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, differentiating between "traditional" monetary policy and communication events, each decomposed into "pure" and information shocks. Communication shocks from the US spill over to risk in the euro area and vice versa. Both monetary policy and communication shocks spill over to stocks, with euro area information spillovers being particularly strong. US spillovers are consistent with global CAPM intuition whereas euro area spillovers are larger. Importantly, we document a strong global component of risk shocks which is 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.

Our analysis takes a less US-centric perspective and 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. One novel feature of our analysis is that we consider multiple distinct kinds of news revealed by central banks. In particular, we consider both "traditional" events – corresponding to policy decision announcements – and additional communication events, associated with central bankers' speeches and releases of policy meetings minutes. For traditional events, we use the framework of Jarociński and Karadi (2020) to separate measures of policy shocks into "pure" MP shocks and central bank information shocks, which reveal central bank information about the economy. We complement these shocks with "communication" pure MP and information shocks that we create from data in Cieslak and Schrimpf (2019), who show that central banks release much relevant information on non-policy meetings days, which are missed if one focuses on traditional events.

Another novel feature is our consideration of international risk shock spillovers and the comparison of their effects to those of monetary policy-induced spillovers. For our risk variable, we use the (square of) option-implied volatility indices for the major stock indices in the three 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] The risk shocks are then orthogonalized with respect to a wide array of macroeconomic announcement shocks

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[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.

[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.

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)).

We first 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. We then compare the effects of the MP-induced shocks and the risk shocks – cleansed of the effects of monetary policy and macro announcement shocks - on asset prices across the three major economies, focusing on short-term interest rates as well as stocks. 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.

Our main results are as follows. First, in this multi-country, multi-shock framework, we find evidence of traditional monetary policy in the US affecting domestic risk, consistent with Bekaert, Hoerova, and Lo Duca (2013) who focus on a pre-2008 sample, although our evidence is statistically weak, suggesting a weakening relationship after the 2008-09 Great Recession. As for international spillovers, we document a strong global common component in risk shocks which is not driven by traditional US monetary policy. US traditional monetary policy does not affect risk in other countries. That is, we find no evidence of monetary policy spillover, through a risk channel, from the US to Japan and the euro area, lending support to Mr. Powell's conclusion. Interestingly, we document that communication shocks do generate significant spillovers to risk, operating both from the US to the euro area and vice versa. Euro area traditional monetary policy also affects US risk.

Second, while monetary policy shocks have their 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)).

Third, US and euro area monetary policy significantly affect domestic stock returns. Our results for the US are quantitively in line with the original results in Bernanke and Kuttner (2005), finding economically important effects on equity prices. Domestic communication shocks also matter for US stock prices.[3] Importantly, risk shocks that are

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[3] See also Swanson (2023) who argues that speeches and Congressional testimony by the Federal Reserve Chair have been more important than FOMC announcements for stocks and other asset prices.

orthogonal to monetary policy and communication affect stock prices significantly and their effects are of a larger economic magnitude than the effects of monetary policy and communication shocks. In terms of international spillovers, those are stronger from the euro area to the US than from the US to the euro area, for both pure monetary policy and information shocks. Euro area communication shocks also spill over to the US and Japanese stock prices. 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. In fact, a back of the envelope computation suggest that the US spillover effect to the euro area is entirely consistent with 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.

Our final set of results regards the relative economic importance of the various monetary policy-induced shocks. We conduct a variance decomposition of the explained variation in our regressions to quantify the relative importance of traditional versus communication monetary policy shocks and of "pure" monetary policy shocks versus information shocks. We find that pure monetary policy (information) shocks matter relatively more for interest rates (stock returns). In addition, we find that on average communication (traditional) monetary policy shocks account for 19% (81%) of the explained variation of interest rates but for 48% (52%) of the explained variation for stock returns. Our work therefore contributes to a growing literature examining the asset pricing effects of monetary policy "communication" (rather than the announcement of the the short term rate). This includes Cieslak and Schrimpf (2019), who examine the effects of communication events for 4 major central banks on the yield curve and stock returns, and Leombroni, Vedolin, Venter, and Whelan (2021), who document credit risk premium changes in response to communication shocks by the ECB both on and outside policy decision days.

One implication of the strong stock return but weak risk effects of pure monetary policy shocks we document for our post-2000 sample is that the monetary policy effects on asset prices may well reflect a persistent pure interest rate effect. This is consistent with Binsbergen (2020) who argues against an important role for equity risk premiums in stock returns over the last 20 years. An investigation of the longer-term effects of shocks is consistent with this conjecture. 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 (see Bekaert, Hoerova, and Xu (2023) for more details).

Our research relates to a voluminous empirical literature on international spillovers of monetary policy to financial asset prices.[4] In terms of recent research, Miranda-Agrippino and Rey (2020b), using monthly data, 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)[5] specifically focuses on the transmission of 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. Cieslak and Schrimpf (2019) also decompose news conveyed by four major central banks, distinguishing between monetary news, news about economic growth or news affecting financial risk premia. They provide evidence of their effects on the yield curve and stock returns but do not consider cross-country spillovers.

Another literature analyzes channels of international transmission of financial shocks and the role that US monetary policy plays in such transmission. Bruno and Shin (2015a,b) document that a contractionary shock to US monetary policy leads to a decrease in cross-border banking capital flows and a decline in the leverage of international banks. Such a

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[4] 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.

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

decrease in bank capital flows is associated with an appreciation of the US dollar. Cetorelli and Goldberg (2012) and Buch, Bussiere, Goldberg, and Hills (2019) focus on the bank lending channel, showing, inter alia, that global banks can partially insulate from monetary policy shocks through internal capital markets (see Morais, Peydró, Roldán-Peña, and Ruiz-Ortega (2019); Schmidt, Caccavaio, Carpinelli, and Marinelli (2018), for additional contributions). 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. However, Cerutti, Claessens, and Rose (2019), for example, show that common shocks (such as those emanating from a central country like the US) drive little of the variation in global capital flows. Jordà, Schularick, Taylor, and Ward (2019) document that the comovement in credit, house prices, and equity prices across 17 advanced economies has reached historical highs in the past three decades. They highlight the role of equity risk premia in driving the equity market synchronization. Relating to all these papers, we study spillovers across three major advanced economies and assess the relative importance of MP shocks and non-MP-driven risk shocks in driving asset prices.

The remainder of the paper is organized as follows. Section 2 describes the conceptual and empirical framework. Section 3 describes the construction of our monetary policy and risk shocks across the three economies and examines the domestic (within-country) and spillover (cross-country) effects of monetary policy shocks on risk. Section 4 distinguishes between the effects of monetary policy shocks and non-monetary policy-driven risk shocks on interest rates and stock returns. We also 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)), and explore longer-horizon effects. Section 5 concludes.

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.

2.1 Conceptual framework

2.1.1 Domestic policy effects

Following Cieslak and Schrimpf (2019) and Bekaert, Hoerova, 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.[6]

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 would be 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

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[6] See, e.g., Pflueger and Rinaldi (2020) for a model with stochastic risk aversion and monetary policy, estimated to match quarterly macroeconomic moments.

