INTERNATIONAL MONETARY FUND

ECB Spillovers to Emerging Europe: The Past and Current Experience

Philipp Engler, Gianluigi Ferrucci, Pawel Zabczyk, and Tianxiao Zheng

WP/24/170

2024
AUG

WORKING PAPER

 WP/24/170

IMF Working Paper
European Department

ECB Spillovers to Emerging Europe: The Past and Current Experience

Prepared by Philipp Engler, Gianluigi Ferrucci, Pawel Zabczyk, and Tianxiao Zheng*

Authorized for distribution by Romain Duval
August 2024

ABSTRACT: We provide new evidence on the spillover effects of ECB monetary policy shocks to emerging European economies, using a combination of empirical methods and model-based simulations and focusing on spillovers from interest rate and balance sheet policies implemented by the ECB. We consider an event study set around the ECB policy announcement in June 2022 and also use local projections to estimate regional spillovers in a panel of 16 Emerging European countries spanning 1999 to 2022. Identifying ECB monetary policy shocks as the unexplained component of changes in the three-month Euribor futures rate, we find that ECB monetary policy tightening induces more than one-for-one changes in government bond yields in Emerging Europe, as well as sizable increases in sovereign spreads, domestic currency depreciations, and significantly lower output. Model simulations using a two-country DSGE calibrated to the euro area and its Eastern European neighbors reveal that a conventional tightening, achieved through interest rate increases, provides a more favorable inflation-output trade-off compared to balance sheet tightenings. The extent of spillovers from quantitative tightening depends on the speed of balance sheet reduction, and it is larger under a fixed exchange rate regime.

JEL Classification Numbers:	E52; E58; F42.
Keywords:	Monetary Policy; Quantitative Easing; International Spillovers
Authors' E-Mail Addresses:	PEngler@imf.org; GFerrucci@imf.org; PZabczyk@imf.org; TZheng@imf.org

* The views expressed in this paper are those of the authors and do not necessarily represent the views of the IMF, its Executive Board, or its management. We are indebted to Marcin Kolasa for his helpful inputs, comments and discussions. We would also like to thank Claire Yi Li and Ben Park for outstanding research assistance, as well as Gabriel Di Bella, Romain Duval, Christopher Erceg, Alexandra Fotiou, Andre Geis, Fazurin Jamaludin, Andy Levin, Tonny Lybek, Giacomo Magistretti, Gabor Meizer, Florian Misch, Alberto Musso, Vina Nguyen, Magali Pinat, Carlo Pizzinelli, Andrea Presbitero, Sebastian Weber, Grzegorz Wesolowski, and seminar participants at the IMF for their insightful comments.

Table of Content

1. Introduction

This paper studies cross-border spillovers of European Central Bank (ECB) monetary policy to the macroeconomic and financial conditions of emerging European economies. Faced in late 2021 with a global surge in inflation starting not seen since the 1970s, many central banks in advanced economies, including the ECB, took steps to normalize policy after a prolonged loose stance. Monetary tightening in major economies can have major repercussions for emerging economies, including capital outflows and currency depreciation, broader financial market stress, and tighter financial conditions. In turn, weaker external demand and tighter financial conditions can slow economic growth.

A large body of literature has investigated the international transmission of US monetary policy, but only few studies have focused on the spillover effects of ECB policies, and their results vary. Notable exceptions are Ca'Zorzi et al. (2020), Colabella (2021), Geis et al. (2020), Moder (2017 and 2021) and Sahay et al. (2014). Bergant et al. (2020) discuss spillovers from the ECB's asset purchase program through international portfolio rebalancing effects. In an empirical investigation of spillovers from the balance sheet policies of the US Federal Reserve (Fed) and the ECB, Ledóchowski and Żuk (2022) find that a balance sheet expansion by the Fed translates into higher portfolio capital inflows into emerging economies, whereas portfolio capital flows to emerging economies, including European ones, do not seem to react to balance sheet policies conducted by the ECB. Walerych and Wesołowski (2021) provide evidence that the international spillovers of both Fed and ECB conventional monetary policies to emerging economies are global, affecting all economies. Moreover, they find that the ECB is the most impactful foreign central bank for economies in Central and Eastern Europe.[1] Using a two-country DSGE setting, Kolasa and Wesolowski (2020) find that foreign quantitative easing depresses output in the short run in a small open economy, because the positive effect on domestic demand is more than offset by the negative one from loss of international price competitiveness. This contrasts with conventional monetary easing abroad, which has positive spillovers along both dimensions and thereby increases output in other countries.

In this paper, we contribute to this literature using both empirical and model-based approaches. First, we analyze the transmission of ECB monetary policy shocks to emerging European economies using daily data and an event study set around the policy announcement of June 2022, as well as using quarterly data and a local projection method over a long time period. The former sheds light on spillovers to financial variables while the latter primarily provides insight into responses of macroeconomic variables, including quarterly output. Second, we discuss spillovers from conventional (i.e., interest rate-based) and unconventional (i.e., balance-sheet-based, with a focus on quantitative tightening) policies employing a DSGE model featuring financial frictions and segmented asset markets.

Starting from the beginning of 2023, the ECB has been unwinding the large balance sheet it had accumulated following the great financial crisis and the European sovereign debt crisis, and then again during the Covid-19 pandemic. The combination of interest rate and balance sheet policies in the most recent tightening episode

[1] More specifically, after controlling for the ECB's monetary policy, Fed policy changes play a very moderate role in driving GDP and prices in Central and Eastern European economies.

raises important questions regarding the comparative international transmission and spillovers from the two types of policies, such as whether the type and composition of the tightening strategy pursued by the ECB, the pace of quantitative tightening, and the strength of fundamentals and policy frameworks in the recipient countries could shape spillovers to emerging European economies. As quantitative tightening is unchartered territory, with few historical episodes that could be studied to understand its effects, the recent tightening episode may offer only limited insights. For this reason, we additionally simulate a two-country open economy model calibrated to mimic the euro area and a stylized emerging European economy (see also Appendix II for an overview of the parameter values used).

Our empirical analysis covers sixteen emerging economies in Europe. In particular, we study the effects of ECB monetary policy on their domestic policy rates, government bond yield curves, exchange rates, as well as on output, inflation, and unemployment. The choice of variables is motivated by the fact that spillovers may arise through various channels. For instance, central banks in emerging economies may raise interest rates in response to monetary tightening in advanced economies in consideration of domestic inflation and foreign funding costs. Higher domestic interest rates would slow down demand, exerting downward pressure on output and inflation. Changes in ECB monetary policy may also spill over to emerging economies through trade linkages, in the form of lower external demand for traded goods and services following monetary tightening, or via exchange rate adjustment and financial channels.

We begin our analysis by conducting an event study focusing on the June 2022 ECB policy announcement. On this occasion, the ECB announced its intention to hike interest rates at the next Governing Council meeting in July 2022, marking the start of a tightening cycle that financial market participants had not anticipated. We then develop a statistical model to systematically analyze the spillovers of ECB monetary policy to emerging European economies over a long time period. To identify shocks from ECB monetary policy, we use the three-month Euribor futures rate, which has been shown to be an unbiased and reliable predictor of changes in the euro area policy rate. We then employ the local projections method to estimate impulse responses of key macroeconomic variables in recipient countries to ECB monetary policy changes. Our results show that ECB tightening generates strong spillovers to emerging Europe. The drop in real output reaches 0.5 percent after two years following an ECB monetary tightening shock. Domestic currencies depreciate, together with larger than one-for-one increases in government bond yields and sizable increases in sovereign spreads of up to 60 basis points. Furthermore, our analysis indicates that country fundamentals matter decisively for spillover size, with weaker fundamentals associated with larger effects.

Next, focusing on the recent ECB policy tightening episode, including the announced pace of balance sheet reduction, we apply a two-country DSGE model with financial frictions based on Erceg et al. (2020). To that effect, we first tailor the model to the euro area and its Eastern European neighbors, calibrating shocks driving the recent business cycles, inflation and explicitly accounting for ECB policy actions. We then use the DSGE model to run simulations, which reveal that the pace and composition of the ECB's monetary policy tightening play a critical role in determining the magnitude of spillovers. In particular, the simulations show that spillover effects are more manageable when quantitative tightening (QT) proceeds at a measured and predictable pace, but can become destabilizing if the pace of QT is accelerated. Notably, the adverse spillover effects from tighter ECB monetary policy tend to be more pronounced under a fixed exchange rate regime than under an inflation

targeting regime with a freely floating currency. This holds true both for both conventional and a mix of conventional and unconventional monetary policy tightening.

We also find that conventional tightening achieved through interest rate hikes engenders a more favorable trade-off between inflation and output compared to a balance sheet tightening, especially in terms of spillovers to the emerging European economy. This result reflects the much larger impact of ECB QT on the emerging European economy's long-term rate and, therefore, on its aggregate demand and ultimately on output. Additionally, inflation in the emerging European economy rises under ECB QT due to the sharp depreciation of the foreign exchange rate.

Such model-based simulations find a strong correspondence in our historical empirical analysis, which reveals that economies with a flexible exchange rate regime, including Albania, Hungary, and Poland, were generally better able to cope with the adverse consequences of the ECB tightening. In contrast, countries with pegged currencies such as Bosnia and Herzegovina, and Bulgaria, as well as outright euroized economies such as Kosovo and Montenegro, faced greater challenges. Furthermore, our empirical analysis supports the notion that strong reserve buffers and strong fundamentals, e.g., in the form of lower financing needs, act as mitigating factors for spillovers.

The remainder of this paper is organised as follows. Section 2 discusses the main channels of monetary policy spillovers. Section 3 describes the data and presents the empirical analysis. Section 4 presents the structural model, while its key insights are discussed in Section 5. Section 6 concludes.

2. Channels of Monetary Policy Spillovers

Monetary policy from an originating country can influence a range of policy, financial and macroeconomic variables in recipient countries. We begin our analysis by documenting the key channels through which monetary policy in the “foreign” jurisdiction – in this case identified with the euro area – may spill over to (“home”) economies in emerging Europe. Depending on the mandate of the central bank, monetary policy may respond to domestic macroeconomic conditions, such as inflation, unemployment, or the output gap, while in some instances, exchange rate considerations can also be significant. In open economies characterized by strong business cycle co-movements with the foreign economy, on account of tight trade or financial linkages, say, monetary policy may also react to shifts in the foreign monetary policy stance. Emerging European countries closely linked to the euro area are a case in point. To fix attention, we focus on four main channels through which the monetary policy of the ECB can affect recipient countries in emerging Europe.[2]

The first channel highlights the *monetary policy response* in the recipient country and domestic monetary policy transmission. Monetary policy cycles are increasingly synchronized worldwide. As the pace of tightening accelerates in advanced economies, central banks in emerging economies may also raise interest rates, considering both external and domestic macroeconomic conditions. The bank lending channel of monetary transmission, as conceptualized by Bernanke and Blinder (1988), highlights how monetary tightening reduces

[2] For an extensive discussion of these channels, see Ammer et al. (2016).

lending by draining liquidity and deposits from the banking system.[3] Contrary to conventional wisdom, this implies that greater reliance on market-based funding enhances the importance of the channel and that banks can either absorb or amplify shocks originating in the financial system, depending on the strength of their balance sheets. Rising interest rates also impact asset prices, as well as the saving and investment decisions of households and firms. This results in reduced consumption and investment, which in turn slows down domestic demand for goods and services, ultimately leading to looser labor market conditions and downward price pressures.

