A Tale of *Two* Global Monetary Policies*

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Abstract

US monetary policy is not the only one with a global reach. We compare the international financial spillovers of the unconventional monetary policies of the Fed and the ECB. Monetary policy tightenings in both areas are followed by a global retrenchment in capital flows, a fall in global stock markets, and a rise in global risk measures. Thus, ECB and Fed monetary policies propagate internationally through equivalent transmission channels. ECB monetary policy shocks also affect significantly the US business and financial cycles. We produce tentative evidence that links the strength of the ECB international spillovers to the € exposure for both trade invoicing and the pricing of financial transactions.

Keywords: Monetary Policy; Global Financial Cycle; International spillovers; Currency Pricing Paradigm; Fed; ECB

JEL Classification: F42, E52, G15

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1 Introduction

The conduct of monetary policy is mostly a national matter. Modern independent central banks typically operate within a mandate that is solely focused on domestic objectives, and set their monetary strategies accordingly. However, when it comes to evaluating the consequences of monetary policy actions in the centre countries of the international financial system, domestic borders tend to disappear. Particularly in a world of increasingly integrated and synchronised global financial activity. The existence of a Global Financial Cycle (GFC, see Rey, 2013) – characterised by the comovement of risky asset prices, leverage of financial intermediaries, credit growth, and gross capital flows around the world – facilitates and amplifies such international spillovers (see also Miranda-Agrippino and Rey, forthcoming, for a review).

US monetary policy is an important driver of the GFC (Miranda-Agrippino and Rey, 2020b; Jorda, Schularick, Taylor and Ward, 2018; Habib and Venditti, 2018). The significant role of Fed's policies in global financial markets is dictated by the dominant role of the dollar (Gopinath, 2016; Ilzetzki, Reinhart and Rogoff, 2019; Maggiori, Neiman and Schreger, 2020). But also, and importantly, by the existence of a risk-taking channel for the international transmission of monetary policy (Miranda-Agrippino and Rey, 2020b; Kalemli-Ozcan, 2019; Bernanke and Kuttner, 2005). A channel that did not evaporate with the introduction of unconventional policy tools (Miranda-Agrippino and Rey, 2020a).

But the US dollar is not the only player in the arena. While still a somewhat distant second, the euro is increasingly consolidating its role as an international safe currency. And taken together, the US dollar and the euro essentially saturate the currency denomination of virtually all international transactions, including international debt and loans, foreign exchange reserves and turnover, and global payments.[1] Hence, ECB policies should in principle also be important in the determination of international financial conditions. However, the evidence in this regard is still surprisingly sparse, and somewhat inconclusive. Dedola, Georgiadis, Gräb and Mehl (2021) show that ECB balance sheet policies can have strong and persistent effects on the €/$ exchange rate. In turn, this

[1] See Figure B.1 in the Appendix from ECB (2020).

could have important consequences on the GFC by affecting the dollar valuation of international balance sheets. However, Ca' Zorzi, Dedola, Georgiadis, Jarociński, Stracca and Strasser (2020) find that international spillovers of ECB conventional monetary policy materialise primarily through standard trade channels, rather than by affecting global financial conditions.

In this paper we revisit this question, and provide a systematic comparison of the international financial spillovers of the monetary policies of the Fed and the ECB, by focusing in particular on unconventional tools. Understanding these mechanisms and transmission channels is important for the conduct of domestic monetary policy in small open economies whose financial conditions can be largely determined by global factors. But it is also important in order to frame the contours of the current equilibrium of the international monetary and financial system. We show that the unconventional monetary policies of the two currency areas propagate internationally through essentially the same channels. That is, by affecting global risk perceptions, global assets valuations and capital flows, and global financing costs. Moreover, ECB monetary policy shocks also affect significantly the US business cycle and financial conditions. This is our main contribution. Our paper is close in spirit to Jarociński (2020), where the comparison focuses on conventional policy tools only.

We start by constructing synthetic measures to summarise monetary policy in the two areas. Here we focus on high-frequency monetary policy surprises along the whole of the maturity spectrum, building on the work of Gürkaynak, Sack and Swanson (2005) and Altavilla, Brugnolini, Gürkaynak, Motto and Ragusa (2019). Using the intuition in Swanson (2021), we disentangle the different dimensions of the monetary policies of the two jurisdictions, and in each case isolate the pure monetary policy component as in Jarociński and Karadi (2020). We show that not only the contamination of information effects is present across all types of policies, but that it also becomes more pronounced for unconventional policy. Controlling for these confounding factors is crucial to unveil the bilateral and global spillovers through financial markets, and particularly so for the ECB (see also Jarociński, 2020).

We then move to analyse the bilateral spillovers of US and euro area (EA) policy surprises at different horizons on asset prices: the two yield curves, € and $ credit

spreads, stock market and volatility indices, and the bilateral €/$ exchange rate. This part of the analysis is performed on daily data, and allows us to evaluate how spillovers build up in financial markets in the month following the two sets of policy announcements (see also Stavrakeva and Tang, 2019; Gürkaynak, Kara, Ksackoğlu and Lee, 2021).

Finally, we extend our analysis to horizons, time-scales and aggregates that are relevant from an international macro perspective. Here we use monthly data to study the dynamic responses of the variables that characterise the GFC, along with global production and trade. We summarise fluctuations in global asset prices using the global factor of Miranda-Agrippino, Nenova and Rey (2019).

Our results are as follows. The event-study analysis shows that the international spillovers of US monetary policy survive the introduction of unconventional tools. But we also document important new findings for the Euro Area. The first strong result that emerges is that ECB policies too have significant international financial spillovers, and of the type and magnitude equivalent to those elicited by the Fed. Monetary policy tightenings that impact mostly medium- and long-term interest rates in the two areas lead to a pronounced fall in global stock market indices, significant moves in the bilateral exchange rate, and a tightening of global financial conditions. ECB policies also significantly affect global risk measures, such as the VIX.

The VAR analysis reveals a very similar pattern. US monetary policy tightenings at the longer end of the yield curve result in a contraction of global real activity and trade, and have strong consequences for the variables that characterise the GFC: global asset prices fall, risk perceptions rise, and there is a strong retrenchment in global capital flows. The dollar appreciates. Importantly, however, we find that ECB unconventional monetary policies too elicit the same type of responses of global variables. While the magnitude of these effects is smaller, EA monetary policy tightenings at the longer end of the curve also result in a contraction of global real activity and trade, a fall of global asset prices, a rise in risk perceptions, and a strong retrenchment in global capital flows. And the euro appreciates. Moreover, ECB monetary policy at the long end has powerful spillovers to the US – an ECB monetary policy contraction is followed by a fall in US output and prices, and a significant tightening of US financial conditions. The introduction of unconventional monetary policy tools has thus changed significantly the relative

positioning of the ECB within the international financial system.

Taken together, these results suggest that the monetary policies of the ECB and the Fed propagate internationally via equivalent transmission channels. And that ECB monetary policy plays an important role in determining international financial conditions, at least for what concerns unconventional policy tools.

Finally, we show that the spillovers of ECB policies are stronger for countries whose external trade is predominantly invoiced in euros, or whose external assets and liabilities are denominated in euros. We interpret these findings as evidence that the strength of the trade linkages with these countries, for which the euro exposure serves as a proxy, provides fertile ground for the international propagation of ECB monetary policy shocks, which is then facilitated and amplified by the strong interconnectedness of international financial markets. A shift towards a heavier use of the euro in the international monetary system, beyond the largest trade partners, could lead to an even more pronounced role of ECB policies as drivers of the Global Financial Cycle.

The paper is organised as follows. In Section 2 we extract high-frequency unconventional monetary policy instruments for the Fed and ECB; we then study the propagation to financial markets using daily projections in Section 3. Section 4 collects the VAR results on the bilateral spillovers of ECB and Fed monetary policies, and on their international propagation to global aggregates. Section 5 focuses on the role of euro exposure in the transmission of the monetary policy of the ECB. Section 6 concludes. Additional details are reported in the Appendix.

2 Monetary Policy Surprises Along the Maturity Spectrum and their Information Content

We start our analysis by looking at the sequence of monetary policy surprises both in the Euro Area (EA) and United States (US). Following the tradition initiated by Kuttner (2001) and Gürkaynak et al. (2005), we use high-frequency price revisions around the monetary policy announcements to measure the extent to which the decision was inter-

preted as a surprise, or news, by market participants. Absent other contemporaneous events, the narrow measurement window guarantees that if a price revision occurs, the monetary announcement was its only trigger.

However, whether that price revision can be used to proxy for a monetary policy shock is a different matter. Indeed, it has become apparent how market participants also extract non-monetary news from monetary policy announcements (Miranda-Agrippino, 2016; Melosi, 2017; Nakamura and Steinsson, 2018; Cieslak and Schrimpf, 2019). A phenomenon known in the literature as the central bank information effect . The literature has identified two complementary ways to deal with the consequences of such effect. Miranda-Agrippino and Ricco (2021) propose to tackle the source of the confounding effect, and explicitly control for central bank official forecasts. Jarociński and Karadi (2020) instead propose to act directly on its consequences, and identify monetary policy news on the basis that they should induce a negative contemporaneous comovement between stock prices and bond yields. The two approaches lead to equivalent results. The latter, while more reduced-form, has the advantage of being very simple to implement, and is the one we follow in this paper. Differently from these previous contributions, here we extend the decomposition into monetary and non-monetary news also to unconventional policy, summarised using appropriately rotated principal components, in the spirit of Gürkaynak et al. (2005) and Swanson (2021).

Swanson (2021) identifies three orthogonal dimensions of US monetary policy that summarise movements in the entire term structure of interest rates: a Federal Funds rate factor, that loads predominantly on the overnight rate, and dominates in the pre-ZLB (zero-lower-bound) sample; a communication/path factor that has higher loadings on 1 to 2-year maturity rates; and an LSAP/QE factor that mostly captures the variation at the long end of the curve, and is constrained to be negligible in the pre-ZLB sample.

The path factor proxies for shocks that affect markets expectations of future medium-term interest rates. Given that the typical horizon of implicit and explicit forward guidance announcements roughly matches the maturity of the interest rates that mostly load on this factor, it quite naturally lends itself to being interpreted as identifying the effects of forward guidance. Technically, however, to the extent that the announcement and implementation of QE can have an impact also on expectations of interest rates at matu-

rities other than 10 years, this factor effectively combines the effects of forward guidance with those of this "signalling channel" of the QE transmission mechanism (see Krishnamurthy and Vissing-Jorgensen, 2011). As a consequence, we think of it collectively as that combination of structural shocks that, prompted by the FOMC announcements, act mainly on the medium-maturity segment of the US yield curve.

Similarly, we interpret the LSAP factor as identifying the combination of primitive shocks that, prompted by the FOMC announcements, lead market participants to revise their expectations about future long-term rates. In essence, it captures residual ways in which FOMC announcements alter long-term rates expectations beyond those that result from direct transmission of changes in shorter-maturity rates.

In what follows, we refer to these three factors as a Short-Maturity Factor, a Medium-Maturity Factor, and a Long-Maturity Factor respectively.

For the US, we replicate exactly Swanson (2021)'s setup, and extract the factors from Federal Funds rate futures (the current-month contract rate and the contract rates for each of the next six months), Eurodollar futures (the current-quarter contract rate and the contract rates for each of the next eight quarters), and Treasury bond yields (2-, 5-, and 10-year maturities). The sample covers all announcements from January 1991 to July 2017. For the EA, we use an equivalent set of contracts, namely, OIS rates at 1- and 3-month, and at 1-, 2-, 5- and 10-year maturities. The sample covers all announcements from January 1999 to December 2018, and we take the data from Altavilla et al. (2019).

Tables 1 and 2 report the loadings of the three factors on the contracts respectively used for their estimation, while the factors themselves are plotted in Figures A.1 and A.2 in the Appendix. In both cases we normalise the factors such that the Short-Maturity factor has a loading of 1 on the shortest-maturity contract, the Medium-Maturity factor has a loading of 1 on 1-year rates, and the Long-Maturity factor has loading of 1 on the 10-year rate.

