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The Role of Exchange Rate in the Monetary Transmission: The Case of the Euro Area

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I thank Martin Melecky, Lucas Berend, Georgios Georgiadis, Maria Siranova, Michal Marencak, Sergey Slobodyan, Jachym Novotny, Filip Ostrihon, and the participants of the ICMAIF 2024, EEFS 2024, SEAM 2024, and CSE 2024 conferences, as well as the participants of the research seminar at the Institute of Economic Research SAS for helpful comments. I also thank Marek Jarocinski for providing the program code to replicate Jarocinski and Karadi (2020), as well as David Vondracek for excellent research assistance. I gratefully acknowl-edge financial support by the National Bank of Slovakia Foundation under the project No. GV-2022-4-P15-Z2 The Role of Exchange Rate Channel in the Transmission of Monetary Policy: The Case of Standard and Non-standard Monetary Policies.

The Role of Exchange Rate in the Monetary Transmission: The Case of the Euro Area

ABSTRACT

Contractionary monetary policy tends to appreciate the exchange rate, which might amplify the macroeconomic effects of monetary p olicy. We use Bayesian structural VAR model to study the role of exchange rate in the transmission of monetary policy in the Euro Area (EA). We distinguish between pure monetary pol-icy shocks and central bank information shocks. We find that contractionary monetary policy appreciates the Euro exchange rate, and decreases real output and consumer prices. Using a counterfactual analysis, we then construct a counterfactual scenario where the exchange rate does not respond to monetary policy shocks and we contrast this counterfactual with our baseline findings. In the absence of exchange rate appreciation, the transmission of monetary policy shocks to both real output and consumer prices is weaker, indicating that the exchange rate channel plays some role in amplifying the transmission of monetary policy in the Euro Area. Exchange rate also plays a larger role in the transmission of non-standard monetary policies, such as the for-ward guidance and large-scale asset purchases, than in the transmission of standard monetary policy. Finally, we find that the exchange rate does not influence the transmission of central bank information shocks.

KEYWORDS: Exchange rates; Monetary policy transmission; Monetary policy shock; Exchange rate channel; Counterfactual analysis; Euro Area

JEL CLASSIFICATION: E31, E52, F31

Úloha výmenného kurzu v transmisii menovej politiky: Prípad eurozóny

ABSTRAKT

Reštriktívna menová politika väčšinou vedie k zhodnoteniu domácej meny, čo môže prispieť k silnejšej transmisii menovej politiky. V tomto príspevku používame bayesovský štrukturálny VAR model na skúmanie úlohy výmenného kurzu v transmisii menovej politiky v eurozóne. Vo výskume rozlišujeme medzi menovopolitickými šokmi a informačnými šokmi centrálnej banky. Naše výsledky naznačujú, že reštriktívna menová politika vedie k zhodnoteniu výmenného kurzu eura ako aj k poklesu reálneho outputu a spotrebiteľských cien. Pomocou kontrafaktuálnej analýzy následne skúmame, aká by bola transmisia menovej politiky v prípade, ak by výmenný kurz eura nereagoval na menovopolitické šoky. V neprítomnosti zhodnotenia výmenného kurzu je transmisia menovej politiky do reálneho outputu aj cien slabšia, čo naznačuje, že výmenný kurz zohráva určitú úlohu pri zosilňovaní transmisie menovej politiky v eurozóne. Z našich výsledkov ďalej vyplýva, že výmenný kurz zohráva väčšiu úlohu v transmisii neštandardných menových politík, ako sú forward guidance a kvantitatívne uvoľňovanie, než v transmisii štandardnej menovej politiky. Na druhej strane, výmenný kurz neovplyvňuje transmisiu informačných šokov centrálnej banky.

KĽÚČOVÉ SLOVÁ: Výmenné kurzy; Transmisia menovej politiky; Menovopolitický šok; Kurzový kanál; Kontrafaktuálna analýza; Eurozóna

JEL KLASIFIKÁCIA: E31, E52, F31

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Introduction

The standard monetary policy framework in most advanced economies relies on steering the short-term interest rates to attain monetary policy objectives. As a result, for most advanced economies, the exchange rate no longer plays an active role in the conduct of monetary policy – instead, it is generally left to float. However, the exchange rate still plays a role in the transmission of monetary policy; the exchange rate channel remains one of the core channels of monetary policy transmission. For instance, contractionary monetary policy tends to appreciate the exchange rate of the domestic currency, which tends to contribute to disinflation by i) reducing import prices, and by ii) reducing international competitiveness of domestic goods ("trade channel"), which contracts demand in both the goods and labour markets (Beyer et al., 2017).

While there is a vast empirical literature that recently explored the transmission of monetary policy, the focus is generally on studying the overall effect of monetary policy on macroeconomic characteristics such as inflation, output, bank interest rates or bank lending (see for instance Breitenlechner et al., 2021; Gambacorta et al., 2014; Gambetti and Musso, 2020; Gregor et al., 2021; Horvath et al., 2018; Jarocinski and Karadi, 2020). Conversely, evidence on the importance of the respective transmission channels of monetary policy remains scarce. Few exceptions include Albertazzi et al. (2021) for bank lending channel, Neuenkirch and Noeckel (2018) for the risk-taking channel, and Bua and Dunne (2019) for the portfolio rebalancing channel. While the role of the exchange rate channel in the transmission of monetary policy remains understudied, high inflation coupled with the depreciation of numerous currencies against the U.S. dollar in 2022 highlighted exchange rate's role in the transmission of monetary policy, as several central banks hiked their policy rates to reverse the depreciation of their currencies and thus dampen inflationary pressures. In this context, Frankel (2022) has coined the term "reverse currency wars", which refers to central banks using their interest rate (or other) policies to strengthen their currencies and dampen the inflationary pressures (via the exchange rate channel). Gambetti and Musso (2020) is one of the very few recent empirical studies that has confirmed the important role of the exchange rate in the transmission of (un)conventional monetary policy.

Another recent branch of empirical literature investigates the effects of (un)conventional monetary policies on exchange rates (Bernoth et al., 2023; Bluwstein and Canova, 2016; Cecioni, 2018; Dedola et al., 2021; Franz, 2020; Gruendler et al., 2023), mostly finding that expansionary (contractionary) monetary policy depreciates (appreciates) the domestic currency, which could be expected to lead to higher (lower) output and by extension to higher (lower) inflation. However, the vast literature studying macroeconomic consequences of exchange rates often finds that weaker (stronger) domestic currency does not always have a positive (negative) effect on output (and by extension on inflation) (Fisera and Horvath, 2022; Nouira and Sekkat, 2012).

Considering the lack of empirical evidence on the role of the exchange rate in the transmission of monetary policy, particularly in larger economies, we provide novel empirical evidence on the importance of the exchange rate channel for the transmission of monetary policy in the case of the Euro Area. We use Bayesian structural vector autoregressive (BSVAR) model to study the transmission of monetary policy of the European Central Bank (ECB), and we distinguish between pure monetary policy shocks and central bank information shocks. We find that, as expected, a contractionary pure monetary policy shock appreciates the Euro, contracts the real economic activity and decreases prices in the Euro Area. Conversely, a positive central bank information shock does not influence the Euro exchange rate, expands economic activity and increases consumer prices slightly.

Next, we conduct a counterfactual analysis to identify the effect of monetary policy shocks in the absence of the exchange rate appreciation. There is a growing body of research that uses counterfactual analysis to study factors that influence the transmission of various types of shocks to the economy (see for example Beckmann et al., 2024; Georgiadis et al., 2024; Ider et al., 2024; Wong, 2015). We construct a counterfactual scenario in which the exchange rate does not respond to monetary policy shock based on the estimated BSVAR model by introducing additional offsetting shocks that ensure that the Euro exchange rate does not respond to the monetary policy shock. This approach thus enables us to construct the most likely path of several macro-financial variables after a monetary policy shock in the absence of the exchange rate channel. We find that in the counterfactual absence of the exchange rate channel, the effect of monetary policy on real economic activity and on consumer prices is smaller in magnitude: While one-standard-deviation monetary tightening reduces consumer price level in the baseline model by 0.2 %, in the counterfactual scenario in which the Euro does not respond to monetary tightening, the consumer prices decrease by less than 0.1 %. Similarly, the time that it takes for the real economic activity to revert back to the pre-shock level is approximately halved when the monetary policy does not operate through the exchange rate channel. The appreciation (depreciation) of the Euro induced by monetary tightening (loosening) augments the transmission of monetary policy. These findings indicate that even in a large (and relatively closed) economy such as the Euro Area, the exchange rate still plays some role in the transmission of monetary policy. We also find that the exchange rate does not play any role in the transmission of central bank information shocks to either the real economy or to the financial markets.

The results of our benchmark model as well as several model extensions further imply that the exchange rate channel enhances monetary transmission primarily through affecting international competitiveness and the economic activity ("trade channel"), and not through affecting import prices. The exchange rate also does not affect the transmission of ECB's monetary policy to other macro-financial variables – except for inflation expectations and consumer sentiment, which are also affected less in the counterfactual scenario. In a model extension, we distinguish between the standard monetary policy, and two types of non-standard monetary policy, large-scale asset purchases (LSAP) and forward guidance (FG). Our results show that, in the Euro Area between 2001 and 2019, the exchange rate played a larger role in the transmission of non-standard monetary policies than in the transmission of standard monetary policy.

Our paper extends the existing literature along several dimensions: First, we are, to the best of our knowledge, the first to conduct counterfactual analysis to explore the role of exchange rate channel in the transmission of monetary policy in the case of Euro Area. The only existing related study, Breitenlechner et al. (2022), only provides evidence on the time-varying contributions of various macroeconomic variables to the transmission of ECB's monetary policy, whereas we study what would, on average, happen if a monetary policy shock was not transmitted through the exchange rate channel. Second, we provide evidence on the transmission of monetary policy to a variety of macro-financial variables, some of which, like inflation expectations, consumer sentiment or financial stability, are understudied in the context of empirical monetary economics. Third, we follow the approach of Jarocinski (2024) to construct the estimates of standard and non-standard monetary policy shocks (LSAP, FG) for the Euro Area, and we study the role of the exchange rate channel for the transmission of these (non-)standard monetary policy shocks.

The remainder of the paper is structured as follows: Section 2 outlines the empirical methodology, while we introduce our dataset in Section 3. Section 4 presents our results and Section 5 concludes the paper. The results of additional robustness checks are available in the Appendix.

1 Empirical Methodology

In the following section, we first introduce the empirical model that we use to identify the macroeconomic effects of monetary policy. Second, we outline the counterfactual analysis that we use to construct counterfactual scenario in which the exchange rate does not respond to monetary policy shocks.

