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US monetary policy spillovers to European banks

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Abstract

The Federal Reserve's (Fed) monetary policy announcements have created massive spillovers to global financial markets. Based on daily data for the sample from 1999 to 2019, this study finds that the Fed's monetary policy announcements created significant international spillovers to bond yields and stock prices of European banks and non-financial corporations (NFCs), while changes in uncertainty around the expected Fed policy path and Fed information effects constituted critical additional dimensions of these spillover effects. International spillovers to bond yields of banks and NFCs were similar, while stock prices of European banks responded somewhat stronger than those of NFCs. The significant spillovers from the Fed's forward guidance to European bond yields show that central bank communication is very relevant for international transmission. In relation to earlier studies emphasizing strong QE-related spillovers, this study suggests that Fed QE announcements created only small spillovers on bond yields and stock prices of European banks and NFCs.

JEL codes: E44, E52, F42, G14, G21

Keywords: High-frequency event study, local projections, monetary policy shocks, monetary policy uncertainty, instrumental variables.

Non-technical summary

International spillovers have received renewed attention after the global financial crisis (GFC) in 2008. Extensive literature has shown that the Federal Reserve's (Fed) monetary policy announcements influence global financial asset prices. Spillovers of Fed monetary policy to the global financial market can be significant and occur independently of the exchange rate regime. The literature has documented a variety of channels through which Fed monetary policy actions are transmitted to the international financial market. Standard open-economy textbook models assume that the Fed's monetary policy affects economies abroad through three main channels: the exchange rate channel, its impact on domestic demand, and the financial channel. More recently, it was discovered that the Fed's monetary policy announcements also transmit to financial asset prices through central bank information effects and policy uncertainty signaling (or "Fed response to news"). Most previous literature has neglected this aspect. Little is known about whether the Fed's announcements spill over to foreign banks and whether such spillovers differ from those of non-financial corporations (NFCs).

A quantification of Fed spillovers to European banks is relevant for policy analysis because knowledge about the side effects of foreign monetary policies helps policymakers assess financial sector vulnerabilities, design appropriate policy measures aimed at banks, and ensure smooth monetary policy transmission. This analysis also informs the debate on why the current ECB's policy tightening has stronger effects on euro area financing conditions than usual. Based on daily data for the sample from 1999 to 2019, this study finds that the Fed's monetary policy announcements created significant international spillovers to bond yields and stock prices of European banks and NFCs, while changes in uncertainty around the expected Fed policy path and Fed information effects constituted critical additional dimensions of these spillover effects. The findings of this study suggest that policymakers need to factor in Fed monetary policy announcements, policy uncertainty, and information effects when assessing financial sector vulnerabilities, especially since they significantly impact the financing costs of the European financial sector and the corporate sector. To this end, this study finds that international spillovers to bond yields of banks and NFCs were similar, while stock prices of European banks responded somewhat stronger than those of NFCs. By showing that the Fed's forward guidance created sizeable spillovers to European bond yields across all sectors, this study supports available evidence on the powerful impact of central bank communication on financial asset prices and extends this point to international transmission. Concerning the strong side-effects of the Fed's QE on global government bond yields found in earlier studies, the study suggests that Fed QE announcements created only small spillovers on bond yields and stock prices of European banks and NFCs.

This event study applies state-of-the-art modeling techniques, and the empirical analysis considers that Fed monetary policy shocks are multi-dimensional. It measures international spillovers related to the Fed's monetary policy actions, communication, and non-standard monetary policy measures on European banks and NFCs based on a host of market-based measures, most importantly stock prices, bond yields, and credit risk. In efficient markets, stock prices reflect all publicly available information about the state of a firm. Bond yields provide insights about firms' market-based financing costs, and credit risk, which is measured by changes in Merton-style default indicators, contains information about asset quality and balance sheet strength of banks and NFCs. The immediate (or causal) response of European asset prices to Fed monetary policy announcements is measured with high-frequency identification (HFI). A robust finding from HFI is that these causal spillovers from Fed monetary policy shocks to European bond yields were sizable and similar large across sectors. Fed uncertainty signaling accounts for about one-fourth of that response of European bond yields. In quantitative terms, the baseline results suggest that a 100 basis point Fed monetary policy easing shock decreased bond yields of euro area banks and non-financial firms by 60 basis points and euro area government bonds by around 50 basis points during the two-day event window. Bank stock prices responded stronger to those shocks than NFCs. Still, those spillovers were typically detected only as a pre-FOMC drift, as Fed information effects have tended to dampen international spillovers on stock prices. These results also document the sizeable impact of FG on European bond yields across sectors, showing that LSAP (initially) only spilled over to 10-year euro area government bond yields but not to bond yields of banks and NFCs or European stock prices. Furthermore, no significant spillovers from Fed monetary policy shocks on bank health and the credit risk of European banks and NFCs are detected no significant spillovers from Fed monetary policy shocks detected – though uncertainty signaling may still impact NFC credit risk.

In terms of the persistence of the response, which is measured by local projections with and without external instruments for a window of up to 25 days after the FOMC meeting, the results suggest that Fed monetary policy announcements spilled over to bond yields and stock prices of euro area banks and non-banks in a reasonably homogeneous manner. The impact of Fed monetary policy shocks on bond yields of banks and NFCs was strong and persistent, and Fed uncertainty signaling impacted bond yields through changing term premia. Fed pure monetary policy shocks - net of information effects - had a stronger impact on the stock prices of European banks than on NFCs. The Fed's forward guidance strongly impacted bond yields across all sectors, while the effects of Fed QE announcements on bond yields and stock prices in Europe were small. Furthermore, the study finds that the transmission of Fed monetary policy shocks to European bank bond yields displayed heterogeneity across the largest euro area countries. Risk characteristics explain heterogeneity in the response of bank bond yields to Fed monetary policy shocks.

1. Introduction

International spillovers have received renewed attention after the global financial crisis (GFC) in 2008. Extensive literature has shown that the Federal Reserve's (Fed) monetary policy announcements influence global financial asset prices. Spillovers of Fed monetary policy to the global financial market can be significant and may exceed those of other central banks (Dedola et al., 2017; Georgiadis, 2016; Chen et al., 2017; Fratzscher et al., 2018; Ca'Zorzi et al., 2021; de Santis and Zimic, 2022) and occur independently of the exchange rate regime (Rey, 2016; Miranda-Agrippina and Rey, 2020). However, despite considerable research efforts, essential questions about Fed monetary policy spillovers to the European financial sector have remained open. Do international spillovers from the Fed's monetary policy announcements matter for European banks, and are they different from those of non-financial corporations (NFCs)? To address the question, this event study quantifies the spillovers from a host of Fed monetary policy shocks to European banks and relative to non-financial corporations.

The literature has documented a variety of theoretical channels through which the Fed's monetary policy actions are transmitted to the international financial market. Standard open-economy textbook models assume that the Fed's monetary policy affects economies abroad through three main channels: the exchange rate channel, its impact on domestic demand, and the financial channel (Ammer et al., 2016). Several additional channels exist that involve foreign financial institutions, namely the international credit channel, the portfolio channel, and the risk-taking channel (Bernanke and Gertler, 1995; Kashyap and Stein, 2000; Krishnamurthy and Vissing Jorgensen, 2011; Bauer and Rudebusch, 2014; Borio and Zhu, 2012; Bruno and Shin, 2015).

A measurement of Fed spillovers on the foreign financial sector is relevant for policy analysis for the following reasons. First, knowledge about the transmission of external shocks helps policymakers assess the market response to the Fed´s monetary policy announcements and facilitates the calibration of policy measures aimed at banks. Second, the quantitative size of international spillovers from the Fed´s monetary policy on foreign banks was considered to be small. However, financial stability risks have moved to the forefront since the GFC. Moreover, the monetary policy response to shocks originating in the financial sector has become substantive because these shocks have the potential to transmit to the real economy and impact domestic inflation. Third, banks are unique because they are essential for credit intermediation. In Europe, banks are important for understanding monetary policy transmission, as can be readily seen from the fact that even today, banks provide the largest share of credit to the private sector, and bank-based transmission of monetary policy still dominates.

This study relates to recent studies showing an increased relevance of novel transmission channels against the background of the Fed's use of communication as a monetary policy instrument, namely information effects (Nakamura and Steinsson, 2018; Jarociński and Karadi, 2020; Cesa-Bianchi and Sokol, 2022; Jarociński, 2022) and the Fed uncertainty signaling channel (Bauer et al., 2022; Bauer and Swanson, 2023; Tillmann, 2020; de Pooter et al., 2021; Lakdawala et al. 2021). It also relates to earlier event studies documenting that Fed monetary policy shocks impact US bank stocks (English et al., 2018) and that ECB monetary policy shocks impact European bank stocks and bank health (Altavilla et al., 2019; Ampudia and van den Heuvel, 2018; Jung and Uhlig, 2019; Jung, 2023).

Many event studies use conventional monetary policy surprises (Kuttner, 2001) or a factor decomposition into target and path surprises (Gürkaynak et al., 2005) to measure the response of financial assets in tight windows around policy announcements. However, most of them do not account separately for the effects related to the Fed's conventional and unconventional measures. However, it is essential to compare the Fed's interest rate policy effects and those arising from changes in the Fed's forward guidance (FG) and its quantitative easing programs (QE). Swanson (2022) showed that both types of unconventional measures had substantial and statistically significant effects on US government bond yields and stock prices, comparable in magnitude to the impact of the federal funds rate in normal times, and that the effect was usually very persistent. Krishnamurthy and Vissing Jorgensen (2011) find that the Fed's QE1 and QE2 programs significantly reduced yields on US government bonds with intermediate- and longer-term maturity, while the effect differed across bond types and maturities.

Traditional event studies mix monetary policy shocks with central bank information shocks when measuring the impact of Fed announcements on financial asset prices (Nakamura and Steinsson, 2018). However, that distinction is relevant for the analysis whenever a monetary policy surprise uncovers the Fed's private information and leads investors to revise their beliefs about the state of the economy, as was more often the case in the aftermath of the GFC.[1] After most FOMC meetings, monetary policy uncertainty declined, mirroring Fed communication about economic fundamentals and its policy actions' rationale.[2] The market response may be conditional on "news" and not reflect the Fed's private information. In that case, identifying the Fed's policy uncertainty signaling may also be relevant (Bauer et al., 2022; Bauer and Swanson, 2023). So far, only few studies have incorporated the novel channels.

The approach of this study is to apply traditional high-frequency identification (HFI) and local projections with and without external instruments (Jordà, 2005; Stock and Watson, 2018). While HFI is applied to a small window of 1 to 2 days around the Fed's policy announcement, local projections can capture the response of financial variables over a more extended period. This way, the study measures

[1] Note that information effects tend to have opposite effects on stock prices compared to pure monetary policy shocks (Jarociński and Karadi, 2020).
[2] Note that this observation is separate from the general trend decline in monetary policy uncertainty owing to the Fed's increased transparency about its monetary policy decisions over the last two decades.

spillovers from several Fed monetary policy shocks to a host of market-based measures of euro area (EA) banks (stocks, bond yields, credit risk), firms (Euro Stoxx 50, NFC bond yields, NFC credit risk), and governments (bond yields) for which daily data are available.[3] The empirical analysis of this study uses daily data covering the (pre-pandemic) period from January 1999 to June 2019 (with a total of 187 FOMC meetings).

Since the late 1990s, the Fed has used forward guidance to enforce its communication signal to markets following FOMC meetings (Nelson, 2021). The Fed's FG provides markets with a signal on the likely future policy path, while markets, in turn, pay less attention to other official communications (e.g., speeches, minutes, dot plots of FOMC members) or news about the economic outlook (Swanson and Williams, 2014). After 2008, FG developed into a more systematic policy tool by which the Fed made public statements on the likely future settings of its policy instruments to increase its monetary policy accommodation further. In the period after the 2008 financial crisis, a new element was that the Fed gave date-based and outcome-based FG. Through FG, the Fed influenced the expectations of US households and firms by committing to low policy rates at an early stage of the recovery, thereby lowering the expected future real interest rate and providing policy stimulus (Levin et al., 2018). Over the last decade, the Fed applied two different types of forward guidance (Delphic, Odyssean), and the related surprises may be transmitted differently to the economy, as suggested by several researchers (Campbell et al., 2012; Hansen et al., 2019; Andrade and Ferroni, 2021). The transmission of Delphic signals involves policy uncertainty signaling, whereas Odyssean signals relate more to the central bank information channel.[4]

In the aftermath of the GFC, the Fed introduced large-scale asset purchases as a monetary policy tool, which created spillovers to foreign economies. Since 2008, the Fed has implemented three QE programs as a policy tool to stabilize the economy close to the zero lower bound on nominal interest rates by conducting large-scale asset purchases that lower long-term interest rates. The programs have differed in terms of size, goal, and implementation. Financial markets responded to Fed communication on the size and duration of its large-scale asset purchases, which drove down long-term interest rates. Effective June 2022, the Fed started to shrink its balance sheet using quantitative tightening (QT). Earlier

[3] This includes a novel composite measure of bank health from principal component analysis on a host of daily indicators of euro area banks (Jung, 2023).

[4] FG is "Delphic" if the news is about future macroeconomic conditions, while FG is "Odyssean" if the news relates to future monetary policy measures or intentions of the Fed. To assess this point, I also used the factor decomposition by Jarociński (2021) which identifies four types of structural monetary policy shocks from a BVAR model, namely conventional monetary policy shocks (u1), Odyssean FG shocks (u2), LSAP shocks (u3), and Delphic FG shocks (u4). However, the results with that decomposition were not fully satisfactory and Swanson (2023) pointed out that the "Delphic forward guidance shock interpretation (of this decomposition) is not very convincing" either.

studies found that these purchases reduced international long-term bond yields and the spot value of the dollar (Neely, 2013; Bauer and Neely, 2014) and had significant signaling effects that lowered expected future short-term interest rates (Bauer and Rudebusch, 2014). Fratzscher et al. (2018) find that international spillovers of different QE rounds were heterogeneous because of various degrees of macro-financial uncertainty.

To capture several dimensions of Fed monetary policy announcements, as needed for the analysis of conventional and unconventional measures, this study uses existing shock decompositions from other researchers that have an economic interpretation and have been identified from Fed monetary policy surprises within tight windows around FOMC announcements (Nakamura and Steinsson, 2018; Jarociński and Karadi, 2020; Swanson, 2022). To account for changes in US (short-run) monetary policy uncertainty (mpu) around FOMC meetings, it uses the (daily) option-based measure of Bauer et al. (2022) as a monetary policy uncertainty shock.