The factors have a very similar behaviour across the two currency areas, and similar characteristics (Table A.1). The loadings of the Short-Maturity factor decline monotonically as the maturity increases, while those of the Long-Maturity factor increase as one moves along the yield curve. The Medium-Maturity factor has very little effect on either end of the curve, and isolates changes in medium-range maturities. The zero loadings

Table 1: Loadings of Monetary Policy Factors, US

	MP1	MP2	ED2	ED3	ED4	ONR2	ONR5	ONR10
Short-M Factor	1	0.94	0.76	0.66	0.55	0.56	0.33	0.16
Medium-M Factor	0	0.24	0.76	0.91	1	0.98	1.06	0.91
Long-M Factor	0	-0.12	-0.24	-0.23	-0.19	0.02	0.49	1

Notes: Factors extracted as in Swanson (2021). The sample includes all FOMC announcements from Jan-1991 to Jul-2017.

Table 2: Loadings of Monetary Policy Factors, EA

	OIS-1M	OIS-3M	OIS-1Y	OIS-2Y	OIS-5Y	OIS-10
Short-M Factor	1	0.91	0.56	0.41	0.19	0.09
Medium-M Factor	0	0.46	1	1.11	0.51	0.39
Long-M Factor	0	-0.09	-0.13	-0.06	0.93	1

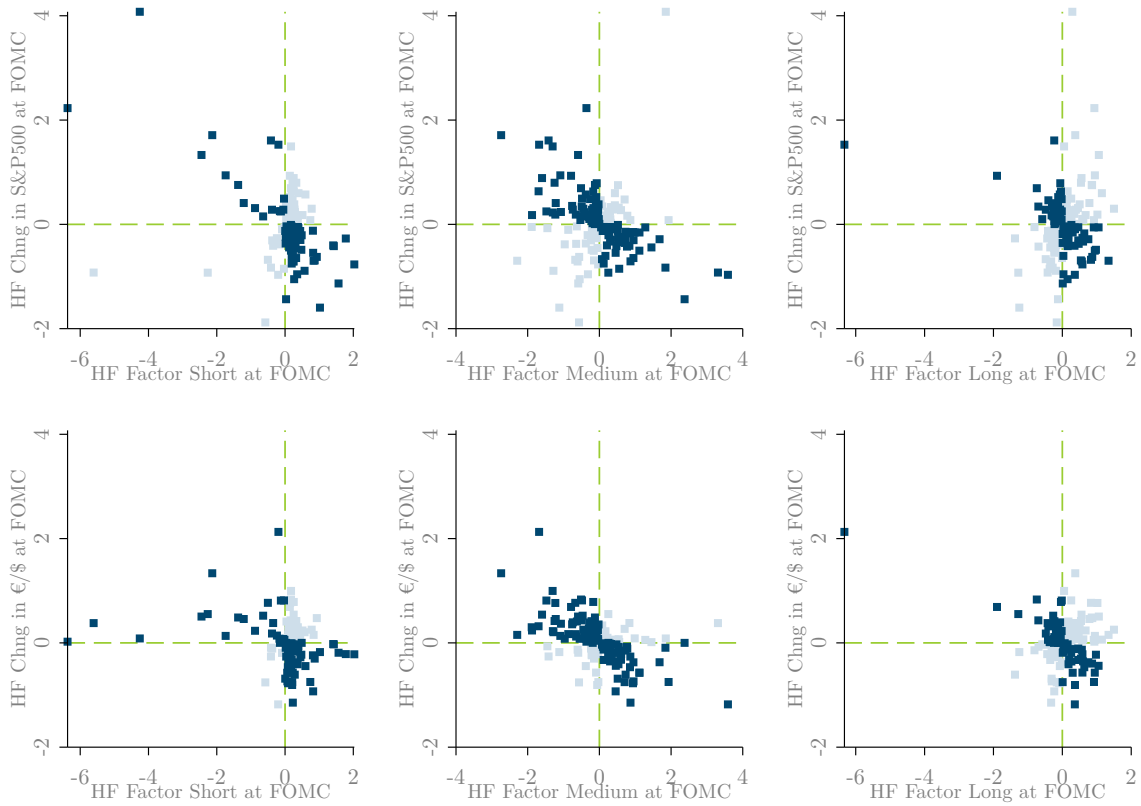
Notes: Factors extracted as in Swanson (2021). The sample includes all ECB Governing Council (GC) announcements from Jan-1999 to Sep-2018.

of both the Medium- and Long-Maturity factors on the shortest maturity contracts is imposed by construction to identify the three components.

Figures 1 and 2 report scatter plots of the high-frequency reaction of financial markets to policy announcements in the two areas. In both figures, the top row compares the reaction of the relevant stock market index with that of the monetary policy surprises, while the bottom row reports the reaction of the bilateral €/$ exchange rate. The two figures confirm the pervasiveness of confounding effects, such as central bank information, across the whole of the maturity spectrum. Classic economic theory would have the stock market reacting negatively to tightening surprises, and the local currency appreciating. As is visible in the two sets of charts, this only occurs in a fraction of all the available announcements (dark markers), and there is a substantial share of cases in which the empirical comovement instead seems to invalidate the theory (light markers). As also noted in Gürkaynak et al. (2020), information effects also affect exchange rates.

In the analysis that follows, we isolate monetary news using the "poor man's" identification of Jarociński and Karadi (2020). This corresponds to identifying monetary policy news using sign restrictions, based on the high-frequency negative comovement between stock prices and bond yields as predicted by economic theory.

FIGURE 1: MONETARY POLICY SURPRISES IN THE US



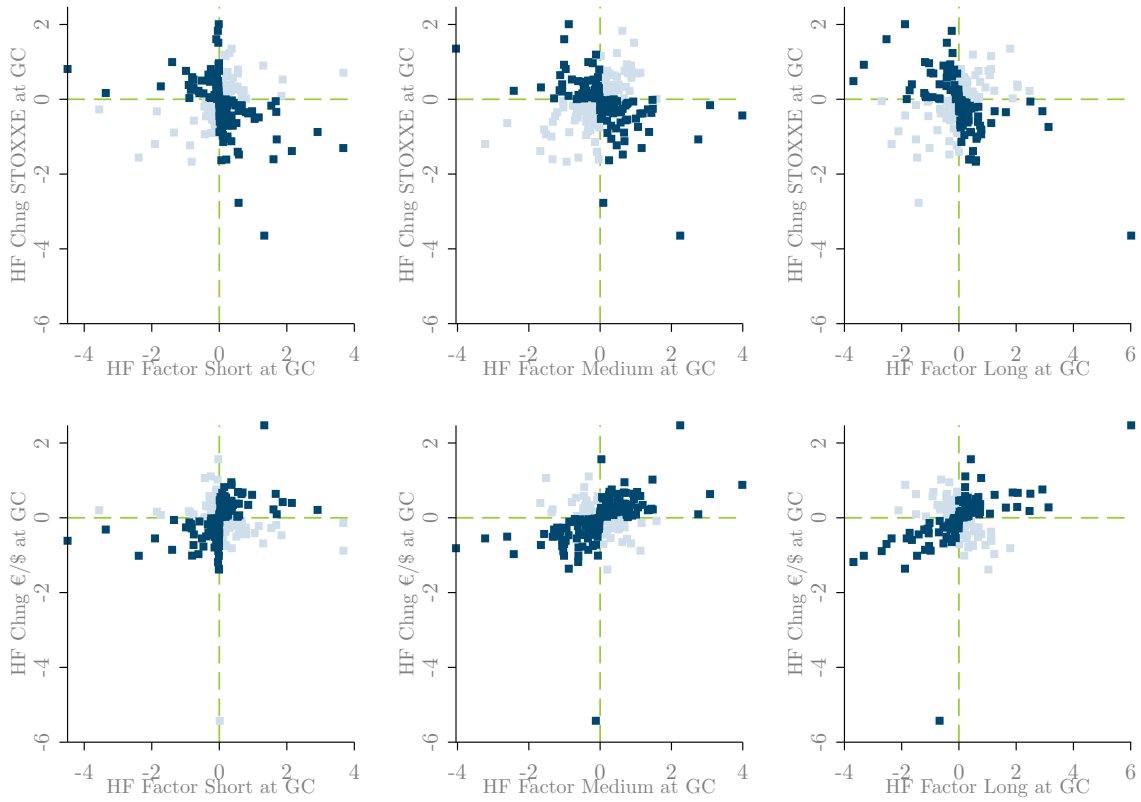
Notes: [Top Panels:] Intraday reactions of monetary policy surprises and the stock market (S&P 500) around FOMC announcements. [Bottom Panels:] Intraday reactions of monetary policy surprises and the bilateral €/$ exchange rate around FOMC announcements. [Across Columns:] Short-Maturity factor, Medium-Maturities factor, Long-Maturities factor.

3 Financial Markets Spillovers

In this section we analyse the way in which Fed and ECB policies affect global financial markets in the days that follow the announcements. Fed policies have been proven to affect global financial markets in a number of different studies. However, the evidence relative to the ECB is more mixed. Here we intend to characterise the extent to which any differences in the transmission of the monetary policies of the two largest central banks materialise, and if they do, in what way do they differ.

We evaluate the spillovers of the two monetary policies on the same set of asset prices, and over the same sample. We consider the overlapping sample across the two sets of factors, that is, from January 1999 to July 2017. Following Jarociński (2020), we also

FIGURE 2: MONETARY POLICY SURPRISES IN THE EA



Notes: [Top Panels:] Intraday reactions of monetary policy surprises and the stock market (EuroSTOXX) around ECB GC announcements. [Bottom Panels:] Intraday reactions of monetary policy surprises and the bilateral €/$ exchange rate around ECB GC announcements. [Across Columns:] Short-Maturity factor, Medium-Maturities factor, Long-Maturities factor.

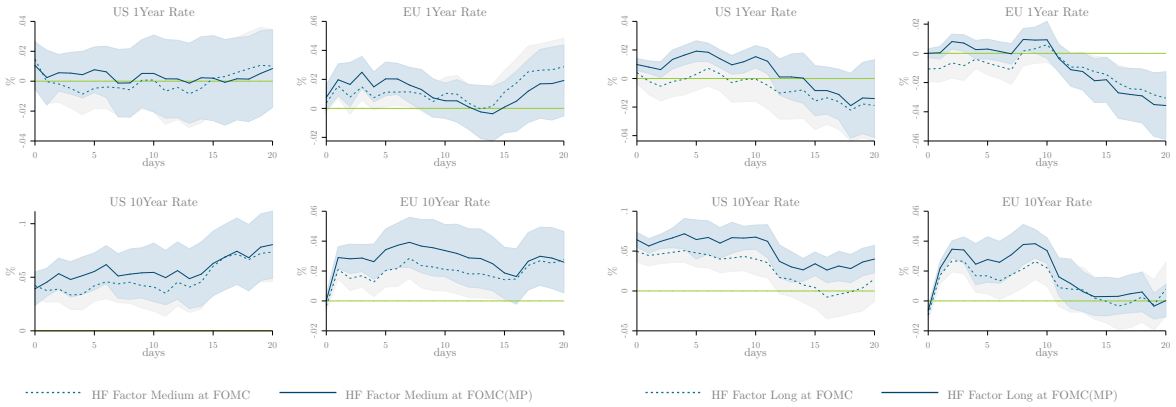
drop from the sample the three joint Fed and ECB announcements that occurred on the 13 and 17 September 2001, and on 8 October 2008. We quantify the spillovers by using daily projections (Jordà, 2005) of the following form

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h mps_{t-\epsilon:t} + \nu_{t+h} \tag{1}$$

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h^* mps_{t-\epsilon:t} \mathbb{1}_- + \nu_{t+h} \tag{2}$$

where $y_{t+h} - y_{t-1}$ is the cumulated daily change in asset prices, $mps_{t-\epsilon:t}$ denotes the value of the relevant factor at the announcement date, and $\mathbb{1}_-$ is an indicator function that isolates only those announcements in which the high-frequency stock market response is in line with economic theory (corresponding to the "poor man's" identification of

FIGURE 3: RESPONSE OF US & EA YIELD CURVE TO UNCONVENTIONAL US MP



(A) Fed Medium-Maturity Shocks

(B) Fed Long-Maturity Shocks

Notes: Daily projections. Sample 1999-01:2017-12. Responses to full announcement (dotted lines), and to monetary news only (solid lines). Shaded areas are one standard deviation bands.