1.1 Bayesian Structural VAR (BSVAR) model

To evaluate the monetary policy transmission in the Euro Area, we estimate a Bayesian structural VAR (BSVAR) model. We follow the approach of Jarocinski and Karadi (2020), as it enables us to identify pure monetary policy shocks by purifying the high-frequency financial market surprises around monetary policy announcements of central bank information shocks. A similar approach was applied more recently by Tanahara et al. (2024). A characteristic feature of this BSVAR framework is that it combines a vector of high-frequency financial market surprises with a vector of low-frequency macro-financial variables:

$$\begin{pmatrix} m_t \\ y_t \end{pmatrix} = \sum_{p=1}^{P} \begin{pmatrix} 0 & 0 \\ B_{YM}^p & B_{YY}^p \end{pmatrix} \begin{pmatrix} m_{t-p} \\ y_{t-p} \end{pmatrix} + \begin{pmatrix} 0 \\ c_Y \end{pmatrix} + \begin{pmatrix} \mu_t^m \\ \mu_t^y \end{pmatrix} \tag{1}$$

where y_t is a vector of low-frequency endogenous macro-financial variables in month t, while m_t is a vector of high-frequency surprises in financial asset prices around ECB monetary policy announcements, or monetary surprises. The high-frequency monetary surprises that occur in the same month (t) are summed to convert the surprises to a monthly frequency. B_{YM}^p and B_{YY}^p are coefficient matrices at lag p, c_y is a vector of constants. Errors are assumed to follow the normal distribution $\binom{\mu_t^m}{\mu_t^y} \sim \mathcal{N}(0, \Sigma)$.

As per equation 1, we place zero restrictions on monetary surprises (m_t) so that they do not depend on either their own lags (m_{t-p}) or on the lags of macro-financial variables (y_{t-p}). That is, we assume that the high-frequency monetary surprises are exogenous. We estimate the baseline model in equation 1 with 24 lags (p), so that we can account for the "long and variable lags" in the transmission of monetary policy (as in Jarocinski and Karadi, 2020; Wong, 2015).

The vector m_t includes changes in the 3-month overnight indexed swap (OIS) rates and the EURO STOXX 50 stock market index during narrow windows around monetary policy announcements. When selecting the variables to include in y_t, we start with the closed-economy VAR model as applied, among others, by Gertler and Karadi (2015), Jarocinski and Karadi (2020), or Swanson (2023). Therefore, we include the following variables in y_t: short-term interest rate, stock market prices, BBB bond spread as a proxy for financial conditions, industrial production and consumer price index. Since our primary aim is to study the effect of exchange rate on monetary transmission, we also include a measure of Euro exchange rate to the vector of endogenous macro-financial variables in our benchmark model.[2] For further details on the variables that we use and on their sources, please see the next section. All the variables, except for those that are expressed in percentages, enter our model in log levels.

1.1.1 Identification

Another distinguishing and useful feature of the BSVAR framework of Jarocinski and Karadi (2020) is that it combines high-frequency identification with sign restrictions to identify monetary policy shocks. This identification strategy builds on two main assumptions.

First, high-frequency surprises in financial asset prices during narrow windows around monetary policy announcements (m_t) are only affected by monetary policy announcements, and are uncorrelated with any other shocks. This assumption is plausible and is assumed by most recent studies in empirical monetary economics. By focusing on high-frequency financial market surprises around monetary announcements, we can isolate the unexpected variation in monetary policy (Gertler and Karadi, 2015; Nakamura and Steinsson, 2018).

Second, a contractionary monetary policy shock leads to an increase in interest rates and a decrease in stock prices (i.e., there is a negative co-movement between the surprises in interest rates and stock prices during the narrow monetary event window). Conversely, a positive central bank information shock leads to an increase in interest rates and an increase in stock prices (i.e., there is a positive co-movement between the surprises in interest rates and stock prices during the narrow monetary event window).[3] The empirical results of Jarocinski and Karadi (2020) and Tanahara et al. (2024) corroborate this assumption. Therefore, to decompose monetary surprises into pure monetary policy shocks and central bank information shocks, we place the corresponding sign restrictions on m_t. The remaining variables remain unrestricted. Table 1 shows the identifying restrictions in our benchmark model.

We follow the procedure of Rubio-Ramirez et al. (2010) to calculate the posterior draws of the shocks. This approach assumes a uniform prior on the space of rotations and it computes the posterior draws conditionally on satisfying the sign restrictions. Following Jarocinski and Karadi (2020) and Tanahara et al. (2024), we use the Bayesian prior for the VAR parameters as recommended by Litterman (1986) and the draws from the posterior are generated using the Gibbs sampler.

[2] In a model extension, we also extend our benchmark model to include the following variables: Composite Indicator of Systemic Stress (CISS), inflation expectations and consumer confidence index.

[3] A central bank information shock occurs when market participants infer from the central bank announcement some information about central bank's view of economic conditions. For instance, if a central bank unexpectedly tightens monetary policy, market participants might infer from this decision that the central bank has a more positive view of the economy. This positive central bank information thus leads to both an increase in interest rate and in stock prices.

Table 1: Restrictions on Contemporaneous Responses of Variables to Shocks

	Shock		
Variable	Monetary policy	CB information	Other
m_t			
Interest rate	↑	↑	0
Stock prices	↓	↑	0
y_t	·	·	·

Notes: ↑, ↓, 0, · represent positive sign restriction, negative sign restriction, zero restriction and unrestricted response, respectively.

1.2 Counterfactual Analysis

Monetary policy influences the economy through several different channels. If a monetary policy shock first appreciates the nominal Euro exchange rate, which then, through lower international competitiveness and/or lower import prices, feeds into real economic activity and prices, we refer to this mechanism as the exchange rate channel. To identify how important the exchange rate channel is for monetary transmission, we use the estimated structural relationships from the BSVAR model and we construct a counterfactual scenario, in which the exchange rate does not respond to monetary policy shocks. Then, if the exchange rate channel plays an important role in the transmission of monetary policy, we should observe a significant difference between the baseline impulse responses, in which the exchange rate is unconstrained and the counterfactual impulse responses. Similar approach to identify the role of some transmission channel in the transmission of shocks was used by a few recent papers: Wong (2015) to explore the role of inflation expectations in the transmission of oil shocks to inflation, Beckmann et al. (2024) to identify the role of the exchange rate in the transmission of aggregate demand, aggregate supply and monetary policy shocks, or Georgiadis et al. (2024) to study the role of the U.S. dollar exchange rate in the transmission of global risk shocks to the world economy.

To construct the counterfactual, we generate a sequence of exchange rate shocks that precisely offset the response of the exchange rate to the monetary policy shock. This approach to generate a counterfactual scenario was used by several earlier studies (Bachmann and Sims, 2012; Beckmann et al., 2024; Bachmann and Sims, 2011; Sims and Zha, 2006; Wong, 2015).

In line with these earlier papers, we compute the counterfactual impulse responses for all the low-frequency macro-financial variables to the (pure) monetary policy shock[4] as follows:

$$\hat{\Psi}_j^k = \Psi_j^k + \sum_{n=0}^{k-1} e_j \Lambda^n e_s^{'} \hat{\epsilon}_n^s \tag{2}$$

where $\hat{\Psi}_j^k$ is the counterfactual impulse response, while Ψ_j^k is the baseline impulse response

[4]We focus on studying the role of exchange rate channel in the transmission of pure monetary policy shocks. However, for comparison, we also generate counterfactual impulse responses of the macro-financial variables to the central bank information shocks (i.e., in this counterfactual scenario, the exchange rate does not respond to the central bank information shock).

function (IRF) of variable j to monetary policy shock at horizon k.[5] $\hat{\epsilon}_n^s$ is the sequence of structural shocks to offset the response of exchange rate (s) to the monetary policy shock for all the horizons k. That is, we solve the equation 2 for a sequence of shocks ($\hat{\epsilon}_n^s$), so that $\hat{\Psi}_s^k = 0$. In equation 2, e_j is a selector row vector that extracts the response of variable j, Λ^n is the matrix of dynamic responses of all variables to shocks at horizon n that comes from the companion form representation of the benchmark BSVAR model.

2 Data

We use monthly data for the aggregate of Euro Area countries for the period between January 2001 and December 2019. Ending the sample just before the outbreak of the COVID-19 pandemic entails two main advantages: First, the extraordinary volatility in macroeconomic variables during the early months of the pandemic does not affect our results. Second, at the time of writing, the inflationary episode of 2022-2023 was not yet fully concluded and including a large spike in inflation that is not yet over at the end of the time series could also affect our results. Several other recent studies on monetary policy also end their sample just before the start of the pandemic (see for instance Ider et al., 2024; Swanson, 2023).

In what follows, we introduce the variables that we include in our benchmark and extended VAR models. To identify monetary policy shocks, we use the high-frequency changes in financial asset prices around monetary policy announcements by the ECB. High-frequency surprise series have been widely used by the recent literature on empirical monetary economics (Franz, 2020; Geiger et al., 2023; Gertler and Karadi, 2015; Guerkaynak et al., 2005; Gruendler et al., 2023; Ider et al., 2024; Jarocinski and Karadi, 2020; McKay and Wolf, 2023). We use the data on high-frequency financial asset price surprises around the monetary policy announcements taken from the updated Euro Area Monetary Policy Event Study Database (EA-MPD) compiled by Altavilla et al. (2019). Following Jarocinski and Karadi (2020), we use the surprises in 3-month overnight indexed swap (OIS) rates and in the EURO STOXX 50 stock market index during the 30-minute window around the ECB press statement and the (subsequent) 90-minute window around ECB press conference on ECB announcement days.[6] This focus on narrow time windows around the monetary policy announcements can help to isolate the unexpected (and exogenous) variation in monetary policy and thus overcome endogeneity issues when studying macroeconomic consequences of monetary policy (Gertler and Karadi, 2015; Jarocinski and Karadi, 2020; Nakamura and Steinsson, 2018). The data on high-frequency surprises are then aggregated to monthly frequency.

Apart from the high-frequency surprises around monetary policy announcements, we also include several low-frequency macro-financial variables in our benchmark VAR model. Our point of departure is the closed-economy VAR of Gertler and Karadi (2015) and Jarocinski and Karadi (2020). Therefore, we include short-term interest rate, stock market prices and a measure financial conditions in our benchmark model. To capture the short-term interest rate, we use yield on 1-year German government bond, which is generally assumed to be the government bond with lowest risk in the Euro Area. For the stock market prices, we use the EURO STOXX 50 stock market index.

[5] In our case, baseline impulse response is the 50th percentile of IRF draws from the benchmark BSVAR model.
[6] That is, we focus on surprises that occur during the monetary event window.

The data on these variables is taken from Refinitiv Eikon. Finally, to capture financial conditions in the Euro Area, Jarocinski and Karadi (2020) used the BBB bond spread. Due to data availability issues, we use the ICE BofA Euro High Yield Index Option-Adjusted Spread as our proxy for financial conditions in the Euro Area and we refer to this variable as the BBB bond spread throughout the paper. The data on BBB bond spread are taken from the Federal Bank of St. Louis' database.