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 / economic areas. Because standard monetary policy seeks to affect short-term interest rates, a logical starting point is to consider interest rate spillovers from the perspective of standard trilemma theory.

The trilemma states that economies cannot simultaneously control monetary policy and the exchange rate while accommodating free capital flows (see, e.g., Obstfeld, Shambaugh, and Taylor (2005); Klein and Shambaugh (2015); 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 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), see Kearns, Schrimpf, and Xia (2020) for a survey. Such monetary policy effects operating through interest rates obviously may have repercussions for international asset prices.

However, recent literature argues that the classic trilemma may have morphed into a dilemma between financial openness and monetary policy autonomy. Rey (2015), Bruno and Shin (2015a,b), and Passari and Rey (2015) stress the critical role played by the US dollar and US monetary policy in setting global liquidity and credit conditions (see also Obstfeld (2015) for a discussion). They suggest that non-US central banks have lost their ability to influence domestic interest rates, even in the presence of flexible exchange rates, due to the existence of "US-driven" global financial cycles in liquidity and credit. The main policy spillover happens through a risk channel; in particular, Miranda-Agrippino and Rey (2020b) show how US monetary policy affects a common component in international risky asset prices.

Of course, 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.[8] In fact, CAPM intuition would

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

[8] Stock return comovements have increased substantially in recent times (see Bekaert and Mehl (2019);

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, we nonetheless use them to help interpret our empirical results.

2.2 Empirical framework and hypotheses

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 4. 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, there are several instances of asset price responses to important monetary policy announcements that mean reverted within the day. Investigating a one-day response therefore is an adequate compromise.

We first test the "risk" channel of monetary policy with the following regression:

$$\Delta RI_{j,t} = \alpha_j + \sum_{i=US,EA,JP} \boldsymbol{\beta_j^{MP,i} MP_t^i} + \sum_{i \neq j} \beta_j^{RI,i} \overline{ri}_t^i + \sum_{i=US,EA,JP} \boldsymbol{\delta_j^i Macro_t^i} + \boldsymbol{\gamma_j D_t} + \varepsilon_{j,t}, \tag{2}$$

where $\Delta RI_{j,t}$ represents changes in the risk variable for countries $j = US$, EA, JP over day t (see Section 3.3). $\boldsymbol{MP_t^i}$ 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). The $\overline{ri_t}$ variable represents "cleansed" risk shocks, that is: $\overline{ri_t^i} = \Delta RI_{i,t} - E[\Delta RI_{i,t} | \boldsymbol{z_t}]$, where the set of $\boldsymbol{z_t}$ instruments include monetary policy shocks, macro shocks, and their event day dummies. The expectation is evaluated by a linear projection. Thus, this procedure cleanses risk changes from any monetary policy influences, but it also removes the effects of the extensive set 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,[9] and labeled as "Non-MP, non-Macro Risk" in tables); for simplicity, we sometimes refer to it

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Christoffersen, Errunza, Jacobs, and Langlois (2012); Jordà, Schularick, Taylor, and Ward (2019)).

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

as a "cleansed" risk shock. $\boldsymbol{Macro_t^i}$ 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. Importantly, this inclusion of event dummies is econometrically critical. 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 "event" shocks. However, because our goal is to contrast the relative directional effects of monetary policy shocks with those of daily pure risk shocks, we use all of the data. Including the monetary policy and macro announcement day dummies ensures that the results we obtain using these daily regressions are very similar to "event-only" regressions; that is, the $\beta_j^{MP,i}$s effectively capture the directional effects of MP shocks on event days. It is conceivable that the mere release of information, irrespective of the sign or the magnitude of the shock, affects uncertainty as information is released to the markets. For example, Brusa, Savor, and Wilson (2020) claim that, following US monetary policy shocks, global stock market returns increase while uncertainty decreases worldwide but this does not happen on policy days for other countries. Analogously, Mueller, Tahbaz-Salehi, and Vedolin (2017) show that forreign currencies earn high returns on FOMC announcement days, as compensation for monetary policy uncertainty. Such effects are not our focus, but are controlled for in our analysis.

The main coefficients of interest are the $\beta_j^{MP,i}$s which measure the domestic and spillover effects of monetary policy shocks on RI: domestic effects through $\beta_j^{MP,j}$, and spillover effects through $\beta_j^{MP,i}$, $i \neq j$. The second set of coefficients of interest are the $\beta_j^{RI,i}$ coefficients, measuring risk spillovers across countries. All standard errors correct for heteroskedasticity.

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, 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.

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.

The remainder of the analysis focuses on the effect of monetary policy shocks, risk shocks and macro-economic announcements on interest rate changes and stock returns with the following regression set-up:

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

where $Y_{j,t}$ is either the change in interest rates or stock returns in country j. 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.

3 Monetary Policy, Macro, and Risk Shocks

In Section 3.1, we discuss the measurement of our monetary policy shocks, which are the key independent variables in Equation (2). Section 3.2 describes the data and the construction of macro shocks. Section 3.3 discusses the measurement of risk and risk shocks, and their economic interpretation. Given our focus on high-frequency data, we infer risk from stock market data. In Section 3.4, we estimate how monetary policy affects risk. Our analysis provides a direct test of the key components of a US monetary policy-induced global financial cycle: Does US monetary policy affect stock market risk in the three major economies / economic areas, US, EA and JP?

3.1 Monetary policy shocks

We investigate two types of monetary policy shocks. The first set are the *traditional* monetary policy shocks, corresponding to policy decision announcements, but we use recent advances to split these shocks into "pure" and information shocks. The second set are *communication* shocks, which we create from the event and high-frequency asset data compiled by Cieslak and Schrimpf (2019). Cieslak and Schrimpf (2019) recognize that the effect of monetary policy extends beyond the regularly scheduled policy meetings and also include press conferences, the release of the minutes of policy meetings and the release of other important reports (such as the inflation report in Japan). The latter events may also convey important information to asset markets and move asset prices.

Traditional Monetary Policy Shocks To decompose traditional announcement shocks into "pure" and information-driven components, we use 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. They document that a "pure" monetary policy tightening leads to a significant tightening of financial conditions (and a contraction in output). In contrast, the central bank "information" shock (with a positive shock signalling good news about the economy) leads to improving financial conditions and persistently higher short-term interest rates (as the central bank tightens its policy to counteract the impact on the macroeconomy).[10]

Note that interpreting this monetary policy "information" shock as revealing additional central bank information is subject to debate. Bauer and Swanson (2020), 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

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[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).

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 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 use Bank of Japan data to compute shocks with the Gürkaynak, Sack, and Swanson (2005) methodology. They measure monetary policy surprises, using changes in 3-month Euroyen futures and 10-year Japanese government bond (JGB) futures, around the Monetary Policy Meeting (MPM) 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. Clearly, we must be careful in the interpretation of these shocks relative to the US and euro area shocks.[11]

Communication Monetary Policy Shocks. As indicated before, Cieslak and Schrimpf (2019) identify a much wider set of dates on which important monetary policy information was released to the public. 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.

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 BoJ, 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

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[11] We also obtain a measure from Rogers, Scotti, and Wright (2014), who compute changes in 10-year Japanese government bond futures yields from 15 minutes before to 15 minutes after the announcements. It is, however, 85% correlated with the high frequency measure in Kubota and Shintani (2022) (before its decomposition).

