Risk, Monetary Policy and Asset Prices in a Global World *

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We study how monetary policy and risk shocks affect asset prices in the US, the euro area, and Japan, decomposing policy shocks into "pure" and information shocks. For stock returns, we document strong spillovers of policy shocks between the US and the euro area, with spillovers emanating from the US (euro area) consistent with (stronger than) what global CAPM intuition would suggest. For short-term rates, there are no significant spillovers, consistent with the trilemma literature. Risk shocks matter greatly for stock returns, and feature a strong global component not driven by monetary policy.

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1 Introduction

Since the global financial crisis, there has been renewed interest in understanding how monetary policy shocks transmit across countries through financial markets and capital flows. The increased synchronization of financial cycles across countries in recent decades (Jordà, Schularick, Taylor, and Ward (2019)) generates the specter of a "hegemon" country, such as the US, whose monetary policy drives risk appetite and thus asset prices globally (Miranda-Agrippino and Rey (2020b)). It is therefore not surprising that the Fed Chairman Jerome Powell devoted a speech to the topic, arguing that: "... while global factors play an important role in influencing domestic financial conditions, the role of US monetary policy is often exaggerated."[1] After all, in globally integrated capital markets, financial risk conditions and therefore asset returns may naturally comove strongly.

This paper assesses the transmission of monetary policy (MP) shocks as well as risk shocks to asset prices across three advanced economies, the US, euro area, and Japan, using high-frequency data over the 2000-2017 period. Following Jarociński and Karadi (2020), we use "pure" MP shocks and central bank information (CBI) shocks, which reveal central bank information about the economy.

We first document that US and euro area monetary policy significantly affect domestic stock returns, with the US results quantitatively in line with the original results in Bernanke and Kuttner (2005). Importantly, risk shocks that are orthogonal to monetary policy shocks affect stock prices significantly and their effects are of a larger economic magnitude than the effects of monetary policy shocks. For our risk variable, we use the (square of) option-implied volatility indices for the major stock indices in the three

[1] Speech by Chairman Jerome Powell on "Monetary Policy Influences on Global Financial Conditions and International Capital Flows," at the Eighth High-Level Conference on the International Monetary System sponsored by the International Monetary Fund and Swiss National Bank, Zurich, Switzerland, May 8, 2018.

economies (the VIX index for the US and the equivalent indices for the euro area and Japan). Indeed, recent research in finance suggests that equity options markets harbor much market-based information on risk aversion.[2] These risk shocks are then orthogonalized with respect to a wide array of macroeconomic announcement shocks as well as to the monetary policy shocks, as the extant literature suggests monetary policy is an important driver of risk aversion (see also Bekaert, Hoerova, and Lo Duca (2013)).

Our new finding here, not explored in Miranda-Agrippino and Rey (2020b), regards international spillovers. The spillovers from the euro area to the US are stronger than from the US to the euro area, for both pure monetary policy and information shocks. Given that the US equity market constitutes a large part of the global equity market, a standard capital asset pricing model (CAPM) would predict the US monetary policy effects to be stronger than those of the euro area. While the World CAPM is an equilibrium relationship between individual markets and the world market, it turns into a predictive relationship in our high-frequency framework, as the trading hours of the three markets barely overlap. Therefore, using a simple market model, we can conduct explicit calculations predicting how a domestic monetary policy shock affects the world stock market, given the relative size of the local market, which then provides a prediction for subsequent responses in other markets, given their risk exposures. Explicit back-of-the-envelope computations under various assumptions suggest that the US spillover effect to the euro area is entirely consistent and even slightly weaker than a simple CAPM prediction, whereas the euro area's effect is much stronger. If anything, it is the spillover effects emanating from the euro area that are surprisingly large.

We provide a conceptual framework building on the habit model in Bekaert, Engstrom, and Xing (2009), where the MP effects on stock markets can operate through a pure interest rate or risk premium channel. While monetary policy shocks have their

[2] Martin (2017) shows that an option-implied volatility index constitutes a lower bound for the equity premium. Bekaert, Engstrom, and Xu (2022) estimate a measure of aggregate risk aversion, pricing equities and corporate bonds, and find it to be highly correlated with the VIX.

usual effect on domestic short-term interest rates, indicating strong and statistically significant pass-through, we fail to find significant international spillover effects through interest rates. This suggests that the monetary autonomy of central banks in Japan and the euro area in setting short-term rates has remained intact, consistent with the trilemma literature (Obstfeld, Shambaugh, and Taylor (2005)).

We then examine how various monetary policy-induced shocks in the US, the euro area, and Japan affect risk variables across countries on a daily basis, while controlling for macroeconomic announcement shocks. In this multi-country, multi-shock framework, monetary policy in the US affects domestic risk positively, which is consistent with Bekaert, Hoerova, and Lo Duca (2013) who focus on a pre-2008 sample, but our evidence is statistically weak, suggesting a weakening relationship after the global financial crisis (see also Miranda-Agrippino and Rey (2020a)). As for international spillovers, US monetary policy does not affect risk variables in other countries, whereas euro area monetary policy does affect US risk. That is, for both interest rates and risk, the global effects of US monetary policy shocks entirely occur through their effect on the US components of world interest rates and global shocks. We document a strong global common component in risk shocks which is not driven by US monetary policy.

Our main contribution is organized in three sections, with Section 2 focusing on the conceptual and empirical framework, Section 3 on the construction of our macro, risk and monetary policy shocks (both "traditional" - occurring on policy announcement days - and "communication" - occurring on non-policy meeting days) across the three economies, and Section 4 containing the main results. In Section 5, we collect a large number of additional results. First, our regressions also include MP communication shocks, which we create from data in Cieslak and Schrimpf (2019), who show that central banks release relevant information on non-policy meetings days. We document that communication shocks do generate significant spillovers to risk, operating both from the US to the euro area and vice versa.

Second, we conduct a variance decomposition of the explained variation in our regressions to quantify the relative importance of the various MP shocks and risk shocks cleansed of monetary policy and macro news influences. We find that pure monetary policy (information) shocks matter relatively more for interest rates (stock returns). In addition, we find that on average traditional (communication) monetary policy shocks account for 81% (19%) of the explained variation of interest rates but for 52% (48%) of the explained variation for stock returns. Thus, monetary policy "communication" matters more for stock returns (see also Cieslak and Schrimpf (2019) and Leombroni, Vedolin, Venter, and Whelan (2021)). The same decompositions show that for stock returns cleansed risk shocks account for a much larger fraction of the variance than do all monetary policy shocks put together.

Third, we consider the effects of an alternative set of monetary policy shocks which accommodate the post-2008 unconventional monetary policies (see Swanson (2021); Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019)). We find that considering these alternative shocks does not alter our main conclusions regarding the spillover effects of US monetary policy.

Finally, we investigate the longer-term effects of MP and risk shocks. Risk shock effects on stock prices partially mean revert within the month, consistent with a risk premium effect, whereas the monetary policy shock effects are more persistent, consistent with a more persistent interest rate effect. Taking these results together with the strong stock return but weak risk effects of pure monetary policy shocks we document for our post-2000 sample suggests that the monetary policy effects on asset prices may well reflect a persistent pure interest rate effect. If true, this could confirm Binsbergen (2020)'s results, who argues against an important role for equity risk premiums in stock returns over the last 20 years (see Bekaert and Xu (2023) for more details).

Our research relates to a voluminous empirical literature on international spillovers of monetary policy to financial asset prices.[3] By considering both domestic and foreign monetary policy shocks, by distinguishing between different types of monetary policy and communication shocks, by differentiating monetary policy shocks from risk shocks orthogonal to monetary policy, and by using data at the daily frequency, we complement the work by Miranda-Agrippino and Rey (2020b) who focus on the effect of traditional US monetary policy shocks on global risk and domestic business cycles at the monthly frequency. They find that monetary policy in the US has large spillovers to the rest of the world by driving the "Global Financial Cycle," which is then reflected in strong comovements of financial asset prices across countries. Their measure of the Global Financial Cycle includes data from emerging markets – which react strongly to US monetary policy changes (see Kalemli-Özcan (2019)) – while we are focusing on spillovers across three developed economies. Ca'Zorzi, Dedola, Georgiadis, Jarociński, Stracca, and Strasser (2020) use monthly data to compare the international transmission of monetary policy of the Fed and the ECB. They document a relatively larger impact of US monetary policy on speculative-grade corporate bond spreads and sovereign bond yields in the euro area, asset classes we do not consider in our study. Kearns, Schrimpf, and Xia (2020) examine the interest rate spillovers from seven advanced economy central banks to the rest of the world. Like us, they also find that there is not much monetary spillover to short term interest rates, but find stronger results for longer-term interest rates. In parallel work, Jarociński (2022)[4] specifically focuses on the transmission of

[3]Many contributions focus on the spillovers of US monetary policy (e.g., Kim (2001), Faust, Rogers, Swanson, and Wright (2003), Ehrmann and Fratzscher (2005), Faust, Rogers, Wang, and Wright (2007), Ammer, Vega, and Wongswan (2010), Hausman and Wongswan (2011) among many others). Ehrmann and Fratzscher (2009) study the transmission of US monetary policy shocks to global equity markets, documenting that the degree of global integration of countries is a key determinant for the transmission process. Some papers also consider spillovers to the US, following monetary policy actions of other central banks; e.g., Ehrmann and Fratzscher (2005) analyze ECB's actions, while Craine and Martin (2008) consider Australian monetary surprises.

[4]The article was publicly disseminated at least one full year after a first version of our article was available on SSRN.

ECB monetary policy to the US (on 1 year Treasury rates, stock prices and corporate bond spreads), finding the spillover effect to be large, and mostly attributable to an information effect. For the spillover effects from the US to the euro area, he finds the pure monetary policy effect to be stronger than the information effect. Because we do not look at one year Treasury rates, our results are not directly comparable; still, we also find strong spillover effects emanating from the ECB and we also find the information spillover effects (for risk and stock prices) to be stronger than the pure policy effects. Rogers, Sun, and Wu (2023) examine the effect of other shocks on the Global Financial Cycle in a VAR framework, finding a US credit spread shock to be more important than the US monetary policy shock. Such a shock may well represent a (non-monetary policy) risk shock.

A more tangentially related literature analyzes how US monetary policy affects global banking variables and capital flows,[5] with sometimes contradictory results. For example, Durdu, Martin, and Zer (2019) show that a contractionary shock to US monetary policy can lead to capital outflows in other countries due to search-for-yield incentives, and may increase the probability of a banking crisis, but Cerutti, Claessens, and Rose (2019) show that common shocks (such as those emanating from a central country like the US) drive little of the variation in global capital flows.

2 Conceptual and Empirical Framework

In this section, we first provide a simple conceptual framework in which to interpret our empirical work. We then present the econometric framework we use to gauge the effects of monetary policy and risk shocks.

[5]See contributions of Bruno and Shin (2015a,b), Cetorelli and Goldberg (2012), Buch, Bussiere, Goldberg, and Hills (2019), Morais, Peydró, Roldán-Peña, and Ruiz-Ortega (2019), Schmidt, Caccavaio, Carpinelli, and Marinelli (2018), and Degasperi, Hong, and Ricco (2021).

2.1 Conceptual framework

2.1.1 Domestic policy effects

Following Cieslak and Schrimpf (2019) and Bekaert and Xu (2023), we think of the short-term real interest rate, rf_t, as driven by three variables:

$$rf_t = \underbrace{\phi_g g_t + \phi_{RI} RI_t}_{rf_t^*} + \phi_{MP} MP_t, \tag{1}$$

where g_t represents expected consumption output growth; RI_t is a state variable measuring "risk"; MP_t is a monetary policy shock. The first two terms represent the equilibrium real interest rate, rf_t^*: better growth prospects increase the interest rate ($\phi_g > 0$); if variation in uncertainty dominates "risk", precautionary savings effects imply that increases in risk lower interest rates ($\phi_{RI} < 0$), but if risk reflects risk aversion, increases in risk may increase or decrease the interest rate depending on whether intertemporal smoothing or precautionary savings effects dominate (see also Wachter (2006)).

Monetary policy can affect the short-term interest rate in three ways. It can work through a risk channel by affecting RI_t, which is now well-understood (see Borio and Zhu (2012) for a survey of various economic mechanisms leading to such a link). Monetary policy can also affect growth expectations g_t when it releases new information, see Gürkaynak, Sack, and Swanson (2005), Nakamura and Steinsson (2018), Jarociński and Karadi (2020) and Miranda-Agrippino and Ricco (2021). Finally, there can be a direct pass-through effect which we model through the MP_t state variable. The indirect effects through g_t and RI_t imply that the ϕ_{MP} coefficient does not necessarily measure the full extent of interest rate pass-through.

Monetary policy can affect equity returns through a discount rate or cash flow effect. The discount rate effect potentially comprises a direct interest rate effect, an indirect interest rate effect (via g_t, RI_t), or a risk premium effect. The standard interpretation of monetary policy effects on stock returns is that they operate through the risk premium (see Bernanke and Kuttner (2005)), which in the model above would be fully captured by changes in the RI_t variable. Note that all these discount rate effects move stock prices in the same direction. In addition, stocks also react to cash flow news. If we assume that cash flows are directly related to expected growth g_t, monetary policy affects stock prices through the information it releases about the economy. Information shocks have the opposite effect on stock prices than do pure monetary policy shocks, as an increased interest rate here signals positive news about the economy, which should increase stock prices. In rational models, discount rate effects naturally imply mean-reverting behavior in returns, whereas cash flow effects ought to be permanent.

2.1.2 International spillovers and asset return comovements

Our focus in this article is on the international spillover effects of monetary policy, among large developed economies. In a financially integrated world, asset returns around the world should comove more or less strongly, in response to any shocks we outlined in Section 2.1.1, including shocks to growth prospects g_t and risk RI_t.[6] In fact, CAPM intuition would indicate that the US *should be* the hegemon country, because the US represents about 40% of the world's equity market capitalization. Therefore, any shock affecting the US equity market should spill over strongly to other countries through simple "beta" effects. With Japan and the euro area each representing less than 10% of world market capitalization, the corresponding reverse effects ought to be small. Whereas these are partial equilibrium relations, they have more bite in our high-frequency framework. For example, when a monetary policy shock moves the US stock market during US trading hours, it changes the world market return but the effects on

[6] Stock return comovements have increased substantially in recent times (see Bekaert and Mehl (2019); Christoffersen, Errunza, Jacobs, and Langlois (2012); Jordà, Schularick, Taylor, and Ward (2019)).

Japanese and euro area stock markets happen during the next trading day. Therefore, we can predict the "CAPM" response for market j to a MP shock in country i as,

$$\beta_j w^i_{t-1} \Delta SR^i_t, \tag{2}$$

where ΔSR^i_t is the stock market i response to a domestic monetary policy shock in day t; w^i_{t-1}, the capitalization weight of market i in the world market from the last period; β_j is the world market risk exposure of the stock market j trading subsequently (whether later the same day or the next day). We use these predictions to help interpret our empirical results.

We also verify directly the spillovers of monetary policy through interest rates and a risk channel. The classic trilemma theory holds that economies cannot simultaneously control monetary policy and the exchange rate while accommodating free capital flows (see, e.g., Obstfeld, Shambaugh, and Taylor (2005); Aizenman, Chinn, and Ito (2016); Bekaert and Mehl (2019); Jordà, Schularick, and Taylor (2020)). Given that the exchange rates between our three countries are flexible, and capital is mobile, the standard trilemma theory implies that monetary authorities should be able to achieve autonomy and no interest rate spillover must happen. However, a variety of alternative economic channels can still lead to short-term interest rate spillovers.[7] For example, monetary policy can reveal information about economic conditions (information about g_t) or affect financial conditions (e.g., uncertainty driving precautionary savings effects, as captured by RI_t). Such monetary policy effects operating through interest rates obviously may have repercussions for international asset prices. Miranda-Agrippino and Rey (2020b) argue that the main policy spillover happens through a risk channel, with US monetary policy affecting a common component in international risky asset prices.

[7] Jotikasthira, Le, and Lundblad (2015) and Bekaert and Ermolov (2023) in fact show that nominal interest rates are highly correlated across countries.

Rey (2015), Bruno and Shin (2015a,b), and Passari and Rey (2015) even suggest that the US dollar and US monetary policy are so critical in setting global liquidity and credit conditions that non-US central banks have lost their ability to influence domestic interest rates, even in the presence of flexible exchange rates. That is, the trilemma has morphed into a dilemma between financial openness and monetary policy autonomy.

2.2 Empirical framework and hypotheses

Main Specification. Monetary policy shocks are best identified using high-frequency data. Since our interest is in the impact on asset prices – which move fast in response to shocks – we conduct our tests mostly using daily data, considering longer term effects briefly in Section 5. It is important to not simply focus on within day, high-frequency changes in asset prices. First, Kurov, Sancetta, Strasser, and Wolfe (2019), investigating high-frequency changes in stock and bonds returns, show substantive price drift ahead of various macroeconomic announcements. Second, occasionally asset price responses to important monetary policy announcements mean revert within the day. Investigating a one-day responses is therefore an adequate compromise.

Our main regression is as follows,

$$Y_{j,t} = \alpha_j + \sum_{i=US,EA,JP} \boldsymbol{\beta_j^{MP,i} MP_t^i} + \sum_{i=US,EA,JP} \boldsymbol{\delta_j^i Macro_t^i} + \boldsymbol{\gamma_j D_t} + \sum_{i=US,EA,JP} \beta_j^{RI,i} \overline{ri}_t^i + \varepsilon_{j,t}, \tag{3}$$

where $Y_{j,t}$ is either stock returns or the change in interest rates in country j on day t. $\boldsymbol{MP_t^i}$ stands for the monetary policy shock series in country i on day t (0 on other days), representing a vector of 4 different types of monetary policy shocks (see Section 3.1). $\boldsymbol{Macro_t^i}$ represent a large set of (21) macroeconomic news series around the world at the daily level (see Section 3.2). $\boldsymbol{D_t}$ represents a vector of monetary policy event date dummies, and macroeconomic announcement event date dummies, for the US, EA and JP. This inclusion of event dummies is econometrically critical, as we explain below.

The $\overline{ri}_t^i$ variable represents "cleansed" risk shocks, defined as $\overline{ri}_t^i = \Delta RI_{i,t} - E[\Delta RI_{i,t}|\boldsymbol{z_t}]$. $\Delta RI_{i,t}$ represents changes in the risk variable for countries i over day t (see Section 3.3). The set of $\boldsymbol{z_t}$ instruments include monetary policy shocks, macro shocks, and their event day dummies as defined above. Specifically,

$$\Delta RI_{j,t} = \alpha_j + \sum_{i=US,EA,JP} \boldsymbol{\beta_j^{MP,i} MP_t^i} + \sum_{i=US,EA,JP} \boldsymbol{\delta_j^i Macro_t^i} + \boldsymbol{\gamma_j D_t} + \overline{ri}_t^i. \quad (4)$$

The linear projection cleanses risk changes from any monetary policy influences, but it also removes the effects of macroeconomic announcements occurring around the world on risk aversion shocks. As a result, this residual is the non-MP- and non-macro-driven risk shock denoted by $\overline{ri^i}$, $i = US,\ EA,\ JP$,[8] and labeled as "Non-MP, non-Macro Risk" in tables. For simplicity, we sometimes refer to it as a "cleansed" risk shock.