Next, we use the industrial production index (excluding construction) for all the Euro Area countries (fixed composition) as our main proxy for real economic activity. We use the harmonized index of consumer price (HICP) for all the Euro Area countries (fixed composition) as our main measure of consumer prices, as this index represents a comprehensive measure of consumer price developments in the Euro Area. The data on industrial production index and HICP are taken from Eurostat.

Finally, as our measure of exchange rate, we use the nominal effective exchange rate (NEER), which is expressed in an indirect quotation (i.e., an increase in its value represents a nominal appreciation of the Euro). The data is taken from the IMF's International Financial Statistics database. While our choices of proxies for real economic activity and prices are consistent with the earlier research, our choice of NEER as our main exchange rate measure is less straightforward. We have opted to use the effective exchange rate instead of bilateral exchange rate because the effective exchange rate helps us to capture the 'average' exchange rate of the Euro against the currencies of Euro Area's main trade partners. Therefore, the effective exchange rate offers us a broader perspective on exchange rate developments in the case of the Euro Area. Effective exchange rates are often used by studies that explore the macroeconomic consequences of exchange rates (see for instance Bahmani-Oskooee and Kanitpong, 2017; Fisera and Horvath, 2022; Nouira and Sekkat, 2012). Moreover, among studies on monetary policy, Gruendler et al. (2023) also used NEER as their main measure of the exchange rate.[7] Following Beckmann et al. (2024) and Fisera (2024), we use nominal exchange rate instead of the real exchange rate because nominal exchange rate does not reflect relative prices, and it thus influences the transmission of monetary policy more directly. Furthermore, the nominal exchange rate can be influenced more directly by the central bank. Finally, over the short-term[8] nominal and real exchange rate developments are highly correlated anyway – since prices are less flexible over the short-term, the real exchange rate developments are driven by developments of the nominal exchange rate.

Next, we also extend our benchmark model for the following variables: composite indicator of systemic stress (CISS) of Hollo et al. (2012) as a proxy for financial stability; average of 12-month-ahead HICP inflation point forecasts from the survey of professional forecasters as a proxy for inflation expectations; aggregate consumer confidence indicator (CCI) as a proxy for consumer sentiment. The data on CISS and inflation expectations for the Euro Area are taken from the ECB's Data Warehouse, while the data on CCI are taken from the Eurostat. The data on inflation expectations are interpolated from quarterly frequency to monthly frequency based on linear interpolation.

The detailed description of the variables and the sources of the data is available in Table A1 in the Appendix.

[7] However, as a robustness check, we also use the bilateral exchange rate of the Euro vis-a-vis the U.S. dollar.
[8] A horizon that is arguably more relevant for anti-cyclical monetary policy.

3 Results

In the following section, we first outline our baseline results. Next, we extend our baseline model for several additional variables. Finally, we report the results of several robustness checks.

3.1 Baseline Results

We report the impulse responses of key macroeconomic and financial variables to a pure monetary policy for the aggregate Euro Area in Figure 1. The solid blue lines represent the impulse responses from the baseline BSVAR model. Our findings are consistent with the recent findings provided for the Euro Area by Jarocinski and Karadi (2020) and are also plausible from the theoretical standpoint: Following a contractionary pure monetary policy shock, the yield on one-year German government bonds (puzzlingly) does not respond on impact and subsequently falls, although its response remains insignificant.[9] The stock market contracts by approximately 0.8 % during the first few months following the monetary tightening. This decrease in stock prices is not very persistent and disappears one year after the shock.

Monetary tightening also contracts the real economy, with the industrial production index decreasing by 0.2 % during the first ten months after an exogenous tightening of monetary policy. Our findings on the negative effect of tighter monetary policy on economic activity in the Euro area are again fully consistent with the recent empirical literature (Geiger et al., 2023; Gruendler et al., 2023; Jarocinski and Karadi, 2020). Price level also decreases persistently following monetary contraction: Consumer price level first decreases sharply following the shock and it then continues to fall gently during the subsequent months. Overall, the price level decreases by approximately 0.2 %. This fall in prices is larger than Jarocinski and Karadi (2020) find for either the United States or for the Euro Area. However, in our case, we use the consumer price index instead of GDP deflator, and we also include the exchange rate in the model, which could lead to the larger observed effect on prices. In contrast to the findings of earlier studies (Gertler and Karadi, 2015; Jarocinski and Karadi, 2020; Swanson, 2023), we find that pure monetary policy shock does not affect the BBB bond spread, our proxy for financial conditions.

Finally, we find that contractionary monetary policy shock appreciates the Euro exchange rate[10] This finding is in line with both the theoretical assumptions about monetary policy shocks made in sign-restricted VARs (Beckmann et al., 2024; Forbes et al., 2018), as well as with the empirical evidence provided by recent papers (Franz, 2020; Yang and Zhang, 2021). Bernoth et al. (2023) also confirms for the United States that a temporary monetary tightening appreciates the domestic currency, while a persistent monetary policy shock depreciates the domestic currency.

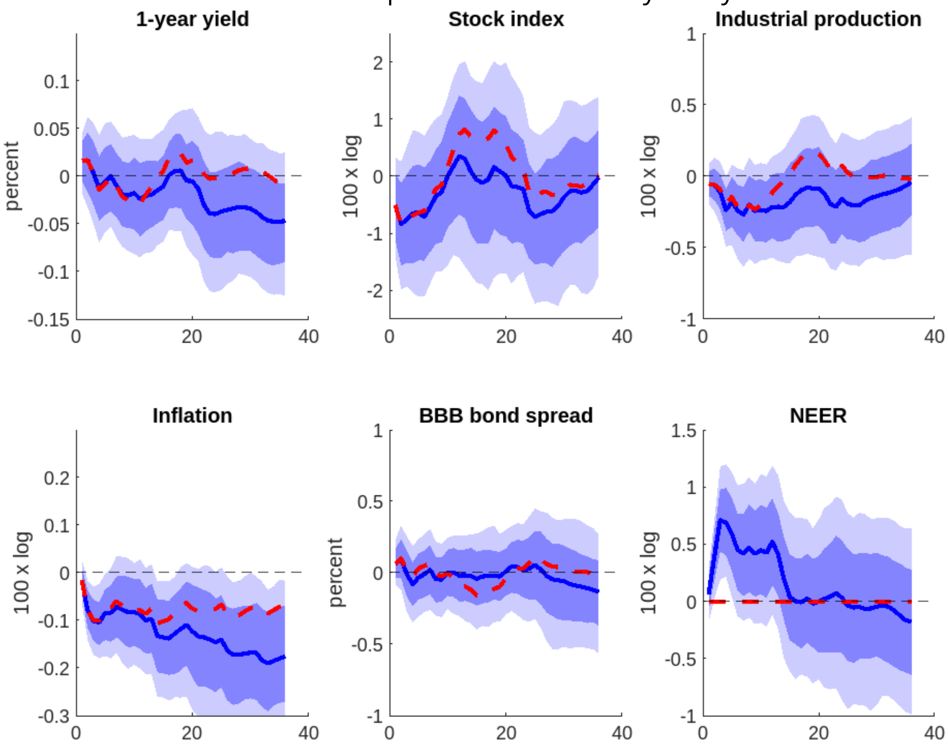
Our results indicate that the Euro appreciates sharply on impact: A one-standard-deviation contractionary monetary policy shock appreciates the Euro by approximately 0.7 %. After the fast initial appreciation, the Euro gradually depreciates. 18 months after the shock, the Euro exchange

[9] In line with Jarocinski and Karadi (2020), in a robustness check, we impose stronger sign restrictions to the identification of pure monetary policy shocks: We also impose that the short-term interest rate (German one-year government bond yield) increases by at least one basis point on impact following a contractionary monetary policy shock. The results of this robustness check are reported in Figure C1 in the Appendix, and they corroborate our baseline findings for other variables.

[10] As our baseline measure of exchange rate, we use the nominal effective exchange rate (NEER).

rate returns back to its pre-shock level. This initial sharp appreciation followed by gradual depreciation appears to be consistent with the overshooting model of Dornbusch (1976): Initially, the flexible exchange rate responds quickly to a monetary policy shock and it "overshoots", helping the economy to achieve a short-term equilibrium. Subsequently, as less flexible prices of goods and services start to adjust (fall), the exchange rate starts to depreciate and the economy converges towards a new equilibrium.

Figure 1: Baseline and Counterfactual Responses to a Monetary Policy Shock



Notes: The figure plots impulse responses to a one-standard-deviation contractionary monetary policy shock. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

Next, we proceed to the results of the counterfactual analysis. Since monetary policy might operate through several channels, in the counterfactual analysis, the exchange rate is constrained to be unresponsive to the monetary policy shock. This approach enables us to isolate the effect of monetary policy that operates through the exchange rate channel: If the exchange rate channel is important in propagating monetary policy shocks, the counterfactual impulse responses should deviate significantly from the baseline (unconstrained) impulse responses. The red dashed lines in Figure 1 are the counterfactual impulse responses. The bottom right panel of Figure 1 confirms that the exchange rate (NEER) does not respond to the monetary policy shock in the counterfactual scenario.

The counterfactual analysis indicates that the exchange rate channel does play a role in influencing the transmission of monetary policy even in the case of a large economy such as the Euro Area, as baseline and counterfactual impulse responses deviate from each other for variables such as the industrial production or consumer prices, with the exchange rate playing a larger role in the transmission of monetary policy to consumer prices than to the industrial production index. In the absence of nominal exchange rate appreciation, the decline in the level of consumer prices is halved in comparison to the baseline response (0.1 % vs. 0.2 %). Although this difference between the counterfactual and the baseline impulse response is economically significant, its statistical significance is limited, as the counterfactual impulse response (barely) escapes the 68 % credible bands. Similarly, we also observe some difference between the baseline and counterfactual impulse responses of industrial production to monetary policy shock, with the counterfactual IRF returning back to the pre-shock level already a year and a half after the shock – compared with some three years for the baseline IRF.