This study finds that the Fed's monetary policy announcements created significant international spillovers to bond yields and stock prices of European banks and NFCs, while changes in uncertainty around the expected Fed policy path and Fed information effects constituted critical additional dimensions of these spillover effects. It thus adds to the theoretical evidence of separate Fed information and uncertainty channels in international monetary policy transmission. In relation to earlier studies that document a significant response of European banks and firms to ECB monetary policy shocks, the findings of this study suggest that policymakers also need to factor in Fed monetary policy announcements, policy uncertainty, and information effects when assessing financial sector vulnerabilities, especially since they significantly impact on the financing costs of the European financial sector and the corporate sector. To this end, this study finds that international spillovers to bond yields of banks and NFCs were similar, while stock prices of European banks responded somewhat stronger than those of NFCs. By showing that the Fed's forward guidance created sizeable spillovers to European bond yields across all sectors, this study supports available evidence on the powerful impact of central bank communication on financial asset prices and extends this point to international transmission. Concerning the strong side-effects of the Fed's QE on global government bond yields found in earlier studies, the study suggests that Fed QE announcements created only small spillovers on bond yields and stock prices of European banks and NFCs.

This paper is structured as follows. Section 2 describes the data, and section 3 introduces the empirical methodology. Section 4 presents the results on spillovers of Fed monetary policy shocks to euro area banks and firms, and section 5 concludes.

2. Data[5]

2.1 Fed monetary policy and policy uncertainty shocks

In the event study literature, it is standard to identify monetary policy shocks from high-frequency monetary policy surprises (Kuttner, 2001; Bernanke and Kuttner, 2005; Gürkaynak et al., 2005; among many others).[6] Gürkaynak et al. (2005), building on work by Kuttner (2001), discovered that monetary policy surprises are multi-dimensional and identified two orthogonal factors ("target" and "path"): target surprises capture conventional policy action and path surprises reflect central bank communications on the future interest rate path. Nakamura and Steinsson (2018) proposed a univariate policy shock, essentially an average of the target and path factors (see Figure 1).[7] All these Fed monetary policy shocks were identified from a tight monetary event window of 30 minutes around policy announcements, during which movements in market interest rates are dominated by the monetary announcement (Nakamura and Steinsson, 2018).[8] However, especially in the aftermath of the GFC, the Fed's unconventional monetary policy measures have moved the path of future interest rates beyond the signal coming from conventional policy actions. Therefore, Swanson (2022) extended the work by Gürkaynak et al. (2005) and separately identified surprise changes in the federal funds rate (FFR shock), forward guidance (FG shock), large-scale asset purchases (LSAP shock) from the tight 30-minute window (see Figure 2). I use this new multidimensional shock decomposition into three orthogonal factors to estimate the impact of the Fed's unconventional measures on banks and NFCs. These shocks require no preliminary estimation, are commonly used, and allow a straightforward interpretation.

***** Figures 1 and 2 here *****

However, these popular shocks may not capture the separate role of communication signals from FOMC press conferences, most notably information effects (Nakamura and Steinsson, 2018). This point has become relevant over the last decade because, effective 27 April 2011, the Fed started to host press conferences following the scheduled FOMC meetings, i.e., outside the 30-minute window, and gave further explanations on its monetary policy decisions and expectations for the future course, which influenced the market response.[9] It is helpful to somewhat enlarge the monetary event window on press

[5] For details on data and sources see Table A.1 in the appendix.

[6] In the literature, the terms policy surprises and policy shocks are often used as synonyms. According to Altavilla, Brugnolini et al. (2019), shocks are orthogonal to the state of the economy, and surprises are orthogonal to the information set of financial market participants. However, both measures overlap under full information.

[7] Their policy news shock is a first principal component on the change in five surprises in fed funds and Eurodollar futures with one year or less to expiration extracted from a tight, 30-minute window around policy announcements at regular scheduled meetings.

[8] Note that surprises from speeches were typically small and are not considered in this study.

[9] During this period, a larger window size that includes the press conference may better capture additional clues

conference days to capture these further clarifications, especially concerning a separate signal on forward guidance (De Pooter, 2021).[10] To this end, this study uses a shock decomposition by Jarociński and Karadi (2020), who identify two orthogonal shocks from Fed monetary policy surprises based on a VAR model with sign restrictions: a ("pure") monetary policy shock and an information shock (Figure 3).[11] A pure monetary policy shock is identified as a positive co-movement shock associated with an increase in interest rates and stock prices. By comparison, an information shock is identified as a negative co-movement shock associated with increased interest rates and decreased stock prices. A median rotation ensures that coefficients related to both shocks are comparable in magnitude since pure monetary policy shocks account for more variation in the interest rates and information shocks for more variation in stock prices.

Figure 3 here

To measure spillovers related to changes in Fed monetary policy uncertainty around FOMC meetings, this study uses the market-based measure by Bauer et al. (2022), which has been derived from prices of highly liquid interest rate derivatives (i.e., Eurodollar futures and options) and is available at a daily frequency.[12] Changes in monetary policy uncertainty (mpu) are defined as the (two-day) change of short-rate uncertainty (SRU) around the FOMC policy meetings, where SRU (see Figure 1) is the risk-neutral conditional standard deviation of three-month US LIBOR rates, given daily observations for prices of futures and options (and measured in percentage points).

2.2 Euro area indicators

Daily indicators are suitable for measuring euro area banks' and non-banks' responses to the Fed's

from the Fed, given that 2011, on press conference days coinciding with the FOMC statement, the Fed published its summary of economic projections (SEP) with information on the ranges and central tendencies of the FOMC members' projections. This happened four times a year following the March, June, September and December FOMC meetings, except in March 2020.

[10] In this respect, an even longer one- or two-day monetary event window, as in Hanson and Stein (2015) and Lakdawala (2019), risks that the identification of the monetary policy shock is distorted by other news.

[11] The shocks have been constructed from (high-frequency) surprises of 3-month fed funds future rates (or the first principal component of surprises in the current month and three-month fed funds futures and two-, three-, and four-quarters ahead three-month eurodollar futures) and the S&P 500, a stock market index based on 500 large companies. Surprises are obtained from a 30-minute window around FOMC announcements. On press conference days, the window is extended until 15 minutes after the press conference ends.

[12] Several ways to measure monetary policy uncertainty have been proposed in the literature. One strand extracts monthly measures form the newspaper coverage of certain key words related to monetary policy uncertainty. Baker et al. (2016) covers the 10 major US newspapers, and Husted et al. (2020) cover three leading US newspapers (New York Times, Wall Street Journal and Washington Post). Another strand favors model-free volatility measures using Eurodollar options to proxy Fed monetary policy uncertainty, including the monthly measures by Swanson and Williams (2014) and Bundick et al. (2017).

monetary policy announcements at high frequency. Stock prices help examine the transmission of monetary policy shocks to firms at high frequency, especially in efficient markets when stock prices reflect all publicly available information about the state of a firm. Bond yields provide insights about firms' market-based financing costs. Default indicators (for details, see appendix A2), which are based on the models of Black and Scholes (1973) and Merton (1974), reflect credit risk.[13] They contain information about asset quality and balance sheet strength of banks and NFCs.

The dataset includes daily market-based measures that capture banks' market value, funding costs, and credit risk (see Figure 4). More specifically, it comprises stock prices of the largest European banks (SX7E: Euro Stoxx banks index; Source: Thomson Reuters Datastream), bank bond yields, and the breakdown into senior and subordinated debt while excluding covered bonds (source: Markit iBoxx), euro area averages of Merton-style indicators of credit risk such as the distance to default (DTD) and the expected default frequency (EDF) (source: Moody's Analytics, KMV CreditEdge) and CDS spreads (source: Thomson Reuters Datastream). The dataset also includes bank bond yields and bank stock prices based on national indices for the four largest euro area countries: Germany (DE), France (FR), Italy (IT), and Spain (ES) (source: Thomson Reuters Datastream).[14] For comparison across sectors, the dataset also includes daily data on US and euro area government bond yields and national government yields (DE, FR, IT, ES) at maturities of 2, 5, and 10 years (source: Board of Governors of the Federal Reserve System and ECB, respectively) and aggregate stock prices of the largest European firms (SX5E: Euro Stoxx 50 index; Source: Thomson Reuters Datastream) and for NFC bond yields (source: Markit iBoxx) and NFC credit risk (DTD and EDF; Source: Moody's Analytics, KMV CreditEdge).[15]

***** Figure 4 here *****

Furthermore, I include the banks' net interest rate margin computed as the difference between composite lending rates of the non-financial private sector (source: ECB)[16] and a novel composite indicator on bank health (Jung, 2023), which summarises the state of the euro area banks using a first

[13] They reflect balance sheet information on banks where daily variation is observed from valuation changes in assets and liabilities (as normalized by asset volatility). CDS spreads provide information on how the market assesses credit risk.

[14] Note that, based on recent data, the duration and residual maturity of these bank bond yields is in a range of 3.5 and 5.5 years.

[15] Note the daily NFC credit risk indicators were only available as of 1 June 2006.

[16] Since daily lending rates for the euro area are not available and the spread between lending rates and a market-based measure of bank funding costs is a better proxy for bank profitability than a daily measure, we mix monthly data for the lending rates of euro area banks are available and daily data on bank bond yields. Hence, the daily variation still comes from changes in bank bond yields. However, the net interest rate margin computed that way ignores the financing of a significant share of bank loans through deposit funding for which again only monthly data are available, and through targeted-longer term refinancing operations, both of which increased the net interest rate margin for the European banking system.

principal component of five components, namely their stock price, net interest rate margin, credit risk and banks' ability to provide loans. Banks' net interest rate margin provides price information that is key for assessing the profitability of the euro area banks at a higher frequency, given that information on their return on assets from the balance sheet is only available at a lower frequency. The bank health indicator captures the notion that the financial health of banks used in supervisory assessments is multi-dimensional. In contrast, single measures for banks may only give a partial perspective on the monetary policy transmission to banks (ECB, 2018).

3. Empirical methodology

3.1 Event study window

The Fed's policymaking committee (FOMC) holds eight regularly scheduled meetings each year – around one meeting every six weeks - which takes two full days.[17] The FOMC statement, released on the second day, includes information on the policy decision, the state of the economy, and the voting record. The Fed has used its post-meeting statement to provide markets with explicit forward guidance on future policy rates.[18] Since April 2011, the Fed has provided further clarifications on its monetary policy course at a press conference (de Pooter, 2021). Regarding timing, the Fed announcement was released at 14:00 (ET), and the press conference started at 14:30 (ET) after 2012.[19]

The size of the event window is crucial for clearly identifying the response of financial asset prices to Fed monetary policy shocks. Fed announcements at meeting days lead markets to revise their interest rate expectations for future meetings because of new information about monetary policy or changes in short-term monetary policy uncertainty. While other essential data releases (e.g., releases on economic activity and inflation) may influence the market response, they can be distinguished from genuine Fed monetary policy shocks based on the release day, which is typically different. Moreover, the same applies to monetary policy announcements by other central banks that are usually not made on the Fed announcement days.[20] Over the last two decades, the average distance between Fed and subsequent ECB

[17] The Fed holds other, unscheduled meetings as needed, which are included in this analysis.

[18] Initially, the Fed gave forward-looking indications for the next meeting within its post-meeting statement only on a few instances, namely in 1999 in the form of an assessment of the perceived risks going forward and between May 2004 and January 2006 by introducing forward-looking language (Thornton, 2006). Between August 2011 and December 2012, the FOMC gave date-based FG. In December 2012, the FOMC moved from date- to outcome-based guidance that was usually linked to labor market conditions in the US.

[19] By comparison, in 2011 and 2012 FOMC announcements were already published at 12:30 and the press conferences started at 14:15.

[20] On two dates related to the GFC, the ECB and the FOMC exceptionally held unscheduled policy meetings on the same day. This was namely on 17 September 2001 and 8 October 2008 when also other central banks held special meetings. These observations had to be excluded from the measurement of spillovers since the responses of financial variables reflect coordinated policy action on these dates.

policy meetings was about 19 days (of which the average length was 13 days pre-crisis and 25 days post-crisis.). The Fed and other central banks may surprise markets in the same or different directions. At consecutive meetings, Fed and ECB monetary policy surprises were in more than 40% of the policy meetings, a similar sign. On those occasions, ECB surprises strengthened the Fed's impact on the euro area economy, while otherwise, they dampened it.

The issue of different time zones must be addressed in the empirical design because differences in trading hours between US and European markets imply a delayed market reaction of European financial assets to Fed policy announcements. European markets close between 11.00 and 12.00 a.m. (ET), so the market reaction to the news is observed on different days. At the same time, it is conceivable that European asset prices display a pre-FOMC announcement drift at scheduled meetings.[21] While Fed policy shocks may affect financial asset prices in Europe already on the same day, the primary market reaction is to be expected one day after the announcement is published. In line with many event studies examining international spillovers, I focus on the response starting from the horizon h=1, i.e., the two-day window.[22] For stock prices, I also account for a potential FOMC drift and report regression results for the one-day window (h=0).

3.2 Event study regressions and local projections

The central goal of this paper is to quantify the spillover effects of different types of Fed monetary policy announcements on euro area banks relative to NFCs. To this end, the study applies traditional HFI (Cook and Hahn, 1989; Cochrane and Piazzesi, 2002) and local projections with and without instrumental variables, namely proxy LP-OLS (Jordà, 2005) and LP-IV (Stock and Watson, 2018). Under HFI, the identification has a causal interpretation if no other shocks influence the dependent variable during the event window and if the monetary policy shock is an exogenous variable. This property is typically assumed to hold if the event window reflects daily changes in financial asset prices and the monetary policy shock is identified from tight windows around policy announcements. Otherwise, the dependent variable could also respond to other news, distorting the identification. Such additional information would imply that the error term in the HFI regressions is not orthogonal to the monetary policy shock. Therefore, if longer horizons are used, endogeneity issues may arise and lead to inconsistent estimates; for example, new data releases or interventions from other central banks may distort the identification. Stock and Watson (2018) show that an external instrumental variables approach allows dealing with

[21] Lucca and Moench (2015) showed that, between 1994 and 2011, the S&P 500 index increased substantially during the day before (scheduled) FOMC announcements, while in the window after the announcement to market close the average return was almost zero.

[22] For h=1 changes in euro area bank indicators are measured as the difference between the end-of-day value after the day of the policy announcement and its end-of-day value one day before the policy announcement.

those endogeneity concerns if strong external instruments are available.

