A Tale of Two Global Monetary Policies*

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Abstract

We compare the international financial spillovers of the unconventional monetary policies of the Fed and the ECB. The global reach of US monetary policy is preserved when switching from conventional Fed Funds Rate policies to tools that instead act primarily on the medium and long end of the yield curve. A US monetary policy contraction is still followed by a global retrenchment in capital flows, a fall in global stock markets, and a rise in global risk measures. But ECB unconventional policies too elicit similar effects on global asset markets and financial aggregates worldwide. While with smaller magnitudes, the international financial spillovers of ECB policies are comparable to those of the Fed. And more prominent for non-EA countries that choose the euro as the primary currency for trade invoicing.

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

JEL Classification: F42, E52, G15

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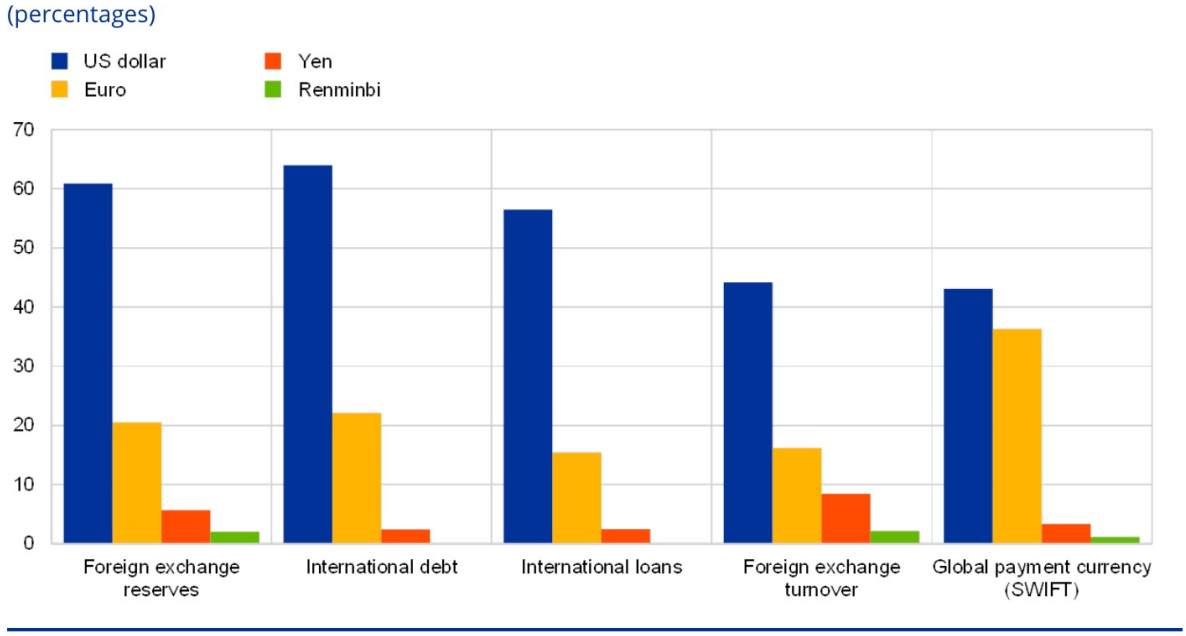
1 Introduction

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, see Figure 1 and ECB, 2020). As a consequence, ECB policies can also be important in the determination of international financial conditions. However, the evidence in this regard is still 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 could have important consequences on the GFC by affecting the dollar valuation of inter-

Figure 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).

national 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 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 monetary policy tools. We study the effects that unconventional monetary policy in the two currency areas has on the price and quantity of risk, measured through asset prices and global capital flows, on long-term interest rates in the two areas, on credit spreads, and on the bilateral exchange rate. We then explore more in detail the role that euro invoicing plays in determining the international transmission of ECB policies.

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. Our paper is close in spirit to Jarociński (2020), where the comparison is instead focused

on conventional policy tools.

We start by looking at the sequence of monetary policy decisions 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 using the algorithm 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 effects that the US and euro Area (EA) policy surprises at different horizons have on asset prices: bond yields, 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 the month following the respective policy announcements (see also Stavrakeva and Tang, 2019; Gürkaynak, Kara, Ksackoğlu and Lee, 2020).

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 most of the results established for US conventional policy carry through to unconventional policies as well. US monetary policy tightenings that impact mostly medium- and long-term interest rates lead to a fall in global stock market indices, a broad-based appreciation of the dollar, and a tightening of global financial conditions. European interest rates respond significantly to Fed policy shocks. 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. While US interest rates do not respond to ECB policy shocks, other

global asset prices do, and with magnitudes comparable to those elicited by Fed policies. EA monetary policy tightenings that impact mostly medium- and long-term interest rates lead to a pronounced fall in global stock market indices, a broad-based depreciation of the dollar, 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. The global spillovers of US monetary policy survive the introduction of unconventional tools, both in terms of sign of the responses, and of their economic significance. 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 the 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.

Taken together, these results suggest that the international financial spillovers of ECB monetary policy are as relevant as those of the Fed. At least for what concerns unconventional monetary policy tools.

Finally, we show that the transmission of ECB policies is stronger for countries whose external trade is predominantly invoiced in euros. We interpret this as tentative evidence that the overall less prominent international role of the euro could help explain the different magnitudes of Fed and ECB policy spillovers. A shift towards a more balanced use of the two currencies in the international monetary system could lead to an even more pronounced role of ECB policies as drivers of the GFC.

The paper is organised as follows. In Section 2 we review the monetary policy surprises of the Fed and ECB, and study their propagation to financial markets using daily projections in Section 3. Section 4 collects the results on the international propagation of ECB and Fed monetary policies to global aggregates, while Section 5 focuses on the

role of euro pricing in the transmission of the monetary policy of the ECB. Section 6 concludes. Additional details are reported in the Appendix.

2 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 calculated in narrow windows around the monetary policy announcements to measure the extent to which the decision was interpreted as a surprise, or news, by market participants. The advantage of working with financial market-based expectations of future interest rates, rather than for example survey-based expectations, is that they allow to narrow down the measurement window to only a few minutes (typically 30) around the relevant announcements. In the absence of other contemporaneous events, this in turn guarantees that if a price revision indeed occurs in that time span, one can be confident that the monetary announcement was its only trigger.

However, whether that price revision can be labelled as a proxy for a monetary policy shock is a different matter. Indeed, it has become apparent how market participants also tend to systematically extract information about the macroeconomic outlook from monetary policy announcements. This phenomenon, known in the literature as the central bank information effect, makes monetary policy surprises a contemporaneous function of at least one other shock, which can have very different transmission to macroeconomic aggregates and their expectations (Miranda-Agrippino, 2016; Melosi, 2017; Nakamura and Steinsson, 2018; Cieslak and Schrimpf, 2019). The literature has identified two complementary ways to deal with the consequence 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 when identifying conventional monetary policy shocks with high-frequency surprises. Jarociński and Karadi (2020) instead propose to act on the consequences that such an effect has on the reaction of financial markets to monetary

announcements, and identify monetary policy news on the basis that they should induce a negative comovement between stock prices and bond yields. The two approaches lead to equivalent results. The latter, while being 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); Swanson (2021).

Swanson (2021) identifies three different dimensions of US monetary policy – orthogonal to one another – that summarise movements in the entire term structure of interest rates: *(i)* a Federal Funds rate factor, that loads predominantly on the overnight rate, and dominates in the period until the zero-lower-bound (ZLB); *(ii)* a communication/forward guidance factor that has higher loadings on 1 to 2-year maturity rates, and that is active throughout the entire sample; and *(iii)* 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 by construction.

The forward guidance (FG) factor proxies for shocks that induce markets participants to revise their expectations of future medium-term maturity interest rates. Given that the typical time horizon covered in both implicit and explicit FG 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 policies. Technically, however, to the extent that the announcement and implementation of quantitative easing measures can have an impact also on expectations of interest rates at maturities other than 10 years, this factor effectively combines the effects of explicit policy communication 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, spurred by the FOMC announcements, act mainly on the medium-end of the US yield curve.

Similar to the FG case, 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. Importantly, this factor is orthogonal to both changes in the overnight rate and in the FG factor. Hence, it can

be thought of as capturing residual ways in which FOMC announcements alter markets' expectations about long-term rates beyond those that result from direct transmission from changes in shorter-maturity interest 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).

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	0.00	0.24	0.76	0.91	1	0.98	1.06	0.91
Long-M Factor	0.00	-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	0.00	0.46	1	1.11	0.51	0.39
Long-M Factor	0.00	-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.

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

In the analysis that follows, we only consider the overlapping sample across the two sets of factors, that is, from January 1999 to July 2017. Following Jarociński (2020), we 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.

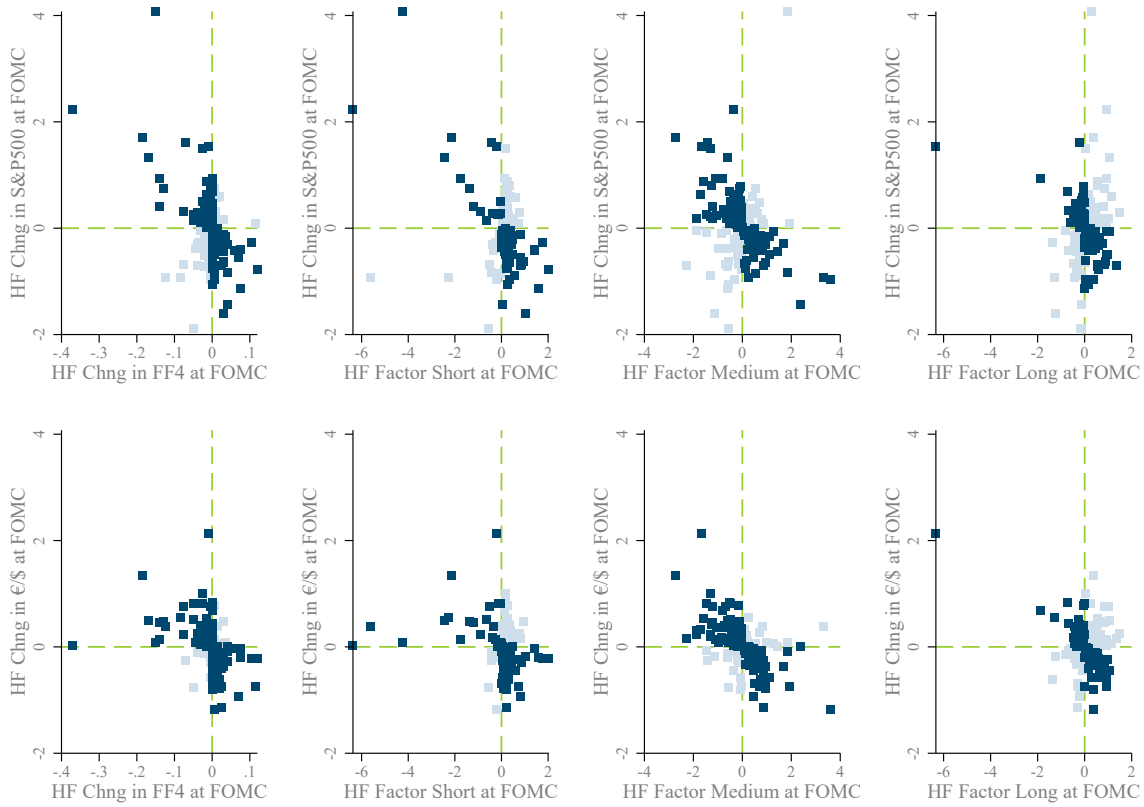
Figures 2 and 3 report scatter plots of the high-frequency reaction of financial markets to policy announcements in the two areas. In both figures, the top row compares the reaction of the relevant stock market index with that of the monetary policy surprises, while the bottom row reports the reaction 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.