Event Day Controls. To examine the directional effects of macro or monetary policy shocks on asset prices, the literature often examines their relation *on* the event dates only. It is a suitable empirical identification framework if all shocks constitute shocks on event days. However, our goal is to contrast the relative directional effects of monetary policy shocks with those of daily risk shocks; thus, we need to use data from all days.

Including the monetary policy and macro announcement day dummies $\boldsymbol{D_t}$ ensures that the results we obtain using these daily regressions are identical to "event-only" regressions. That is, the $\beta_j^{MP,i}$s effectively capture the directional effects of MP shocks on event days.[9]

[8] Lower case ri is used to differentiate this shock variable with the level variable denoted using upper case RI.

[9] In a simple system with one event regressor, it is straightforward to show that the two approaches deliver identical coefficients (a proof is available upon request). We empirically verify that the coefficients are nearly identical in our multi-country, multi-shock framework in Appendix Table A4.

It is conceivable that the mere release of information, irrespective of the sign or the magnitude of the MP shock, affects uncertainty and thus asset prices. For example, Brusa, Savor, and Wilson (2020) examine global stock market returns, and Mueller, Tahbaz-Salehi, and Vedolin (2017) examine foreign exchange returns on FOMC announcement days. Such effects are not our focus, but are controlled for in our analysis.

The main coefficients of interest are the $\beta_j^{MP,i}$ and $\beta_j^{RI,i}$ coefficients which help contrast the effects of various types of monetary policy shocks, as captured in the vector $\boldsymbol{MP_t^i}$ with the effects of cleansed risk shocks. Domestic monetary policy effects are captured through $\beta_j^{MP,j}$, and spillover effects through $\beta_j^{MP,i}$, $i \neq j$, with a similar distinction applying to the $\beta_j^{RI,i}$ coefficients. All standard errors correct for heteroskedasticity.

Time Zone Adjustments. One last challenge our analysis must overcome, given its high-frequency nature, is the non-synchronous trading schedules of the three parts of the world economy. The rule of thumb is that subscript t is adjusted to reflect the information set of any variable in the regression. In particular, for the US, which trades last during a calendar day, all US and foreign MP and macroeconomic shocks enter contemporaneously, except for those shocks that are released after the US market closes (those only enter the information set on the next trading day). For the euro area, JP and EA shocks that materialize before or during the European opening hours enter contemporaneously while the other shocks as well as the US shocks enter the information set on the next trading day. For Japan, JP shocks that materialize while Japanese financial markets are open enter contemporaneously, while the EA and US shocks dated on the same day enter the information set on the next trading day.

Risk Channel. For the regressions involving the MP effects on the risk variables, that is, where $Y_{j,t} = \Delta RI_{j,t}$, our regression framework must be slightly adjusted in that the risk shocks on the right-hand side obviously only include risk shocks in other countries.

The presence of the cleansed risk shocks from other countries aids the identification of monetary policy shock effects on risk. Imagine a typical US monetary policy announcement on day t, which tends to happen in the early afternoon, US time (GMT-5). The daily US risk aversion change may be influenced by events earlier in the day, during European or Japanese market hours. The presence of $\overline{ri_t^{EA}}$ and $\overline{ri_t^{JP}}$ controls for these events. Their coefficients also reveal how global risk travels across time zones. In addition, because these shocks are cleansed of the effect of MP, they do not reflect earlier MP shocks.

3 Monetary Policy, Macro, and Risk Shocks

In Section 3.1, we discuss the measurement of our MP shocks, which are the key independent variables in Equation (3). Section 3.2 describes the construction of macro shocks. Section 3.3 discusses the measurement of risk and risk shocks, and their economic interpretation.

3.1 Monetary policy shocks

We investigate two types of MP shocks: traditional monetary policy shocks correspond to policy decision announcements, and communication shocks include monetary policy information events extending beyond the regularly scheduled policy meetings.

Traditional Monetary Policy Shocks We decompose traditional announcement shocks into "pure" and information-driven components, using the measures developed by Jarociński and Karadi (2020) for the US and the euro area. They disentangle monetary policy shocks from a contemporaneous information shock by analyzing the high-frequency comovement of interest rates (US: 3-month Federal funds futures rate; EA: 3-month Eonia Euro Overnight Index Average interest rate swap rates) and stock prices around the policy announcement. The shocks are measured in a narrow window (10 minutes before and 20 minutes after) around the announcement events. For the US, these events include FOMC announcements, mostly at 14:00 on the day of the meeting; for the EA, they include ECB press conferences and key press releases as well as a few major speeches by the ECB Executive Board members providing information on ECB unconventional measures, e.g., the "Whatever it takes" speech of Mario Draghi from July 26, 2012. The bulk of these events correspond to what Cieslak and Schrimpf (2019) call "monetary policy decisions" (MPD), reflecting the traditional monetary policy events, examined in most of the literature.

Jarociński and Karadi (2020) argue that a pure monetary policy tightening should unambiguously lower stock market valuations through a discount rate effect (higher real interest rates and risk premia) and a cash flow effect (expected payoffs declining with the deteriorating outlook caused by the policy tightening). Therefore, they identify a monetary policy shock through a negative high-frequency comovement between interest rate and stock price changes. In contrast, stock markets and interest rates comoving positively is interpreted as an indication for the presence of an accompanying information shock, with a positive shock signaling good news about the economy, where the central bank tightens to counteract its macroeconomic impact.[10]

Note that interpreting this monetary policy "information" shock as revealing additional central bank information is subject to debate. Bauer and Swanson (2023), for example, argue that a detailed analysis of these effects in the US suggests that such shocks are more consistent with both the private sector (e.g. macroeconomic forecasters) and the Fed reacting to public news. Importantly, we include a wide set of macro news shocks into our regressions (see below), controlling for public news effects. Even

[10] An advantage of using the Jarociński and Karadi (2020) decomposition is that it gives us a consistent decomposition for both the US and the euro area, for our entire sample period. Several recent papers similarly propose measures of monetary policy shocks which control for central bank information effects, e.g., Miranda-Agrippino and Ricco (2021) and Nakamura and Steinsson (2018).

under this interpretation and controlling for economic news, monetary policy shocks may still have an effect on the economy and asset prices if the private sector ex-ante under-estimated the Fed's reaction to public news (see also Cieslak (2018)).

For Japan, we use the data shared by Kubota and Shintani (2022), who measure monetary policy surprises using changes in 3-month Euro-Yen futures and 10-year Japanese government bond futures around the Monetary Policy Meeting press releases between 1999 and 2020. The use of 10-year government bond futures is common in examining Japanese monetary policy as short rates were constrained by the zero lower bound for most of our sample period. They use a tight window of 10 minutes before to 20 minutes after the announcement. Unfortunately, they do not split up the shocks into a "pure" and information shock, but rather use the decomposition proposed by Gürkaynak, Sack, and Swanson (2005), splitting monetary policy surprises in a "target" factor, which mainly affects current short-term rates, and a "path" factor, which affects the expected path of future short rates. Because of the lack of comparability with the MP shocks for the US and the euro area, we view the Japanese shocks as control variables in our analysis, without detailing the corresponding results.

Communication Monetary Policy Shocks. Cieslak and Schrimpf (2019) identify a much wider set of dates on which important monetary policy information was released to the public, also including press conferences, the release of the minutes of policy meetings and the release of other important reports (such as the inflation report in Japan). To define a new set of monetary policy "communication" events, we use all of their dates and events that are not in our traditional monetary policy set. This leads to 160 communication events for the Fed, 90 for the ECB, and 196 for the Bank of Japan, substantially expanding our set of MP event dates. Appendix B describes the communication events in more detail, including discussing some summary statistics. We discuss the results regarding communication shocks in Section 5, focusing our main discussion on traditional MP shocks.

Cieslak and Schrimpf (2019) already show that these shocks induce large domestic asset price responses. Because they also record high-frequency changes (typically, 10 minutes before till 20 minutes after the event) for stock returns and 3-month yields (10-year yield for Japan), we can mimic the construction of "pure" and information shocks for these communication events. Specifically, when the covariance between stock returns and changes in the government yield is negative (positive), the shock is a pure (information) shock.[11] The magnitude of the shock is the change in the government yield over the short window around the communication event. Of course, we must stress that at such events the central bank does not change the rate of the actual policy instrument (e.g. the Fed funds rate in the US), but the observed changes in the (short-term) yield likely reflect an adjustment of expectations regarding such changes.

Summary Statistics. We analyze monetary policy shocks for the overlapping sample for the three countries, January 2000 – December 2017. Table 1, Panel A, provides summary statistics for the standard MP measures (all quoted in basis points). Over this time period, we have 153 traditional monetary policy shocks for the US, 277 for the euro area, and 257 for Japan. A positive (negative) shock indicates monetary policy tightening (easing). For the central bank (CB) information shocks, a positive value indicates good news about the economy and vice versa. All measures are quoted in basis points. Note that the standard deviations of the pure monetary policy and information shocks for the US and euro area are comparable at about 5.5 to 6.3 basis points. For Japan, the shocks are much less variable at around 0.8 basis points.

[11] This methodology is not identical to the one used in Jarociński and Karadi (2020), but they use a similar identification as a robustness check, finding similar results. Note that Cieslak and Schrimpf (2019) use these high-frequency comovements, together with comovements of 2- and 10-year yields with stock returns to decompose monetary policy shocks into monetary policy, growth and risk shocks. While different from our decomposition, it is clear (see Table 8, p. 311) that their risk premium shocks have little effect on short term yield changes and stock returns, and primarily reflect a term premium effect.

[Insert Table 1 here]

3.2 Macroeconomic news

In addition to the monetary policy shocks, we collect data on macroeconomic news releases and the corresponding survey expectations prior to the news release (source: Bloomberg). As is standard in the literature, we define a macroeconomic news shock as the actual realization minus the survey expectation, divided by the sample standard deviation. For the US, we use a total of 18 series. Our coverage is wider or comparable to that of recent articles focusing on US macro-announcements, such as Boehm and Kroner (2023) and Elenev, Law, Song, and Yaron (2022). We include all announcements that have a significant effect on either bond or stock returns as demonstrated in Kurov, Sancetta, Strasser, and Wolfe (2019), with the full list reported in Appendix Table A1. Similarly, we obtain 11 series for both the euro area and Japan.

Economically, these shocks should span new information about changes in g_t in Equation (1). Boehm and Kroner (2023) show that US macro news is an important driver of global risk and global asset prices, however, Bekaert, Engstrom, and Xu (2022) find that variation in their risk aversion index is dominated by non-macro factors. We simply control for, but do not focus on analyzing, the effect of macro news on risk and asset prices.

3.3 Risk and risk shocks

Our main measure of risk must necessarily rely on high-frequency data, and is the "risk-neutral" volatility index, which can be inferred from option prices (see Britten-Jones and Neuberger (2000) and Bakshi, Kapadia, and Madan (2003)). For example, the VIX index calculation uses a weighted average of European-style S&P500 call and put option prices that straddle a 30-day maturity (22 trading days) and cover a wide range of strikes (see CBOE (2004) for more details). For the euro area, we use a similar implied volatility index on the STOXX50, for Japan on the Nikkei225. Importantly, this estimate is model-free and does not rely on an option pricing model (see e.g. Bakshi and Madan (2000)).

The option-implied volatility index is determined in financial markets and reflects the forward-looking risk attitudes of their market participants. Bekaert, Engstrom, and Xu (2022) compute a measure of US risk aversion within the context of a dynamic habit model, while Miranda-Agrippino and Rey (2020b) compute a risk measure from a very large set of risky asset prices, inferring a common component using a factor model. Both articles provide evidence that the VIX is highly correlated with their risk (aversion) measures.[12]

To create "cleansed" risk shocks (or $\overline{ri}_t^i$ in Equation (3)), we project daily changes (first differences) in country risk measures onto domestic and foreign monetary policy, macroeconomic shocks and all their event dummies. Our interpretation of these "non-MP, non-macro" risk shocks as not driven by monetary policy is strengthened by our use of a comprehensive set of monetary policy shocks and communication shocks. The similarly extensive controls for macro shocks ensure that the risk shocks likely reflect sentiment/confidence changes of investors and consumers, driven by other news. Likely candidates are (geo)political news or economic news (e.g. of a company specific nature) not captured by formal announcements. Bekaert, Engstrom, and Xu (2022)'s risk aversion index is quite highly correlated with the VIX, at 0.87, and is also highly correlated with various measures of investor and consumer sentiment and confidence. It is most highly correlated with the Sentix sentiment index which measures investor emotion (fear,

[12]In a previous draft of our research, we confirmed our results using the variance risk premium (see Bekaert and Hoerova (2014)). Miranda-Agrippino and Rey (2020b) also correct their risk measure for volatility but regress it on a realized variance measure and use the (inverse of the) residuals to provide a measure of risk aversion. While such a measure may approximate risk aversion (see e.g. Bekaert, Engstrom, and Xu (2022)), it is rather highly correlated with the VIX itself. Rompolis (2022) examines the effects of ECB unconventional monetary policy shocks on the variance risk premium and uncertainty.

greed) using weekly surveys. Huang and Xu (2022) show that risk (aversion) spillovers from the US to other countries are not only driven by economic and business news, but also by a wide variety of political, societal and environmental news events.

4 Monetary Policy, Risk, and Asset Prices

In this section, we first study the effect of monetary policy and risk shocks on stock returns and quantify whether the US monetary policy shock effects indeed are unusually large (Section 4.1). We then investigate the same effects for interest rates (which provides a direct test of the trilemma hypothesis) in Section 4.2 and for risk in Section 4.3. Section 4.4 provides some cautious economic interpretation of our results. In this section, we focus on standard monetary policy effects, using the communication shocks simply as controls for wider monetary policy effects, and we focus on the euro area/US results, given our different measurement for Japanese monetary policy. The results for communication shocks and Japanese variables are briefly discussed in Section 5.

4.1 Monetary policy, risk, and stock returns

All stock returns are measured in percent (log first-differences of total return indices multiplied by 100) and in local currency, and are sourced from DataStream. For the euro area, we use the same countries as for the EA 3-month composite interest rate with the same GDP weights, which we discuss in more detail in Section 4.2. The relevant results from estimating Equation (3) for stock returns are reported in Table 2.

To conserve space, we only report the coefficients related to the monetary policy shocks, $\beta_j^{MP,i}$, or to direct risk spillovers, $\beta_j^{RI,i}$. While Equation (3) is run at the country level, we organize the results according to the economic nature of the coefficients (policy or risk effects emanating from the US, and the euro area), rather than by regression. For example, columns (1) and (4) of Table 2 come from one regression with the left-hand-side variable being US stock returns and the right-hand-side variables including the MP shocks, macro shocks, and all MP and macro event dummies from the US, EA, and Japan as well as non-MP-driven risk shocks. All reported coefficients are standardized. That is, a coefficient of 1 indicates that a one standard deviation (SD) change in the independent variable is associated with a one standard deviation change in the dependent variable. To do so, we use the sample standard deviation for risk shocks, but use the standard deviation of MP shocks across event days.

[Insert Table 2 here]

4.1.1 Empirical Results

We commence with discussing the domestic effects, reported on the left-hand side of Panel A of Table 2. US monetary policy tightening leads to negative stock returns in the US. The effect is economically large, representing 0.4 standard deviations. If we transform it in the standard basis points units, a 10 basis points 3-month pure MP shock leads to a 81 basis points drop in the stock market, confirming the large effects documented in the seminal Bernanke and Kuttner (2005) article. The domestic MP effect is of the same order of magnitude and highly statistically significant in Europe. The information shock effect is, as expected, robustly positive, with the effect in the euro area (0.51) about 2.5 times as large as in the US (0.21).

Moving to the right panel of the table, we observe significant international spillover effects between the US and the euro area with the signs as expected. The US traditional pure MP shock has a negative effect on the euro area stock market, a bit less than 30% of the magnitude of the own market effect. The US information shock has also a positive and significant effect on the euro area stock market, which is, in economic terms, stronger than the domestic information effect. However, the strongest spillover effects come from the euro area, with the pure MP shock generating a 0.27 standard deviation drop in the US market; the information shock a 0.45 standard deviation increase. These effects are about double the ones we observe in the opposite direction.

The last line of Table 2, Panel A, reports the effects of the risk shocks. The domestic effects dominate the international spillover effects, which are economically tiny, being about one tenth of the economic magnitude of the domestic effects.[13] The direct effects of risk shocks on the stock market are negative and large, amounting to -0.70 standard deviations. These effects are larger than what we observe for MP shocks. This is consistent with risk shocks generating the expected effects, but not operating through a monetary policy channel.

4.1.2 CAPM Interpretation

In Table 2, we also provide a world CAPM interpretation of the results, following Equation (2) in Section 2.1.2. The computation uses three ingredients: (1) the original domestic MP effect on stock returns of country i, ΔSR^i; (2) the market capitalization of stock market i within the world market, w^i; and (3) the sensitivity of stock market returns j to the world market return, β_j. For instance, we can compute the CAPM-implied effect of US MP shocks on the EA stock market (i=US, j=EA) as $\beta_{EA} w^{US} \Delta SR^{US}$. Because the coefficients are in standard deviation units, we must adjust the coefficients from Panel A, using the relative standard deviation of the respective stock market returns to obtain the correctly scaled ΔSR^i. In our example, the Table A coefficient must be adjusted by the ratio of the US stock return volatility over the volatility of EA stock returns. We report this CAPM-implied effect of US MP shocks on EA stock returns in Column (3) of Table 2. Using a similar method, in Column (4), we report the EA shock-US stock return effect; that is, how much the US stock market is predicted to move, as a result of the world market return incorporating the euro area stock market

[13] Ehrmann, Fratzscher, and Rigobon (2011) also find stronger within-country than across-country shock transmission for various asset classes in the US and the Europe, but we do not confirm their finding that US-driven international spillover effects dominate.

response to euro area monetary policy shocks. We use constant betas estimated over the full 2000-2017 daily return sample and the MSCI World total return index to proxy for world stock returns. We then calculate the average country market capitalization weights relative to the world total (source: annual numbers from the World Bank) from 2000 to 2017. We also report the range over the sample period.

To be concrete, let's illustrate the computation of the expected response of the euro area stock market to a US monetary policy shock (Column (3) of Table 2). Using our full daily sample 2000-2017, the β of the EA stock market with respect to world equity returns is 1.144 (SE=0.011) and the US market represents 39.47% of world market capitalization on average. Moreover, the volatility of the US stock market is 1.207% per day and the volatility of the euro area stock market is 1.463% per day. The standardized domestic MP effect on stock returns in US is -0.418, according to Panel A. Therefore, the predicted effect in standard deviation units is -0.156 (1.144*39.47%*-0.418*1.207/1.463). In economic terms, a one SD traditional MP shock from the US is expected to result in a -0.156 SD effect in EA stock returns. This number is reported in Column (3). The computation for column (4) is similar. We do this for all MP shocks.