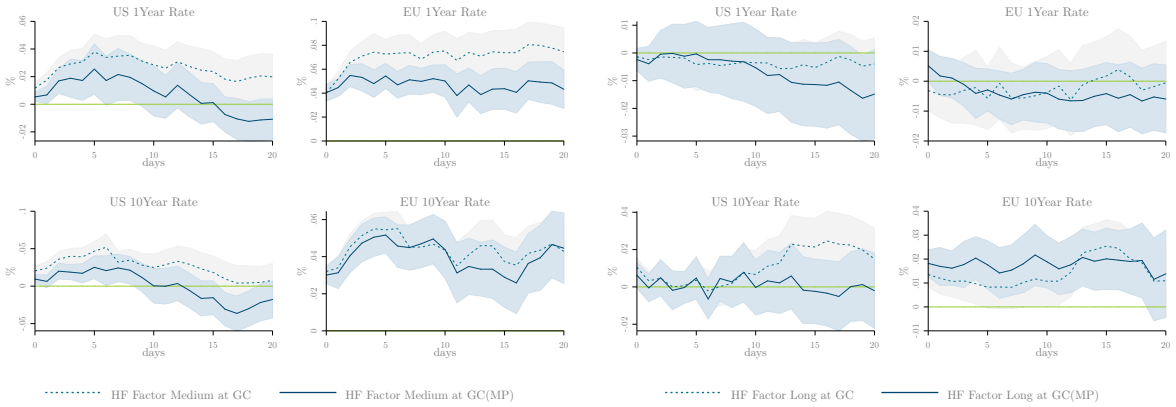
Jarociński and Karadi, 2020). We report results for the cases in which $mps_{t-\epsilon:t}$ is either the Medium-Maturity or the Long-Maturity factor.[2] The figures that follow report the estimated β_h (response to full announcement, dotted lines) and β_h^* (response to monetary policy news only, solid lines) for horizons covering the first 20 business days following the announcements, which corresponds to a one-month horizon. Shaded areas are one standard deviation bands. All factors are interpretable as tightening surprises.

We focus on two sets of asset prices. In Figures 3 and 4 we evaluate the response of the two yield curves, summarised by the interest rates at maturities equal to 1 and 10 years. In Figures 5 and 6 we look at the response of the stock market indices (S&P 500 and EuroSTOXX), of volatility indices (VIX and VSTOXX), of corporate bond spreads ($ and € investment-grade and high-yield spreads), and of currencies ($ and € broad indices excluding the €/$ bilateral exchange rate, and separately the bilateral €/$ rate). Variables definitions and sources are in Table B.1 in the Appendix.

We start by discussing the responses of the two yield curves in Figures 3 and 4. A number of results emerge. First, both types of unconventional policies are very effective at affecting the relevant interest rates domestically. While the persistence of the effects is different, the 10-year US rate is significantly higher after both Fed policies (Figure

[2]Results for conventional monetary policy are reported in the Appendix.

FIGURE 4: RESPONSE OF US & EA YIELD CURVE TO UNCONVENTIONAL EA MP



(A) ECB Medium-Maturity Shocks (B) ECB Long-Maturity Shocks

Notes: Daily projections. Sample 1999-01:2017-12. Responses to full announcement (dotted lines), and to monetary news only (solid lines). Shaded areas are one standard deviation bands.

3). Similarly, long term rates in the Eurozone are significantly and persistently higher following both Medium- and Long-Maturities ECB policies (Figure 4). Second, important asymmetries in the spillovers to the yield curves emerge. European interest rates respond significantly to Fed policies, and particularly so at long horizons.[3] On the contrary, US interest rates are little affected by ECB unconventional policies within the month. Third, isolating monetary policy news does not lead to a different assessment of the average effects. While the coefficients are somewhat more precisely estimated, the response functions largely overlap in the vast majority of cases.

The asymmetry in the spillovers of Fed and ECB policies almost vanishes when considering the responses of other financial markets variables. Also, the consequences of the presence of information effects become more apparent.[4]

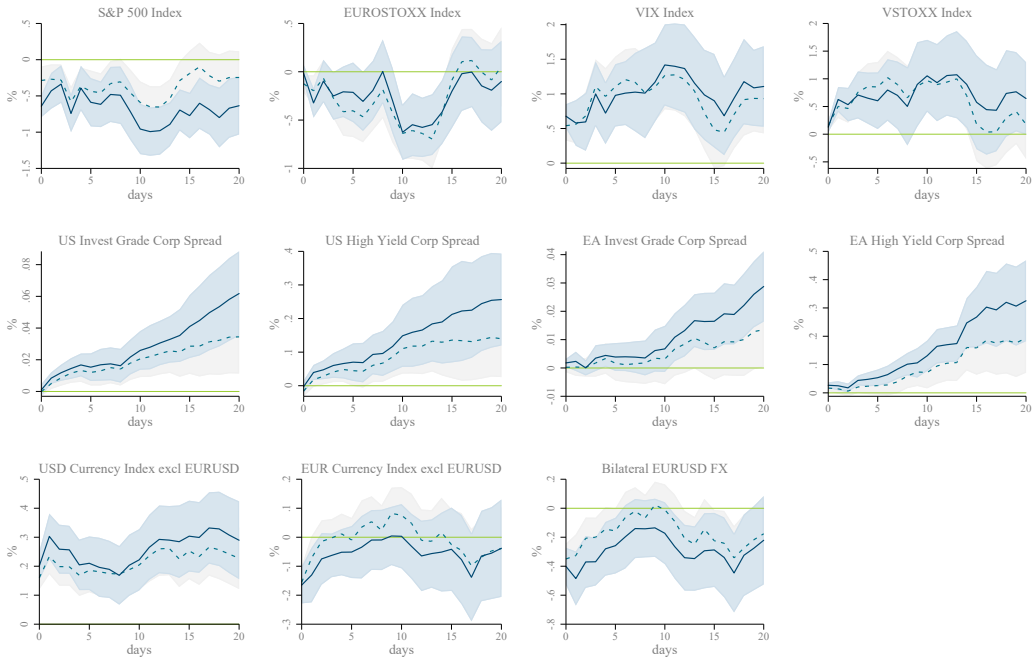
Previous results in the literature have shown how contractionary US monetary policy shocks spill over to international financial markets by affecting global risk aversion and global stock markets. We confirm these results also for unconventional policies. Tighter US monetary policy that pushes medium and long domestic rates to higher levels gen-

[3]The zero impact responses are mechanically induced by the different time zones at which decisions take place. The effects of Fed policies on European markets are visible from the day following that of FOMC announcements.

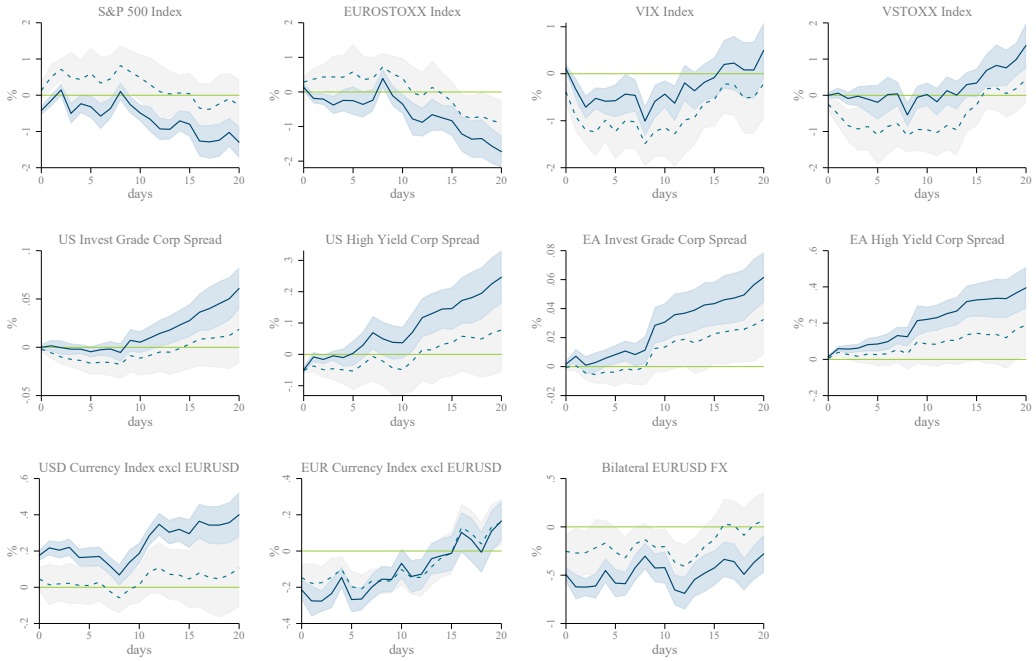
[4]Again here we focus on the responses to the Medium-Maturity and Long-Maturity factors and report those elicited by conventional monetary policy in the Appendix.

Figure 5: Response of Asset Prices to Unconventional US MP

(a) Fed Medium-Maturity Shocks



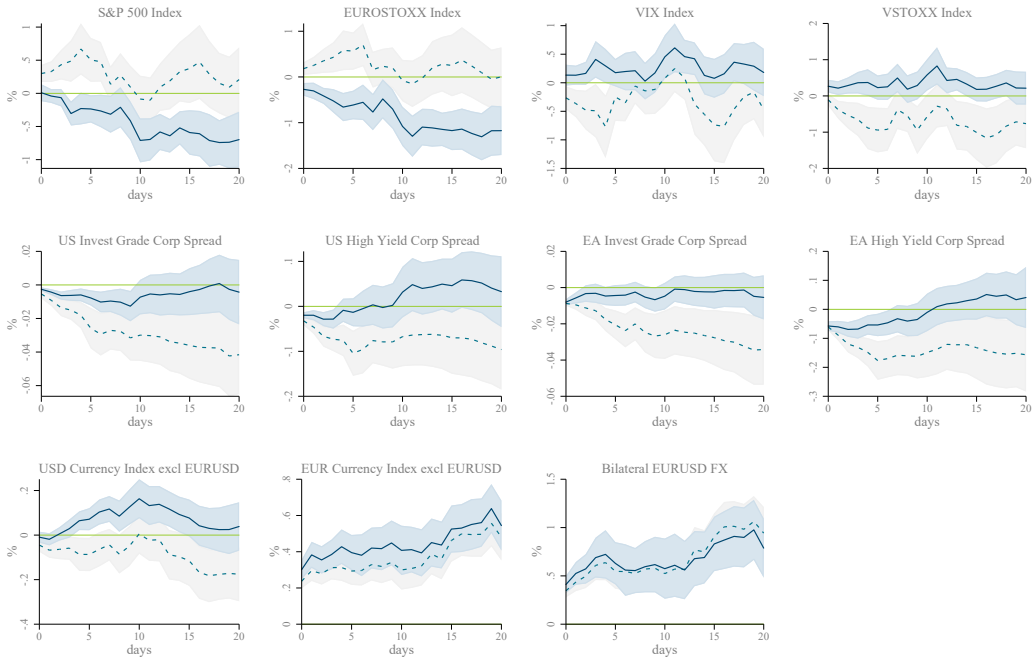
(b) Fed Long-Maturity Shocks



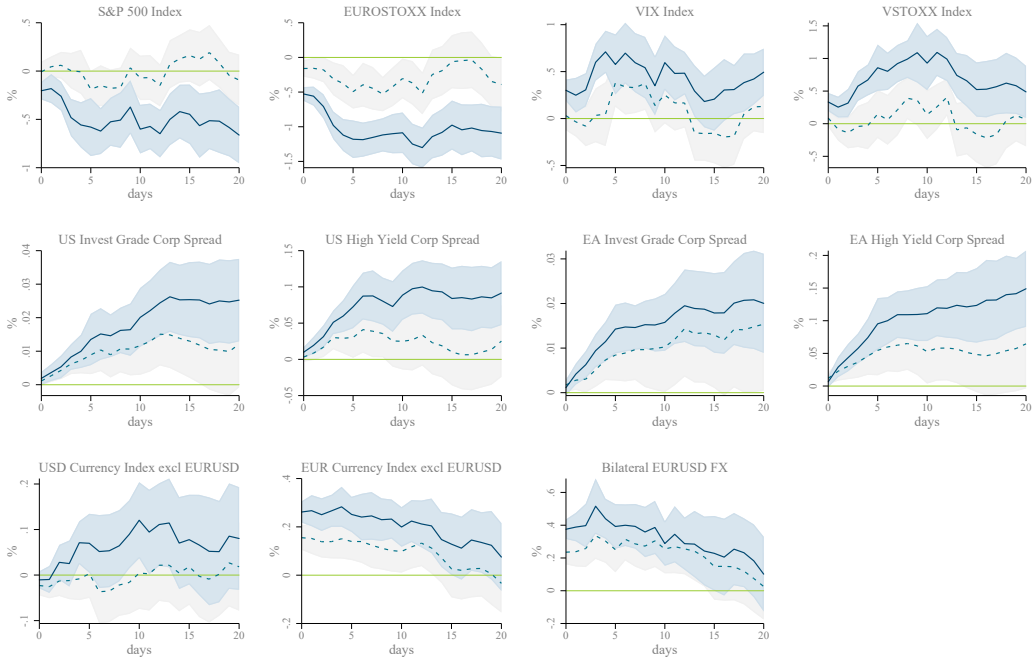
Notes: Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