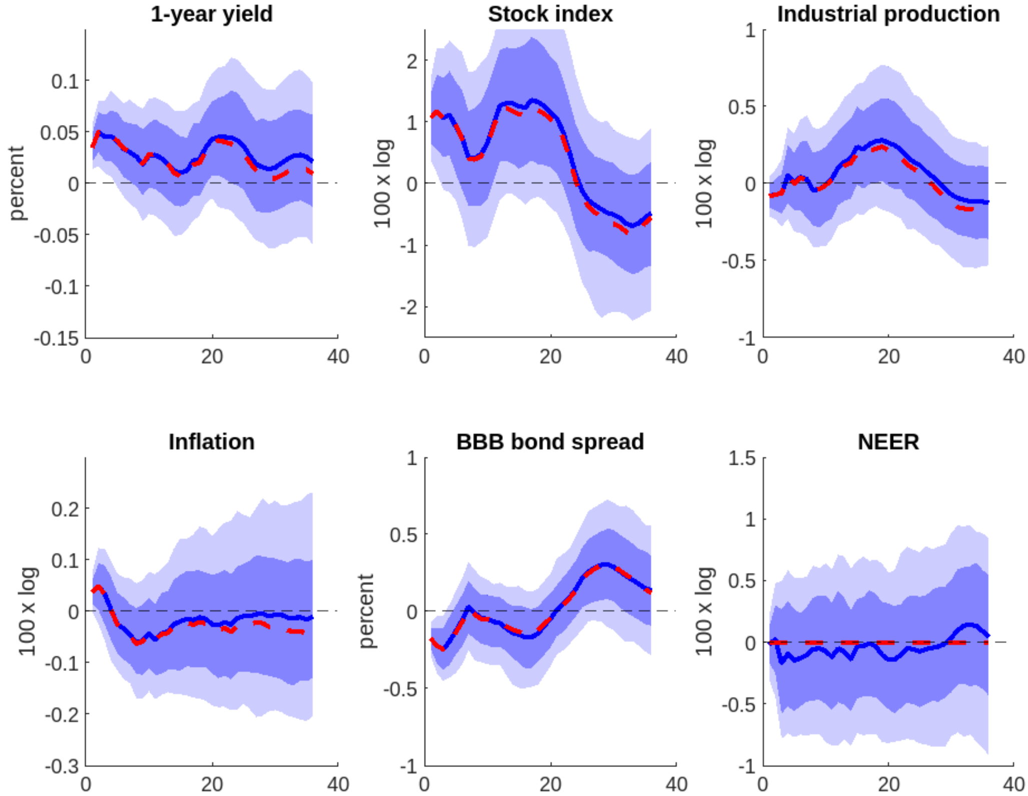
We conclude that the exchange rate seems to enhance the transmission of monetary policy, but this effect seems to be relatively small. In the absence of a nominal appreciation, contractionary monetary policy still manages to bring down the price level, but this decrease is smaller in magnitude. Interestingly, even though the exchange rate responds to the monetary policy shock on impact, the difference between the baseline and counterfactual responses for industrial production and consumer prices starts to appear only with some lag – approximately a year after the shock. For industrial production, this gap peaks around 20 months after the shock, while for consumer prices, this difference grows over time, peaking at the end of the impulse response horizon (36 months). This finding indicates that the exchange rate channel influences the monetary transmission primarily by influencing the real economy through the "trade channel" (and not by influencing the import prices). That is, nominal appreciation following a contractionary monetary policy shock makes domestic goods and services relatively more expensive, leading to expenditure switching from domestic (Euro Area) to foreign goods and services, which contracts the domestic economic activity. Consistent with the J-curve hypothesis, the exchange rate influences the real economy only with some delay (Badinger and de Clairfontaine, 2019; Fisera, 2024; Magee, 1973). The slowdown in real economic activity then reduces the consumer price level – again with some delay, owing to less flexible prices.

For financial variables (short-term interest rate, stock prices, and the BBB bond spread), the differences between baseline and counterfactual IRFs as shown in Figure 1 are generally small and not statistically significant. And any larger differences only appear with longer delay, which could indicate that these differences are rather driven by the smaller contraction in real economic activity in the counterfactual scenario instead of a direct effect of exchange rate on these financial indicators.

Next, Figure 2 shows baseline and counterfactual impulse responses to a positive central bank information shock. A positive central bank information shock represents a positive information inferred by economic agents about the state of the economy from the central bank announcement. The baseline impulse responses are in accordance with the findings provided by previous research: A positive central bank information shock increases both the short-term interest rate and stock prices on impact. The former increases by some 5 basis points, while the latter increases by approximately 1 %. Both in terms of magnitude and direction of the effect, our findings echo the results reported by Jarocinski and Karadi (2020). As economic agents become more optimistic due to positive information from the central bank announcement, their risk aversion decreases. Therefore, the investors shift their investments toward the stock market, instead of the (short-term) bonds, leading to higher short-term bond yields and higher stock prices. Short-term interest rates and stock prices revert back to 0 after roughly two years. A positive central bank information shock also improves financial conditions, as the BBB bond spread falls on impact by some 20-25 basis points: When investors' risk aversion falls, their demand for riskier bonds with lower investment grade increases, contributing to a decrease in BBB bond spread.

We find that a positive central bank information shock positively influences economic activity, as the industrial production index increases in the months following the central bank information shock – increasing by approximately 0.25 % 20 months after the initial shock. The positive macroeconomic effect of central bank information shock is in line with theoretical assumptions: When economic agents extract a positive information about the current state of the economy from a decision by the central bank, they are likely to improve their own expectations of the state of the economy, which could lead to both a higher supply by the firms and higher consumption by the households. Similarly, a positive central bank information shock increases prices on impact, though in this case, the effect quickly reverts back to 0. Our findings on the positive effect of central bank information shock on both the economic activity and prices corroborate the earlier findings provided by Franz (2020) and Jarocinski and Karadi (2020).

Figure 2: Baseline and Counterfactual Responses to a Central Bank Information Shock



Notes: The figure plots impulse responses to a one-standard-deviation positive central bank information shocks. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to central bank information shock. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

We find that the central bank information shock does not influence the Euro exchange rate.

This finding seems to be in line with the findings of Franz (2020), who found that a central bank information shock in the Euro Area tends to appreciate the Euro against some currencies and depreciate it against others. Namely, a positive central bank information shock increases investors' risk appetite, which increases carry trade flows. Then, the Euro appreciates against low-yield currencies, while it depreciates against high-yield currencies. Consequently, since as a proxy for exchange rate, we use the nominal effective exchange rate, which captures the average exchange rate developments of the Euro against the currencies of all Euro Area's main trade partners, we hypothesize that positive and negative effects of central bank information shock on different bilateral exchange rates could cancel each other out, explaining the insignificant effect of central bank information shocks that we observe.

Since the exchange rate does not respond to the central bank information shock, the baseline and counterfactual impulse responses reported in Figure 2 are not different from each other. Therefore, we conclude that the exchange rate does not play any role in the transmission of central bank information shocks to either the real economy or to the financial system. As this result proved fairly consistent across numerous robustness checks and model extensions, we do not report the results of these additional estimations for the central bank information shock for brevity, and we only focus on the estimations concerning the pure monetary policy shock throughout the rest of the paper.[11]

3.2 Model Extensions

3.2.1 Additional Variables

In the previous sub-section, we have extended the standard monetary policy VAR specification used in monetary economics by including the exchange rate, as well as by conducting counterfactual analysis to evaluate the role of the exchange rate channel in monetary transmission. The results reported in the previous section indicate that the exchange rate does play a role in monetary transmission – primarily by influencing the real economy and not by influencing import prices. Next, we aim to shed some further light on the exchange rate transmission channel: We extend our model from the previous sub-section and we include three additional variables through which the exchange rate might also influence monetary policy transmission.

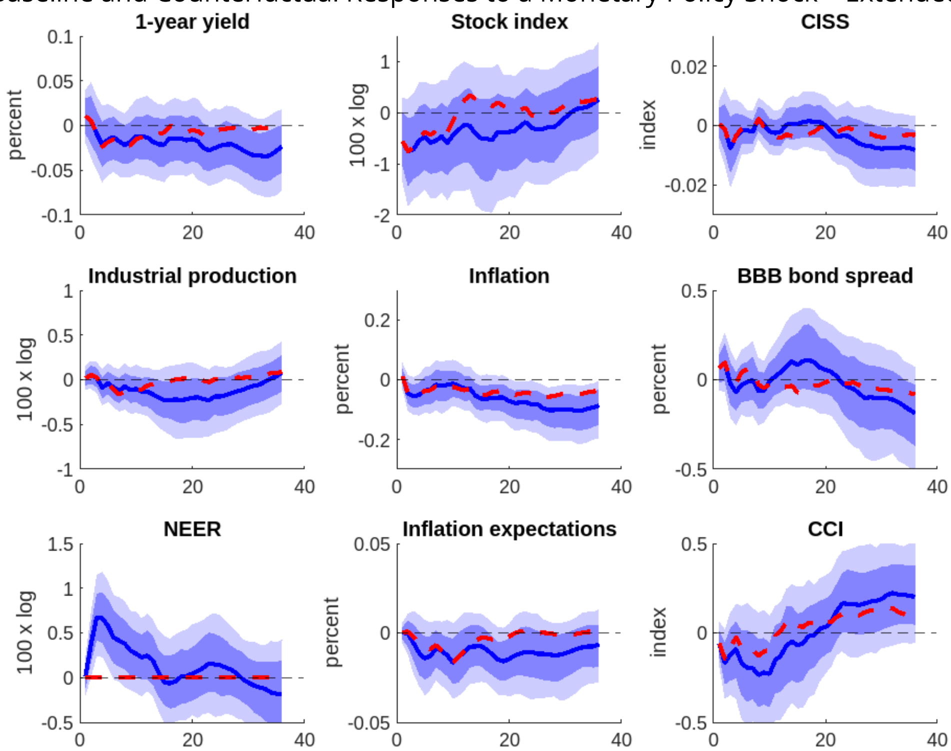
First, we augment our benchmark model with the composite indicator of systemic stress (CISS) for the Euro Area, which we use as a proxy for financial stability. Georgiadis et al. (2023) and Georgiadis et al. (2024) provide both empirical and theoretical evidence that the U.S. dollar plays a crucial role in the transmission of the global financial cycle and global risk shocks to the world economy, respectively. The findings of these two papers for the U.S. dollar and the findings of Fisera (2024) for a global sample of countries thus highlight the role of the "financial channel" of the exchange rate. Euro appreciation (depreciation) induced by monetary tightening by the ECB makes non-Euro-denominated financial inflows to the Euro Area cheaper (more expensive), while it makes Euro-denominated financial outflows from the Euro Area more expensive (cheaper).[12] Therefore,

[11]The results of the additional estimations for the central bank information shock are available upon request from the authors.

[12]For instance, Euro appreciation makes Euro-denominated loans more expensive for non-Euro Area residents, as their

exchange rate changes induced by monetary policy decisions might influence financial stability, an effect which we aim to capture with the inclusion of the CISS in the extended model. Impulse responses to monetary tightening are shown in Figure 3. The financial stability, as captured by the CISS, does not appear to be affected by monetary policy; financial stability only improves (i.e., CISS falls) towards the end of the IRF horizon, presumably on the back of improving economic conditions. The exchange rate also does not appear to play any role in affecting the transmission of monetary policy to financial stability, as the baseline and counterfactual responses of CISS are not different from each other. This finding could be explained by the relatively smaller international role of Euro Area's financial system: Ca'Zorzi et al. (2023) found evidence that Euro Area's monetary policy influences the rest of the world by affecting trade and not by affecting financial conditions. The responses of those macroeconomic and financial variables that were already included in the benchmark model (both baseline and counterfactual) remain unchanged in the extended model (Figure 3). However, in this extended model in contrast to the benchmark model, BBB bond spread increases after monetary policy tightening (as expected) on impact but this effect quickly disappears.

