A COMPREHENSIVE LOOK ON THE GLOBAL SPILLOVERS OF US MONETARY POLICY:

THE ROLE OF THE "FED INFORMATION EFFECT" AND UNCERTAINTY

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ECONOMIC AND FINANCIAL MATHEMATICAL ANALYSIS PROGRAMME, 5TH YEAR

CORVINUS UNIVERSTIY OF BUDAPEST

FAKT COLLEGE FOR ADVANCED STUDIES

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April 17th, 2024

Made possible by the professional support of the New National Excellence Program with code number ÚNKP-23-2-I, initiated by the Ministry of Culture and Innovation and financed from the National Research, Development, and Innovation Fund.

KULTURÁLIS ÉS INNOVÁCIÓS MINISZTÉRIUM

Új Nemzeti Kiválóság Program

Abstract

Recent advancements in the literature of international monetary policy spillovers emphasized the role of central bank information effects and monetary policy uncertainty in driving global asset prices around FOMC announcements. This study conducts a comprehensive analysis of global spillover effects using a wide and long panel of FOMC announcements and asset prices responses. We find that the level of monetary policy uncertainty determines how policy shocks spill over on a global scale, especially in advanced countries and through term premia. We show that the Fed information effect is a prominent factor in global spillovers. An interest rate hike associated with the Fed being optimistic about economic fundamentals has expansionary effects on global risk-taking and equity prices, and an information-type hike does not translate into higher long-term bond yields in emerging economies. We find that countries with more financial depth are associated with larger information spillovers to long-term yields, and larger spillovers are present in countries with fixed exchange rate regimes. Our study calls attention to the importance of controlling for information effects and uncertainty in event-study regressions to achieve a better understanding on why international spillovers occur.

JEL classification: E43, E58, F36, F42, G15

Keywords: *International spillovers, Fed information effect, monetary policy uncertainty*

Contents

1. Introduction

FOMC announcements[1] are very important for global financial markets as the Fed's monetary policy is an important driver of the global financial cycle (GFC), as highlighted by e.g. Miranda-Agrippino and Rey (2020). Fed announcements have sizable "spillover" effects on global asset prices, including equity prices, bond yields, exchange rates, and global risk appetite (e.g. Hofman & Takáts, 2015; Brusa et al., 2020; Kearns et al., 2023).

A wide literature investigated various aspects of how US monetary policy surprises affect global asset prices. There are two highly influential recent developments in this research area. First, Lakdawala et al. (2021) shows that changes in monetary policy uncertainty are important contributors to global spillovers around FOMC announcements and neglecting them from event study regressions significantly overestimates the true effects of first moment (target rate) shocks. Related to this, De Pooter et al. (2021) finds that a level of uncertainty about monetary policy preceding an FOMC announcement significantly alters how policy shocks translate into long-term Treasury yields. Secondly, recent works in the central bank information literature have emphasized the dual nature of central bank communication, stressing the idea that central bank announcements involve a "policy" component and an "information" component (e.g. Nakamura & Steinsson, 2018; Jarocinski & Karádi, 2020). The main idea behind this strand of literature, pioneered by Romer & Romer (2000), is that central bank communication affects agents' expectations for two main reasons: by communicating the implementation of unexpected monetary policy measures (the monetary effect), and by communicating its assessment of the economic outlook, which justifies its policy decision (the central bank information effect).

The aim of this study, inspired by the recent works described above, is to conduct a comprehensive analysis of global spillover effects using a wide and long panel of FOMC announcements and asset prices responses. We have two primary questions of interest. First, we investigate how the level of monetary policy uncertainty influences the response of international equity indices, exchange rates and government bond yield to US announcement-day shocks.

[1] Federal Open Market Committee. The FOMC holds eight scheduled meetings annually, as well as additional meetings as needed. At these meetings, it reviews economic and financial conditions, sets monetary policy, and assesses risks to its long-term goals of price stability and economic growth (federalreserve.org, 2024).

Second, we identify “true” US monetary policy shocks and information effects and study whether these two types of shocks translate into global asset prices differently.

Our work adds to the literature in at least two ways. First, as we know no other studies investigate the role of the level of monetary policy uncertainty as a potential mitigating factor of spillovers on a global scale. Second, our study uses a wide and long panel of international asset price data (collected mostly from Lakdawala et al., 2021) to study the international transmission of Fed information effects. Previous studies on this matter were mostly confined to a few advanced economies or solely a set of emerging countries, so this study expands the literature by providing a more clear and more comprehensive picture on the global nature of the Fed information effect and also its potential interaction with uncertainty. For both of these questions we employ the classical event-study framework, similarly to the studies of Albagli et al. (2019), Lakdawala et al. (2021) and Kearns et al. (2023).

Our paper provides at least three new and important findings. We show that high (low) levels of uncertainty mitigate (strengthen) global spillover effects, especially in advanced countries and through term premia. Next, we show that Fed information effect (identified based on Jarocinski & Karádi, 2020) is a prominent factor in global spillovers. An interest rate hike associated with the Fed being optimistic has expansionary effects on global risk-taking and equity prices and does not translate into higher long-term bond yields in emerging economies. Lastly, we argue that the different levels of financial depth of countries may cause the heterogeneity in the size of local yield responses.

Our study relates to several strands of literature. Most of the studies use only first moment changes (monetary policy surprises) to explain changes in financial variables (e.g. Albagli et al. 2019, Hofman & Takáts, 2015, Miranda-Agrippino & Nenova, 2019, Kearns et al., 2023), while an increasing number of studies recognize the importance of controlling for second moment variables (monetary policy uncertainty), such as Lakdawala et al. (2021), De Pooter et al. (2021) and Ying & Wang (2022). Nakamura & Steinsson (2018), Jarocinski & Karádi (2020) and Jarocinski (2022) study the role of information. We also build upon Kearns et al. (2023) who conduct a very detailed analysis of monetary policy spillovers and the country characteristics influencing their magnitude. In section 2, we provide an overview of the related literature and emphasize how our study relates to the objectives of previous works in the field.

In Section 3, we describe our dataset, the identification of information shocks and our measure for monetary policy uncertainty. Section 4 contains a description of our pooled panel regression specifications and addresses methodological considerations. In Section 5 we deliver our results. First, we focus on the effects of standard monetary policy shocks and its interaction with monetary policy, not accounting for information effects (5.1, 5.2). Then we repeat our analysis using "true" monetary shocks (stripped from information effects) and information shocks in Section 5.3 and 5.4. Section 5.5 provides a brief test on how macroeconomic, financial and FX regime characteristics of countries affect their vulnerability to Fed shocks. Section 5.6 provides robustness checks and Section 6 concludes.

2. Related literature

2.1. Monetary policy surprises and information effects

An extensive literature studies the effects of monetary communications of large central banks on domestic and international bond yields and asset prices. Early literature includes Kuttner (2001), Cochrane & Piazessi (2002) and Gürkaynak et al. (2005), who were the first to propose a high-frequency identification of US monetary policy surprises (MPS) to establish causal relationships in an event-study setting. The key assumption of these studies is that responses occurring within the announcement window are solely attributable to these unexpected monetary policy measures. Kuttner (2001) argues that the change of the target Fed Funds rate in a window around an FOMC announcement is not able to disentangle expected and unexpected policy actions. He proposes a measure of monetary policy surprises, i.e. the change in one-year ahead Fed Funds Rate Futures on FOMC announcement days and finds that it can explain a significantly larger share of variation in the changes of financial variables on announcement days than plain Fed Funds Target Rate changes. Hanson & Stein (2015) and Gilchrist et al. (2015) define monetary policy surprises on FOMC days by examining the change in the 2-year on-the-run nominal Treasury yield to capture both short- and long-term surprises. Gürkaynak et al. (2005) reject the hypothesis that announcement day movements in Fed Funds Rate Futures can be sufficiently explained by one factor. Using intraday data and factor analysis, they construct a "target factor" and "path factor" of monetary policy surprises in a 30-min window around the announcement, the latter being indicative of policy measures affecting expectations, such as forward-guidance and communicating policy intentions. Moving forward, Swanson (2021) proposes three factors of surprises (target, path and LSAP surprises) to account for the presence of unconventional monetary policy tools after the global financial crisis.

A relatively new avenue of research, which our research aims to extend, investigates the so-called central bank information effect. Nakamura & Steinsson (2018) argue that Fed announcements affect beliefs not only about the future of the policy rate but also about economic fundamentals. Policy actions by central banks inadvertently reveal private information due to the information asymmetries between the central bank and private agents, as discussed by Romer & Romer (2000). Hansen et al. (2019) identifies three key channels of information effects, including an expectations channel, which entails investors revising their expectations about long-term economic conditions based on the content of the announcement. For example, when investors receive a positive interest rate surprise, they might interpret it as a signal of the central bank's optimism about the economy, making them more optimistic as well (Romer & Romer, 2000). Some recent studies show that controlling for central bank information effects is vital in correctly identifying monetary policy shocks (e.g. Nakamura & Steinsson, 2018; Lakdawala et al., 2021; Hansen et al., 2019; Miranda-Agrippino & Ricco, 2021).

According to economic theory, monetary policy shocks typically lead to a negative co-movement between interest rates and stock prices. An expansionary monetary policy shock (i.e. an interest rate cut) lowers discount rates and raises expected future dividends, resulting in higher stock prices. However, this is not the case in many instances, monetary policy surprises and stock market returns have shown positive co-movement on a considerable number of announcement days. For example, in the dataset described below, 67 of 204 announcements resulted in positive stock market returns in the S&P 500. This puzzling behaviour of stock returns is clearly not attributable to true monetary policy shocks, so there must be some information element at play. Jarocinski & Karádi (2020) use this assumption as their starting point to identify information shocks.

Jarocinski & Karadi (2020) directly estimate the information effect and decompose standard monetary policy shocks into “true” monetary policy shocks and information shocks, using stock market data and QR decomposition, which procedure is described in detail in Section 3. Jarocinski (2022) demonstrates, through event studies and vector autoregressions, that central bank information effects play a significant role in transmitting monetary policy spillovers between the USA and the Eurozone. Around Fed policy announcements both “true” monetary shock and information shocks play a crucial role in generating spillovers to Bund yields, while in the case of ECB announcements, only information effects spill over the Atlantic and reflect in US Treasury yields. Interest rate hikes by the ECB are interpreted as positive news, resulting in eased, rather than tightened, US financial conditions and economic expansion. Interestingly he also finds that the transmission induced by information effects is highly similar to that of regular macroeconomic news releases.

2.2. Monetary policy uncertainty

Our research also intersects the literature on the spillover effects of monetary policy uncertainty (MPU). The spillover-literature has predominantly concentrated on changes in the level of the Federal Reserve's policy rate or futures rates (known as first moment change) to quantify the effects of announcements. However, some recent studies highlighted the importance of controlling for uncertainty around announcements and measuring the change in perceived MPU on FOMC days. The significance of uncertainty as an additional aspect of FOMC announcements becomes evident when considering the August 2011 FOMC meeting (Lakdawala et al., 2021). This meeting marked the introduction of explicit calendar-based forward guidance, specifying low rates until "mid-2013". While traditional first-moment monetary policy measures – like changes in futures rates up to one year ahead – remained largely unchanged, the announcement led to a significant reduction in market-perceived uncertainty, which then had significant effects on long-term yields both domestically and internationally. This is also confirmed by Bauer et al. (2022) who argues that the uncertainty channel of transmission is especially powerful when interest rates are constrained by the zero lower bound after 2009. Lakdawala et al. (2021) find that including second moment changes in the event-study regressions reduced the coefficient of the first moment MPS by nearly 50% in some instances, and the model saw a noticeable increase in its explanatory power.