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)).

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.[12] 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.

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.

Summary Statistics. We analyze monetary policy shocks for the overlapping sample for the three countries, January 2000 – December 2017. Table 1 provides summary statistics for these measures (all quoted in basis points). Panel A shows that, 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.

In Panel B, we focus on the communication shocks. For the US, we have about as

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[12] 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.

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. The large dispersion in variability across the different types of shocks prompts us to employ standardized monetary policy shocks in our empirical work below (where we employ the standard deviation over event days as reported in Table 1).

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.

In terms of coverage, we want to make sure to include all the major, impactful macro-announcements, and therefore cast a very wide net. For the US, we use a total of 18 announcements. Our coverage is wider or comparable to that of recent articles focusing on US macro-announcements, such as Boehm and Kroner (2020) and Elenev, Law, Song, and Yaron (2022). Kurov, Sancetta, Strasser, and Wolfe (2019) investigate 31 US macro announcements, which is the most comprehensive set we encountered. Importantly, we include all announcements that have a significant effect on either bond or stock returns in their study. These data include announcements regarding national income (e.g. GDP Annualized); employment (e.g. Initial Jobless claim); industrial activity (e.g. industrial production); investment (e.g. Durable Good Orders); consumption (e.g. Advance Retail Sales); the housing sector (e.g. Housing Starts); inflation (e.g. CPI); external accounts (e.g. Trade Balance); consumer confidence (e.g. Conference Board Consumer Confidence); and producer confidence (e.g. the ISM Manufacturing Index).

A full list is given in Appendix Table A1. We obtain 18 announcements for the US, 11 for the euro area, and 11 for Japan. Note that some announcements are on the same day so that the number of event dummies included in our regressions is lower than the number of announcements.

We assume that these shocks span new information about changes in g_t in Equation (1). Boehm and Kroner (2020), in fact, argue that US macro news is an important driver of global risk and global asset prices. Bekaert, Engstrom, and Xu (2022) show that their risk aversion index responds to certain types of macro news (e.g., industrial production, the unemployment rate) in a direction consistent with a habit model, with positive macro news decreasing risk aversion. However, they also find that variation in risk aversion is dominated by non-macro factors. In the present research, we simply control for, but do not analyze, the effect of macro news on risk and asset prices.

3.3 Risk and risk shocks

Our main measure of risk 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)) and is often viewed as a "fear index" (Whaley (2000)). 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 implied volatility indices for the euro area and Japan are constructed using the same methodology.

The main advantage of using an option-implied volatility index to measure risk is that the 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 measures.[13]

To create risk shocks (or $\overline{ri}_t^i$ in Equations (2) and (3)), we project daily changes (first differences) in country risk measures onto domestic and foreign monetary policy, macroeconomic shocks and all their event dummies. As mentioned before, the residual term is the "non-MP, non-macro risk" shock (or sometimes referred to as the cleansed risk shock in the paper), representing risk shocks cleansed from the effects of monetary policy shocks and macro announcements.

Our interpretation of the risk shocks as not driven by monetary policy is strengthened by our use of a comprehensive set of monetary policy shocks, including communication

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[13] 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.

shocks. We can therefore be pretty confident that the variation in these shocks is not dominated by monetary policy news. 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 the formal announcements. Bekaert, Engstrom, and Xu (2022) create a risk aversion index, which is quite highly correlated with the VIX, at 0.87, and show that it is 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, greed) using weekly surveys. In addition, in a case study on the Covid crisis, they show that the risk aversion measure reacts more strongly to changes in the volume of Covid cases, than to an economic news sentiment measure (see Buckman, Shapiro, Sudhof, and Wilson (2020)). 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.

3.4 Monetary policy and risk

With all shock measures in hand, we now show the estimation results of Equation (2) in Table 2. Note that all coefficients are transformed in economic units. 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. In standardizing the coefficients, we used the sample standard deviation for risk shocks, but used the standard deviation of MP shocks across event days. From the perspective of the full sample, monetary policy events only happen on a limited number of days, despite the fact that we cast a wider net in terms of monetary policy events than most other studies.

Section 3.4.1 focuses on the domestic effects; and Section 3.4.2 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 travelling across time zones.

3.4.1 Monetary policy and domestic risk

The dependent variables are daily changes in our risk measures in the three countries. 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 summarize information from all three country regressions by organizing results according to the economic nature of the coefficients (policy or risk aversion effects emanating from the US, the euro area, and Japan). For example, columns (1), (6) and (8) of Table 2 come from one regression with the left-hand-side variable being the first-differenced US risk (RI) and the right-hand-side variables including the 3-month pure MP shocks, CB information shocks, macro shocks, and all MP and macro event dummies from the US, EA, and Japan as well as non-MP-driven foreign RI shocks.

We start by discussing the domestic monetary policy effects, which are collected on the left of Table 2. Note that 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 are overall positive for traditional MP shocks, 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.

For the *communication* shocks, which are reported on the third and fourth lines, we observe two statistically significant effects. The traditional shocks generate a small positive effect in the US, and a much larger one in the euro area, but only the Euro area effect is statistically significant at the 5% level. For "information" communication shocks, the roles are reversed with a one standard deviation US communication shock generating an almost 0.4 standard deviations drop in risk, with the effect significant at the 5% level. There are no significant risk effects for Japanese communication shocks.

Overall, we conclude that traditional monetary policy has surprisingly weak effects on risk, from the high-frequency perspective we focus on. This appears inconsistent with the assumptions underlying the work in Miranda-Agrippino and Rey (2020b). It is also inconsistent, at first glance, with 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 GFC ushered in an era of unconventional monetary policy. Bekaert, Hoerova, and Xu (2023) document how the risk channel of monetary policy, as measured through high-frequency regressions, has waned over time in terms of statistical significance and economic magnitude. 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 GFC and its aftermath. In contrast, the risk effects of both information and communication shocks are mostly stronger than those of the "pure" monetary policy shocks.

3.4.2 Monetary policy and international risk spillovers

The right-hand side part of Table 2 reports the "international spillover" part of the three risk regressions. The first 4 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 pure risk shocks. Again, 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, the first important result is the total lack of significant effects emanating from US monetary policy on risk in other countries (see columns (4) and (5)). 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 the expected positive, respectively, negative effects, which are statistically significant at respectively, 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.

The next two lines focus on communication shocks. We find statistical significance in perhaps unexpected places. 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 they are also economically larger (representing a 0.27 to 0.37 standard deviations decrease in international stock market risk given a 1 SD US communication information shock). For the euro area, communication MP shocks significantly spill over to both the US and Japan, and the effects are statistically significant at the 5% level and economically large (representing, respectively, a 0.89 and 0.37 standard deviations effect).

The final line 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).

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 A6. The one consistent pattern that emerges from this analysis is that the pure monetary policy shocks (through both traditional and communication events) often partially or fully reverse after one month. This is consistent with rapidly mean-reverting risk premiums (see also Section 4.5). One exception is the risk effect in the US to a pure US monetary policy shock which becomes stronger with horizon, but the coefficients are invariably 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 Monetary Policy, Risk, and Asset Prices

In this section, we examine monetary policy and risk spillovers to short-term interest rates (Section 4.1), and stocks (Section 4.2). Section 4.3 characteristics 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 4.4, and consider dynamic effects in Section 4.5.