Figure 3: Baseline and Counterfactual Responses to a Monetary Policy Shock – Extended Model



Notes: The figure plots impulse responses to a one-standard-deviation contractionary monetary policy shock for the extended model. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

Second, we augment the benchmark model with inflation expectations. Exchange rate move-

local currencies depreciate vis-a-vis Euro. As a result, the debt burden of non-Euro Area residents who had taken Euro-denominated loans increases with stronger Euro, which could affect their ability to repay their debts and, by extension, undermine financial stability in the Euro Area.

ments influence inflation expectations (Coibion and Gorodnichenko, 2015; Nasir et al., 2020), which themselves play an important role in the monetary policy transmission. A stronger Euro brought about by contractionary monetary policy might therefore convince economic agents to lower their inflation expectations, which might lower the prices. Indeed, the middle figure in the bottom panel of Figure 3 shows that while monetary policy tightening decreases inflation expectations (by some 0.02 % for a one-standard-deviation monetary contraction), this effect is only persistent with the nominal appreciation of the Euro. In the counterfactual scenario without Euro appreciation, the decrease in inflation expectations is only temporary, as the inflation expectations revert back to 0 approximately one and a half year after the shock. Nonetheless, the difference between the baseline and counterfactual impulse responses only appears with some time lag. Therefore, it seems that exchange rate changes induced by monetary policy do not directly affect inflation expectations. Instead, the smaller contraction in economic activity in the counterfactual scenario seems to contribute to relatively higher inflation expectations – explaining why the gap between baseline and counterfactual inflation expectations only turns significant some 20 months after the shock.

Third, we also include the consumer confidence index (CCI) as a measure of consumer sentiment in the extended model. A stronger domestic currency improves terms of trade (provided that nominal appreciation leads to a real appreciation), which benefits consumers by contributing to higher disposable income and thus enabling higher consumption (Lane and Stracca, 2018). Therefore, the stronger currency induced by monetary tightening might constrain the contractionary consequences of monetary policy by lifting the consumer confidence and, thus, increasing consumption, limiting the disinflationary effect of monetary policy. The baseline and counterfactual responses of consumer confidence index to a monetary contraction can be seen in the bottom right panel of Figure 3. Tighter monetary policy first reduces consumer confidence, but the effect – presumably driven by improving economic conditions and the decrease in price level. Initially, the response of the CCI is somewhat smaller in the counterfactual scenario.[13] This finding indicates that when the stronger Euro is associated with monetary tightening, consumers do not interpret it as an increase in their purchasing power, but rather as (contractionary) monetary policy operating unhindered. On the other hand, in the counterfactual scenario when monetary tightening does not appreciate the exchange rate, consumers might interpret this as the monetary transmission being impeded and, as a result, their confidence does not fall as much.

3.2.2 Different Types of Monetary Policy Shocks

So far, we have used high-frequency changes in financial asset prices around monetary policy announcements to identify monetary policy shocks, and we have used the approach of Jarocinski and Karadi (2020) to purify the pure monetary policy shocks from central bank information shocks. Although this approach enables us to identify the overall effect of monetary policy, it does not allow us to distinguish between the effect of standard and non-standard monetary policies. In response to the Global Financial Crisis of 2008-2009 (GFC), the ECB had started to implement different types of non-standard monetary policies, such as the credit easing, forward guidance, and, starting in

[13] Though the effect is barely significant. Nevertheless, the difference between the baseline and counterfactual response of the CCI is more pronounced in some of the robustness checks. That is, the appreciation of the Euro exacerbates the negative effect of monetary tightening on consumer confidence.

2015, quantitative easing. As the role of the exchange rate channel might be different for these non-standard monetary policies, in the following extension of our benchmark model, we use an alternative approach to identify monetary policy shocks, which also enables us to distinguish between four different types of monetary policy: standard monetary policy, Odyssean forward guidance, large-scale asset purchases (LSAP), and Delphic forward guidance. Jarocinski (2024) applied this data-driven approach to identify different monetary policy shocks in the case of the United States, and we extend this methodology to the Euro Area. In this case, the identification is also based on high-frequency responses of financial asset prices (yield curve represented by 3-month OIS rates, 2- and 10-year yields on German government bonds, Euro Stoxx 50 stock market index) around monetary policy announcements. However, this identification relies on excess kurtosis of these financial market responses to disentangle four different structural shocks.

We report the high-frequency responses of the yield curve and the stock market to the four structural shocks in Figure B1 in the Appendix. The four identified structural shocks have a plausible (ex-post) economic interpretation and their effects are consistent with Jarocinski (2024)'s findings for the United States.[14] The first shock, contractionary standard monetary policy shock, increases primarily the short end of the yield curve (3-month OIS rate). The second shock, Odyssean forward guidance, does not affect the 3-month OIS rate, but it significantly increases yield on 2-year government bonds, and it also has some effect on 10-year yield. The third shock, large-scale asset purchase, has the largest effect on the long end of the yield curve. All three shocks contract stock market prices – especially Odyssean forward guidance. Finally, the fourth shock, Delphic forward guidance, increases both the interest rates and stock market prices – akin to the central bank information shocks in our benchmark model.

Next, we re-estimate our benchmark BSVAR model with these different types of monetary policy shocks. Instead of using sign restrictions, we just use the Choleski decomposition for VAR identification, placing the shocks first. We report the impulse responses to a contractionary standard monetary policy shock in Figure B2 in the Appendix. For standard monetary policy shock, majority of impulse responses are insignificant, including the response of the exchange rate. This insignificant effect could be driven by the period of the zero lower bound and the period of rather low interest rates, which make up significant portion of our sample. As the exchange rate does not respond to standard monetary policy shock, no differences appear between the baseline and counterfactual impulse responses.

On the other hand, Odyssean forward guidance, which is commitment-based, exerts significant effect on both macroeconomic and financial variables (Figure B3 in the Appendix). Monetary tightening exercised by Odyssean forward guidance[15] contracts real economic activity, decreases the price level, and it drives down both inflation expectations and consumer confidence. Importantly, it also sharply appreciates the Euro exchange rate on impact – by approximately 0.6 % for a one-standard-deviation FG shock. In the counterfactual scenario without the Euro appreciation, the decrease in prices and industrial production is smaller. Although for the latter variable, the effect is not statistically significant. Similar picture appears when we inspect baseline and counterfactual responses to the LSAP shock in Figure B4 in the Appendix. The only difference being that LSAP

[14]Except that for the Euro Area, we find that a contractionary LSAP shock decreases stock prices – instead of increasing them.

[15]As an example, central bank commits to keep interest rates elevated for an extended period of time.

shock has a more pronounced effect on financial variables, as contractionary LSAP shock[16] leads to a large decrease in stock prices, tightens financial conditions (BBB bond spread increases), and reduces financial stability (CISS increases). To conclude, both Odyssean FG and LSAP seem to have enhanced monetary policy transmission in the Euro Area, and the exchange rate channel improves the transmission of these two types of monetary policy shocks to consumer prices. However, the role of the exchange rate channel appears to be somewhat muted. Our findings on the significant effects of FG and LSAP are consistent with the evidence provided by Swanson (2021) for the United States.

Finally, Figure B5 in the Appendix depicts the impulse responses to one-standard-deviation Delphic forward guidance shock, which is similar in nature to the central bank information shocks in our benchmark model because it is a forecast-based type of forward guidance. Moreover, a positive Delphic FG shock does indeed increase interest rates, stock prices, industrial production, inflation expectations, and consumer sentiment. That is, Delphic FG shock captures the positive information about the economy that the economic agents extract from central bank announcements, which leads to higher risk-taking, consumption and economic activity. Consistent with increased risk-taking, Figure B5 in the Appendix shows that financial conditions and financial stability improve after the shock. This effect is later reversed though: Increased risk-taking might eventually lead to unsustainable credit or asset price booms, which later undermine financial stability. In contrast to our findings for positive central bank information shock, positive Delphic FG shock depreciates the Euro on impact. The lower risk aversion can entice investors to shift their investments from the Euro Area to higher yielding currencies, decrease the value of the Euro in the process. The results of the counterfactual analysis imply that this Euro depreciation augments the positive macroeconomic effects of positive Delphic FG shock: In the counterfactual scenario, in this case in the absence of Euro depreciation, industrial production, consumer prices and inflation expectations rise less than in the baseline scenario with Euro depreciation. Consequently, these results highlight the positive (negative) macroeconomic effects of exchange rate depreciation (appreciation) that monetary policy might bring about.

3.3 Robustness Checks

In our main BSVAR model specifications discussed above, we use the index of industrial production as our main measure of economic activity because this enables us to estimate the model in a monthly frequency. While many related papers use the index of industrial production (Franz, 2020; Geiger et al., 2023; Georgiadis et al., 2024; Gruendler et al., 2023), industrial production might not be a suitable proxy to capture the trends in overall economic activity in the increasingly service-dominated European economies. Therefore, we reestimate our baseline BSVAR model with real GDP interpolated to monthly frequency instead of the industrial production index. We report the results of this alternative specification in Figure C2 in the Appendix. These results corroborate our baseline findings: We find that a one-standard-deviation contractionary monetary policy shock appreciates the Euro exchange rate, reduces stock prices, reduces the consumer price level, and contracts the real economic activity. Real GDP, as a more comprehensive measure of economic

[16] For instance, central bank shrinks its balance sheet by selling bonds from its portfolio.

activity that also incorporates more stable government consumption, falls somewhat less than the industrial production index in our baseline model – by approximately 0.1 %. However, the response of real GDP to monetary tightening behaves similarly to the response of industrial production index: Real GDP gradually falls during the first 20 months following the shock, and it reverts back to 0 towards the end of IRF horizon. Albeit the response of real GDP is more statistically significant.

In the counterfactual analysis, we once again find that the transmission of monetary policy to consumer prices is smaller in the absence of a nominal exchange rate appreciation: While monetary tightening decreases consumer price level by 0.1 % three years after the shock, in the absence of the Euro appreciation, this effect is reduced to less than 0.05 %. Therefore, the results of this alternative specification seem to underline the role of the exchange rate in the monetary transmission: Though the economic magnitude of the effect of exchange rate on monetary transmission to consumer prices is rather small, the difference between baseline and counterfactual IRFs remains statistically significant since the counterfactual IRF is outside the 68 % credibility band. Moreover, this alternative specification with real GDP corroborates our conclusion that the exchange rate enhances monetary transmission by affecting the real economy, since in the counterfactual scenario without Euro appreciation, the contraction in real GDP is significantly smaller than in the baseline model where the monetary policy operates also by influencing the exchange rate. The difference between baseline and counterfactual IRFs of real GDP is larger – both economically and statistically – than the difference for industrial production index. Although the results with real GDP shown Figure C2 are both economically and statistically significant – and real GDP serves as a broader proxy for economic activity – we treat these findings with some caution because real GDP is interpolated to a monthly frequency and it thus represents a generated regressor. Therefore, we prefer to keep the specification with industrial production as our baseline model specification.