The conclusions are quite strong. First, information shocks generate larger than expected spillovers, both for shocks emanating from the US (to EA) and from the euro area (to US), and this is true over the whole range of observed market capitalizations. Second, the actual effect of a US standard monetary policy shock is slightly smaller than the predicted CAPM effect. In fact, with the empirical effect at -0.116, it is still slightly smaller in absolute magnitude than the lowest measured number over the range of market capitalizations (which is -0.120). Third, the euro area spillover effects are substantially larger than the CAPM predictions suggest. Because the euro area represents a relatively small fraction of the world equity market, its MP spillover effects are much larger in magnitude than simple CAPM predictions would suggest. Thus, if anything, it is the euro area's monetary policy that has surprisingly substantial effects on global asset prices. These results extend significantly beyond the analysis in Miranda-Agrippino and Rey (2020b) as they did not benchmark the effects of US monetary policy on global asset prices, nor did they examine the corresponding effects of euro area monetary policy.

Our empirical results are very robust, both in terms of magnitude and statistical significance. In Internet Appendix Tables A4 and A5, we show the raw coefficients in many alternative US and EA stock return regression specifications. First, we examine specifications without control variables; Columns (1)-(3) use monetary policy event days only and Columns (4)-(6) expand the data to all trading days, adding an event-day dummy. As expected, both specifications yield the exact same results. The three different specifications consider alternative MP shocks, raw one month, three month MP shocks, and then the Jarociński and Karadi (2020) decomposed shocks. For US stock returns, the MP shock coefficients are statistically significant, with the sign consistent with our main specification. The one month and three month monetary policy shocks are no longer statistically significant for the euro area, reflecting the importance of information shocks in the euro area. Second, we add one group of major control variables at a time in Columns (4)-(12). Across all specficiations, the key coefficients, capturing the effects of MP and non-MP risk shocks on both domestic and international stock market returns, are remarkably similar in magnitude and consistently statistically significant for both the euro area and the US.[14] Finally, in Internet Figure A1, we show the results of a jackknife analysis for our main spillover coefficients, leaving out one year of data at a time. Both statistical and economic magnitudes remain similar, suggesting that our results are not driven by one particular year. Further unreported analysis suggests that neither the Great Financial Crisis, nor the European sovereign debt crisis account for

[14]Columns (7)-(8) control for pure risk shocks; Column (9), international monetary policy shocks and the corresponding dummy variables; Column (10), international risk variables; Column (11), US macro announcements and their dummy variables; Column (12) international macro announcements, and their dummy variables.

the results.

4.2 Monetary policy and interest rates

Table 3 reports our baseline regression with daily changes in 3-month interest rates as the dependent variable. Specifically, we use three-month Treasury interest rates for the US and three-month government interest rates for the euro area, reflecting GDP-weighted interest rates for the original 11 euro countries.[15] As with most financial data used in this article, they are downloaded from DataStream. Again, the variables are standardized, so that the coefficients present the economic effect of a one standard deviation shock in terms of standard deviations of interest rates. The standard deviation of interest rate changes over the sample period is 4.95 bps for US and 3.44 bps for the EA. Further summary statistics are provided in Appendix Table A2. As before, the columns present the key coefficients (domestic and spillover effects on interest rates) in country-specific regressions of US and EA.

[Insert Table 3 here]

The traditional, "pure" monetary policy effects are on the left-hand side of the table on the first line, allowing us to verify that monetary policy indeed passes through to interest rates as expected. All these coefficients are positive and highly statistically significant. Economically, the effects are in a 0.35-0.43 standard deviations range. It is more customary to present these results in terms of the pass-through of a 10-basis point change in the policy instrument. The effect of a 10 basis points tightening of US monetary policy (the MP shocks purged from CB information) is a 3.4-basis point

[15] We construct the EA 3-month composite interest rate as the GDP-weighted average of country government bond 3-month rates across 11 euro area countries: Germany, France, Italy, Spain, Netherlands, Belgium, Austria, Ireland, Finland, Portugal, Greece. We use the last available quarterly GDP data to calculate the weights, and for 2000, the GDP weights are calculated without Greece to reflect its non-euro area member status at the time. The quarterly GDP data are obtained from Eurostat (series "NAMQ_10_GDP"). For Japan, we use 10-year government bond yields as short-term interest rates barely moved throughout the sample period.

increase in US Treasury rates, or a 34% pass-through. The pass-through is 22% in the euro area.

The second line represents the interest rate effects of information shocks, which are statistically significant for both the US and the euro area. For the US, they are economically double the size of the pure shocks; for the euro area, they are a bit smaller in economic magnitude than the effect of pure shocks.

We do not see any strong spillover effects, neither for the pure shocks, nor for the information shocks. These weak interest rate spillovers are consistent with the findings in Kearns, Schrimpf, and Xia (2020), who show weak evidence of short-term interest rate spillovers, for a large number of countries. Our results are consistent with monetary policy retaining its autonomy in the three major economies.[16] Ehrmann and Fratzscher (2005) document strong reactions of interest rates in the euro area to monetary policy and macroeconomic news in the US, but they do not use a high-frequency framework, and their sample largely precedes ours. While our results are inconsistent with US monetary policy affecting foreign stock markets through a direct local interest rate effect, part of its spillover effects may still work through interest rates to the extent that the world interest rate depends on US interest rates in a financially integrated market.

Finally, we find negative coefficients for risk shocks, which is consistent with precautionary savings effects. Only the U.S. coefficient is statistically significant, though small economically.

[16] Kearns, Schrimpf, and Xia (2020) do claim that there are significant US spillovers to long-term interest rates in other countries through a term premium channel, as does Dilts Stedman (2019) but only through unconventional monetary policy. Ermolov, Lu, and Luo (2024) document that the effect of US monetary policy on international stock markets is partially due to interest rate effects using a simultaneous spatial panel model.

4.3 Monetary policy and risk

Table 4 shows the estimation results with $Y_{j,t} = \Delta RI_{j,t}$, daily changes in our risk measures. Section 4.3.1 focuses on the domestic effects; and Section 4.3.2 discusses spillover effects. Apart from testing the domestic and foreign risk channel effect of monetary policy, we also examine how non-monetary policy-driven risk shocks are directly correlated across countries. While we sometimes refer to these effects as "risk spillovers," they could simply follow from a global risk shock traveling across time zones. For this reason, we also show the results for Japan. Our analysis here provides the most direct test of a key component of a US monetary policy-induced global financial cycle: Does US monetary policy directly affect stock market risk in the three major economies we study?

[Insert Table 4 here]

4.3.1 Monetary policy and domestic risk

We start by discussing the domestic monetary policy effects, which are collected on the left of Table 4. The first three columns (US; EA and Japan) report coefficients from three different regressions for the risk variables of the three countries. The first two lines focus on the traditional MP shocks, split up in "pure MP" and information shocks. The coefficients for traditional MP shocks are overall positive, but not statistically significant. The p-value for the US is just above the 10% rejection level (at 12%). The information shocks generate negative risk effects with the effect only statistically significant for the euro area. If such shocks indeed reflect positive growth prospects, it is to be expected that they entail lower uncertainty and/or risk aversion, consistent with the conceptual framework described in Section 2.1.1.

We conduct an extensive robustness analysis of this result, with the results for the US shown in Internet Appendix Table A6. Over six different specifications (with the pure and information MP shocks, adding one group of control variables at a time), we find 10% statistical significance half of the time. The magnitude of these raw coefficients is very similar across all specifications. In regressions with MP shocks using one month futures or 3 month futures not decomposed into pure and information shocks, we find positive but insignificant coefficients. In addition, we consider an alternative measurement of the risk variable, using the variance risk premium (see Bekaert and Hoerova (2014)) in Internet Appendix Table A7. Again, the main traditional pure MP and information shock coefficients are similar across specifications, but only significant in one case. However, we find stronger economic and statistical significance for the specification using one-month futures to measure MP shocks.

Overall, the effects of monetary policy on risk have weakened, relative to the original findings in Bekaert, Hoerova, and Lo Duca (2013), who find a strong causal effect of monetary policy shocks on risk aversion in the US. However, these authors focused on a sample ending in 2007, before the Global Financial Crisis ushered in an era of unconventional monetary policy. Bruno and Shin (2015a) and Miranda-Agrippino and Rey (2020a), analyzing the relationship between monetary policy and risk in vector autoregressive frameworks, also document a weakening relationship in samples that include the Global Financial Crisis and its aftermath. In contrast, the risk effects of both information and communication shocks (see Section 5.1) are mostly stronger than those of the "pure" monetary policy shocks.

4.3.2 Monetary policy and international risk spillovers

The right-hand side part of Table 4 reports the "international spillover" part of the three risk regressions. The first 2 lines report the international effects of MP shocks on risk; the last line in each column reports the $\beta_j^{RI,i}$ coefficients on the cleansed risk shocks. Columns (6) and (8) are drawn from the US regression, columns (4) and (9) from the EA regression, and columns (5) and (7) from the Japan regression.

Focusing first on traditional "pure MP" and "information" shocks, there are no significant effects emanating from US monetary policy on risk in other countries (see columns (4) and (5)). Unless global risk is entirely driven by US variables, this lends support to central bank governor Powell's claim that the hegemon role of US monetary policy in setting global risk may be exaggerated. Note that the signs are as expected but importantly, the effects are also economically very small representing less than a 0.1 standard deviation effect to a 1 standard deviation shock. Hence, our result cannot just be due to a low power econometric test. In addition, we find rather strong effects from euro area monetary policy to risk in the US. Both pure and information shocks have, respectively, the expected positive and negative effects, which are statistically significant at the 5% and 1% level. The effects are also economically much larger at around 0.2 standard deviations. There are no significant spillover effects emanating from Japan.

In the Internet Appendix Tables A6 and A8, we verify the robustness of these results. As discussed earlier, these tables include one group of controls at a time (domestic or international communication shocks, macro shocks, and risk shocks). The main take-away is that these spillover results are also quite robust, featuring insignificant US monetary policy shocks on the EA risk variable whereas the effects from EA MP shocks to the US are stronger and mostly statistically significant.

The final line of Table 4 essentially focuses on the correlation of risk shocks across countries, where, as mentioned before, these shocks are "cleansed" of the effects of monetary policy and a wide range of macro shocks. The presence of these shocks in each country-specific regression also ensures that any effect on risk captured by the independent variables is due to risk changes during the trading hours of that particular country.

The results show strong comovements. US risk shocks transmit to both Japanese and euro area stock market risk, with the former effect economically and statistically the strongest. euro area risk shocks transmit to US stock market risk but the effect on Japanese stock market risk is statistically insignificant. Japanese risk shocks only show a statistically significant effect on euro area stock market risk. These non-fundamental risk spillovers are potentially consistent with a strong global factor structure in risk aversion whereby, over the course of a day, information about global risk aversion is first released in Japan, then in Europe and the US and spillovers happen as markets open. We note that these effects are economically mostly quite strong when the countries are adjacent in terms of time zones, varying between 0.34 standard deviations (Japan to euro area) and 0.47 standard deviations (euro area to US).

These results reveal an interesting dichotomy between normal risk spillover effects and monetary policy induced risk spillovers. For the US, monetary policy shocks only affect domestic risk, but generate little effect on the risk variables in Germany and Japan the next day. Of course, global risk is still affected to the extent it depends on US risk, which helps explain the domestic and international stock market responses. For the euro area, we do observe a significant risk spillover to the US during the US trading hours within the same day, although even there the effect is weaker than what is observed for normal risk spillovers. This of course helps explain that we observe stronger stock return spillover from euro area MP shocks to the US than vice versa.

Finally, we also verify whether there are longer-term effects on risk by projecting cumulative changes in risk up till a horizon of 1 month (21 trading days after the initial day response) on monetary policy shocks. We use HAC standard errors with the number of Newey and West (1987) lags equal to twice the horizon. While important because the work on the global financial cycle in Miranda-Agrippino and Rey (2020b) uses monthly VARs to establish a link between monetary policy and global risk, such projections are less well identified than our high-frequency regressions, especially at longer horizons. Because the majority of the long run coefficients are insignificantly different from zero, results are shown in Appendix Table A13. Pure monetary policy shocks mostly partially or fully reverse after one month, when emanating from the euro area. This is consistent with rapidly mean-reverting risk premiums. However, the risk effects following a pure US monetary policy shock mostly become stronger with the horizon, but the coefficients are mostly insignificantly different from zero. In contrast, information shocks often show momentum, with the effects increasing over time; they are statistically significant in a few cases. It is possible that news about the economy builds slowly, for example, affecting stock market risk gradually over time. The traditional information shock effect in the US is an exception, in that this effect fully reverses after 21 days.

4.4 A cautious interpretation of the spillover results

Our results extend beyond and greatly qualify the narrative about the global financial cycle. We find that standard US monetary policy shocks affect stock returns in the euro area, consistent with the lower frequency results in Miranda-Agrippino and Rey (2020b). However, these effects are (slightly) weaker than what would be expected under a market model. Moreover, the reverse spillover effects from the euro area to the US are larger and exceed predictions of a world CAPM model, an effect that was never examined in Miranda-Agrippino and Rey (2020b), but confirms results in the contemporaneous paper of Jarociński (2022). These results are more consistent with the claims of chairman Powell than the narrative and language used in Miranda-Agrippino and Rey (2020b), suggesting US monetary policy is dominating global asset prices. Importantly, the Miranda-Agrippino and Rey (2020b) paper does not even show that the US monetary policy shock is the most important shock affecting global asset prices in their VAR. Rogers, Sun, and Wu (2023) recently show that a credit spread shock, which may well be highly correlated with our risk shock, is the most important shock affecting global asset prices in Miranda-Agrippino and Rey (2020b) type VARs. This finding is also consistent with the results of our high-frequency framework, which demonstrate very strong risk shock effects on stock prices, but where these risk shocks are cleansed of MP shocks. In contrast, the spillover effects of information shocks are stronger than what a market model would predict, in both directions.

Through the lens of the model outlined in Section 2.1.1, we can use our interest rate and risk results to interpret the channels through which MP affects stock returns. Under the null of the model, monetary policy can affect cash flows through the information effect whereas standard monetary policy shocks affect discount rates, either through affecting the real interest rate (Table 3) or the risk premium (Table 4). In a financially integrated world, the variables of interest are global risk and global interest rates. Because of this, it is difficult to quantify the various effect precisely as it would entail multiple assumptions on the weights of the various markets in the world market. However, our results paint a rather intuitive picture. First, information spillover effects are pretty strong, as Jarociński (2022) has also stressed. Second, for pure standard monetary policy shocks, Figure 1 summarizes our various results. Given that the direct spillover effects of US monetary policy shocks on either interest rates or risk in the EU are weak, the stock return spillovers must come entirely from the "own market" effects and their effects on the relevant global variables. The lack of a direct spillover effect weakens the spillover power of US monetary policy. For the euro area, in contrast, MP shocks have a significant spillover effect on US risk as well, increasing the spillover effect on stock returns. With the euro area trading hours in the middle of the day, they may well play an important role in absorbing economic shocks. In fact, in ongoing research, Bekaert, Xu, and Ye (2024) extract the global risk factor from risk realizations in the three countries and find the euro area time zone to be often the dominant contributor to global risk in a given day.

[Insert Figure 1 here]

Because the interest rate pass through of monetary policy is economically and statistically significant, it is possible that the monetary policy effects now work more through a direct interest rate channel than through a risk channel. However, recall that the risk effects on the stock market are quite strong, so the risk effects may still dominate.[17] In section 5.4, we consider dynamic effects that also indirectly suggest a potential increased role for interest rates.

5 Further Results

In this section, we report on a large number of additional results, while mostly relegating the detail results to the Internet Appendix, to conserve space. Section 5.1 provides a brief summary of our results on communication shocks and for Japan. Section 5.2 characterizes the relative importance of the various monetary policy shocks using variance decompositions. We discuss additional results on structural breaks and unconventional monetary policies in Section 5.3, and consider dynamic effects in Section 5.4.

5.1 Communication Shock Effects and Results from Japan

We report full versions of our tables on stock returns, interest rates, and risk effects in Internet Appendix Table A10. The table includes both the results for communication shocks and for Japan. We only provide a short summary here. The direct effects of communication shocks on stock returns are mostly economically and statically significant with the expected sign for US shocks, and for the euro area pure MP shocks. The strongest spillover effects are observed for euro area pure and information communication shocks, including to Japanese stock prices. The interest rate effects of communication

[17] In ongoing work, Bekaert and Xu (2023) analyze similar results for the US and infer the pure interest rate and risk premium effects of monetary policy shocks implied by regressions such as these ran in this paper. They find that over the full sample, the risk shocks are the main contributor to the MP effect on stock returns, confirming the results in Bernanke and Kuttner (2005). However, in sub-sample analysis they do show that the relative contribution of interest rates has increased over time.

shocks are sometimes hard to interpret as for multiple shocks the interest rate effects revert with the day, which is perhaps not surprising as no policy rates are changed on such days.

Communication shocks generate two statistically significant domestic risk effects, in the euro area for pure MP shocks, in the US for information shocks. Here, in contrast to the standard policy shocks, we find stronger spillover effects.

For the US, there is a highly significant but small spillover effect from communication MP shocks to euro area risk, but the communication information spillover effects from the US are significant to both the euro area and Japan, and also economically larger. For the euro area, communication MP shocks spill over to both the US and Japan in a statistically significant and economically large fashion.

5.2 The economic importance of shocks

Both standard MP shocks and risk shocks decrease stock returns, but the effects of risk shocks are economically larger than those of MP shocks. Yet, the monetary policy effects are exaggerated as in our standardized regression results, we standardize event variables by their event standard deviation. Obviously, on most days, the monetary policy shock is simply zero. One advantage of our framework in Equation (3), compared to event-day regressions is that we are able to compare the relative economic importance in explaining asset returns for our various types of shocks: Monetary policy, macro announcements, and risk. To do so, we compute the proportion of the explained variation in our regressions accounted for by different shocks. For this exercise, we also include the event dummies as part of the various sets of explanatory variables. Such a variance decomposition answers the question of which set of variables explain most variation in the dependent variable on a day-to-day basis. Thus, this exercise uses the overall sample standard deviation of the event variables. Across our three sets of variables (MP, macro, and risk shocks), the percentages add up to one, as we compute the fraction of the explained dependent variable variation that is explained by explanatory variable x as $\frac{\hat{\beta}_x \times cov(x,\hat{y})}{var(\hat{y})} \times 100\%$ where $\hat{\beta}_x$ is the coefficient estimate and $\hat{y}$ is the fitted value of dependent variable y.

The results are in Figure 2, and they are stark. We average the results for the three-country regressions to obtain an overall picture. For interest rates, about 35% of the variation is accounted for by monetary policy shocks; 38% by macro shocks and only 27% by risk shocks. However, for stock returns, close to 90% is driven by risk shocks (cleansed of MP and macro shocks), and only 7%, respectively, 4% by monetary policy, respectively macro shocks. To understand day to day variation in the stock market, understanding what drives risk is much more important than understanding monetary policy.