The second channel focuses on the *exchange rate*. Most emerging European economies are open, with flexible exchange rates playing a critical part of monetary transmission. A surprise tightening of ECB monetary policy relative to that in emerging Europe strengthens the euro, leading to a depreciation of the currency of the recipient country, all else being equal. A weaker exchange rate typically increases the cost of imports, and it fuels inflation. However, that effect is counterbalanced by the fact that a currency depreciation enhances export competitiveness, boosting net exports and resulting in stronger aggregate demand. A weaker domestic currency also implies higher debt servicing costs when external debt is denominated in foreign currency, leading to tighter financing conditions at home. Notably, among emerging European economies, Hungary, Poland, and Türkiye exhibit high proportions of foreign currency-denominated external debt (see Ahmed et al., 2021).[4] In some cases, these foreign currency (gross) positions may be partially hedged, e.g., through financial instruments, holdings of foreign currency-denominated assets offsetting liabilities, and foreign currency invoicing. However, to the extent that they are not hedged fully, a depreciating currency may still weaken borrowers' and lenders' balance sheets and restrict their ability to borrow and extend credit.[5]

The third channel works through *foreign trade*. Changes in the monetary policy of the originator country influence the saving and investment decisions of its households and firms. All else being equal, an increase in the policy rate depresses household consumption and firm investment thereby reducing the demand for traded goods and services in recipient economies. Lower external demand subsequently translates into downward pressure on inflation and output growth.

The fourth channel, the *bond risk premium and financial channel*, captures the effects of the rise of long-term yields in the euro area that typically accompanies tighter ECB monetary policy. With globally integrated capital markets, movements in euro area long-term yields and term premia can impact their counterparts in emerging European economies.[6] This can occur, for instance, through international portfolio flows seeking higher yields. Spillover effects may also emerge due to the presence of global intermediaries operating subject to relevant

[3] Bernanke (2007) and Disyatat (2011) later reformulated this channel, emphasizing that it operates primarily through the impact of monetary policy on banks' balance sheet strength and risk perception.

[4] As discussed, for example, in Brandao et al. (2020) and the references therein.

[5] Emerging economies have significantly shifted their borrowing practices since the 1990s, when vulnerabilities stemming from currency mismatches, often referred to as the "original sin", were far more common and pronounced than they are today. However, pockets of vulnerability remain, as discussed, for example, in Ahmed et al. (2021) and Caldara et al. (2022). Relatedly, Pienkowski (2023) documents large sectoral and non-resident foreign currency mismatches in Türkiye.

[6] The financial spillovers channel has been the subject of particularly active research in recent years, including Borio and Zhu (2012), Rey (2015), and Morris and Shin (2014), among others.

risk constraints. Depending on the degree of financial integration, the effects of monetary policy spillovers on the yield curve in recipient economies may vary in intensity between the short and long ends.

The overall impact of ECB monetary policy on emerging European recipient economies will depend on the relative strength of the channels mentioned above. Furthermore, the spillover effects are likely to differ across recipient economies reflecting various country-specific features, such as the exchange rate regime, the degree of trade openness, the currency of invoicing of foreign trade, financial depth, and financial vulnerabilities to currency depreciation (Ammer et al., 2016). As discussed in Kearns et al. (2023), for countries with fixed exchange rate regimes, or significantly euroized, exchange rate movements play a less significant role as a buffer to external shocks. Therefore, exchange rate movements may not be the dominant channel of transmission with monetary policy reactions and trade playing more prominent roles.[7]

Differences in the liquidity and structure of interbank money markets, and overall financial development are also likely to impact the transmission of foreign policy rates to the home economy (see IMF, 2008). An increase in nominal interest rates in advanced economies drains liquidity from emerging economies and often leads to capital outflows.[8] A shallow domestic financial market could magnify the negative impact of credit declines and generate more disruptions to real output. Conversely, market segmentation, limited access to financing, and the presence of dominant state banks may reduce transmission of policy rates to lending rates.[9]

The adoption of (flexible) inflation targeting, the degree of central bank independence, and the extent of central bank transparency also influence the transmission of interest rate shocks. By anchoring inflation expectations, monetary policy can guide economic agents' expectations of future inflation and, in turn, influence price developments. A central bank with a high degree of credibility can thus more effectively anchor price expectations and mitigate the adverse spillover effects of a foreign policy shock.[10]

3. Data and Empirical Analysis

In this section, we discuss the empirical strategy that we employ to assess the impact of the ECB's interest rate hikes on a range of financial asset prices and macroeconomic variables in emerging European economies. We start by outlining the dataset, which includes data at the daily frequency for the event study and quarterly data

7 Some emerging economies may also use foreign exchange intervention to cushion the response of exchange rates reinforcing capital flows and their effects on bond yields through movements in term premia (Blanchard et al., 2015; Adler et al., 2021).

8 Rey (2013) and Iacoviello and Navarro (2018) explore the mechanisms by which foreign lenders may become reluctant to extend credit to emerging economies when faced with high global interest rates, commonly referred to as the "financial channel" of monetary spillovers.

9 For example, Georgiadis (2015) finds that the magnitude of spillovers from US monetary policy to non-advanced economies is magnified when: (i) their industry structure is tilted towards the production of manufactured goods; and (ii) they are more integrated in global value chains while allowing only limited flexibility of their exchange rate. The paper also finds that financial integration is associated with larger spillovers if non-advanced economies have an inflexible exchange rate. Similarly, Edwards (2007) argues that financial integration is associated with stronger contagion effects.

10 Escayola et al. (2023) find that emerging economies with greater vulnerabilities in terms of: (i) exchange rate misalignment; (ii) the anchoring of inflation expectations; and (iii) US dollar-denominated foreign liabilities; have stronger responses to US monetary policy shocks. They show that the impact of such shocks can be mitigated by prudent domestic monetary policy in the recipient economies. In particular, when monetary policy at home is at least as tight as that implied by estimates of its central bank reaction function, spillovers are more limited, suggesting an important role for policy credibility in mitigating spillovers.

for the historical analysis. As alluded to previously, daily data, coupled with the event study, will serve to evaluate financial spillovers, while the quarterly dataset is employed to examine spillovers on macroeconomic variables. The modelling analysis of the ECB's quantitative tightening measures then follows in Section 4.

3.1. Data

We examine a dataset comprising sixteen emerging European economies.[11] For the event study, the dataset covers a twelve-week period, including daily data on high-frequency financial variables such as CDS spreads, government bond yields, and bilateral exchange rates vis-à-vis the euro. For the historical analysis, the dataset spans the period 1999Q1 to 2022Q4 and contains quarterly data on real GDP, the unemployment rate, bilateral nominal exchange rates against the euro, short-term policy rates, government bond yields at different maturities, and CDS spreads. Additional details regarding the country coverage and data sources utilized in each case are provided in Appendix I.

Data regarding ECB monetary policy shocks are inferred from the three-month Euribor futures rate. As shown by Bernoth and von Hagen (2004), this rate serves as an unbiased and reliable predictor of changes in the euro area policy rate. Following established literature, we proxy unanticipated changes in the ECB policy stance by examining unexpected fluctuations in the three-month Euribor futures rate. The next section will provide an in-depth account of our shock construction method.

An alternative approach to identify monetary policy shocks involves scrutinizing high-frequency intraday changes in the monetary market rate. In the euro area context, notable examples include the Euro Area Monetary Policy Event-Study Database (EA-MPD) developed and maintained by Altavilla et al. (2019). This database comprises intraday data concerning Overnight Index Swap (OIS) rates surrounding ECB Governing Council press releases and press conference windows. The OIS rates data cover various tenures, including 1, 3, 6 months, 1 to 10-, 15-, and 20-year maturities. We will later discuss why this methodology was not adopted in our analysis.

We incorporate a range of macroeconomic and structural variables to capture various country characteristics that may influence the transmission of monetary policy shocks. These variables encompass factors such as the exchange rate regime, level of financial development, official reserves, gross financing needs, and the type of monetary policy framework.

3.2. Event Study

We conduct an event study to assess the impact of the ECB's announcement of monetary tightening in June 2022. We select the outcome of the June Governing Council meeting as the core event for our study because it represents an unexpected and exogenous shift in monetary policy that financial markets had neither

[11] We follow the country classification of IMF (2022) and include the following economies in our analysis: Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Kosovo, Macedonia, Moldova, Montenegro, Poland, Romania, Russian Federation, Serbia, Türkiye, and Ukraine.

anticipated, nor priced in.[12] Expressed alternatively, while in June there were no immediate adjustments to the key ECB interest rates – these changes occurred later at the July meeting – the announcement of the ECB's intention to initiate a tightening cycle largely took financial markets by surprise, causing marked swings in financial asset prices (ECB, 2022).

Although the July 2022 announcement demarcated the actual start of the ECB's hiking cycle, we consider it less suitable for our event study because the interest rate hike had already been anticipated due to the pre-announcement in June, owing to which, asset price movements on the day of the press conference may have been confounded by other factors, such as the introduction of the Transmission Protection Instrument (TPI).[13] The next section evaluates the spillover effects of the ECB's tightening measures beyond June.

We begin by using daily data to conduct a "before and after" analysis in response to the June policy announcement of the ECB. More specifically, we scrutinize the responses of government bond yields at different tenures, as well as those of CDS spreads and the bilateral exchange rates against the euro. To isolate the impact of global and country-specific factors, we run the following Ordinary Least Square (OLS) regression, controlling for the countries' macroeconomic fundamentals and global risk factors, such as the CBOE VIX indicator of financial market volatility, U.S. equity prices, and oil price fluctuations. The regression equation is:

$$Y_{i,t} = \alpha + \beta\, ECB_{i,t}^{Dummy} + \delta ECB_{i,t}^{Dummy} * Z_i + \theta Q_t + I_i + \epsilon_{i,t}.$$

Here, $Y_{i,t}$ represents the respective endogenous variable of interest, while Z_i denotes country *i*'s structural features in the quarter before the ECB June meeting. These features include the reserves position, as well as measures of domestic financial development, the exchange rate regime, and gross financing needs. In addition, Q_t represents global risk factors and I_i denotes country fixed effects. For country *i*, a high (low) value of fundamental Z_i is identified as a value above (below) the median of the distribution across countries.

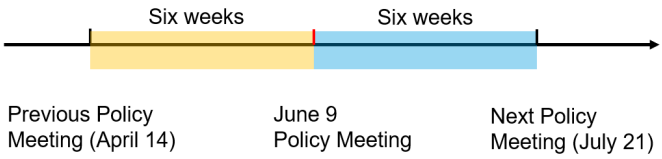
We then establish a twelve-week event window from $T_1 = -6$ to $T_2 = +6$, with $T_0 =$ June 9, which marks the day of the ECB Governing Council meeting, when the announcement of the upcoming monetary tightening was made. The six-week periods before and after the event correspond to the frequency of the regularly scheduled

[12] In June 2022, following a series of upside surprises in inflation and signals of broadening and intensifying price pressures, the Governing Council of the ECB announced several steps to normalize its monetary policy. First, it decided to end net purchases under its Asset Purchase Program (APP) as of July 1, 2022, while continuing to fully reinvest the principal payments from maturing securities in its APP portfolio. Second, it committed to continue reinvesting the principal payments from maturing securities purchased under the Pandemic Emergency Purchase Program (PEPP) "until at least the end of 2024". Third, it left the key ECB interest rates unchanged, but announced its intention to raise them by 25 basis points at its next monetary policy meeting in July, anticipating the expectation of further increases in September. As such, the June 2022 policy statement included elements of both conventional and quantitative tightening. It is worth noting that the latter may have been anticipated by financial markets, as the Governing Council had already signaled the intention to cease asset purchases "in the third quarter" at its previous meeting in April 2022. However, the event study is unable to differentiate the effects of the two announcements. In July 2022, the ECB raised interest rates by 50 basis points, marking the end of an eight-year period of negative interest rates and representing the first hike since 2011. The increase was also the largest since 2000. Additionally, the ECB introduced the Transmission Protection Instrument (TPI), a contingency facility designed to address fragmentation in the euro area bond market and ensure the smooth transmission of the monetary policy stance across all euro area countries.