In the next robustness check, we use an alternative measure of exchange rate: the bilateral U.S. dollar and Euro exchange rate (USD/EUR). Our primary measure of exchange rate, the nominal effective exchange rate (NEER), captures the trends in overall (average) value of the currencies of Euro Area's main trading partners. However, the dominant currency pricing introduced by Gopinath et al. (2020) highlights the crucial role of the U.S. dollar in international trade and the model of Georgiadis et al. (2023) underlines the central role of the U.S. dollar in affecting the transmission of the Global Financial Cycle to the world economy. Moreover, for a large economy such as the Euro Area, a large proportion of imports is invoiced in the domestic currency, but imports of oil (and some other energy sources) are invoiced in U.S. dollars. Therefore, USD/EUR exchange rate could be a more appropriate exchange rate measure to capture the transmission of monetary policy through the exchange rate channel by influencing import prices. We report the results of this robustness check in Figure C3 in the Appendix. The baseline BSVAR model with USD/EUR exchange rate produces plausible impulse responses that align well with our baseline impulse responses. Similar to our findings for NEER, Euro first appreciates sharply against the U.S. dollar by more than 1 % after Euro Area's monetary tightening. Following the initial appreciation, Euro gradually depreciates against the dollar, and it reverts back to 0 about a year after the initial monetary policy shock. As a result, the response of USD/EUR exchange rate is qualitatively similar to the response of Euro Area's NEER. However, quantitatively, the appreciation of the Euro against the U.S. dollar is larger than Euro's appreciation against the weighted average of its main trading partners' currencies. Once we fix the USD/EUR exchange rate with respect to Euro Area's monetary policy shocks, the (counterfactual) impulse responses are qualitatively similar to the counterfactual impulse responses from our main model specification: In the absence of Euro appreciation against the U.S. dollar, monetary policy's effect on industrial production and consumer prices is less pronounced. But the difference between baseline and counterfactual impulse responses of consumer prices is somewhat smaller in this robustness check in comparison to our baseline model. We derive two takeaways from this finding: First, this finding seems to corroborate our conclusion that the exchange rate channel of monetary transmission operates primarily by first influencing the real economy, which then affects the consumer prices. Namely, most of Euro Area's international trade is not with the United States. As a result, Euro's average exchange rate (NEER) is likely to have a larger effect on real economy (and by extension on consumer prices) than Euro's value vis-a-vis the U.S. dollar. Second, the exchange rate channel of monetary transmission in the Euro Area does not seem to operate by influencing the import prices.[17]

In the last robustness check, we apply an alternative strategy for identifying pure monetary policy shocks and central bank information shocks – we apply "poor man's sign restrictions" of Jarocinski and Karadi (2020). In our baseline model, we use sign restrictions to achieve identification: This approach relies on weaker identifying assumptions and it enables us to decompose the high-frequency surprises around policy announcements to the two types of shocks but is also rather complex. Therefore, in the following robustness check, we apply the alternative "poor man's approach", which is simpler. In this alternative approach, pure monetary policy shocks are identified as being equal to the high-frequency change in interest rates around the central bank announcement for those monetary announcements that were followed by high-frequency increase in interest rates and decrease in stock prices. Conversely, central bank information shocks equal high-frequency change in interest rates around those central bank announcements that were followed by high-frequency increase in interest rates and increase in stock prices. Therefore, in this alternative approach, a monetary policy announcement is either associated with pure monetary policy shock or with central bank information shock but the two types of shocks do not occur simultaneously. The results of this robustness check for pure monetary policy shocks are shown in Figure C4 in the Appendix and they corroborate our main conclusions about both the consequences of monetary policy and the role of exchange rate channel in the transmission of monetary policy.

4 Conclusion

We study the role of the exchange rate channel in the transmission of monetary policy in the Euro Area. Using a Bayesian structural vector autoregression (BSVAR), we first find that contractionary pure monetary policy shocks appreciate the Euro exchange rate, contract real economic activity, and decrease consumer price level, while positive central bank information shocks do not influence the Euro exchange rate, expand economic activity and increase consumer prices slightly.

[17] Import prices themselves might influence inflation in the Euro Area. However, our results imply that exchange rate channel of monetary transmission does not operate through affecting import prices. In other words, a Euro appreciation caused by monetary tightening does not decrease consumer prices by lowering import prices. Presumably because Euro Area's imports are largely invoiced in Euros and for those imports that are invoiced in other currencies (chiefly U.S. dollars), the importers do not pass on the lower import prices (expressed in Euros) to consumers.

Next, to explore the role of the exchange rate in monetary transmission, we construct a counterfactual scenario in which the exchange rate does not respond to monetary policy shock. That is, in the counterfactual scenario, we "switch off" the exchange rate channel and we obtain impulse responses of several macro-financial variables to a monetary policy shock under this counterfactual scenario. We find that in the absence of the exchange rate channel, monetary policy tightening leads to a smaller decrease in economic activity and in consumer price level. Our results show that the exchange rate influences the monetary transmission mainly by influencing the real activity ("trade channel"), and not by influencing import prices or financial variables ("financial channel"). That is, when monetary tightening appreciates the Euro, the stronger domestic currency reduces Euro Area's international competitiveness, leads to expenditure-switching towards foreign goods, contracts Euro Area's economic activity, and, with some lag, decreases consumer prices. As a result, in the absence of Euro appreciation (depreciation), contractionary (expansionary) effects of monetary tightening (expansion) are more muted.

Next, we find that the exchange rate does not play any role in the transmission of central bank information shocks to either economic activity or to consumer prices. Moreover, in an extension of our benchmark model, we distinguish between standard and non-standard monetary policy shocks (LSAP and FG shocks): Our results indicate that non-standard policies did help to enhance monetary policy transmission in the Euro Area. Furthermore, the exchange rate play plays a larger role in the transmission of non-standard policies than in the transmission of standard monetary policy.

Our findings thus underline that the exchange rate channel is important for an effective transmission of monetary policy even in a large and relatively closed economy such as the Euro Area. This is particularly true in the case of monetary transmission to the real economy. In terms of policy conclusions, our results illustrate for monetary policy-makers the importance of ensuring that the monetary policy also operates through the exchange rate channel. A non-functioning exchange rate channel, perhaps owing to large international financial flows, might impair the transmission of monetary policy. Our findings also open an interesting avenue for future research that could explore the effectiveness of various policy options available to policy-makers for enhancing the monetary transmission via the exchange rate channel, such as interventions in the foreign exchange (FX) market.

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Appendices

Appendix A: Data Coverage and Sources

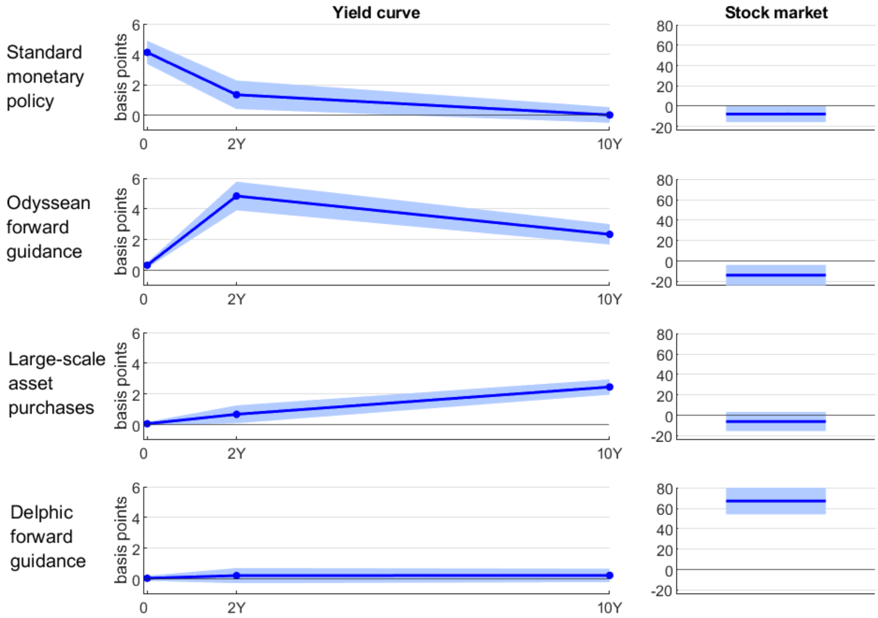
Table A1: Description and Sources of Variables

Variable	Description	Source
	Benchmark model	
(Pure) monetary policy shock	Sum of responses of financial market variables during narrow windows around ECB monetary policy announcements (monetary event window) on regular ECB announcement dates. (Pure) monetary policy shock is identified based on the negative co-movement between interest rates and stock prices during these narrow windows using sign restrictions. A positive value represents (unexpected) contractionary monetary policy shock (i.e., monetary tightening); interest rates are 3-month OIS rates and stock prices are represented by the EURO STOXX 50 index	self-calculated; EA-MPD
Central bank information shock	Sum of responses of financial market variables during narrow windows around ECB monetary policy announcements (monetary event window) on regular ECB announcement dates. Central bank information shock is identified based on the positive co-movement between interest rates and stock prices during the narrow windows using sign restrictions. A positive value represents (unexpected) positive central bank information shock (i.e., better assessment of economic outlook by the central bank inferred by market participants); interest rates are 3-month OIS rates and stock prices are represented by the EURO STOXX 50 index	self-calculated; EA-MPD
Exchange rate	Nominal effective exchange rate (NEER); index 2015=100; broad index; indirect quotation – an increase in its value reflects appreciation of the Euro	IMF
Industrial production	Volume index of production; Mining and quarrying, manufacturing, electricity, gas, steam and air conditioning supply, excluding construction; index 2015=100	Eurostat
Inflation	All-items Harmonized Index of Consumer Prices (HICP); index 2015=100	Eurostat
1-year yield	Yield on 1-year German government bond; in percent	Refinitiv Eikon
Stock index	EURO STOXX 50 stock market index; blue-chip index for the Eurozone	Refinitiv Eikon
BBB bond spread	ICE BofA Euro High Yield Index Option-Adjusted Spread; spread between a computed OAS index of Euro denominated below investment grade corporate debt that is publicly issued in the euro domestic or eurobond markets, and a spot government bond curve; in percent	FRED
	Model extensions	
CISS	Composite indicator of systemic stress (CISS); calculated based on market-based financial stress measures that are split equally into five categories (financial intermediaries sector, money markets, equity markets, bond markets, foreign exchange markets); index with values ranging from 0 to 1	ECB
Inflation expectations	Average of 12-month-ahead HICP inflation point forecasts from the survey of professional forecasters; interpolated from quarterly to monthly frequency using linear interpolation; in percent	ECB
CCI	Consumer confidence index (CCI); arithmetic average of the (seasonally adjusted) balances of answers to selected questions in a survey of consumers; balances are the differences between positive and negative answering options	Eurostat
	Robustness checks	
Real GDP	Gross domestic product; chain linked volumes; index 2015=100; interpolated to monthly frequency using quarterly interpolation based on monthly values of industrial production index	self-calculated; Eurostat
USD/EUR	Bilateral exchange rate of the U.S. dollar and Euro; expressed as number of units of U.S. dollar per one Euro; period average; indirect quotation – an increase in its value reflects appreciation of the Euro	IMF

Notes: IMF = International Monetary Fund; EA-MPD = Euro Area Monetary Policy Event Study Database; ECB = European Central Bank; FRED = Federal Reserve Bank of St. Louis.