[Insert Figure 2 here]

It is conceivable that even with our comprehensive set of events, we are still underestimating the effects of monetary policy on stock returns. However, as the pie chart on the right shows, the communication shocks in fact account for close to half of the stock return variation explained by monetary policy shocks. For interest rates, they also account for almost 20% of all variation explained by monetary policy shocks. Our variance decompositions confirm the economic importance of the new communication shocks. It is hard to imagine what other monetary policy events we can be possibly missing. Kroencke, Schmeling, and Schrimpf (2021) show that even on MP decision days much of the variation in stock returns is not driven by MP shocks, which they label as "risk shifts."

5.3 Unconventional Monetary Policy Results

The unconventional policies employed by central banks in the aftermath of the global financial crisis, and interest rates moving to the zero lower bound may have caused a structural break over our sample. We perform break tests on our main specifications linking risk to monetary policy using the Bai, Lumsdaine, and Stock (1998) methodology. Across several configurations, we invariably find break dates in the October-November 2008 period, but the break tests do not yield significant rejections of the no break null and the confidence intervals for the break dates are large. Miranda-Agrippino and Rey (2020a) also fail to find a structural break in the transmission of US monetary policy to global asset prices after 2009. However, they do no longer find that a loosening of US monetary policy leads to a decrease in the VIX, consistent with our full and post Great Recession results regarding the risk channel of monetary policy (see also Section 4.3).

To better reflect the effects of the post-2008 unconventional monetary policies, we now use alternative decompositions of monetary policy shocks, due to Swanson (2021) for the US and to Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019) for the euro area.[18] Both build on the seminal work of Gürkaynak, Sack, and Swanson (2005) (GSS, henceforth) differentiating target rate shocks and shocks revealing information about the future path of interest rates ("forward guidance"), but also construct quantitative easing shocks associated with asset purchases by central banks.

For the US, Swanson (2021) relies on high-frequency data to separately identify surprise changes in the federal funds rate, forward guidance and large-scale asset purchases. He assumes that forward guidance shocks have no effect on the current federal funds rate. To identify the asset purchase factor, he assumes that this factor should be as

[18] We downloaded the data from Eric Swanson's and Carlo Altavilla's website, respectively. For the euro area series, we extended the data to go back to 2000, using the code and the data provided by the authors. There is a large literature investigating the effects of unconventional monetary policy, see e.g. Neely (2015), Wright (2012), D'Amico and King (2013), and Kuttner (2018).

close to zero as possible during the pre-zero-lower-bound period. While the federal rate surprises have the largest effect at the short end of the yield curve, forward guidance surprises have a peak influence on one-year rates while asset purchases affect long-term (10-year) yields. Employing the methods developed by GSS and Swanson (2021) for the US, Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019) identify four separate monetary policy shocks in the euro area: in addition to the target rate, forward guidance and quantitative easing surprises similar to those defined for US data by Swanson (2021), they also detect a "timing" factor which predominantly affects six-month interest rates. The timing surprise captures the shift in market expectations about policy over the next few meetings, in a way that leaves longer-term policy expectations approximately unchanged. Note that to maintain consistency with our other monetary policy shocks, we re-sign asset purchase shocks such that a positive shock is contractionary.

The shocks from both articles are available over our full sample period and we use them together with our previously identified communication shocks. Importantly, these shocks are identified through a factor model extracting information from the full-term structure of interest rates. They do not attempt to distinguish "pure" from information shocks as our previous shocks did. If such shocks are important in the post Great Recession period, the signs of the effects may not always match up with our previous findings. We relegate full tables and some more extensive discussions to the Appendix Tables A11 (for risk) and A12 (for interest rates and stock returns), focusing here on the key spillover findings.

In terms of the effects of monetary policy on risk, we again find that the domestic risk effects continue to be somewhat weak with the exception of asset purchase shocks in the euro area. In terms of spillovers, the lack of significant risk spillovers emanating from the US is confirmed, with one exception. Asset purchase shocks do spill over significantly to Japan. However, the sign is negative, which could mean that the asset purchase shocks mostly acted as information shocks. Shocks originating in the euro area affecting US risk are statistically significant for path, asset purchase and timing shocks, with the signs not always as expected. Again, recall that for the euro area information shocks may be particularly important. However, the asset purchase shock spillover does have a positive sign.[19]

For interest rates, we observe weak spillover effects. The only exception for traditional shocks is that for the US, the path shock transmits to the euro area, but the effect is only statistically significant at the 10% level.

For stock returns, we confirm that the strongest and most significant monetary policy spillover effects emanate from the euro area, not from the US. For the US, there is one statistically significant spillover effect: a positive asset purchase shock (recall that this is coded to be a contractionary shock) lowers stock market returns in the euro area, as expected. Path, asset purchases and timing shocks emanating from the euro area all have a statistically significant effect on US stock returns, although the signs of the coefficients again suggest they are mostly information shocks (the exception is once again, the asset purchase shock). We also observe statistically significant spillover effects from Japan (especially from the path shock) to both the US and the euro area.

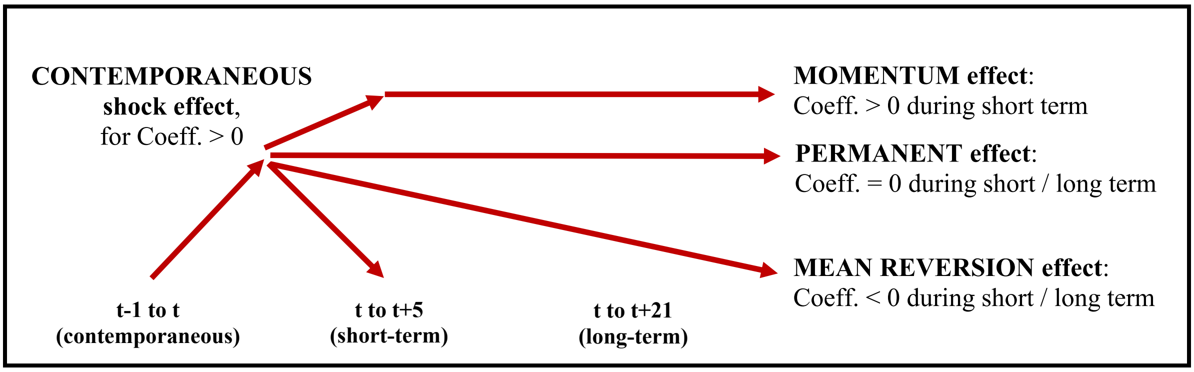
Finally, we observe strong and mostly significant spillover effects for the pure communication shocks generated by information releases in all three countries. This again suggests that these alternative monetary policy events are not to be ignored as a channel of monetary policy transmission to financial markets.

[19] Miranda-Agrippino and Nenova (2022) claim that the risk spillover effect is alive and well for both the US and the euro area. They focus on path and asset purchase shocks and consider regressions that do neither control for macroeconomic announcements, nor for risk shocks. However, we verify that the spillover effect is not statistically significant contemporaneously for the asset purchase shocks emanating from the US, even in their empirical setup. In addition, using their econometric setup, there is no statistical significance for risk spillovers from target shocks, the main focus of our article. These latter regressions were not reported in Miranda-Agrippino and Nenova (2022). Note that in terms of public availability, our paper precedes this article by a couple of years.

5.4 Dynamic effects

So far, we have solely discussed the well-identified high-frequency effects. Of course, much of the related literature uses relatively low frequency empirical settings, such as vector autoregressions with monthly or quarterly data. The relative importance of monetary policy shocks may increase if monetary policy has persistent effects. Studying the persistence of the effects also helps interpret the economic channels behind the results.

To do so, we compare three price change responses: (1) the contemporaneous response or price changes from $t-1$ to t (as in our Tables 2 to 4); (2) short-term cumulative price changes from t to $t+5$; (3) long-term cumulative price changes from t to $t+21$. In practice, these changes represent the same day ((1)) or cumulative log changes/returns ((2),(3)). For the latter regressions, the standard errors use a Newey and West (1987) serial correlation correction with 2h lags, where h is the horizon. Because there is a clear trade-off between identification and the horizon in the regressions, we do not go beyond the one month horizon. The diagram below demonstrates the corresponding channel interpretations, given various coefficient estimates of (1) versus (2) and (3):



Suppose a one unit shock has caused the price today to increase (Coeff.>0). The first possibility is that the effect on the first day does not represent a full response, and the effect continues in the same direction for a few days (momentum effect). A second possibility is that the first day effect is simply permanent, and subsequent returns are simply noise. This would be the case, for example, for a pure cash flow effect; stock prices should increase and not change any further. Finally, discount rate effects naturally lead to mean reversion: higher prices today reflect lower future returns. This effect cannot be fully disentangled from a price pressure effect, apart from the fact that the latter should be reversed in the short run, whereas the former is likely to last longer, depending on the persistence of the interest rate or risk premium shock.

Unfortunately, the regressions prove noisy, and we relegate the full results to the Appendix Tables A14 and A15. Here, we summarize the key findings. First, pure monetary policy shocks on traditional monetary policy decision days induce seemingly permanent effects on interest rates. To be more precise, there is a partial reversion of the interest rate effect in the US, but the coefficients are statistically insignificant. In the euro area and Japan, there is short-term momentum but it becomes insignificant at the one-month horizon. For stock returns, the longer-term effects are mostly negative but insignificant, for both the US and euro area, suggesting more permanent or less slowly mean-reverting effects.

Second, in direct contrast, the effects of risk shocks on stock prices show more evidence of mean reversion. Importantly, this reversal is statistically significant for all three economic areas and economically large. The reversal is about 16% for the US, and well over 30% for Japan and the euro area over the course of a month. While this may seem inconsistent with standard notions of slow-moving risk premiums as implied by habit models (see Campbell and Cochrane (1999)), or variation in equity risk premium captured by a very persistent dividend yield variable, the result matches recent estimates in the persistence of risk aversion measures. For example, the risk aversion index for the US in Bekaert, Engstrom, and Xu (2022) has a 0.74 monthly autocorrelation coefficient. These results are consistent with risk shocks affecting the risk premium on stocks, where risk premiums may not be as persistent as previously thought. Martin (2017) also shows that equity risk premiums do not show strong persistence.

Summarizing our main results for the MP shock incidence, we find near permanent effects on interest rates and stock returns, and relatively weak effects on risk variables. However, risk premium shocks tend to revert substantially within the month. This evidence does not square well with the original results in Bernanke and Kuttner (2005) arguing that the effect of MP shocks on stock returns is mostly a risk premium effect. This opens the possibility that the effects of monetary policy on asset prices may not occur through a risk premium channel, but through a direct interest rate channel, which has become more potent given the unusually low interest rates in the last 10-15 years. This finding is consistent with Binsbergen (2020)'s recent assertion that equity returns in the US show little or no evidence of any risk premium over long term bonds. With interest rates highly persistent, interest rate effects may mean revert extremely slowly.

Third, the domestic effects of information shocks emanating from the Fed and the ECB on interest rates show momentum, with the effects larger at the one-month horizon in a statistically significant fashion. For stock returns, the effects of an information shock emanating from the ECB are consistent with them representing permanent cash flow effects, both in its domestic and spillover effects. In fact, the ECB information shock effect on domestic stock returns does exhibit week-long momentum. US information shocks show some short-run mean reversion, which is insignificantly different from zero at the monthly horizon.

6 Conclusion

This paper studies the effects of monetary policy and risk shocks on risk and asset prices in a global world. Our main results for the effects of monetary policy are as follows.

First, monetary policy has a strong domestic effect on stock market prices, both in the US and the euro area and through "pure" and information shocks. Internationally, the economic magnitude of US spillover effects are slightly weaker than would be expected given the importance of the US stock market in global equity markets. In contrast, the spillover effects from euro area monetary policy are economically stronger than those emanating from the US, and certainly stronger than one would expect given the small relative size of stock markets in Europe.

Second, despite strong and persistent domestic interest rate effects, we do not find significant spillovers through a direct interest rate channel, suggesting that the trilemma is alive and well. This is further confirmed by our last key result: U.S. monetary policy weakly affects domestic risk but does not affect foreign risk variables. In contrast, Euro monetary policy shocks significantly affect risk in the US. This does not square well with the narrative in Miranda-Agrippino and Rey (2020b), which suggests that the US is the hegemon country setting global risk conditions worldwide. However, their analysis only shows that US monetary policy affects a global risk variable, not that it is the dominant variable, or that other countries may contribute more significantly to global risk. Our framework also allows us to contrast the effects of monetary policy driven risk shocks to those of non-monetary policy driven shocks. Risk shocks are much more important for stock returns than are monetary policy shocks, accounting for the bulk of their predictable variation.

Non-MP-driven risk shocks are highly correlated across countries, with global shock spillovers following a strong time zone pattern. Not surprisingly, they have strong, mean reverting effects on stock prices, but weaker effects on interest rates, where monetary policy effects are relatively more important. These results, taken together with the longer-term effects of the monetary policy shocks, open up the possibility that monetary policy shocks affect equity prices substantially through persistent interest rate effects.

Finally, we document somewhat stronger risk spillover effects using non-traditional communication MP shocks.

In sum, our analysis mostly confirms Mr. Powell's conjecture that the role of US monetary policy in setting global financial conditions is exaggerated. Of course, our analysis is restricted to the major developed economies. Kalemli-Özcan (2019), for example, claims that there is substantial risk spillover from US monetary policy to emerging economies, whereas Hoek, Kamin, and Yoldas (2020) argue that the effects differ greatly across "pure" and information shocks. Our results do implicitly suggest global risk perceptions may not be solely or primarily driven by US monetary policy.

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Table 1: Summary statistics for monetary policy and risk shocks.

This table reports summary statistics for our main MP and risk shock measures from 2000 to 2017; Panel A considers traditional shocks, and Panel B risk shocks. **Traditional MP shocks:** For US and EA, we use MP and central bank information shocks constructed on traditional monetary policy decision (MPD) event dates, as recognized and produced by Jarociński and Karadi (2020) (JK for short); for JP, we use Gürkaynak, Sack, and Swanson (2005)'s Target and path shocks constructed on traditional MPD event date, and we thank Kubota and Shintani (2022) (KS for short) for sharing their updated shock data with us. **Risk shocks:** To obtain a country's risk shock, we run three country-level regressions as in Equation (4), where we project a country's first differences in risk (VIX-squared) onto all three countries' monetary policy shocks (4 shocks each; 12 in total) and macro shocks (18 from US, 11 from EA, 11 from JP), after correcting for time-zone differences; the residuals are called a country's risk (RI, or $\overline{ri}$) shocks in the rest of the paper. This first pass regression results are reported in Appendix Table A9. Traditional monetary policy shocks are measured in basis points; risk shocks are in monthly percentages squared. Summary statistics of communication shocks are in Internet Appendix Table A3.

Shock	N	Mean	SD	5%	95%
Panel A. Traditional MP shocks, constructed from decision events					
US traditional MP JK	153	-0.623	6.303	-11.111	6.738
US traditional CBI JK	153	-0.848	6.277	-11.075	8.313
EA traditional MP JK	277	0.355	5.508	-8.444	7.994
EA traditional CBI JK	277	-0.276	5.454	-9.770	7.977
JP Target KS	257	-0.015	0.839	-0.914	0.870
JP Path KS	257	0.017	0.754	-1.078	1.109
Panel B. Non-MP, non-Macro risk shocks					
US non-MP, non-Macro Risk	4199	0.051	10.382	-9.731	9.728
EA non-MP, non-Macro Risk	4199	0.053	11.907	-12.716	13.230
JP non-MP, non-Macro Risk	4199	0.075	12.499	-11.391	12.352

Table 2: Monetary policy and stock returns.

This table reports the domestic and spillover effects of monetary policy (MP) shocks on log country stock returns (SR), in terms of economic magnitude (i.e., number of SDs changes in stock returns given a 1 SD shock). **Panel A.** The columns in this table come from three regression results, with $j \in \{US, EA, JP\}$, (see Section 3):

$$SR_{j,t} = \alpha_j + \boldsymbol{\gamma_j D_t} + \sum_{i=US,EA,JP} \boldsymbol{\beta_j^{MP,i} MP_t^i} + \sum_{i=US,EA,JP} \beta_j^{RI,i} \overline{ri}_t^i + \sum_{i=US,EA,JP} \boldsymbol{\delta_j^i Macro_t^i} + \varepsilon_{j,t}.$$

Variable details in this equation are explained in Equation 3, Section 3. The regressions that generate cleansed risk shocks ($\overline{ri}_t^i$) are presented in the Appendix Table A9. Columns (1) and (4) come from the same US regression with LHS being US SR; columns (2) and (3), LHS=EA SR. Raw regression coefficients of US and EA stock returns are shown in Internet Appendix Tables A4 and A5. Full results (for communication shocks and for Japan) are shown in the Internet Appendix Table A10. Bold values indicate significant coefficients; *** at the 1%, ** at the 5%, and * at the 10% significance level. **Panel B.** We report the average market capitalization weights of US and EA out of the world total from 2000 to 2017 (source: World Bank). **Panel C.** We report CAPM-implied spillover effects as discussed step-by-step in Section 4.1.2. All numbers are statistically significant given both US and EA domestic effects (see Panel A above) are significant.

Panel A. Actual Effects (in SD units)				
	(1)	(2)	(3)	(4)
Shock origin:	**US**	**EA**	**US**	**EA**
Asset:	**US**	**EA**	**EA**	**US**
Traditional MP JK	**-0.418*** **	**-0.343*** **	**-0.116** **	**-0.269*** **
Traditional CBI JK	**0.213** **	**0.514*** **	**0.283*** **	**0.447*** **
Non-MP, non-Macro Risk	**-0.697*** **	**-0.684*** **	0.035	-0.020
Panel B. Market weights				
	US		**EA**	
MCAP Weight (2000-2017 Average)	39.5%		13.2%	
(Lowest)	30.4%		9.5%	
(Highest)	49.8%		16.9%	
Panel C. CAPM-Implied Effects (in SD units)				
Shock origin:	**US**	**EA**	**US**	**EA**
Asset:	**US**	**EA**	**EA**	**US**
Traditional MP JK (2000-2017 Average)	-	-	-0.156	-0.058
(Lowest)	-	-	-0.120	-0.042
(Highest)	-	-	-0.196	-0.074
Traditional CBI JK (2000-2017 Average)	-	-	0.079	0.087
(Lowest)	-	-	0.061	0.062
(Highest)	-	-	0.100	0.111

Table 3: Monetary policy and interest rates.