How to measure monetary policy uncertainty? The most common measures of uncertainty include VIX and EPU. VIX is a volatility index derived from S&P 500 options and captures both stock market uncertainty and the variance risk premium (Whaley, 2000). Economic Policy Uncertainty (EPU) is constructed based on news articles from major news sites, measuring their uncertainty content by counting the number of words conveying uncertain sentiment (Baker et al., 2016). Although these two measures are proven to be good indicators of uncertainty, they capture a broader sense of uncertainty than what follows from monetary policy actions. The VIX and EPU are highly affected by monetary policy actions (see e.g. Bekaert et al. 2013), but central banks are only able to control the path of the policy rate and how uncertain the market is about the path of the future short-term interest rates. Therefore, several measures of monetary policy specific uncertainty were proposed. Swanson & Williams (2014), and De Pooter et al.

(2021) use the width of the market-implied distribution for the expected federal funds rate at the one-year horizon, as inferred from interest rate derivatives prices. News-based approaches are also present: Husted et al. (2020) and Baker et al. (2016) both constructed a monetary policy specific indicator based on news articles, however they are only available at lower frequencies (weekly/monthly), which are not suitable for event studies. In this paper, following Lakdawala et al. (2021) we use the novel MPU metric developed by Bauer et al. (2022) derived from Eurodollar futures and options prices, termed the market-based conditional volatility of the future short-term interest rate. This measure, being model-free and derived from highly liquid interest rate derivatives, is accessible on a daily basis, and enables the use of event studies. Their methodology is briefly described in the next section.

How does monetary policy uncertainty affect the transmission mechanism? The related literature has so far been scarce on this question, and according to our literature review, no studies focus on the interaction between uncertainty and information shocks. De Pooter et al. (2021) and Tillman (2020) control for the level on monetary policy uncertainty on announcement days when investigating the effect of monetary policy shocks on long-term Treasury yields. Although the two papers use different uncertainty measures, they both observe that at times of policy tightening (easing), the increase (decrease) in long-term bond yields is less pronounced if there is high uncertainty about the policy at that moment. The dampened response in yields mainly results from a sharper decline in term premia, especially during periods of heightened policy uncertainty. As for the mechanism behind, De Pooter et al. (2021) shows, by using data on the net positions of primary dealers and speculators, that investors adjust their positions more when monetary policy uncertainty is low than when uncertainty is high. One explanation for this observation is that investors exhibit greater complacency during periods of low monetary policy uncertainty. Consequently, they may be more willing to undertake larger or riskier positions. When confronted with an unexpected monetary policy event, investors may need to swiftly make substantial adjustments to mitigate losses or reduce risk exposure, thereby influencing changes in risk premiums (De Pooter et al., 2021). Ying & Wang (2022) measures the uncertainty that is endogenously created by monetary policy communication during an announcement. They show that uncertainty arising from FOMC announcements affects the transmission of policy shocks to long-term bond yields. Specifically, contemporaneous uncertainty moderates the transmission of forward guidance shocks, but it does not influence Fed funds rate and Large Scale Asset Purchase (LSAP) shocks. The literature on the international transmission of uncertainty is overviewed in the following subsection.

2.3. Monetary policy and the global financial cycle

In a domestic context, monetary policy influences prices and quantities by shaping local financial conditions. Specifically, it guides the rates of return on a diverse set of assets, including interest rates for various maturities and borrowers. Then changes in financial conditions trigger responses in domestic consumption, investment, and firms' business decisions, ultimately affecting the rate of inflation.

In the context of international integration and interconnectedness through trade and financial markets, the impact of domestic monetary policy goes beyond national borders. Actions taken to influence the domestic economy through monetary policy lead to cross-border effects and ”spill over” to the global stage. Moreover, these spillovers seem to be so large in recent decades, that interest rates tend to move together closely in advanced and emerging market economies, even when countries are at different stages of the business cycle (Hofman & Takáts, 2015). Enhanced financial and economic integration presents significant challenges to smaller economies, when it comes to maintaining autonomy and achieving financial conditions that are aligned with domestic macroeconomic positions. Various studies, such as those by Rey (2015), Passari & Rey (2015), Miranda-Agrippino and Rey (2020) belong to this ongoing discourse on the possibilities of monetary policy autonomy.

Yield curves are shaped by a multitude of domestic and international factors. Short-term rates are more influenced by domestic policy decisions (see e.g. Obstfeld, 2015; Miyajima et al., 2014), while central banks usually have limited control over long-term rates. This is due to the fact that long-term government bond yields not only mirror current and anticipated short-term rates but also incorporate risk premiums, including term premia, and occasionally credit risk premia (Kearns et al., 2023). It is therefore a common practice to decompose yields into “expected” and “term premium” components and investigate the spillover to these variables alongside overall yield responses. The expected component only encompasses the expected future path of the policy rate, so this yield would be present in risk-neutral conditions. A hike in the expected component of a long-term rate therefore means that the market expects the short rate to rise in the future. The term premium reflects the compensation investors seek for bearing the risk of interest rate changes over the life of the bond (Adrian et al., 2013). In this concept, the term premium of bond yields encompasses various types of risk premia, including credit risk premium (which accounts for a considerable part of yield in emerging countries) and term premium in a narrower sense.

The two components are not observable and therefore need to be estimated from a sufficiently wide and long panel of yield curve data. Several techniques were proposed to dissect nominal yields into these two components. Ang & Piazessi (2012), Kim & Wright (2005) and Dai & Singleton (2000) use computationally heavy maximum likelihood estimations to model the term structure and arrive at estimates. The works of Joslin et al. (2011) and Adrian et al. (2013) provided alternative and more efficient solutions to replace hands-on ML methods, by replacing parts of the procedure with linear regressions. Bauer et al. (2012) makes use of the procedure of Joslin et al. (2011) and provides an indirect inference approach to reduce bias in the estimation of parameters. In this study, we rely on the estimates of Joslin et al. (2011), corrected by the approach of Bauer et al. (2012).

A vast literature has focused on analysing the international spillover effects of monetary policy actions of large central banks. One strand of literature focuses on the spillover effects on output and prices using VAR models (e.g. Georgiadis, 2016; Potjagailo, 2017), while others use both event study and VAR models to study how monetary shocks spill over to bond markets and influence financial conditions all over the world (e.g. Ehrmann et al., 2011; Albagli et al., 2019; Gilchrist et al., 2019; Kearns et al., 2023). Our study belongs to the latter category, focusing on the global financial effects of US monetary policy using an event-study approach. Related to our study, Hofman & Takáts (2015) estimate a fixed-effects panel regression on a dataset containing 30 emerging and advanced countries between 2000 and 2014. They find significant spillovers of US interest rates to both short-term and long-term interest rates abroad, with the latter showing twice the size in magnitude than the former. This is partially in line with Obstfeld (2015) and Miyajima et al. (2014), who only find significant spillover on the longer end of the yield curve, suggesting that smaller central banks are still able to control domestic short-term financial conditions. The change in VIX also significantly affects yields internationally, with higher VIX resulting in higher yields abroad (Hofman & Takáts, 2015). The most comprehensive analysis in recent years was conducted by Kearns et al. (2023), who use target, path and “long rate” surprises (similar to Swanson (2019)) from four major central banks (Fed, ECB, BoJ, BoE) and a panel of 47 advanced and emerging countries to estimate international spillovers to sovereign bond yields. They find significant predominance of spillovers in long-term interest rates over short-term rates. The Fed consistently stands out in terms of global significance, being the only central bank that has significant spillover effects to both advanced and emerging countries. ECB spillovers have increasing prominence over time, but its effect is mostly confined to advanced economies. Albagli et al. (2019) finds on a dataset of 12 emerging and 12 developed economies that spillovers work through different channels in the two sets of countries. In developed countries the response is concentrated in risk-neutral rates (expected component), while term premia are more responsive in emerging economies. They propose a possible mechanism for this phenomenon based on the different vulnerability of advanced and emerging countries to exchange rate fluctuations and the subsequent policy responses.

Lakdawala (2019), Bhattarai et al. (2020) and Chiang (2021) investigates the effect of US monetary policy uncertainty on stock markets in a limited set of countries. Their findings point to the same direction: US monetary policy uncertainty decreases asset prices and increases spreads in emerging countries, with an amplified effect since the global financial crisis. Our paper strongly builds upon the work of Lakdawala et al. (2021), who conduct an extensive analysis on 47 emerging and advanced economies between 1995 and 2019. They demonstrate that fluctuations in uncertainty about the anticipated path of monetary policy represent a significant supplementary aspect of spillover effects on global bond yields, and omitting MPU from the event study regression leads to a significant overestimation of the first moment effect. An increase in MPU raises bond yields and lowers equity prices in both advanced and emerging economies, which is consistent with standard asset pricing theory. An increase in the conditional volatility of bond returns (signalled by an MPU shock) in theory leads to an increase in risk premia and excess returns. However, they argue that spillovers are driven by different mechanisms in the two sets of countries. In advanced countries MPU shocks affect term premia and bonds of countries that are more substitutable with US bonds receive larger spillovers, consistently with an international portfolio balance channel, also proposed by Alpanda & Kabaca (2020). In emerging countries, however, the expected component of bond yields is affected, and after an MPU increase investors flee the countries that are perceived more risky, consistent with a flight to safety channel, just as in Miranda-Agrippino & Rey (2020) and Ahmed (2023). Comparing the works of Albagli et al. (2019) and Lakdawala et al. (2021) it is worth noticing that first moment and second moment shocks affect the expected and term premium components of yields differently. While first moment shocks spill over through expected future short-rates, MPU affects term premia in advanced countries, while the pattern is reversed in emerging economies.

There are few papers which goals closely align with that of our study: to move beyond standard monetary shocks and investigate the information effect embedded into monetary surprises in an international setting. Franz (2020), Gürkaynak et al. (2021) and Pinchetti & Szczepeniak (2023) investigate the role of information shocks in responses of exchange rates and find that the dollar generally depreciates instead of appreciating after a hike that signals positive information. Pinchetti & Szczepeniak (2023) connect this phenomenon to an increase in investors' risk appetite and capital inflows into emerging markets. Hoek et al. (2022) and Camara (2021) examine wider effects of Fed information shocks on emerging markets. Hoek et al. (2022) use data of several assets from 20 emerging countries, with a methodology simpler than ours, using the "poor man's" identification strategy of information shocks proposed by Jarocinski & Karádi (2020). They find that changes in Treasury yields resulting from monetary news exert significantly greater effects on emerging market economy (EME) asset prices compared to yields driven by information shocks (which are in most cases insignificant), and these effects are more dependent on the vulnerability of the countries in the case of monetary shocks. On the other hand, Camara (2021) shows, using an SVAR methodology on 18 emerging and advanced countries, that US information shocks (defined as in Jarocinski & Karádi (2020)) are a significant and non-neglectable factor of global spillovers. A US tightening resulting from a pure monetary policy shock typically triggers an economic recession, currency depreciation, and tighter financial conditions abroad. Conversely, a tightening of US monetary policy stemming from the FOMC's positive disclosure about the US economy generally leads to economic expansion, currency appreciation, and looser financial conditions. However, none of the above studies addresses the potential interplay between MPU and information shocks, which our study aims to focus on, using a wider panel of countries than any of the related works.

2.4. Why do international spillovers occur?

Several studies explore the mechanism through which the global co-movement in yields occurs. The literature of international transmission channels is diverse and highly intertwined with the literature that investigates conditionality of spillovers on country characteristics. For example, Kearns et al. (2023) study how country characteristics and fundamentals affect countries' exposure to spillovers. They categorize the causes of spillovers as either macroeconomic, exchange rate and financial links. In Section 5.5 we follow the same categorization when investigating the role of country characteristics in information and monetary policy spillovers. Now, we provide a short overview of the concepts of these links and how we expect them to influence spillover effects.