Figure 6: Response of Asset Prices to Unconventional EA MP

(A) ECB Medium-Maturity Shocks



(B) ECB Long-Maturity Shocks



Notes: Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

erally leads to a fall in global stock markets – both the S&P 500 and the EuroSTOXX fall –, and a rise of both $- and €-denominated corporate bond spreads (Figure 5). Not surprisingly, financial conditions tighten more for more financially constrained firms, with high-yield spreads responses being an order of magnitude larger than the corresponding investment-grade ones. The dollar appreciates significantly; a result that is consistent with findings in Inoue and Rossi (2019). This is the case both in bilateral terms against the euro, and generally relative to a broader basket of currencies. These results hold for both dimensions of unconventional policy; however, some important differences emerge. US policies that are predominantly associated with changes at the long end of the curve (i.e. asset purchases) result in a strong broad-based depreciation of the euro against currencies other than the $, and generally do not lead to an increase in risk perceptions. Instead, policies that act predominantly over medium maturity rates (i.e. forward guidance and QE signalling) have only a short-lived effect on the value of the euro beyond the bilateral FX, and lead to higher perceived risk levels, consistent with the tightening of financial conditions. Isolating pure monetary policy news is particularly important when evaluating the financial market responses to US Long-Maturity policies, and becomes crucial in evaluating the effectiveness and international spillovers of ECB policies.

Figure 6 reports the responses of the same set of asset prices to ECB policies. The first strong result that emerges is that ECB policies are as important as Fed policies from an international financial spillovers point of view. But that information effects are also much stronger for the ECB than they are for the Fed, and therefore, these results can only be appreciated once the confounding factors have been appropriately controlled for. Both types of ECB policy tightenings lead to a contraction in global stock market indices (both the S&P 500 and the EuroSTOXX fall), and to a broad-based appreciation of the euro.

In contrast to the exchange rate spillovers from US monetary policy news, ECB shocks are associated with a modest broad-based appreciation of the US dollar, beyond that in the bilateral FX. Coupled with the increase in risk perceptions (as captured by the rise in both VIX and VSTOXX), this points to the role of the dollar as a barometer of risk-taking by global financial intermediaries (Bruno and Shin, 2015; Avdjiev, Du, Koch and Shin, 2019), and further reinforces the potency of ECB policy spillovers via global risk attitudes

(see also Dilts Stedman, 2019). The VIX and the VSTOXX increase substantially, and to a very similar degree.

Long-maturity ECB policies also lead to sustained tightening of international financial conditions. All corporate spreads rise, and the effects have equivalent magnitudes whether one considers either $-denominated or €-denominated debt. In contrast, Medium-maturity ECB policies have very modest effects on risk and spreads.

Taking our results together, we conclude that ECB monetary policy is as relevant as Fed monetary policy for what concerns international financial spillovers. And that these spillovers operate through essentially the same channels. That is, by affecting global risk perceptions, global assets valuations, and global financing costs. One difference that remains between the two currency areas is the behaviour of their broad-based exchange rates following a foreign monetary policy shock – while the dollar displays properties of a safe haven currency and appreciates when risk perceptions rise, the value of the euro falls. In the next sections we explore to what extent these results carry through when we move to consider aggregates and frequencies that are more relevant from a macro perspective.

4 Global Spillovers of ECB and Fed Monetary Policy

US monetary policy decisions reverberate strongly at the global level. The importance of the dollar in the international monetary system, together with the relative weight of the US in terms of trade and output shares, translate into global aggregates reacting significantly to Fed's policies. A number of studies have highlighted the spillovers of US conventional monetary policy that operate through the Global Financial Cycle, and through more standard trade channels (see e.g. Ha, 2016; Georgiadis, 2016; Dedola, Rivolta and Stracca, 2017; Degasperi, Hong and Ricco, 2020; Miranda-Agrippino and Rey, 2020b; Miranda-Agrippino, Nenova and Rey, 2019).

The evidence that relates to ECB policies is instead limited, and more mixed. In a recent paper, Ca' Zorzi et al. (2020) note how conventional ECB policies transmit mainly through trade channels, while the effects on global financial variables is less pronounced.

In this section we revisit this evidence and compare the spillovers of unconventional US and EA monetary policy to the same set of global macro and financial aggregates

over the same sample.[5] We estimate monetary policy spillovers using monthly VARs identified with external instruments. As in Section 3, we distinguish between the total announcement effect (dotted lines), and that of monetary policy news only (solid lines). The setup is identical for the US and EA. The VAR includes global output and global trade, global private liquidity and capital flows as a share of global GDP, the global factor in asset prices of Miranda-Agrippino et al. (2019), the VIX index, the bilateral €/$ exchange rate, and the domestic term structure slope, measured as the spread between the 10-year and 2-year rates. Variables definitions and sources are in Table B.2 in the Appendix. Both VARs are estimated with six lags over the sample 2000-01:2018-12 with standard macroeconomic priors. We report results based on median impulse response functions, and normalised such that all shocks induce a steepening of the domestic yield curve that raises by 1% on impact. The shocks are identified using the factors extracted in Section 2 as external instruments.

The estimated spillovers of long-run US and EA monetary policy are reported in Figure 7, while those elicited by shocks at medium maturities are in Figure 8.

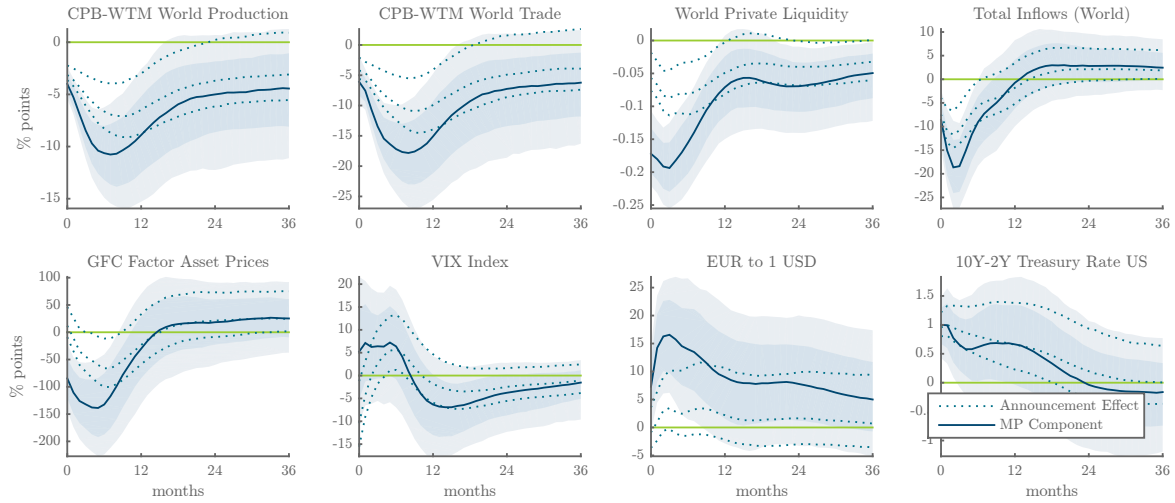
The responses in Figure 7a are in line with what documented by Miranda-Agrippino and Rey (2020b), and suggest that the global transmission channels of US monetary policy was not altered by the global financial crisis, or indeed by the implementation of unconventional monetary policy. A tightening at the long end of the US yield curve depresses global activity and global trade and has dramatic effects on the variables that characterise the GFC: global asset prices fall, risk perceptions rise, and there is a strong retrenchment in global capital flows and a contraction in global private liquidity. The dollar appreciates strongly against the euro.

Figure 7b shows that ECB tightenings at the long end induce the same type of global spillovers, consistent with what noted in the previous section. While the magnitude of the peak effects is smaller, an ECB unconventional monetary policy tightening produces essentially the same types of spillovers to global macroeconomic and financial aggregates. Global output and trade contract, and there is an important effect on the variables of the GFC. Global stock markets fall, the VIX rises, and global capital flows contract. The

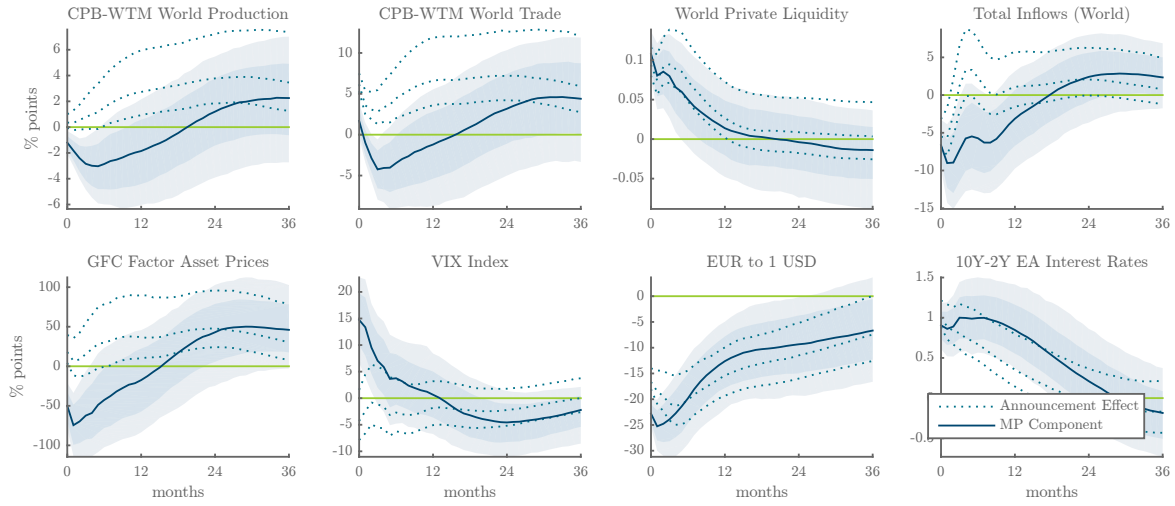
[5] As was the case with the daily local projections, we find that the international effects of ECB conventional policies are more limited than unconventional policies. Our results confirm the findings in Ca' Zorzi et al. (2020) and Jarociński (2020) and are not reported here for brevity.

FIGURE 7: SPILLOVERS OF MP TIGHTENINGS AT THE LONG END

(A) Fed Long-Maturity Shocks.



(B) ECB Long-Maturity Shocks.