This table reports the domestic and spillover effects of monetary policy (MP) shocks on changes in interest rate (IR), in terms of economic magnitude (i.e., number of SDs changes in the IR variable given a 1 SD shock). The columns in this table come from three regression results, with $j \in \{US, EA, JP\}$, (see Section 3):

$$\Delta IR_{j,t} = \alpha_j + \boldsymbol{\gamma_j D_t} + \sum_{i=US,EA,JP} \boldsymbol{\beta_j^{MP,i} MP_t^i} + \sum_{i=US,EA,JP} \beta_j^{RI,i} \overline{ri}_t^i + \sum_{i=US,EA,JP} \boldsymbol{\delta_j^i Macro_t^i} + \varepsilon_{j,t}.$$

Variable details in this equation are explained in Equation 3, Section 3. The regressions that generate cleansed risk shocks ($\overline{ri}_t^i$) are presented in the Appendix Table A9. Columns (1) and (4) come from the same US regression with LHS being US SR; columns (2) and (3), LHS=EA IR. Full results (for communication shocks and for Japan) are shown in the Internet Appendix Table A10. Bold values indicate significant coefficients; *** at the 1%, ** at the 5%, and * at the 10% significance level.

	(1)	(2)	(3)	(4)
Shock origin:	**US**	**EA**	**US**	**EA**
Asset:	**US**	**EA**	**EA**	**US**
Traditional MP JK	**0.433*****	**0.349*****	0.130	-0.016
Traditional CBI JK	**0.853*****	**0.266****	0.139	0.056
Non-MP, non-Macro Risk	**-0.080***	-0.048	-0.039	-0.113

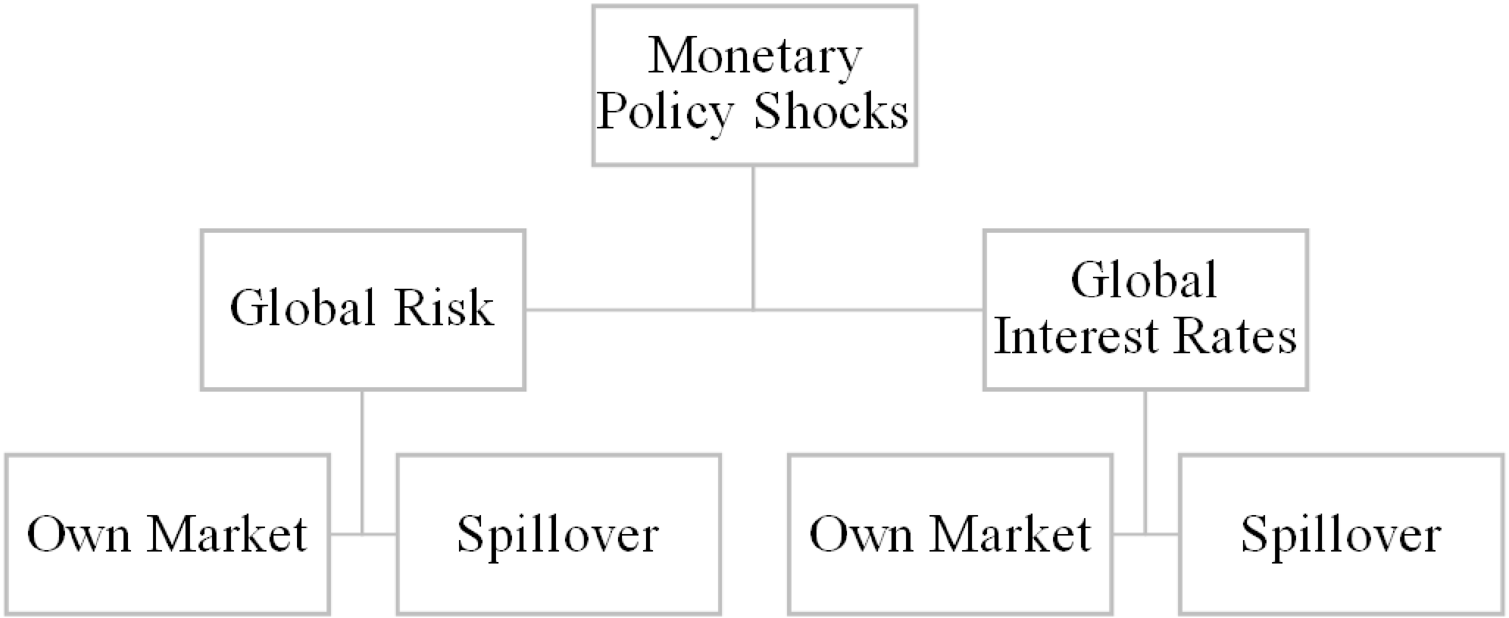
Table 4: Monetary policy and risk.

This table reports the domestic and spillover effects of monetary policy (MP) shocks on changes in Risk (RI), in terms of economic magnitude (i.e., number of SDs changes in the Risk variable given a 1 SD shock). The columns in this table come from three regression results, with $j \in \{US, EA, JP\}$, (see Section 3):

$$\Delta RI_{j,t} = \alpha_j + \boldsymbol{\gamma_j D_t} + \sum_{i=US,EA,JP} \boldsymbol{\beta_j^{MP,i} MP_t^i} + \sum_{i \neq j} \beta_j^{RI,i} \overline{ri}_t^i + \sum_{i=US,EA,JP} \boldsymbol{\delta_j^i Macro_t^i} + \varepsilon_{j,t}.$$

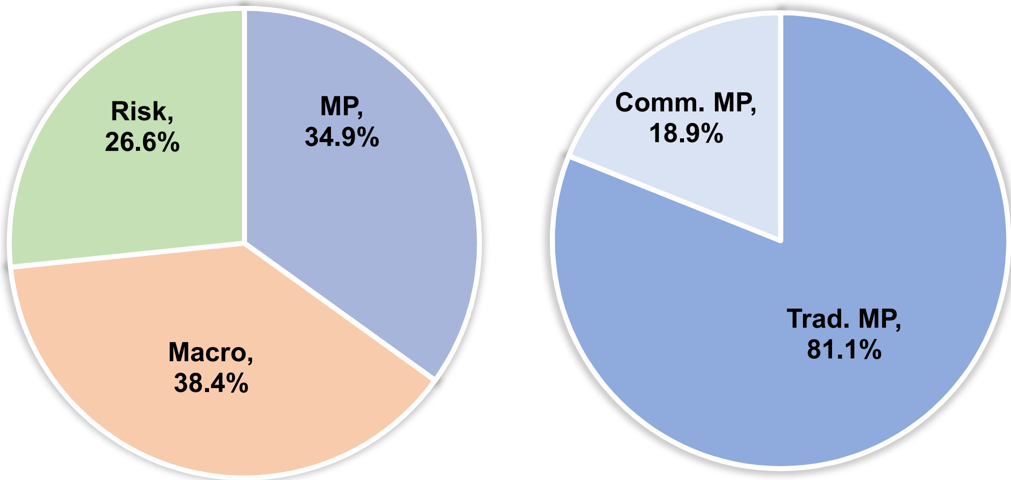
Variable details in this equation are explained in Equation 3, Section 3. The regressions that generate cleansed risk shocks ($\overline{ri}_t^i$) are presented in the Appendix Table A9. Columns (1), (6) and (8) come from the same US regression with the LHS being US risk; for Columns (2), (4) and (9), LHS=EA risk; for Columns (3), (5) and (7), LHS=JP risk. Full results (for communication shocks and for Japan) are shown in the Internet Appendix Table A10. Bold values indicate significant coefficients; *** at the 1%, ** at the 5%, and * at the 10% significance level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		◇ *Domestic*				◇ *Spillover*			
Shock origin:	**US**	**EA**	**JP**	**US**	**US**	**EA**	**EA**	**JP**	**JP**
Asset:	**US**	**EA**	**JP**	**EA**	**JP**	**US**	**JP**	**US**	**EA**
Traditional MP JK	0.160	0.144	0.041	0.080	0.090	**0.173****	-0.012	-0.009	-0.017
Traditional CBI JK	-0.214	**-0.228*****	-0.168	-0.105	-0.093	**-0.203*****	-0.057	-0.011	0.001
Non-MP, non-Macro Risk				**0.149*****	**0.468*****	**0.417*****	-0.006	-0.045	**0.340*****

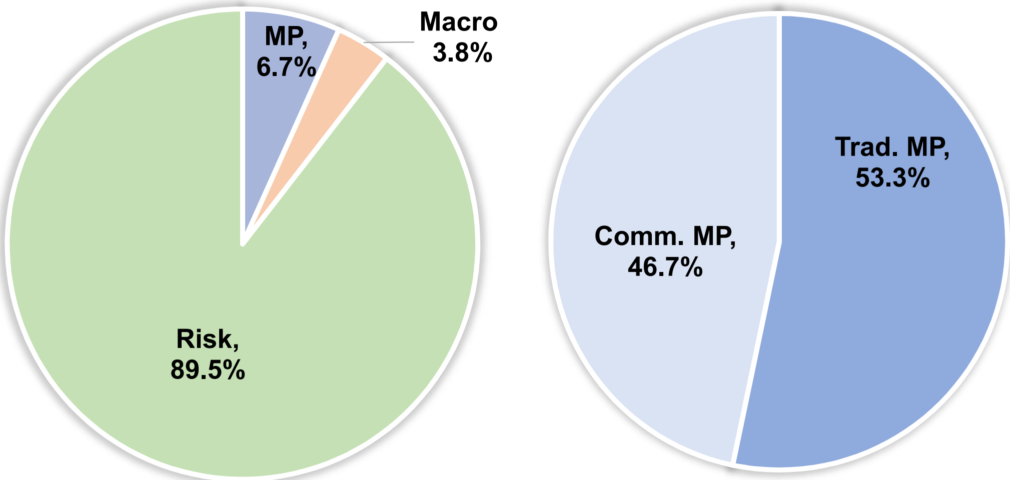


US:	Weak	None	Strong and significant	None
EA:	Weak	Significant	Strong and significant	None

Figure 1: The Economics of MP Spillover Results.



(a) Interest Rate Effects



(b) Stock Return Effects

Figure 2: Asset Price Effects of Monetary Policy (MP), Risk, and Macro variables. Note: The left pie charts show the headline variance decomposition results, within all shocks and dummies, averaged across the three countries' regressions. The right pie charts focus on the further decomposition of MP effects: traditional or communication MP.

Appendix

A Additional Tables and Figures

Table A1: Full lists of macroeconomic announcements included in the regressions

Category	**Announcement**	**N. Observations**	**Release Time**	**Start Date**
		Panel A. US		
Consumer Confidence	Conf. Board Consumer Confidence	240	10:00	1/25/2000
Consumer Confidence	U. of Mich. Sentiment	480	10:00	1/14/2000
Consumption	Retail Sales Advance MoM	240	8:30	1/13/2000
Employment	Change in Nonfarm Payrolls	240	8:30	1/7/2000
Employment	Unemployment Rate	240	8:30	1/7/2000
Employment	Initial Jobless Claims	1043	8:30	1/6/2000
External	Trade Balance	240	8:30	1/20/2000
Housing Sector	New Home Sales	240	10:00	1/6/2000
Housing Sector	Housing Starts	240	8:30	1/19/2000
Income	GDP Annualized QoQ	239	8:30	1/28/2000
Inflation	CPI MoM	240	8:30	1/14/2000
Inflation	PPI Final Demand MoM	240	8:30	1/13/2000
Industrial Activity	Industrial Production MoM	240	9:15	1/14/2000
Industrial Activity	Factory Orders	240	10:00	1/5/2000
Investment	Durable Goods Orders	273	8:30	1/27/2000
Investment	Construction Spending MoM	43	10:00	1/4/2000
Producer Confidence	ISM Manufacturing	240	10:00	1/3/2000
Producer Confidence	ISM Non-Manufacturing	241	10:00	1/5/2000
		Panel B. Euro area		
Consumer Confidence	Consumer Confidence	342	08:45 - 11:00	1/5/2000
Consumption	Retail Sales MoM	225	12:00	4/5/2001
Employment	Unemployment Rate	235	12:00	1/4/2000
External	Trade Balance NSA	219	12:00	10/23/2001
Income	GDP SA QoQ	215	08:50 - 12:00	1/13/2000
Industrial Activity	Industrial Production SA MoM	268	12:00	10/24/2000
Industrial Activity	Industrial New Orders SA (MoM)	99	11:00	1/26/2004
Inflation	CPI MoM	238	12:00	1/26/2000
Inflation	PPI MoM	223	12:00	1/13/2000
Producer Confidence	Business Climate Indicator	204	12:00	1/8/2001
Producer Confidence	IFO Business Climate	240	10:00	1/20/2000
		Panel C. Japan		
Consumer Confidence	Consumer Confidence Index	162	14:00	1/28/2000
Consumption	Retail Sales MoM	201	8:50	4/28/2003
Employment	Jobless Rate	239	8:30	2/29/2000
External	Trade Balance	239	8:50	2/23/2000
Housing Sector	Housing Starts YoY	237	12:00	1/31/2000
Income	GDP SA QoQ	150	8:50	3/13/2000
Industrial Activity	Industrial Production MoM	287	11:30	4/18/2000
Industrial Activity	Core Machine Orders MoM	239	14:00	2/10/2000
Inflation	Natl CPI YoY	237	8:00	3/31/2000
Inflation	PPI MoM	239	8:50	2/10/2000
Producer Confidence	Tankan Large Mfg Index	80	8:50	4/3/2000

Table A2: Summary statistics for dependent variables

This table reports summary statistics for the dependent variables in the regressions with monetary policy shocks. Sample period is January 3, 2000 - December 31, 2017 (end of sample for Cieslak and Schrimpf (2019)). VIX-squared is expressed in monthly percentages-squared, with statistics referring to the first-differences. Three-month (3M) and 10-year (10Y) interest rates are expressed in basis points, with statistics referring to the first-differences. All the other variables are expressed in percent (log first-differences multiplied by 100). For EA area asset prices, the EA 3M composite rate is the GDP-weighted average of country government bond 3M rates across 11 euro area countries (Germany, France, Italy, Spain, Netherlands, Belgium, Austria, Ireland, Finland, Portugal, Greece); the EA log stock return is log change in the EUROSTOXX50 total return index. All raw data mentioned above are obtained from DataStream, Bloomberg, and ECB.

Dependent Variables	N	Mean	SD	5%	95%
VIX squared US (1st diff)	4199	-0.036	13.429	-19.464	22.160
VIX squared EA (1st diff)	4199	-0.077	11.757	-16.923	20.144
VIX squared JP (1st diff)	4199	0.017	11.811	-16.009	18.904
US 3M rate (1st diff)	4199	-0.167	4.947	-5.000	4.000
EA 3M composite rate (1st diff)	4198	-0.099	3.443	-3.530	3.162
JP 10Y rate (1st diff)	4199	-0.043	2.628	-4.000	4.000
stock returns US (log diff)	4199	0.005	1.207	-1.898	1.737
stock returns EA (log diff)	4199	-0.016	1.463	-2.386	2.224
stock returns JP (log diff)	4199	-0.004	1.520	-2.384	2.255

Table A3: Summary statistics for Communication MP shocks, constructed from minutes/speech dates.

This table reports summary statistics for our main MP and risk shock measures from 2000 to 2017. We construct our communication MP and CBI shocks using JK's "poor-man's" methodology, but using non-MPD or communication event dates as collected by Cieslak and Schrimpf (2019) (for US, EA, and JP). Within a narrow window of minus 10 min (pre-event)∼plus 20 min (post-event), if the covariance between country stock returns and changes in 3m government bond yield (10yr for Japan) is ≤ 0 (>0), changes in 3m government bond yield are our communication MP (CBI) shock. The choice of "communication event dates" uses the dates collected in Cieslak and Schrimpf (2019), but minus those that overlap with Jarociński and Karadi (2020). Communication monetary policy shocks are measured in basis points.

Shock	N	Mean	SD	5%	95%
US communication MP CS	160	-0.111	1.203	-1.000	0.625
US communication CBI CS	160	-0.136	1.209	-1.750	1.000
EA communication MP CS	90	-0.028	0.321	-0.500	0.500
EA communication CBI CS	90	0.065	0.846	-0.500	1.000
JP communication MP CS	196	-0.093	1.055	-1.360	1.028
JP communication CBI CS	196	0.095	0.941	-1.017	1.689

Table A4: US return raw regression results.

This table reports several useful raw regressions results that build up to column (12), which reports the raw coefficients of our main specifications with US stock returns as the dependent variable (as in Table 2). Columns (1)-(3) report regression results on MP event days only, which can also be seen from the number of observations. Columns (4)-(6) use full daily sample with MP shocks being zero on non-event days and a MP event day dummy variable. Columns (7)-(12) add other groups of variables, one group at a time.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
GSS (1M)	-0.0984***			-0.0984***								
	(0.033)			(0.033)								
GSS (3M)		-0.0605*			-0.0605*							
		(0.033)			(0.033)							
Traditional MP JK (US)			-0.0833***			-0.0833***	-0.0833***	-0.0833***	-0.0871***	-0.0838***	-0.0825***	-0.0804***
			(0.023)			(0.023)	(0.016)	(0.016)	(0.014)	(0.016)	(0.016)	(0.016)
Traditional CBI JK (US)			0.0545***			0.0545***	0.0545***	0.0545***	0.0499***	0.0414**	0.0425**	0.0413**
			(0.020)			(0.020)	(0.019)	(0.019)	(0.017)	(0.017)	(0.017)	(0.017)
MP Event Day Dummy (US)				0.2262*	0.2472**	0.2960***	0.2944***	0.2984***	0.2876***	0.2884***	0.3012***	0.2993***
				(0.123)	(0.126)	(0.113)	(0.076)	(0.076)	(0.069)	(0.072)	(0.074)	(0.075)
Non-MP, non-Macro Risk (US)							-0.0820***	-0.0820***	-0.0820***	-0.0813***	-0.0813***	-0.0813***
							(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Traditional MP JK (EA)									-0.0574***	-0.0564***	-0.0584***	-0.0586***
									(0.013)	(0.013)	(0.013)	(0.013)
Traditional CBI JK (EA)									0.0950***	0.0961***	0.0994***	0.0992***
									(0.012)	(0.012)	(0.012)	(0.012)
MP Event Day Dummy (EA)									-0.0071	-0.0168	-0.0575	-0.0456
									(0.056)	(0.057)	(0.063)	(0.064)
Non-MP, non-Macro Risk (EA)										-0.0019	-0.0020	-0.0020
										(0.003)	(0.003)	(0.003)
Constant	0.2308*	0.2519**	0.3006***	0.0046	0.0046	0.0046	0.0062	0.0022	-0.0003	-0.0039	-0.0679***	-0.0692***
	(0.122)	(0.126)	(0.113)	(0.018)	(0.018)	(0.018)	(0.013)	(0.013)	(0.014)	(0.014)	(0.021)	(0.026)
Observations	153	153	153	4525	4525	4525	4514	4514	4514	4199	4199	4199
R-squared	0.068	0.042	0.21	0.0057	0.0043	0.014	0.51	0.51	0.54	0.54	0.55	0.56
MP event day only:	X	X	X									
All day with MP event dummy:				X	X	X	X	X	X	X	X	X
+ US; risk							X	X	X	X	X	X
+ US; communication								X	X	X	X	X
+ EA, JP; MP, communication									X	X	X	X
+ EA, JP; risk										X	X	X
+ US; macro											X	X
+ EA, JP; macro												X

Table A5: EA stock return raw regression results.