To evaluate the extent to which the presence of confounding factors alters the estimation of average effects of monetary policy announcements, in Tables 3 and 4 we report the results of two sets of regressions, estimated at announcement frequency for the two areas. Namely, the tables report the estimated beta coefficients from the following regressions:

$$\Delta y_{t-\epsilon:t} = \alpha + \beta mps_{t-\epsilon:t} + \nu_t \tag{1}$$

$$\Delta y_{t-\epsilon:t} = \alpha + \beta^* mps_{t-\epsilon:t}\mathbb{1}_- + \nu_t \tag{2}$$

FIGURE 2: MONETARY POLICY SURPRISES IN THE US

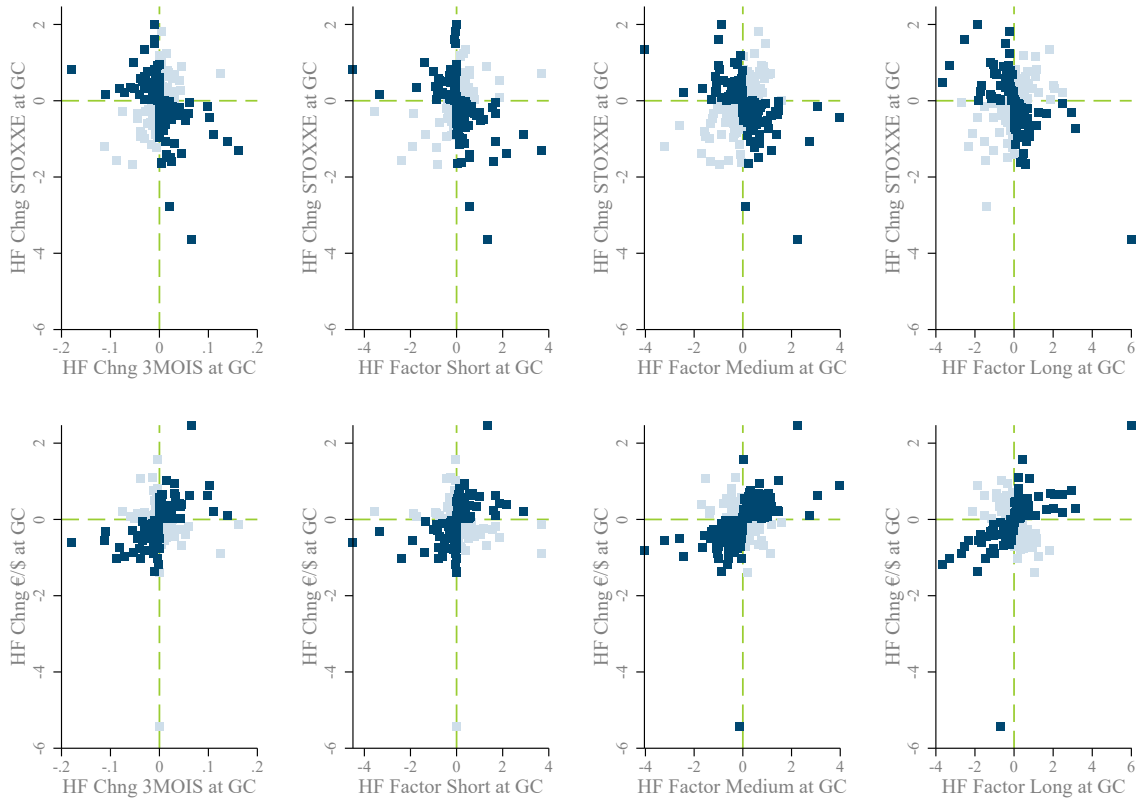


Notes: [Top Panels:] Intraday reactions of monetary policy surprises and the stock market (S&P 500) around FOMC announcements. [Bottom Panels:] Intraday reactions of monetary policy surprises and the bilateral €/$ exchange rate around FOMC announcements. [Across Columns:] High-frequency change in the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

where $\Delta y_{t-\epsilon:t}$ denotes the high-frequency change in either the stock market index or the bilateral exchange rate, $mps_{t-\epsilon:t}$ denotes either the high-frequency change in a synthetic contract used to capture the effects of monetary policy (the 4th Fed Funds Futures for the US, and the 3-month OIS for the EA), or 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. This corresponds to the "poor man's" identification of Jarociński and Karadi (2020). Robust standard errors and t-statistic are reported in brackets.

There are a number of elements that are worth highlighting. First, in both cases, moving from a single contract to summarise monetary policy to instead using a set of

FIGURE 3: 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:] High-frequency change in the 3-month OIS, Short-Maturity factor, Medium-Maturities factor, Long-Maturities factor.

factors increases the number of instances in which the negative comovement restriction is violated. Second, on average, the confounding factors are not strong enough to completely undo the effects of monetary policy, at least in the event-study framework. This aligns with findings in Bauer and Swanson (2020). In fact, in general it is the case that positive monetary surprises, that correspond to tightening episodes, lead to a decline in the stock market and an appreciation of the local currency (top panels of both tables). This is true across the whole of the maturity spectrum. Third, information effects seem to affect in a similar manner both the stock market and the exchange rate. In fact, it is the case that in the announcements classified as monetary policy events, the response of the bilateral exchange rate becomes much stronger, both in terms of magnitude, and significance. It is worth stressing that the "poor man's" classification of the announcements, summarised

TABLE 3: STOCK MARKET AND EXCHANGE RATE AT FED ANNOUNCEMENTS

All Announcements	S&P 500				€/$			
4th Fed Funds Fut	-6.483				-2.917			
	(1.381)				(1.066)			
	[-4.696]				[-2.738]			
Short-M Factor		-0.301				-0.091		
		(0.142)				(0.037)		
		[-2.116]				[-2.462]		
Medium-M Factor			-0.183				-0.260	
			(0.090)				(0.052)	
			[-2.025]				[-5.005]	
Long-M Factor				-0.013				-0.163
				(0.130)				(0.093)
				[-0.100]				[-1.757]
N	159	159	159	159	159	159	159	159
Announcements Classified as MP	S&P 500				€/$			
4th Fed Funds Fut	-8.699				-2.716			
	(1.607)				(1.142)			
	[-5.413]				[-2.378]			
Short-M Factor		-0.564				-0.106		
		(0.117)				(0.052)		
		[-4.812]				[-2.042]		
Medium-M Factor			-0.462				-0.311	
			(0.049)				(0.066)	
			[-9.467]				[-4.685]	
Long-M Factor				-0.352				-0.322
				(0.080)				(0.028)
				[-4.412]				[-11.31]
N	121	83	100	77	121	83	100	77

Notes: Announcement frequency, all regressions include a constant. Robust SE in parentheses, t-stats in square brackets. Sample 1991-01:2017-12.

by $\mathbb{1}_-$, only uses information in the stock market high-frequency change, and it is thus not at all surprising that the coefficients of Eq. (2) are stronger when $\Delta y_{t-\epsilon:t}$ is the change in the stock market index. However, a priori it is not clear that the events identified by $\mathbb{1}_-$ should also be those in which the information effect is stronger also for the bilateral exchange rate, or indeed that the bilateral exchange rate abides by the same type of dynamics. However, the results in Tables 3 and 4 both show that *(i)* this is indeed the case, and *(ii)* that once the monetary policy announcements are correctly classified, monetary policy tightening along the whole of the maturity spectrum elicit strong exchange rates reaction, and that these become stronger as the maturity of the

TABLE 4: STOCK MARKET AND EXCHANGE RATE AT ECB ANNOUNCEMENTS

All Announcements	STOXX50				€/$			
3-Month OIS	-3.112				3.958			
	(1.683)				(1.190)			
	[-1.849]				[3.327]			
Short-M Factor		-0.111				0.085		
		(0.070)				(0.045)		
		[-1.597]				[1.878]		
Medium-M Factor			-0.054				0.244	
			(0.078)				(0.042)	
			[-0.694]				[5.843]	
Long-M Factor				-0.138				0.205
				(0.097)				(0.053)
				[-1.416]				[3.858]
N	249	249	249	249	249	249	249	249
Announcements Classified as MP	STOXX50				€/$			
3-Month OIS	-9.485				5.323			
	(1.677)				(1.423)			
	[-5.654]				[3.742]			
Short-M Factor		-0.418				0.167		
		(0.084)				(0.050)		
		[-4.998]				[3.314]		
Medium-M Factor			-0.418				0.362	
			(0.091)				(0.062)	
			[-4.611]				[5.820]	
Long-M Factor				-0.459				0.336
				(0.071)				(0.047)
				[-6.465]				[7.177]
N	151	134	124	127	151	134	124	127

Notes: Announcement frequency, all regressions include a constant. Robust SE in parentheses, t-stats in square brackets. Sample 1991-01:2017-12.

decision lengthens. That is, unconventional policy decisions seem to elicit stronger FX reactions, compared to conventional ones.[1]

3 Financial Markets Spillovers

In this section we explore more in detail the way in which Fed and ECB policies affect global financial markets in the days that follow the announcements. Our aim here is to

[1]The larger β coefficients associated with the changes in the 4th Fed Funds Futures and the 3-Month OIS are the mechanical result of the much lower standard deviation of these contracts, when compared to that of the factors. See Table A.1 in the Appendix.

evaluate the persistence of the effects, and also to highlight any differences in the way in which the policy decisions spill over to other jurisdictions. 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.