Baseline results on the causal effect of a monetary policy shock on the (two-day) change of a foreign variable (y_t) are obtained by estimating HFI regressions with OLS:

$$y_{t+1} - y_{t-1} = \alpha + \beta \, mps_t + u_t \quad (1)$$

where t is the policy announcement day of a FOMC meeting, mps_t is a (univariate) Fed monetary policy shock (i.e., the policy news shock by Nakamura and Steinsson, 2018: "NS-shock"), α is a constant, β is the parameter of interest, and u_t is an error term; t runs over the dates of Fed monetary policy announcements from 1 January 1999 to 30 June 2019. The size, sign, and significance of the structural coefficient β allows inference about the causal impact of the Fed monetary policy shock on the foreign variable of interest. The results are reported using robust (i.e., heteroskedasticity- and autocorrelation-consistent) standard errors.

To capture the multi-dimensionality of the monetary policy shock, I replace the univariate policy shock (mps) in the canonical form (1) with a set of orthogonal factors obtained from the respective shock decompositions (see section 2.1). Specifically, I estimate:[23]

$$y_{t+1} - y_{t-1} = \alpha + \beta_1 \, mpu_t + \beta_2 \, mps_t + u_t \,, \quad (1a)$$

$$y_{t+1} - y_{t-1} = \alpha + \beta_1 \, pure_t + \beta_2 \, info_t + u_t \,, \quad (1b)$$

$$y_{t+1} - y_{t-1} = \alpha + \beta_1 \, target_t + \beta_2 \, FG_t + \beta_3 QE_t + u_t \quad (1c)$$

for each indicator y_t (the above formulations are for a two-day window around Fed announcements). Equation (1a) examines the distinct impact from Fed uncertainty signaling controlling for the NS-shock, where mpu_t measures Fed monetary policy uncertainty.[24] Equation (1b) examines Fed monetary policy shocks and information effects, where $pure_t$ are pure Fed monetary policy shocks and $info_t$ are Fed information shocks - I use the two orthogonal, median-rotated shocks from Jarociński and Karadi (2020). Equation (1c) measures the causal influence from (unexpected) Fed fund rate changes, Fed forward guidance and Fed large-scale asset purchases on foreign asset prices - I use the three orthogonal shocks from Swanson (2022).

A baseline proxy LP-OLS regression examines the (cumulated) effect of Fed monetary policy shocks on foreign asset prices. This method allows to assess the persistence of the international spillover

[23] If the regressors are generated rather than directly observed, the standard errors via bootstrapping are also computed to capture the additional sampling error associated with the first-stage factor estimation procedure. However, one can show that the statistical significance of the results is essentially identical when bootstrapped or heteroskedasticity- and autocorrelation-consistent standard errors are used.
[24] Note that mps and mpu are uncorrelated but have not been orthogonalized, whereas this was done for the other shock decompositions used in this study by construction.

(for h>1).[25] For all regressions, I report results for a euro area indicator (y) with a horizon h = 1,2, …, H days:[26]

$$y_{t+h} - y_{t-1} = \alpha_h + \alpha_{1,h}\ mps_t + u_{t,h} \quad (2)$$

with the following breakdowns for Fed monetary policy shocks:

$$y_{t+h} - y_{t-1} = \alpha_h + \alpha_{1,h}\ mpu_t + \alpha_{2,h}\ mps_t + u_{t,h} \quad , \quad (2a)$$

$$y_{t+h} - y_{t-1} = \alpha_h + \alpha_{1,h}\ pure_t + \alpha_{2,h}\ info_t + u_{t,h} \quad , \quad (2b)$$

$$y_{t+h} - y_{t-1} = \alpha_h + \alpha_{1,h}\ FG_t + \alpha_{2,h}\ LSAP_t + u_{t,h} \quad (2c)$$

with notations as above, where t is the policy announcement day of a FOMC meeting; mps_t is a monetary policy shock or a shock decomposition as above; α_h is a constant, $\alpha_{1,h}$ is the parameter of interest, and $u_{t,h}$ is an error term; t runs over the dates of Fed monetary policy announcements from 1 January 1999 to 30 June 2019.

To address potential endogeneity issues for the measurement, I follow the approach by Stock and Watson (2018) and use GMM to estimate the two-stage LP-IV regression given by:

$$\Delta r_t = \alpha_0 + \sum_{i=1}^{2} \alpha_i\, factor_{i,t} + \varepsilon_t \quad ,$$

$$y_{t+h} - y_{t-1} = \alpha_h\, \Delta\widehat{r_t} + u_{t,h} \quad (3)$$

with notations as above, the interest rate change (Δr_t) is proxied by the 1-year US government bond rate (GS1), and $factor_i$ refers to the respective shock decomposition and two instruments are used. Based on the requirements for external instruments set out in Stock and Watson (2018), I choose instruments that are relevant – i.e., correlated with the disturbance of interest - and exogenous – i.e., uncorrelated with the other disturbances. As shown by Gertler and Karadi (2015), monetary policy shocks identified from tight windows around policy announcements are strong instruments for changes in (shorter-term) interest rates. To examine the distinct impact of Fed monetary policy and policy uncertainty shocks, I use the univariate policy shock from Nakamura and Steinsson (2018) and the Fed monetary policy uncertainty shock (mpu) as instruments. To examine the impact from pure monetary policy and information shocks, I use the the two factors from Jarociński and Karadi (2020) as instruments. For the measurement of the Fed's unconventional measures I use two of the three orthognonal factors from the Swanson (2022) decomposition as instruments (namely FG and LSAP). I estimate regressions for the above specifications for the sample from 1 January 1999 to June 2019, while using a shorter subsample from 1 October 2008 to June 2019, when assessing the Fed's QE, which was implemented during the post-crisis sample only. All the results are reported using robust standard errors.

[25] Note that proxy LP-OLS results for the shortest horizon (h=1) should be identical to those from HFI (equation 1), if no further covariates are specified.
[26] Note, I report a maximum horizon (H) of 25 days for charts.

4. Results on international spillovers

4.1 Results from HFI on causal spillovers

The causal impact of Fed monetary policy post-meeting announcements on euro area indicators is estimated using several shock decompositions from other researchers based on HFI, thereby capturing the distinct effects from Fed monetary policy action, communication, and non-conventional measures (Equation 1). Table 1 shows the baseline results using the univariate "NS-shock." Accordingly, Fed monetary policy shocks spilled over to a wide range of European bond yields (banks, NFCs, governments) and stock prices of European banks as a pre-FOMC drift only (i.e., the effect cannot be detected one day later). No (initial) spillovers from Fed announcements to stock prices of European firms (Euro Stoxx 50) and to credit risk (or bank health) of banks and NFCs are detected. In quantitative terms, the baseline results suggest that a 100 basis point Fed monetary policy easing shock decreased bond yields of euro area banks and non-financial firms by, on average, 60 basis points and euro area government bonds by around 50 basis points during the two-day window. The same shock increased bank stock prices in the euro area by about 5.5 percentage points on the second FOMC meeting day in the form of a pre-FOMC drift. The results for the subsample suggest that the spillover effects on longer-term government bonds and bank stock prices in Europe likely became stronger post-crisis, while those for bond yields of banks and NFCs held up.

Table 1 here

Recent studies emphasize the increasing role of a Fed uncertainty signaling channel for the monetary policy transmission to financial asset prices (Bauer et al., 2022; Bauer and Swanson, 2023; Tillmann, 2020; de Pooter et al., 2021). Lakdawala et al. (2021) find that increased Fed policy uncertainty raises government bond yields and lowers equity prices in advanced countries. Based on equation (1a), I investigate this point and find that changes in short-rate uncertainty around FOMC announcements are significant for explaining the responses of European bond yields and stock prices. Table 2 (upper panel) suggests an increase in Fed monetary policy uncertainty spills over to bond yields of European banks, NFCs, and governments (at longer maturities). The effect is significant and similar for banks, NFCs, and 10-year government bond yields. It explains about one-fourth of European bond yields' (initial) response to Fed announcements (as seen from the decrease in the coefficient for mps relative to baseline). Fed uncertainty signaling also spills over to European stock prices of all firms in the form of a pre-FOMC drift, which was again stronger for banks than for firms, and to credit risk of firms.

Other recent studies have pointed to an increased relevance of information effects against the background of the Fed's use of communication as a monetary policy instrument (Nakamura and

Steinsson, 2018; Jarociński and Karadi, 2020; Cesa-Bianchi and Sokol, 2022). According to Jarociński (2022), central bank information effects are an essential channel of the international spillover of Fed monetary policy to European asset prices, where a positive Fed information shock implies a strong expansionary effect of European financial variables (stock prices, government bond yields). To examine this point further, I use the decomposition by Jarociński and Karadi (2020). Applying HFI to equation (1b), the results show that information effects dampened the response of European stock prices. Table 2 (lower panel) suggests that Fed pure monetary policy shocks - net of information effects - exerted a significant impact on stock prices of European banks and firms that are now also detected in the two-day window. These spillover effects on stock prices were again stronger for banks than for firms. Net of information effects, a 100 basis point Fed monetary policy easing shock led on average to an increase of 6.6 percentage points for banks compared with 4.5 percentage points for firms (Euro Stoxx 50).

Table 2 here

To study the effect of QE announcements and FG, I use the monetary policy shock decomposition by Swanson (2022) based on three (orthogonal) factors: FFR, FG, and LSAP (see Equation 1c).[27] The results show that FG spilled over to bond yields across all sectors and maturities and likely to stock prices of European banks, while QE spilled over only to long-term government bond yields in Europe. As for conventional policy, the Fed's unconventional measures did not create significant spillovers to credit risk in the euro area. Table 3 (upper panel) shows that a one standard deviation increase in the Fed FG shock, which according to Swanson (2022) translates into an unexpected rise in the 10-year US Treasury yield by 3.9 basis points, caused an average increase of the 2-year and 10-year euro area government bond yields by 1 and 2 basis points, respectively. The spillover on euro area bank bond yields and NFC bank bond yields are around two basis points on impact, i.e., similar to the response of long-term bonds. The same shock likely decreased bank stock prices by 0.19 percentage points on average in the form of a pre-FOMC drift but did not impact aggregate stock prices, and the effect was absent post-crisis (see Table 3, lower panel). Spillovers from the Fed's QE need to be assessed based on the post-crisis sample during which these measures were implemented. Table 3 (lower panel) shows that an (unexpected) expansion of Fed asset purchases by one standard deviation, i.e., a USD 215 billion surprise that, according to Swanson (2022), translates into an unexpected decline in the 10-year US Treasury yield by 5.4 basis points, caused the 10-year euro area rate to decrease on average by around three basis points, but no other spillovers can be detected.

[27] Note that the shocks from Swanson (2022) are in units of basis points per standard deviation surprise in each monetary policy instrument.

Table 3 here

HFI robustly finds that causal spillovers from Fed monetary policy shocks to European bond yields were sizable and similar large across sectors. Fed uncertainty signaling accounts for about one-fourth of that response of European bond yields. Bank stock prices responded stronger to those shocks than NFCs. Still, those spillovers were typically detected only as a pre-FOMC drift since Fed information effects have tended to dampen international spillovers on stock prices. The results also document the sizeable impact of FG on European bond yields across sectors, showing that LSAP only spilled over to 10-year euro area government bond yields but not to bond yields of banks and NFCs and not European stock prices. Furthermore, no significant spillovers from Fed monetary policy shocks on bank health and the credit risk of European banks and NFCs are detected – though uncertainty signalling may still impact NFC credit risk. These findings suggest that policymakers must factor in Fed monetary policy announcements when assessing financial sector vulnerabilities, especially since they significantly impact the financing costs of the European financial and corporate sectors.

4.2 Results from local projections on the persistence of spillovers

The transmission of Fed monetary policy announcements on euro area indicators is estimated using several shock decompositions from other researchers and applying local projections without and with external instruments (Equations 2 and 3). Given the results from HFI, this section focuses on the response of European bond yields and stock prices to Fed monetary policy shocks. Figure 5 shows graphically the distribution of the estimated coefficients for a horizon of 25 (business) days after the FOMC meeting using the univariate monetary policy shock by Nakamura and Steinsson (2018) and the policy uncertainty measure by Bauer et al. (2022). The coefficients for the monetary policy shock are plotted in blue, and those for the Fed policy uncertainty shock in red. The results show that Fed monetary policy tightening shocks increase bond yields of banks and NFCs in the euro area similarly. The chart also shows that a decrease in Fed monetary policy uncertainty lowers those yields with a similar persistence and with similar effects on banks and NFCs, and it does so by decreasing (term) risk premia.[28] These findings align with Swanson (2022), who finds a strong impact of Fed announcements on the US yield curve, and Lakdawala et al. (2021), who detect spillovers from Fed announcements to government bond yields of advanced countries involving Fed uncertainty signaling. The chart also

[28] According to Bauer et al. (2022), the domestic effect of Fed monetary policy surprises on US government bond yields also depends on the level of short-rate policy uncertainty on the day before the FOMC announcement; it is stronger (weaker) when uncertainty is low (high). For the international transmission to bank bond and NFC yields, I find that the level of uncertainty does not change the international spillover in a significant manner. For brevity of the exposition, these results are not reported here and are available from the author.

suggests that Fed monetary policy tightening shocks decrease aggregate stock prices – and likely decrease bank stock prices similarly - while Fed uncertainty signaling has no persistent impact on European stock prices. This result is also in line with Lakdawala et al. (2021). A comparison between LP-OLS and LP-IV estimates suggests that the calculations are pretty robust.

Figure 5 here

Figure 6 shows graphically the distribution of the estimated coefficients for a horizon of 25 (business) days using the pure monetary policy shock and information shock by Jarociński and Karadi (2020). The pure monetary policy shock coefficients are plotted in blue, and those for the information shock in red. The results in Figure 6 confirm the assessment that (pure) monetary policy tightening shocks increase bond yields of banks and NFCs in the euro area in a (broadly) similar manner. Because information effects were significant for NFC bond yields but not for bank bond yields, the transmission to NFC bond yields might have been stronger since information shocks can influence risk premia. More importantly, Fed (pure) monetary policy tightening shocks are found to decrease aggregate stock prices and bank stock prices persistently, and the effect is stronger for bank stocks than for NFCs. Interestingly, the statistical significance of the impulse responses for monetary policy shocks to stock prices is higher once Fed information effects are excluded. The reason is that, if present, information effects create pessimism (optimism) in financial markets, which tends to decrease (increase) stock prices irrespective of the intended monetary policy signal. As shown in Figure 3, monetary policy and information shocks typically have opposite signs. Interestingly, information shocks were more frequent pre-crisis than post-crisis. LP-IV estimates suggest that the spillovers from Fed (pure) monetary policy shocks to the euro area were possibly somewhat larger, and the effects from information shocks were weaker than proxy LP-OLS estimates suggest.

