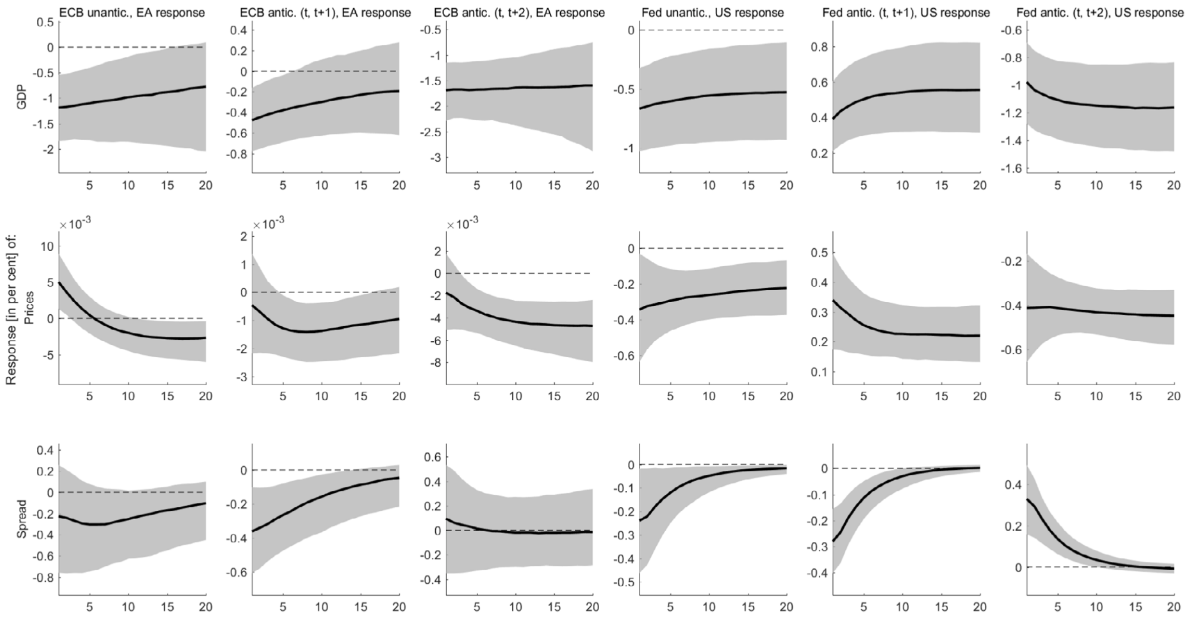


Fig. 3. Impact of Fed and ECB shocks on the business cycles in the US and the EA.

Importantly, the conclusions about the contractionary role of the identified monetary policy shocks are robust to changes in the model specifications, such as dropping the linear trend or VIX index, as well as replacing headline CPI/HICP with core CPI/HICP and simultaneously excluding oil prices. Moreover, the results from the BVAR model for the US economy do not change if we control for proxies of the foreign economic activity (GDP of the EA or GDP of OECD countries excluding the US).

3. Policy spillovers

Having identified the US and the EA monetary shocks both in unanticipated and anticipated interest rate changes, we move to the analysis of their impact on business cycles in EMEs. First, in Section 3.1 we present our modelling framework that follows Jarociński (2010). Second, we describe the data in Section 3.2. Third, in Section 3.3 we discuss the main result of the paper, i.e. the reactions of main macroeconomic variables in EMEs to ECB and Fed conventional policy shocks.