In particular, we evaluate the effect of the two monetary policies on the same set of asset prices, and over the same sample 1999-01:2017-07. We do so by using daily projections (Jordà, 2005) of the following form

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h mps_{t-\epsilon:t} + \nu_{t+h} \tag{3}$$

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h^* mps_{t-\epsilon:t} \mathbb{1}_- + \nu_{t+h} \tag{4}$$

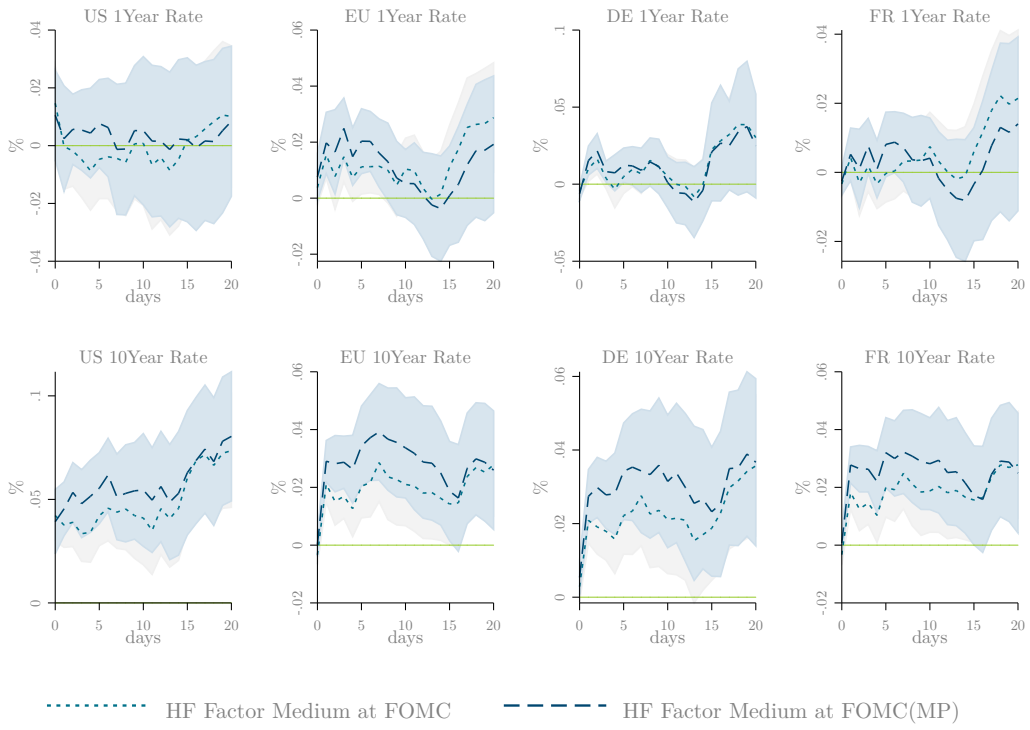
where $y_{t+h} - y_{t-1}$ is the cumulated daily change in asset prices, and $mps_{t-\epsilon:t}$ and $\mathbb{1}_-$ are as in Section 2. We report results for the cases in which $mps_{t-\epsilon:t}$ is either the Medium-Maturity or the Long-Maturity factor at the relevant announcement dates. Results for conventional monetary policy are reported in the Appendix.

We focus on two sets of asset prices. In Figures 4 and 5 we evaluate the response of interest rates at maturities equal to 1 and 10 years, in the US, EA, Germany and France. In Figures 6 and 7 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, and the €/\$ bilateral exchange rate). Variables definitions and sources are in Table B.1 in the Appendix.

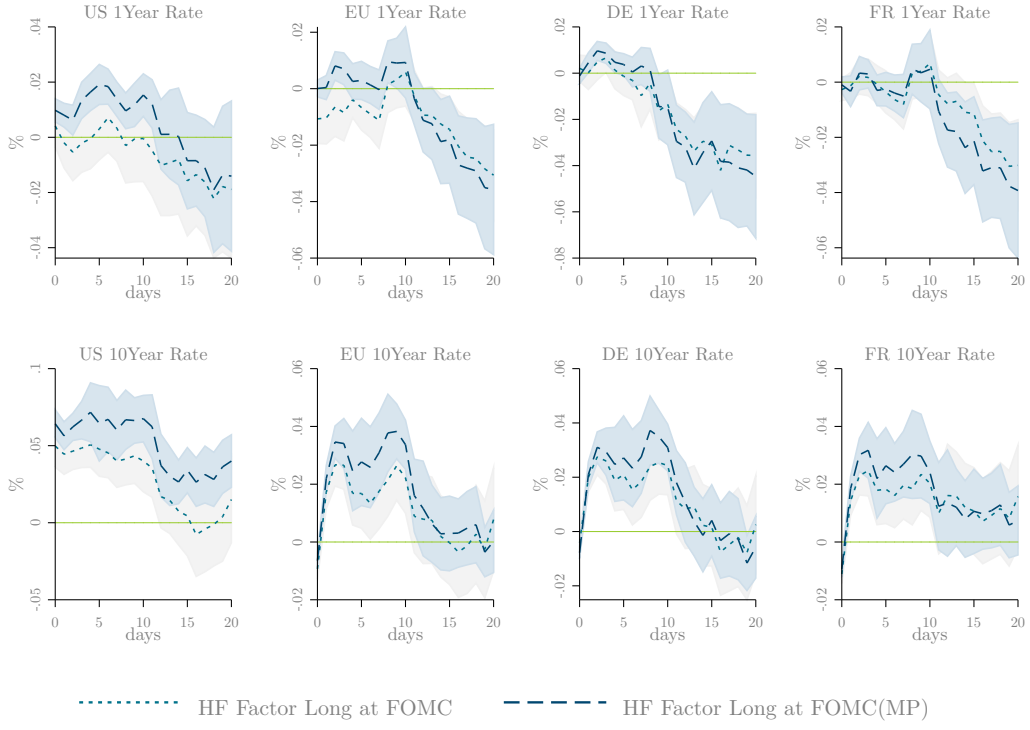
The figures report the estimated β_h (dotted lines) and β_h^* (dashed lines) coefficient for horizons covering the first 20 business days following the announcements, which corresponds to a one-month horizon. Shaded areas are one standard deviation bands. All factors are interpretable as tightening surprises.

We start by discussing the results in Figures 4 and 5. The top panel of the figures reports the responses to the Medium-Maturity factors (Figures 4a and 5a), while the bottom panel reports the responses to the Long-Maturity factors (Figures 4b and 5b).

FIGURE 4: RESPONSE OF INTEREST RATES TO UNCONVENTIONAL US MP

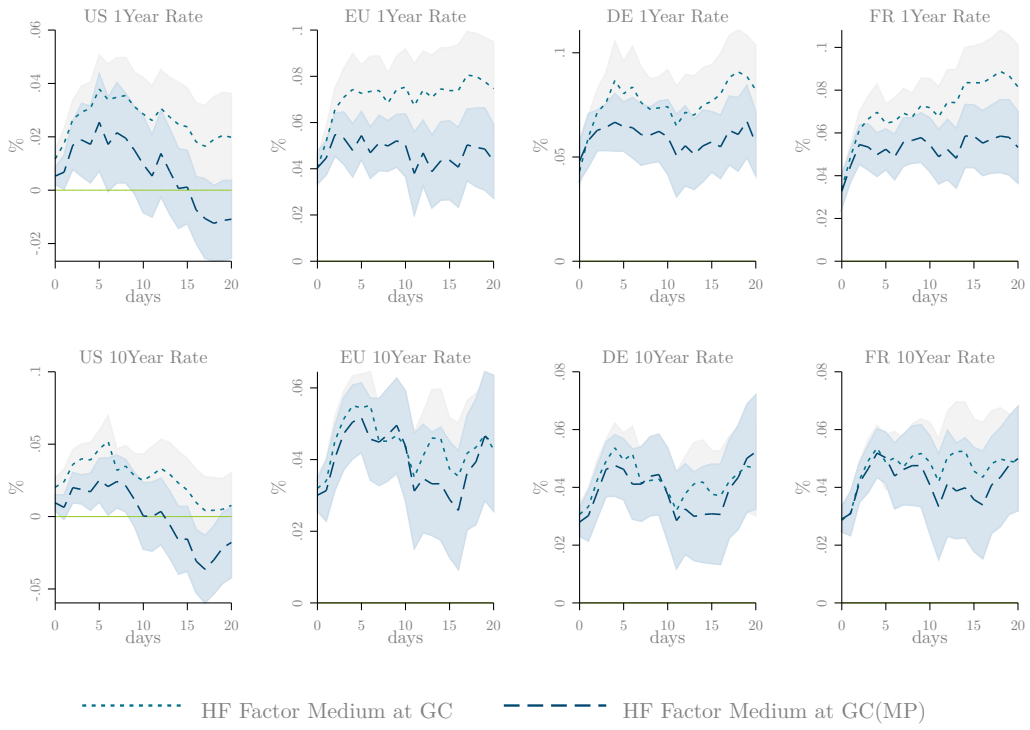


(A) *Notes:* **Medium-Maturity Shocks.** Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

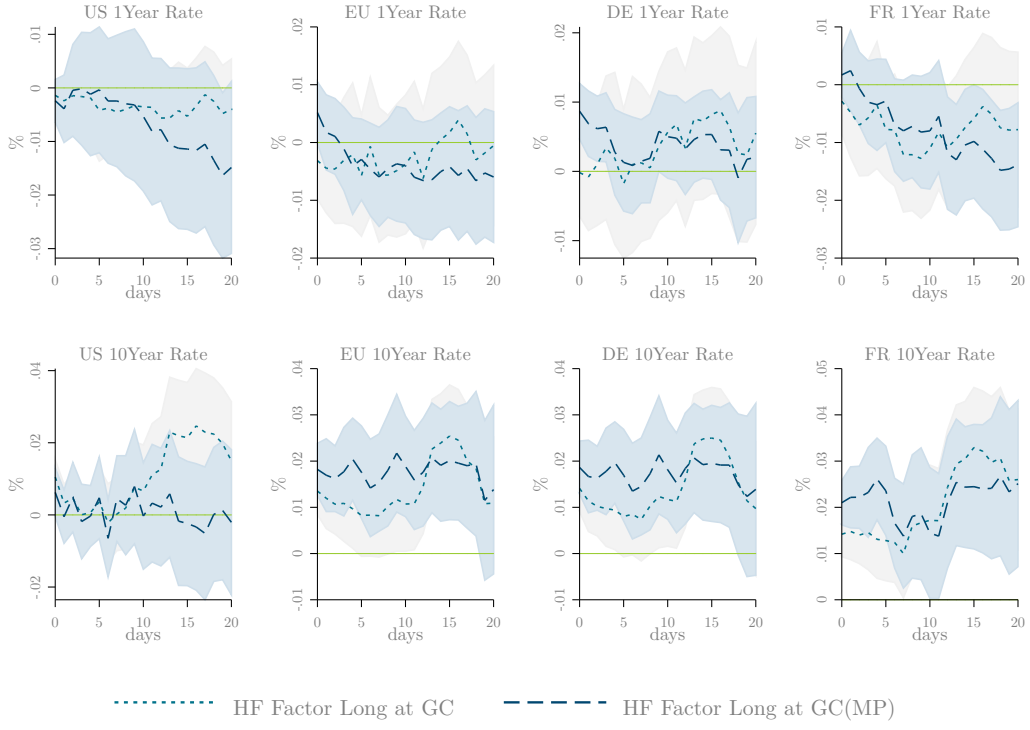


(B) *Notes:* **Long-Maturity Shocks.** Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

FIGURE 5: RESPONSE OF INTEREST RATES TO UNCONVENTIONAL EA MP



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



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

Both factors lead to an increase in the relevant domestic 10-year rate.