Macroeconomic links. Monetary policy announcements in the originating economy can reveal new economic news, as discussed by Nakamura and Steinsson (2018), which can lead to investors adjusting their expectations regarding macroeconomic conditions, trade flows, the state of the business cycle and future policy rates in the recipient country due to the interconnectedness between the two economies. Due to their nature, we can expect information shocks to cause a greater extent of spillover effect in countries which are more macroeconomically linked to the originator economy. The macroeconomic links channel also determines how real variables, such as output and trade balance respond to foreign monetary shocks. The well-known Mundell-Fleming framework underpins the interaction between small open and large open economies (see e. g. in Obstfeld & Rogoff (1996); Rogoff (2002) and the critique by Rey (2016)), but their implications are out of scope of this study.

Financial links. Financial spillover channels have been in centre of attention in recent years. This may be due to the fact after the GFC expansionary monetary policies by major central banks resulted in several years of a very favourable, never-before-seen financial environment on a global scale. A growing body of research highlights the significance of a ”global financial cycle” in influencing capital flows worldwide, which cycle is characterized by the synchronized movement of gross capital flows, credit conditions, and asset prices across various countries, as outlined by Rey (2015) and Passari & Rey (2015). Rey (2016) argues that the primary driver of this cycle is the monetary policy conducted by the Fed. The financial openness of a country could determine what extent it receives spillovers. For example, globally important financial intermediaries are sensitive to US shocks and may need to deleverage and reduce their lending when their financial constraints become tighter (Zorzi et al., 2021). The significant role of this so-called international credit channel in driving financial conditions in EMEs has been confirmed both in conventional (e.g. Miranda-Agrippino & Rey, 2020) and unconventional periods (e.g. Rogers et al., 2018). Additionally, investors may perceive bonds across different countries as imperfect substitutes, creating a connection where changes in bond term premia in one country can impact those in another (portfolio balance channel – see e.g. Lakdawala et al., 2021, Alpanda and Kabaca, 2020). Also, changes in US financial conditions and policy uncertainty may affect the willingness of market participants to take on risk exposures (risk-taking channel, coined by Borio & Zhu (2012)). Changes in US investor risk aversion have implications for capital flows and exchange rate dynamics. Investments in emerging economies, known for their higher risk-return profiles, are especially impacted (Ahmed & Zlate, 2014). Pinchetti & Szczepeniak (2023) shows evidence that US information shocks also effect EME asset prices through the risk-taking channel.

We can expect all these financial channels to play a stronger role in countries that are more connected to the global financial system, the hypotheses we test in Section 5.5. However, we do not undertake the empirically difficult problem of disentangling these specific channels from each other.

Exchange rate regime. Exchange rate regimes also determine the extent of spillovers received by a country. For example, if a country's exchange rate can adjust freely after a US interest hike, it is likely to depreciate against the dollar. This depreciation plays a stabilizing effect, so smaller adjustments are required in interest rates to recover interest rate parity. However, the more managed (or even pegged) a currency is relative to the dollar, the more domestic interest rates have to bear the spillover effects. Assuming an open capital account, a country implementing a peg must keep its interest rates in line with those of the larger economy to prevent too large capital flows (Shambaugh, 2004). However, this theoretical implication is not entirely confirmed to be present in empirics. Hofman & Takáts (2015) find no significantly larger spillovers to peggers, while Kearns et al. (2023) find some evidence supporting the theory. The nature of the exchange rate channel is also determined by how foreign central banks choose to react to a US MP shock. Albagli et al. (2019) shows by extending the Mundell-Fleming model with long-term rates that spillovers to EMEs and AEs may differ due to different policy reactions. EMEs tend to perform FXI to mitigate exchange rate differentials, which reinforces capital flows as adjustments in the exchange rate are subdued. The financial spillovers are mostly concentrated in the term premium part of the yield curve due to effect of capital flows. AEs adjust in a manner consistent with freely floating regimes, resulting in stronger exchange rate adjustment, lower capital inflows and short-rate expectations following those of the larger economy. In Section 5.5 we also add to the debate by investigating the role of exchange rate regimes on information and monetary policy spillovers.

3. Data

In this section, we describe the data used in the analysis of international spillovers of US monetary policy. Our dataset is primarily based on the dataset made public by Lakdawala et al. (2021). The original data were downloaded from Bloomberg. The dataset includes 204 FOMC announcements between 1995 January and June 2019[2]. The end of the sample is limited due to the availability of yield curve data[3].

We are interested in measuring the response of key asset prices to US monetary policy shocks in a wide range of countries.[4] Our dependent variables are two-day changes in 3-month, 2-year and 10-year government bond yields (measured in local currencies), stock return and exchange rates vis-à-vis the US dollar. Stock returns are expressed as two-day changes in the price of the main composite stock market index of the respective countries. Exchange rates are expressed in units of foreign currency per US dollar. Therefore, an increase in the exchange rate indicates a depreciation of the foreign currency relative to the US dollar.

Following Lakdawala et al. (2021), Albagli et al. (2019) and Brusa et al. (2020), two-day changes are used to account for time zone differences.[5] We investigate spillovers to stock prices and exchange rates in 28 advanced and 16 emerging economies. Data on government bond yields are available for 22 advanced and 8 emerging economies. The panel is unbalanced, due to lack of reliable data in some countries in certain periods. Summary statistics of the variables in the dataset are available in Table 1. The data coverage including the list of countries and their classification is detailed in the Appendix.

[2] The 17/9/2001, 11/03/2008, 10/8/2008 announcements were excluded, as several central banks held joint announcements on these days.

[3] The majority of works in the literature work with data until 2019, because that is the end of the high-frequency yield curve dataset of Gürkaynak et al. (2022) – e.g. Jarocinski (2022), Kearns et al. (2023), Pinchetti & Sczepeniak (2023).

[4] The key assumption we make is that US monetary policy shocks are the primary common driver of asset price changes within the two-day window. This is a very common practice in the literature. To support this assumption, after dropping the dates mentioned above, none of the ECB, BoJ and BoE announcements occurred on the same day as an FOMC meeting in the investigated period (Brusa et al., 2020).

[5] Some markets are not open during an FOMC announcement. These markets can only react to monetary news the day after the announcement. Using a two-day change in asset prices accounts for these time-zone differences. The two-day change is calculated as the difference between the asset's closing price on the day after the announcement and the closing price on the day before the announcement.

Table 1. Summary statistics

	Mean	Std.	Min	Max	N	Source
US policy variables						
MPS_{total}	-0.013	0.066	-0.328	0.208	204	Lakdawala et al. (2021)
MPS_{true}	-0.012	0.050	-0.192	0.161	204	Own calculation
CBI	-0.002	0.043	-0.156	0.11	204	Own calculation
$\mathrm{MPU}_{\mathrm{level}}$	0	0.325	-0.526	0.772	204	Bauer et al. (2022)
ΔMPU	-0.495	1	-4.964	2.065	204	Bauer et al. (2022)
International asset prices						
Response of 3-month government bond yield						
Advanced	-0.009	0.103	-2.467	2.210	4154	Lakdawala et al. (2021)
Emerging	-0.004	0.167	-1.970	1.060	1270	Lakdawala et al. (2021)
Response of 2-year government bond yield						
Advanced	-0.008	0.095	-1.276	2.044	4154	Lakdawala et al. (2021)
Emerging	-0.012	0.163	-3.140	1.044	1270	Lakdawala et al. (2021)
Response of 10-year government bond yield						
Advanced	-0.009	0.084	-0.976	0.409	4154	Lakdawala et al. (2021)
Emerging	-0.018	0.179	-2.188	0.813	1270	Lakdawala et al. (2021)
Response of exchange rates						
Advanced	0.030	0.930	-10.047	7.103	5709	Lakdawala et al. (2021)
Emerging	0.023	1.199	-13.734	30.763	3130	Lakdawala et al. (2021)
Response of stock returns						
Advanced	0.191	1.982	-12.208	13.863	5129	Lakdawala et al. (2021)
Emerging	0.289	2.401	-18.414	18.411	3102	Lakdawala et al. (2021)

The table provides summary statistics of our main variables used in the panel regression. The dataset includes 204 FOMC announcements between 1995 January and June 2019. Total policy shocks are rescaled to have standard deviation equal to that of the 1-year ahead 3-month eurodollar future instrument. True monetary shocks and information shocks are calculated by decomposing total shocks based on Jarocinski & Karádi (2020). The $\mathrm{MPU}_{\mathrm{level}}$ variable was centered around zero. The ΔMPU variable was scaled to have unit standard deviation for easier interpretation. International government bond yield data are available in 22 advanced and 8 emerging economies and measured in percentage points. Changes in stock returns and exchange rates vis-à-vis the US dollar are available in 26 advanced and 16 emerging economies and are measured in percentages. All the data on international asset prices are two-day changes around the corresponding FOMC announcement.

To measure monetary policy and central bank information shocks, we build upon Jarocinski & Karádi (2020). The surprise-identification procedure consists of three steps:

- First, we calculate a total interest rate surprise. Following Gürkaynak et al. (2005) and Lakdawala et al. (2021), this is done by extracting the first principal component of the two-day changes in 1, 2-, 3-, and 4- quarters ahead eurodollar futures on the 3-month

LIBOR rate.[6] Jarocinski & Karádi (2020) originally work with a narrower window, but we prefer to use a two-day window, as our international asset prices are also measured is two-day changes. We obtain the scores of the first principal component from Lakdawala et al. (2021), who find that it explains 90% of the variation in the four instruments. We rescale the first principal component to have its mean and standard deviation equal to those of the 1-year ahead instrument. We label this variable MPS_{total}, as it reflects a total policy surprise that includes the information component as well as the "true" monetary policy surprise component.

- Next, we calculate the change in the S&P 500 index in the same event window (Δs). After a contractionary (expansionary) surprise, stock prices are expected to drop (rise) according to standard economic theory. However, interest rate surprises and stock price surprises showed same-sign responses on almost 1/3 of the announcement days in our dataset. Jarocinski & Karádi (2020), building upon Romer & Romer (2000), interpret these same-sign responses as a sign of potential information shocks: a contractionary (expansionary) policy surprise might be interpreted as a sign of the central bank being bullish (bearish) about the economy, which makes the investors more bullish (bearish) as well, as reflected in the response of the stock market. Following this hypothesis, we use stock price surprises to extract the information component from the total policy surprise.
- Finally, we decompose MPS_{total} into two components: a "true" monetary policy surprise ($\mathrm{MPS}_{\mathrm{true}}$) and a central bank information effect surprise (CBI). A simple identification strategy proposed by Jarocinski & Karádi (2020) is to set MPS_{true} (CBI) equal to MPS_{total}, whenever the stock market shows an opposite (same) sign change as MPS_{total} , and set the other component to zero.