[13] TPI was not designed to affect the monetary stance but rather to ensure the smooth transmission of policy across all euro area member states.

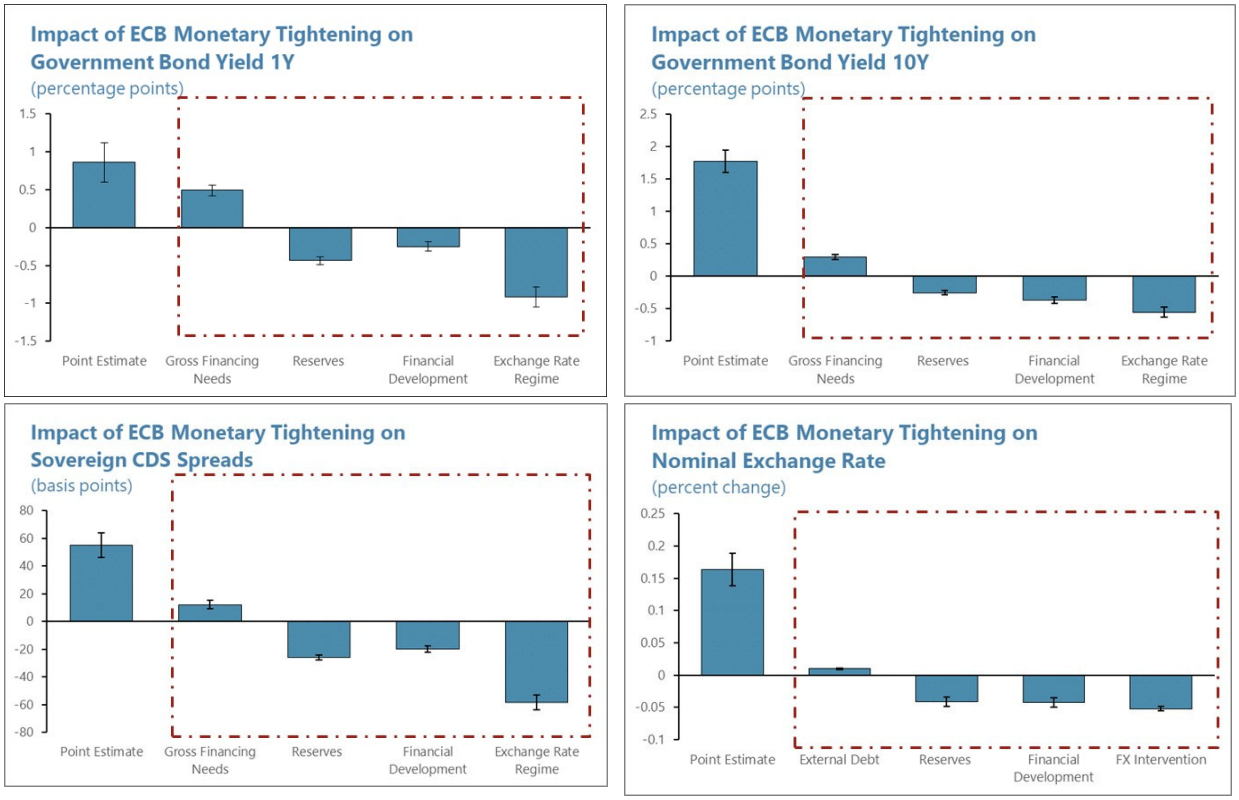
monetary policy meetings of the ECB. Figure 1 illustrates this event timeline, which is also reflected in the construction of the ECB policy dummy $ECB_{i,t}^{Dummy}$, which takes the value of 0 before the event and 1 after it.

Figure 1. Timeline of Event Study



The key findings of this exercise are shown in Figure 2. Emerging European economies experienced strong pressures on their exchange rate and government bond yields when there was a notable shift in expectations regarding future monetary tightening by the ECB. Bond yields rose amid rising policy rates and risk premia, as strong financial spillovers pushed up CDS spreads and the price of insuring sovereign debt against default.

Figure 2. Impact of ECB Monetary Tightening on Emerging European Economies



Note: The columns in the various panels show the estimated differential impact of an ECB monetary policy tightening by 100 basis point for high and low values of various fundamentals mentioned on the x-axis, where the exchange rate regime bar refers to the relative difference between floating and fixed exchange rate regimes.

The impact of these developments varied across countries. Economies with substantial financing gaps experienced more pronounced effects, while those with strong fundamentals, such as higher reserves and a more developed financial sector, and more flexible exchange rate regimes, saw a more muted impact.

Many currencies depreciated significantly against the euro, especially those of countries where foreign currency-denominated debt levels were elevated. Some economies, like Albania, Moldova, and Serbia, intervened in foreign exchange markets to stabilize excessive short-term exchange rate volatility.[14] These findings remain robust after controlling for country-specific factors such as unemployment and inflation, as well as global factors like the VIX and oil prices.[15]

3.3. Local Projections Method

We will now discuss our approach to estimating the responses of macro-financial variables in emerging European economies to a monetary policy shock in the euro area, using panel regressions and the local projections method developed by Jordà (2005).

To empirically assess the impact of monetary policy on economic activity and macro-financial variables, we need exogenous variation in policy variables. In our paper, we identify monetary policy shocks based on three-month Euribor one-year futures rates, following the approach of Romer and Romer (2004).[16] While an alternative, high-frequency identification method has gained popularity in recent literature, it has limitations because it mainly captures intraday changes in money market rates around a monetary event. These can only capture a small portion of changes in macroeconomic variables, which are usually measured at a quarterly frequency. For this reason, we eschew high-frequency identification and follow Romer and Romer (2004). More specifically, we use the following regression to identify ECB monetary policy shocks:

$$\Delta i_t = \alpha + \beta E_t \Delta y_{t+12} + \gamma E_t \pi_{t+12} + \sum_{j=0}^{1} \beta_{1j} \Delta y_{t-j} + \sum_{j=0}^{1} \gamma_{1j} \Delta \pi_{t-j} + \sum_{j=1}^{2} \zeta_{1j} \Delta i_{t-j} + i_{t-1} + \epsilon_t$$

where: $E_t \Delta y_{t+12}$ and $E_t \pi_{t+12}$ represent twelve-month ahead forecasts of euro area's GDP growth rate and inflation, as measured by the Survey of Professional Forecasters, Δy_{t-j} are the current and lagged GDP growth rates, $\Delta \pi_{t-j}$ stands for the current and lagged inflation rate, and Δi_t represents changes in the three-month Euribor futures rate. The monetary shock is captured by the residual term ϵ_t and it is shown in Figure 3

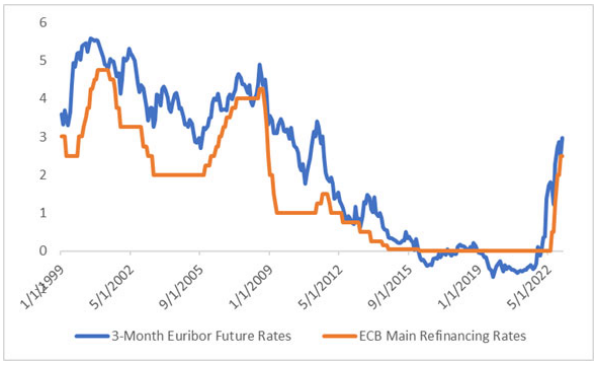
[14] For an account of such FX interventions, see: 2023 Communication on EU Enlargement for Albania, 2023 Communication on EU Enlargement for Moldova; and 2022 Communication on EU Enlargement for Serbia by the EU Commission. See also BIS (2024) for a broader discussion of FX interventions during the recent monetary policy tightening episode.

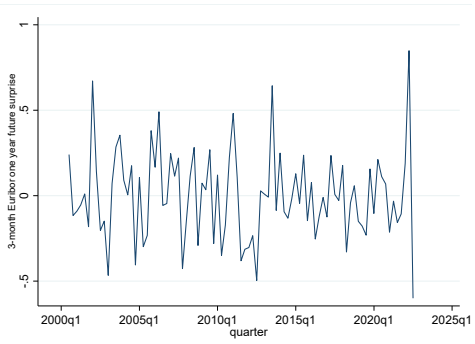
[15] In the empirical study, we do not control for the changing currency composition of external liabilities. While this could be an important issue in some countries, absence of consistent data on the FX composition of foreign liabilities impedes such analysis.

[16] In contrast to the event study in the previous section, the local projection analysis distills conventional shocks only, because it looks at unexplained contemporaneous changes in the short-term rate. This makes the two exercises complementary, but also not fully comparable.

(right-hand side).[17] In other words, deviations from this estimated equation capture the non-systematic and unexpected part of monetary policy.[18]

Figure 3. Euribor Futures Rate (LHS) and Constructed Monetary Shock Series (RHS)





We then estimate the responses of Eastern European countries' output and macro-financial variables to the ECB monetary policy shocks using local projections, following the method introduced by Jordà (2005). The local projections method directly estimates the response of macroeconomic variables to identified policy shocks. It does not require the specification and estimation of the unknown true multivariate dynamic data-generating process and is therefore more robust to misspecification, although it sacrifices some efficiency. Furthermore, local projections are more amenable to highly non-linear and flexible specifications, including interactive effects with specific country characteristics, which are of interest in our study.

The econometric specification involves the estimation of the following process:

$$y_{it+h} = \alpha_i^h + \sum_{j=0}^{4} \gamma_j^h \hat{\epsilon}_{t-j} + \sum_{j=1}^{4} \beta_j^h Z_{it-j} + \lambda^h X_{it} + \epsilon_{it}^h$$

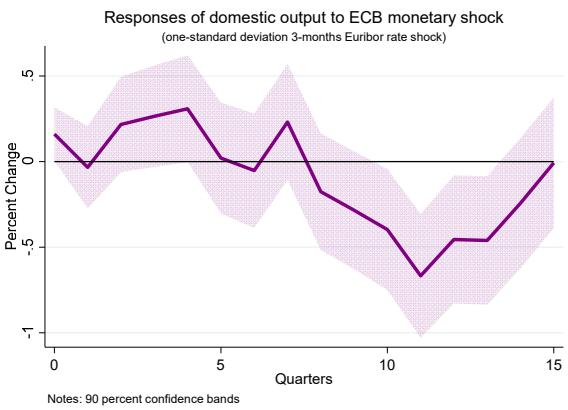
where y_{it+h} represents endogenous variables, $\hat{\epsilon}_{t-j}$ captures the monetary shocks, Z_{it-j} denotes the lagged dependent variables accounting for the dynamics of the dependent variables with four lags included, and X_{it} contains global and country-specific controls, including the US Federal Funds Rate, the VIX, the country's exchange rate regime, reserves position, domestic financial development, and the fiscal position. The coefficient γ_j captures the impact of ECB monetary policy shocks at different horizons j. The equations are estimated with quarterly data for real GDP and other macro-financial dependent variables, with the impacts examined in a fifteen-quarter window following the shocks, and presented in Figures 4a and 4b.