A number of results emerge. First, unconventional policies are very effective at affecting the relevant interest rates domestically. While the persistence of the effects is different, we see in Figure 4 how the 10-year US rate is significantly higher in both cases. Similarly, long term rates in the Eurozone are significantly and persistently higher following both Medium- and Long-Maturities policies (Figure 5). Second, important asymmetries in the spillovers emerge. European interest rates respond significantly to Fed policies, and particularly so at long horizons.[2] On the contrary, US interest rates are little affected by ECB unconventional policies within the month. Third, isolating the monetary policy events (i.e. those picked up by the indicator $\mathbb{1}_{-}$) 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.

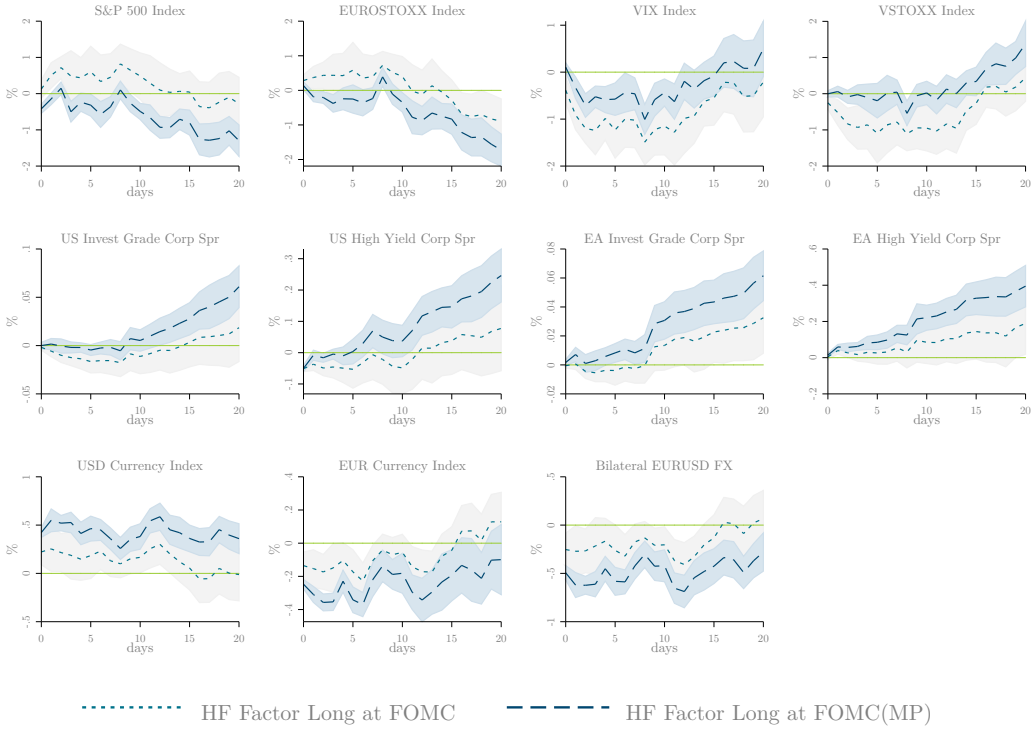
The asymmetry in the spillovers of Fed and ECB policies vanishes when considering the responses of other financial markets variables. Also, the consequences of the presence of information effects become more apparent. Figures 6 and 7 report the responses of the stock market, volatility indices, corporate bond spreads and currencies to the two sets of monetary policies. Again here we focus on the responses to the Medium-Maturity factors (Figures 6a and 7a), and to the Long-Maturity factors (Figures 6b and 7b) and report those elicited by conventional monetary policy in the Appendix.

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 generally leads to a fall in global stock markets, a rise of corporate bond spreads, and an appreciation of the US dollar. The responses in Figure 6 show that both the S&P 5000 and the EuroSTOXX fall in response to US monetary policy contractions, and that financial conditions generally deteriorate, as shown by the slow but persistent rise in both \$- and €-denominated corporate bond spreads. Not surprisingly, financial conditions tighten more for more financially constrained firms, with high-yield spreads responses

[2]The zero impact responses is 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.

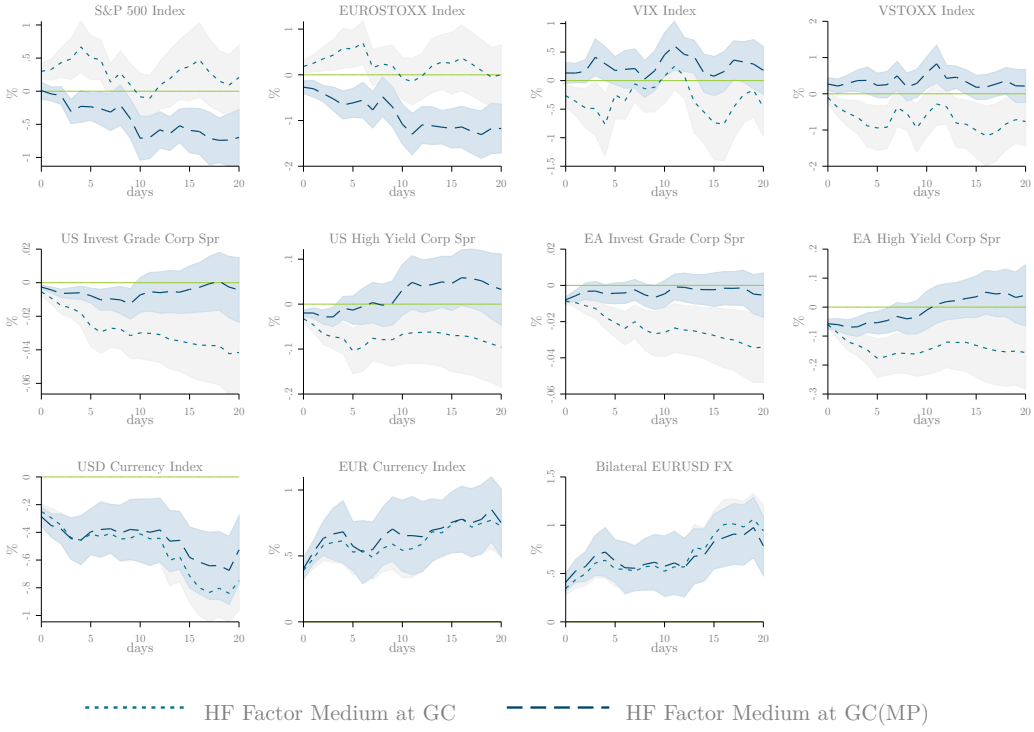
FIGURE 6: RESPONSE OF ASSET PRICES TO UNCONVENTIONAL US MP

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

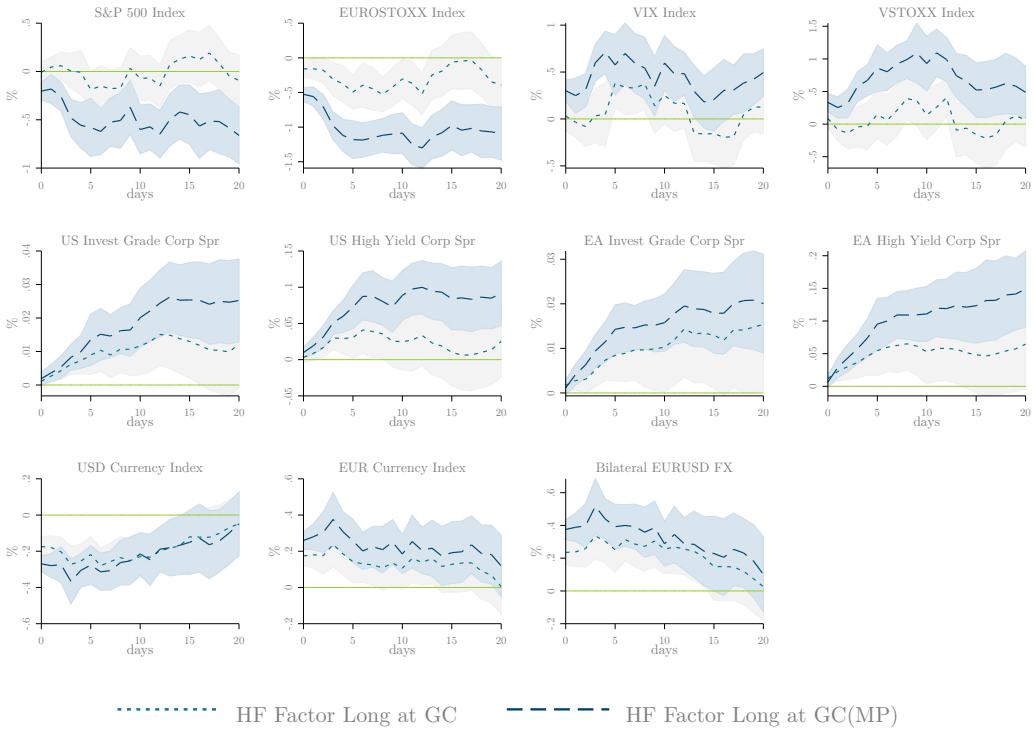


(B) *Notes:* **Long-Maturity Shocks.** Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

FIGURE 7: RESPONSE OF ASSET PRICES TO UNCONVENTIONAL EA MP



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



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

being an order of magnitude larger than the corresponding investment-grade ones. The dollar appreciates significantly. This 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, 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 signalling QE effects) do not seem to affect 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 7 reports the responses of the same set of asset prices to Medium-maturity (Figure 7a) and Long-Maturity (Figure 7b) 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 5000 and the EuroSTOXX fall), and to a broad-based appreciation of the euro. Importantly, they also lead to a broad-based depreciation of the US dollar, beyond that in the bilateral FX. Medium-maturity policies have an overall negligible effect on broader financial conditions, with spreads being essentially unresponsive, and volatility indices only marginally positive. On the contrary, Long-maturity ECB policies lead to sustained tightening of international financial conditions. Corporate spreads rise substantially, and the effects have equivalent magnitudes whether one considers either $-denominated or €-denominated debt. Moreover, they lead to significantly higher risk perceptions. The VIX and the VSTOXX increase substantially, and to a very similar degree.