3.1. Empirical model

In order to assess monetary policy spillovers we use the random effect panel BVAR model with a hierarchical prior (see e.g. Jarociński, 2010; Dieppe et al., 2016). In contrast to the standard panel models, this framework allows for the cross-subsectional heterogeneity, i.e. the VAR coefficients and residual variances are unit-specific. At the same time, the model coefficients are assumed to be similar across the panel since they are drawn from a distribution with similar mean and variance. Common mean and variance are random variables, and therefore have their own prior and posterior distributions. More precisely, we consider the following model:

$$y_{c,t} = A_c^1 y_{c,t-1} + \cdots + A_c^p y_{c,t-p} + C_c w_t + e_{c,t} \tag{7}$$

where $y_{c,t}$ is a vector of n endogenous variables, w_t is a vector of m exogenous variables common for all units, $e_{c,t}$ is a vector of VAR innovations which are i.i.d. $N(0, \Sigma_c)$, p denotes number of lags, $c = 1 \ldots$ C stands for country c, and $t = 1 \ldots$ T denotes time period.

We define a vector $x'_{c,t} = [y'_{c,t-1} \ldots y'_{c,t-p} w'_t]$, stack vertically $y'_{c,t}$ and $x'_{c,t}$ for all t to obtain:

$$Y_c = X_c B_c + E_c \tag{8}$$

and then rewrite the model in the vectorized form:

$$y_c = \bar{X}_c \beta_c + e_c \tag{9}$$

where $y_c = vec(Y_c)$, $\bar{X}_c = \left(I_n \otimes X_c\right)$, $\beta_c = vec(B_c)$, $e_c = vec(E_c)$ and is i.i.d. $N(0, \bar{\Sigma}_c)$ with $\bar{\Sigma}_c = \Sigma_c \otimes I_T$.

For the error variances we assume the standard diffuse priors:

$$\pi(\Sigma_c) \propto |\Sigma_c|^{-\frac{n+1}{2}} \tag{10}$$

and the coefficients in β_c are assumed to be drawn from normal distribution with a mean $\bar{\beta}$ common for all units in the panel and common variance Σ_b, i.e. $\beta_c \sim N(\bar{\beta}, \Sigma_b)$.

For $\bar{\beta}$ we use the non-informative uniform hyperprior:

$$\pi(\bar{\beta}) \propto 1 \tag{11}$$

and the covariance matrix Σ_b is given by:

$$\Sigma_b = \left(\lambda_1 \otimes I_q\right) \Omega_b \tag{12}$$

where q is a number of coefficients to be estimated for a given unit, $q = n(np + m)$, λ_1 determines the overall tightness of the prior and is treated as a random variable, and Ω_b is a diagonal matrix of dimension $q \times q$ in which:

- elements which control the variance of the prior for parameters relating ith endogenous variable to its own lth lag are given by:

$$\sigma^2_{b_{ii}} = \left(\frac{1}{l^{\lambda_3}}\right)^2 \tag{13}$$

- elements which control the variance of the prior for parameters relating ith endogenous variable to the lth lag of the jth variable are given by:

$$\sigma^2_{b_{ij}} = \left(\frac{\sigma_i^2}{\sigma_j^2}\right)\left(\frac{\lambda_2}{l^{\lambda_3}}\right)^2 \tag{14}$$

- elements which control the variance of the prior for parameters relating to exogenous variables are given by:

$$\sigma^2_{c_i} = \sigma_i^2 \left(\lambda_4\right)^2. \tag{15}$$

The parameters σ_i and σ_j control for the differences in the size of coefficients on variables i and j and are calculated as the standard errors from autoregressive models fitted by OLS and estimated for each of the endogenous variable on the pooled data from all units.

For the prior for parameter λ_1 we choose the inverse Gamma distribution:

$$\lambda_1 \sim IG(s/2, v/2) \tag{16}$$

The values of the parameters of prior distributions are set based on the VAR literature, see, e.g. Canova (2007) and Dieppe et al. (2016). Hence, λ_2 is set to 0.5, λ_3 to 1, λ_4 equals 100 and s and v amount to 0.001.

3.2. Data

We consider two panels. The first one comprises a number of EMEs for which appropriate time series are available: Brazil, Chile, Colombia, Indonesia, Mexico, Philippines, Russia, South Africa and Turkey. The second consists of three CEE countries: Poland, Czechia and Hungary. Other countries from this region are excluded from the analysis either due to their currency regimes (currency boards in the Baltic countries) or limited data availability.