4.1 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;[14] for Japan, we use 10-year government bond yields as short-term interest rates barely moved throughout the sample period. 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, 3.44 bps for EA, and 2.63 bps for JP. Further summary statistics are provided in Appendix Table A2.

The regression now includes both domestic and foreign risk shocks, as described in Equation (3). As before, the columns present the key coefficients (domestic and spillover effects on interest rates) in the three country-specific regressions, expressed in standard deviations.

The first goal of this table is to verify that monetary policy does indeed pass through to interest rates as expected. The traditional, "pure" monetary policy effects are on the left-hand side of the table on the first line. All these coefficients are 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 passthrough 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 increase in US Treasury rates, or a 34% pass-through. The pass-through is 22% in the euro area, and 83% in Japan.

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 are, they are a bit smaller in economic magnitude than the effect of the pure shocks. Recall that we do not have information shocks for Japan, but that the second line represents the forward guidance shocks (as defined by Gürkaynak, Sack, and Swanson (2005)). These shocks do not have a significant effect on 10-year government bond yields; in fact, the effect is slightly negative.

The interest rate effects of the communication shocks are surprising. Recall that a

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[14] 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").

pure shock here represents an event that raises short term interest rates in the short period around the event, and lowers stock prices. These interest rate effects revert within the day on average and even become significantly negative for the US. The information shocks do not generate statistically significant effects.

We do not see any strong spillover effects, neither for the pure shocks, nor for the information shocks. Only one coefficient is statistically significantly different from zero: there is a 0.08 standard deviation effect from euro area pure shocks to Japanese interest rates, which is significant at the 5% level, but has a negative sign.

In general, our results suggest weak interest rate spillovers across countries, 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.[15] 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.

In terms of communication shocks spillovers, Japanese pure communication shocks spill over to both US and euro area interest rates, with the effect on US interest rates particularly large. The only other significant effect is US communication CBI shocks, spilling over to Japan (a negative 0.16 SD effect).

Finally, we examine the interest rate effects of changes in risk. We find overwhelmingly negative coefficients for risk shocks, which is consistent with precautionary savings effects. The only significant effects are risk shocks having negative domestic interest rate effects in the US and Japan.

4.2 Monetary policy, risk, and stock returns

In terms of data, 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 weights. The results from estimating Equation (3) for stock returns are reported in Table 4.

We commence with discussing the domestic effects, reported on the left-hand side of the table. First, 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

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[15] Kearns, Schrimpf, and Xia (2020) do claim that there are significant spillovers to long-term interest rates through a term premium channel, as does Dilts Stedman (2019) but only through unconventional monetary policy.

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). There are no significant effects generated by traditional Japanese monetary policy shocks.

The communication shock effects are strong in the US, with a one standard deviation pure shock causing a 0.21 standard deviations drop in the stock market, and a communication information shock causing a 0.35 standard deviations uptick in the market. In the euro area, the "pure" communication shock has a particularly large effect (-0.72 SDs) which is significant at the 1% level; whereas the information effect is surprisingly negative (but only significant at the 10% level). Another puzzling result at first glance is with Japanese stock returns being significantly positive after a positive pure communication shock. However, recall that the Japanese interest rate actually falls on average during communication shock days (reversing the high-frequency response), so that this effect is expected.

In general, more persistent discount rate effects – whether induced by a change in the real interest rate or a change in the risk premium – should generate larger immediate price effects when viewed as permanent. While Bernanke and Kuttner (2005) argue the effect of MP shocks on stock returns is mostly a risk premium effect, this channel does not square well with the weak evidence for a risk channel for monetary policy in our post-2000 sample (see Table 2). Instead, it is conceivable that the "real interest rate effects" of monetary policy are viewed as more persistent than its risk effects, so that monetary policy drives asset prices more through a "direct interest rate" channel. Binsbergen (2020) also argues for strong pure interest rate effects on stock market returns over the last 20 years. We return to this possibility below.

Moving to the right panel of the table, we also observe large international spillover effects, but mostly between the US and the euro area. 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. This effect is not at all surprising. The beta of the euro area with respect to world equity returns is 1.02 (measured over a 1970-2019 sample). Thus, with the US market being 40-45% of world market capitalization, a "direct" CAPM prediction would be a 40% move or more for a foreign market with a beta of about 1. Of course, these effects are on non-standardized returns, whereas we report standardized effects. Because the volatility of the US stock market is about 82.7% of the volatility of the euro market during our sample period, the predicted "CAPM effect" relative to the original domestic effect is $0.82 * 0.4 \approx 0.33$. That is, the results are consistent with the CAPM.[16]

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 both the pure MP and information shocks affecting US stock market returns in the expected direction. The effects are economically large, with the pure 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. Because the euro area represents a relatively small fraction of the world equity market, the latter 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 risk prices. Note that there is no significant spillover from either the US or the euro area to Japanese stock markets or vice versa.

The large effect of the euro area MP shocks on global asset prices extends to communication shocks, with pure shocks leading to 0.80, respectively 0.48 standard deviation drops in US, respectively Japanese stock prices. A positive US MP communication shock is associated with increases in euro area stocks, but recall that interest rates in the US on average drop during the day for such events. Similarly, a positive US information communication shock is associated with a decrease in Japanese stock prices.

The last line of Table 4 reports the effects of the risk shocks. Risk shocks have negative effects on stock markets, no matter what area they originate from, with only a few exceptions. The domestic effects dominate the international spillover effects, which are economically tiny. The direct effects of risk shocks on the stock market are large, ranging from 0.52 to 0.70 standard deviations. These effects are larger than what we observe for MP shocks. In contrast, the international spillover effects are not always statistically significant and sometimes have a surprising positive sign (e.g. risk shocks from Japan to the US and the euro area). However, these spillover effects are only about one tenth of the economic magnitude of the domestic effects.[17] The relatively weak spillover effects are not surprising because of the strong direct risk spillover effects documented in Table 2. Thus, part of the domestic effects shown here likely reflect a global component in risk. These results confirm that risk shocks generate the expected effects, but do not operate through a monetary policy channel.

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[16] The CAPM effect is relatively weak, consistent with weak but positive direct spillover effects from US monetary policy to interest rates and risk in the euro area.

[17] 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.

4.3 The economic importance of shocks

Our results so far challenge the idea that US monetary policy is a key driver of global asset prices along multiple dimensions. During our sample period since 2000, we find little to no evidence of strong international effects of traditional US monetary policy on risk variables, but do find such effects emanating from the euro area or from communication MP shocks. In addition, we continue to find strong evidence of international MP effects on stock returns, which is consistent with the literature, but these effects are again stronger from the euro area to the US than vice versa. Risk shocks, in comparison, act in the expected way, decreasing stock returns, and their effects are economically large, and larger than those of MP shocks.

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. 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.[18]

The results are in Figure 1, 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.

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

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[18] Importantly, this exercise uses the overall sample standard deviation of the event variables, whereas in our standardized regression results, we standardize event variables by their event standard deviation.