Taking our results together, we conclude that ECB monetary policy is as relevant as Fed monetary policy for what concerns international financial spillovers. 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 for what concerns trade and output shares, translate into global macroeconomic and financial aggregates reacting significantly to the Fed's policies.

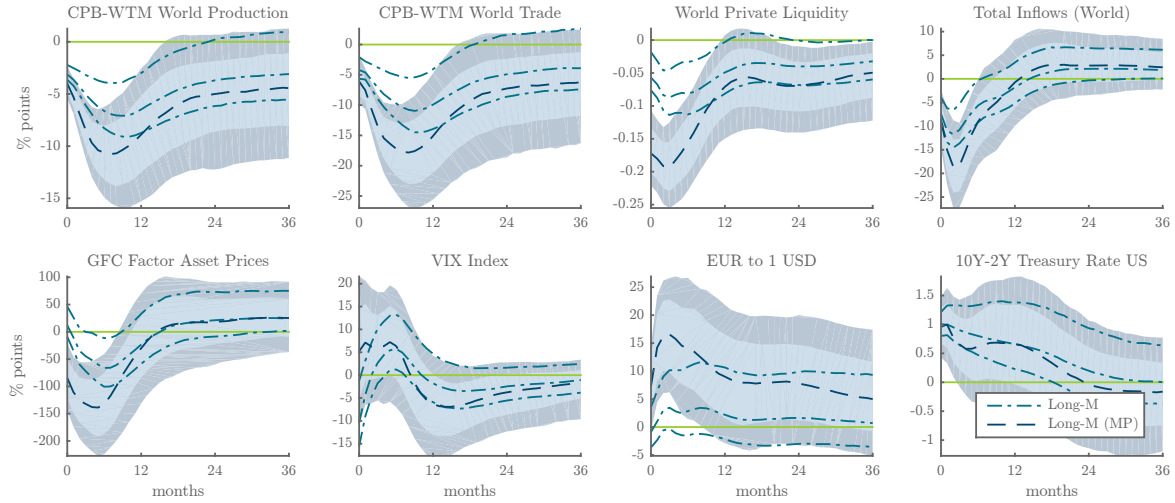
Focusing on conventional monetary policy, a number of studies have highlighted the strong spillovers that operate through the GFC, and through more standard trade channels (see e.g. Ha, 2016; Georgiadis, 2016; Dedola et al., 2017; Degasperi et al., 2020; Miranda-Agrippino and Rey, 2020b; Miranda-Agrippino et al., 2019). The evidence that relates to ECB policies is more mixed. In a recent paper, Ca' Zorzi et al. (2020) note how conventional ECB policies transmit chiefly through trade channels, while the effects on global financial variables is less pronounced.

In this section we extend the comparison of Section 3 to global macro and financial aggregates and evaluate whether the strong international financial spillovers of the ECB unconventional policies documented at the daily frequency persist at lower frequencies.[3]

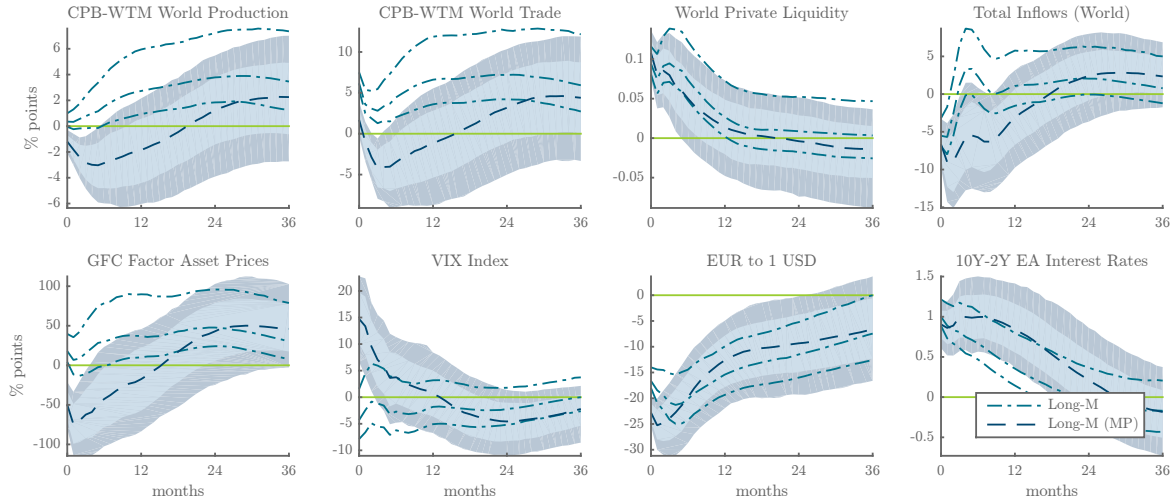
We estimate global macro and financial spillovers using monthly VARs. The estimated effects of the Long-Maturity factors for the Fed and ECB are reported in Figure 8, while those elicited by shocks at medium maturities are in Figure 9. We distinguish between the effects elicited by the factors computed around all central banks announcements (dash-dotted lines), and those identified as monetary policy events (solid lines) as in Sections 2 and 3. The setup is identical in the case of the US and EA. In each case the VARs include a measure of global output and global trade, both distributed by the CBP in their World Trade Monitor publication, a measure of global private liquidity, expressed as a share of global GDP and distributed by Cross-Border Capital Ltd., total world capital inflows as a share of world GDP, the global factor in asset prices of Miranda-Agrippino

[3]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 8: RESPONSES TO MP TIGHTENINGS AT THE LONG END



(A) *Notes:* **US Shocks.** Median IRFs with 68% and 90% posterior credible sets. All announcements (dash-dotted lines), announcements classified as monetary policy events (dashed lines). BVAR(6). 2000:01-2018:12.



(B) *Notes:* **EA Shocks.** Median IRFs with 68% and 90% posterior credible sets. All announcements (dash-dotted lines), announcements classified as monetary policy events (dashed lines). BVAR(6). 2000:01-2018:12.

et al. (2019), the VIX index, the bilateral €/$ exchange rate, and the term structure slope, measured as the spread between 10-year and 2-year rates. Variables definitions and sources are in Table B.2 in the Appendix.[4] Both VARs are estimated with six lags

[4]At the domestic level, unconventional monetary policy tightenings generally lead to a contraction in real activity and prices, and a tightening of domestic financial conditions. The effects of these shocks are estimated to be stronger for Long-Maturity policies than for Medium-Maturity ones, but with significant uncertainty around the exact magnitudes. Results are available upon request.

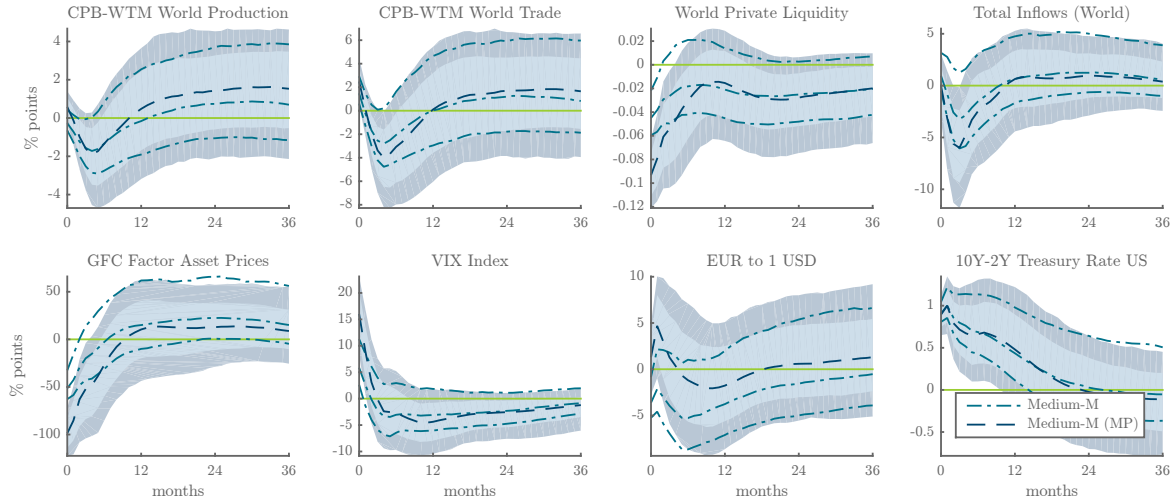
over the sample 2000-01:2018:12 with standard macroeconomic priors. We report results based on impulse response functions at the mode of the posterior distribution of the parameters, and normalised such that all shocks induce a steepening of the domestic yield curve that raises by 1% on impact. The shocks are identified using the factors as external instruments.

Isolating the monetary policy events 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. The responses in Figure 8a confirm the presence of strong monetary policy spillovers also for US 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. These results are in line with what documented by Miranda-Agrippino and Rey (2020b) for conventional US monetary policy, 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 tools.

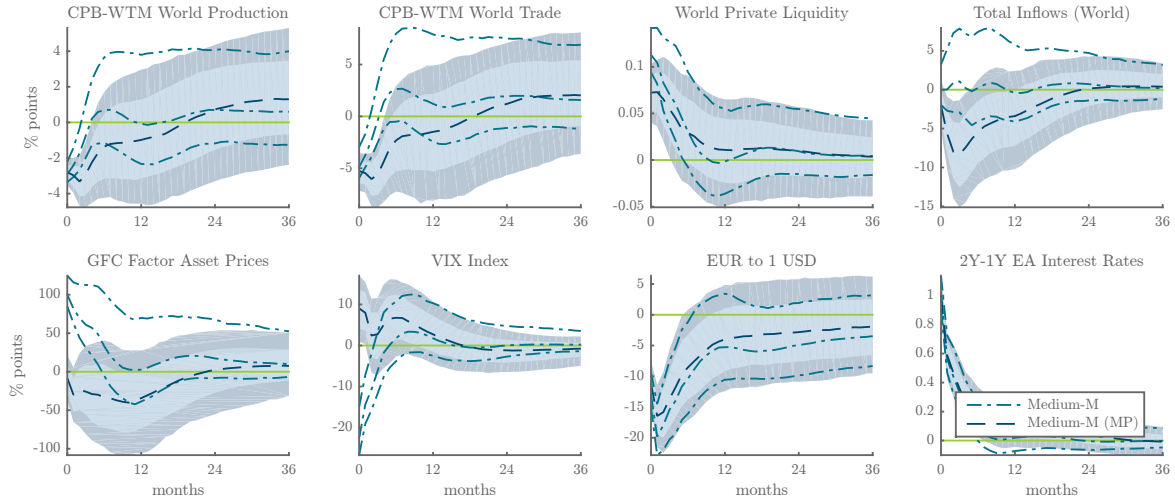
Figure 8b reports the responses to an ECB tightening at the long end. The broad picture that emerges is one in which, as already noted in Section 3, the monetary policy of the ECB is as relevant as the Fed for global spillovers, at least for what concerns unconventional tools. While the magnitude of the responses is smaller, an ECB unconventional monetary policy tightening elicits essentially the same types of responses in 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 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.