  A more delicate approach is to apply QR decomposition according to eq. (1) below. Here $\mathrm{M} = (\mathrm{MPS}_{total}\,, \Delta\, s)$ is a $T\ \times 2$ matrix, $U = (\mathrm{MPS}_{true}\,, \mathrm{CBI})$ is a $T\ \times 2$ matrix, and $\mathrm{MPS}_{\mathrm{true}}$ and CBI are orthogonal. The C matrix represents how the two components affect the two markets. The first column contains the restriction that the two components add up to the total policy surprise. The second column demands that the two components affect stock returns through opposite signs. There are many elasticities (c_{CBI} and $c_{\mathrm{MPS}_{true}}$) which satisfy these restrictions and yield different times series of $\mathrm{MPS}_{\mathrm{true}}$ and

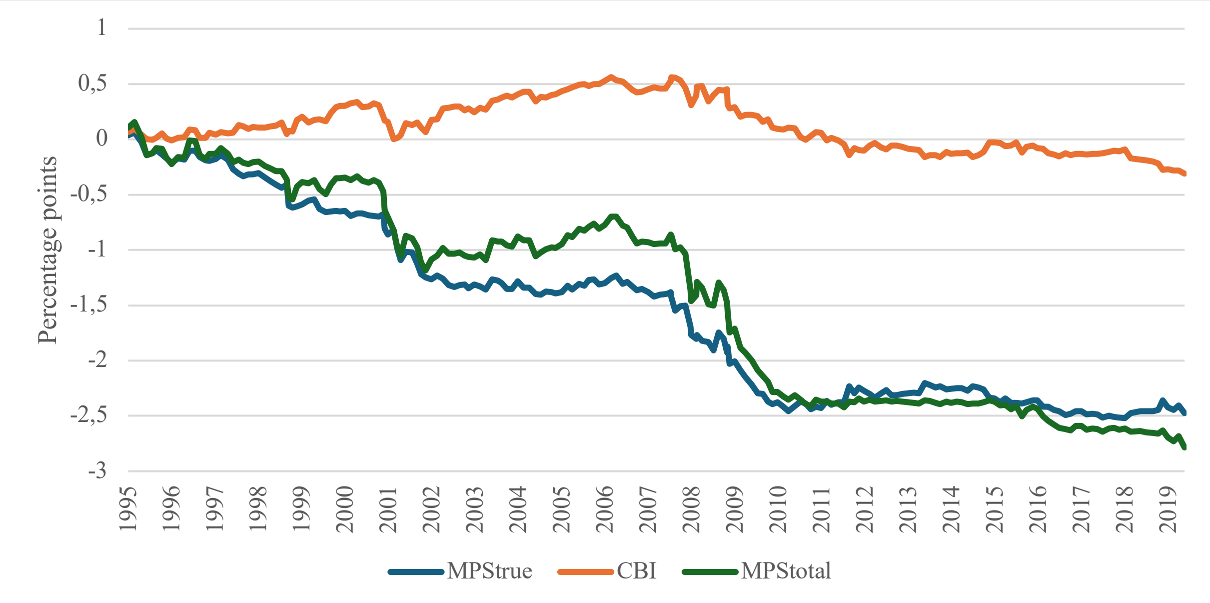
[6] The two-day changes are constructed in the same manner as we did in international asset prices: the difference between the asset's closing price on the day after the announcement and the closing price on the day before the announcement.

CBI. Jarocinski & Karádi (2020) argue for using the median of these admissible rotations and show that using different rotation angles does not qualitatively affect their results. Therefore, we also stick with the median rotation and use the simple identification approach as a robustness check[7].

$$M = UC, \qquad U'U \text{ is a diagonal matrix} \qquad \text{and } C = \begin{pmatrix} 1 & c_{MPS_{true}} < 0 \\ 1 & c_{CBI} > 0 \end{pmatrix} \tag{1}$$

The obtained shocks are plotted cumulatively on Figure 1.

Figure 1. Cumulated announcement-day US policy shocks



The figure plots the cumulated values of announcement-day US "total" monetary policy shocks (green), US "true" monetary policy shocks (blue) and central bank information shocks (orange) in our full sample. Total policy shocks are rescaled to have standard deviation equal to that of the 1-year ahead 3-month eurodollar future instrument. True monetary shocks and information shocks are calculated by decomposing total shocks based on Jarocinski & Karádi (2020).

We can conclude that in the sample period "true" MP shocks were the primary factor in easing financial conditions. Even though CBI shocks had near-zero mean in the long run, they are an important part of total MPS: CBI shocks' standard deviation is only marginally lower than that of true MP shocks (Table 1). Our time series of shocks show a slightly different picture than that of Jarocinski (2022), who find that CBI shocks strongly contributed to lowering interest rates. Since our methodology is the same, our wider event-window and slightly different future instruments explain the difference. Also, our decomposition yield expected and intuitive results. Table 2 shows that unlike MP shocks, a positive CBI shock is expansionary to foreign stock

[7] The decomposition was carried out using the publicly available replication code from Marek Jarocinski's website: https://marekjarocinski.github.io/.

markets and does not lead to the appreciation of the dollar. True MP shocks seem to affect foreign stock markets to a much larger extent than regular total MP shocks. This is because the latter is likely contaminated with the central bank information effect which works towards the opposite direction.

Following Lakdawala et al. (2021), we choose the measure of Bauer et al. (2022) as our indicator for US monetary policy uncertainty (MPU). Daily data on MPU are available on the website of Michael D. Bauer[8]. They use the prices of call options and put options on eurodollar futures to calculate the market-based conditional variance of 1-year ahead 3-month LIBOR rate[9]. The level of monetary policy uncertainty ($\mathrm{MPU}_{\mathrm{level}}$) on announcement days in our sample is plotted on Figure 2. Figure 2 tells us that the level of uncertainty around the future policy rates has been below its historic average since 2011. This coincides with the period of the Fed placing more emphasis on new forms of policy communication (e.g. quantitative forward guidance) and suggests that the Fed was successful at mitigating uncertainty.[10] Consistent with De Pooter et al. (2021) lower $\mathrm{MPU}_{\mathrm{level}}$ is associated with a higher response of global yields (Table 2). Global stock markets generally respond more strongly when uncertainty is high and shrink when MPU decreases, which are consistent with standard financial theory.

Table 2. Pearson correlations between the main dependent and independent variables

	MPS_{total}	MPS_{true}	CBI	$\mathrm{MPU}_{\mathrm{level}}$	ΔMPU
change in 3-month yield	0.13***	0.11***	0.11***	-0.08***	0.11***
change in 2-year yield	0.26***	0.22***	0.24***	-0.08***	0.24***
change in 10-year yield	0.24***	0.17***	0.23***	-0.04***	0.32***
change in exchange rates	0.16***	0.23***	0.01	-0.07***	0.06***
change in stock prices	-0.10***	-0.36***	0.26***	0.11***	-0.12***

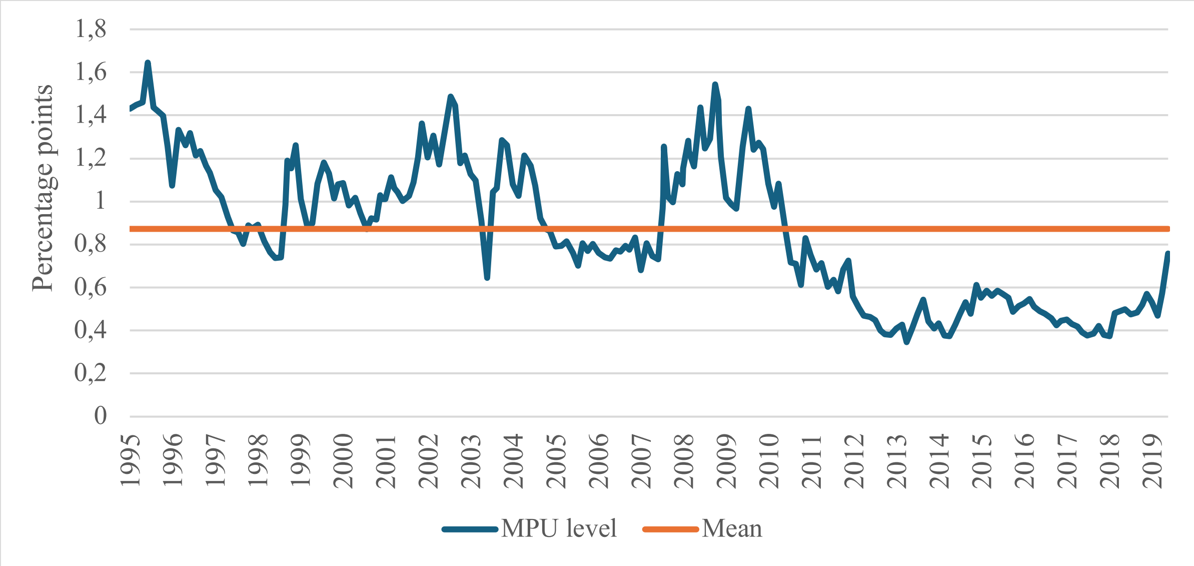
The values in the table indicate Pearson correlation coefficients between two (a row and a column) variable. Observations of changes in asset prices include both advanced and emerging economies and every announcement where data are available in our sample. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

Figure 2. Level of US monetary policy uncertainty before FOMC announcement days

[8] https://www.michaeldbauer.com/research/

[9] Options on the LIBOR rate are used instead of federal funds options due to the lack of reliable available for the latter. However, Bauer et al. (2022) argue that the LIBOR-OIS spread has been consistently stable, expect for one year during the financial crisis, therefore the uncertainty around LIBOR generally provides a good proxy for uncertainty around the federal funds rate.

[10] However, interest rates have been considerably lower after 2008 than in previous years and were at near-zero levels between 2008 and 2014 (the so-called Zero Lower Bound period), which might also contribute to a decline in the variance of market expectations. Therefore, it is important to control for the current level of US Treasury yields in our regressions, as we do so.



The figure displays the closing level of US monetary policy uncertainty on the day preceding FOMC announcement days. MPU is obtained from Bauer et al. (2022) and is measured in percentage points.

In our regression specifications (Section 4, Eq. 2 and Eq. 3) we use both the closing level of MPU on the day before the announcement (MPU_{level}), and the two-day change in MPU around the announcement, calculated as the difference between the closing level of MPU on the day after and before the announcement day (ΔMPU). Although it is not our main variable of interest, the reason for including ΔMPU in regressions is that it significantly affects global yields and leaving it out leads to an overestimation of first moment coefficients (Lakdawala et al., 2021). MPU_{level} is centered to 0 by subtracting its historic average for better interpretability. ΔMPU is rescaled to have unit standard deviation. Also, Bauer et al. (2022) emphasizes that MPU_{level} (i.e. uncertainty about the future short rate) is not only driven by uncertainty around the future stance of monetary policy, but also by uncertainty about the future economic outlook. To account for other types of macroeconomic uncertainty, we also control for the level of VIX in our regressions. Data on VIX were collected from Bloomberg.

We obtain the expected and term premium component of international yields from Lakdawala et al. (2021) to study more closely how different policy shocks spill over on a global level. Lakdawala et al. (2021) estimate the two components by the approach of Joslin et al. (2011) and apply the bias correction method of Bauer et al. (2012). As described in the previous section, the expected component of the yield curve encompasses only the expected future path of the policy rate, while the term premium reflects various types of risk premia i.e. the premia that investors receive for bearing the risk of interest rate changes over the life of the bond (Adrian et al., 2013).