This table reports several useful raw regressions results that build up to column (12), which reports the raw coefficients of our main specifications with EA stock returns as the dependent variable (as in Table 2). Columns (1)-(3) report regression results on MP event days only, which can also be seen from the number of observations. Columns (4)-(6) use full daily sample with MP shocks being zero on non-event days and a MP event day dummy variable. Columns (7)-(12) add other groups of variables, one group at a time.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
EA (1M)	0.0333			0.0333								
	(0.074)			(0.073)								
EA (3M)		0.0072			0.0072							
		(0.063)			(0.063)							
Traditional MP JK (EA)			-0.0893***			-0.0893***	-0.0893***	-0.0893***	-0.0901***	-0.0891***	-0.0892***	-0.0912***
			(0.032)			(0.032)	(0.017)	(0.017)	(0.018)	(0.017)	(0.018)	(0.017)
Traditional CBI JK (EA)			0.1276***			0.1276***	0.1276***	0.1276***	0.1282***	0.1344***	0.1344***	0.1376***
			(0.020)			(0.020)	(0.014)	(0.014)	(0.014)	(0.015)	(0.015)	(0.015)
MP Event Day Dummy (EA)				-0.0131	-0.0117	0.0556	0.0535	0.0555	0.0498	0.0327	0.0442	0.0078
				(0.108)	(0.108)	(0.094)	(0.069)	(0.070)	(0.068)	(0.070)	(0.070)	(0.078)
Non-MP, non-Macro Risk (EA)							-0.0808***	-0.0808***	-0.0808***	-0.0835***	-0.0835***	-0.0837***
							(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Traditional MP JK (US)									-0.0220	-0.0248*	-0.0226*	-0.0273**
									(0.014)	(0.013)	(0.013)	(0.014)
Traditional CBI JK (US)									0.0643***	0.0648***	0.0663***	0.0659***
									(0.019)	(0.019)	(0.019)	(0.020)
MP Event Day Dummy (US)									-0.0399	-0.1050	-0.1082	-0.1346
									(0.113)	(0.115)	(0.116)	(0.122)
Non-MP, non-Macro Risk (US)										0.0044	0.0045	0.0052
										(0.005)	(0.005)	(0.005)
Constant	-0.0175	-0.0161	0.0512	-0.0044		-0.0044	-0.0023	-0.0043	0.0009	-0.0003	-0.0048	-0.0671**
	(0.107)	(0.107)	(0.092)	(0.022)		(0.022)	(0.017)	(0.017)	(0.018)	(0.019)	(0.022)	(0.030)
Observations	277	277	277	4602		4602	4580	4580	4580	4183	4183	4183
R-squared	0.0032	0.00015	0.27	0.00028		0.023	0.46	0.46	0.47	0.47	0.47	0.49
MP event day only:	X	X	X									
All day with MP event dummy:				X	X	X	X	X	X	X	X	X
+ EA; risk							X	X	X	X	X	X
+ EA; communication								X	X	X	X	X
+ US, JP; MP, communication									X	X	X	X
+ US, JP; risk										X	X	X
+ EA; macro											X	X
+ US, JP; macro												X

Table A6: US changes in VIX^2 raw regression results.

This table reports several useful raw regressions results that build up to column (10), which reports the raw coefficients of our main specifications with daily changes in US risk as the dependent variable (as in Table 4). Columns (1)-(3) report regression results on MP event days only, which can also be seen from the number of observations. Column (4)-(10) use full daily sample with MP shocks being zero on non-event days and a MP event day dummy variable, and then add other groups of variables, one group at a time.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GSS (1M)	0.1326			0.1326						
	(0.260)			(0.258)						
GSS (3M)		0.1544			0.1544					
		(0.231)			(0.230)					
Traditional MP JK (US)			0.3557*			0.3557*	0.3557*	0.3357	0.3079	0.3406
			(0.205)			(0.203)	(0.203)	(0.210)	(0.211)	(0.219)
Traditional CBI JK (US)			-0.3593			-0.3593	-0.3593	-0.3601	-0.3651	-0.4579
			(0.236)			(0.233)	(0.233)	(0.230)	(0.232)	(0.322)
MP Event Day Dummy (US)				-3.9589***	-4.4420***	-1.6862	-1.7248	-1.8451	-2.1520*	-1.2608
				(1.365)	(1.406)	(1.164)	(1.164)	(1.169)	(1.181)	(0.971)
Traditional MP JK (EA)								0.4183	0.4270	0.4235**
								(0.342)	(0.345)	(0.175)
Traditional CBI JK (EA)								-0.4710**	-0.4944**	-0.5011***
								(0.218)	(0.218)	(0.153)
MP Event Day Dummy (EA)								0.7277	0.9875	0.8875
								(0.748)	(0.915)	(0.764)
Non-MP, non-Macro Risk (EA)										0.4702***
										(0.066)
Constant	-1.4558	-1.4185	-1.6404	0.0458	0.0458	0.0458	0.0843	0.1897	0.7211**	0.7050***
	(1.253)	(1.293)	(1.164)	(0.160)	(0.160)	(0.160)	(0.159)	(0.171)	(0.306)	(0.265)
Observations	153	153	153	4514	4514	4514	4514	4514	4514	4199
R-squared	0.0012	0.0026	0.053	0.00081	0.00091	0.0046	0.0070	0.056	0.075	0.32
MP event day only:	X	X	X							
All day with MP event dummy:				X	X	X	X	X	X	X
+ US; communication							X	X	X	X
+ EA, JP; MP, communication								X	X	X
+ US, EA, JP; macro									X	X
+ EA, JP; risk										X

Table A7: US changes in VRP raw regression results.

This table reports several useful raw regressions results that build up to column (10), with daily changes in US variance risk premium as the dependent variable. Variance risk premium is constructed using VIX-squared minus the expected variance; the expected variance is a fitted value of realized 22-day variance as a linear function of past 22-day, 5-day, and 1-day realized variances and VIX-squared. Columns (1)-(3) report regression results on MP event days only, which can also be seen from the number of observations. Column (4)-(10) use full daily sample with MP shocks being zero on non-event days and a MP event day dummy variable, and then add other groups of variables, one group at a time.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GSS (1M)	1.1206***			1.1206***						
	(0.354)			(0.352)						
GSS (3M)		0.4175			0.4175					
		(0.376)			(0.373)					
Traditional MP JK (US)			0.4190			0.4190	0.4190	0.5283*	0.5081	0.2977
			(0.311)			(0.308)	(0.308)	(0.300)	(0.313)	(0.298)
Traditional CBI JK (US)			-0.2047			-0.2047	-0.2047	-0.1458	-0.1449	-0.0214
			(0.348)			(0.345)	(0.345)	(0.322)	(0.329)	(0.372)
MP Event Day Dummy (US)				-3.9589***	-4.4420***	-4.7299***	-4.7717***	-4.3411***	-4.6428***	-3.5893***
				(1.365)	(1.406)	(1.297)	(1.298)	(1.167)	(1.186)	(1.122)
Traditional MP JK (EA)								0.7282**	0.7203**	0.7399**
								(0.356)	(0.362)	(0.318)
Traditional CBI JK (EA)								-0.3470	-0.3589	-0.3696*
								(0.235)	(0.234)	(0.217)
MP Event Day Dummy (EA)								0.0196	0.3849	0.3339
								(0.841)	(1.026)	(1.009)
Non-MP, non-Macro Risk (EA)										0.2542***
										(0.069)
Constant	-3.8005***	-4.2837***	-4.5716***	0.1583	0.1583	0.1583	0.2001	0.3913**	0.9658***	0.9138***
	(1.363)	(1.405)	(1.299)	(0.164)	(0.164)	(0.164)	(0.165)	(0.174)	(0.291)	(0.297)
Observations	153	153	153	4514	4514	4514	4514	4514	4514	4199
R-squared	0.070	0.016	0.036	0.012	0.0074	0.0091	0.014	0.057	0.088	0.14
MP event day only:	X	X	X							
All day with MP event dummy:				X	X	X	X	X	X	X
+ US; communication							X	X	X	X
+ EA, JP; MP, communication								X	X	X
+ US, EA, JP; macro									X	X
+ EA, JP; risk										X

Table A8: EA changes in VIX^2 raw regression results.

This table reports several useful raw regressions results that build up to column (6), which reports the raw coefficients of our main specifications with EA risk as the dependent variable (as in Table 4). Column (1) report regression results on MP event days only, which can also be seen from the number of observations. Column (2)-(6) use full daily sample with MP shocks being zero on non-event days and a MP event day dummy variable, and then add other groups of variables, one group at a time.

	(1)	(2)	(3)	(4)	(5)	(6)
Traditional MP JK (EA)	0.3455	0.3455	0.3455	0.3472	0.3667	0.3070
	(0.464)	(0.461)	(0.461)	(0.460)	(0.465)	(0.301)
Traditional CBI JK (EA)	-0.5005**	-0.5005**	-0.5005**	-0.5022**	-0.5329**	-0.4921***
	(0.219)	(0.218)	(0.218)	(0.216)	(0.217)	(0.184)
MP Event Day Dummy (EA)		-0.7002	-0.7514	-0.7845	-0.5656	-0.4648
		(0.795)	(0.795)	(0.797)	(0.977)	(0.791)
Traditional MP JK (US)				0.1957	0.1998	0.1489
				(0.184)	(0.181)	(0.181)
Traditional CBI JK (US)				-0.1585	-0.2118	-0.1972
				(0.352)	(0.347)	(0.428)
MP Event Day Dummy (US)				-0.0920	-0.1647	0.1924
				(1.474)	(1.604)	(1.593)
Non-MP, non-Macro Risk (US)						0.1687***
						(0.065)
Constant	-0.6878	0.0124	0.0636	0.0874	0.6026**	0.5861**
	(0.776)	(0.189)	(0.186)	(0.201)	(0.292)	(0.297)
Observations	277	4580	4580	4580	4580	4183
R-squared	0.070	0.0051	0.022	0.051	0.074	0.23
MP event day only:	X					
All day with MP event dummy:		X	X	X	X	X
+ EA; communication			X	X	X	X
+ US, JP; MP, communication				X	X	X
+ US, EA, JP; macro					X	X
+ US, JP; risk						X

Table A9: Monetary policy and risk: first pass.

This table reports the *first-pass* results of domestic and spillover effects of monetary policy (MP) shocks on changes in Risk (RI), in terms of economic magnitude (i.e., number of SDs changes in the RI variable given a 1 SD shock). In other words, the residuals from the following three regressions yield $\overline{ri}_t^{US}$, $\overline{ri}_t^{EA}$, and $\overline{ri}_t^{JP}$ in Tables 4, 3 and 2 in the main paper. Specifically, the columns in this table come from three regression results, with $j \in \{US, EA, JP\}$:

$$\Delta RI_{j,t} = \alpha_j + \boldsymbol{\gamma_j D_t} + \sum_{i=US,EA,JP} \boldsymbol{\beta_j^{MP,i} MP_t^i} + \sum_{i=US,EA,JP} \boldsymbol{\delta_j^i Macro_t^i} + \varepsilon_{j,t}.$$

Variable details in this equation are explained in Table 4 or Section 3. Bold values indicate significant coefficients; *** at the 1%, ** at the 5%, and * at the 10% significance level.

	◇ *Domestic*			◇ *Spillover*					
Shock origin:	**US**	**EA**	**JP**	**US**	**US**	**EA**	**EA**	**JP**	**JP**
Asset:	**US**	**EA**	**JP**	**EA**	**JP**	**US**	**JP**	**US**	**EA**
Traditional MP JK	0.145	0.172	0.005	0.107	0.020	0.175	0.025	-0.009	-0.031
Traditional CBI JK	-0.171	**-0.247****	-0.004	-0.113	-0.112	**-0.201****	-0.103	-0.011	0.030
Communication MP CS	0.068	**0.990***	-0.284	0.045	-0.088	**1.050****	0.352	-0.146	-0.774
Communication CBI CS	-0.274	0.002	0.026	**-0.265***	-0.136	0.144	-0.029	0.127	-0.096

Table A10: Full results of our main specification.

This table reports the full domestic and spillover effects of monetary policy (MP) shocks on stock returns (SR), changes in interest rates (IR), and changes in Risk (RI), in terms of economic magnitude using specification in Equation (3). Some parts of the results below have been organized into Tables 2, 3, and 4 in the main paper. Detailed table notes follow Table 4. Columns (1), (6) and (8) come from the same US regression with the LHS being US risk; for Columns (2), (4) and (9), LHS=EA risk; for Columns (3), (5) and (7), LHS=JP risk. Bold values indicate significant coefficients; *** at the 1%, ** at the 5%, and * at the 10% significance level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		⋄ *Domestic*				⋄ *Spillover*			
Shock origin:	**US**	**EA**	**JP**	**US**	**US**	**EA**	**EA**	**JP**	**JP**
Asset:	**US**	**EA**	**JP**	**EA**	**JP**	**US**	**JP**	**US**	**EA**
Panel A. Stock returns, ΔSR									
Traditional MP JK	**-0.418*** **	**-0.343*** **	-0.049	**-0.116** **	-0.046	**-0.269*** **	0.011	-0.023	0.006
Traditional CBI JK	**0.213** **	**0.514*** **	-0.065	**0.283*** **	-0.087	**0.447*** **	0.065	-0.033	0.042
Communication MP CS	**-0.212*** **	**-0.720*** **	**0.368*** **	**0.137** **	0.002	**-0.795*** **	**-0.478*** **	-0.040	0.255
Communication CBI CS	**0.351*** **	**-0.136* **	-0.015	0.017	**-0.228** **	-0.067	-0.097	-0.057	0.047
Non-MP, non-Macro Risk	**-0.697*** **	**-0.684*** **	**-0.518*** **	0.035	**-0.068** **	-0.020	**-0.094*** **	**0.041** **	**0.043* **
Panel B. Changes in interest rate, ΔIR									
Traditional MP JK	**0.433*** **	**0.349*** **	**0.383*** **	0.130	0.094	-0.016	**-0.082** **	0.104	0.090
Traditional CBI JK	**0.853*** **	**0.266** **	-0.057	0.139	-0.019	0.056	-0.060	-0.042	0.007
Communication MP CS	**-0.250*** **	-0.015	-0.109	0.012	0.007	-0.040	-0.086	**0.446*** **	**0.139** **
Communication CBI CS	-0.103	-0.097	-0.103	0.083	**-0.158* **	0.042	0.005	-0.004	0.016
Non-MP, non-Macro Risk	**-0.080* **	-0.048	**-0.124*** **	-0.039	-0.004	-0.113	-0.018	0.008	-0.022
Panel C. Changes in risk, ΔRI									
Traditional MP JK	0.160	0.144	0.041	0.080	0.090	**0.173** **	-0.012	-0.009	-0.017
Traditional CBI JK	-0.214	**-0.228*** **	-0.168	-0.105	-0.093	**-0.203*** **	-0.057	-0.011	0.001
Communication MP CS	0.069	**0.464** **	-0.125	**0.093*** **	-0.024	**0.887*** **	**0.372** **	-0.144	-0.737
Communication CBI CS	**-0.385** **	0.064	0.137	**-0.372*** **	**-0.272*** **	0.140	0.084	0.134	-0.071
Non-MP, non-Macro Risk				**0.149*** **	**0.468*** **	**0.417*** **	-0.006	-0.045	**0.340*** **

Table A11: Alternative monetary policy shocks: Monetary policy and risk.

This table reports the effects of a set of alternative monetary policy shocks on risk, in terms of economic magnitude (i.e., number of SDs changes in the dependent variable given a 1 SD shock): Swanson (2021) shocks for US and Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019) shocks for EA) in Panel B. Other variable details in this equation are explained in Table 4 or Sections 3 and 4. Bold values indicate significant coefficients; *** at the 1%, ** at the 5%, and * at the 10% significance level.

	◇ *Domestic*			◇ *Spillover*					
Shock origin:	**US**	**EA**	**JP**	**US**	**US**	**EA**	**EA**	**JP**	**JP**
Asset:	**US**	**EA**	**JP**	**EA**	**JP**	**US**	**JP**	**US**	**EA**
Swanson Target / Altavilla et al. Target / JP Target	-0.239	-0.141	**0.161***	0.239	0.123	0.040	-0.451	0.053	0.032
Swanson FG / Altavilla et al. FG / JP Path	0.426	-0.120	-0.001	0.003	0.623	**-0.142****	-0.094	-0.152	-0.003
Swanson AP / Altavilla et al. AP	-0.060	**0.264*****		0.025	**-0.291*****	**0.182*****	-0.079		
EA Timing		-0.155				**-0.146*****	0.123		
Communication MP CS	0.059	**0.458***	**0.486****	-0.005	0.178	**0.682***	**0.571****	**0.106***	0.181
Communication CBI CS	0.088	-0.324	0.098	0.008	0.073	**-0.680***	0.139	0.202	-0.106
Non-MP, non-Macro Risk				0.064	**0.432*****	**0.530*****	**0.115****	-0.012	**0.213*****

Table A12: Alternative monetary policy shocks: Monetary policy and asset prices.

This table complements Table A12 and reports the effects of a set of alternative monetary policy shocks on asset prices, in terms of economic magnitude (i.e., number of SDs changes in the dependent variable given a 1 SD shock): Swanson (2021) shocks for US and Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019) shocks for EA. Other variable details in this equation are explained in Table 4 or Sections 3 and 4. Bold values indicate significant coefficients; *** at the 1%, ** at the 5%, and * at the 10% significance level.

	◇ *Domestic*			◇ *Spillover*					
Shock origin:	**US**	**EA**	**JP**	**US**	**US**	**EA**	**EA**	**JP**	**JP**
Asset:	**US**	**EA**	**JP**	**EA**	**JP**	**US**	**JP**	**US**	**EA**
Panel A. Interest Rates									
Swanson Target / Altavilla et al. Target / JP Target	-0.002	0.102	**0.096*** **	0.189	0.081	0.009	0.012	0.005	0.028
Swanson FG / Altavilla et al. FG / JP Path	**0.040*** **	0.014	-0.015	**0.109***	-0.001	0.016	-0.006	0.009	0.026
Swanson AP / Altavilla et al. AP	0.009	-0.014		-0.014	-0.015	0.014	-0.019		
EA Timing		**0.120*** **				-0.003	0.005		
Communication MP CS	-0.001	0.018	**-0.061*** **	-0.040	0.017	0.022	-0.027	0.015	-0.024
Communication CBI CS	-0.014	-0.051	**-0.049*** **	-0.005	0.045	**-0.144*** **	0.007	-0.006	-0.002
Non-MP, non-Macro Risk	0.005	**0.035*** **	**-0.020*** **	0.002	-0.004	-0.002	-0.008	**0.004*** **	-0.007
Panel B. Stock Returns									
Swanson Target / Altavilla et al. Target / JP Target	**-0.050*** **	0.010	-0.012	-0.005	0.028	-0.003	-0.010	**-0.011***	-0.002
Swanson FG / Altavilla et al. FG / JP Path	**-0.037*** **	0.008	-0.009	0.011	0.015	**0.015*** **	0.003	**0.015***	**0.022***
Swanson AP / Altavilla et al. AP	-2.04E-04	**-0.051*** **		**-0.013***	-0.010	**-0.032*** **	0.007		
EA Timing		**0.023*** **				**0.028*** **	0.005		
Communication MP CS	**-0.025*** **	**-0.037*** **	-0.001	0.012	**-0.025***	**-0.030***	**-0.045*** **	**-0.011***	-0.010
Communication CBI CS	**-0.069*** **	-0.079	0.004	0.013	0.000	**0.048***	**-0.078***	-0.008	0.005
Non-MP, non-Macro Risk	**-0.065*** **	**-0.113*** **	**-0.065*** **	0.004	**-0.014*** **	**-0.010*** **	**-0.014*** **	0.001	0.002

Table A13: Dynamic effects of MP and risk shocks on country-level risk variables.