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."

Figure 2 further decomposes the *total* MP effects on asset prices into its several components: the four directional effects (from the four MP shocks) and the event day effects. That is, in our regression framework, traditional MP events affect asset prices through pure MP shocks, information shocks, and their event dummy; and the same applies to communication events. The left hand side of Figure 2 shows the variance decomposition of the explanatory power by monetary policy for interest rates (Panel (a)) and stock returns (Panel (b)) into these six effects, with the bars adding up to 100%. The figures here use all MP effects, aggregating domestic and spillover effects. All plots average the effects over the three countries (traditional Japanese path shocks are classified as information shocks). On the right-hand side, the figures split up the variance contributions of traditional versus communication shocks into domestic and spillover effects; with the event day effects also repeated for completeness. Note that the pure non-directional announcement effects, while studied in a number of recent articles (see e.g. Brusa, Savor, and Wilson (2020)), almost invariably represent the smallest fraction of the total explanatory power of monetary policy shocks. They do matter in a non-negligible manner for interest rates on monetary policy decision days (traditional MP events), where they represent 11.9% of the explanatory power. The risk shift identified on monetary policy days by Kroencke, Schmeling, and Schrimpf (2021), is also not consistently related to the sign of monetary policy shocks.

Focusing first on the left-hand side plots of Figure 2, the two figures confirm what is illustrated in Figure 1: traditional monetary policy shocks dominate communication shocks for interest rates, but their explanatory power is more even for stock returns. However, the relative importance in terms of "pure" versus information effects is different across the traditional or communication shocks. For communication shocks, the pure monetary policy shocks (shocks associated with a negative stock return and interest rate increase) dominate, but for traditional shocks, this is only true for interest rates but for stock returns, information shocks actually dominate. In general, on traditional monetary policy decision days, information effects are highly important, representing 27% of the total explanatory power for interest rates and 32% for stock returns.

The split up into domestic versus spillover effects on the right-hand side plots of Figure 2 confirm that interest rate spillover effects are negligible relative to domestic effects; that is, the effect of traditional MP shocks on international interest rates is quite small, explaining 6.3% of total explanatory power by monetary policy. However, the spillover effects of communication shocks (where the policy instrument is not actually changed) exhibit higher explanatory power than those of traditional shocks (on monetary policy decision days). These effects mostly come from pure not information shocks.

For stock returns, domestic effects of traditional shocks also have higher explanatory power than spillover effects, but the difference is much smaller than for interest rates, and spillover effects already account for about 21% of the total explanatory power. Recall from Table 4 that there are particularly strong effects associated with spillover effects from the euro area. For communication effects, both domestic and spillover communication effects account for about 23% of total explained variation, again demonstrating the importance of these new shocks for asset prices.

4.4 Additional 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 3.3).

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.[19] Both build on the seminal work of Gürkaynak, Sack, and Swanson (2005) (GSS, henceforth) but also construct quantitative easing shocks associated with asset purchases by central banks. GSS argue that in addition to changing the Federal funds rate, monetary policy also reveals important information about the future path of interest rates, which may have important effects on asset prices and the economy.

Our alternative monetary policy shock measure for the US relies on high-frequency data to separately identify surprise changes in the federal funds rate, forward guidance and large-scale asset purchases. Swanson (2021) assumes that forward guidance shocks

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[19] 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 investiating the effects of unconventional monetary policy, see e.g. Neely (2015), Wright (2012), D'Amico and King (2013), and Kuttner (2018).

have no effect on the current federal funds rate. To identify the asset purchase factor, he assumes that this factor should be as 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 A4 (for risk) and A5 (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.

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.

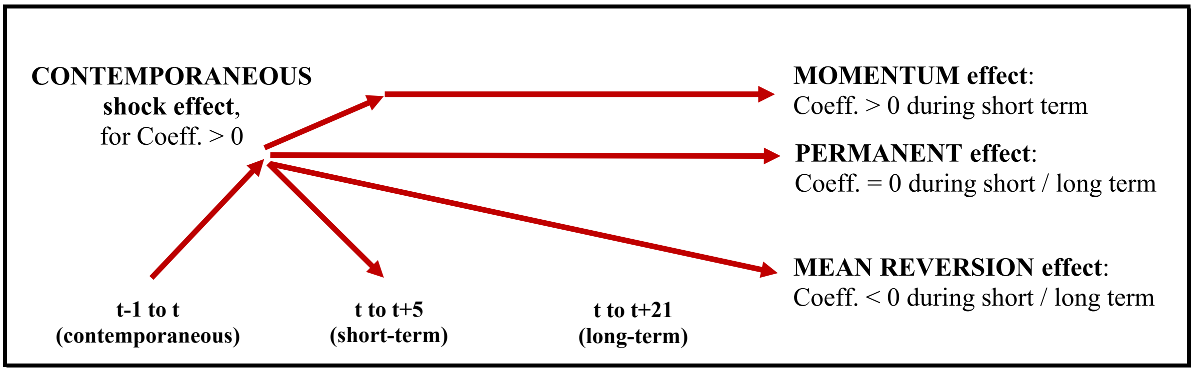
For stock returns, we confirm that the strongest and most significant monetary policy spillover effects emanate from the euro area, not from the US. For the US, there is one statistically significant spillover effect: a positive asset purchase shock (recall that is this coded to be a contractionary shock) 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.

4.5 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 3 and 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 A7 and A8. 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. This suggests 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. Japan, which featured an insignificant stock return effect, is special in that the "pure" monetary policy effect more than reverses and becomes statistically significantly positive at the one-month horizon. Recall that we cannot split Japanese monetary policy shocks into pure and information shocks, but our pure shocks are simply target shocks (as opposed to "path" shocks). It may well be that such shocks mix information and "pure" monetary policy shocks. The spillover effects are either insignificant or similar (but mostly weaker) than the domestic 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.

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.

Fourth, the effects of communication pure MP shocks, from both the Fed and the ECB (both domestic and spillover), on stock returns exhibit significant dynamic effects that are more consistent with the "risk channel" interpretation, with the cumulative return effects reversing the {t-1,t} effect at month end. In contrast, for traditional pure MP shocks, the coefficients for {t,t+h} for $h \geq 1$ remain mostly negative and are often insignificant. Communication information shocks mostly exhibit some momentum, at longer horizons.

Next, as a concrete demonstration, Figure 3 shows the economic magnitude of the dynamic domestic and spillover effects of various euro area MP shocks on stock returns. The euro area (EA) case is of particular interest because various EA shocks show surprisingly strong spillover effects. The graphs on the left plot the dynamic responses to pure monetary policy shocks, the top panel showing the effects of traditional, the bottom panel showing the effects of communication shocks. The domestic (spillover) effects are shaded dark blue (light blue). Clearly, the cumulative responses to traditional shocks after the initial negative effect are all over the place and ultimately do not mean revert at all within the month. In contrast, the communication shocks generate stronger contemporaneous effects but the effects partially mean revert within the month. These results are therefore consistent with either a rapidly mean-reverting risk premium effect, or with the original effect representing temporary price pressure that is reversed quickly.