Figure 6 here

Figure 7 graphically shows the distribution of the estimated coefficients for a horizon of 25 (business) days using Swanson's FG and LSAP shock (2022). The coefficients for the FG shock are plotted in blue, and those for the LSAP shock in red. The results show that international spillovers from the Fed's FG to bond yields of banks and NFCs are sizeable and persistent. Fed communication of prospective changes in the monetary policy stance spilled over to bond yields in the euro area and was similar for banks and NFCs. If anything, the effects were slightly stronger and more persistent for NFCs than banks. The Fed information signaling also played a role here since the most extensive changes in Fed monetary policy uncertainty coincided with significant changes in the Fed forward guidance language (Lakdawala et al., 2021). Regarding the stock price response, the results show that the Fed's

FG created no persistent spillovers to European stock prices. Turning to Fed announcements to increase the pace of its large-scale asset purchases, this measure potentially decreased bond yields of euro area banks and NFCs and affected stock prices. The results show some persistence in the response of bond yields of banks and NFCs to the Fed's LSAP shocks. At the same time, for stock prices, they are hardly significant at conventional levels and may reflect coordinated international policy action. Moreover, the estimates from LP-OLS and LP-IV differ considerably, and the instrumental variable approach suggests that the effects from LSAP on European bond yields and stock prices were small.

Figure 7 here

Overall, local projections suggest that Fed monetary policy announcements spill over to bond yields and stock prices of euro area banks and non-banks fairly homogeneously. The impact of Fed monetary policy shocks on bond yields of banks and NFCs was strong and persistent, and Fed uncertainty signaling impacted bond yields through changing term premia. Fed pure monetary policy shocks - net of information effects - are found to exert a more substantial impact on the stock prices of European banks than those of NFCs. The Fed's unconventional measures also spilled over to the euro area, where Fed communication strongly impacted bond yields across all sectors. In contrast, the impact of Fed QE announcements on bond yields and stock prices in Europe was small.

4.3 Other results

Endogeneity related to ECB monetary policy shocks

Focussing on euro area banks, I examine whether ECB monetary policy announcements following Fed announcements give rise to endogeneity. Suppose monetary policy shocks of the ECB at a consecutive meeting have the same sign as those of the Fed. In that case, spillovers measured during the event window will strengthen because euro area banks also reflect the causal effect of ECB monetary policy shocks (Jung, 2023). For the same reason, the measured spillovers could be weaker if ECB monetary policy shocks at a consecutive meeting have the opposite sign.

To examine the response in both states, I estimate the coefficient α_1 when the signs of the monetary policy shocks from the Fed and the ECB are aligned (A) and when they are not aligned (NA). Specifically, I estimate the proxy LP-OLS regression

$$y_{t-h} - y_{t-1} = \alpha_h + \begin{cases} \alpha_{1,h}^{A} \quad mps_t \times D[mps_{FED} \times mps_{ECB} > 0] + u_{1t,h} \\ \alpha_{1,h}^{NA} \quad mps_t \times D[mps_{FED} \times mps_{ECB} < 0] + u_{2t,h} \end{cases} \tag{2d}$$

where D[·] is a dummy that equals 1 if the expression is true and 0 otherwise. To have a consistent measure of monetary policy shocks for the Fed and the ECB and to be able to abstract from information effects by both central banks, which possibly dampen the stock market response, here I use pure monetary policy shocks from Jarociński and Karadi (2020), which they have consistently identified for both central banks.

As shown by the point estimates for "aligned" and "not aligned" monetary policy shocks (Table 4), the results for bank stock prices and bond yields show that the significant impact from Fed spillovers relates to episodes when Fed and ECB monetary policy shocks were not aligned, i.e., they do not reflect coordinated policy action by both central banks.

Table 4 here

Asymmetries in the response to euro area banks

Next, I examine whether spillovers transmit asymmetrically to banks following the Fed's monetary policy announcements. An unexpected Fed tightening can transmit faster to the international bond market, creating funding pressure for foreign borrowers while driving up risk premia. Likewise, an unexpected Fed easing could be more stimulative for stock markets when monetary policy uncertainty is high and the central bank signals its readiness to act further.

I conduct additional tests that allow positive and negative monetary policy shocks to enter the regression (2b) with different coefficients using the pure Fed monetary policy shock from Jarociński and Karadi (2020), which excludes the presence of information effects from the measurement. Specifically, I estimate the proxy LP-OLS regression:

$$y_{t-h} - y_{t-1} = \alpha_h + \alpha_{1,h}^{+}\, mps_t \times D[mps_t > 0] + \alpha_{1,h}^{-}\, mps_t \times D[mps_t < 0] + u_{t,h} \qquad (2e)$$

where D[·] is a dummy that equals 1 if the expression is true and 0 otherwise, and modify Equation 2 accordingly.

As shown by the point estimates on the positive and negative monetary policy shocks (Table 5), asymmetries in the response to bank stock prices and bank bond yields to (pure) monetary policy shocks are present. The results reveal that the significant effects of monetary policy shocks on stock prices relate to episodes when Fed monetary policy eased unexpectedly. In contrast, the significant impact on bank bond yields relates to unexpected Fed tightening of monetary policy. The asymmetries are also visible from the higher, significant coefficients.

Table 5 here

Heterogeneity in the response of euro area banks

The literature points to the presence of heterogeneity in the international monetary policy transmission of Fed monetary policy through banks (Buch et al., 2019), which can be seen in reactions of global stock (Ehrmann and Fratzscher, 2009) and bond markets (Iacoviello and Navarro, 2019) to Fed monetary policy shocks. To check for heterogeneity in the transmission of Fed announcements to euro area banks of the four largest euro area countries, I reestimate LP-OLS (Equation 2b) for the post-crisis sample using pure monetary policy and information shocks from Jarocinski and Karadi (2020) and investigate heterogeneity in the response of bank stock prices and bank bonds.

Figure 8 shows that spillovers from Fed pure monetary policy and information shocks on stock prices and bank bond yields of banks in the euro area and its four main countries display some heterogeneity in the strength of the transmission, reflecting known differences in the degree of global integration of the financial systems of euro area countries and banks' balance sheet exposure to US interest rate risk. Regarding the stock price response to Fed monetary policy and information shocks, it is shown that it is pretty homogeneous, while banks in Germany and France respond somewhat stronger than in Italy and Spain (Figure 8a). This pattern could reflect different strengths of the economies and lower impairments of the credit channel. Regarding the response of bank bond yields, it is shown that banks' reaction in the four largest euro area countries to Fed monetary policy shocks is homogeneous but the response to Fed information shocks is heterogenous (Figure 8b). This pattern could reflect differences in the asset quality of banks' balance sheets across euro area countries but could also be owing to different business models. To assess the impact of changes in the risk premium on bank bond yields, I decompose total euro area bonds into senior and subordinated bank bonds, which carry different risk premia (Figure 8c) shows that Fed information shocks drive a wedge between bank bond yields with varying characteristics of risk and Fed information effects related to monetary policy easing reduce the yields of senior bonds but increase the yields of subordinated bonds.

Figure 8 here

5. Conclusion

Measuring international monetary policy spillover effects of the Fed's policy actions, communication, and large-scale asset purchases to European banks and NFCs is relevant for policymakers. This study sheds new light on international spillovers from Fed monetary policy announcements to euro area banks and non-financial corporations. It also informs the debate on why the current ECB's policy tightening has stronger effects on euro area financing conditions than usual. Based on daily data for the sample from 1999 to 2019, this study finds that the Fed's monetary policy announcements created significant international spillovers to bond yields and stock prices of European banks and NFCs, while changes in uncertainty around the expected Fed policy path and Fed information effects constituted critical additional dimensions of these spillover effects. The findings of this study suggest that policymakers need to factor in Fed monetary policy announcements, policy uncertainty, and information effects when assessing financial sector vulnerabilities, especially since they have a potentially large impact on the financing costs of the European financial sector and the corporate sector. To this end, this study finds that international spillovers to bond yields of banks and NFCs were similar, while stock prices of European banks responded somewhat stronger than those of NFCs.The study also supports available evidence on the powerful impact of central bank communication on financial asset prices and finds that this point is relevant for explaining international spillovers, especially bond yields. Concerning the strong side-effects of the Fed's QE on global government bond yields seen in earlier studies, the study suggests that Fed QE announcements created only small spillovers on bond yields and stock prices of European banks and NFCs.

In principle, the empirical measurement of international spillovers from US monetary policy to the euro area banking sector is complicated by the presence of other shocks to which euro area bank variables may respond for reasons unrelated to US monetary policy and which are related to other news releases and ECB monetary policy announcements. Endogeneity concerns have been carefully addressed in this study through the design of the econometric analysis. The study also finds that the transmission of Fed monetary policy shocks to European bank bond yields displayed heterogeneity across the largest euro area countries. Risk characteristics explain heterogeneity in the response of bank bond yields to Fed monetary policy shocks. Future research could further examine heterogeneity, for example, based on a large cross-section of banks examining the potential role that different business models of banks may play for the international transmission of Fed monetary policy announcements.

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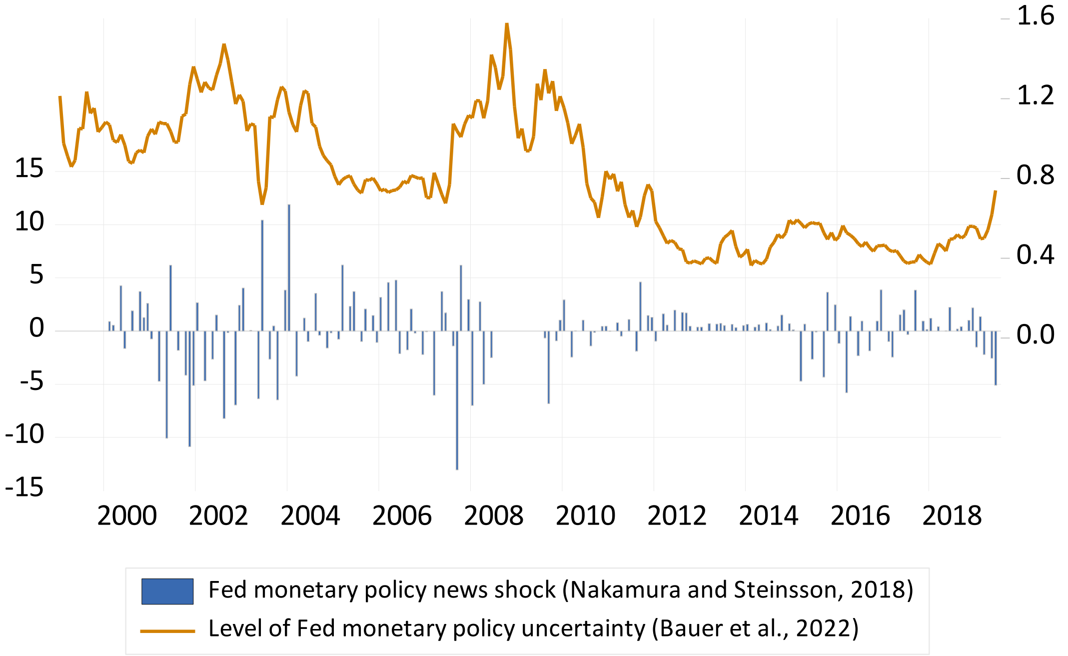
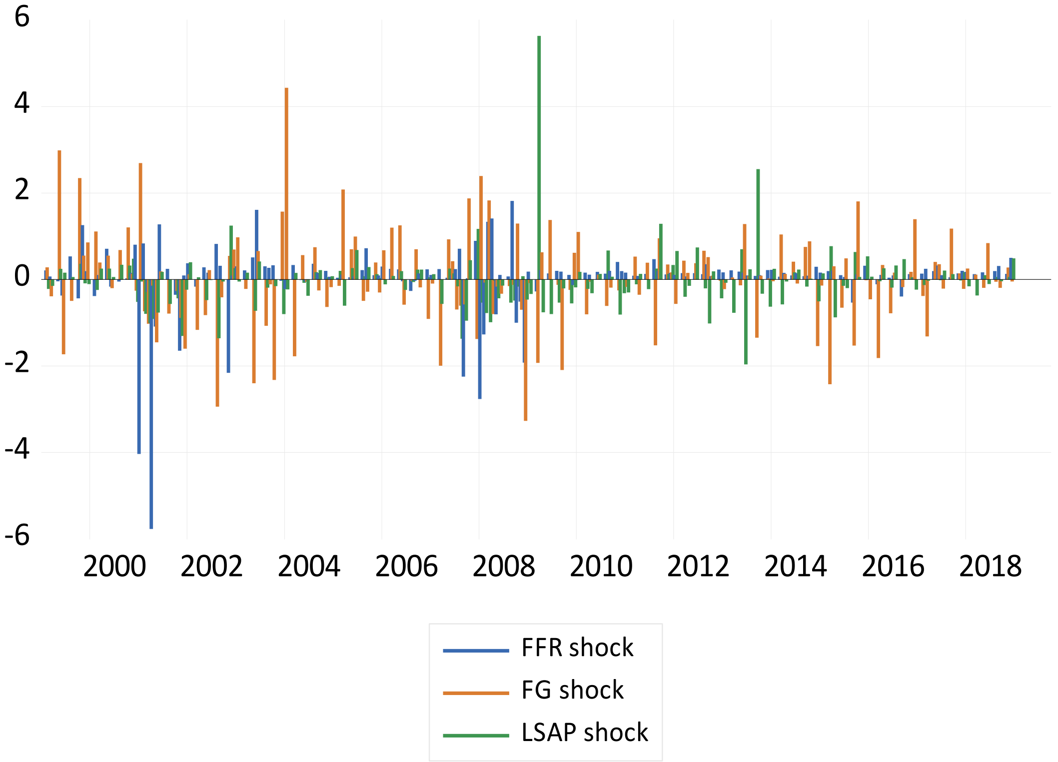
Figure 1: Fed monetary policy shocks and monetary policy uncertainty



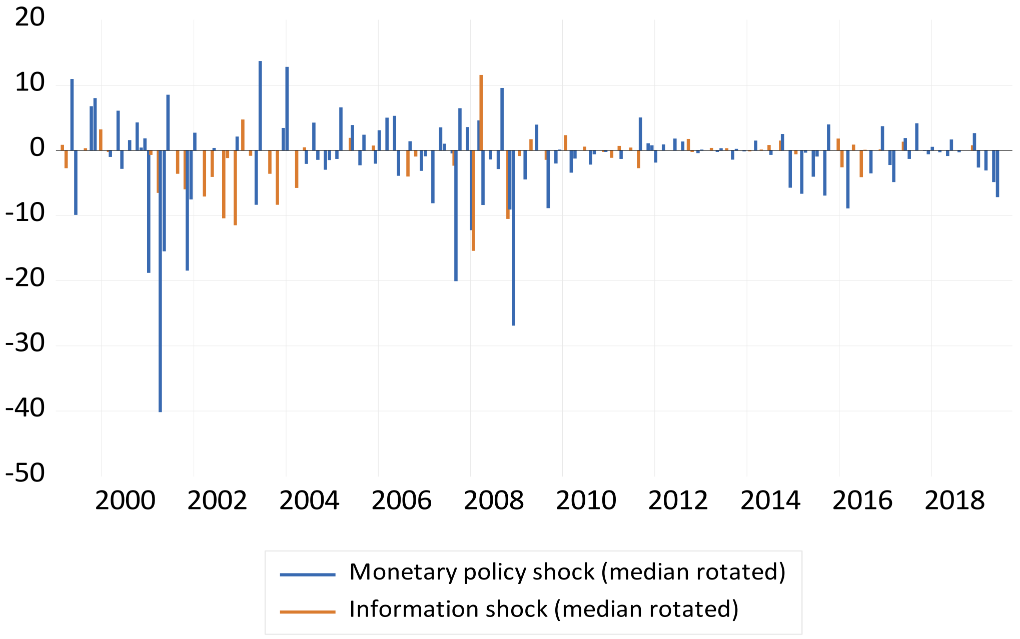
Notes: The y-axis (LHS) refers to basis points; the y-axis (RHS) refers to percent; the x-axis denotes years. The univariate policy news shock from Nakamura and Steinsson (2018) and the option-based estimate of short-rate uncertainty by Bauer et al. (2022) are shown.