[17] To identify the monetary policy shock, we include data from the latest available vintage of each variable. Due to data revisions and lags in data availability, this may differ from the original vintage and the information set available to the central bank when making its monetary policy decisions. However, we believe that this is not a major source of bias for our estimates because, apart from GDP, the data considered are generally not subject to revisions. For euro area GDP, revisions tend to be relatively small and non-systematic, with the flash release providing an accurate estimate of the final quarterly GDP growth rate. Revision triangles, regularly updated by Eurostat, demonstrate the reliability of European GDP estimates, showing an average absolute revision of 0.2 percentage points to the quarter-on-quarter GDP growth rate for the euro area between the flash and the final releases during 2021-2023 (Eurostat's revision triangles are available at this link, last accessed on May 20, 2024).

[18] The monetary policy shock captures the monetary policy component that is orthogonal to the economic outlook, as well as the ECB information effect, i.e., its private information on the economy, the model it used, or its own preferences (Bu et al., 2019).

Figure 4a. Impulse Responses of Emerging Europe Real Output to ECB Monetary Shock

Full sample



COVID period (2020 Q2 onwards) excluded

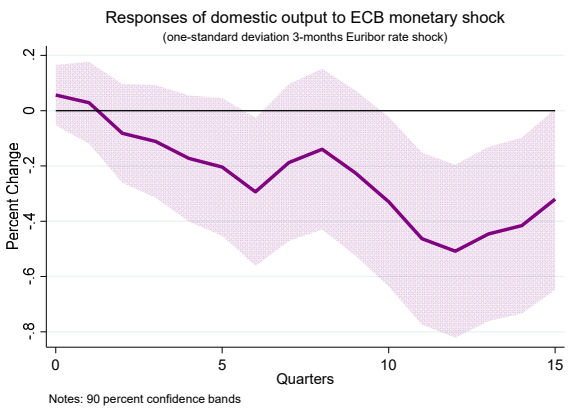
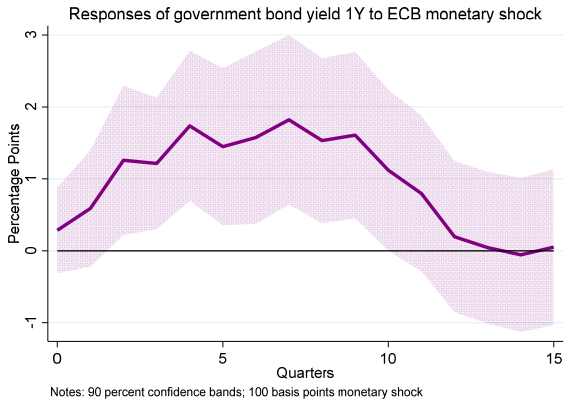
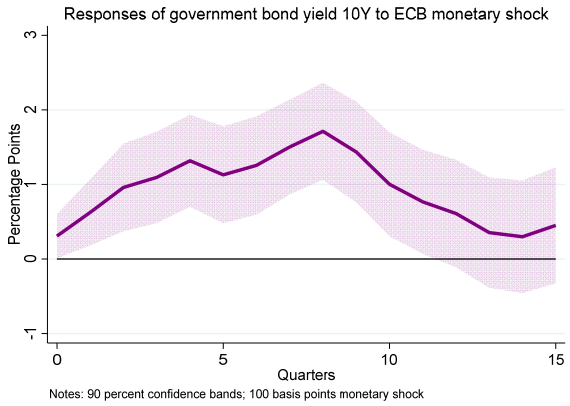
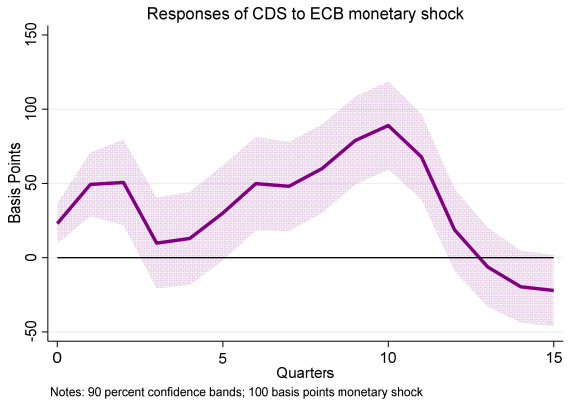
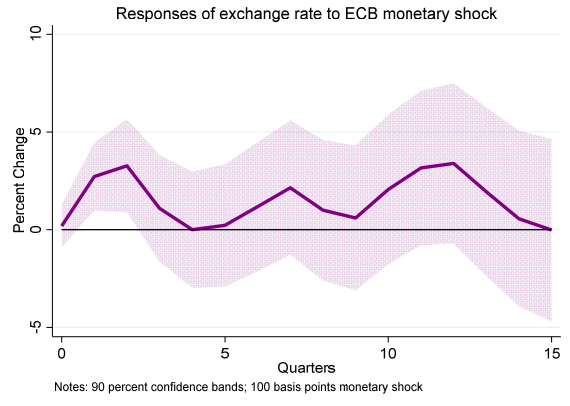


Figure 4b. Impulse Responses of Emerging Europe Government Bond Yields, CDS Spread, and Exchange Rate to ECB Monetary Shock









Note: The figures show the impulse responses of: (the natural logarithm of) real GDP (top panel); government bond yields (mid panels); and CDS and the bilateral exchange rate against the euro to a one-standard-deviation ECB monetary tightening shock ($\sigma = 0.26$), based on quarterly data for 16 countries between the first quarter of 1999 and the third quarter of 2022. The shaded area indicates significance at the 90 percent level, based on standard errors two-way clustered at the country and quarter levels.

Our analysis indicates that contractionary monetary policy shocks have a persistent negative impact on real output growth in emerging Europe. Domestic output decreases following a contractionary ECB monetary shock, with the trough occurring after about 10 quarters (see Figure 4a, top panels).

Our analysis also shows that tightening of ECB monetary policy leads to strong spillovers in the sovereign debt markets of emerging Europe, resulting in more than one-for-one changes in government bond yields in response to higher ECB interest rates (Figure 4b, mid panels). These spillovers also lead to substantial increases in sovereign spreads and depreciation in domestic currencies (see Figure 4b, bottom panels).

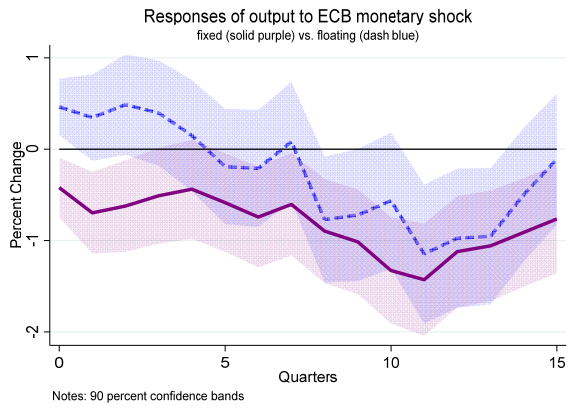
Furthermore, we also inspect the role of country fundamentals and policy regimes with the following variant of the above specification:

$$y_{it+h} = \alpha_i^h + \sum_{j=0}^{4} \gamma_j^h \hat{\epsilon}_{t-j} + \sum_{j=1}^{4} \beta_j^h Z_{it-j} + \delta_0 \widehat{\epsilon_t} \times X_{it} + \lambda^h X_{it} + \epsilon_{it}^h$$

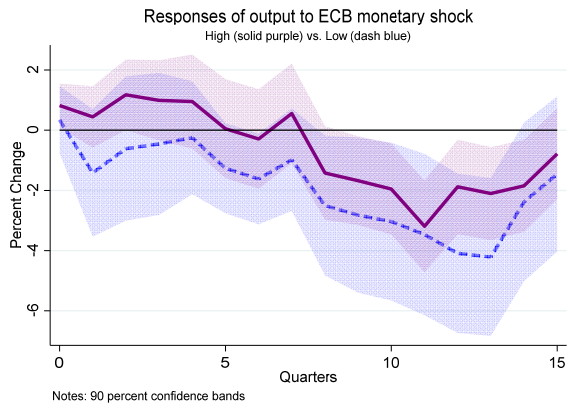
The conditioning variables reflected in the added interaction term include country-specific fundamental indicators such as reserves (as a percentage of GDP), fiscal balance (as a percentage of GDP), public debt (as a percentage of GDP), financial sector development (M2 over GDP), and monetary/FX policy regime.

Figure 5. Impulse Response of ECB Monetary Policy Shock by Country Fundamentals

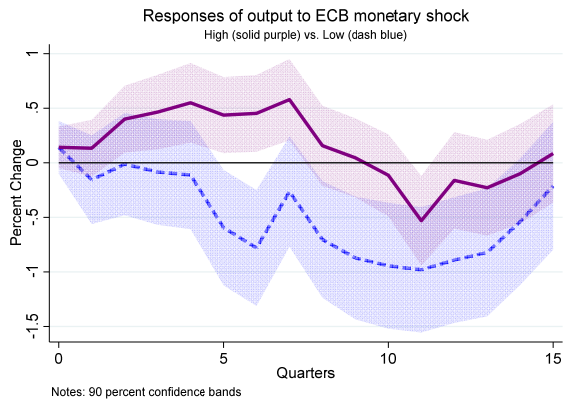
A. Exchange rate regime



B. Reserve position



C. Financial development



D. Source of the shock

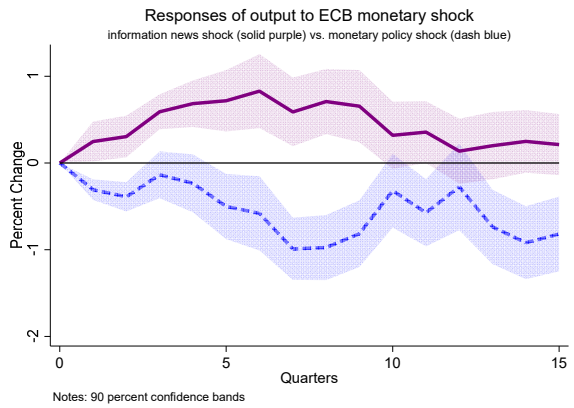


Figure 5 shows that country-specific fundamentals can amplify or mitigate the spillover effects from the ECB's monetary policy decisions. The results indicate that countries with a fixed exchange rate regime and weak fundamentals—lower reserves and lower financial development—experience more significant negative impacts from contractionary monetary policy shocks. In contrast, countries with a more flexible exchange rate regime and strong fundamentals exhibit resilience in terms of both the overall shock size and more gradual impact. The source of the shock also matters, in particular whether the change in monetary policy is driven by the economic outlook (panel 5.D., see also Bu et al., 2021). While spillovers are negative in the case of pure monetary policy tightening shocks, relevant in the most recent tightening episode, they could instead be positive if the policy tightening is driven by a more positive outlook in the euro area.[19]

4. Structural Model

A distinctive feature of the recent ECB tightening cycle is its combination of a sequence of significant interest rate hikes with plans to gradually reduce the size of bond holdings as part of the asset purchase program. In theory, the central bank could achieve its desired monetary policy stance through different combinations of conventional and unconventional measures. Thus, an important question in the context of the recent tightening cycle is to what extent the particular mix the ECB has implemented since summer 2022 has affected the size and nature of spillovers to emerging European economies. Another important question is how spillovers from conventional and unconventional measures transmit to countries with different exchange rate regimes.