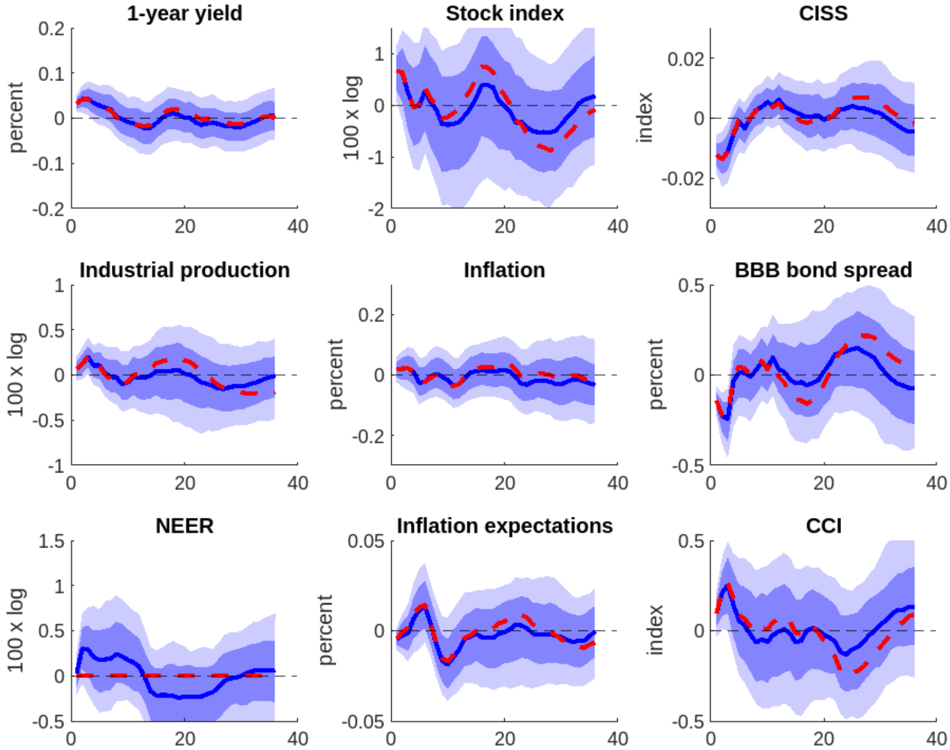
Appendix B: Other Results

Figure B1: High-frequency Responses of Financial Asset Prices to Different Types of Monetary Policy Shocks



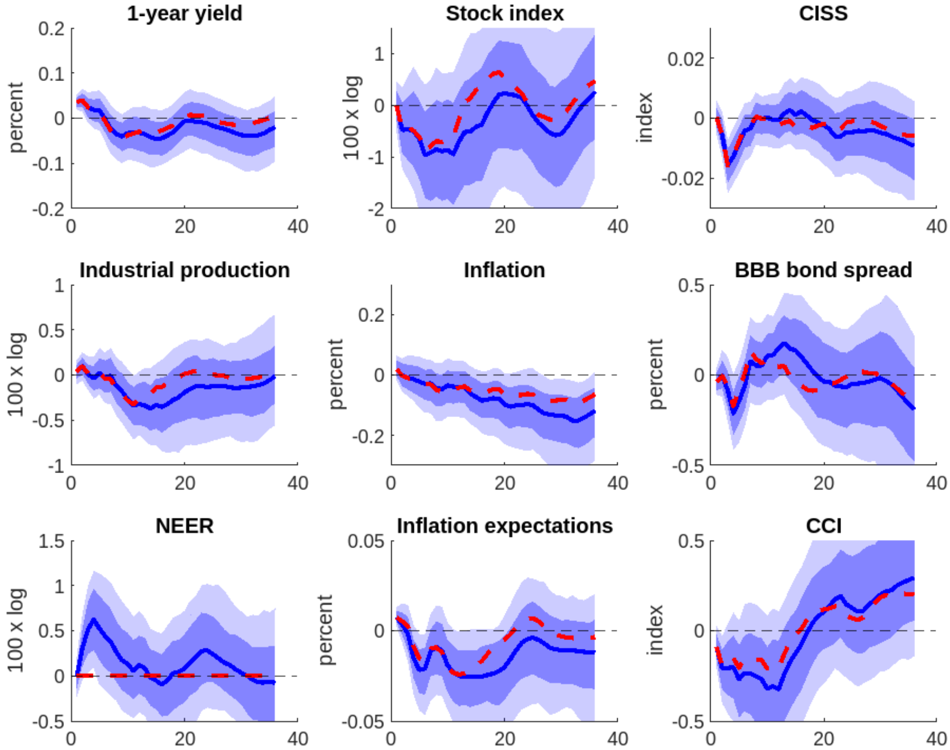
Notes: The figure plots high-frequency responses of the yield curve and the stock market to the different types of monetary policy shocks identified with the approach of Jarocinski (2024). Shaded area represents 95 % bands. y-axis: deviation from pre-shock level in basis points.

Figure B2: Baseline and Counterfactual Responses to a Standard Monetary Policy Shock



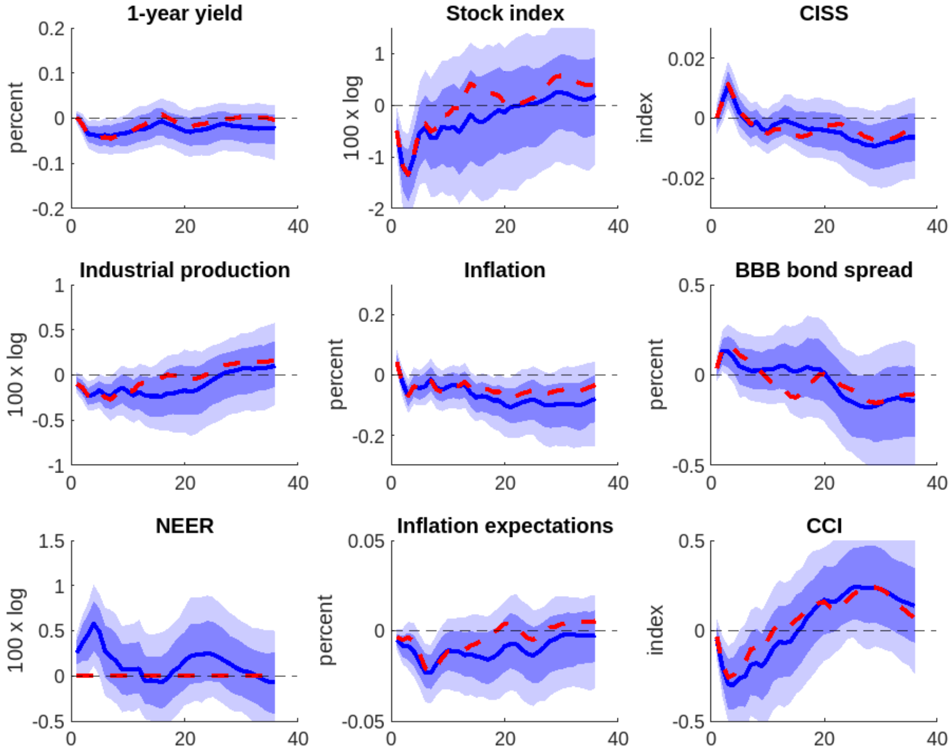
Notes: The figure plots impulse responses to a one-standard-deviation contractionary standard monetary policy shock for the extended model. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

Figure B3: Baseline and Counterfactual Responses to Odyssean Forward Guidance Shock



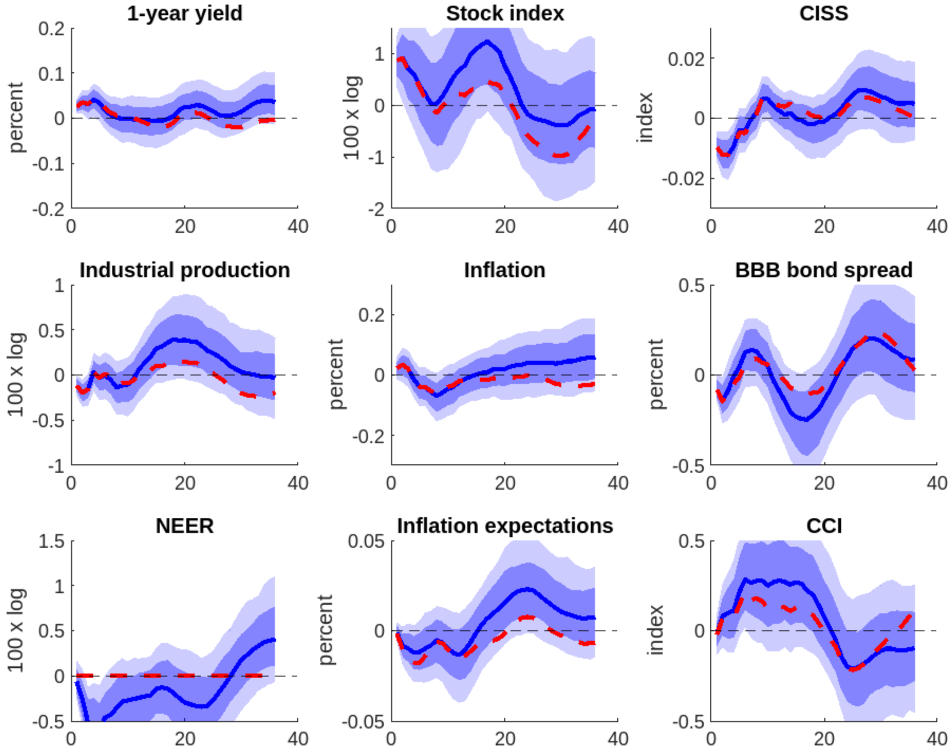
Notes: The figure plots impulse responses to a one-standard-deviation Odyssean forward guidance shock for the extended model. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

Figure B4: Baseline and Counterfactual Responses to a Large-Scale Asset Purchases (LSAPs) Shock



Notes: The figure plots impulse responses to a one-standard-deviation contractionary LSAP shock for the extended model. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