The plots on the right present analogous dynamic responses for information shocks. There, we see that for traditional shocks, the cumulative responses show some momentum that peters out at the monthly horizon, but there is clearly no mean reversion, consistent with the contemporaneous positive response representing a permanent effect. For communication information shocks, the responses have the wrong sign and both the contemporaneous and dynamic responses are economically small (and statistically insignificant).

5 Conclusion

This paper studies the effects of monetary policy and risk shocks on risk and asset prices in a global world. Importantly, we cast a wide net in terms of monetary policy shocks also adding "communication" shocks as defined by Cieslak and Schrimpf (2019). Our main results for the effects of monetary policy are as follows.

First, in contrast to the extant literature focusing on a longer and low-frequency sample (Miranda-Agrippino and Rey (2020b)), we do not find evidence of the US "hegemon" affecting risk across large advanced economies, since the turn of the century, through traditional monetary policy shocks. Instead, we find evidence of monetary spillovers to risk in unexpected places: Euro monetary policy shocks affecting risk in the US, and communication shocks in both the US and euro area spilling over to risk in other countries.

Second, despite strong and persistent domestic interest rate effects, we do not find significant spillovers through a direct interest rate channel. Our first two empirical findings suggest that the trilemma is alive and well.

Third, 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, and also through communication shocks. Internationally, the economic magnitude of US spillover effects are what would be expected given the importance of the US stock market in global equity markets. By contrast, spillover effects from the 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. Similarly, there are relatively stronger and significant spillover effects from the euro area "pure" communication shocks, compared to those generated by US communication shocks.

Fourth, our decomposition of traditional monetary policy shocks into pure and information shocks and the addition of communication shocks is important. The latter account for 20% of the explanatory power of monetary policy shocks for interest rates, and for almost 50% of their explanatory power for stock returns. For traditional shocks, information shocks are very important contributors to the explanatory power of monetary policy shocks to asset prices, representing 39.2% (64.1%) of the total explanatory power of traditional directional shocks for interest rates (stock returns). However, for communication shocks this fraction only amounts to respectively 19.3%, respectively 18.8%.

We also consider the effects of non-monetary policy-driven risk shocks, which are highly correlated across countries. 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, support the interpretation of the monetary policy shocks affecting equity prices through persistent interest rate effects.

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 (end of sample for Cieslak and Schrimpf (2019)); Panel A considers traditional shocks, Panel B communication shocks, and Panel C 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. **Communication MP shocks:** 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). **Risk shocks:** To obtain a country's risk shock, we run three country-level regressions as in Equation (2), 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 A3. Traditional and communication monetary policy shocks are measured in basis points; risk shocks are in monthly percentages squared.

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. Communication MP shocks, constructed from minutes/speech dates					
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
Panel C. 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 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):

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

where $\boldsymbol{D_t}$ is a vector of traditional and communication monetary policy event date dummies and macroeconomic announcement event date dummies for US, EA and JP; therefore, including $\boldsymbol{D_t}$ takes out all the announcement effects, econometrically. Next, $\boldsymbol{MP_t^i}(4 \times 1) = \left[TraditionalMP_t^i \quad TraditionalCBI_t^i \quad CommunicationMP_t^i \quad CommunicationCBI_t^i\right]'$ is a vector of monetary policy shocks for country i on day t (i.e., 0 if there is no event), and therefore $\boldsymbol{\beta_j^{MP,i}}$ contains 36 (3 countries affecting 3 countries, 4 MP shocks; 12 domestic effects as shown in the left part of the table below, 24 foreign effects as shown in the right part of the table below) coefficients. Note that, given the event dummies, $\boldsymbol{\beta_j^{MP,i}}$ measure directional effects on the event day, which is econometrically equivalent to projecting asset price changes on shocks on event dates. $\overline{ri}_t^i$ denotes a country's VIX-squared residual after projecting it on $\boldsymbol{D_t}, \boldsymbol{MP_t^i}, \boldsymbol{Macro_t^i}$; therefore, there is a foreign effect of $\overline{ri}_t^{EA}$ on $\Delta RI_{US,t}$, but not a domestic effect. The regressions that generate $\overline{ri}_t^i$ are presented in the Appendix Table A3. $\boldsymbol{Macro_t^i}$ is a vector of macroeconomic announcement shocks for country i at time t (i.e., 0 if there is no event); we consider a total of 40 macro announcements for US (18), EA (11), JP (11); see details summarized in Appendix Table A1. 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**
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 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 Table 2 or Section 3. Columns (1), (6) and (8) come from the same US regression with LHS being US ΔIR; columns (2), (4) and (9), LHS=EA ΔIR; columns (3), (5) and (7), LHS=JP ΔIR. 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	**0.433*** **	**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

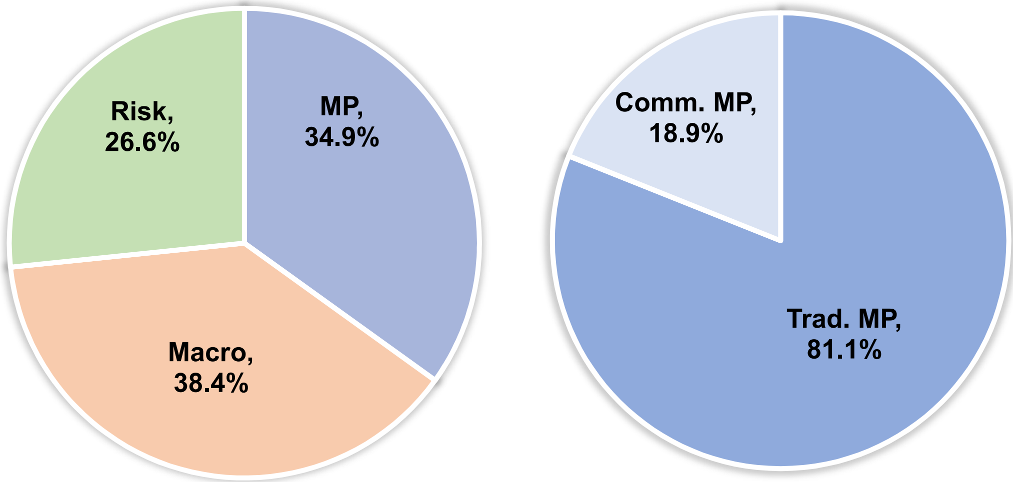
Table 4: Monetary policy and stock returns.