We use quarterly data in estimation. The sample spans the period from 2001 Q4 to 2018 Q3, which gives 68 observations for each country in the panel. We estimate the model using the Bayesian Estimation, Analysis and Regression toolbox (BEAR) presented in Dieppe et al. (2016).

In the model, there are four endogenous variables commonly used in the open economy monetary VAR models, i.e. output, prices, nominal effective exchange rate and domestic short-term interest rate. Our main focus is on the impact of contemporaneous Fed and ECB shocks that are exogenous variables in the system. Apart from them, we also control for the exogenous impact of external business cycle (lagged US GDP) that captures shifts in foreign demand, commodity (oil) prices that control for exogenous supply shocks, VIX that accounts for shifts in global risk perception, as well as the time trend since we estimate BVAR models in levels.

Similarly to the US and the EA BVAR estimations, GDP is measured as the log of seasonally adjusted real GDP. As a measure of prices, we use the log of HICP for CEE countries and the log of CPI for EMEs. Output and prices are taken from Eurostat (CEE countries), IMF International Financial Statistics and OECD (EMEs) databases. The nominal effective exchange rates for all countries come from the BIS statistics. Finally, as the short-term interest rates we use 3-month money market interest rates from Eurostat (CEE countries) and OECD (EMEs) datasets. Basing on DIC criterion, we estimate the VAR model with two lags. We use the same number of draws from Gibbs sampler as in country BVAR estimations (see Section 2.3).

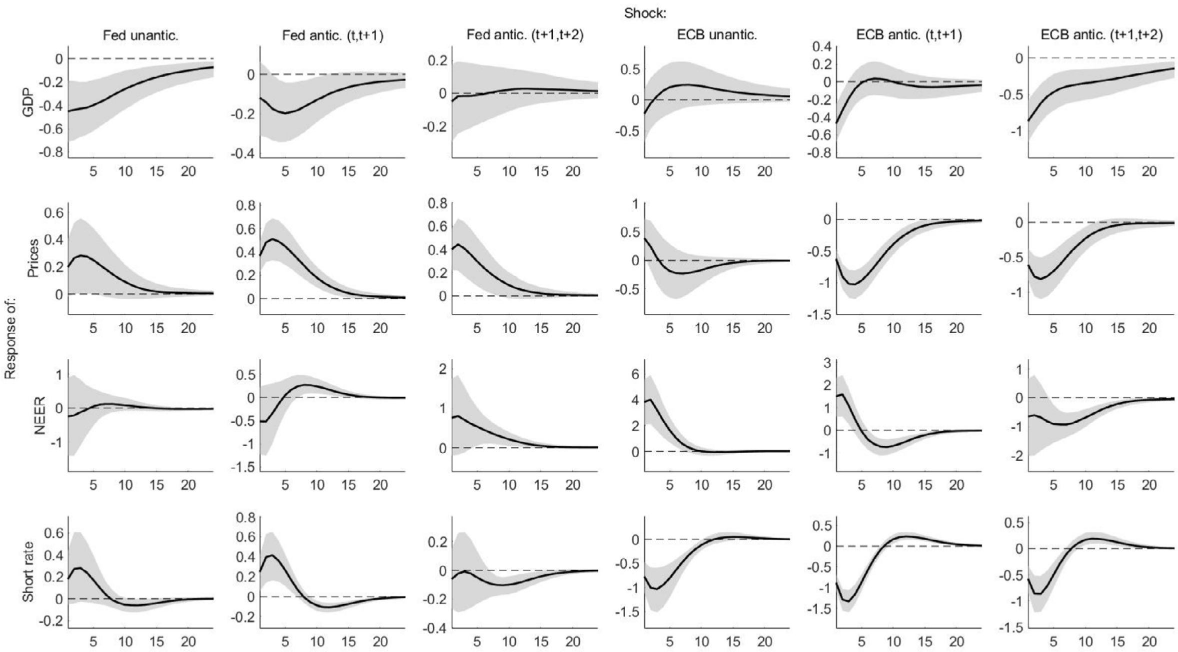


Fig. 4. Fed and ECB shocks in Emerging Market Economies (excluding CEE).