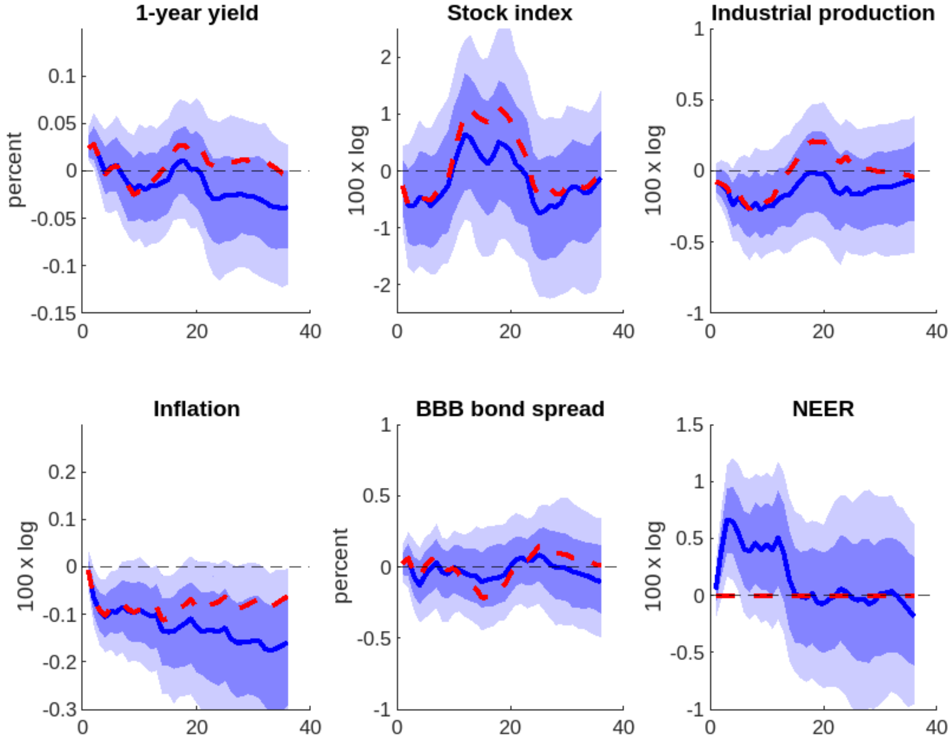
Figure B5: Baseline and Counterfactual Responses to Delphic Forward Guidance Shock



Notes: The figure plots impulse responses to a one-standard-deviation Delphic forward guidance shock. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

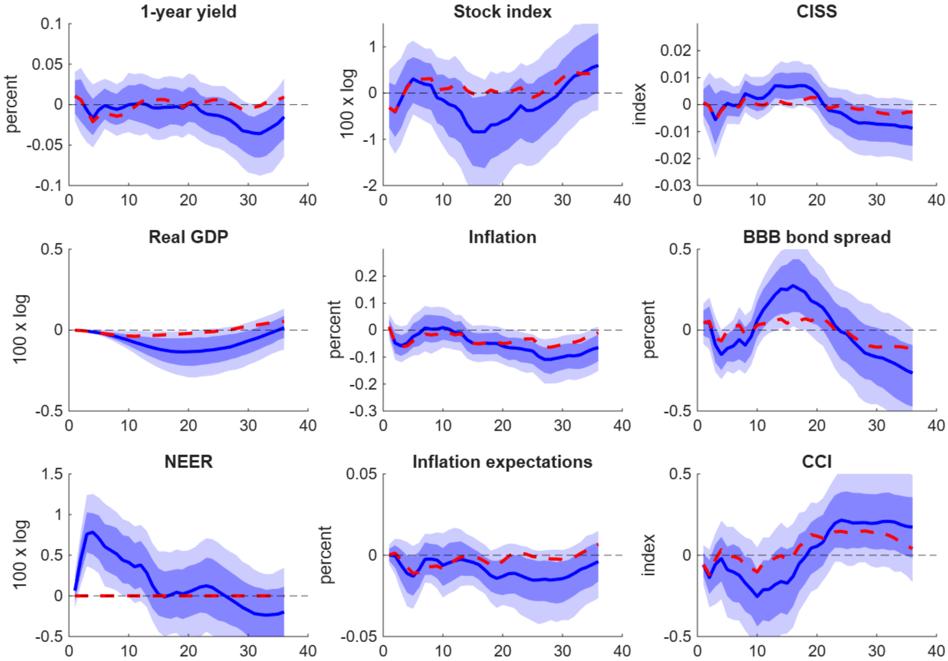
Appendix C: Robustness Checks

Figure C1: Baseline and Counterfactual Responses to a Monetary Policy Shock – with Stronger Sign Restriction Identification



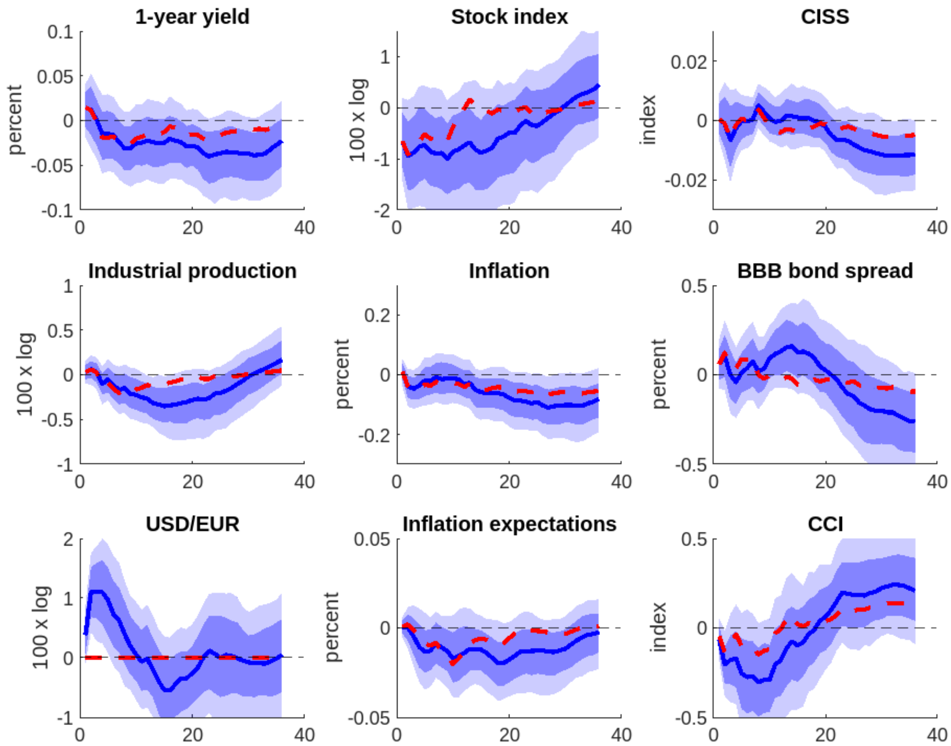
Notes: The figure plots impulse responses to a one-standard-deviation contractionary monetary policy shock. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. For this robustness check, we use alternative (stronger) sign restrictions for identification: On top of the baseline sign restrictions, we also impose that the short-term interest rate (one-year government bond yield) increases on impact after the monetary policy shock by at least one basis point. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

Figure C2: Baseline and Counterfactual Responses to a Monetary Policy Shock – with Real GDP



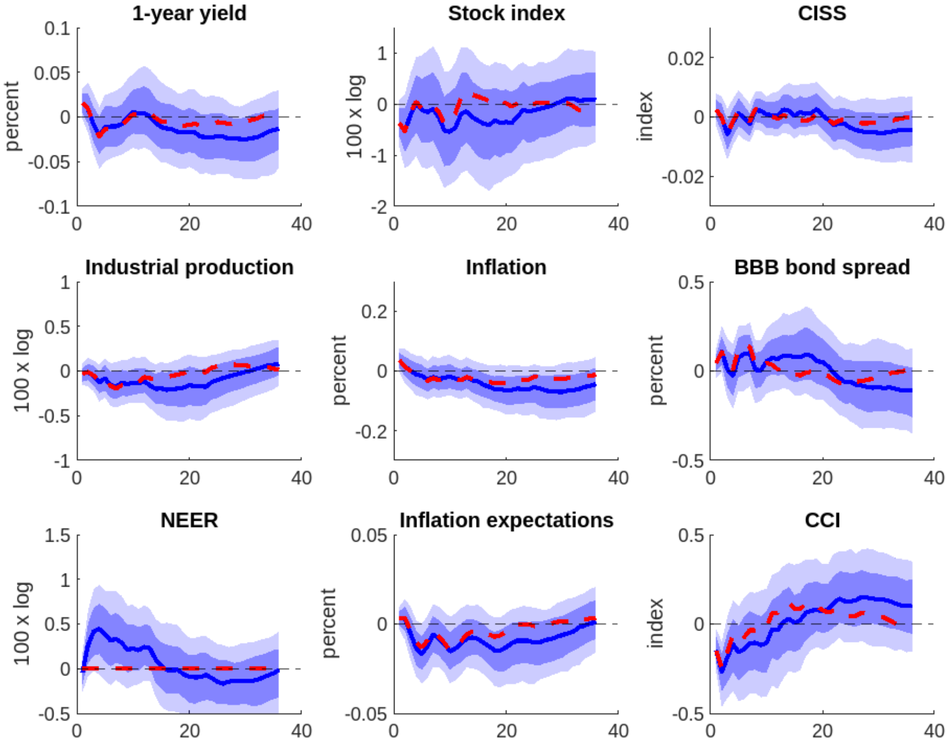
Notes: The figure plots impulse responses to a one-standard-deviation contractionary monetary policy shock for the extended model. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. For this robustness check, we replace the industrial production index with real GDP interpolated to monthly frequency. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

Figure C3: Baseline and Counterfactual Responses to a Monetary Policy Shock – with USD/EUR Exchange Rate



Notes: The figure plots impulse responses to a one-standard-deviation contractionary monetary policy shock for the extended model. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. For this robustness check, we replace the nominal effective exchange rate (NEER) with USD/EUR exchange rate as our main proxy for exchange rate. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.

Figure C4: Baseline and Counterfactual Responses to a Monetary Policy Shock – with Alternative Sign Restrictions



Notes: The figure plots impulse responses to a one-standard-deviation contractionary monetary policy shock for the extended model. The figure shows the impulse responses from the baseline model (blue solid) and the counterfactual impulse responses (red dashed) when the exchange rate does not respond to monetary policy shock. For this robustness check, we use the alternative "poor man's" sign restrictions of Jarocinski and Karadi (2020) to distinguish between monetary policy shocks and central bank information shocks. Solid line represents median, light-shaded area represents 5-95 percentiles, while dark-shaded area denotes 16-84 percentiles. x-axis: deviation from pre-shock level; y-axis: time in months.