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). The columns in this table come from three regression results, with $j \in \{US, EA, JP\}$, (see Section 3):

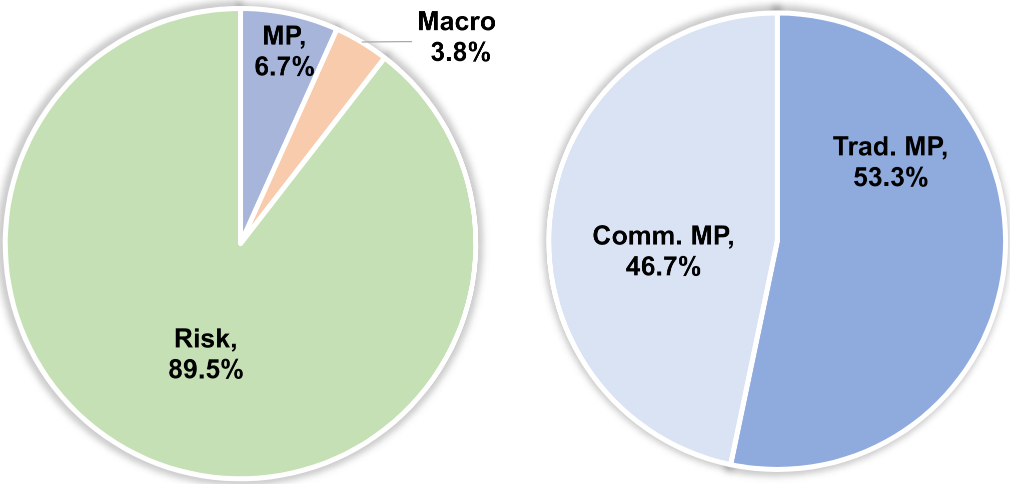
$$SR_{j,t} = \alpha_j + \boldsymbol{\gamma_j D_t} + \sum_{i=US,EA,JP} \boldsymbol{\beta_j^{MP,i} MP_t^i} + \sum_{i=US,EA,JP} \beta_j^{RI,i}\overline{ri}_t^i + \sum_{i=US,EA,JP} \boldsymbol{\delta_j^i Macro_t^i} + \varepsilon_{j,t}.$$

Variable details in this equation are explained in Table 2 or Section 3. Columns (1), (6) and (8) come from the same US regression with LHS being US SR; columns (2), (4) and (9), LHS=EA SR; columns (3), (5) and (7), LHS=JP SR. 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	**-0.418*** **	**-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***

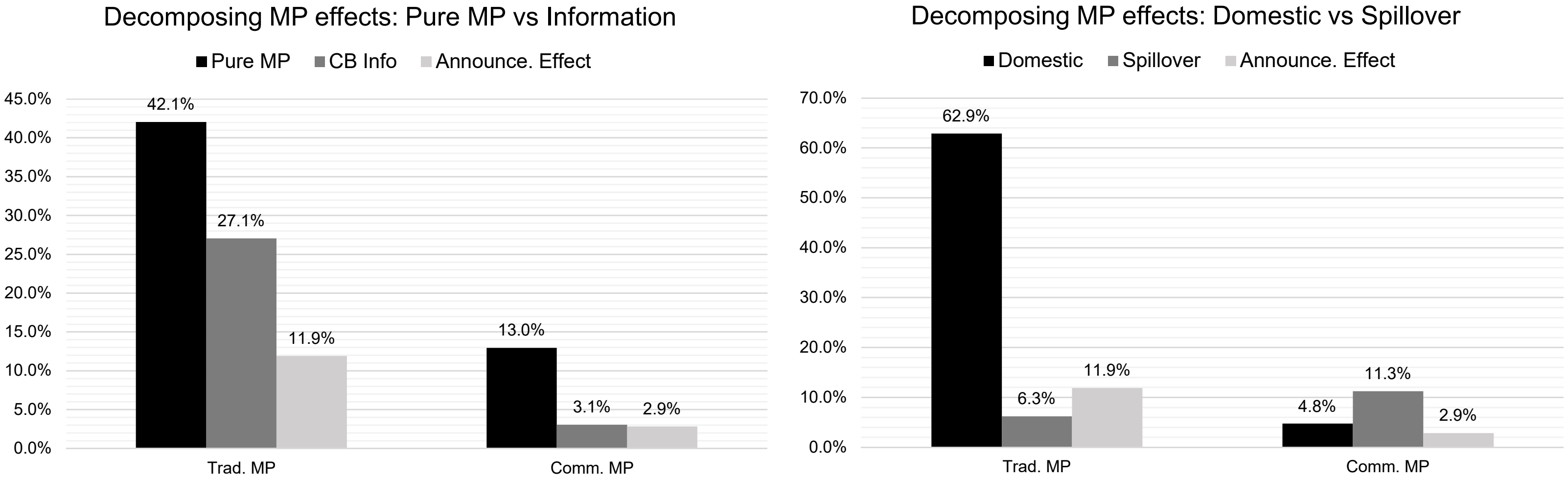


(a) Interest Rate Effects

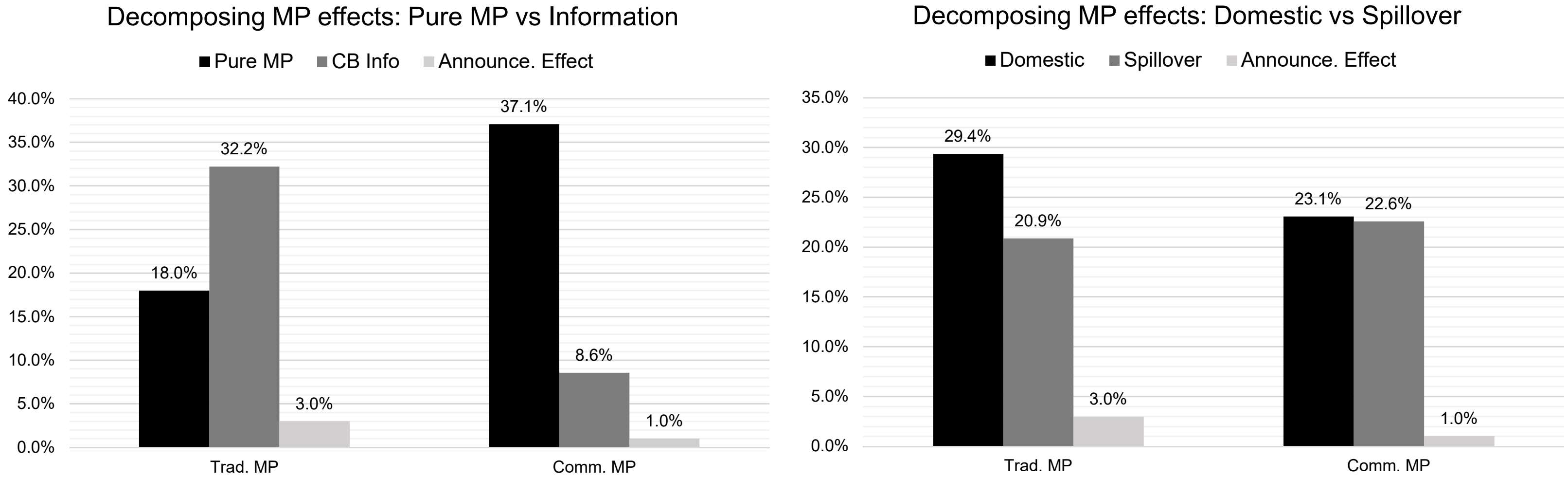


(b) Stock Return Effects

Figure 1: 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.



(a) Interest Rate Effects



(b) Stock Return Effects

Figure 2: Decomposing the total Monetary Policy Effects: Pure MP vs. Central Bank Information (left), and Domestic vs. Spillover (right). Note: The six bars in each figure add up to 100%. Monetary policy effects in our regressions come from the shocks (directional effects) and the event day dummies (announcement effects); for instance, traditional (communication) MP events affect asset prices through pure MP shocks, information shocks, and their event dummy.