4. Methodology

We apply event study analysis and run several panel regressions with different dependent and independent variables. The key assumption we make here is that US monetary policy shocks are the primary common driver of asset price changes within a two-day window around the FOMC announcement. Our main equation of interest are Equation 2 and Equation 3, but we run several other specifications, gradually entering independent variables into the equation. Equation 2 focuses on the effects of standard monetary shocks, identified as the first principal component of the two-day changes in 1, 2-, 3- and 4-quarters ahead eurodollar futures on the 3-month LIBOR rate based on Lakdawala et al. (2021). Equation 3 investigates the separate effects of true monetary policy shocks and information shocks, identified based on Jarocinski & Karádi (2020). Δy_{it} denotes our main international asset prices of interest: the two-day changes in government bond yields, exchange rates and stock returns. We standardize all outcome variables to have unit standard deviation in every country. This is done to account for the substantial between-country heterogeneity in the scale of responses. For example, as apparent from Table 1, emerging countries generally show larger and more heterogenous responses than advanced countries. Ω_t contains control variables included in every specification: the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement, following De Pooter et al. (2021). The former is sometimes marginally significant, while the level of VIX is almost never a powerful explanatory variable. The coefficients of control variables are not reported due to space considerations.

$$\Delta y_{it} = \alpha + \beta_1\, MPS_{total,t} + \beta_2\, MPU_{level,t-1} + \beta_3\, MPS_{total,t} \times MPU_{level,t-1} + \\ + \beta_4\, \Delta MPU_t + \gamma\, \Omega_{t-1} + e_{it} \tag{2}$$

$$\Delta y_{it} = \alpha + \beta_1\, MPS_{true,t} + \beta_2\, CBI_t + \beta_3\, MPU_{level,t-1} + \beta_4\, MPS_{true,t} \times MPU_{level,t-1} + \\ + \beta_5\, CBI_t \times MPU_{level,t-1} + \beta_6\, \Delta MPU_t + \gamma\, \Omega_{t-1} + e_{it} \tag{3}$$

We find no evidence for the necessity of group/time fixed effects and random effects in the majority of our models after conducting F-tests and Breusch-Pagan-Lagrange Multiplier tests. For comparability we stick to pooled panel regressions in every case and estimate by OLS, similarly to Kearns et al. (2023) and Lakdawala et al. (2021). The majority of the models' residuals have unfavourable properties, including cross-sectional dependency (testified by

Pesaran test) and serial correlations (Breusch-Godfrey test). We therefore cluster our standard errors both by country and time dimension to guarantee the resolution of both issues and arrive at sufficiently robust standard errors. In the cases where the presence of serial correlation is not confirmed by Breusch-Godfrey test, the two-way clustered standard errors yield slightly larger standard errors than if standard errors had been clustered only by the group dimension. However, we apply two-way clustered standard errors in every case to facilitate comparability and reduce the risk of type I errors.

5. Results

5.1. Response of bond yields to standard policy shocks

We start by investigating the response of government bond yields to standard policy shocks (MPS_{total}) and answer the question whether the level of monetary policy uncertainty (MPU_{level}) plays a role in the global spillovers of US monetary policy. Table 3 shows our full-sample estimates of the responses at three different parts of the yield curve. As noted above, international yields were normalized to have unit standard deviation in each country. We run 3 different specifications (Reg. 1-3). Reg. 1 contains MPS_{total} and the above-mentioned control variables as independent variables. MPU_{level} and its interaction with MPS_{total} enter in Reg. 2. In Reg. 3, we also include ΔMPU.

First, we notice that the short end of the yield curve is only influenced my first moment shocks.[11] The magnitude of spillovers (coefficients and R^2) is substantially smaller at the short end of the yield curve than at the longer end. This is consistent with Hofmann & Takáts (2015), Obstfeld (2015), Kearns et al. (2023) and suggest that countries have been able to retain control over their short-term financial conditions. Interpreting the coefficients of Reg. 3 in Table 1, a 10-basis point policy tightening on average results in a positive response of 2.4 basis points in 3-month yields, 4.8 basis points in 2-year yields and 4.2 basis points in 10-year yields. These estimates fit into the literature, although slightly larger than those of Albagli et al. (2019), who also use 2-day changes as shock variables but on a different set of countries.

Table 3. Response of international yields to standard monetary policy shocks

Total panel

[11] In Table A1 in the Appendix, we show that this result appears because advanced countries comprise the majority of the dataset. Short yields in emerging countries do respond to MPU shocks, consistently with Lakdawala et al. (2021).

	Reg 1	Reg 2	Reg 3
a) Response of 3-month local-currency bond yield			
MPS_{total}	2.17***	2.05***	2.00***
	(6.40)	(4.82)	(4.47)
MPU_{level}		-0.20	-0.19
		(-1.03)	(-1.01)
$\text{MPS}_{total} \times \text{MPU}_{level}$		0.26	0.28
		(0.09)	(0.20)
ΔMPU			0.01
			(0.21)
R^2 (p-value of F-test)	0.04 (0.00)	0.04 (0.00)	0.04 (0.00)
b) Response of 2-year local-currency bond yield			
	Reg 1	Reg 2	Reg 3
MPS_{total}	4.84***	4.93***	4.34***
	(10.70)	(8.64)	(7.41)
MPU_{level}		-0.11	-0.07
		(-0.6)	(-0.36)
$\text{MPS}_{total} \times \text{MPU}_{level}$		-0.70	-0.47
		(-0.26)	(-0.17)
ΔMPU			0.10***
			(3.20)
R^2 (p-value of F-test)	0.12 (0.00)	0.12 (0.00)	0.13 (0.00)
c) Response of 10-year local-currency bond yield			
	Reg 1	Reg 2	Reg 3
MPS_{total}	4.08***	5.24***	3.86***
	(6.55)	(6.79)	(5.19)
MPU_{level}		-0.08	0.03
		(0.36)	(0.14)
$\text{MPS}_{total} \times \text{MPU}_{level}$		-6.29***	-5.73***
		(2.60)	(2.39)
ΔMPU			0.24***
			(5.96)
R^2 (p-value of F-test)	0.09 (0.00)	0.10 (0.00)	0.14 (0.00)
N	5424	5424	5424

The table contains the results of pooled panel regressions estimated by OLS on the entire sample. The columns represent different specifications. The outcome variables are two-day changes of 3-month (panel a), 2-year (panel b) and 10-year government bond yields (panel c) measured in local currencies. Each of them has been normalized to have unit standard deviation within every country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercept are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

Two novel findings emerge from Table 3. Firstly, we find that the level of MPU before the announcement significantly moderates the strength of spillovers to 10-year yields (Panel c, coefficient of $\text{MPS}_{total} \times \text{MPU}_{level}$). When uncertainty is at the 25th percentile of its historic distribution, international yields are expected to rise by 6.3 basis points, while at the 75th percentile, the effect is only 2.6 points. This implies that the domestic findings of De Pooter et al. (2021) (that uncertainty level is negatively related to the strength of transmission to long-term Treasury yields) are also present on a global scale. An intuitive explanation behind this finding is that under low uncertainty the same monetary shock hits investors more adversely. Investors might take higher risks and durations in less uncertain times and a surprise in financial conditions consequently require them to make larger corrections. De Pooter et al. (2021) shows that after a policy shock, both primary dealers and speculators adjust their net Treasury positions to a larger extent if monetary policy uncertainty is low. The adjustments in international portfolios might also be the main driver of our results – and we leave the investigation of international capital flows to further research. This result on the role of uncertainty has serious implications. Countries outside the US should expect larger spillovers in low uncertainty levels and plan their domestic policies accordingly. Also, if the Fed wants to pursue an effective monetary policy not only domestically, but on a more international scale: it should take efforts to reduce uncertainty around their announcements.

Our second finding from Table 3 is that the significant effect of MPU_{level} on 10-year yields does not vanish if we control for ΔMPU in Reg 3. This suggests that the level of uncertainty and uncertainty shocks are two separate, important factors of international spillovers, and they are both necessary for a correct specification[12].

To investigate the effect of uncertainty more closely, we run the Reg 3 specification separately for the two sets of countries (Table 4). Effects on the short- and mid-term part of the yield curve are reported in Table A2 in the Appendix. According to Table 4, the interaction coefficient is significant only in advanced countries, but not in emerging countries. A 10 basis point tightening leads to 4.1 basis point increase in emerging countries' 10-year yields, while in advanced countries, if MPU is at its 1st quartile, the response is 5.2 basis points, compared to a significantly smaller 2.1 basis point increase at the 3rd quartile. This suggests that uncertainty driving the extent of investor adjustments is a behaviour that is confined to advanced economies. In other words, a monetary shock always hits actors investing to emerging economies, regardless of the uncertainty about future US monetary policy. However, in advanced economies, investors do not respond as strongly to monetary shocks if uncertainty is high. The rationale behind this might be that uncertainty level in the US is generally more correlated with the uncertainty level in advanced economies, therefore a surprise under low US MPU hits hard in all advanced economies, extending the argument of De Pooter et al. (2021).

[12] Results also hold when controlling for the interaction between MPU_{level} and ΔMPU (not reported).

On the other hand, bonds in emerging countries may hold larger and more persistent sovereign risks and sources of vulnerability, independent of uncertainty in the US, which could be more important drivers of international adjustments than MPU.

Table 4. Response of yields in emerging and advanced economies to standard shocks

	Response of 10-year local-currency bond yield	
	Emerging	Advanced
MPS_{total}	2.27***	4.39***
	(4.11)	(3.91)
MPU_{level}	0.10	0.013
	(0.48)	(0.07)
$\text{MPS}_{total} \times \text{MPU}_{level}$	-2.99	-6.76**
	(-0.97)	(-2.22)
ΔMPU	0.15***	0.27***
	(3.71)	(4.77)
N	1270	4154
R^2 (p-value of F-test)	0.06 (0.00)	0.17 (0.00)

The table contains the results of pooled panel regressions estimated by OLS on the emerging country sample (8 countries) in the first column and advanced country sample (22 countries) in the second column. The outcome variable is two-day changes of 10-year government bond yields measured in local currencies, normalized to have unit standard deviation within every country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercept are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

There is an ongoing debate in the literature whether international spillovers from US monetary policy shocks have become stronger after the global financial crisis. For example, Albagli et al. (2019) and Ha (2021) both demonstrate an increase in spillover effects after the GFC, while Lakdawala et al. (2021) and Kearns et al. (2023) find no difference between the pre-GFC and post-GFC periods. However, none of these studies controlled for the level on monetary policy uncertainty. We may suspect that the historically low levels of MPU after 2011 (as seen in Figure 1) could have been contributing to increased spillover effects. To answer the question, we split our dataset to pre-2011 and post-2011 periods. We standardize MPU_{level} in both periods for better interpretability. Results are shown in Table 5. We notice that after 2011 the coefficient of MPS_{total} (which represents spillover effects at average MPU_{level} in the respective period) is significantly larger after 2011 in both advanced and emerging economies. The interaction coefficient is only significant after 2011. This provides strong evidence that the historically certain times between 2011 and 2019 exhibited larger international spillover effects and it was at least partially due to the lower level of uncertainty. Additionally, as Lakdawala et al. (2021) discuss in detail, the effects of ΔMPU are also more prominent after the GFC. All in all, we see that both the level of uncertainty and unexpected shifts in uncertainty have gained more importance in driving international spillovers in the 2010s.

Table 5. The role of uncertainty before and after 2011.