In this section, we examine the questions above through the lens of a two-country, open economy DSGE model based on Erceg et al. (2024), which, in turn, builds on Kolasa and Wesołowski (2020). A crucial feature of the model is that it incorporates two types of households, defined as restricted and unrestricted, which are distinguished by their access to bond markets, as described in Table 1. While restricted households, meant to proxy specialized financial institutions such as pension funds, trade only in long-term bonds, unrestricted households conduct transactions in long-term bonds, both foreign and domestic, and in short-term bonds issued by their own country. Furthermore, when trading in long-term bonds, unrestricted households, which are a stand-in for less-specialized private investors, face a transaction cost, whereas their restricted counterparts do not bear such an expense. The presence of these constraints allows for the segmentation of the asset market between long- and short-term bonds. This segmentation results in non-trivial effects of central bank interventions in the long-term bond market.[20]

Table 1. Asset Market Segmentation in Erceg et al. (2024)

	Short-term		Long-term	
	Home	Foreign	Home	Foreign
Home unrestricted	+		⊕	⊕
Foreign unrestricted		+	⊕	⊕
Home restricted			+	
Foreign restricted			+	+

Note: A plus means that an agent has access to a given asset and a circle around it indicates that trading in this asset is subject to transaction costs.

[19] Results follow one standard deviation of ECB monetary policy shock with $\sigma = 0.26$.

[20] A detailed description of the model can be found in Erceg et al. (2024).

To shed light on recent macroeconomic developments the model is first calibrated to the euro area and a small open emerging European economy (see also Appendix II for an overview of the calibration). We then apply it to analyze a scenario in which the European economy started to recover from the pandemic when a strong acceleration in inflation caused central banks to tighten their stance substantially.

We first analyze the spillover effects of ECB interest rate policy and balance sheet interventions in this macroeconomic environment. The interest rate and balance sheet policies act upon securities of different maturities, with the former mainly influencing short-term interest rates and the latter primarily affecting longer-term rates. Historically, experience with Quantitative Tightening (QT) is limited: there was only one round of QT, which was initiated in October 2017 and ended in September 2019. Using our structural model thus helps to fill the gap, overcoming QT data limitations affecting empirical methods. Furthermore, the inclusion of a number of macroeconomic shocks that drive European business cycles allows for a realistic description of the systematic component of monetary policy as well as ECB and emerging European central bank policy shocks.

We then focus on the spillover effects from monetary policy shocks based on different exchange rate regimes of the small open economy, comparing endogenously determined floating to an exogenous exchange rate peg. This analysis helps understand how the exchange rate might buffer the cross-border pass-through of foreign monetary policy shocks. In addition, the analysis helps to isolate the role of other important channels such as international trade and financial linkages, and provides further support to the empirical findings described in the previous sections.

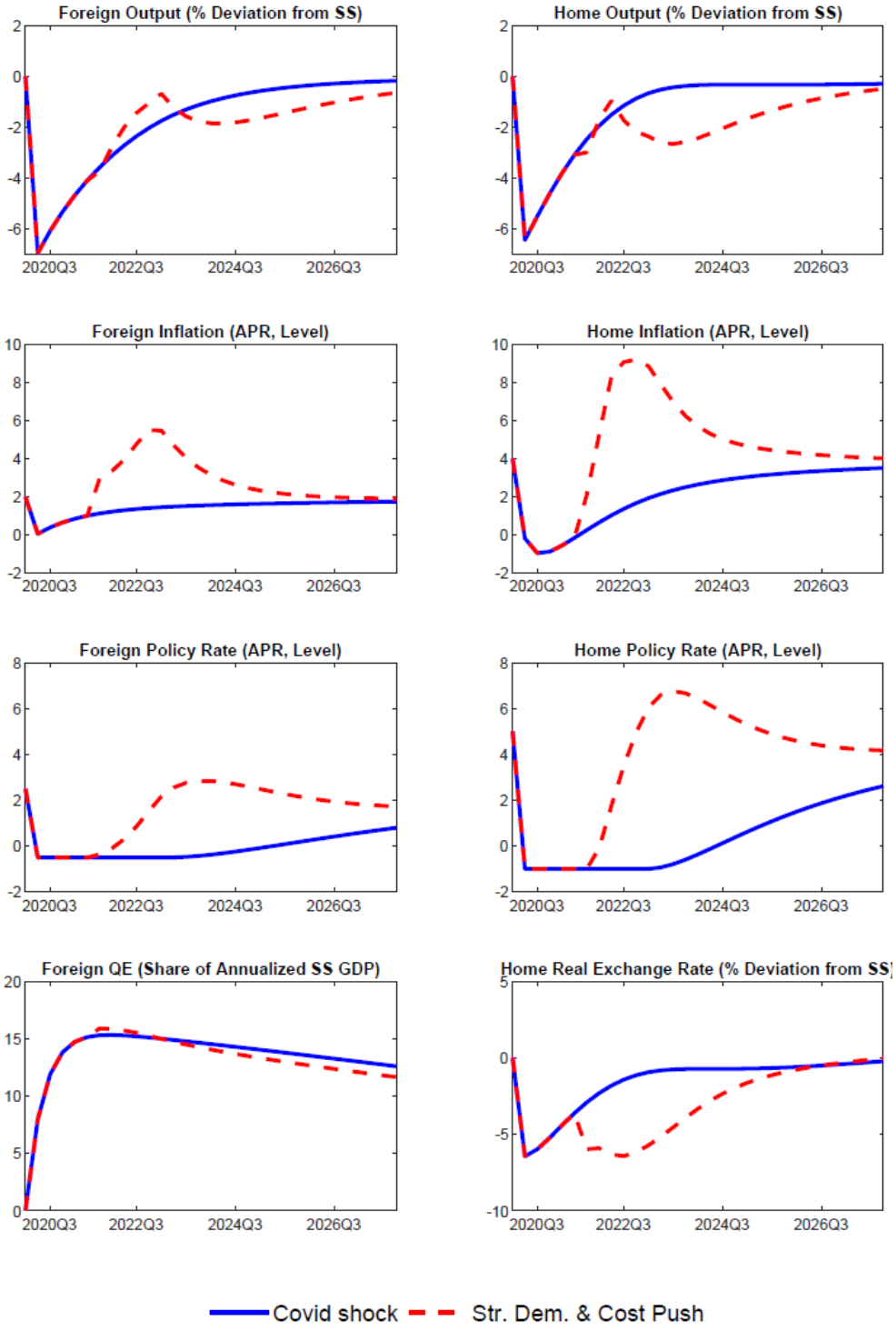
5. Model Results

In our first exercise, we assess the spillovers from ECB tightening, separating those from conventional and unconventional monetary policy measures. To do so, we start from a baseline scenario comprising a Covid shock followed by an unanticipated inflation surge in both the euro area and the Emerging European (EE) economy. We focus first on the case where the central bank in the EE economy follows inflation targeting with a flexible exchange rate. In Figure 6 the impulse responses to the Covid shock are shown as blue lines, while impulse responses related to the additional inflation shocks are shown as red dashed lines.

The Covid shock takes the form of a negative demand shock in both the euro area (Foreign) and the EE economy (Home), triggering a deep recession and inflation drifting below targets.[21] In response, the ECB cuts the interest rate, thereby hitting the effective lower bound. To inject further monetary stimulus, the ECB launches a program of asset purchases with portfolio holdings soon reaching 15 percentage points of GDP. The central bank in the emerging European economy also responds to the shock by cutting the policy rate and launching a more limited program of QE purchases.

[21] Other researchers have modelled the Covid shock in DSGE models as a demand shock (Chen et al., 2020) as we do, a shock to savings and labor hoarding (Cardani et al., 2022) and shocks to aggregate demand and sector-specific labor supply and productivity (Corrado et al., 2021). Outside the DSGE literature Balleer et al. (2020) report that demand shocks dominated in Germany during the Covid period.

Figure 6. The Baseline Scenario



The Covid shock is followed by an unanticipated inflation surge engendered by strong demand and cost push shocks that build for four quarters in both the home and foreign economies. Figure 6 shows that the impact of these shocks differs in the two economies, with the size of impact capturing actual developments in the

respective economies during the post-Covid recovery and the surge in energy prices following the war in Ukraine. In particular, the emerging European economy is hit much more strongly by the inflation shock, i.e., the inflation hike is “synchronous but asymmetric”. IMF (2022) shows that this asymmetry was related to the higher weights of food and energy spending in the EE’s CPI basket and a generally more rapid pass-through of energy prices.

The inflation shock triggers a reversal of the exceptional monetary accommodation provided in the wake of the Covid shock, with the baseline policy rate following the predictions from a standard Taylor rule in both countries. Output rises initially in line with strong demand, and then falls as the underlying drivers (which in the data included fiscal policy support and unwinding of Covid-era excess savings) fade. However, inflation and the policy rates decline only gradually.