Figure 2: Fed monetary policy shocks: Unconventional measures



Notes: The y-axis refers to standard deviations; the x-axis denotes years. FFR, FG, and LSAP shocks are obtained from Swanson (2022) and are normalized to refer to unit standard deviation.

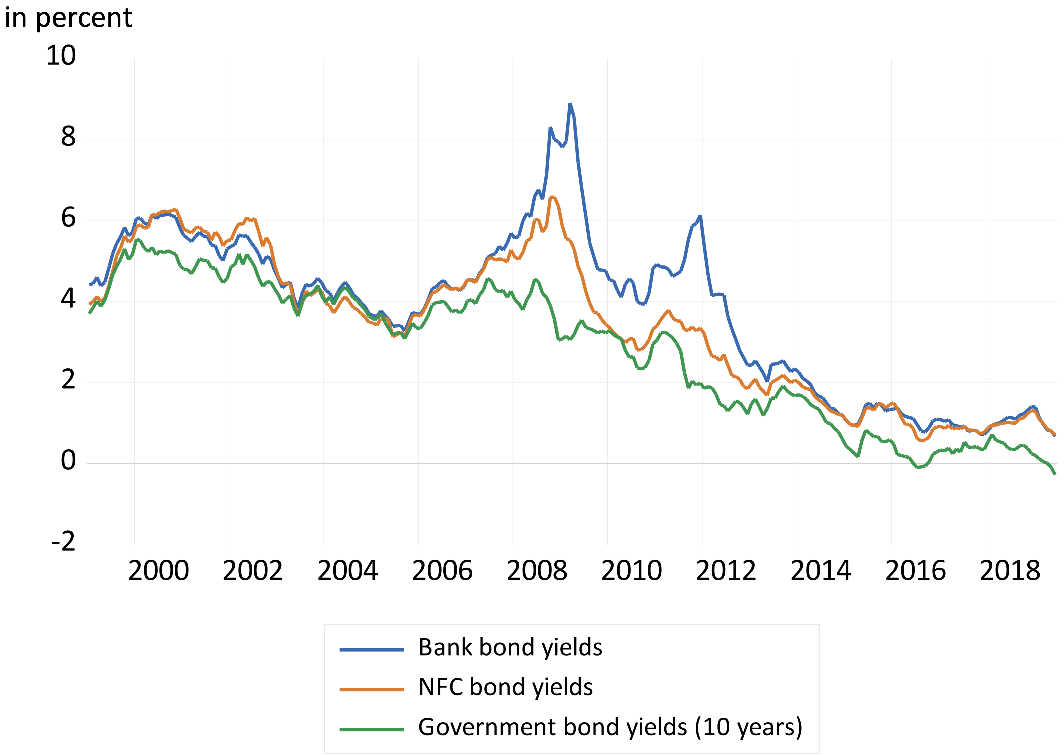
Figure 3: Fed monetary policy and information shocks



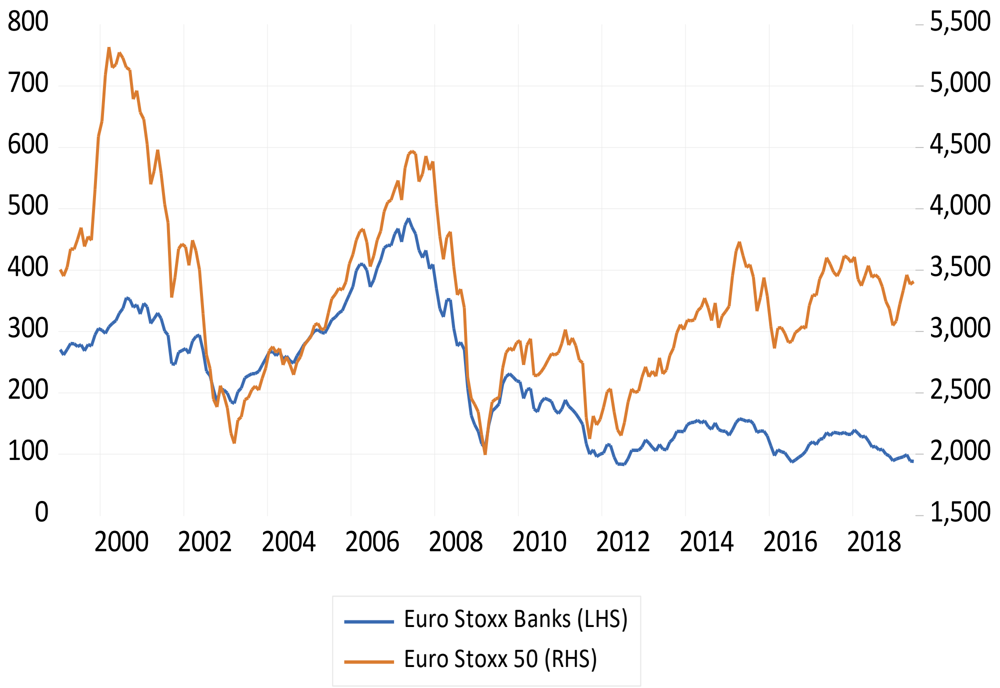
Notes: The y-axis refers to basis points; the x-axis denotes years. Monetary policy and information shocks are obtained from Jarociński and Karadi (2020).