Next, we compare the international transmission of Fed and ECB shocks to medium-term maturities of their respective yield curves. Results are in Figures 9a and 9b for US

FIGURE 9: RESPONSES TO MP TIGHTENINGS AT THE MEDIUM END



(A) *Notes:* **US Shocks.** Median IRFs with 68% and 90% posterior credible sets. All announcements (dash-dotted lines), announcements classified as monetary policy events (dashed lines). BVAR(6). 2000:01-2018:12.



(B) *Notes:* **EA Shocks.** Median IRFs with 68% and 90% posterior credible sets. All announcements (dash-dotted lines), announcements classified as monetary policy events (dashed lines). BVAR(6). 2000:01-2018:12.

and EA shocks respectively.[5]

Overall, 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. However, the magnitudes are smaller and the effects tend to die out more quickly.

[5]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 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).

Again, we note how confounding factors are more pervasive for ECB policies.

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.

5 The International Role of the Euro and ECB Monetary Transmission

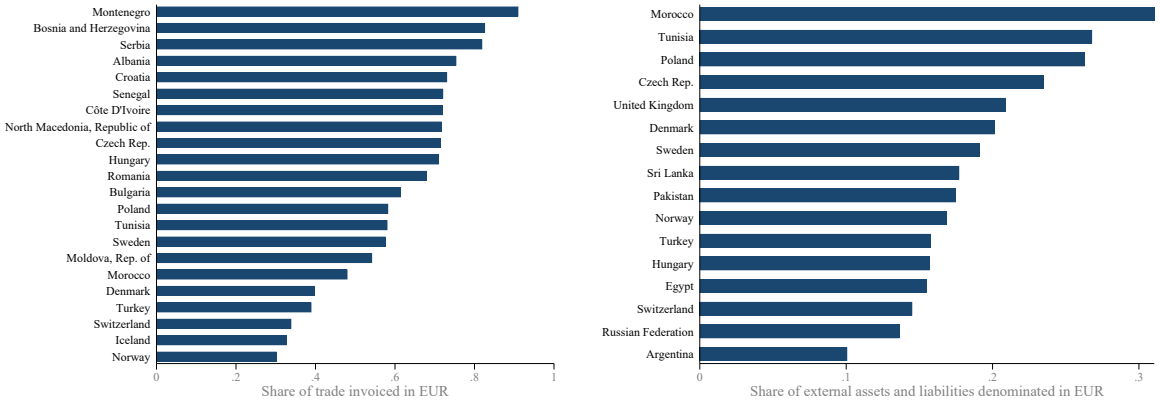
The powerful international spillovers from US unconventional monetary policy speak to an influential strand of literature that studies the dominant role of the US dollar in trade invoicing and international transactions (Gopinath et al., 2020; Ilzetzki et al., 2019; Gopinath, 2016). The less prominent 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 international transmission of ECB monetary policy shocks. In particular, we study the response of capital flows for those countries that use the euro as an invoicing currency, or have external assets and liabilities denominated in euros. 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.

In Figure 10 we show the top international users of the euro for what concerns trade invoicing (left panel), and the denomination of external assets and liabilities (right panel).[6] The shares are relative to all other currencies used. Invoicing shares are constructed as

[6]The figure only reports countries with a euro share in trade invoicing of at least 30%, and euro financial exposures of at least 10%.

FIGURE 10: SHARES OF € EXPOSURE



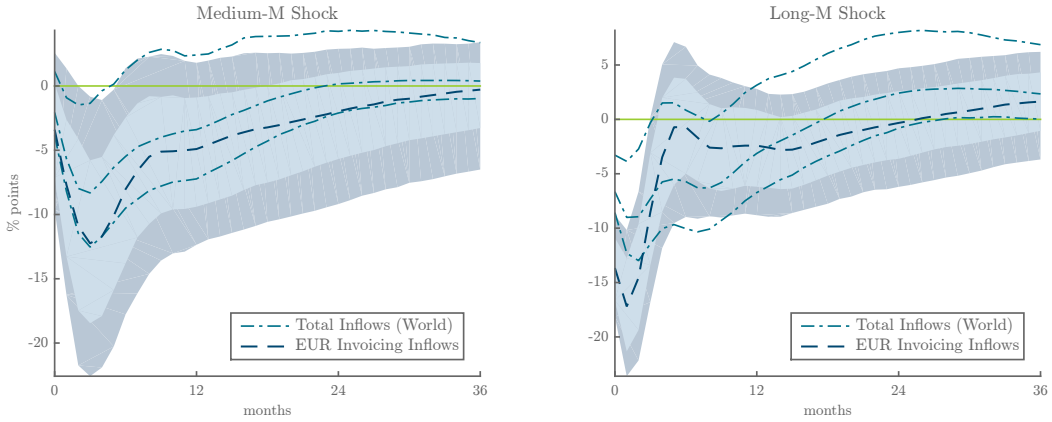
Notes: **LEFT: Share of external trade invoiced in €.** Weighted averages of the share of imports and exports invoiced in euros, as reported in Boz et al. (2020). Cut-off above 30%. **RIGHT: Share of external assets and liabilities denominated in €.** Weighted averages of the share of external assets and liabilities denominated in euros, as reported in Benetrix et al. (2020). Cut-off above 10%.

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). For countries where invoicing or denomination shares are provided for multiple periods, we use the average over all available periods.

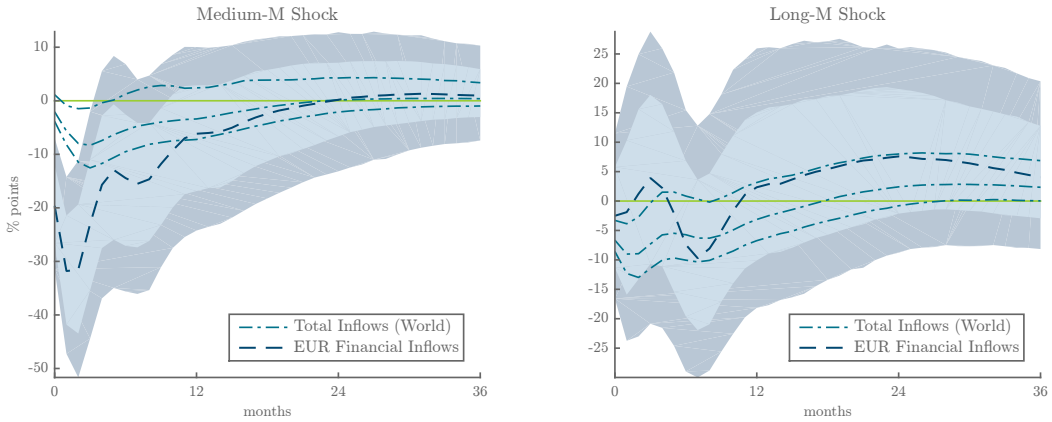
The average use of the euro for trade invoicing falls short of that of the US dollar. However, the euro is the dominant currency for invoicing in a significant subset of the countries. These heavy euro users are primarily European countries outside of the EA, as well as several countries in nearby North and Western Africa. We focus on the top quartile of countries by euro trade invoicing share. This quartile consists of the first 18 countries in the left panel Figure 10 (from Montenegro to Denmark). Similarly, we focus on the top quartile of countries by euro financial exposure. This results in a sample of 10 countries (from Morocco to Norway). As visible from the right panel of Figure 10, however, the share of external assets and liabilities denominated in euros does not exceed 30% of the total.

We compare the responses of capital inflows to ECB unconventional monetary policy shocks in the top euro users, with those estimated in Section 4. The composition of the VARs is the same as in the previous section, with the exception of the capital inflows

FIGURE 11: € EXPOSURE AND ECB MP SPILLOVERS



(A) *Notes:* **Trade Invoicing.** Median IRFs with 68% and 90% posterior credible sets. All countries (dash-dotted lines), top quartile of € users (dashed lines). BVAR(6). 2000:01-2018:12.



(B) *Notes:* **Financial Exposure.** Median IRFs with 68% and 90% posterior credible sets. All countries (dash-dotted lines), top quartile of € users (dashed lines). BVAR(6). 2000:01-2018:12.

variables that are constructed as aggregates for the subsets of heavy euro users in terms of trade and financial exposures instead of the entire world.[7] Figure 11 reports the results. In the figure, the dashed-dotted lines are the responses of world aggregates, as estimated in Section 4 and are the same in the two sets of subplots. Impulse response functions are only reported for the announcements classified as monetary policy events. Lags included and the estimation sample are unchanged.

Figure 11a reports the responses of capital flows for the countries that invoice most of their external trade in euros. Figure 11b reports instead results for the top quartile of

[7]Country aggregates for these variables are constructed by dividing the sum of capital flows (expressed in current US dollars) by the sum of the nominal GDP of the same country sample (also expressed in current US dollars).

countries that have the largest euro financial exposure. A few interesting results emerge. Capital inflows into € invoicing countries contract more in response to ECB shocks at long maturities compared to the responses of world inflows. At the peak, the fall in inflows is more than 1.5 bigger than relative to world aggregates. Responses are instead equivalent for medium-maturity shocks. This suggests that trade currency denomination is an important channel through which international monetary policy spillovers occur. In fact, in unreported results we find that inflows and liquidity of the heaviest US dollar users, in contrast, respond more weakly to ECB policies than the world aggregates. The relative importance of the two types of ECB monetary policy shocks is instead reversed when looking at the countries with a high share of external assets and liabilities denominated in euros. In this case it is policies that act on the central segments of the curve that elicit the strongest effects, with peak effects more than three times the size of those recorded for world aggregates. It is worth stressing, however, that the sample of countries in this latter exercise is relatively small, and hence the comparison of the magnitude of the effects needs to be interpreted with some caution.

These results suggest that currency usage in international transactions is an important channel for the international transmission of monetary policy shocks, and can help us understand the different magnitudes of monetary policy spillovers. Were the euro to be used as widely as the dollar in international trade, 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 the unconventional monetary policy of the ECB has 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. For the purpose of evaluating international monetary policy spillovers of the ECB, it is crucial to disentangle the monetary policy component in the announcements of the Governing Council. Confounding factors such as e.g. information effects can be as powerful as to overturn the effects of monetary policy shocks altogether. The magnitude of the international spillovers of ECB policies is however smaller than that documented for Fed policies.