3.3. Results

Figs. 4 and 5 present the main result of the paper — the 16th, 50th and 84th percentiles of the posterior distributions of the impulse responses to the Fed and ECB interest rate shocks, derived from the mean model for each panel, i.e. the model implied by the mean parameters $\bar{\beta}$ (see Section 3.1).

Starting with responses of EMEs, we observe that the US contractionary interest rate shocks (by 1 p.p.) result in declining GDP and increasing prices (Fig. 4). These results are in line with Vicondoa (2019) who investigated impact of similarly-defined Fed policy shocks on another panel of EMEs. One plausible explanation for rising prices amidst output contraction, that has been proposed in the earlier literature, is EMEs' currency depreciation. This effect is also present in our estimation, even though it is statistically insignificant.

Furthermore, the two-period ahead Fed anticipated shock turns out to be of lesser statistical importance for EMEs. This result may be driven by substantial responses of these countries to ECB anticipated disturbances, and in particular to the ECB two-period ahead shock. Interestingly, ECB anticipated shocks are contractionary for both GDP and prices in EMEs.

Next, we analyse CEE responses to foreign monetary policy shocks (Fig. 5). In contrast to other EMEs, GDP in this group seems not to react significantly to Fed policy. At the same time, the ECB policy turns out to be contractionary. This regards particularly two-period ahead anticipated policy disturbances that are significant also for other EMEs. As far as prices in CEE are concerned, ECB policy shocks tend to lead to the depreciation of nominal effective exchange rate and increasing prices, while their Feds' counterparts — to currency appreciation and lower prices. Thus, CEE economies react to ECB policy similarly to how other EMEs respond to Fed shocks (lower GDP, higher prices, currency depreciation). This shows that in the context of conventional monetary policy, the ECB seems to be the main foreign central bank for CEE economies.

Summing up, adding ECB shocks to the panel regressions for EMEs sheds new light on policy spillovers from advanced economies. It turns out that not only Fed but also ECB policy has global effects. This result is obtained from the panel regression that does not include CEE countries, thus, if anything, it underemphasizes the global role of the ECB monetary policy. Furthermore, panel regression for the CEE economies shows that the ECB is the main foreign central bank for countries that are tightly linked (both in terms of trade and financial bonds) to the EA.

4. Conclusions

This paper investigates the conventional monetary policy spillovers of the ECB and the Fed to EMEs. To this end, we first identify anticipated and unanticipated monetary policy shocks of the Fed and the ECB explicitly accounting for the effective lower bound episodes.

We use the future contracts and swap rates to calculate the anticipated and unanticipated changes in the Fed and ECB short-term interest rates. Next, we assume that the central banks follow Taylor rules while conducting their monetary policy and estimate the