Figure 4: Euro area indicators

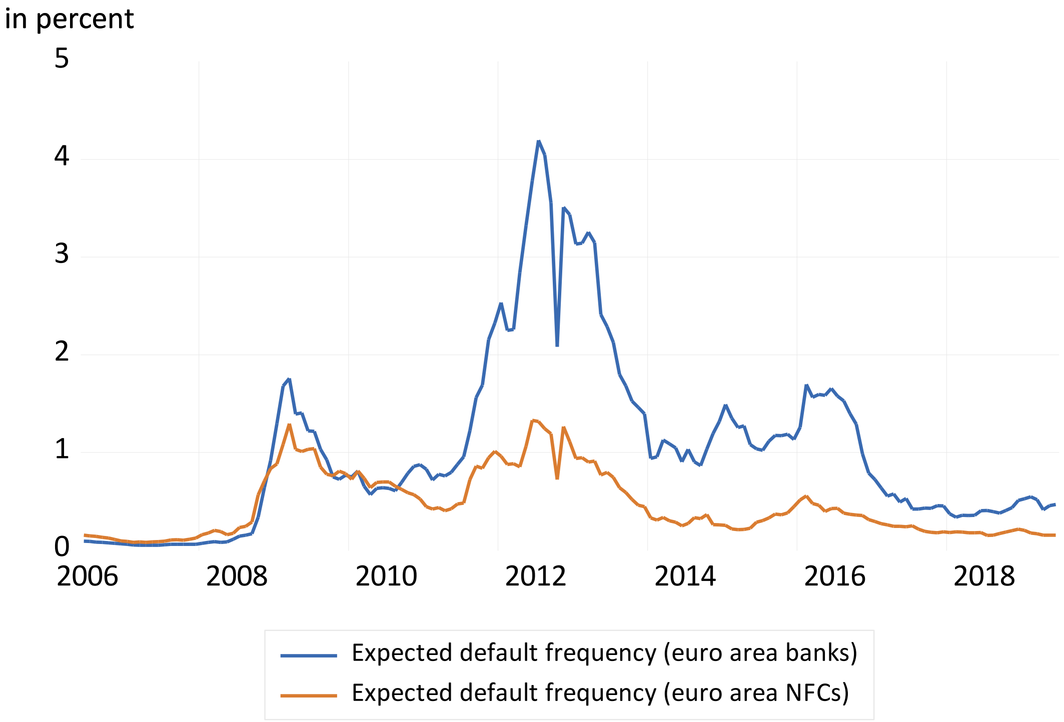
a) Bond yields



b) Stock prices

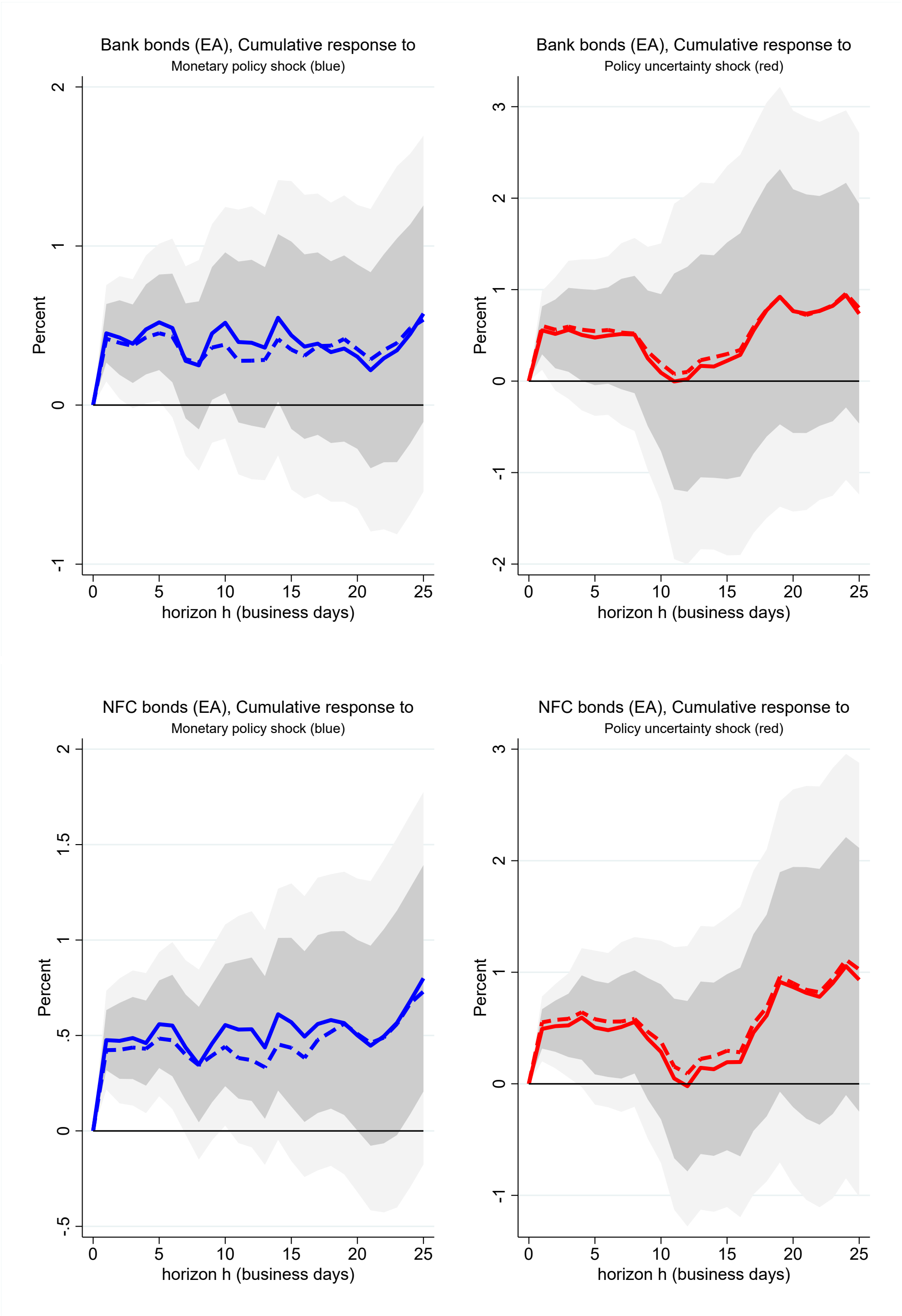


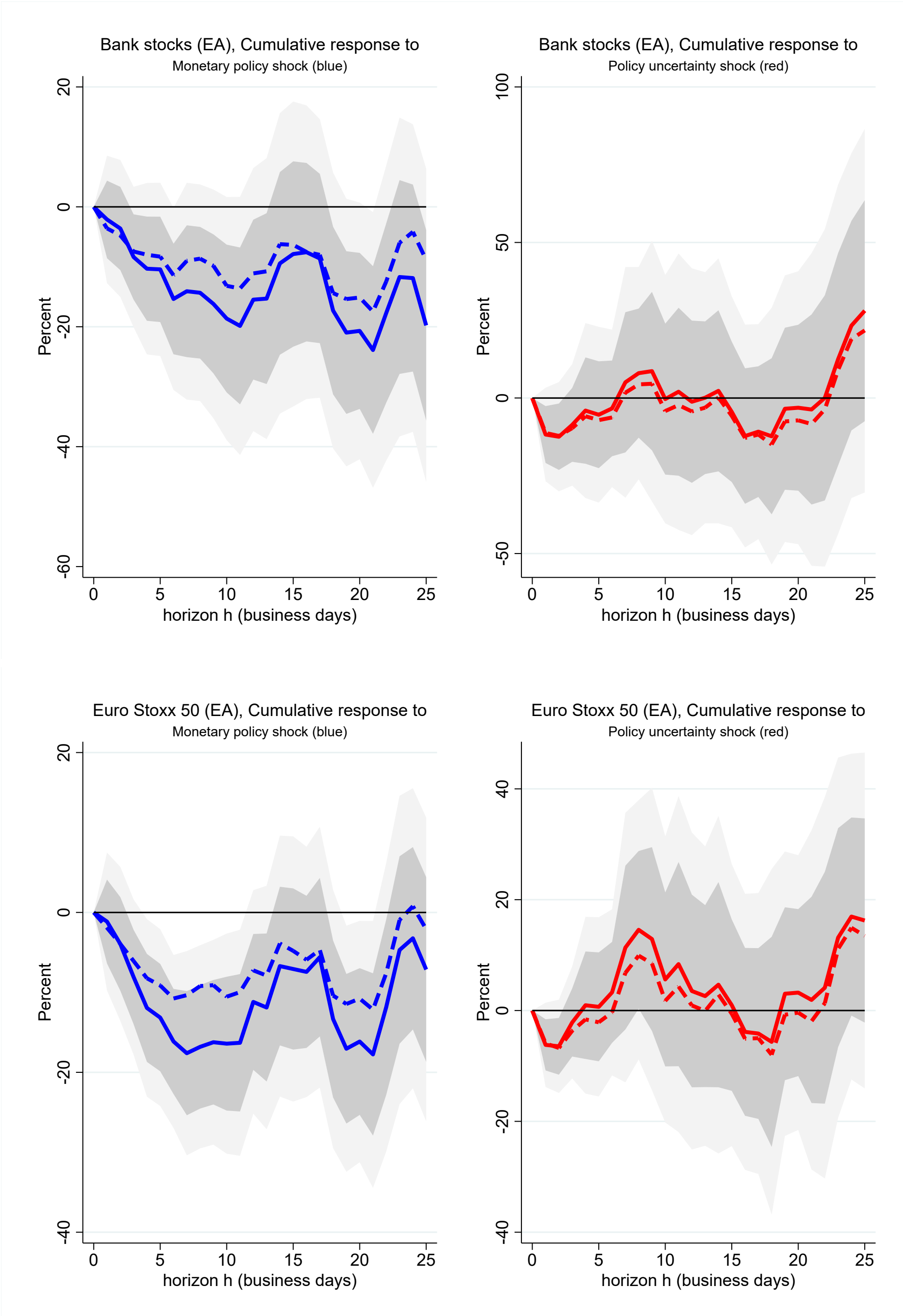
c) Credit risk



Notes: The x-axis denotes years; Euro Stoxx Banks and Euro Stoxx 50 as index; EDF as euro area averages. Sources: Thomson Reuters Datastream, Markit iBoxx, Moody's Analytics.

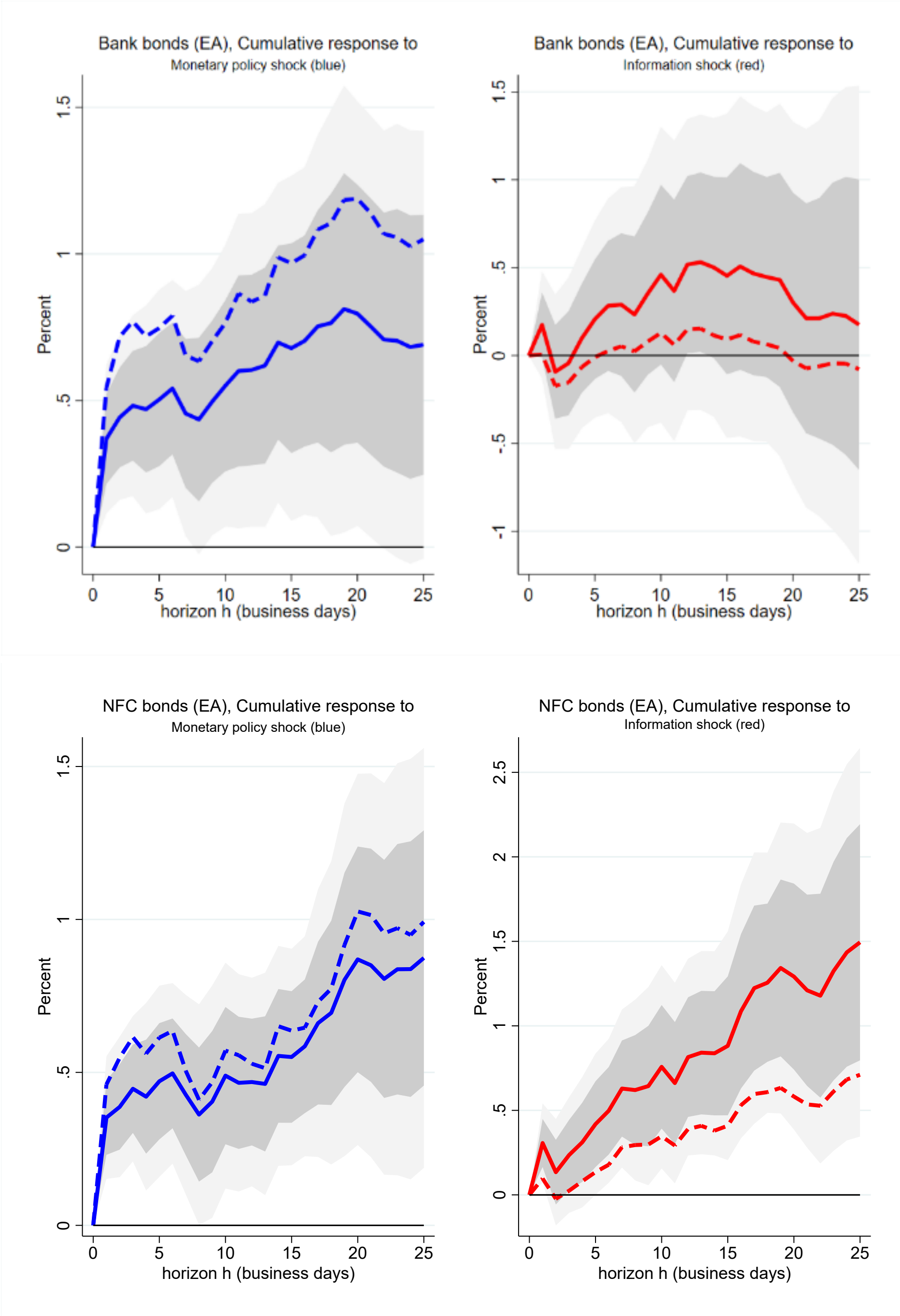
Figure 5: Spillovers from Fed monetary policy and uncertainty shocks to the euro area

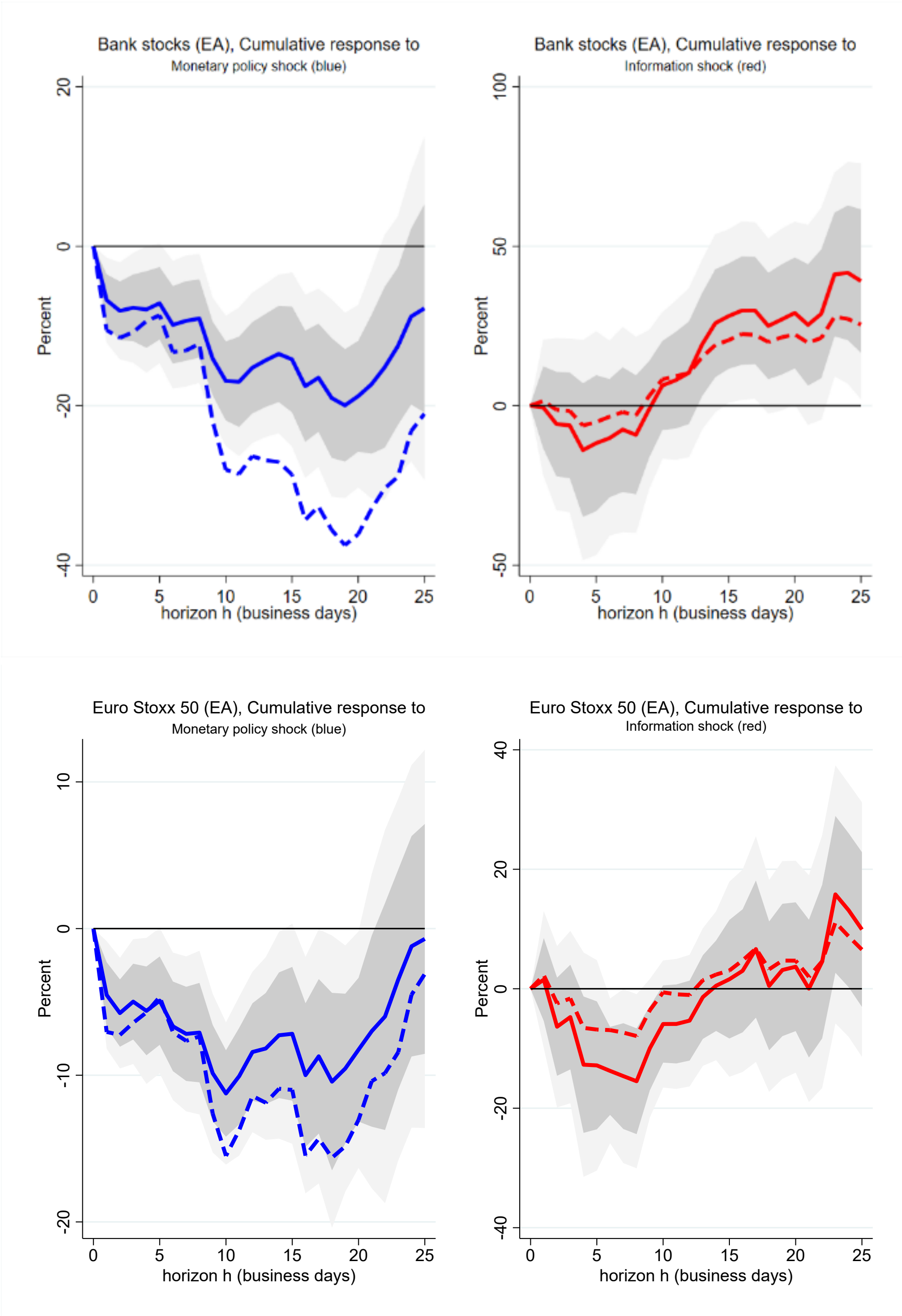




Notes: Sample 1 January 1999 to 30 June 2019. Proxy LP estimates are displayed with a solid line and 1 S.D. (dark grey) and 90% (light grey) confidence bands; LP-IV estimates with a dashed line. Monetary policy shocks are from Nakamura and Steinsson (2018), and uncertainty shocks are obtained from Bauer et al. (2022). All regressions have 185 observations.

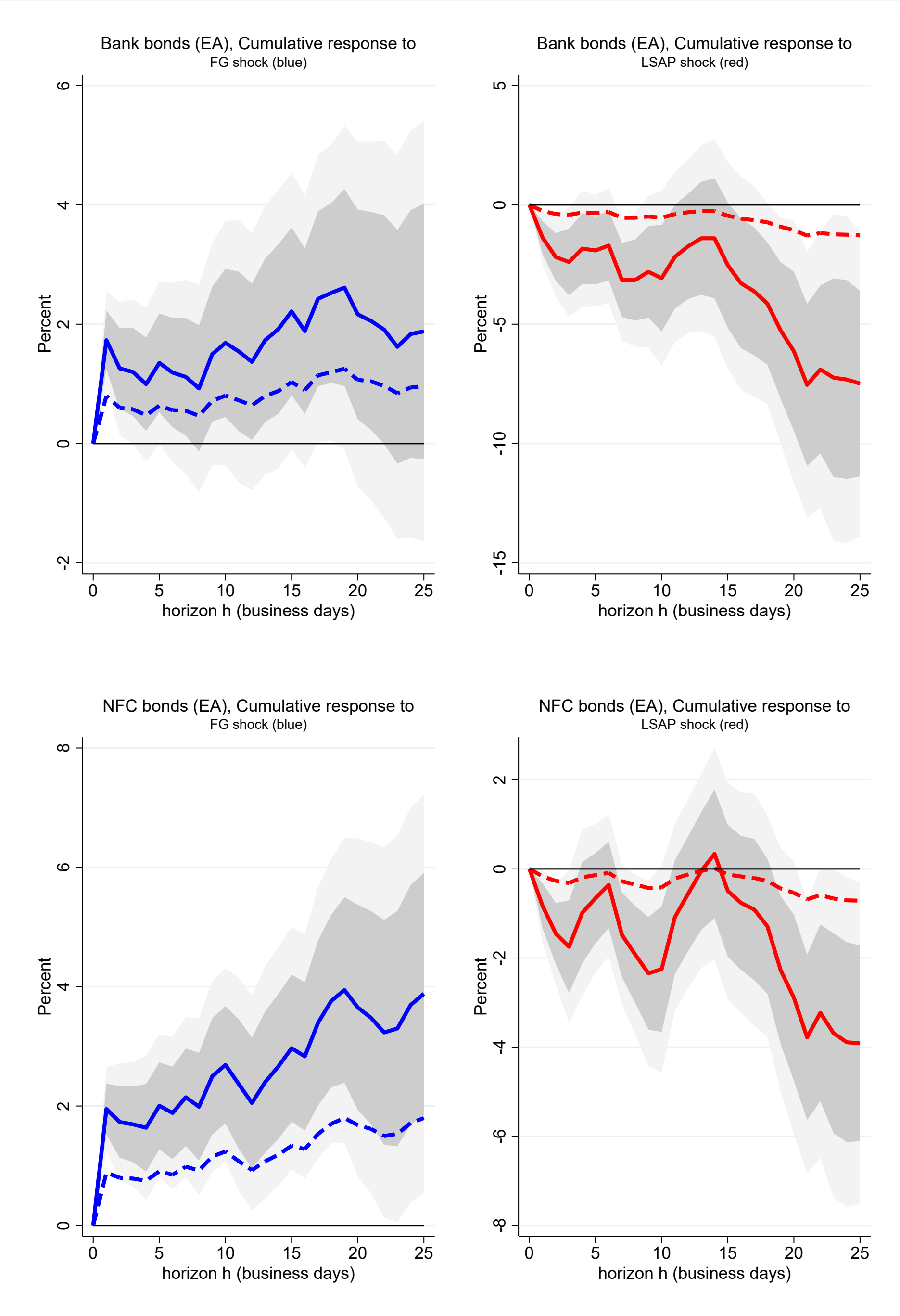
Figure 6: Spillovers from Fed monetary policy and information shocks to the euro area