We explore the role that currency usage has in determining the strength of the international monetary policy transmission, and find that it constitutes a very important channel. Countries that use the € as the primary currency for invoicing suffer stronger spillovers from ECB policies 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.

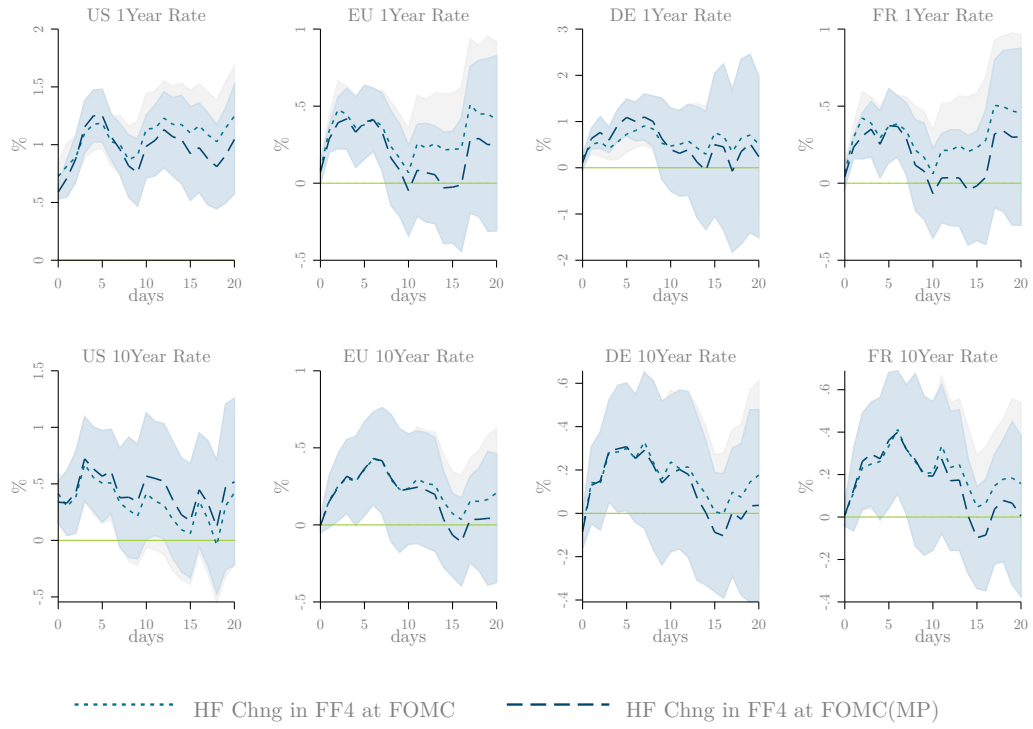
Figure A.1: Monetary Policy Factors, US

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

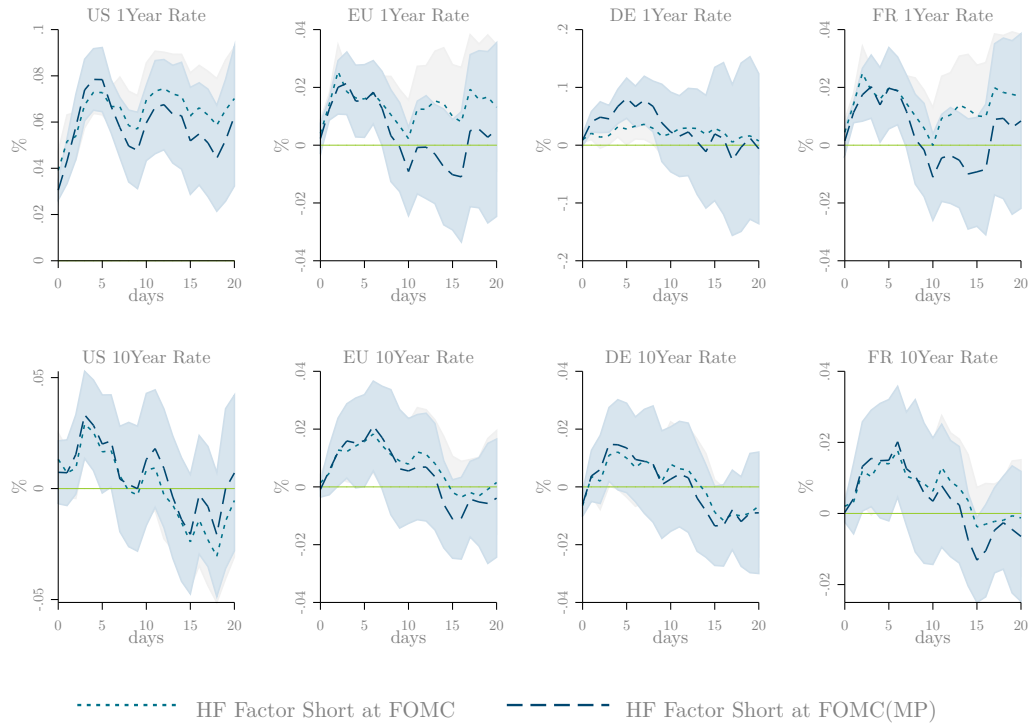
Figure A.2: Monetary Policy Factors. EA

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

FIGURE A.3: RESPONSE OF INTEREST RATES TO CONVENTIONAL US MP

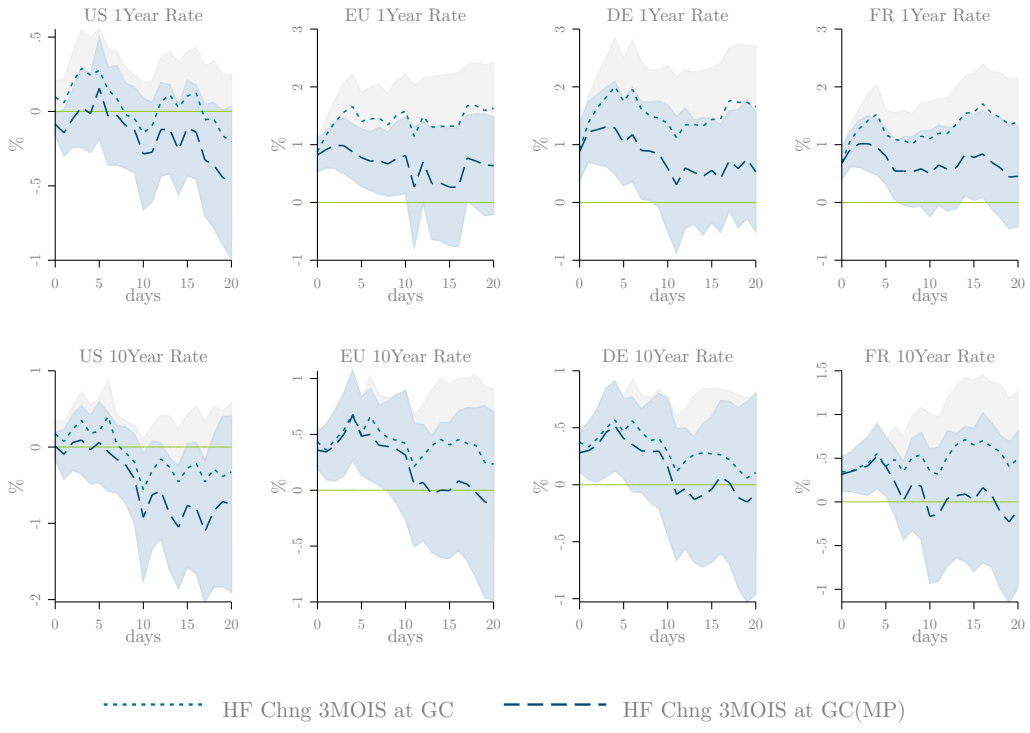


(A) *Notes:* Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

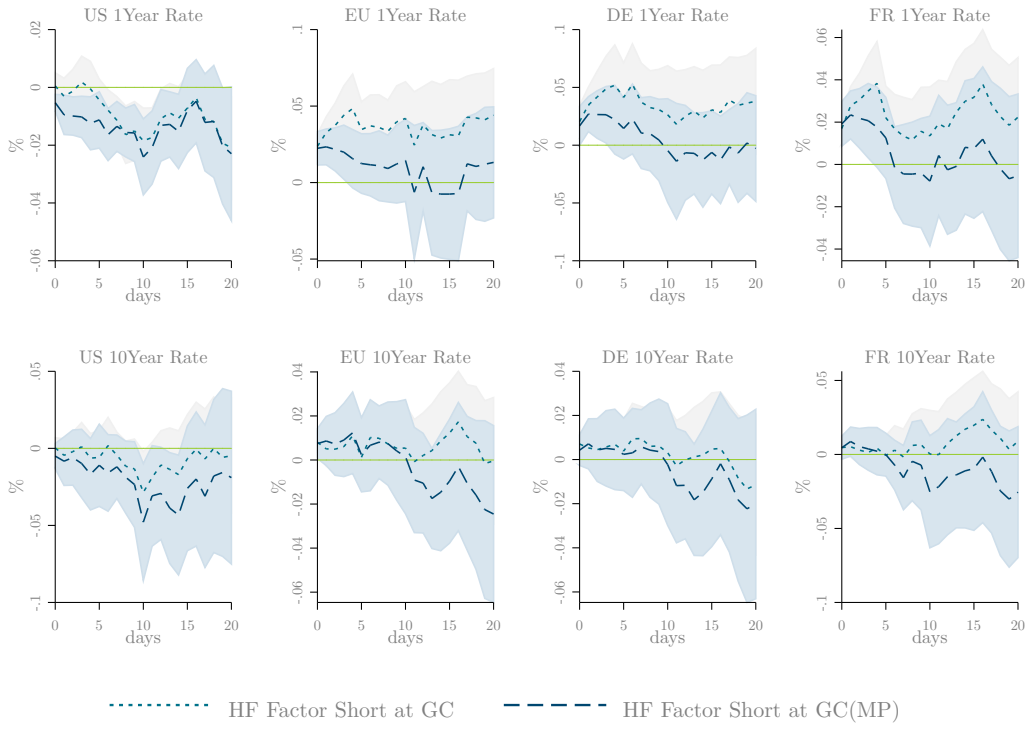


(B) *Notes:* Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

FIGURE A.4: RESPONSE OF INTEREST RATES TO CONVENTIONAL EA MP

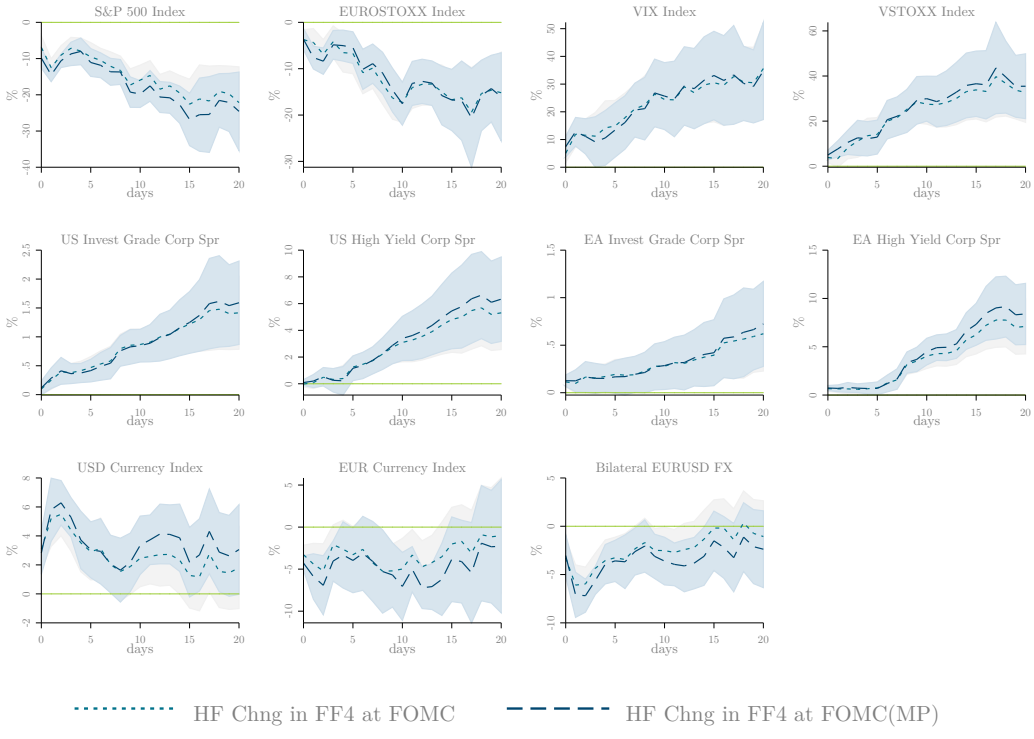


(A) *Notes:* Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

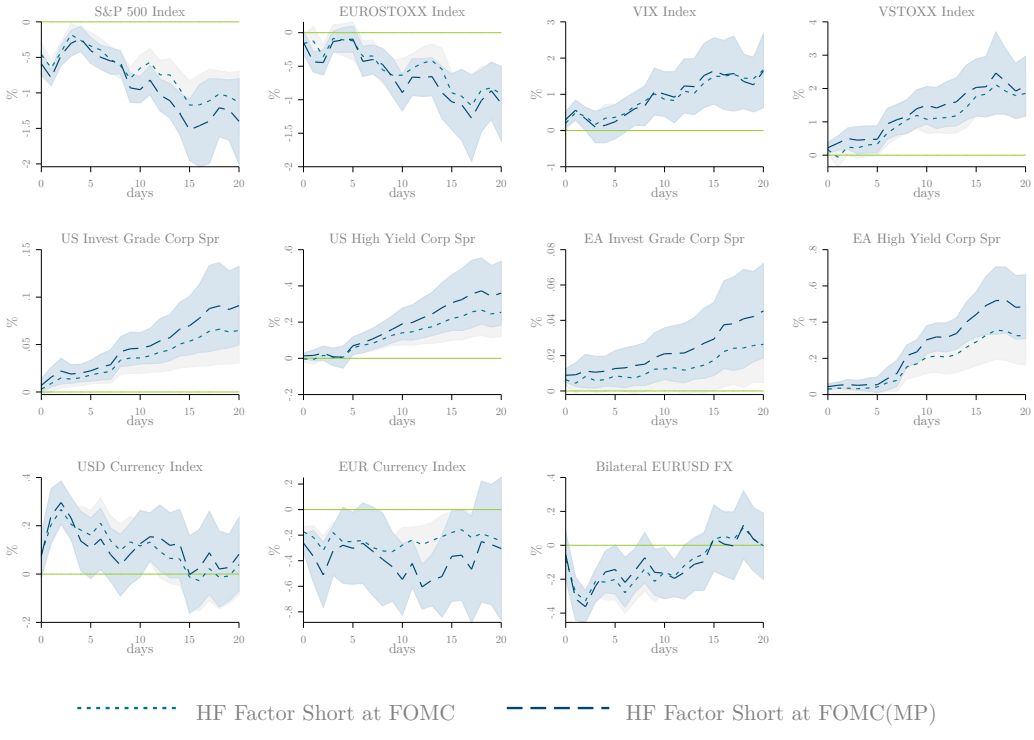


(B) *Notes:* Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

FIGURE A.5: RESPONSE OF ASSET PRICES TO CONVENTIONAL US MP

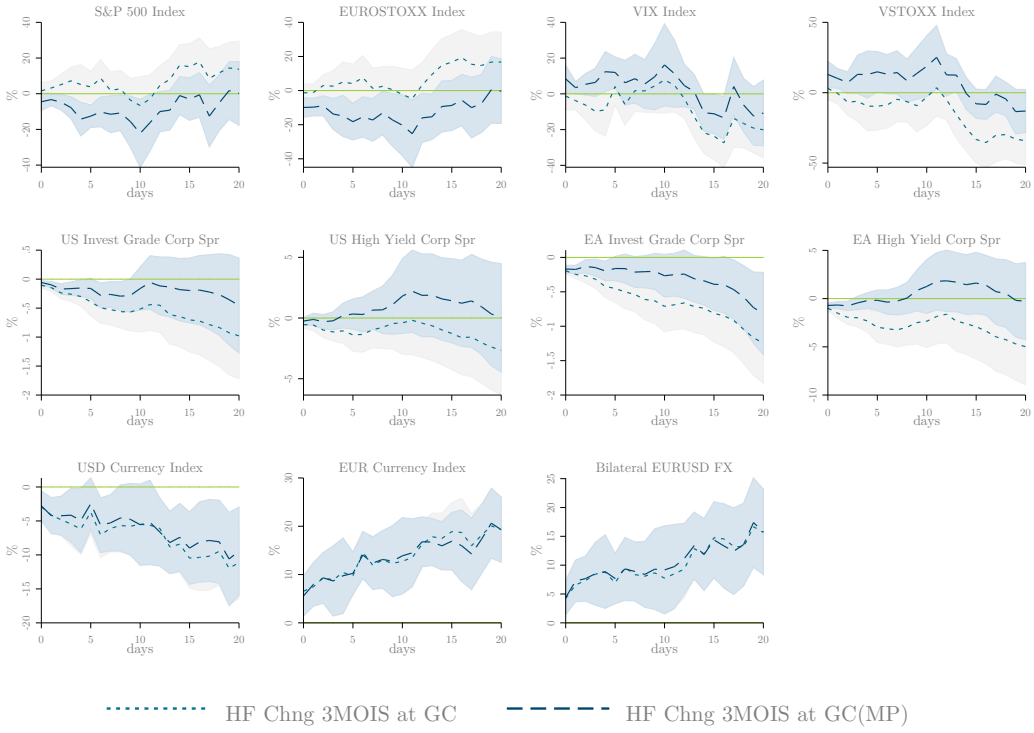


(A) *Notes:* Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