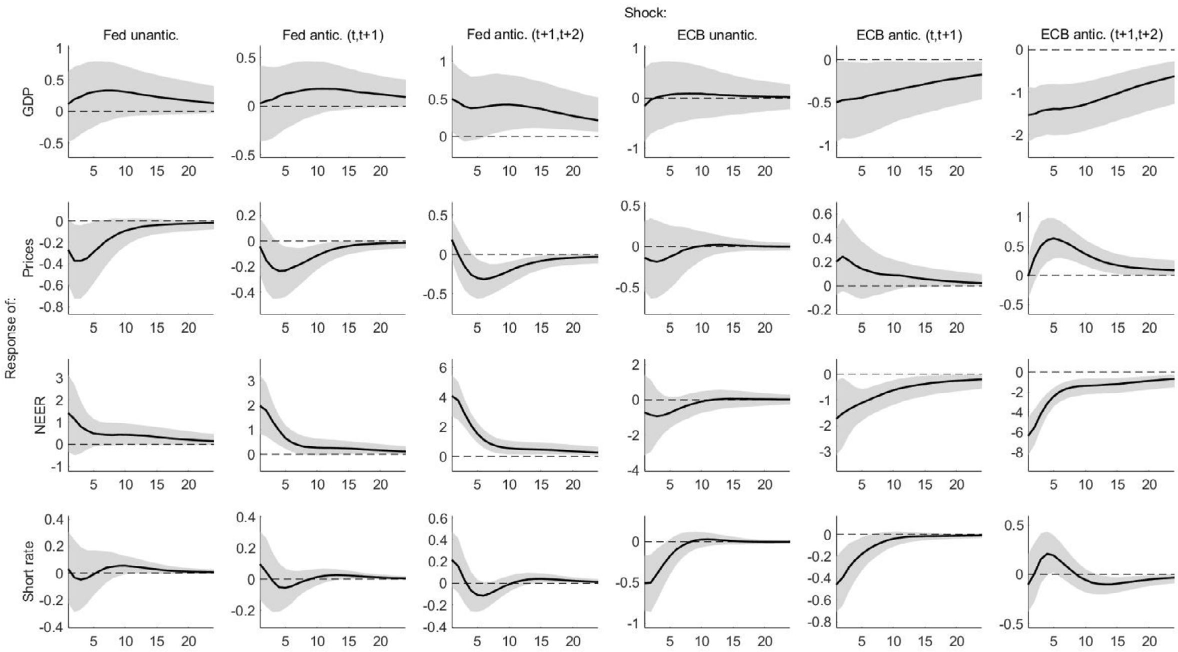


Fig. 5. Fed and ECB shocks in the Central and Eastern Europe.

coefficients of such rules on the long historical samples. We then take the results of these estimations together with the survey data on market expectations about GDP, inflation and unemployment and use them to calculate the anticipated and unanticipated policy shocks in both economies. Finally, we show that the latter have plausible, mostly contractionary impacts on the business cycles in the US and the EA.

In the final step, we estimate the Bayesian random effect panel VAR models with hierarchical priors for two groups of countries: nine EMEs other than CEE countries and three CEE economies. In each model, we include the previously identified Fed and ECB policy shocks as exogenous variables. Overall, we find that both the Fed and the ECB play an important role for the global business cycle since the monetary policies of both central banks significantly spill over to the EMEs. Moreover, the CEE countries, which have strong trade and financial linkages with the EA, turn out to be affected more significantly by the conventional monetary policy of the ECB than by the one of the Fed.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Sensitivity analysis

The appendix presents two robustness exercises which we perform to assess the reliability of the key results and check to which extent our findings are driven by the specific modelling choices. It complements the sensitivity analysis of the US and EA BVAR models reported in Section 2.3.

Alternative samples used to estimate Taylor rules. The shock identification strategy in the paper is based on the assumption that both the Fed and the ECB follow the Taylor rules, see Section 2.2. The parameters of these rules in our baseline model are estimated using the sample from 1960 Q3 to 2008 Q4 for the US and from 1970 Q1 to 2012 Q4 for the EA. To account for different monetary policy regimes over these periods, we estimate the Taylor rules using shorter samples, starting in 1980 Q1 and 1990 Q1, respectively. Additionally, we run estimations using the samples extended with the recent periods, i.e. ending in 2018 Q3. The results of such estimations are presented in Table A.1.

Table A.1
Estimates of Taylor rule parameters: baseline vs alternative samples.