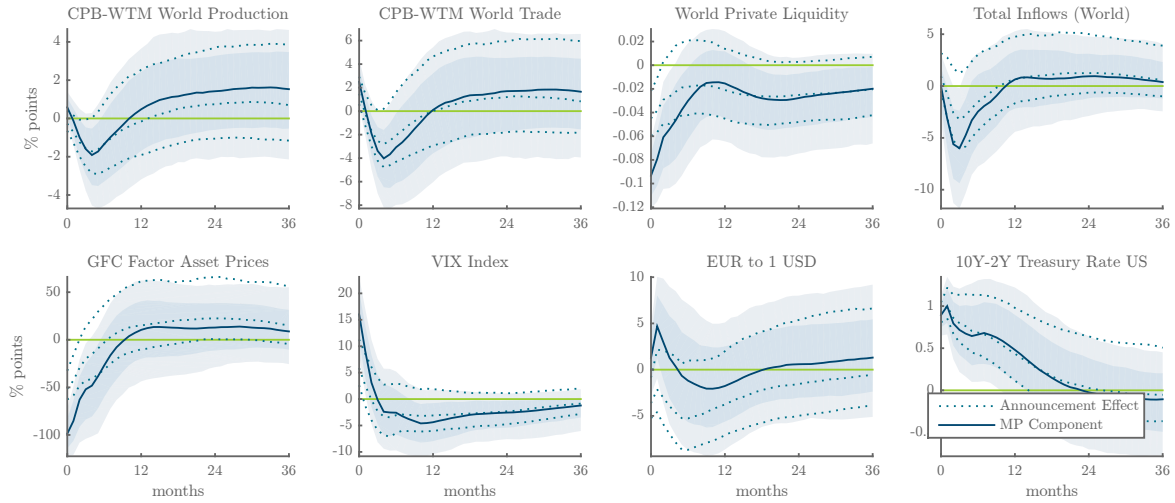
Notes: Median IRFs with 68% and 90% posterior credible sets. All announcements (dotted lines), monetary policy news (solid lines). BVAR(6). 2000:01-2018:12.

euro appreciates strongly relative to the US dollar. In turn, this contributes to explain the rise in global private liquidity – disproportionately denominated in US dollars.[6] The different effects of ECB and Fed policies on global non-bank credit are also in line with the heterogenous cross-border transmission of monetary policies documented using granular

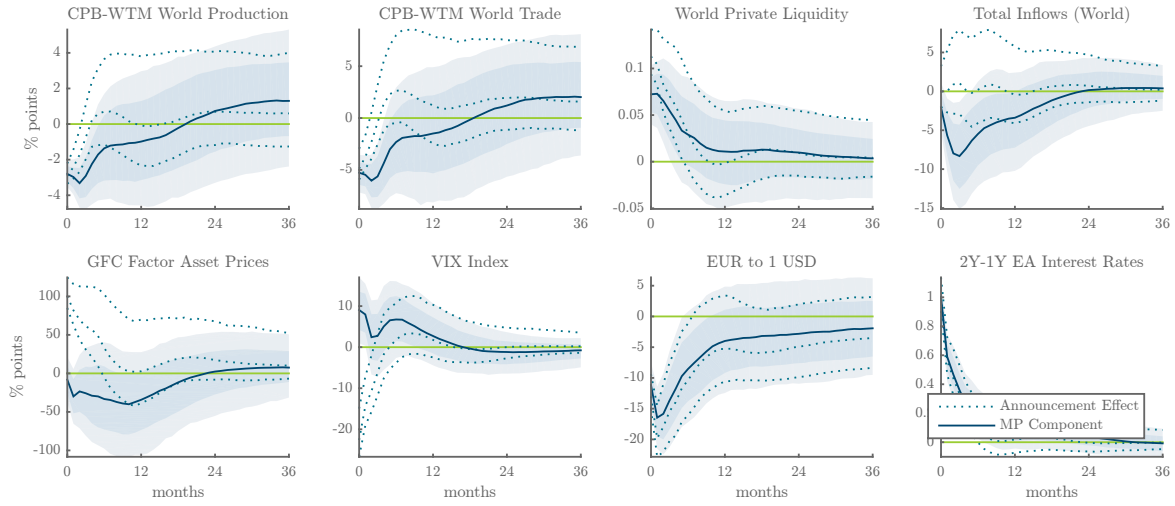
[6]Isolating the monetary policy news turns out to be crucial to characterise the spillovers of unconventional policies, for which information effects are more relevant. In both the case of the US and EA the two sets of responses are systematically different, despite relatively similar shapes of the slope's response.

FIGURE 8: SPILLOVERS OF MP TIGHTENINGS AT THE MEDIUM END

(A) Fed Medium-Maturity Shocks.



(B) ECB Medium-Maturity Shocks.



Notes: Median IRFs with 68% and 90% posterior credible sets. All announcements (dotted lines), monetary policy news (solid lines). BVAR(6). 2000:01-2018:12.

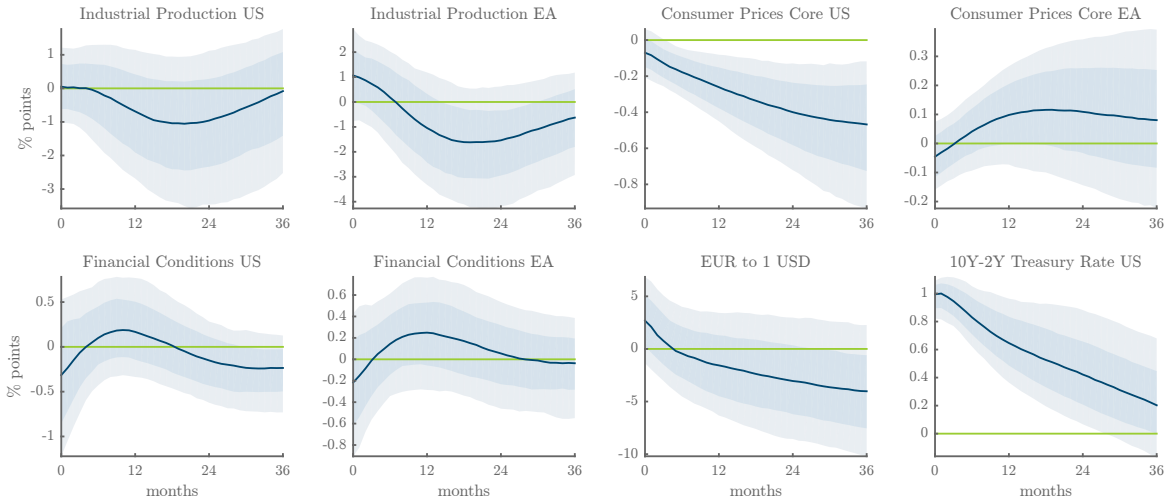
bank-level data in Buch, Bussierè, Goldberg and Hills (2019).

The effects of policies that act on the central segments of the yield curves elicit qualitatively similar spillovers relative to those that act primarily on the longer end (Figure 8). However, the magnitudes are smaller and the effects tend to die out more quickly. Again, we note how confounding factors are more pervasive for ECB policies.[7]

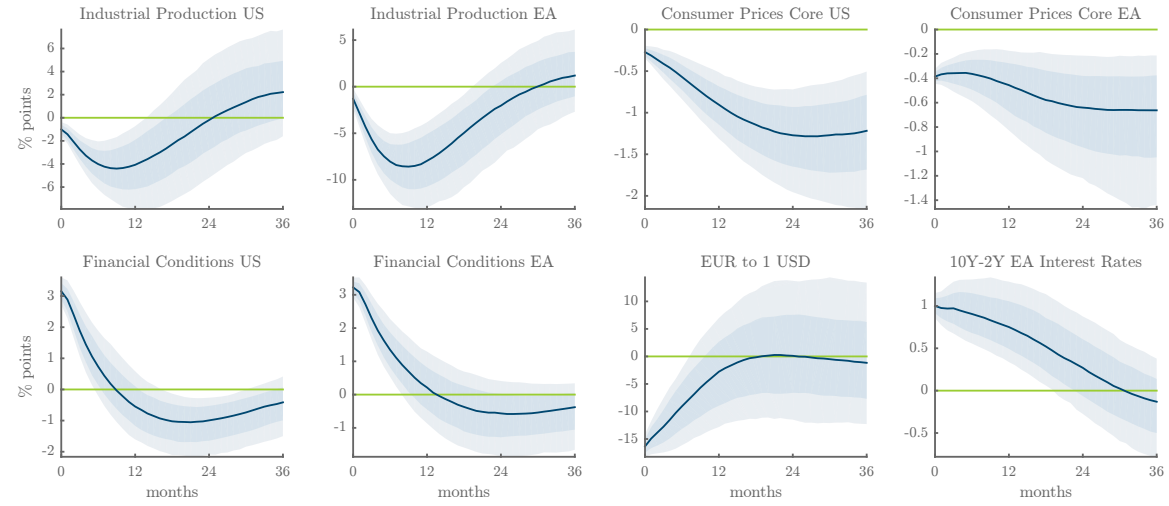
[7]For ECB medium-maturity shocks we instrument a 'mini-slope' constructed as the spread between 2 and 1 year yields. The first-stage F statistics reveal that the Medium-M ECB factor is a weak instrument

Figure 9: Bilateral EA/US Spillovers

(A) Fed Long-Maturity Shocks.



(B) ECB Long-Maturity Shocks.



(C) *Notes:* Median IRFs to monetary policy shocks with 68% and 90% posterior credible sets. BVAR(6). 2000:01-2018:12.

Bilateral EA-US Spillovers These global spillovers could also include direct bilateral effects of ECB and Fed policies. We investigate the extent of bilateral monetary policy spillovers between the US and EA in Figure 9. The VAR in this case replaces the global variables with industrial production, core CPI, and the Goldman Sachs financial conditions indices for the US and EA. Very interestingly, we find that ECB unconventional

for the standard slope (F-stat=5.393 with 10Y-2Y slope, vs F-stat=10.181 with 2Y-1Y). The opposite holds true for Fed Medium-M shocks (F-stat=9.432 with 10Y-2Y, vs F-stat=0.016 with 2Y-1Y).

monetary policy tightenings at the long end are much more effective both domestically, and in terms of bilateral spillovers than Fed policy. EA shocks have a powerful effect on the US business cycle and on broad US financial conditions. The direct effects of US long-maturity policies on EA variables is relatively modest and not very precisely estimated. Indeed, US tightenings elicit a rise in core Eurozone inflation, potentially as the depreciation of the euro vis-à-vis the dollar and its pass-through to domestic prices outweighs the deflationary impact of lower US external demand. Consistent with the global spillovers characterised earlier, Fed tightening is followed by a modest rise in both risk indices, whereas ECB shocks trigger a much sharper jump in risk perceptions across the two currency areas. These results are confirmed if we substitute the financial condition indices with the VIX and VSTOXX (see Figure A.7).

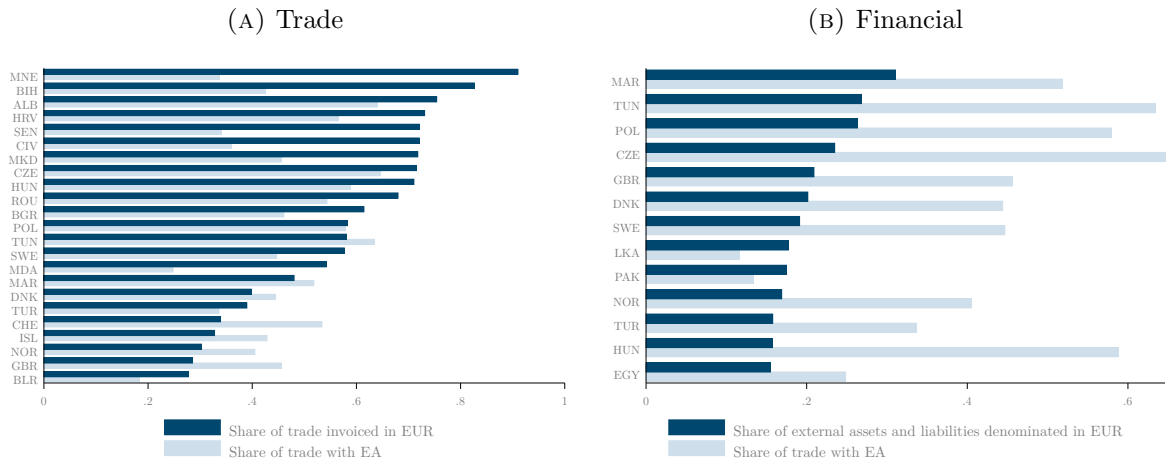
To summarise, Fed unconventional monetary policy news spill over significantly to global financial and real variables. Controlling for central bank information effects helps us to better characterise these spillovers. Our estimates also lead to the novel finding that unconventional policies by the ECB also affect global financial conditions and real variables in a similar manner as Fed policies, albeit to a somewhat more moderate degree. Moreover, the bilateral spillovers of ECB unconventional policies to the US economy and US financial conditions are significant.