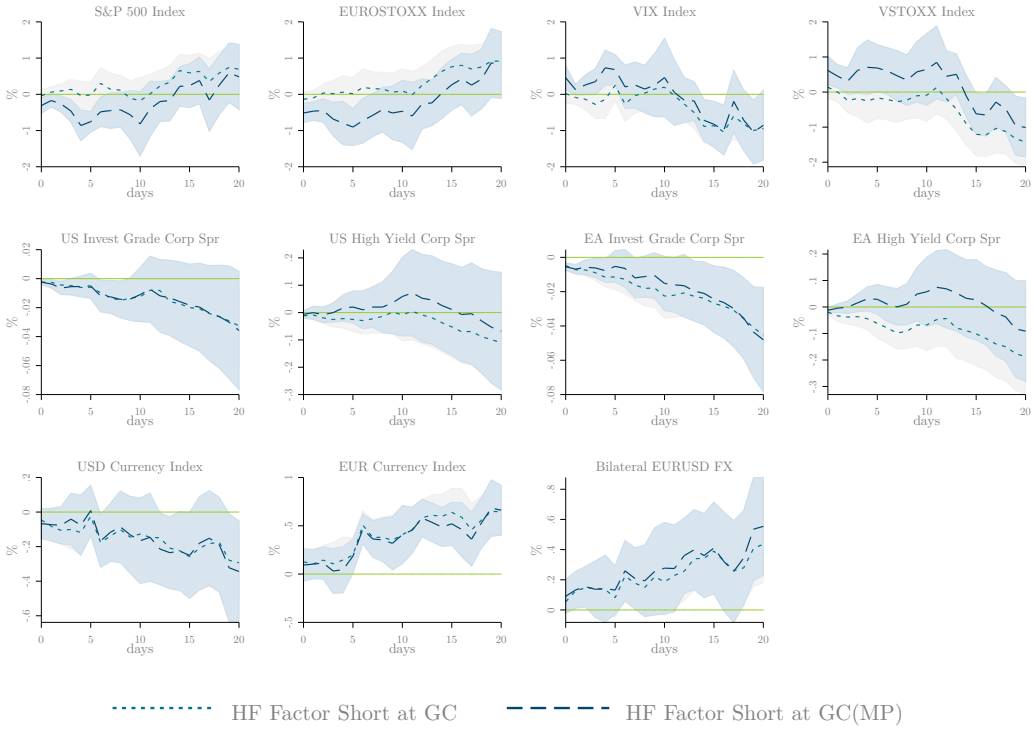


(B) *Notes:* Daily projections. Sample 1999-01:2017-12. Shaded areas are one standard deviation bands.

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



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



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

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
DE 1Year Rate	DE1YT=RR
DE 10Year Rate	DE10YT=RR
FR 1Year Rate	FR1YT=RR
FR 10Year Rate	FR10YT=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	=USD
EUR Currency Index	=EUR
Bilateral EURUSD FX	EUR=

Source: Eikon by Refinitiv.

Table B.2: Monthly Series for Bayesian VARs

Code	Variable Description	Source
WORLDIP	CPB-Wolrd Trade Monitor, World Production, 2010=100, Production Weights	CPB + Own Calculations
WORLDTRADE	CPB-Wolrd Trade Monitor, World Total Merchandise Trade, Volume Index	CPB + Own Calculations
WORLDPLIQ	World Private Liquidity, % of GDP	CBC, WEO + Own Calculations
PLIQEURINV	EUR Invoicing Private Liquidity, Sum for countries in top quartile by 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 in top quartile by 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 in top quartile by 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 in top quartile by 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
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