Response to:	Formula	ECB				Fed			
		1	2	3	4	1	2	3	4
lagged interest rate	$\hat{\gamma}_r$	0.94	0.95	0.96	0.94	0.93	0.93	0.95	0.92
inflation	$\frac{\hat{\gamma}_\pi}{1-\hat{\gamma}_r}$	1.18	1.75	2.87	1.36	1.84	1.80	1.11	1.52
output growth	$\frac{\hat{\gamma}_y}{1-\hat{\gamma}_r}$	1.31	1.54	1.99	0.68	1.40	2.04	1.79	1.09
unemployment	$\frac{\hat{\gamma}_u}{1-\hat{\gamma}_r}$	−0.22	−0.45	−0.86	−0.18	−1.17	−1.29	−1.14	−0.72

Notes: Based on the data from the periods: (1) US: 1960Q3-2008Q4, EA: 1970Q1-2012Q4 (baseline sample); (2) US: 1980Q1-2008Q4, EA: 1980Q1-2012Q4; (3) US: 1990Q1-2008Q4, EA: 1990Q1-2012Q4; (4) US: 1960Q3-2018Q3, EA: 1970Q1-2018Q3.

Table A.2
Correlation coefficients between.

	ECB			Fed		
	1	2	3	1	2	3
s^u_t	1.00	0.99	0.99	0.96	0.81	1.00
$s^a_{t,t}$	1.00	0.99	1.00	0.99	0.84	1.00
$s^a_{t,t+1}$	1.00	1.00	1.00	0.99	0.96	0.97

Notes: Correlation coefficients between shocks based on the baseline Taylor rule estimates and shocks based on the Taylor rules estimated using data from the periods: (1) US: 1980Q1-2008Q4, EA: 1980Q1-2012Q4; (2) US: 1990Q1-2008Q4, EA: 1990Q1-2012Q4; (3) US: 1960Q3-2018Q3, EA: 1970Q1-2018Q3.

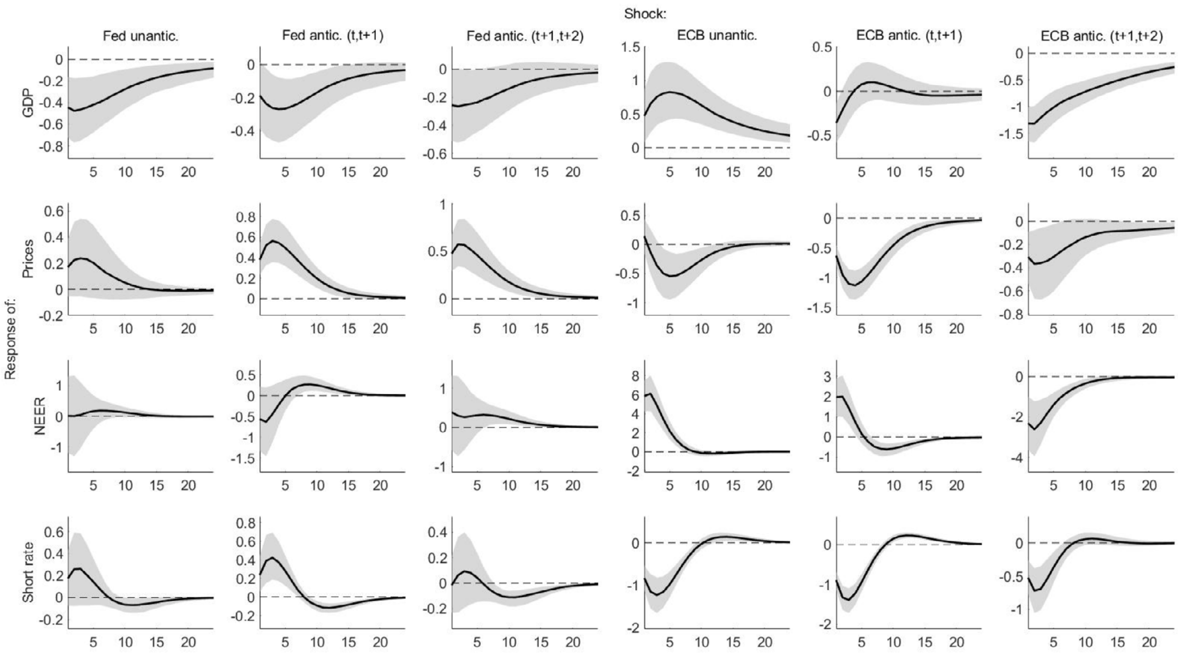

Fig. A.1. Fed and ECB shocks in Emerging Market Economies (excluding CEE): model excluding the VIX index.