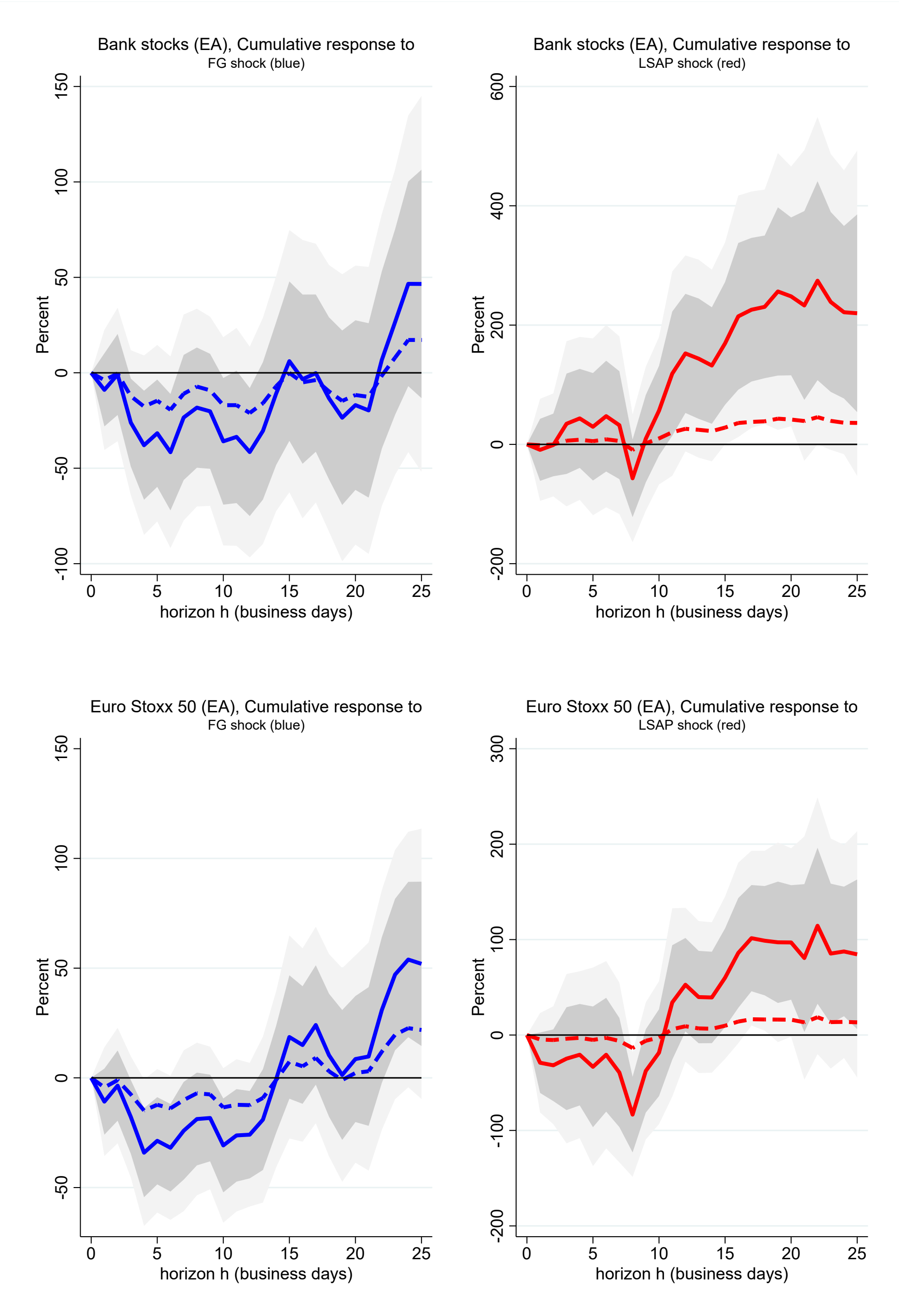




Notes: Sample 1 January 1999 to 30 June 2019. Proxy LP estimates are displayed with a solid line and 1 S.D. (dark grey) and 90% (light grey) confidence bands; LP-IV estimates with a dashed line. Monetary policy and information shocks are obtained from Jarociński and Karadi (2020). All regressions have 185 observations.

Figure 7: Spillovers from Fed FG and LSAP shocks to the euro area

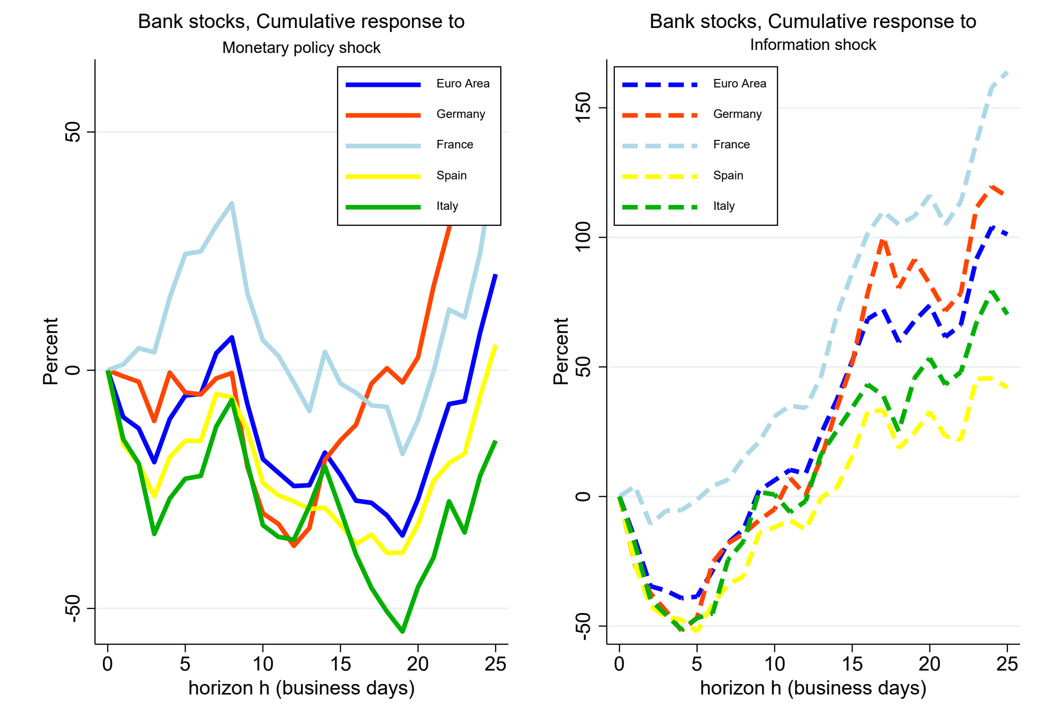




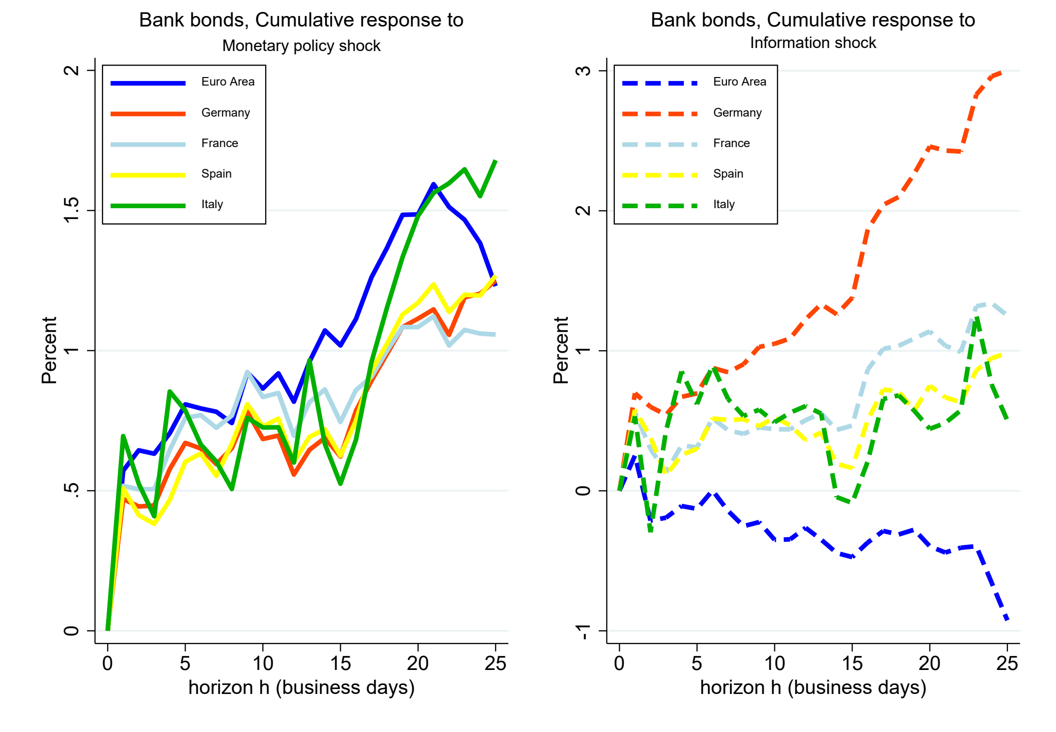
Notes: Sample 1 October 2008 to 30 June 2019. Proxy LP estimates are displayed with a solid line and 1 S.D. (dark grey) and 90% (light grey) confidence bands; LP-IV estimates with a dashed line. FG and LSAP shocks are obtained from Swanson (2022) and are normalized to have a unit standard deviation. All regressions have 101 observations.

Figure 8: The effect of Fed pure monetary policy and information shocks: heterogeneity

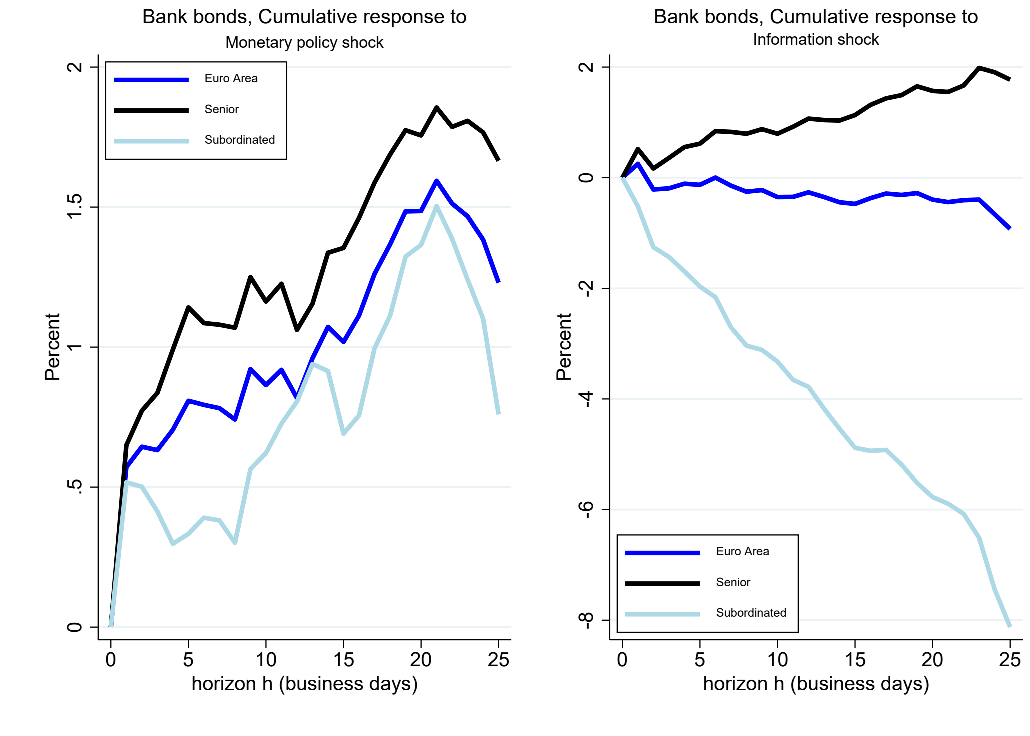
a) Bank stocks



b) Bank bond yields



c) Bank bond yields with different risk classes



Notes: Sample 1 October 2008 to 30 June 2019. LP-OLS estimates in all panels. Monetary policy and information shocks are obtained from Jarociński and Karadi (2020). All regressions have 101 observations.

TABLE 1: Spillovers from Fed shocks to the euro area (baseline)

	Stock prices				Bond yields				Credit risk		Health
	Banks		All firms		Banks	NFCs	Government		Banks	NFCs	Banks
VARIABLES	*SX7E 2 days*	*SX7E 1 day*	*SX5E 2 days*	*SX5E 1 day*	*Euro area*	*Euro area*	*2 years, Euro area*	*10 years, Euro area*	*EDF, Euro area*	*EDF, Euro area*	*Euro area*
Full sample											
Monetary policy shock	-5.10	-5.51**	-2.72	-2.51	0.59***	0.60***	0.48**	0.46**	0.05	0.06	-0.43
	(6.09)	(2.56)	(5.17)	(2.17)	(0.17)	(0.15)	(0.20)	(0.20)	(0.07)	(0.09)	(0.27)
Observations	185	185	185	185	185	185	185	185	185	124	143
R-squared	0.00	0.01	0.00	0.00	0.05	0.10	0.05	0.05	0.00	0.00	0.01
Post-crisis sample											
Monetary policy shock	-4.04	-14.92*	-0.85	-5.25	0.63*	0.61***	0.36*	0.75**	0.22	0.11	-0.28
	(16.15)	(7.77)	(12.12)	(4.06)	(0.32)	(0.14)	(0.19)	(0.29)	(0.34)	(0.19)	(0.53)
Observations	101	101	101	101	101	101	101	101	101	101	101
R-squared	0.00	0.01	0.00	0.00	0.02	0.03	0.02	0.04	0.01	0.00	0.00

Notes: Full sample 1 January 1999 to 30 June 2019; post-crisis subsample 1 October 2008 to 30 June 2019. Results of HFI with robust standard errors in parentheses; ***, **, and * refer to the 1%, 5%, and 10% significance levels, respectively; the dependent variable is in differences (for stock prices, I use logs of the index). Monetary policy shocks are obtained from Nakamura and Steinsson (2018).