Response of 10-year local-currency bond yield				
	a) Emerging		b) Advanced	
	Pre-2011	Post-2011	Pre-2011	Post-2011
MPS_{total}	1.47***	5.49***	3.51***	6.80**
	(2.07)	(3.55)	(3.42)	(2.41)
MPU_{level}	0.08	-0.15***	0.009	-0.19**
	(1.47)	(-2.77)	(0.17)	(-2.15)
$\text{MPS}_{total} \times \text{MPU}_{level}$	0.30	-3.59***	-1.48	-7.16***
	(0.60)	(-3.15)	(-1.58)	(-3.62)
ΔMPU	0.11***	0.25***	0.24***	0.41***
	(2.91)	(2.76)	(4.09)	(2.65)
N	734	536	2680	1474
R^2 (p-value of F-test)	0.05 (0.00)	0.20 (0.00)	0.18 (0.00)	0.23 (0.00)

The table contains the results of pooled panel regressions estimated by OLS on the emerging country sample (8 countries) in panel a) and advanced country sample (22 countries) in panel b). The first (second) column of the panels are estimated on observations before (after) 2011.01.01. The outcome variable is two-day changes of 10-year government bond yields measured in local currencies, normalized to have unit standard deviation within every country. MPU_{level} is standardized in both periods for better interpretability. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercepts are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

5.2. Response of equity prices and exchange rates to standard policy shocks

To arrive at a broader picture of spillovers, we investigate the response of global stock returns and exchange rates to US policy shocks. We also run a cross-sectional regression on the two-day change of the Global Risk Aversion (GRA) index, developed by Bekaert et al. (2022). GRA is a utility-based global risk aversion measure, derived from a range of international variables such as detrended earnings yield, corporate return spread, term spread, realized variance of equity returns, realized variance of corporate bond returns, and risk-neutral variance of equities (Bekaert et al., 2022). Results are reported in Table 6.

Table 6. Response exchange rates, stock returns and global risk aversion to standard US policy shocks

Response of financial variables					
	Stock Returns		Exchange rates		GRA
	Emerging	Advanced	Emerging	Advanced	
MPS_{total}	-2.25***	-0.20	2.55***	5.19***	-0.79
	(-2.69)	(-0.20)	(3.71)	(4.68)	(-1.21)

MPU_{level}	-0.15	-0.12	-0.21	-0.38	0.08
	(-0.89)	(-0.48)	(-1.32)	(-1.56)	(0.74)
$\mathrm{MPS}_{total} \times \mathrm{MPU}_{level}$	1.96	-1.95	-6.56***	-6.05*	3.07
	(0.25)	(-0.63)	(-3.26)	(-1.72)	(1.20)
$\Delta\mathrm{MPU}$	-0.11**	-0.06	0.09**	-0.10	0.09***
	(-1.96)	(-1.00)	(2.16)	(-1.63)	(2.96)
N	3102	5109	3130	5709	204
R^2 (p-value of F-test)	0.05 (0.00)	0.03 (0.00)	0.03 (0.00)	0.07 (0.00)	0.31(0.00)

The table contains the results of pooled panel regressions estimated by OLS on the emerging country sample (16 countries) and advanced country (26 countries) sample. The last column displays the results of a linear regression with Global Risk Aversion as outcome variable The outcome variables are two-day changes of exchange rates vis-à-vis the US dollar and stock returns (both measured in percentages) and Global Risk Aversion developed by Bekaert et al. (2022). The former two have been normalized to have unit standard deviation within every country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercepts are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. T-statistics of the regression on GRA are calculated using heteroskedasticity-robust standard errors. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

The estimates in Table 6 are in many ways match the predictions of standard economic theory. Global exchange rates depreciate after a tightening in US monetary policy. Exchange rates in emerging countries depreciate to a much smaller extent than rates in advanced economies, which is in line with Albagli et al. (2019) and might be attributable to different policy responses in the two sets of countries. A 10 basis point US MP shock on average implies 0.48 % (0.3%) depreciation in advanced (emerging) countries' currencies. However, we also shed light on the fact that this depreciation is conditional on the level of MPU in both sets of countries. Two puzzling results appear from Table 6 that do not match our expectations. Neither stock returns in advanced countries, nor Global Risk Aversion show significant responses to standard policy shocks, the latter even seems to slightly decrease after a tightening. This is inconsistent with the literature of international spillovers, arguing that the US policy shocks changes investors' risk perceptions, which are important drivers of spillovers via international capital flows (Passari & Rey. 2015, Kalemli-Özcan, 2019, Saini et al., 2019). In the next section, we solve this puzzle by showing that the two types of shocks, MPS_{true} and CBI are both effective in moving global stock returns and risk perceptions but have opposite effects offsetting each other.

5.3. Response of equity prices and exchange rates to decomposed shocks

Next, we turn our attention to Eq. (3) and estimate international spillovers using the components of policy shocks: true monetary policy shocks and information shocks, estimated according to Jarocinski & Karádi (2020). First, we estimate spillovers to stock returns, exchange rates and global risk aversion (Table 7).

Table 7. Response exchange rates, stock returns and global risk aversion to true monetary policy and information shocks

	Response of financial variables				
	Stock Returns		Exchange rates		GRA
	Emerging	Advanced	Emerging	Advanced	
MPS_{true}	-6.34***	-6.06***	4.23***	6.84***	1.29*
	(-7.16)	(-7.52)	(4.63)	(6.35)	(1.84)
CBI	3.82***	8.48***	-0.30	2.42	-3.68***
	(4.11)	(8.58)	(-0.42)	(1.37)	(-4.05)
MPU_{level}	-0.25**	-0.28*	-0.19	-0.36	1.39
	(-2.13)	(-1.68)	(-1.23)	(-1.49)	(1.32)
$\text{MPS}_{true} \times \text{MPU}_{level}$	1.70	-3.24	-9.68***	-8.98**	4.86
	(0.72)	(-1.35)	(-4.56)	(-2.43)	(1.21)
$\text{CBI} \times \text{MPU}_{level}$	-1.06	-5.67**	-0.61	-0.42	2.02
	(-0.57)	(-2.11)	(-0.29)	(-0.09)	(1.14)
ΔMPU	-0.09*	-0.02*	0.08**	-0.11	7.30***
	(-1.87)	(-0.65)	(2.19)	(-1.81)	(2.76)
N	3102	5109	3130	5709	204
R^2 (p-value of F-test)	0.15 (0.00)	0.25 (0.00)	0.06 (0.00)	0.09 (0.00)	0.48 (0.00)

The table contains the results of pooled panel regressions estimated by OLS on the emerging country sample (16 countries) and advanced country (26 countries) sample. The last column displays the results of a linear regression with Global Risk Aversion as outcome variable The outcome variables are two-day changes of exchange rates vis-à-vis the US dollar and stock returns (both measured in percentages) and Global Risk Aversion index, developed by Bekaert et al. (2022). The former two have been normalized to have unit standard deviation within every country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercepts are omitted for brevity. T-statistics of panel models are calculated with two-way clustered standard errors and are reported in parentheses. T-statistics of the regression on GRA are calculated using heteroskedasticity-robust standard errors. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

The results suggest that our shock identification was indeed successful. A rise in interest rates which signal positive information (i.e. a CBI hike) has expansionary effects on a global scale and is associated with decreased risk aversion and higher stock returns (2nd row), in line with Gai & Tong (2022), Pinchetti & Szczepeniak (2023) and Jarocinski (2022). Also, shocks that are associated with information effects do not significantly affect exchange rates, and seem to have smaller effects on EME countries than advanced economies. Pinchetti & Szczepeniak (2023) find a depreciation of the dollar after a CBI shock, which our results do not confirm. However, the contrast between exchange rate spillovers of true monetary shocks and information shocks is obvious and suggest that there are some dollar-depreciating elements at play after an interest rate hike associated with information effects. The effects of true monetary policy shocks (first row) are now match with the expectations from theory: a true monetary policy shock is contractionary on a global scale and lead to the appreciation of the dollar. To sum up, only those shocks lead to the depreciation of foreign currencies that also effect stock markets and global risk taking negatively. If stock returns co-move with interest rates on announcement days, currencies are not expected to respond.

What does Table 7 tell us about the role of uncertainty? First, stock prices are affected negatively by a higher level of MPU, irrespective of the magnitude of policy shocks (3rd row). Secondly, a higher level of uncertainty mitigates the effect of MPS_{true} shocks (4th row). This is intuitive, if we believe that different levels of MPU induce different magnitudes of international portfolio adjustments, as argued in Section 5.1, building upon De Pooter et al. (2021). In case of lower (higher) levels of uncertainty, investors make larger (smaller) corrections in their international positions after the same surprise, leading to larger (smaller) effects on the currencies their investments are denominated in. The idea of this potential mechanism is also applicable to spillovers on stock returns: the effect of CBI shocks is significantly conditional on uncertainty levels in advanced economies (5th row).

5.4. Response of bond yields to decomposed shocks

In this section we investigate the effects of true monetary policy shocks and information shocks on international bond yields based on Eq. 3. In Section 5.1, we argued that the level of uncertainty influences the strength of global spillovers to 10-year bond yields. Controlling for information effects, we find that this phenomenon is still present. The global effects of MPS_{true} and CBI on 10-year yields are both mitigated by high levels of uncertainty, and MPU_{level} is important to include in a correct specification (Table 8).

Table 8. Response of international yields to true monetary and information shocks

	Total panel			
	Response of 2-year yields		Response of 10-year yields	
	Reg 1	Reg 2	Reg 1	Reg 2
MPS_{true}	3.64***	3.74***	1.70*	2.80***
	(4.33)	(4.31)	(1.75)	(2.58)
CBI	5.11***	5.22***	4.15***	5.34***
	(5.36)	(5.27)	(3.79)	(4.57)
MPU_{level}		-0.09		-0.01
		(0.46)		(0.03)
$\mathrm{MPS}_{true} \times \mathrm{MPU}_{level}$		-0.94		-7.03*
		(0.27)		(1.85)
$\mathrm{CBI} \times \mathrm{MPU}_{level}$		-0.42		-4.98*
		(0.15)		(1.68)
$\Delta\mathrm{MPU}$	0.11***	0.11***	0.25***	0.25***
	(2.68)	(2.60)	(5.05)	(5.12)
N	5424	5424	5424	5424
R^2 (p-value of F-test)	0.13 (0.00)	0.13 (0.00)	0.13 (0.00)	0.15 (0.00)

The table contains the results of pooled panel regressions estimated by OLS on the entire sample. The outcome variables are two-day changes of 2-year and 10-year government bond yields measured in local currencies. Each of them has been normalized to have unit standard deviation within every country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercept are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

Next, we run Eq. 3. separately on emerging and advanced economies, with two-day changes in 10-year yields and their expected and term premium components as dependent variables, the latter two estimated by Lakdawala et al. (2021), using the methodology of Joslin et al. (2011). All three have been normalized to have unit within-country standard deviation. Results are presented in Table 9. Interestingly, we observe that CBI shocks only affect advanced economies, and a one-basis point CBI shock exert larger effects on advanced countries' bond yields than a one-basis point true MP shock (1^{st} and 2^{nd} rows). Additionally, it is only CBI shocks, that affect term premia in more developed economies. At the same CBI shocks do not spill into bond yields in emerging economies.

In Section 5.1 we established that MPU_{level} is only influential on spillovers towards advanced economies (Table 4). After controlling for information effects, this observation still holds (Table 9, first and fourth column). Based on Table 9 we add to the picture that the mitigating effect of higher uncertainty on spillovers work through the term premium (6^{th} column). The same policy shock implies larger corrections in advanced countries' risk premia if uncertainty is low.