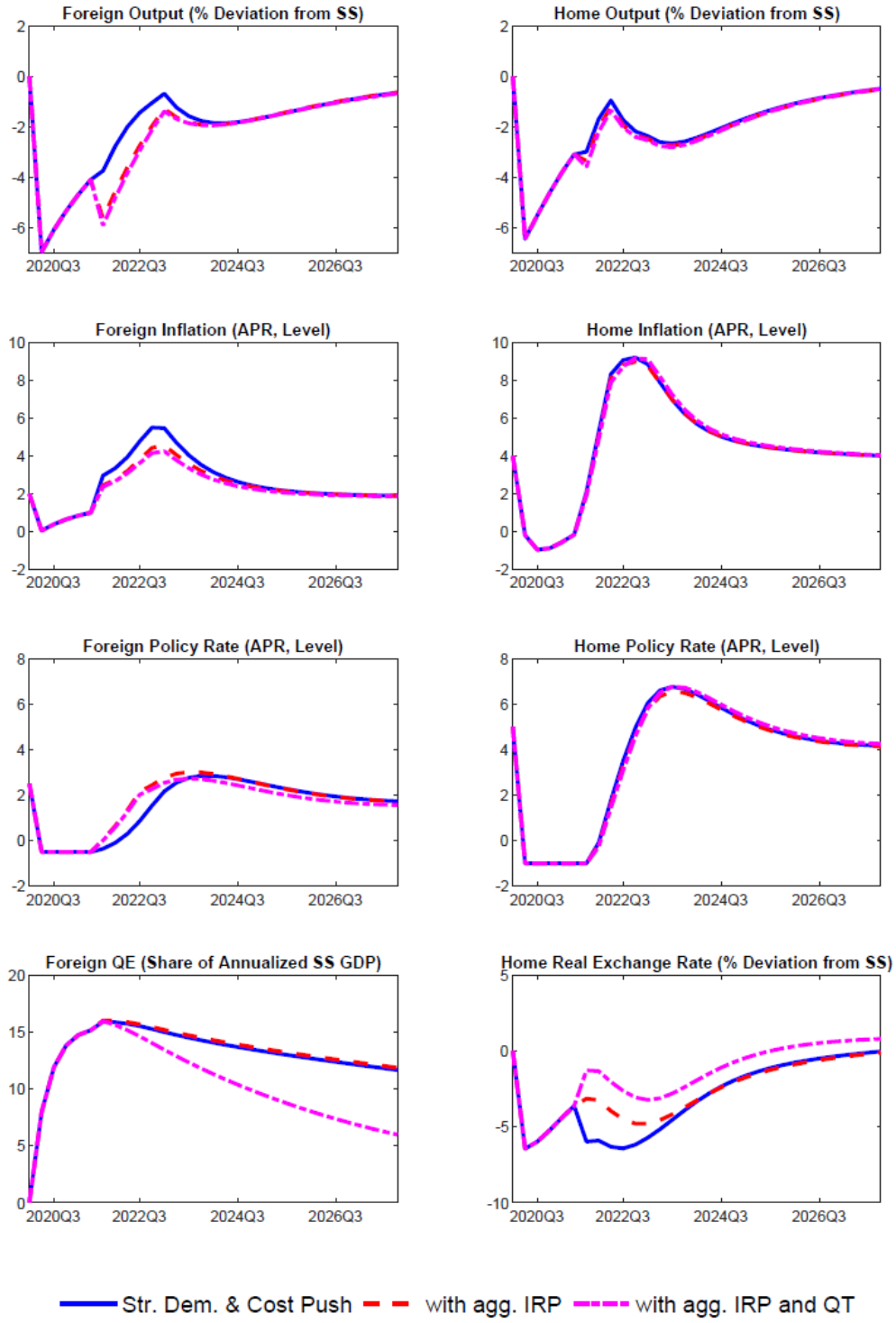
The home real exchange rate appreciates after the Covid shock and then depreciates somewhat after the inflation shocks. The initial appreciation is due to the quantitative easing policy pursued by the ECB, which is much stronger than that in the emerging European economy. Erceg et al. (2024) explain that quantitative easing policies have a much stronger impact on long-term rates than conventional rate changes. Such impact, in turn, affects the exchange rate. By contrast, when the inflation shock hits the emerging European economy much more forcefully than the euro area, the real exchange rate responds in the opposite direction.

In this simulation, it is assumed that the ECB tightens policy only through conventional tools, i.e., through hikes in the short-term interest rate, in line with what happened between July 2022 and March 2023. The mild decline in the Foreign (i.e., the ECB’s) QE stock as a share of GDP in Figure 6 is the result of GDP growth in the presence of a monetary policy portfolio that is held constant in nominal terms by the central bank. The emerging European central banks’ rate hikes are much more aggressive than the ECB’s. Long-term rates (not shown in Figure 6) therefore rise more in emerging Europe, appreciating the real exchange rate.

While the finding of a depreciating real exchange rate after the inflationary shock appears in line with the empirical finding of the event study, the initial appreciation following the Covid shock is not. One reason for the difference could be that the tightening cycle started much earlier in emerging Europe (IMF 2022, p.1) so that the ECB’s rate hike in June 2022 occurred in an environment of already elevated emerging European interest rates which then did not rise one-for-one with ECB rates. Another reason could be that exchange rate movements during the pandemic were driven by changes in various risk premia which our stylized model cannot adequately capture.

To isolate the effect of a pure interest rate shock, Figure 7 takes the baseline with gradual tightening depicted above as a starting point (solid blue line) and assumes that the policy rate is increased more aggressively than in the baseline (red dashed line). The size of the interest rate hike is calibrated to resemble the tightening witnessed in the euro area after July 2022. It assumes that the policy rate is raised 12.5bps more than the prediction from a standard Taylor rule in four steps, leading to a cumulative monetary policy shock of 50bps over a year. We interpret the difference between this scenario of tighter interest rate policy and the gradual exit scenario as the effect of aggressive ECB interest rate policy.

Figure 7. Impact of Aggressive Interest Rate Policy and QT in the Baseline Scenario



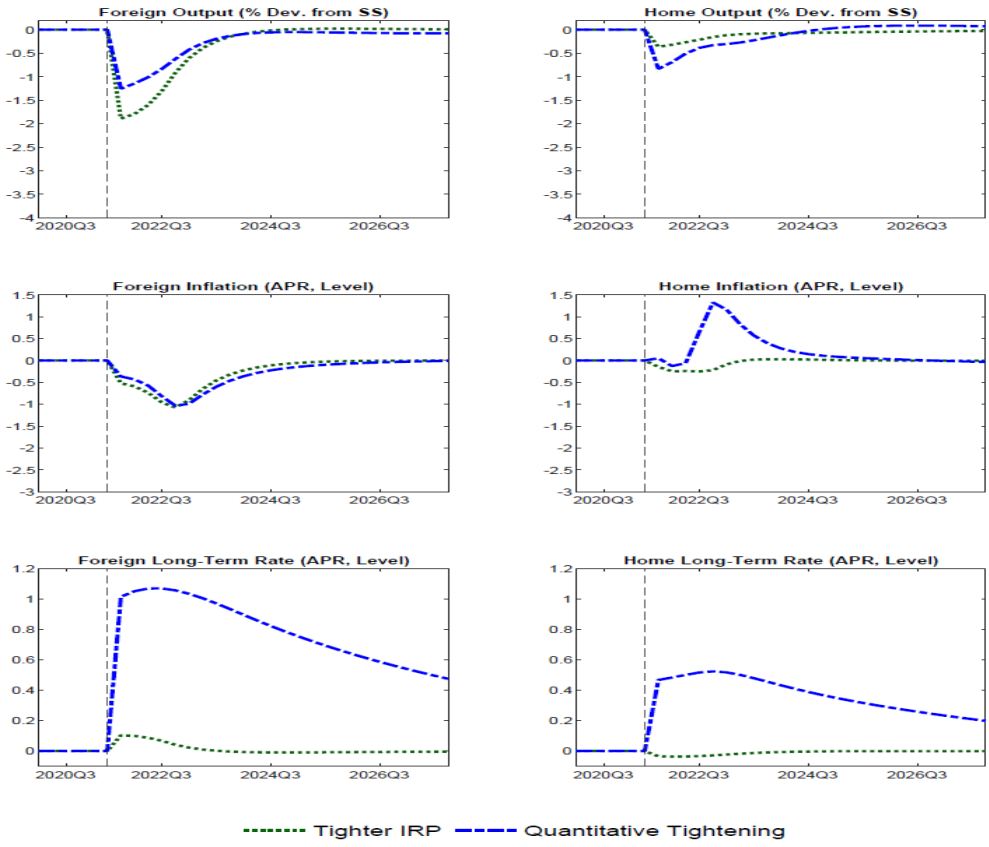
As the Figure shows, the tighter policy stance has a contractionary effect on euro area GDP, delaying the recovery from the Covid-related recession but containing inflation somewhat. However, the spillover effects are rather small, as we discuss further below. Next, we take the tighter interest rate scenario and adds a gradual

and predictable unwinding of the ECB asset purchase portfolio accumulated during the pandemic (dash-dotted magenta line in Figure 7). This is meant to mimic the gradual and predictable unwinding of the APP announced by the ECB in December 2022, envisaging a quarterly pace of reduction of APP holdings of EUR45bn. The difference with the baseline scenario gives an estimate of the spillovers from an interest rate surprise and quantitative tightening (QT) policy from the ECB.

5.1. Spillovers Under Alternative Tightening Strategies

Equipped with the simulations above, we can now compare spillovers under a tightening strategy where only interest rates are hiked with one where the ECB's assets stock is contracted faster, with the respective intervention sizes adjusted to ensure similar effects on euro area inflation. The results are depicted in Figure 8, which additionally reports them as deviations from the baseline (i.e., the solid blue line in Figure 7) to help partial out their marginal effects.

Figure 8. Spillovers Under Tighter IRP and QT: Deviations from Baseline



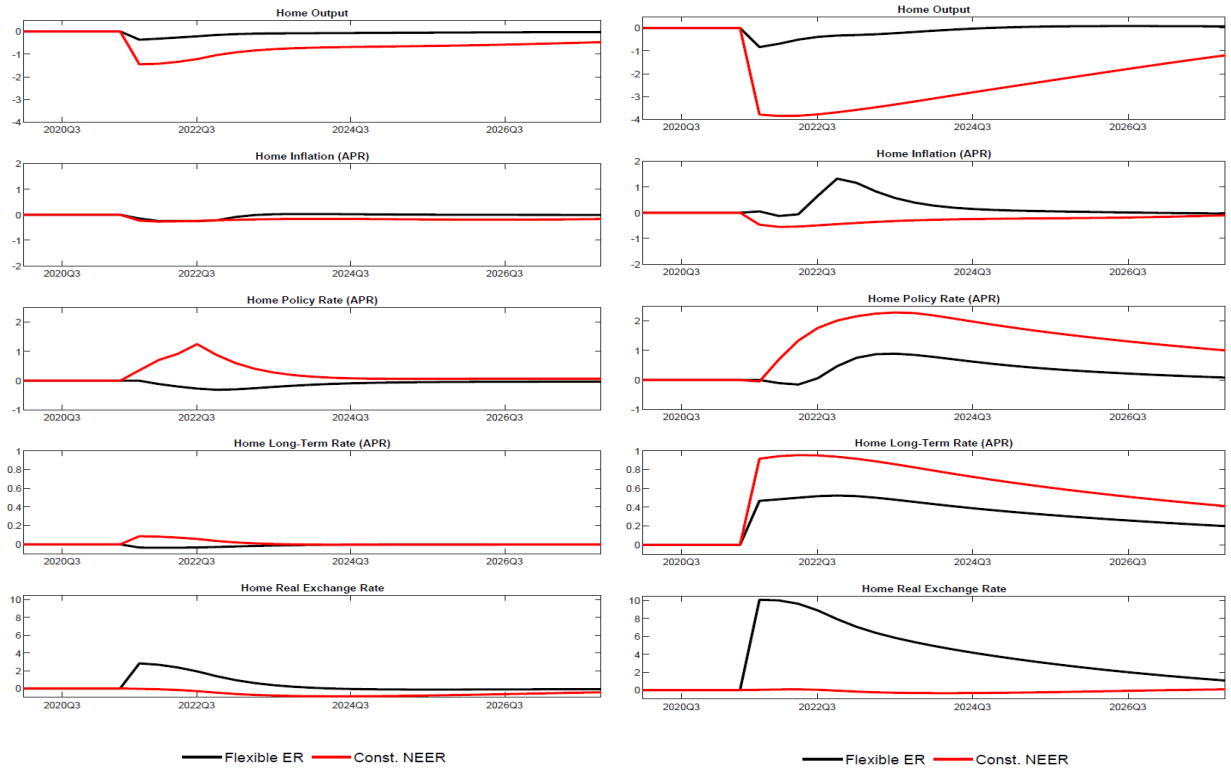
The figure shows that while euro area output takes a bigger hit under the pure interest rate strategy (dotted green line), spillovers to home output are smaller compared to the case of a faster-paced QT (dash-dotted blue line), reflecting the much larger impact of ECB QT on the emerging European economy's long-term rate and domestic demand compared to conventional ECB tightening.