TABLE 2: Spillovers from Fed shocks to the euro area (uncertainty signaling and information effects)

	Stock prices				Bond yields				Credit risk		Health
	Banks		All firms		Banks	NFCs	Government		Banks	NFCs	Banks
VARIABLES	*SX7E 2 days*	*SX7E 1 day*	*SX5E 2 days*	*SX5E 1 day*	*Euro area*	*Euro area*	*2 years, Euro area*	*10 years, Euro area*	*EDF, Euro area*	*EDF, Euro area*	*Euro area*
Full sample											
Monetary policy shock	-2.10	-1.32	-1.14	0.03	0.45**	0.48***	0.38*	0.33*	0.04	0.01	-0.41
(MPS)	(6.46)	(2.79)	(5.24)	(2.35)	(0.18)	(0.16)	(0.21)	(0.20)	(0.07)	(0.10)	(0.28)
Policy uncertainty shock	-11.73	-16.36***	-6.20	-9.95***	0.55**	0.49***	0.39	0.51***	0.02	0.16**	-0.08
(MPU)	(9.14)	(5.37)	(4.62)	(3.25)	(0.26)	(0.18)	(0.27)	(0.18)	(0.10)	(0.07)	(0.25)
Observations	185	185	185	185	185	185	185	185	185	124	143
R-squared	0.02	0.07	0.01	0.06	0.10	0.16	0.09	0.11	0.00	0.04	0.01
Full sample											
Pure monetary policy shock	-6.62**	-4.41**	-4.53**	-2.45	0.37**	0.35***	0.27*	0.17	0.02	0.06	-0.28
(MPS median)	(3.26)	(1.71)	(2.23)	(1.62)	(0.15)	(0.12)	(0.16)	(0.14)	(0.04)	(0.04)	(0.19)
Central bank information shock	-2.34	-13.22*	1.53	-9.20**	0.23	0.31**	0.31	0.17	-0.09	0.11	-0.26
(CBI median)	(12.81)	(7.02)	(6.96)	(3.89)	(0.18)	(0.14)	(0.19)	(0.18)	(0.09)	(0.18)	(0.48)
Observations	185	185	185	185	185	185	185	185	185	124	143
R-squared	0.02	0.04	0.02	0.06	0.07	0.12	0.06	0.02	0.01	0.02	0.02

Notes: Sample 1 January 1999 to 30 June 2019. Results of HFI with robust standard errors in parentheses; ***, **, and * refer to the 1%, 5%, and 10% significance levels, respectively; the dependent variable is in differences (for stock prices, I use logs of the index). In the upper half, monetary policy shocks are obtained from Nakamura and Steinsson (2018) and monetary policy uncertainty shocks from Bauer et al. (2022); in the lower half, pure monetary policy shocks and central bank information shocks are obtained from Jarociński and Karadi (2020).

TABLE 3: Spillovers from Fed shocks to the euro area (unconventional measures)

	Stock prices				Bond yields				Credit risk		Health
	Banks		All firms		Banks	NFCs	Government		Banks	NFCs	Banks
VARIABLES	*SX7E 2 days*	*SX7E 1 day*	*SX5E 2 days*	*SX5E 1 day*	*Euro area*	*Euro area*	*2 years, Euro area*	*10 years, Euro area*	*EDF, Euro area*	*EDF, Euro area*	*Euro area*
Full sample											
Target surprise	-0.41	-0.29*	-0.20	-0.19	0.02	0.02**	0.02	0.01	0.00	0.00	-0.02
(FFR)	(0.29)	(0.17)	(0.24)	(0.16)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.02)
Forward guidance	-0.12	-0.19*	-0.12	-0.11	0.02***	0.02***	0.01**	0.02***	0.00	0.00	-0.01
(FG)	(0.20)	(0.11)	(0.15)	(0.07)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)
Large-scale asset purchases	-0.06	-0.18	-0.28	-0.29*	-0.02**	-0.01*	0.00	-0.03***	-0.00	0.00	-0.01
(LSAP)	(0.51)	(0.26)	(0.31)	(0.15)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.02)
Observations	185	185	185	185	185	185	185	185	185	124	143
R-squared	0.01	0.02	0.02	0.04	0.09	0.17	0.07	0.13	0.00	0.02	0.02
Post-crisis sample											
Target surprise	-1.43	-1.47	-1.12	-0.99*	0.06***	0.06***	0.07***	0.06***	-0.00	0.02	-0.03
(FFR)	(2.15)	(1.11)	(0.93)	(0.54)	(0.02)	(0.01)	(0.03)	(0.02)	(0.02)	(0.02)	(0.05)
Forward guidance	-0.12	-0.29	-0.13	-0.09	0.01	0.02***	0.01*	0.02***	-0.00	0.00	-0.00
(FG)	(0.46)	(0.23)	(0.32)	(0.12)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Large-scale asset purchases	0.16	-0.05	-0.20	-0.16	-0.01	-0.01	0.01	-0.03**	-0.01	0.00	-0.00
(LSAP)	(0.58)	(0.24)	(0.36)	(0.13)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Observations	101	101	101	101	101	101	101	101	101	101	101
R-squared	0.01	0.04	0.02	0.04	0.07	0.17	0.18	0.23	0.01	0.03	0.01

Notes: Full sample 1 January 1999 to 30 June 2019; post-crisis subsample 1 October 2008 to 30 June 2019. Results of HFI with robust standard errors in parentheses; ***, **, and * refer to the 1%, 5%, and 10% significance levels, respectively; the dependent variable is in differences (for stock prices, I use logs of the index). Monetary policy shocks are obtained from Swanson (2022).

TABLE 4: Spillovers from Fed and ECB monetary policy shocks to euro area banks

	h=1	h=2	h=3	h=4	h=5	h=10	h=15
LP-OLS							
Bank stocks							
Aligned	-4.75	0.25	3.40	0.10	-0.32	-17.92**	-10.48
	(6.60)	(7.65)	(7.90)	(10.69)	(10.34)	(7.92)	(8.74)
Observations	82	82	82	82	82	82	82
R-squared	0.01	0.00	0.00	0.00	0.00	0.05	0.01
Not aligned	-6.53	-11.12**	-12.76**	-9.40	-10.00	-16.77**	-22.35**
	(4.41)	(4.77)	(5.29)	(5.81)	(6.13)	(7.66)	(9.98)
Observations	90	90	90	90	90	90	90
R-squared	0.03	0.04	0.06	0.02	0.02	0.04	0.04
Bank bond yields							
Aligned	0.15	0.30	0.36	0.27	0.26	0.30	0.55
	(0.17)	(0.23)	(0.23)	(0.26)	(0.26)	(0.41)	(0.41)
Observations	82	82	82	82	82	82	82
R-squared	0.02	0.04	0.04	0.02	0.02	0.01	0.03
Not aligned	0.50***	0.58***	0.58**	0.60**	0.62*	0.61	0.71
	(0.19)	(0.22)	(0.26)	(0.29)	(0.31)	(0.37)	(0.52)
Observations	90	90	90	90	90	90	90
R-squared	0.16	0.12	0.08	0.08	0.08	0.05	0.03

Notes: Sample 1 January 1999 to 30 June 2019. Results of proxy LP-OLS with robust standard errors in parentheses; ***, **, and * refer to the 1%, 5%, and 10% significance levels, respectively; the dependent variable is in differences (for stock prices, I use logs of the index). Pure monetary policy shocks are obtained from Jarociński and Karadi (2020).

TABLE 5: The asymmetric effect of Fed monetary policy shocks on euro area banks

	h=1	h=2	h=3	h=4	h=5	h=10	h=15
LP-OLS							
Bank stocks							
MPS >0	7.34	11.75	25.54*	22.08	22.23	3.63	14.02
	(12.06)	(14.37)	(14.21)	(18.55)	(18.68)	(16.07)	(18.25)
MPS <0	-12.08***	-14.62***	-19.32***	-16.77**	-16.17**	-26.04***	-30.58***
	(3.81)	(4.86)	(6.65)	(6.47)	(6.42)	(7.51)	(9.24)
Observations	185	185	185	185	185	185	184
R-squared	0.03	0.03	0.06	0.03	0.03	0.04	0.04
Bank bond yields							
MPS >0	0.91***	1.17**	1.23**	1.30**	1.48**	1.55**	1.78
	(0.33)	(0.48)	(0.59)	(0.61)	(0.64)	(0.76)	(1.09)
MPS <0	0.13	0.18	0.20	0.13	0.09	0.08	0.16
	(0.15)	(0.16)	(0.16)	(0.18)	(0.19)	(0.24)	(0.30)
Observations	185	185	185	185	185	185	184
R-squared	0.10	0.07	0.06	0.06	0.06	0.04	0.03

Notes: Sample 1 January 1999 to 30 June 2019. Results of proxy LP-OLS with robust standard errors in parentheses; ***, **, and * refer to the 1%, 5%, and 10% significance levels, respectively; the dependent variable is in differences (for stock prices, I use logs of the index). MPS>0 holds for 76 observations, and MPS<0 for 97 observations. Pure monetary policy shocks are obtained from Jarociński and Karadi (2020); GS1 refers to the 1-year US government bond rate.

Appendices

Appendix A: Data

Table A.1: Overview of data used in this study

Variable	Source	Brief description
Monetary policy uncertainty (US) - SRU - MPU	Bauer et al. (2022)	Short-run uncertainty; the daily, risk-neutral standard deviation of the three-month LIBOR rate at a one-year horizon, estimated from Eurodollar futures and options; Daily change in SRU around FOMC announcements;
Monetary policy shocks (US) - Policy news shock	Nakamura and Steinsson (2018)	The first principal component of the change in five interest rates: the federal funds rate immediately following the FOMC meeting, the expected federal funds rate immediately following the next FOMC meeting, and expected 3-month eurodollar interest rates at horizons of two, three, and four quarters. in fed funds and Eurodollar futures with one year or less to expiration, 30-minute window;
- Federal funds rate factor - FG factor - LSAP factor	Swanson (2022)	Orthogonal factors based on federal funds 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), Treasury bond yields (3-month, 6-month, and 2-, 5-, 10-, and 30-year maturities), the stock market (S&P 500), and exchange rates (yen/dollar and dollar/euro), 30-minute window;
- Pure monetary policy shock - Information shock	Jarociński and Karadi (2020)	SVAR identification based on high-frequency surprises in 3-month fed funds futures (or the first principal component of surprises in the current month and three-month fed funds futures and two-, three-, and four-quarters ahead three-month eurodollar futures) and the S&P 500 stock market index, 30-minute window (plus extension for press conferences);
Policy rate (US) - Fed funds rate	FRED, Fed St. Louis	Code: FEDFUNDS and DFF
Government bond yields (US) 1, 2, 5, 10 years	FRED, Fed St. Louis	Code: DGS1, DGS2, DGS5, DGS10
Government bond yields (EA) - 2 years - 5 years - 10 years	ECB SDW	Code: FM.B.U2.EUR.RT.BB.EU2YT_RR.YLD Code: FM.B.U2.EUR.RT.BB.EU5YT_RR.YLD Code: FM.B.U2.EUR.RT.BB.EU10YT_RR.YLD

Stock prices (EA) - Euro Stoxx 50 - Euro Stoxx banks - EA countries	ECB SDW Datastream	Price index (SX5E) Price index (SX7E) The price index for banks in DE, FR, IT, and ES
Bond yields (EA) - Banks - Banks senior - Banks subordinated - Banks by countries - NFCs	Datastream iBoxx	Code: IBCBANK(RY) Code: IBEBSNR(RY) Code: IBEBSUB(RY) IBX.B.XX.EUR._T.COR.FIN.RA.S122.TT._Z._T.MV_A YLD with XX= DE, FR, IT, and ES Code: MLNFNCL(RY)
Credit risk (EA) - DTD - EDF - CDS spread (5 years)	ECB SDW Moody's Analytics, KMV CreditEdge	Euro area average, Code: KMV.B.I7.Z0Z.4F.DTD.XX.WAVA Code: KMV.B.I7.Z0Z.4F.EDF01.XX.WAVA XX=SCT_FIN for banks and SCT_NFC for firms Code: M.B.U2.Z01.4F.SC.EABKS5_MED.HST for banks
Net interest rate margin (EA)	ECB SDW	Difference between a composite lending rate to the non-financial private sector and bank bond yields, using: Code: MIR.M.U2.B.A2I.AM.R.A.2240.EUR.N Code: MIR.M.U2.B.A2C.AM.R.A.2250.EUR.N Code: BSI.M.U2.N.A.A20.A.1.U2.2240.Z01.E Code: BSI.M.U2.N.A.A20.A.1.U2.2250.Z01.E
Loan deposit margin (EA)	ECB SDW	Monthly loan-deposit margin on new business rates, computed from composite loan rates to the non-financial private sector and composite cost of deposits.
Private loans (EA) to the non-financial private sector	ECB SDW	Annual growth rates, Code: BSI.M.U2.Y.U.A20TA.A.I.U2.2200.Z01.A
Search data for credit (EA)	Google Trends	Daily (monthly), for six euro area countries, DE, FR, IT, ES, BE, NL; respective keywords: Kredit+Darlehen, credit, credito, credito, credit, credit+Kredit.
Bank health (EA)	Jung (2023)	First principal component (PC) of five euro area bank indicators: (Euro Stoxx banks) stock prices, banks' net interest rate margin, distance to default, expected default frequency, and private loans.

Notes: 1) An overnight swap (OIS) is a financial contract between two counterparties to exchange a fixed interest rate against a geometric average of overnight interest rates over the contractual life of the swap.

A2. Conceptual explanations:

Distance to default

The DTD measures the distance from a specified default point for a firm. I use an approximation based on calculations by Moody's, whereby the risk-free rate is omitted:

$$DTD_t = \frac{\log\left(\frac{A_t}{D_t}\right) + \left(r_t - \frac{1}{2}\sigma^2_{A_t}\right)(T-t)}{\sigma_{A_t}\sqrt{T-t}} \approx \frac{\log\left(\frac{A_t}{D_t}\right)}{\sigma_{A_t}\sqrt{T-t}} \quad \text{(A1)}$$

where A is (the market value of) total assets of a firm, D is (the market value of) debt and r the risk-free rate of interest (Euribor), σ_A denotes a standard deviation that measures the volatility of asset returns, and T-t is usually set to 1 year.

Expected default frequency

A firm is thought to default when the market value of its assets (the value of the ongoing business) falls below its liabilities payable (the default point). "Default" is defined as the failure to make scheduled principal or interest payments. The EDF determines the likelihood of a firm defaulting on its debt obligations over a specified period (i.e., one year). I use the EDF indicator, as reported by Moody's KMV Credit Edge model, for which the probabilities of default are derived from the DTD using the above approximation of the Merton model:

$$EDF_t = 1 - N(DTD_t) = N(-DTD_t) \quad \text{(A2)}$$

where DTD is taken from Equation (A1) and this value is matched with a (known) distribution of default probabilities from a large sample of firms, including firms with and without default. DTD and EDF have broadly similar information content for assessing credit risk since they differ only in terms of the known default distribution of firms while moving in the opposite direction.

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The author remains responsible for any errors or omissions.

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