Table A.2 presents the correlation coefficients between our baseline shocks and the respective shocks calculated using the alternative Taylor rule estimates. The presented correlation measures are very high and point to a very close comovement of the respective series. Hence, we conclude that the results presented in the main part of our paper are robust to changes in the data samples used to estimate the central banks' Taylor rules.

Alternative panel BVAR models specification. In the baseline specification of our panel BVAR models, the set of exogenous variables includes the VIX index as a measure of market uncertainty. The comparison of Figs. 4–5 and Figs. A.1–A.2 suggests that inclusion of this variable is not key for our results. The exclusion of VIX barely changes the impulse responses to ECB and FED monetary policy shocks both in EMEs and CEE countries.

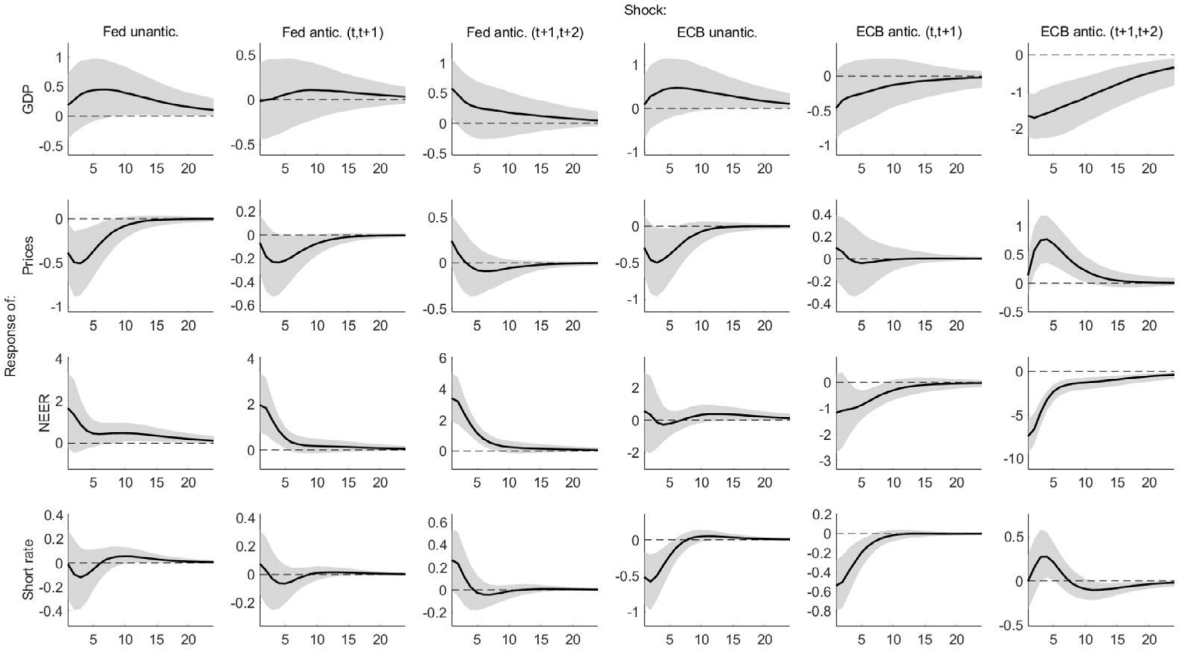

Fig. A.2. Fed and ECB shocks in the Central and Eastern Europe: model excluding the VIX index.

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