Of course, we could have equally normalized the two policies by requiring them to have an identical effect on euro area output. In such case, based on a simple loss function, the two policies would be close to a wash in the euro area, but the negative spillovers to emerging Europe would be significantly larger. In that sense, interest rate tightening seems to offer a better output-inflation trade-off in both the Home and Foreign economies, suggesting that a gradual, predictable runoff of the APP portfolio, which underlies the baseline scenario, could be in the interest of the region. This result is based on calculations of a simple sacrifice ratio, indicating, for a given monetary policy mix, the amount of output growth that is foregone to achieve a unit reduction in inflation. While for the euro area, the sacrifice ratio under the interest rate policy is marginally more favorable than under the balance sheet policy in the calibration considered in our exercise, the ratio is significantly more favorable for the emerging European economy. Thus, for the euro area, the relative merits of the two policies are likely to depend on the particular calibration of the exercise and the loss function. A deeper analysis is needed to establish a clear ranking between the two policies, which we leave to future research. At the same time, a clear message of our exercise is that the two policies do make a large difference in terms of policy spillovers for the EE, mostly due to the much larger impact of ECB quantitative tightening on the EE's long-term rate and, therefore, on its aggregate demand and ultimately on output. Additionally, EE inflation rises under ECB QT due to the sharp depreciation of the foreign exchange rate.

5.2. Spillovers Under Alternative FX Regimes

In an additional set of simulations, we compare spillovers from conventional and unconventional monetary policy tightening under alternative assumptions about the foreign exchange regimes in place in the EE economy. Specifically, Figure 9 shows that the adverse output spillovers from tighter ECB monetary policy tend to be larger under a fixed exchange rate regime compared to an inflation targeting regime with a freely floating currency. This holds true under both a tighter interest rate path (corresponding to the dotted green line in Figure 8) and faster ECB QT (corresponding to the dash-dotted blue line in Figure 8). Broadly, these results follow from the finding that quantitative tightening is associated with notably larger downward pressure on the exchange rate of the typical Emerging European economy, with the associated competitiveness gains mitigating the drop in output. By and large, they are thus a reminder of the potential costs of a fixed exchange rate regime when the economy is exposed to large shocks with potentially asymmetric effects.

Figure 9. Spillovers Under Alternative FX regimes: Role of NEER Stabilization
More Aggressive ECB Interest rate policy (left panel) and Faster ECB QT (right panel)



6. Conclusions

The ECB's announcement of monetary policy tightening in the summer of 2022 had substantial impacts on emerging European economies. Historical analysis over a long time period further indicates that ECB monetary policy generally entails large financial and real spillovers to emerging European countries. The extent of these spillovers is influenced by a combination of factors, including the economic fundamentals of recipient economies. Countries with strong fundamentals and robust policy frameworks are better equipped to mitigate these spillovers.

Additionally, the composition and pace of ECB monetary policy tightening plays a critical role in determining the magnitude of spillovers. Our model simulations reveal that conventional tightening, achieved predominantly through interest rate increases, provides a more favorable trade-off between inflation and output compared to balance sheet tightening. This holds true both for the euro area domestically and in terms of spillovers to neighboring emerging European economies. The extent of spillovers from quantitative tightening also depends on the speed at which the balance sheet reduction is carried out. Spillover effects are moderate when QT is carried out in a measured and predictable manner, but they can become significant if the pace of QT is significantly accelerated. Finally, the adverse spillover effects from tighter ECB monetary policy tend to be more pronounced under a fixed exchange rate regime than under an inflation targeting regime with a freely floating currency. This holds true for both a tighter interest rate rule and a combination of tighter interest rate and quantitative tightening.

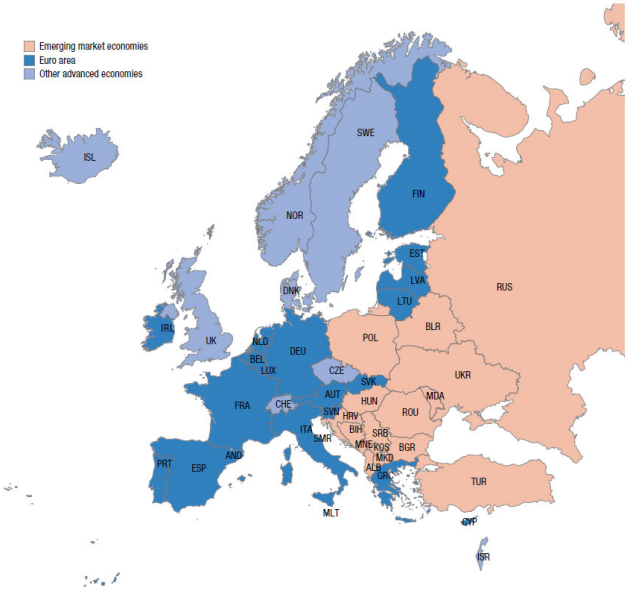
Appendix I. Country List and Data Sources

Country List

The sample for the empirical analysis includes the following sixteen emerging European economies:

Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Kosovo, Macedonia, Moldova, Montenegro, Poland, Romania, Russian Federation, Serbia, Türkiye, and Ukraine.

Given the war in Ukraine, Russia and Ukraine are excluded from the sample in all regressions.



ECB Government Council Monetary Policy Announcement Dates

In 2022, ECB Government Council monetary policy announcement dates are February 3rd, March 10th, April 14th, June 9th, July 21st, September 8th, October 27th, and December 15th.

Exchange Rate Regime of Emerging European Economies as of 2022

Country	Exchange Rate Regime	Category
Albania	Floating	Float
Belarus	Pegged Exchange Rate within Horizontal Bands	Soft pegs (intermediate)
Bosnia and Herzegovina	Currency Board	Hard pegs
Bulgaria	Currency Board	Hard pegs
Croatia	Pegged Exchange Rate within Horizontal Bands	Soft pegs (intermediate)
Hungary	Floating	Float
Kosovo	No Separate Legal Tender (euroized)	Hard pegs
North Macedonia	Stabilized Arrangement	Soft pegs (intermediate)
Moldova	Floating	Float
Montenegro, Rep. of	No Separate Legal Tender (euroized)	Hard pegs
Poland	Free Floating	Float
Romania	Crawl-like Arrangement	Managed Float
Russia	Floating	Float
Serbia	Stabilized Arrangement/	Managed Float
Türkiye	Floating	Float
Ukraine	Floating	Float

Adoption of Inflation Targeting in Emerging Economies of Europe

Country	Adoption of Inflation Targeting
Albania	Yes
Belarus	Yes
Bosnia and Herzegovina	Currency Board
Bulgaria	Currency Board
Croatia	Exchange Rate Targeting with Euro
Hungary	Yes
Kosovo	Euroized (no separate legal tender)
North Macedonia	Exchange Rate Targeting with Euro
Moldova	Yes
Montenegro, Rep. of	Euroized (no separate legal tender)
Poland	Yes
Romania	Yes
Russia	Yes
Serbia	Yes
Türkiye	Yes
Ukraine	Yes

Source: IMF (2022), Annual Report on Exchange Arrangements and Exchange Restrictions 2021, July.

Appendix II. Model Calibration

Parameter	Symbol	Value
SIZE OF THE SMALL ECONOMY	ω	0.01
SHARE OF RESTRICTED HOUSEHOLDS	ω_r	015
INVERSE FRISCH ELASTICITY OF LABOR SUPPLY	φ	2
DISCOUNT FACTOR, UNRESTRICTED HOUSEHOLDS	β_u	0.9975
DISCOUNT FACTOR, RESTRICTED HOUSEHOLDS	β_r	0.9925
COGNITIVE DISCOUNTING, UNRESTRICTED HOUSEHOLDS	m_u	0.95
COGNITIVE DISCOUNTING, RESTRICTED HOUSEHOLDS	m_r	1
STEADY-STATE INFLATION	π	1.01
LONG-TERM BOND DURATION	D	40
TRANSACTION COST ON LONG-TERM BONDS	ξ	0.015
PRICE MARKUP	μ	1.15
KIMBALL PARAMETER	ψ	-12
CALVO PROBABILITY FOR DOMESTIC PRODUCTION	θ_H, θ^*_F	0.66
CALVO PROBABILITY FOR HOME EXPORTS	θ^*_H	0.88
CALVO PROBABILITY FOR HOME IMPORTS	θ_F	0.5
PRICE INDEXATION IN HOME ECONOMY	ζ	0.75
PRICE INDEXATION IN FOREIGN ECONOMY	ζ^*	0
ELASTICITY OF SUBSTITUTION BETWEEN HOME AND FOREIGN GOODS	v	0.8
HOME-BIAS	η	0.75
INTEREST RATE SMOOTHING	γ	0.82
INTEREST RATE RESPONSE TO INFLATION	γ_π	1.9
INTEREST RATE RESPONSE TO OUTPUT GAP	γ_y	0.125
REINVESTMENT STRATEGY	ϱ	0.5525

Appendix III. Monetary Transmission in the Model (based on Erceg, Kolasa, Linde, Mumtaz, and Zabczyk, 2024)

The model used for the simulations is a standard New-Keynesian setup featuring home bias in consumption preferences and prices that are sticky in local currency. Its distinguishing feature is that asset markets are segmented in the fashion advocated for in Chen et al. (2012). More specifically, short- and long-term bonds are imperfect substitutes because of the presence of portfolio transaction costs. These costs depend on positions taken by agents in long-term bonds and are hence influenced by central banks' asset purchases, as these effectively determine the outstanding bond supply. It is also assumed that not all agents can trade short-term bonds, which further implies that changes in term premia engendered by central bank interventions cannot be arbitraged away. Accordingly, since a share of agents' consumption decisions are tied to the long-rate, changes in the term-premium end up mattering for real allocations.

Segmented asset markets provide an attractive mechanism through which QE can stimulate the economy when the policy rate is constrained by the ELB. To provide a rationale for the central bank to conduct large scale asset interventions, instead of relying exclusively on forward guidance, the model additionally allows for strategic complementarities in price setting by adopting Kimball's (1995) quasi-kinked demand curves instead of relying on standard, log-linear Dixit-Stiglitz (1977) ones.[22] This tends to moderate the impact of forward guidance on current and future real rates by making inflation expectations less sensitive to various shocks (including monetary announcements) particularly in a recessionary environment with inflation below target. Second, it is assumed that households exhibit a moderate degree of bounded rationality, in the spirit of Gabaix (2020), with the associated discounting of future real rates making consumption less sensitive to future policy rate announcements.

For a full description of the underlying model, we refer to Erceg, Kolasa, Linde, Mumtaz, and Zabczyk (2024), which this appendix is based on, devoting its remainder to a discussion of the transmission of asset purchases and interest rate policy. Broadly the macroeconomic effects of asset purchases depend on their impact on the term structure of interest rates and on the exchange rate. To see how central bank asset purchases work in the model, it is thus instructive to examine the following linearized equilibrium arbitrage condition linking the expected one-period rate of return on long-term bonds to the risk-free interest rate paid on one-period bonds:

$$E_t R_{L1,t+1} = R_t + \zeta_F(B^u_{L,t}). \quad (1)$$

The last term in eq. (1) captures transaction costs, which effectively drive a wedge between the two rates of return. These costs are an increasing function of long-term bond holdings of unrestricted agents (i.e., of those who can hold both types of assets). As a result, for a given short-term policy rate, asset purchases by central banks reduce the supply of long-term bonds available for investment and generate a fall in the associated

[22] The Kimball aggregator has been shown by Harding et al. (2021) to resolve the "missing deflation puzzle", which it achieves by flattening the pricing curves in a slump.

expected return. By implication, consumption rises for agents who are exclusively trading long-term bonds and whose transaction costs are negligible, which generates an expansion of aggregate output.