This table presents country-level regression results, in terms of original coefficient estimates (which are of particular interest in the dynamic effects), of projecting current or cumulative changes in volatility index-squared on domestic and foreign monetary policy shocks (pure MP, information; traditional, communication) and risk shocks. Row "t-1,t" uses the contemporaneous changes in volatility index-squared (main risk measure as in the rest of the paper); row "t,t+5" for instance uses the cumulative future 5-day changes in volatility index-squared. Bold values indicate that a coefficient is significant; *** at the 1% significance level; **, 5%; *, 10%.

	◇ *Traditional*						◇ *Communication*						◇ *Risk*		
Shock:	**US Pure MP**	**US Info**	**EA Pure MP**	**EA Info**	**JP Target**	**JP Path**	**US Pure MP**	**US Info**	**EA Pure MP**	**EA Info**	**JP Pure MP**	**JP Info**	**US Risk**	**EA Risk**	**JP Risk**
							Panel A. LHS = US Risk								
t-1,t	0.34	-0.46	__0.42**__	__-0.50***__	-0.15	-0.20	0.77	__-4.28**__	__37.10***__	2.22	-1.83	1.91		-0.05	-0.06
t, t+1	0.35	__0.73*__	__-0.50*__	-0.11	1.84	0.90	0.17	0.22	-3.66	1.99	5.50	-1.72		-0.06	-0.06
t, t+5	0.19	1.19	-0.72	-0.48	-0.32	-0.70	-1.04	-2.92	-4.30	2.44	-0.35	-0.99		-0.17	-0.14
t, t+21	0.83	1.51	__-0.84**__	__-0.64*__	-1.07	-5.23	__-17.49***__	__-19.22**__	__-27.80***__	2.28	-6.42	-0.56		__-0.08*__	-0.08
							Panel B. LHS = EA Risk								
t-1,t	0.15	-0.20	0.31	__-0.49***__	-0.23	0.02	__0.91***__	__-3.62***__	__16.99**__	0.89	-8.22	-0.89	__0.17***__		__0.33***__
t, t+1	0.16	__0.68***__	-0.04	-0.24	1.27	1.82	-0.03	-9.29	-1.39	2.00	5.74	-1.12	-0.06		-0.02
t, t+5	__0.58*__	__1.15***__	-0.29	-0.48	-1.78	0.05	__-2.01**__	-1.71	1.48	0.20	__1.85*__	0.17	-0.16		__-0.22*__
t, t+21	1.82	__2.48*__	__-0.53**__	__-0.81**__	__-7.53**__	-1.28	__-9.32***__	-4.11	-10.10	0.05	-2.56	-0.38	__-0.28***__		-0.13
							Panel C. LHS = JP Risk								
t-1,t	0.17	-0.18	-0.02	-0.12	0.58	-2.63	-0.24	__-2.66***__	__13.70**__	1.17	-1.40	1.72	__0.53***__	-0.01	
t, t+1	0.23	-0.25	__0.37*__	__-0.53*__	3.52	4.25	0.11	-1.54	6.82	-1.02	__5.70**__	-2.48	-0.08	-0.03	
t, t+5	__1.11*__	0.06	-0.56	__-1.08**__	0.74	4.17	-0.01	-0.16	6.67	0.31	8.69*	-0.20	0.00	-0.13	
t, t+21	0.69	1.27	-1.02	__-2.26*__	__-5.23*__	5.83	__-11.46***__	-19.49	-15.49	-1.47	-8.92	0.32	__-0.17*__	-0.04	

Table A14: Dynamic effects of MP and risk shocks on country-level interest rate.

This table presents country-level regression results, in terms of original coefficient estimates (which are of particular interest in the dynamic effects), of projecting current or cumulative changes in interest rates on domestic and foreign monetary policy shocks (pure MP, information; traditional, communication) and risk shocks. Row "t-1,t" uses the contemporaneous changes in interest rates; row "t,t+5" for instance uses the cumulative future 5-day changes in interest rates. Bold values indicate that a coefficient is significant; *** at the 1% significance level; **, 5%; *, 10%.

	⋄ *Traditional*						⋄ *Communication*						⋄ *Risk*		
Shock:	**US Pure**	**US Info**	**EA Pure**	**EA Info**	**JP Target**	**JP Path**	**US Pure**	**US Info**	**EA Pure**	**EA Info**	**JP Pure**	**JP Info**	**US Risk**	**EA Risk**	**JP Risk**
Panel A. LHS = US IR															
t-1,t	**0.34*** **	**0.67*** **	-0.01	0.05	0.62	-0.27	**-1.03*** **	-0.42	-0.62	0.25	**2.09*** **	-0.02	**-0.04***	-0.05	0.00
t, t+1	-0.10	0.16	0.01	-0.01	**-0.54** **	**-0.66** **	**-4.01** **	0.03	1.13	-0.22	2.68	-0.07	-0.01	**0.04** **	-0.03
t, t+5	-0.18	0.02	0.21	-0.06	0.35	-1.16	**-2.73** **	**3.29*** **	-1.22	-0.67	-2.97	-0.90	-0.03	**0.06** **	-0.04
t, t+21	-0.14	**0.87** **	-0.17	0.12	0.50	-1.49	-1.42	2.74	-1.23	-2.75	**3.35** **	-4.84	-0.04	0.06	**-0.05***
Panel B. LHS = EA IR															
t-1,t	0.07	0.08	**0.22*** **	**0.17** **	0.37	0.03	0.03	0.24	-0.16	-0.39	**0.45** **	0.06	-0.01	-0.01	-0.01
t, t+1	-0.01	-0.06	**0.17*** **	**0.15*** **	0.07	-0.18	0.12	0.98	1.02	0.10	0.09	**0.56** **	-0.01	**-0.02** **	0.01
t, t+5	-0.17	-0.10	0.17	**0.26** **	-0.68	-0.09	**3.70*** **	1.62	-1.88	1.30	0.43	**0.84***	**-0.02***	**-0.03** **	0.00
t, t+21	-0.28	0.22	0.02	**0.49***	**2.47***	-0.30	**9.12*** **	2.41	3.32	0.89	5.83	0.18	-0.03	-0.01	-0.01
Panel C. LHS = JP IR															
t-1,t	0.04	-0.01	**-0.04** **	-0.03	**1.20*** **	-0.20	0.01	**-0.34***	-0.71	0.01	-0.27	-0.29	0.00	0.00	**-0.03*** **
t, t+1	0.02	-0.03	0.01	**0.09** **	**0.37** **	-0.04	0.03	**0.60*** **	0.07	-0.11	-0.06	**0.74*** **	0.00	0.01	**0.01** **
t, t+5	0.20	0.13	-0.01	0.05	**0.72***	0.17	**0.38** **	**1.58*** **	-0.83	0.55	-0.08	**1.11** **	-0.01	**0.02*** **	**0.01** **
t, t+21	0.24	**0.51*** **	-0.14	**-0.23***	0.78	-0.72	**-0.71** **	-0.05	3.50	0.87	-0.09	0.57	-0.01	**0.02** **	**0.02** **

Table A15: Dynamic effects of MP and risk shocks on country-level stock returns.

This table presents country-level regression results, in terms of original coefficient estimates (which are of particular interest in the dynamic effects), of projecting current or cumulative stock returns on domestic and foreign monetary policy shocks (pure MP, information; traditional, communication) and risk shocks. Row "t-1,t" uses the contemporaneous stock returns; row "t,t+5" for instance uses the cumulative future 5-day stock returns. Bold values indicate that a coefficient is significant; *** at the 1% significance level; **, 5%; *, 10%.

	◇ *Traditional*						◇ *Communication*						◇ *Risk*		
Shock:	**US Pure**	**US Info**	**EA Pure**	**EA Info**	**JP Target**	**JP Path**	**US Pure**	**US Info**	**EA Pure**	**EA Info**	**JP Pure**	**JP Info**	**US Risk**	**EA Risk**	**JP Risk**
							Panel A. LHS = US SR								
t-1,t	**-0.08*** **	**0.04** **	**-0.06*** **	**0.10*** **	-0.03	-0.05	**-0.21*** **	**0.35*** **	**-2.99*** **	-0.10	-0.05	-0.07	**-0.08*** **	0.00	**0.00* **
t, t+1	**-0.06** **	**-0.07** **	0.03	0.00	-0.10	-0.08	-0.19	-0.05	**0.74** **	-0.18	-0.35	0.19	0.01	0.00	0.00
t, t+5	-0.02	-0.05	0.03	0.05	0.02	-0.12	0.18	0.25	1.18	-0.43	-0.17	-0.01	**0.02*** **	**0.01* **	**0.01* **
t, t+21	-0.08	0.00	0.08	0.05	0.41	0.12	**1.52*** **	**1.57** **	**5.66** **	-0.17	0.96	-0.08	**0.01* **	**0.01* **	0.00
							Panel B. LHS = EA SR								
t-1,t	**-0.03** **	**0.07*** **	**-0.09*** **	**0.14*** **	0.01	0.08	**0.17** **	0.02	**-3.28*** **	**-0.23* **	0.35	0.07	0.01	**-0.08*** **	**0.01* **
t, t+1	-0.02	**-0.07** **	0.00	0.00	-0.12	**-0.22* **	0.07	0.21	**1.23** **	-0.08	-0.27	**0.33** **	**0.01** **	0.00	0.00
t, t+5	-0.04	**-0.10** **	-0.01	**0.09* **	-0.02	-0.17	**0.31* **	0.23	1.39	-0.31	-0.26	0.09	**0.01** **	**0.02*** **	0.01
t, t+21	-0.10	-0.05	-0.01	0.12	**0.62** **	0.00	**1.40*** **	0.47	**5.35* **	-0.36	**0.77* **	0.13	**0.02*** **	**0.03*** **	0.00
							Panel C. LHS = JP SR								
t-1,t	-0.01	-0.02	0.00	0.02	-0.09	-0.13	0.00	**-0.29* **	**-2.26*** **	-0.17	**0.53*** **	-0.02	**-0.01** **	**-0.01*** **	**-0.06*** **
t, t+1	-0.02	-0.02	**-0.05*** **	**0.08*** **	-0.10	-0.28	-0.14	0.18	-0.31	-0.23	**-0.57* **	**0.34** **	0.00	0.00	**0.01* **
t, t+5	-0.06	0.06	-0.07	**0.14*** **	-0.03	-0.19	-0.04	-0.02	1.42	-0.22	**-0.60** **	0.27	0.00	0.02	**0.02*** **
t, t+21	-0.13	0.05	-0.09	**0.18** **	**1.08** **	-0.40	**1.24*** **	0.78	**4.56** **	-0.06	0.83	0.28	**0.01* **	0.01	**0.02** **

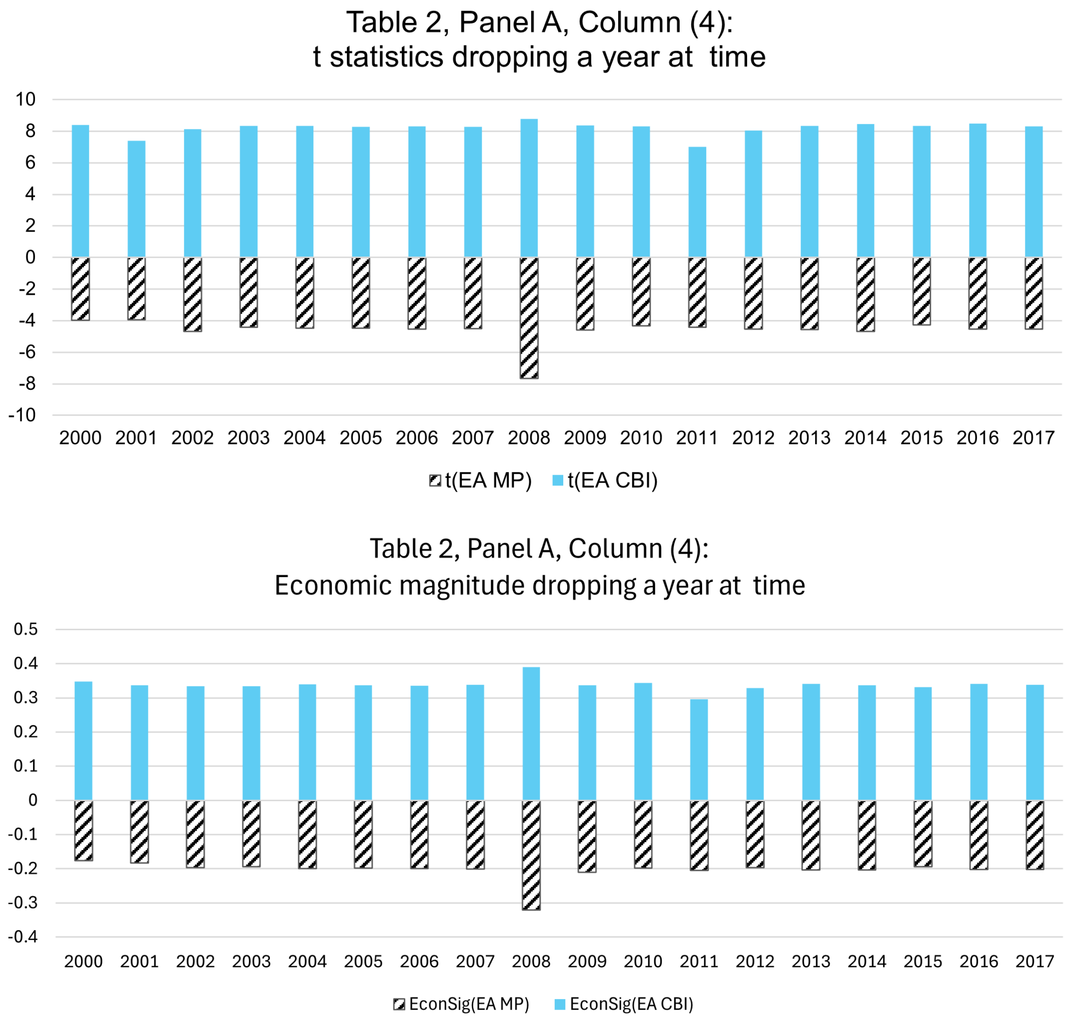


Figure A1: Jackknife exercise dropping one year at a time of our main result in Table 2, Panel A, Column (4).

B Appendix: Communication shocks

For the US, we identify 160 communication monetary policy event dates: among them, 135 events correspond to the release of the minutes of the policy meetings, 20 events correspond to liquidity-provision related unconventional policies (14 in the global financial crisis years, 2 each in 2010/2011/2014), and 5 events correspond to Ben Bernanke's speeches (3 at Jackson Hole, 1 at the Boston Fed) or Congress testimony. For the ECB, we identify 90 communication events; 70 of them correspond to key policy makers' speeches, while the rest belong to unconventional policies such as granting loans and euro stability packages. For the Bank of Japan, we identify 196 events; like the US, BoJ also publishes meeting minutes in a delayed fashion, which explain 179 of these events, and the remaining 17 events include unconventional monetary policy announcements and some unusual BoJ statements to the public (e.g., stating "BoJ will monitor the Greek Crisis".) BoJ policy makers made no speeches during the sample period we study. Lastly, there are no "Press Conferences" (PC) in our communication events; press conferences occur on monetary policy decision days, and we follow the state-of-the-art practice in the literature to group responses to PCs in calculating the total responses to the traditional monetary policy events (see Gürkaynak, Sack, and Swanson (2005) and Jarociński and Karadi (2020)).

For the US, we have about as many communication shocks as traditional shocks, but for Japan we have fewer communication shocks (181 versus 257 traditional shocks) and for the euro area we only have 90 communication shocks, whereas there were 277 traditional shocks. For the US and Japan, the standard deviation of these shocks is around 1 basis point, with the variability of EA communication information shocks a bit lower at 0.85 basis points and the variability of EA communication shocks, classified as pure monetary policy shocks, much lower at around 0.3 basis points.

C Appendix: A simple dynamic asset pricing model for Section 2

We set out a consumption-based asset pricing model, which is a variant of the model in Bekaert, Engstrom, and Xing (2009), BEX henceforth. The model features three key state variables, expected consumption growth (g_t), uncertainty (the conditional variance of consumption growth, UC_t), and stochastic risk aversion (RI_t). The modelling of consumption and dividend growth is simpler than in BEX, who assume they are cointegrated.

C.1 Fundamental and preferences

The dynamics of the state variables for consumption growth (Δc_{t+1}) and its conditional moments are given by:

$$\Delta c_{t+1} = \mu_c + g_t + \sqrt{UC_t}\varepsilon_{c,t+1}, \tag{C1}$$

$$UC_{t+1} = \mu_{UC} + \rho_{UC}UC_t + \sigma_{UC}\sqrt{UC_t}\varepsilon_{UC,t+1}, \tag{C2}$$

$$g_{t+1} = \rho_g g_t + \sigma_{gc} \underbrace{\sqrt{UC_t}\varepsilon_{c,t+1}}_{\Delta c_{t+1}-E_t[\Delta c_{t+1}]} + \sigma_{gg}\sqrt{UC_t}\varepsilon_{g,t+1}. \tag{C3}$$

The risk aversion process loads on the consumption growth shock, but also features an uncorrelated preference shock, which is heteroskedastic, that is, risk aversion becomes more variable as it increases in value:

$$RA_{t+1} = \mu_{RI} + \rho_{RI} RI_t + \sigma_{RAc}\sqrt{UC_t}\varepsilon_{c,t+1} + \sigma_{RI}\sqrt{RI_t}\varepsilon_{RA,t+1}. \tag{C4}$$

Dividend growth (Δd_{t+1}) similarly loads on consumption growth and an independent homoskedastic shock:

$$\Delta d_{t+1} = \mu_d + \rho_{dg} g_t + \sigma_{dc}\sqrt{UC_t}\varepsilon_{c,t+1} + \sigma_d \varepsilon_{d,t+1}. \tag{C5}$$

Shocks $\varepsilon_{c,t+1}, \varepsilon_{UC,t+1}, \varepsilon_{g,t+1}, \varepsilon_{RA,t+1}$ and $\varepsilon_{d,t+1}$ are independently and normally distributed $N(0, 1)$.