5 The International Role of the Euro and ECB Monetary Transmission

The powerful international spillovers from US unconventional monetary policy speak to an influential strand of literature that studies the dominant role of the US dollar in trade invoicing and international transactions (Gopinath et al., 2020; Ilzetzki et al., 2019; Gopinath, 2016). The less prominent but still sizeable international role of the euro historically (see e.g. ECB, 2020) provides one possible explanation for why the ECB policy spillovers documented in earlier sections mirror those elicited by the Fed in terms of channels, but not in terms of magnitude.

In this section we explore more in detail the role that € invoicing plays in the interna-

FIGURE 10: SHARES OF € EXPOSURE



Notes: [Left] Weighted average of the share of imports and exports invoiced in euro (dark bars) for top tercile of € exposure relative to share of trade with EA (light bars). [Right] Weighted averages of the share of external assets and liabilities denominated in euros (dark bars) for top tercile of € exposure relative to share of trade with EA (light bars).

tional transmission of ECB monetary policy shocks. In particular, we study the response of capital flows, liquidity, trade and production for those countries that use the euro as an invoicing currency, or have external assets and liabilities denominated in euros, and compare them with those estimated in Section 4. To that end we take advantage of a rich dataset on the use of different currencies for invoicing external trade made available by Boz, Casas, Georgiadis, Gopinath, Mezo, Mehl and Nguyen (2020) as well as a dataset on the denomination of countries' cross-border assets and liabilities by Benetrix, Gautam, Juvenal and Schmitz (2020). These contain historical information on the currency usage for trade and financial transactions by a large and diverse sample of countries.

Figure 10 reports the top international € users for what concerns trade invoicing (left panel), and the denomination of external assets and liabilities (right panel). Invoicing shares are constructed as weighted averages of the share of imports and exports invoiced in euros, as reported in Boz et al. (2020). Similarly, financial exposures are calculated as weighted averages of the share of external assets and liabilities denominated in euros, as reported in Benetrix et al. (2020). The shares are relative to all other currencies used; for countries where invoicing or denomination shares are provided for multiple periods, we use the average over all available periods. In both panels we also report

each country's share of external trade with Euro area counterparts (light bars). The comparison highlights that a positive correlation exists between trade links and currency usage, but euro dominance is not equivalent to EA countries' role in international trade.

The average use of the euro for trade invoicing falls short of that of the US dollar. However, the euro is the dominant currency for invoicing in a significant subset of the countries. And in many cases it well exceeds the share of trade with EA counterparts. These heavy euro users are primarily European countries outside of the EA, as well as several countries in nearby North and Western Africa. We note that the share of external assets and liabilities denominated in euros barely reaches 30% of the total even for the 'heavy' euro users.

Figures 11 and 12 report the results. The composition of the VARs is the same as in the previous section, with the exception that world aggregates are replaced with those computed for the subsets of heavy euro users.[8,9] In both figures the dash-dotted lines are the responses estimated in Section 4, and impulse response functions are only reported for the announcements classified as monetary policy events.

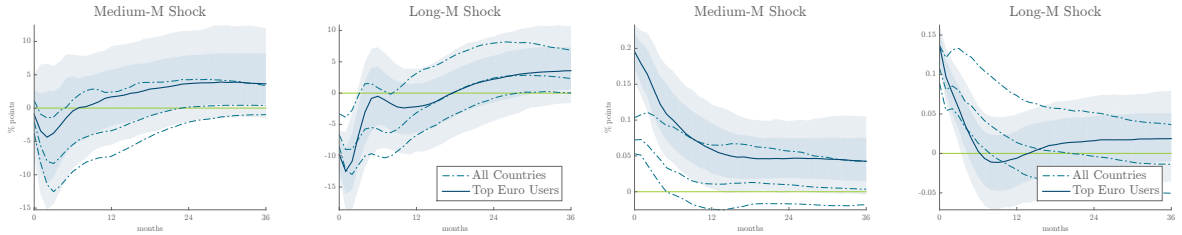
The responses plotted in both figures suggest that countries that rely more on the euro tend to be more sensitive to ECB monetary policy shocks relative to world aggregates. This is particularly visible in the response of external trade and could reflect the positive association between euro exposure and trade shares with EA counterparts that we noted at the onset. Similarly, the heavy euro users tend to experience more persistent falls in output relative to the rest of the world.

Consistently, countries that have larger financial exposure to the euro experience a significantly more severe contraction in capital inflows relative to the rest of the world following ECB shocks to medium maturity rates. Instead, trade invoicing does not seem

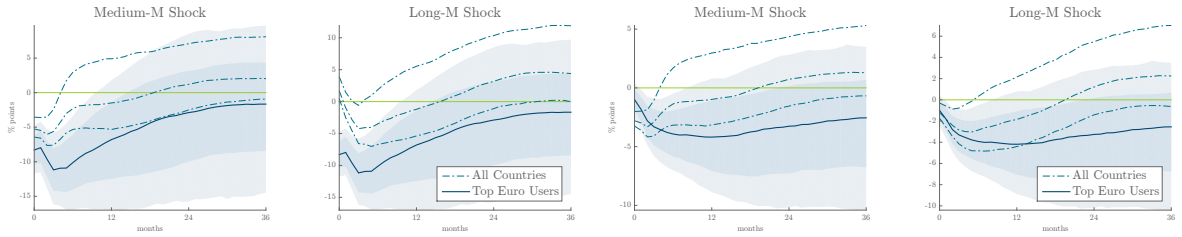
[8]We construct capital inflows and private liquidity aggregates for the top quartile of euro users. Monthly data for trade and production are available for a smaller cross-section of countries; for these variables we focus on the top tercile instead. A full list of countries with available data for each variable of interest is in Table B.3.

[9]We construct aggregates for capital flows and private liquidity by dividing the sum of the respective financial variable (expressed in current USD) by the sum of the nominal GDP of the same sample of countries (also expressed in current USD). Trade volumes data was provided by the CPB World Trade Monitor and is reported in real terms expressed in euros and aggregates are constructed as the sum across relevant countries. Industrial production, also from CPB, is supplied as an index, and we follow the CPB's methodology to construct weighted averages across the countries in our samples of euro users. We use the production weights reported in Table 2.5 of Ebregt (2016), based on countries shares of global value added in mining, manufacturing and utilities as of 2010.

Figure 11: € Trade Invoicing and ECB MP Spillovers



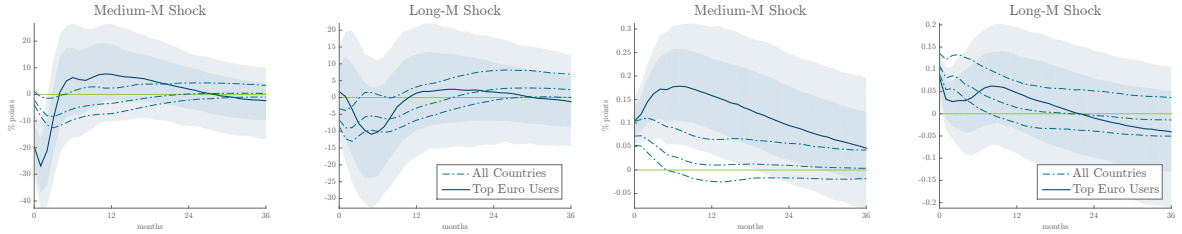
(A) Capital Inflows (B) Private Liquidity



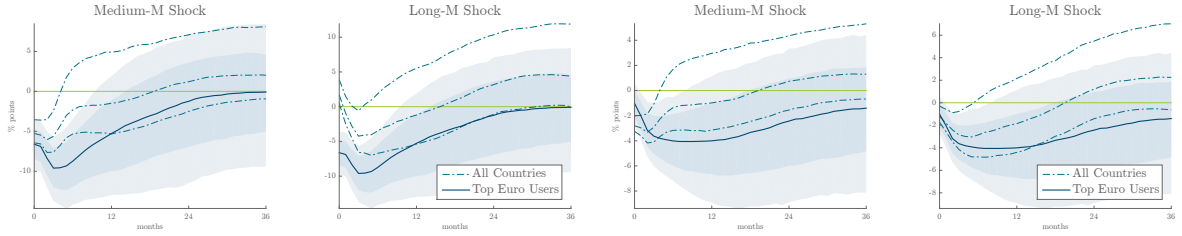
(C) Trade (D) Industrial Production

Notes: Median IRFs with 68% and 90% posterior credible sets. All countries (dash-dotted lines), top € users (solid lines with shaded areas). BVAR(6). 2000:01-2018:12.

Figure 12: € Cross-Border Financial Exposures and ECB MP Spillovers



(A) Capital Inflows (B) Private Liquidity



(C) Trade (D) Industrial Production

Notes: Median IRFs with 68% and 90% posterior credible sets. All countries (dash-dotted lines), top € users (solid lines with shaded areas). BVAR(6). 2000:01-2018:12.

to be associated with a stronger retrenchment in capital flows (Figure 11 panel A). Private liquidity for the heavy euro users is significantly more sensitive to ECB medium maturity shocks relative to world aggregates.

Overall, our results tentatively suggest that currency usage in international transactions could be one important channel for the international transmission of monetary policy shocks, and could help us understand the different magnitudes of monetary policy spillovers. Were the euro to be used as widely as the dollar in international trade and cross-border financial activity, the effects of the two central banks' actions could have much closer magnitudes.

6 Conclusions

This paper consolidates the findings of a growing body of literature on the powerful spillovers from Fed monetary policy to financial conditions and economic activity in the rest of the world. Our first set of results shows that the international channels of transmission of US monetary policy was not altered by the global financial crisis of 2008, or indeed by the introduction of unconventional monetary policy tools.

Importantly, however, we document that ECB policies have very similar effects on global aggregates and on the variables that characterise the Global Financial Cycle. An ECB unconventional monetary policy tightening leads to a fall in global activity and trade, global retrenchments in capital flows, a fall in global stock market indices, and a rise in global risk measures. The euro appreciates strongly. Thus, ECB policies can and do affect global financial conditions. Moreover, ECB unconventional monetary policy has also strong effects on the US business cycle and US financial conditions.

We explore the role that trade and financial linkages with the EA – proxied by the use of the € for invoicing and the pricing of cross-border assets and liabilities – have in determining the strength of the international monetary policy transmission, and find tentative evidence that they constitute an important channel. Heavy euro users are more sensitive to ECB monetary policy spillovers relative to world aggregates. Conversely, countries that invoice primarily in $ are less exposed to ECB monetary policy shocks relative to world aggregates.

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A Additional Results

Table A.1: Summary Statistics

	N	Mean	Std. Dev	Min	Max
US Sample					
4th Fed Fund Fut	159	-0.008	0.051	-0.370	0.120
Short-M Factor	159	0.037	0.944	-6.371	2.030
Medium-M Factor	159	-0.009	0.883	-2.741	3.587
Long-M Factor	159	0.036	0.711	-6.328	1.500
EA Sample					
3-Month OIS	249	0.001	0.032	-0.180	0.162
Short-M Factor	249	0.050	0.785	-4.494	3.679
Medium-M Factor	249	-0.012	0.806	-4.043	3.987
Long-M Factor	249	0.001	0.900	-3.684	6.018

Notes: Factors extracted as in Swanson (2021). The sample includes all FOMC and ECB Governing Council (GC) announcements from Jan-1999 to Jul-2017.