The second key equilibrium relationship is associated with portfolio choices made by agents who trade both home and foreign long-term bonds. This leads to the following linearized long-UIP condition:

$$E_t R_{L1,t+1} = E_t R^*_{L1,t+1} + E_t \Delta\varepsilon_{t+1}. \quad (2)$$

This relationship postulates the equalization of one-period holding returns on long-term bonds denominated in different currencies, where ε_t is the nominal exchange rate. Here, a fall in the expected return on long-term bonds issued by one country, possibly associated with quantitative easing conducted by its central bank, must generate a decrease in the other country's expected bond return and/or expected exchange rate appreciation. The latter implies that the exchange rate of the country undertaking QE will depreciate on impact.

The exact proportion in which the fall in long-term rates translates into domestic depreciation and a fall in foreign long-term rates depends on the policies endogenously pursued by the neighboring central bank. For example, in the case in which the monetary authority operates an exchange rate peg, the effects of foreign QE would be fully transmitted to domestic long-term rates. If, on the other hand, the central bank adopted a standard Taylor-type instrument rule, then our model implies that a 100 basis points fall in foreign long-term rates would reduce the same maturity domestic rates by about 35 basis points.

References

Adler, G., K.S. Chang, R. Mano, and Y. Shao (2021), Foreign Exchange Intervention: A Dataset of Public Data and Proxies, *IMF Working Paper*, No 21/047.

Ahmed, S., O. Akinci, and A. Queralto (2021), US Monetary Policy Spillovers to Emerging Markets: Both Shocks and Vulnerabilities Matter, *Fed Board Working Paper*, No 1321.

Altavilla, C., L. Brugnolini, R. Gurkaynak, R. Motto, and G. Ragusa (2019), Measuring Euro Area Monetary Policy, *Journal of Monetary Economics*, Vol 108, December, pp 162-179.

Ammer, J., M. De Pooter, C. Erceg, and S. Kamin (2016), International Spillovers of Monetary Policy, *IFDP Notes*, February.

Balleer, A., Link, S., Menkhoff, M., and Zorn, P. (2020), Demand or supply? Price adjustment during the Covid-19 pandemic, *CESifo Working Paper* 8394

Bergant, K., M. Fidora, and M. Schmitz (2020), International Capital Flows at the Security Level - Evidence from the ECB's Asset Purchase Programme, *IMF Working Paper*, No 20/046.

Bernanke, B., and A. Blinder (1988), Credit, Money, and Aggregate Demand, *American Economic Review*, Vol 78, No 2, pp 435-439.

Bernoth, K., and J. von Hagen (2004), The Euribor Futures Market: Efficiency and the Impact of ECB Policy Announcements, *International Finance*, Vol 7, No 1, March, pp 1-24.

Blanchard, O., G, Adler, and I. de Carvalho Filho (2015), Can Foreign Exchange Intervention Stem Exchange Rate Pressures from Global Capital Flow Shocks?, *IMF Working Paper*, No 15/159.

BIS (2024), FX Markets and FX Interventions: Insights from a Markets Committee Workshop, Mimeo, Available here.

Borio, C., and H. Zhu (2012), Capital Regulation, Risk-Taking and Monetary Policy: A Missing Link in the Transmission Mechanism?, *Journal of Financial Stability*, Vol 8, December, pp 236-51.

Brandão-Marques, L., G. Gelos, T. Harjes, R. Sahay, and Y. Xue (2020), Monetary Policy Transmission in Emerging Markets and Developing Economies, *IMF Working Paper*, No 20/35.

Bu, C., J. Rogers, and W. Wu (2019), A Unified Measure of Fed Monetary Policy Shocks, *Finance and Economics Discussion Series*, No 2019-043, Washington: Board of Governors of the Federal Reserve System.

Cardani, R., O. Croitorov, M. Giovannini, P. Pfeiffer, M. Ratto, and L. Vogel (2022), The euro area's pandemic recession: A DSGE-based interpretation, *Journal of Economic Dynamics and Control*, Vol 143, October 2022.

Ca'Zorzi, M., L. Dedola, G. Georgiadis, M. Jarociński, L. Stracca, and G. Strasser (2020), Monetary Policy and Its Transmission in a Globalised World, *ECB Working Paper Series*, No 2407.

Chen, H., V. Curdia, and A. Ferrero (2012), The Macroeconomic Effects of Large-scale Asset Purchase Programmes, *The Economic Journal*, Vol. 122, pp. F289–F315.

Chen, W., Negro, M.D., Goyal, S., and Johnson, A. (2020), The New York Fed DSGE Model Forecast-December 2020, *Liberty Street Economics*, Federal Reserve Bank of New York (2020)

Christiano, L.J., M. Eichenbaum, and C.L. Evans (1999), What Have We Learned and to What End? In Woodford, M., and J.D. Taylor (eds.), Handbook of Macroeconomics. Elsevier, Amsterdam.

Christiano, L.J., M. Eichenbaum, and C.L. Evans (2005), Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy, *Journal of Political Economy*, Vol 113, No 1, pp 1–45.

Colabella, A. (2021), Do ECB's Monetary Policies Benefit EMEs? A GVAR Analysis on the Global Financial and Sovereign Debt Crises and Postcrises Period, *Oxford Bulletin of Economics and Statistics*, Vol. 83, pp 472-494.

Corsetti, G., J. Duarte, and S. Mann (2022), One Money, Many Markets, *Journal of the European Economic Association*, Vol. 20, No 1, pp 513-548.

Disyatat, P., (2011), The Bank Lending Channel Revisited, *Journal of Money, Credit and Banking*, Vol. 43, No. 4 (June), pp 711-734.

Dixit, A.K., and J.E. Stiglitz (1977), Monopolistic Competition and Optimum Product Diversity, *The American Economic Review*, Vol. 67, pp. 297–308.

Edwards, S., (2007), Capital Controls, Capital Flow Contractions, and Macroeconomic Vulnerability, *Journal of International Money and Finance*, Vol 26, No 5, pp 814–840.

Escayola, E.A., P. McQuade, C. Schroeder, and M. Tirpák (2023), What Shapes Spillovers from US Monetary Policy Shocks to Emerging Market Economies?, *ECB Economic Bulletin*, Issue 2/23.

Erceg, C., M. Kolasa, J. Linde, H. Mumtaz, and P. Zabczyk (2024), Central Bank Exit Strategies: Domestic Transmission and International Spillovers, *IMF Working Paper*, No 24/073.

European Central Bank (2022), *Economic Bulletin*, Issue 5.

Gabaix, X., (2020), A Behavioral New Keynesian Model, *American Economic Review*, Vol. 110, pp. 2271-2327.

Geis, A., I. Moder, and T. Schuler (2020), Who's Afraid of Euro Area Monetary Tightening? CESEE Shouldn't, *ECB Working Paper Series*, No 2416.

Georgiadis, G. (2015), Determinants of Global Spillovers from US Monetary Policy, *ECB Working Paper Series*, No 1854.

Gertler, M., and P. Karadi (2015), Monetary policy surprises, credit costs, and economic activity, *American Economic Journal: Macroeconomics*, Vol 7, No 1, pp 44–76.

Gurkaynak, R.S., B. Sack, and E. Swanson (2005), The Sensitivity of Long-Term Interest Rates to Economic News: Evidence and Implications for Macroeconomic Models, *American Economic Review*, Vol 95, No 1, pp 425–436.

Harding, M., J. Linde, and M. Trabandt (2021), Resolving the Missing Deflation Puzzle, *Journal of Monetary Economics*, Vol. 126, pp. 15–34.

Jarocinski, M., and P. Karadi (2020), Deconstructing Monetary Policy Surprises—The Role of Information Shocks, *American Economic Journal: Macroeconomics*, Vol 12, No 2, pp 1-43.

Iacoviello, M., and G. Navarro (2019), Foreign Effects of Higher U.S. Interest Rates, *Journal of International Money and Finance*, Vol 95, pp 232–250.

International Monetary Fund (2022), *Regional Economic Outlook Europe*, October.

International Monetary Fund (2008), Stress in Bank Funding Markets and Implications for Monetary Policy, in *Global Financial Stability Report*, Chapter 2, October.

Jordà, Ò. (2005), Estimation and Inference of Impulse Responses by Local Projections, *American Economic Review*, Vol 95, No 1, pp161-182.

Kearns, J., A. Schrimpf, and F. D. Xia (2023), Explaining Monetary Spillovers: The Matrix Reloaded, *Journal of Money, Credit and Banking*, Vol 55, No 6, pp 1535-1568.

Kimball, M.S. (1995), The Quantitative Analytics of the Basic Neomonetarist Model, *Journal of Money, Credit and Banking*,Vol. 27, pp. 1241–1277.

Kolasa, M., and G. Wesolowski (2020), International Spillovers of Quantitative Easing, *Journal of International Economics*, No 126.

Ledóchowski, M., and P. Żuk (2022), What Drives Portfolio Capital Inflows into Emerging Market Economies? The Role of the Fed's and ECB's Balance Sheet Policies, Emerging Markets Review, Vol. 51(B), June.

Moder, I. (2021), The Transmission of Euro Area Monetary Policy to Financially Euroised Countries, *ECB Working Paper Series*, No 2611.

Moder, I. (2017), Spillovers from the ECB's Non-Standard Monetary Policy Measures on South-Eastern Europe, *ECB Working Paper Series*, No 2095.

Morris, S., and H.S. Shin (2014), Risk-Taking Channel of Monetary Policy: A Global Game Approach, *Princeton University Working Paper Series*, January.

Pienkowski, A. (2023), Foreign Currency Balance Sheets in Türkiye: Exposure and Interconnectedness, *IMF Working Paper*, No 23/132.

Rey, H. (2015), Dilemma Not Trilemma: The Global Financial Cycle and Monetary Policy Independence, *NBER Working Paper*, No 21162.

Romer, C.D., and D.H. Romer (2004), A New Measure of Monetary Policy Shocks: Derivation and Implications, *American Economic Review*, Vol 94, No 4, pp 1055–1084.

Sims, C.A. (1980), Macroeconomics and Reality, *Econometrica*, No 48, pp 1–48.

Smets, F., and R. Wouters (2003), An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area, *Journal of the European Economic Association*, Vol. 1, No 5, pp 1123–1175.

Smets, F., and R. Wouters (2007), Shocks and Frictions in U.S. Business Cycles: a Bayesian DSGE Approach, *American Economic Review*, Vol 97, No 3, pp 586–606.

Stock, J.H., and M.W. Watson (2012), Disentangling the Channels of the 2007–09 Recession, *Brookings Papers of Economic Activity*, Spring, pp. 81–135.

Walerych, M., and G. Wesołowski (2021), Fed and ECB Monetary Policy Spillovers to Emerging Market Economies, *Journal of Macroeconomics*, Vol. 70(C).

PUBLICATIONS

ECB Spillovers to Emerging Europe: The Past and Current Experience

Working Paper No. WP/2024/170