The agent maximizes $E_t\left[\sum_{t=0}^{\infty}\beta^t \frac{(C_t - H_t)^{1-\gamma}}{1-\gamma}\right]$, with $C_t > H_t$ and H_t is the habit stock. Define $Q_t \equiv \frac{C_t}{C_t - H_t} > 1$. This is the inverse of Campbell and Cochrane (1999)'s surplus consumption ratio. The equilibrium pricing kernel is $M^*_{t+1} = \beta\frac{(C_{t+1}/C_t)^{-\gamma}}{(Q_{t+1}/Q_t)^{-\gamma}}$, and the equilibrium log real pricing kernel is,

$$\begin{aligned} m^*_{t+1} &= log\beta - \gamma\Delta c_{t+1} + \gamma(q_{t+1} - q_t) \\ &= log\beta - \gamma(\mu_c + g_t - \mu_{RI} + (1 - \rho_{RI})RI_t) - \gamma(1 - \sigma_{RI})\sqrt{UC_t}\varepsilon_{c,t+1} + \gamma\sigma_{RI}\sqrt{RI_t}\varepsilon_{RA,t+1}. \end{aligned} \tag{C6}$$

In this model q_t essentially represents stochastic risk aversion, so $q_t = RI_t$.

C.2 Asset price: Real interest rate

First, the real rate in equilibrium is, (using a superscript $*$ to denote equilibrium value)

$$\begin{aligned} rf^*_t &= -logE^*_t\left[\exp\left(m_{t+1}\right)\right], \\ &= k_0 + k_g g_t + k_{RI} RI_t + k_{UC} UC_t, \end{aligned} \tag{C7}$$

where

$$\begin{aligned} k_0 &= -log\beta + \gamma(\mu_c - \mu_{RI}) \\ k_g &= \gamma \\ k_{RI} &= \gamma(1 - \rho_{RI}) - \frac{1}{2}\gamma^2\sigma^2_{RI} \\ k_{UC} &= -\frac{1}{2}\gamma^2(1 - \sigma_{RAc})^2. \end{aligned}$$

We do not model the monetary policy transmission function directly, instead assuming there exists a non-persistent monetary policy shock, $MP_t \sim N(0, \sigma_{MP})$, that can affect the various state variables directly and is uncorrelated with $\{\varepsilon_{c,t+1}, \varepsilon_{UC,t+1}, \varepsilon_{g,t+1}, \varepsilon_{RA,t+1}, \varepsilon_{d,t+1}\}$. This is tantamount to adding $\phi_x MP_{t+1}$, with $x = UC$, g, and RA, to Equations (C2), (C3), and (C4), respectively. We discuss the various channels through which such effects can occur in the main text in Section 2.

Because the shock is not persistent, it will not affect pricing equations. In addition, we must allow for monetary policy to affect interest rates directly. Assume that there is a wedge between the equilibrium real pricing kernel and the true pricing kernel, M_{t+1}, such that $M_{t+1} = M^*_{t+1}exp(-\phi_{MP}MP_t)$. This is equivalent to assuming that monetary policy affects liquidity in the market for short term securities; a contractionary shock decreases liquidity and drives up the liquidity premium and vice versa. Therefore, the actual real rate equals:

$$rf_t = rf_t^* + \phi_{MP} MP_t. \tag{C8}$$

With this structure, monetary policy potentially transmits to the real economy through an information shock/expected cash flow channel (through ϕ_g), though risk channels (through ϕ_{UC} and ϕ_{RI}) and directly through ϕ_{MP}. MP_t here acts as a pure term structure level factor.

For simplicity, we focus on the special case of $\phi_g = 0$, $\phi_{RI} = 0$, and $\phi_{UC} = 0$ to describe the model solutions, which are correct up to a constant term for the general case as well.

C.3 Asset prices: Long-term real bond prices

C.3.1 Two-period zero-coupon bond price

As derived above, the price for the one-period zero-coupon real bond is,

$$P_{1,t} = E_t\left[\exp\left(m_{t+1}\right)\right] = \exp\left(A_1 + B_1 g_t + C_1 RI_t + D_1 UC_t - \phi_{MP} MP_t\right), \tag{C9}$$

where

$$\begin{aligned}
A_1 &= log\beta - \gamma(\mu_c - \mu_{RI}) \\
B_1 &= -\gamma - \rho_{\pi g} \\
C_1 &= -\gamma(1-\rho_{RI}) + \frac{1}{2}\gamma^2\sigma_{RI}^2 \\
D_1 &= \frac{1}{2}\gamma^2(1-\sigma_{RAc})^2
\end{aligned}$$

The price for the two-period zero-coupon real bond is,

$$\begin{aligned}
P_{2,t} &= E_t\left[M_{t+1}P_{1,t+1}\right] \\
&= E_t\left[\exp\left(m_{t+1} + \underbrace{A_1 + B_1 g_{t+1} + C_1 RA_{t+1} + D_1 UC_{t+1} - \phi_{MP} MP_{t+1}}_{\Delta_{t+1} \equiv -rf_{t+1}}\right)\right].
\end{aligned} \tag{C10}$$

We can rewrite m_{t+1} and Δ_{t+1} in matrix representations:

$$\begin{aligned}
m_{t+1} &= m_0 + \boldsymbol{m_1}\begin{bmatrix} g_t \\ RI_t \end{bmatrix} + \boldsymbol{m_2}\begin{bmatrix} \sqrt{UC_t}\varepsilon_{c,t+1} \\ \sqrt{RI_t}\varepsilon_{RA,t+1} \end{bmatrix} - \phi_{MP} MP_t, \\
\Delta_{t+1} \equiv -rf_{t+1} &= \Delta_0 + \boldsymbol{\Delta_1}\begin{bmatrix} g_t \\ RI_t \\ UC_t \end{bmatrix} + \boldsymbol{\Delta_2}\begin{bmatrix} \sqrt{UC_t}\varepsilon_{c,t+1} \\ \sqrt{RI_t}\varepsilon_{RA,t+1} \\ \sqrt{UC_t}\varepsilon_{UC,t+1} \\ MP_{t+1} \end{bmatrix}.
\end{aligned}$$

Then, Equation (C10) can be solved as follows:

$$\begin{aligned}
P_{2,t} &= \exp\left\{\begin{array}{l} E_t(m_{t+1}) + \frac{1}{2}V_t(m_{t+1}) \\ +E_t(\Delta_{t+1}) + \frac{1}{2}V_t(\Delta_{t+1}) \\ +Cov_t(m_{t+1}, \Delta_{t+1}) \end{array}\right\} \\
&= \exp\left[A_2 + B_2 g_t + C_2 RA_t + D_2 UC_t - \phi_{MP} MP_t\right].
\end{aligned} \tag{C11}$$

C.3.2 Term premia

The yield rate for the two-period real bond, $y_{2,t} = -\frac{\log(P_{2,t})}{2}$, can be derived as:

$$y_{2,t} = -\frac{1}{2}\left\{\begin{array}{ll} E_t(m_{t+1}) + \frac{1}{2}V_t(m_{t+1}) & [= -rf_t^* - \phi_{MP}MP_t] \\ +E_t(\Delta_{t+1}) & [1.\text{ Expectations Hypothesis terms}] \\ +\frac{1}{2}V_t(\Delta_{t+1}) & [2.\text{ Jensen's inequality term}] \\ +Cov_t(m_{t+1}, \Delta_{t+1}) & [3.\text{ Bond term premium channel}] \end{array}\right\}.$$

$$= \frac{1}{2}(rf_t^* + \phi_{MP}MP_t) + \frac{1}{2}E_t(rf_{t+1}) - \frac{1}{4}V_t(rf_{t+1}) + \frac{1}{2}Cov_t(m_{t+1}, rf_{t+1}), \quad \text{(C12)}$$

where the term premium component $tp_t = Cov_t(m_{t+1}, rf_{t+1})$ is given by:

$$tp_t = \underbrace{(-m_{2,c}\Delta_{2,c})}_{\eta_{UC}} UC_t + \underbrace{(-m_{2,RA}\Delta_{2,RA})}_{\eta_{RI}} RI_t, \quad \text{(C13)}$$

which was shown in Section 2.

C.3.3 N-period zero-coupon real bond price

By induction, it can be easily shown that

$$P_{N,t} = \exp\left[A_N + B_N g_t + C_N RA_t + D_N UC_t - \phi_{MP}MP_t\right], \quad \text{(C14)}$$

where,

$$\begin{aligned} A_N &= log\beta - \gamma\mu_c + \gamma\mu_{RI} + A_{N-1} + C_{N-1}\mu_{RI} + D_{N-1}\mu_{UC} + \frac{1}{2}\phi_{MP}^2\sigma_{MP}^2 \\ B_N &= -\gamma - \rho_{\pi g} + B_{N-1}\rho_g \\ C_N &= -\gamma(1-\rho_{RI}) + C_{N-1}\rho_{RI} + \frac{1}{2}\left(\gamma\sigma_{RI} + C_{N-1}\sigma_{RI}\right)^2 \\ D_N &= D_{N-1}\rho_{UC} + \frac{1}{2}\left(-\gamma(1-\sigma_{RAc}) + B_{N-1}\sigma_{gc} + C_{N-1}\sigma_{RAc}\right)^2 + \frac{1}{2}(B_{N-1})^2\sigma_g^2 + \frac{1}{2}(D_{N-1})^2\sigma_{UC}^2 \end{aligned}$$

Equation (C14) shows that the price of a N-period zero-coupon real bond is determined by expected growth, risk aversion, uncertainty, and the monetary policy shock. Intuitively, a positive MP shock leads to a lower long-term bond price today, with the pass-through depending on the persistence of the various shocks affecting short-term interest rate. Apart from this EH effect, the MP shock can also affect the state variables itself through an information (expected growth) or risk (risk aversion, uncertainty) channel.

C.3.4 Contemporaneous log long-term bond returns

Denote $\boldsymbol{Y_t} = \begin{bmatrix} g_t & RI_t & UC_t & MP_t \end{bmatrix}'$. The contemporaneous log bond return, $\tilde{r}_t^b = log\left(\frac{P_{N-1,t}}{P_{N,t-1}}\right)$, can be derived as follows:

$$r_t^b = \xi_0^b + \boldsymbol{\xi_1^b Y_{t-1}} + \boldsymbol{\xi_2^b}\begin{bmatrix} g_t - E_{t-1}(g_t) \\ RA_t - E_{t-1}(RA_t) \\ UC_t - E_{t-1}(UC_t) \\ MP_t \end{bmatrix}, \quad \text{(C15)}$$

where ξ^b_0, $\boldsymbol{\xi^b_1}$, and $\boldsymbol{\xi^b_2}$ are implicitly defined. This equation motivates the four shocks that the paper uses.

C.4 Asset prices: Stock price

C.4.1 Price-dividend ratio

The price-dividend ratio, $PD_t = E_t\left[M_{t+1}\left(\frac{P_{t+1}+D_{t+1}}{D_t}\right)\right]$, can be rewritten as,

$$PD_t = \sum_{n=1}^{\infty} E_t\left[\exp\left(\sum_{j=1}^{n} m_{t+j} + \Delta d_{t+j}\right)\right]. \tag{C16}$$

Let $F_{n,t}$ denote the n-th term in the summation:

$$F_{n,t} = E_t\left[\exp\left(\sum_{j=1}^{n} m_{t+j} + \Delta d_{t+j}\right)\right], \tag{C17}$$

and $F_{n,t}D_t$ can be interpreted as the price of zero-coupon equity that matures in n periods. We can rewrite $\Delta d_{t+1} = d_0 + d_1 g_t + \boldsymbol{d_2}\begin{bmatrix}\sqrt{UC_t}\varepsilon_{c,t+1}\\ \varepsilon_{d,t+1}\end{bmatrix}$. The first term, $F_{1,t}$, can be solved as follows:

$$\begin{aligned}
F_{1,t} &= E_t\left[\exp\left(m_{t+1} + \Delta d_{t+1}\right)\right]\\
&= \exp\left\{\begin{array}{ll} E_t(m_{t+1}) + \frac{1}{2}V_t(m_{t+1}) & [\text{1. Interest rate channel, } = -rf^*_t - \phi_{MP}MP_t]\\ +E_t(\Delta d_{t+1}) + \frac{1}{2}V_t(\Delta d_{t+1}) & [\text{2. Cash flow channel}]\\ +Cov_t(m_{t+1}, \Delta d_{t+1}) & [\text{3. premium channel (from pure cash flow)}]\end{array}\right\}\\
&= \exp\left(e_{1,0} + \boldsymbol{e_{1,1}}\left[g_t \quad RI_t \quad UC_t\right]' - \phi_{MP}MP_t\right)
\end{aligned} \tag{C18}$$

Suppose $F_{N-1,t} = \exp\left(e_{N-1,0} + \boldsymbol{e_{N-1,1}}\left[g_t \quad RI_t \quad UC_t\right]' - \phi_{MP}MP_t\right) \equiv \exp(f_{N-1,t})$, and $f_{N-1,t+1}$ can be rewritten as $f_{N-1,0} + \boldsymbol{f_{N-1,1}}\left[g_t \quad RI_t \quad UC_t\right]' + \boldsymbol{f_{N-1,2}}\begin{bmatrix}\sqrt{UC_t}\varepsilon_{c,t+1}\\ \sqrt{RI_t}\varepsilon_{RA,t+1}\\ \sqrt{UC_t}\varepsilon_{UC,t+1}\\ MP_{t+1}\end{bmatrix}$.

By induction,

$$\begin{aligned}
F_{N,t} &= E_t\left[\exp\left(m_{t+1}\right)\underbrace{E_{t+1}\left(\exp\left(\sum_{j=1}^{N-1} m_{t+j+1} - \pi_{t+j+1} + \Delta d_{t+j+1}\right)\right)}_{F_{N-1,t+1}}\right]\\
&= \exp\left\{\begin{array}{ll} E_t(m_{t+1}) + \frac{1}{2}V_t(m_{t+1}) & [\text{1. Interest rate channel, } = -rf^*_t - \phi_{MP}MP_t\\ +E_t(f_{N-1,t+1}) + \frac{1}{2}V_t(f_{N-1,t+1}) & \\ +(m_{2,c}f_{N-1,2,c})UC_t + (m_{2,RA}f_{N-1,2,RA})RI_t & [\text{2. risk premium channel}]\end{array}\right\}\\
&= \exp\left(e_{N,0} + \boldsymbol{e_{N,1}}\left[g_t \quad RI_t \quad UC_t\right]' - \phi_{MP}MP_t\right).
\end{aligned} \tag{C19}$$

Hence, the price-dividend ratio is approximately affine:

$$
\begin{aligned}
PD_t &= \sum_{n=1}^{\infty} E_t\left[\exp\left(\sum_{j=1}^{n} m_{t+j} + \Delta d_{t+j}\right)\right] \\
&= \sum_{n=1}^{\infty} F_{n,t} \\
&= \sum_{n=1}^{\infty} \exp\left(e_{n,0} + \boldsymbol{e_{n,1}}\left[g_t \quad RI_t \quad UC_t\right]' - \phi_{MP} MP_t\right), \qquad \text{(C20)}
\end{aligned}
$$

which implies that a positive MP shock could result in a lower stock price today (hence a lower contemporaneous stock return). Similarly, apart from this EH effect, the MP shock can also affect the state variables itself through an information or risk channel.

C.4.2 Contemporaneous log stock returns

As previously defined, $\boldsymbol{Y_t} = \left[g_t \quad RI_t \quad UC_t \quad MP_t\right]'$. We apply first-order Taylor approximations to the log stock return, from $t-1$ to t (as our paper focuses on contemporaneous changes), and obtain a linear system.

$$
\begin{aligned}
r_t^{eq} &= \Delta d_t + \ln\left[\frac{1 + \sum_{n=1}^{\infty} \exp\left(e_{n,0} + \boldsymbol{e_{n,1}} \boldsymbol{Y_t}\right)}{\sum_{n=1}^{\infty} \exp\left(e_{n,0} + \boldsymbol{e_{n,1}} \boldsymbol{Y_{t-1}}\right)}\right] \\
&\approx \Delta d_t + \text{const.} + \frac{\sum_{n=1}^{\infty} \exp\left(e_{n,0} + \boldsymbol{e_{n,1}} \bar{\boldsymbol{Y}}\right) \boldsymbol{e_{n,1}}}{\frac{1+\sum_{n=1}^{\infty} \exp\left(e_{n,0}+\boldsymbol{e_{n,1}}\bar{\boldsymbol{Y}}\right)}{\sum_{n=1}^{\infty} \exp\left(e_{n,0}+\boldsymbol{e_{n,1}}\bar{\boldsymbol{Y}}\right)}} \boldsymbol{Y_t} - \frac{\sum_{n=1}^{\infty} \exp\left(e_{n,0} + \boldsymbol{e_{n,1}} \bar{\boldsymbol{Y}}\right) \boldsymbol{e_{n,1}}}{\sum_{n=1}^{\infty} \exp\left(e_{n,0} + \boldsymbol{e_{n,1}} \bar{\boldsymbol{Y}}\right)} \boldsymbol{Y_{t-1}} \\
&= \xi_0^{eq} + \boldsymbol{\xi_1^{eq}} \boldsymbol{Y_{t-1}} + \boldsymbol{\xi_2^{eq}} \begin{bmatrix} g_t - E_{t-1}(g_t) \\ RA_t - E_{t-1}(RA_t) \\ UC_t - E_{t-1}(UC_t) \\ MP_t \end{bmatrix}, \qquad \text{(C21)}
\end{aligned}
$$

where ξ_0^{eq}, $\boldsymbol{\xi_1^{eq}}$, and $\boldsymbol{\xi_2^{eq}}$ are implicitly defined.

C.4.3 Equity risk premium

Given the no-arbitrage condition and that log stock return is quasi-linear and multinormal shock assumptions, the equity risk premium can be solved as follows:

$$
\begin{aligned}
E_t\left(r_{t+1}^{eq} - rf_t\right) + \frac{1}{2} V_t(r_{t+1}^{eq}) &\approx -Cov_t(m_{t+1}, r_{t+1}^{eq}) \\
&= \underbrace{\left(-m_{2,c}\xi_{2,c}^{eq}\right)}_{\kappa_{UC}} UC_t + \underbrace{\left(-m_{2,c}\xi_{2,RA}^{eq}\right)}_{\kappa_{RI}} RI_t, \qquad \text{(C22)}
\end{aligned}
$$

where $\xi_{2,c}^{eq}$ indicates the loading of r_{t+1}^{eq} on $\sqrt{UC_t}\varepsilon_{c,t+1}$ (which comes from dividend growth's exposure to consumption shock and the expected growth's exposure to consumption shock), and $\xi_{2,RA}^{eq}$ indicates the loading of r_{t+1}^{eq} on $\sqrt{RI_t}\varepsilon_{RA,t+1}$ (which comes from risk aversion).