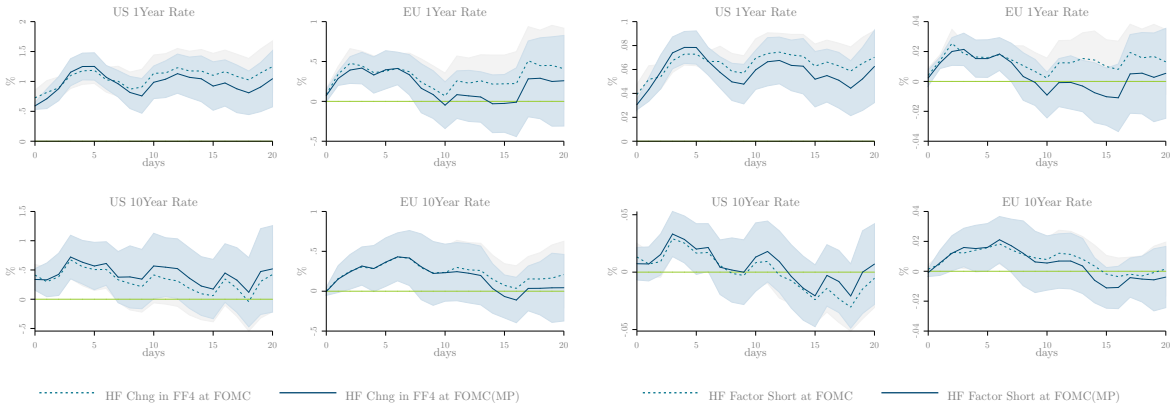
Figure A.1: Monetary Policy Factors, US

Notes: Dimensions of Fed monetary policy. Estimation follows Swanson (2021).

Figure A.2: Monetary Policy Factors. EA

Notes: Dimensions of ECB monetary policy. Estimation follows Swanson (2021).

Figure A.3: Response of US & EA Yield Curve to Conventional US MP

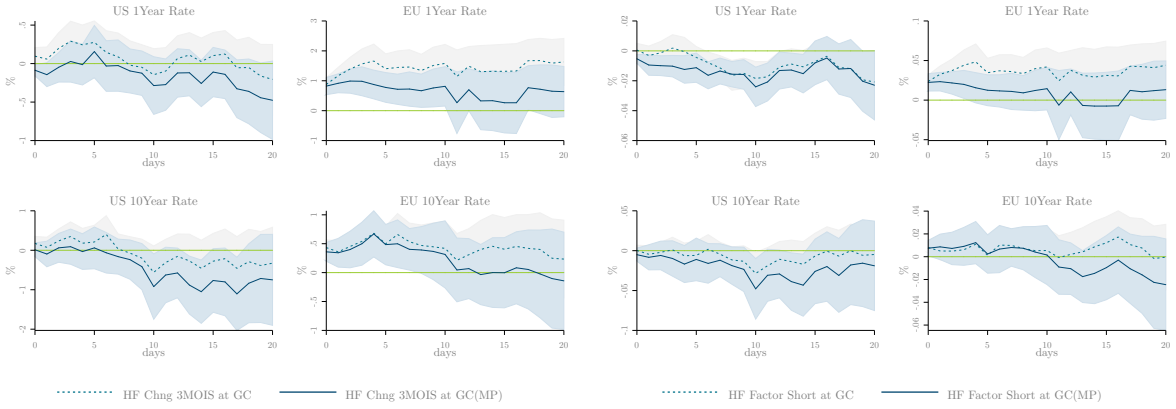


(A) FF4 Shocks

(B) Short-Maturity Shocks

Notes: Daily projections. Sample 1999-01:2017-12. Responses to full announcement (dotted lines), and to monetary news only (solid lines). Shaded areas are one standard deviation bands.

Figure A.4: Response of US & EA Yield Curve to Conventional EA MP

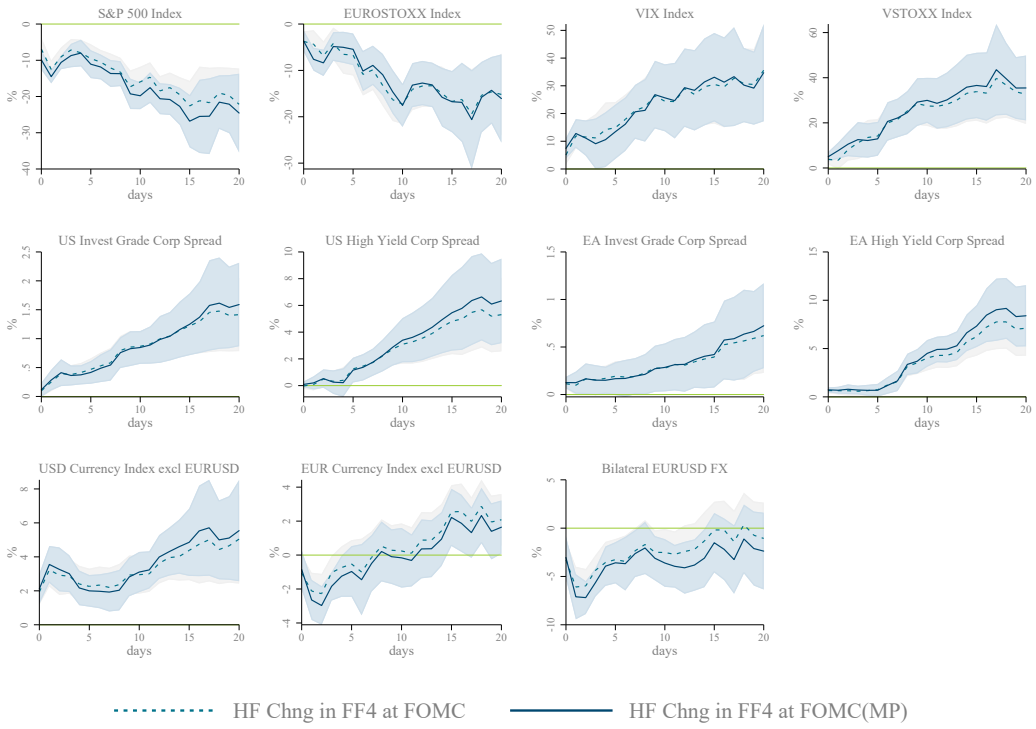


(A) 3-Month OIS Shocks

(B) Short-Maturity Shocks

Notes: Daily projections. Sample 1999-01:2017-12. Responses to full announcement (dotted lines), and to monetary news only (solid lines). Shaded areas are one standard deviation bands.

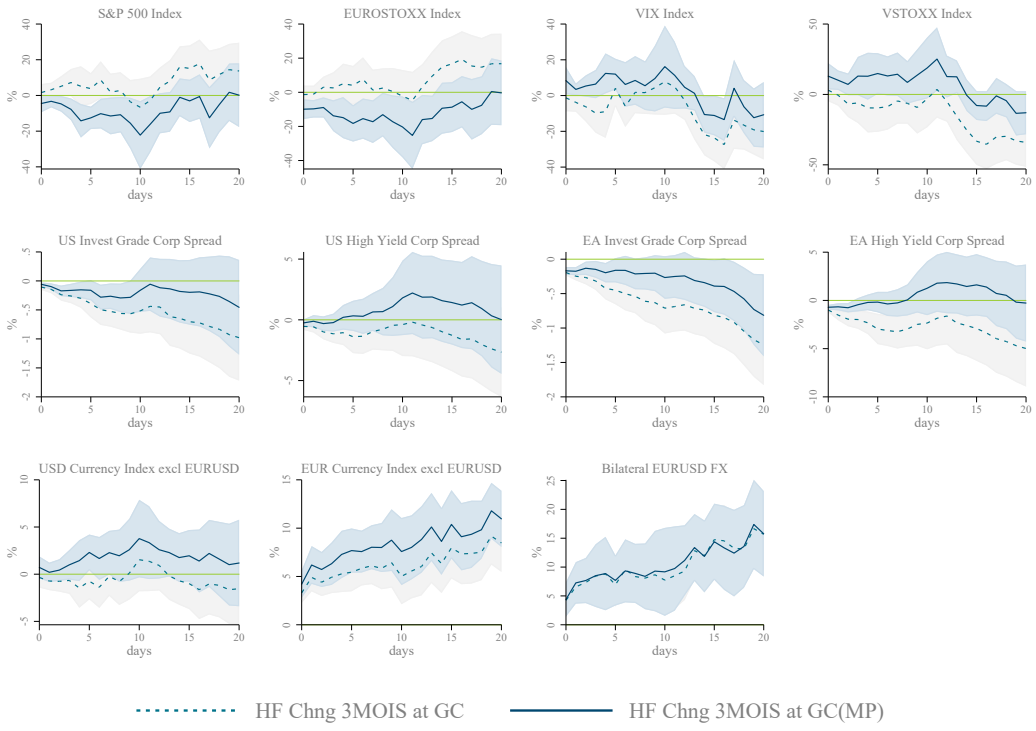
Figure A.5: Response of Asset Prices to Conventional US MP



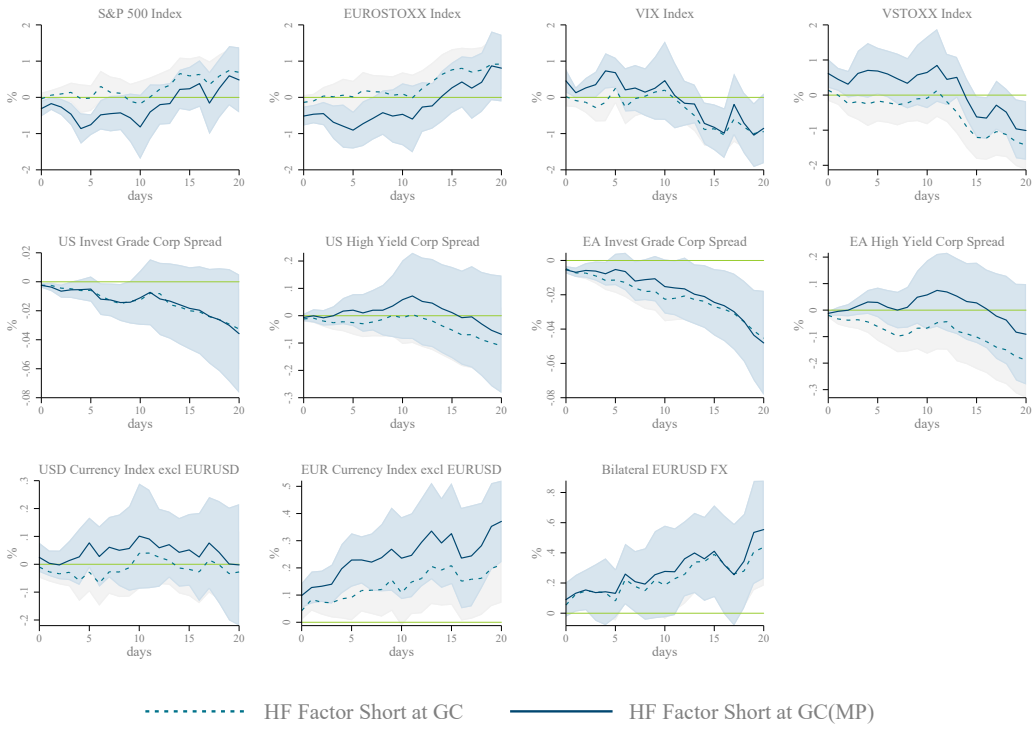
(A) *Notes:* **FF4 Shocks.** Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

(B) *Notes:* **Short-Maturity Shocks.** Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

FIGURE A.6: RESPONSE OF ASSET PRICES TO CONVENTIONAL EA MP

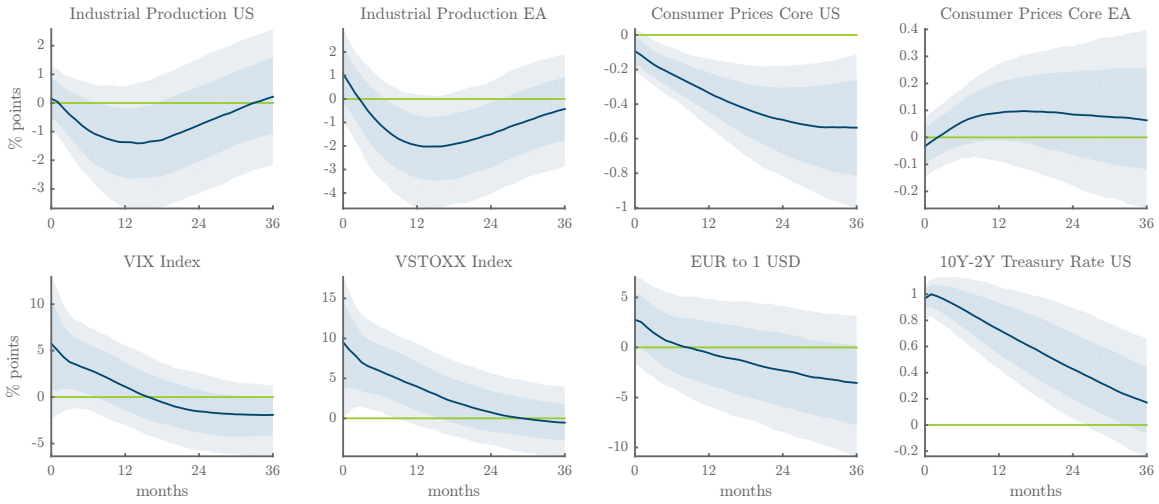


(A) *Notes:* **3-Month OIS Shocks.** Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