Table 9. Response of 10-year yields and its components to true monetary and information shocks

Response of 10-year yields						
	a) Emerging			b) Advanced		
	Total	Expected	Term	Total	Expected	Term
MPS_{true}	3.77***	2.62***	1.22**	2.58*	2.74***	0.30
	(4.40)	(3.41)	(2.19)	(1.90)	(3.06)	(0.25)
CBI	-0.27	0.38	-0.21	6.95***	3.74***	3.53***
	(0.50)	(0.67)	(0.33)	(5.28)	(4.2)	(3.11)
MPU_{level}	0.12	-0.31*	0.48***	-0.04	-0.15	0.09
	(0.61)	(1.92)	(4.86)	(0.21)	(0.54)	(0.36)
$MPS_{true} \times MPU_{level}$	-1.55	-0.87	-1.42	-8.39*	1.21	-8.18
	(0.57)	(0.67)	(0.65)	(1.85)	(0.23)	(1.61)
$CBI \times MPU_{level}$	-1.63	-0.56	-1.84	-4.98*	3.36	-8.67***
	(1.21)	(0.25)	(1.03)	(1.88)	(1.15)	(2.59)
ΔMPU	0.13***	0.09***	0.05	0.28***	-0.03	0.28***
	(3.68)	(3.70)	(1.29)	(5.07)	(0.62)	(4.91)
N	1270	1270	1270	4154	4154	4154
R^2	0.08	0.05	0.01	0.20	0.07	0.09
(p-value of F-test)	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)

The table contains the results of pooled panel regressions estimated by OLS on the emerging country sample (8 countries) in panel a) and advanced country sample (22 countries) in panel b). The outcome variables are two-day changes of 10-year government bond yields and their expected and term premium components based on Joslin et al. (2011). Yields are measured in local currencies. All outcome variables have been normalized to have unit standard deviation within each country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercept are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

How do we make a consistent interpretation out of Table 7 and Table 9? In Table 7 we saw that positive CBI shocks are expansionary on a global level and result in decreased global risk aversion globally. Pinchetti & Sczepeniak (2023) show that Fed information shocks trigger debt and equity flows towards emerging markets, suggesting the importance of a risk-taking channel. Table 9 shows that emerging countries' yields do not even increase after a CBI-type interest rate hike, which suggests that these capital flows are so large in emerging countries that the increased demand on bonds completely counteract the increase in domestic interest rates. This is also consistent with the findings of Table 7, namely that foreign currencies do not depreciate after CBI shocks. Capital inflows increase the demand for local currencies, counteracting the otherwise expected depreciation of the currency after a hike in US interest rates. Although our findings are completely in line with Pinchetti & Sczepeniak (2023) regarding emerging economies, we add to the picture that advanced economies behave differently. Yields respond positively to a CBI shock, which suggest less response in capital flows after a revelation of information about economic fundamentals, with uncertainty playing a role in how markets react. Additionally, after a CBI shock, the expected component of the yield curve shows significant response (5^{th} column), which means that the markets expect advanced countries' central banks to respond with tightening to a positive CBI shock. In the next subsection, we investigate which features of countries determine the extent of true monetary policy and information spillovers. However, we note the importance of testing this finding by using data on international capital flows, which we leave for further research.

The results on spillovers to 2-year yields is presented in the Appendix on Table A3. The conclusions to be drawn are similar, with uncertainty playing a less significant role in advanced economies.

5.5. What determines the size of spillovers?

In this section we investigate how different country characteristics contribute to the strength of spillovers of MPS_{true} and CBI shocks. We adopt the methodology of Iacoviello & Navarro (2019) and Lakdawala et al. (2021). We are interested in the impact on spillovers of three country characteristics. We adhere to the categorization of Kearns et al. (2023) and test the relative role of macroeconomic, financial and exchange rate linkages. For a short review on how these channels operate, see Section 2.4. To measure macroeconomic linkages we use trade openness, the sum of total exports and imports divided by GDP.[13] To test the exchange rate channel, we use the categorization of Ilzetzki et al. (2019), with categories of flexible exchange rate, a partial peg and a fixed regime. For financial links, we use the value of credit provided to the private sector, as a percentage of GDP, assuming it also reflects how integrated countries are to the global financial system. All the data on country characteristics were obtained from Lakdawala et al. (2021). The country characteristics are time-varying and represent the value of the respective indicator in the year of the corresponding announcement. Note that the choice of proxy variables for linkages is somewhat arbitrary and far from robust. We chose these for their easy availability, but in further research we plan to include more diverse characteristics[14]. Following Iacoviello & Navarro (2019), we estimate the following equation:

[13] Due to the multi-country nature of spillovers and potential indirect secondary spillovers we remain agnostic about whether countries' mostly trade with the US or with other countries.

[14] For example, Georgiadis (2016) demonstrates that extent of spillovers from US policy (total shocks) is contingent upon factors such as the receiving country's level of trade and financial integration, financial openness, exchange rate regime, development of financial markets, rigidity within the labour market, structure of industries, and involvement in global value chains.

$$\Delta y_{i,t} = \alpha + \beta_1 MPS_{true,t} + \beta_2 CBI_t + \sum_{v\in V} \gamma_1^v \left(e^v{}_{i,t} MPS_{true,t}\right)^{\perp} + \sum_{v\in V} \gamma_2^v \left(e^v{}_{i,t} CBI_t\right)^{\perp} + \delta\Omega_t + \epsilon_{i,t} \tag{4}$$

where $e^v{}_{i,t}$ denote the value of exposure index v on FOMC announcement day t for country i. The interaction terms are such that β_1 and β_2 coefficients measure the response to an MPS_{true} and CBI shock, respectively, when the indices are at their 25th percentile values, while the γ_1^v and γ_2^v coefficients capture the marginal response to an MPS_{true} and CBI shock, respectively, when the index is at its 75th percentile value (Lakdawala et al., 2021).[15] In Ω_{t-1} we include control variables such as MPU$_{level}$, ΔMPU, the level of 10-year US Treasury yields, and the level of VIX.

The interaction terms are constructed in two steps, based on Iacoviello & Navarro (2019):

- First, we construct the exposure indices ($e^v{}_{i,t}$) from the three link variables. First, each link variables are standardized and are collapsed to a unit interval by logistic transformation. Second, we scale the transformed exposure variables to the distance between the 25th and 75th percentiles.
- Second, we construct the $\left(e^v{}_{i,t} MPS_{true,t}\right)^{\perp}$ and $\left(e^v{}_{i,t} CBI_t\right)^{\perp}$ terms for every v by recursively orthogonalizing the interactions between shocks and exposure variables. At first, we orthogonalize the interaction between $e^1{}_{i,t}$ and $MPS_{true,t}$ with respect to $MPS_{true,t}$ and CBI_t. This is done by regressing the interaction on $MPS_{true,t}$ and CBI_t and obtaining the residuals. Second, we orthogonalize the interaction between $e^1{}_{i,t}$ and CBI_t, with respect to $MPS_{true,t}$, CBI_t and the $\left(e^1{}_{i,t} MPS_{true,t}\right)^{\perp}$ term that we just estimated. Next, we orthogonalize $e^2{}_{i,t} MPS_{true,t}$ on both shocks and the already obtained orthogonalized interaction terms. This continues for all 6 interaction terms.

The described procedure offers several advantages. Firstly, by orthogonalizing, we effectively handle within-country correlations among various characteristics, which would otherwise significantly impact the precision of the estimation. Secondly, the coefficient for each additional characteristic becomes interpretable as a marginal effect, controlling for the influence of previous characteristics. Although the order of variable orthogonalization can impact the results, we find that our findings remain the same if we order our variables differently. In the

[15] For the exchange rate channel, this effectively means moving from a floating regime to a fixed exchange rate regime.

model we report, we work with the following order: trade openness, exchange rate regime and financial depth.

We run Eq. (4) in a pooled panel regression setup for the entire sample. Our goal is to investigate which of the three types of links determine how US policy shocks spill over to long term yields in foreign countries. Results are reported in Table 10.

Table 10. Role of country characteristics in spillovers of true MP and CBI shocks

	Response of 10-year local-currency bond yields
MPS_{true}	1.25
	(1.20)
CBI	4.70***
	(4.41)
MPS_{true} × trade_openness	0.23
	(0.48)
CBI × trade_openness	-0.65
	(-1.14)
MPS_{true} × fin_depth	-1.99***
	(-3.35)
CBI × fin_depth	2.26**
	(2.28)
MPS_{true} × fx_regime	2.13**
	(2.30)
CBI × fx_regime	1.61
	(1.07)
N	3541
R^2	0.14
(p-value of F-test)	(0.00)

The table contains the results of pooled panel regressions according to Eq. 4 estimated by OLS on the entire sample, where data are available. The interaction terms are recursively orthogonalized based on Lakdawala et al. (2021) and Iacoviello & Navarro (2019). The outcome variable is two-day changes 10-year government bond yields measured in local currencies and has been normalized to have unit standard deviation within every country. Control variables are the level of the 10-year US Treasury yield, the level of VIX and MPU on the day preceding the announcement, and two-day change in MPU. Their coefficients and the intercept are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

In general, the financial links channel is the most determinant factor in line with Kearns et al. (2023). Surprisingly, true MP shocks affect countries less if they have more financial depth (3rd row), which fits into our results and may partially explain why true MP spillovers dominate in emerging countries. However, we find the sign of this interaction generally puzzling and highlight the need for further research. Financial depth affects information spillovers in the expected direction, the more financially developed a country is, the more CBI shocks are relevant (4th row). Financial depth might be the strongest proxy among our variables to how correlated financial cycles are in US and a foreign country, which might explain why a revelation of information of information about the state of the US economy is more influential in countries with high financial depth. We also find some evidence of FX regime playing an important role in the transmission of monetary shocks, in line with economic theory and Kearns et al. (2023). Moving from a floating regime to a pegged regime ceteris paribus more than doubles the size of spillovers. Macroeconomic channels are the least important predictors of spillover effects, also in line with Kearns et al. (2023).

5.6. Robustness checks

A key assumption we made in Section 3 is that information effects can be properly identified by the QR decomposition of stock returns and standard policy shocks according to Eq. 1. Firstly, we note that although the puzzling positive correlation between interest rates and stock returns around announcement days is a valid starting point for identifying information shocks, it is not likely that this is puzzle alone is able to detect every type of information effects described by Nakamura & Steinsson (2018). The only "safe" way to think about the shocks of Jarocinski & Karádi (2020) is as shocks that may signal positive information (because they are followed by a positive co-movement in stock returns and risk-taking) and may account for a part of broader information effects. The literature is lacking a more consistent and more theory-based identification. Secondly, the result of the QR decomposition is not unique. Therefore, we aim to validate our instrument by using a different identification procedure, but still staying within the framework of Jarocinksi & Karádi (2020). This is the simple or as Jarocinski & Karádi (2020) call it, "poor man's" approach. As described in Section 3.1, this entails simply categorizing standard policy shocks based on the response of S&P 500 returns. For example, if S&P 500 comoved positively with the total shock, the shock is entirely attributed to information effects. We rerun the regressions of Table 7 and Table 9 with the decomposed shocks identified via this "simple" approach. Results are reported in Appendix Table A4. and Table A5. We find that our main findings still hold when using the simple identification strategy, however the coefficient are sometimes less significant.

6. Conclusions

According to our literature review this paper was the first to investigate the effects of the level of US monetary policy uncertainty on the transmission of policy shocks. We also added an additional element to our analysis building upon Jarocinski & Karádi (2020): decomposing policy shock into a true monetary and information element. We used a long and wide panel of FOMC announcement and asset price responses to get a comprehensive picture on what contributes to international spillover effects.

Our paper yielded important findings. We showed that high (low) levels of uncertainty mitigate (strengthen) global spillover effects, especially in advanced countries and through term premia. We provided some evidence that the historically low levels of uncertainty after 2011 contributed to larger spillover effects. Next, we showed that Fed information effect (identified based on Jarocinski & Karádi, 2020) is a prominent factor in global spillovers. An interest rate hike associated with the Fed being optimistic has expansionary effects on global risk-taking and equity prices and a CBI- hike does not translate into higher long-term bond yields in emerging economies. Also, a CBI-hike does not affect local currencies, contrary to monetary policy shocks. Lastly, we ran a brief investigation on what causes the different nature spillovers in advanced and emerging economies. We found somewhat puzzling results but confirmed that the more financial depth a country has, the more it is subject to spillovers.