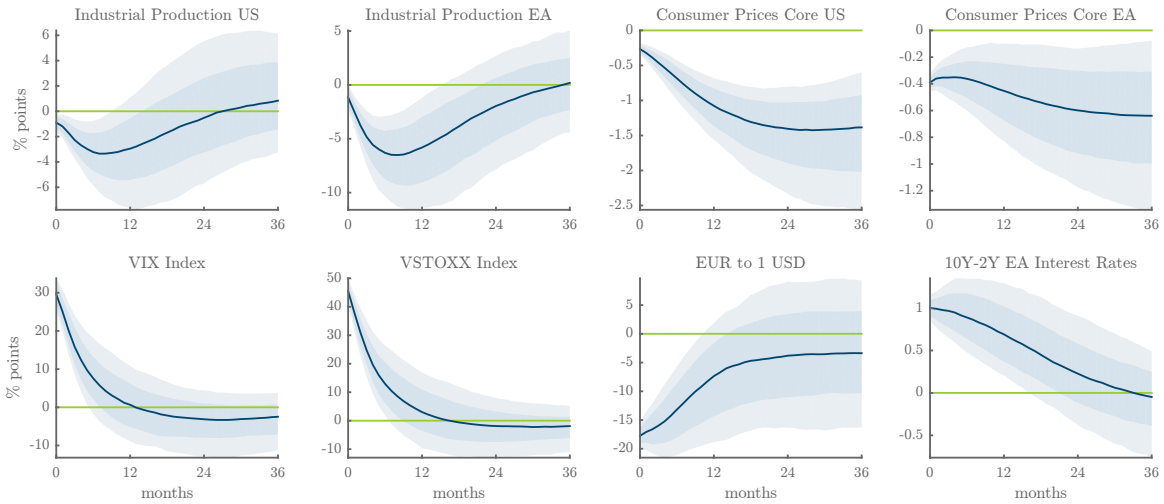


(B) *Notes:* **Short-Maturity Shocks.** Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

FIGURE A.7: SPILLOVERS BETWEEN US AND EA – MP TIGHTENINGS AT THE LONG END #2



(A) *Notes:* **US Shocks.** Median IRFs to monetary policy news (solid lines) with 68% and 90% posterior credible sets. BVAR(6). 2000:01-2018:12.



(B) *Notes:* **EA Shocks.** Median IRFs to monetary policy news (solid lines) with 68% and 90% posterior credible sets. BVAR(6). 2000:01-2018:12.

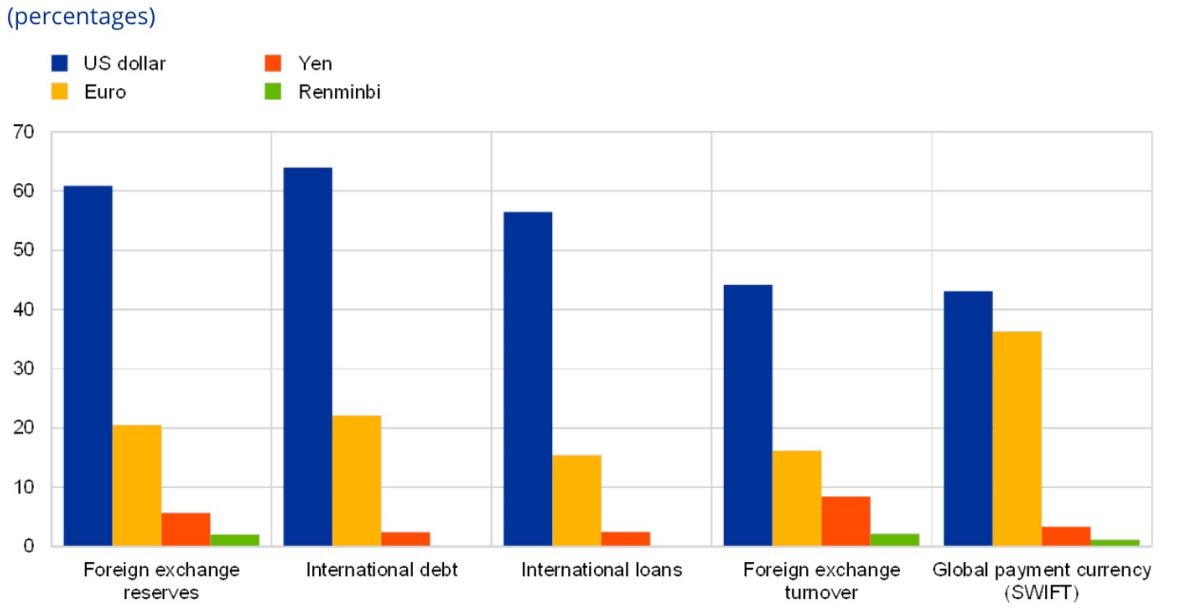
B Data Appendix

Table B.1: Daily Series for Local Projections

Variable	RIC Code
US 1Year Rate	US1YT=RR
US 10Year Rate	US10YT=RR
EU 1Year Rate	EU1YT=RR
EU 10Year Rate	EU10YT=RR
S&P 500 Index	.SPX
EUROSTOXX Index	.STOXXE
VIX Index	.VIX
VSTOXX Index	.V2TX
US Invest Grade Corp Spread	C0A0
US High Yield Corp Spread	H0A0
EA Invest Grade Corp Spread	ER00
EA High Yield Corp Spread	HE00
USD Currency Index excl EURUSD	Own calculations*
EUR Currency Index excl EURUSD	Own calculations*
Bilateral EURUSD FX	EUR=

Source: Eikon by Refinitiv.
* USD bilateral exchange rates are sourced from Eikon by Refinitiv; the trade weights to construct effective exchange rates excluding the €/$ bilateral are from the Bank for International Settlements (BIS).

Figure B.1: International Use of Major Currencies



Sources: BIS, IMF, SWIFT and ECB calculations.Note: The latest data are for the fourth quarter of 2019.

Source: ECB (2020).

Table B.2: Monthly Series for Bayesian VARs

Code	Variable Description	Source
WORLDIP	CPB-World Trade Monitor, World Production, 2010=100, Production Weights	CPB + Own Calculations
INDPRO	US Industrial Production Index, Index 2012=100, Seasonally Adjusted	FRED
EAINDPRO	Euro area 19 (fixed composition) as of 1/1/15 - Industrial Production Index, Total Industry (excluding construction), Working day and seasonally adjusted	Eurostat
IPEURINV	EUR Invoicing Production, Production weighted average for countries with high share of trade invoiced in EUR, Index 2010=100	Boz et al. (2020), CPB + Own Calculations
IPEUREXP	EUR Financial Production, Production weighted average for countries with high share of external assets and liabilities denominated in EUR, Index 2010=100	Benetrix et al. (2020), CPB + Own Calculations
CPILFESL	Consumer Price Index for All Urban Consumers: All Items Less Food and Energy, Index 1982-1984=100, Seasonally Adjusted	FRED
EACPIC	Euro area (changing composition) - HICP - All items excluding energy and food, Working day and seasonally adjusted	European Central Bank
WORLDTRADE	CPB-World Trade Monitor, World Total Merchandise Trade, Volume Index	CPB + Own Calculations
USTRADE	CPB-World Trade Monitor, US Total Merchandise Trade, Volume Index	CPB + Own Calculations
EATRADE	CPB-World Trade Monitor, Euro Area Total Merchandise Trade, Volume Index	CPB + Own Calculations
TRADEEURINV	EUR Invoicing Trade, Sum for countries with high share of trade invoiced in EUR, Trade volume in EUR billions, base year prices	Boz et al. (2020), CPB + Own Calculations
TRADEEUREXP	EUR Financial Trade, Sum for countries with high share of external assets and liabilities denominated in EUR, Trade volume in EUR billions, base year prices	Benetrix et al. (2020), CPB + Own Calculations
WORLDPLIQ	World Private Liquidity, % of GDP	CBC, WEO + Own Calculations
PLIQEURINV	EUR Invoicing Private Liquidity, Sum for countries with high share of trade invoiced in EUR, % of GDP	Boz et al. (2020), UNCTAD, CBC, WEO + Own Calculations
PLIQEUREXP	USD Financial Private Liquidity, Sum for countries with high share of external assets and liabilities denominated in USD, % of GDP	Benetrix et al. (2020), CBC, WEO + Own Calculations
WORLDINFL	Total Inflows (World), % of GDP, All Flows Types, Interpolated from Quarterly Original	IFS, BOPS, WEO + Own Calc.
INFLEURINV	EUR Invoicing Inflows, Sum for countries with high share of trade invoiced in EUR, % of GDP	Boz et al. (2020), UNCTAD, IFS, BOPS, WEO + Own Calculations
INFLEUREXP	EUR Financial Inflows, Sum for countries with high share of external assets and liabilities denominated in EUR, % of GDP	Benetrix et al. (2020), IFS, BOPS, WEO + Own Calculations
GFCFAC	Common Factor in Risky Asset Prices, 2019 Vintage, Standardized	Miranda-Agrippino et al. (2019)
VIX	CBOE Volatility Index, Annualized Percentage Points, NSA	Datastream
VSTOXX	VSTOXX Volatility Index, Annualized Percentage Points, NSA	Datastream
FCIUS	Goldman Sachs, US Financial Conditions Index, Standard Deviations from Historic Average	Bloomberg
FCIEA	Goldman Sachs, EA Financial Conditions Index, Standard Deviations from Historic Average	Bloomberg
EURUSD	Euro to 1 US Dollar, Exchange rate, Average of Daily Figures, NSA	FRED + Own Calculations
GS1	1-Year Treasury Constant Maturity Rate, Percent, NSA	FRED
GS2	2-Year Treasury Constant Maturity Rate, Percent, NSA	FRED
GS10	10-Year Treasury Constant Maturity Rate, Percent, NSA	FRED
OIS1Y	European 1-Year Benchmark OIS, Percent, NSA	Datastream
OIS2Y	European 2-Year Benchmark OIS, Percent, NSA	Datastream
OIS10Y	European 10-Year Benchmark OIS, Percent, NSA	Datastream

Table B.3: Euro Users Country Samples

Variable	Euro Exposure	Countries
Trade	Trade Invoicing	Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Iceland, North Macedonia, Norway, Poland, Romania, Sweden, Switzerland, Turkey, United Kingdom
	External Assets & Liabilities	Czech Republic, Denmark, Hungary, Norway, Poland, Sweden, Turkey, United Kingdom
Industrial Production	Trade Invoicing	Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Iceland, Montenegro, North Macedonia, Norway, Poland, Romania, Serbia, Sweden, Switzerland, Turkey, United Kingdom
	External Assets & Liabilities	Czech Republic, Denmark, Hungary, Norway, Poland, Sweden, Turkey, United Kingdom
Capital Inflows	Trade Invoicing	Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Moldova, Montenegro, Morocco, North Macedonia, Poland, Serbia, Sweden
	External Assets & Liabilities	Czech Republic, Denmark, Morocco, Norway, Pakistan, Poland, Sri Lanka, Sweden, United Kingdom
Private Liquidity	Trade Invoicing	Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Morocco, Poland, Romania, Serbia, Sweden
	External Assets & Liabilities	Czech Republic, Denmark, Morocco, Norway, Pakistan, Poland, Sri Lanka, Sweden, United Kingdom

Note: The countries in our euro-exposure trade and IP aggregates come from the top third of non-EA euro users plotted in Figure 10. Better data availability for monthly capital flows and private liquidity allow us to focus on the top quartile of the same set of countries.