Our results have serious implications. In a methodological regard, we demonstrated that controlling for the level of uncertainty in event study regressions improves the estimates of the spillover effects of US policy shocks. In a practical sense, central banks of the world should expect larger spillovers to their exchange rate and domestic yields in low uncertainty levels and plan their policies accordingly. They should also consider the diverse nature of spillovers. Interest rate hikes are not always bad news. Hikes that boost US stock markets do not induce significant changes in yields in emerging economies, do not have depreciating effect on foreign currencies and are expansionary on a global scale. Also, if the Fed wants to pursue an effective monetary policy not only domestically, but on a more international scale: it should make effort to reduce uncertainty around their announcements and acknowledge that a revelation of information induces different spillover effects than standard policy changes.

There are several avenues to pursue in the comprehensive exploration of global spillover effects of US policy. The immediate continuation of our research would be investigating the response of international capital flows and its underlying role in driving our results. This could help shed light on the different transmission channels that are operating after information and policy shocks and the role of different levels of uncertainty. Also, our finding should be validated by performing more tests of robustness: different event window, different identification of shocks and more diverse country characteristics. Finally, exploring the diverse spillover effects of US monetary policy on macroeconomic variables (e.g. output, inflation) over longer timeframes in both advanced and emerging economies seems to be a promising avenue for future research.

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Appendix

Table A1. Data coverage

Country Name	Exchange rate	Equity index	Yields
	Emerging economies		
Argentina	F	F	
Chile	F	F	
China	8/23/2010	8/23/2010	9/12/2003
Hungary	F	2/1/1995	7/1/1998
India	F	F	11/17/1998
Indonesia	F	F	3/18/2003
Malaysia	F	F	10/5/1999
Mauritius	F	F	
Pakistan	F	F	
Peru	F	F	
Philippines	F	F	
Poland	F	F	7/1/1998
Russian Federation	F	9/30/1997	1/31/2007
South Africa	F	7/6/1995	2/1/1995
Thailand	F	8/22/1995	
Turkey	F	F	
	Advanced economies		
Australia	F	F	2/1/1995
Austria	F	2/3/1999	5/19/1998
Belgium	F	F	5/19/1998
Canada	F	F	2/1/1995
Czech Republic	F	2/1/1995	7/1/1998
Denmark	F	F	2/1/1995
Estonia	F	6/26/2002	
Finland	F	2/1/1995	7/1/1998
France	F	2/3/1999	5/19/1998
Germany	F	2/3/1999	F
Hong Kong	F	F	7/1/1998
Iceland	F	5/9/2007	
Ireland	F	F	5/19/1998
Israel	F	F	
Italy	F	2/4/1998	2/4/1998
Japan	F	F	F
Netherlands	F	2/3/1999	5/19/1998
New Zealand	F	1/3/2001	2/1/1995
Norway	F	1/31/1996	8/18/1998
Portugal	F	2/3/1999	5/19/1998
Republic of Korea	F	F	
Singapore	F	10/5/1999	7/1/1998
Slovakia	F	2/3/1999	
Slovenia	5/20/1997	6/26/2002	
Spain	F	2/3/1999	5/19/1998
Sweden	F	1/31/1996	2/1/1995
Switzerland	F	F	2/1/1995
United Kingdom	F	F	2/1/1995

The table describes the availability of data for each country in our dataset. F denotes that data are available for the full sample period, between January 1995 and June 2019. Otherwise, the dates indicate the start of the availability of data. Blank cells indicate that data are not available. The entire dataset is taken from the replication package of Lakdawala et al. (2021) and was originally obtained from Bloomberg.

Table A2. Response of yields in emerging and advanced economies to standard shocks and uncertainty

	Emerging	Advanced
a) Response of 3-month local-currency bond yield		
	Emerging	Advanced
MPS_{total}	1.75***	2.05***
	(2.60)	(3.64)
MPU_{level}	-0.35*	-0.16
	(-1.82)	(-0.66))
$\text{MPS}_{total} \times \text{MPU}_{level}$	-1.81	0.93
	(-1.41)	(0.27)
ΔMPU	0.08**	-0.01
	(2.04)	(-0.26)
R^2 (p-value of F-test)	0.04 (0.00)	0.04 (0.00)
b) Response of 2-year local-currency bond yield		
MPS_{total}	2.35***	4.96***
	(4.12)	(5.19)
MPU_{level}	-0.19	-0.04
	(-0.83)	(-0.16)
$\text{MPS}_{total} \times \text{MPU}_{level}$	-2.05	-0.19
	(-1.23)	(-0.14)
ΔMPU	0.11***	0.10**
	(3.23)	(1.98)
R^2 (p-value of F-test)	0.08 (0.00)	0.15 (0.00)
c) Response of 10-year local-currency bond yield		
MPS_{total}	2.27***	4.39***
	(4.11)	(3.91)
MPU_{level}	0.10	0.013
	(0.48)	(0.07)
$\text{MPS}_{total} \times \text{MPU}_{level}$	-2.99	-6.76**
	(-0.97)	(-2.22)
ΔMPU	0.15***	0.27***
	(3.71)	(4.77)
R^2 (p-value of F-test)	0.06 (0.00)	0.17 (0.00)

The table contains the results of pooled panel regressions estimated by OLS on the emerging country sample (8 countries) in the first column and advanced country sample (22 countries) in the second column. The outcome variables are two-day changes of 3-month, 2-year and 10-year government bond yields measured in local currencies. Each of them has been normalized to have unit standard deviation within every country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercept are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

Table A3. Response of 2-year yields and components to true monetary and information shocks

	Response of 2-year yields					
	a) Emerging			b) Advanced		
	Total	Expected	Term	Total	Expected	Term
MPS_{true}	3.71***	2.40***	1.17	3.76***	1.42*	2.61***
	(5.22)	(2.76)	(1.32)	(3.58)	(1.82)	(3.04)
CBI	0.42	0.20	0.17	6.69***	2.57***	4.87***

	(0.56)	(0.26)	(0.18)	(5.95)	(3.20)	(5.39)
MPU_{level}	-0.15	-0.23	0.27	-0.07	-0.22	0.19
	(0.67)	(1.38)	(1.61)	(0.31)	(0.97)	(1.06)
$MPS_{true} \times MPU_{level}$	-0.98	-0.42	-1.49	-0.94	2.42	-3.23
	(0.35)	(0.22)	(0.55)	(0.22)	(0.57)	(1.04)
$CBI \times MPU_{level}$	-2.02	-1.09	-1.19	-0.28	3.57	-4.5
	(0.87)	(0.61)	(0.72)	(0.08)	(1.17)	(1.48)
ΔMPU	0.10***	0.03	0.07**	0.10**	-0.05	0.18***
	(3.06)	(1.13)	(2.01)	(2.20)	(1.08)	(4.00)
R^2	0.09	0.04	0.01	0.16	0.05	0.09
p-value of F-test	(0.00)	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)

The table contains the results of pooled panel regressions estimated by OLS on the emerging country sample (8 countries) in panel a) and advanced country sample (22 countries) in panel b). The outcome variables are two-day changes of 10-year government bond yields and their expected and term premium components based on Joslin et al. (2011). Yields are measured in local currencies. All outcome variables have been normalized to have unit standard deviation within each country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercept are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

Table A4. Response exchange rates, stock returns and global risk aversion to true monetary policy and information shocks (simple identification)

	Response of financial variables				
	Stock Returns		Exchange rates		GRA
	Emerging	Advanced	Emerging	Advanced	
MPS_{true}^{simple}	-3.39***	-1.27	3.40***	6.63***	1.29*
	(-3.69)	(-1.17)	(3.98)	(5.84)	(1.84)
CBI	-0.04	2.50	1.08	2.53	-2.22***
	(-0.03)	(1.45)	(1.22)	(1.14)	(-4.23)
MPU_{level}	-0.17	-0.14	-0.21	-0.37	0.11
	(-0.93)	(-0.54)	(-1.32)	(-1.58)	(0.38)
$MPS_{true}^{simple} \times MPU_{level}$	1.99	-4.42	-7.56***	-6.69**	5.32***
	(0.78)	(-1.50)	(-3.43)	(-1.59)	(2.71)
$CBI \times MPU_{level}$	2.59	1.09	-5.86***	-6.22	0.25
	(0.78)	(0.20)	(-2.21)	(-1.14)	(1.118)
ΔMPU	-0.12**	-0.08	0.10**	-0.08	2.08***
	(-2.20)	(-1.42)	(2.45)	(-1.37)	(3.13)
N	3102	5109	3130	5709	204
R^2 (p-value of F-test)	0.06 (0.00)	0.05 (0.00)	0.03 (0.00)	0.09 (0.00)	0.32 (0.00)

The table contains the results of pooled panel regressions estimated by OLS on the emerging country sample (16 countries) and advanced country (26 countries) sample. The last column displays the results of a linear regression with Global Risk Aversion as outcome variable The outcome variables are two-day changes of exchange rates vis-à-vis the US dollar and stock returns (both measured in percentages) and Global Risk Aversion index, developed by Bekaert et al. (2022). The former two have been normalized to have unit standard deviation within every country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercepts are omitted for brevity. T-statistics of panel models are calculated with two-way clustered standard errors and are reported in parentheses. T-statistics of the regression on GRA are calculated using heteroskedasticity-robust standard errors. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.

Table A5. Response of 10-year yields and its components to true monetary and information shocks (simple identification)

	Response of 10-year yields					
	a) Emerging			b) Advanced		
	Total	Expected	Term	Total	Expected	Term
MPS_{true}^{simple}	2.21***	1.66**	0.53	3.37**	2.80***	0.95
	(4.55)	(2.46)	(0.85)	(2.30)	(2.97)	(0.77)
CBI	1.67	1.14	-0.21	6.30***	2.77**	3.71***
	(1.34)	(1.44)	(0.33)	(5.14)	(2.38)	(3.58)
MPU_{level}	0.09	-0.35***	0.46***	0.02	-0.11	0.11
	(0.46)	(-2.25)	(4.67)	(0.10)	(-0.46)	(0.59)
MPS_{true}^{simple}	0.03	1.64	-0.9	-5.83	7.35	-10.99
$\times$ MPU_{level}	(0.01)	(0.48)	(-0.66)	(-1.26)	(1.57)	(-1.10)
CBI $\times$ MPU_{level}	-5.55*	-3.52	-2.72	-7.02**	-2.97	-3.95***
	(-1.84)	(-1.38)	(-1.37)	(-1.99)	(-0.64)	(-2.77)
ΔMPU	0.15***	0.11***	0.05	0.25***	-0.03	0.26***
	(4.10)	(4.09)	(1.60)	(4.56)	(-0.62)	(5.14)
N	1270	1270	1270	4154	4154	4154
R^2	0.07	0.05	0.01	0.18	0.08	0.10
(p-value of F-test)	(0.00)	(0.00)	(0.06)	(0.00)	(0.00)	(0.00)

The table contains the results of pooled panel regressions estimated by OLS on the emerging country sample (8 countries) in panel a) and advanced country sample (22 countries) in panel b). The outcome variables are two-day changes of 10-year government bond yields and their expected and term premium components based on Joslin et al. (2011). Yields are measured in local currencies. All outcome variables have been normalized to have unit standard deviation within each country. Control variables are the level of the 10-year US Treasury yield and the level of VIX on the day preceding the announcement. Their coefficients and the intercept are omitted for brevity. T-statistics are calculated with two-way clustered standard errors and are reported in parentheses. Stars denote significance levels: *** = P <0.01, ** = P <0.05, * = P <0.1.