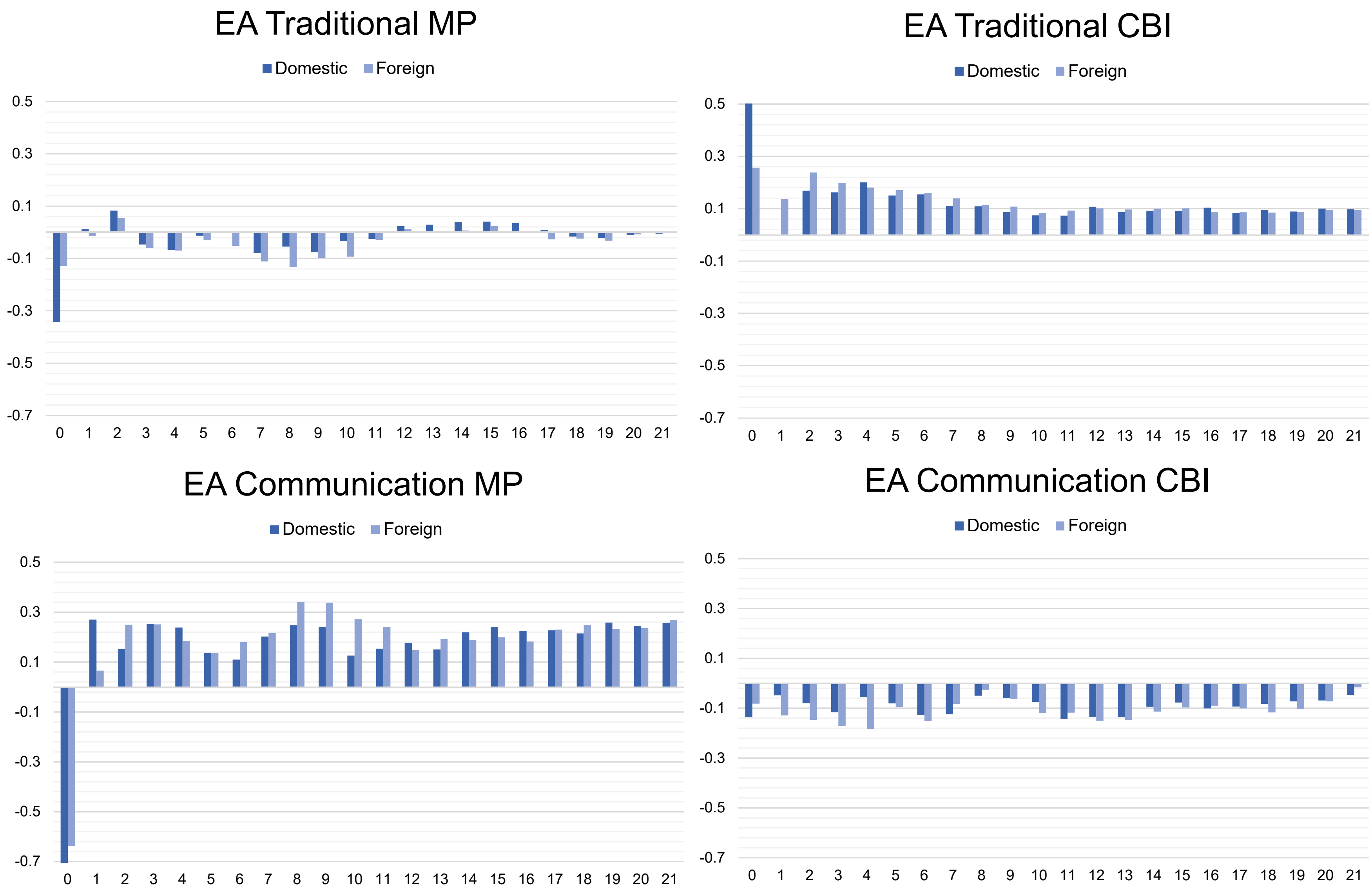


Figure 3: Economic magnitude of dynamic effects of euro area MP shocks on stock returns. In the x-axis, "0" denotes the contemporaneous effect (price changes from t-1 to t), as shown in main regression tables; starting from "1", we obtain cumulative returns from t to a certain day after that (i.e., 1=t∼t+1, 2=t∼t+2 and so on) and calculate the economic magnitude of this predictive effect (in unit of SD). The y-axis has the unit of SD.

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: 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 2, 3 and 4 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 2 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 A4: 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 2 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 A5: Alternative monetary policy shocks: Monetary policy and asset prices.

This table complements Table A5 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 2 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 A6: 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 A7: 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 A8: 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** **

B 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.

B.1 Fundamental and preferences

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

$$\Delta c_{t+1} = \mu_c + g_t + \sqrt{UC_t}\varepsilon_{c,t+1}, \tag{B1}$$

$$UC_{t+1} = \mu_{UC} + \rho_{UC} UC_t + \sigma_{UC}\sqrt{UC_t}\varepsilon_{UC,t+1}, \tag{B2}$$

$$g_{t+1} = \rho_g g_t + \sigma_{gc} \underbrace{\sqrt{UC_t}\varepsilon_{c,t+1}}_{\Delta c_{t+1} - E_t[\Delta c_{t+1}]} + \sigma_{gg}\sqrt{UC_t}\varepsilon_{g,t+1}. \tag{B3}$$

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:

$$RA_{t+1} = \mu_{RI} + \rho_{RI} RI_t + \sigma_{RAc}\sqrt{UC_t}\varepsilon_{c,t+1} + \sigma_{RI}\sqrt{RI_t}\varepsilon_{RA,t+1}. \tag{B4}$$

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

$$\Delta d_{t+1} = \mu_d + \rho_{dg} g_t + \sigma_{dc}\sqrt{UC_t}\varepsilon_{c,t+1} + \sigma_d \varepsilon_{d,t+1}. \tag{B5}$$

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,

$$\begin{aligned} m^*_{t+1} &= log\beta - \gamma \Delta c_{t+1} + \gamma(q_{t+1} - q_t) \\ &= log\beta - \gamma(\mu_c + g_t - \mu_{RI} + (1-\rho_{RI})RI_t) - \gamma(1-\sigma_{RI})\sqrt{UC_t}\varepsilon_{c,t+1} + \gamma\sigma_{RI}\sqrt{RI_t}\varepsilon_{RA,t+1}. \end{aligned} \tag{B6}$$

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

B.2 Asset price: Real interest rate

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

$$\begin{aligned} rf_t^* &= -logE_t^*\left[\exp\left(m_{t+1}\right)\right], \\ &= k_0 + k_g g_t + k_{RI} RI_t + k_{UC} UC_t, \end{aligned} \tag{B7}$$

where

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

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 (B2), (B3), and (B4), 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:

$$rf_t = rf_t^* + \phi_{MP} MP_t. \tag{B8}$$

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.

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

B.3.1 Two-period zero-coupon bond price

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

$$P_{1,t} = E_t\left[\exp\left(m_{t+1}\right)\right] = \exp\left(A_1 + B_1 g_t + C_1 RI_t + D_1 UC_t - \phi_{MP} MP_t\right), \tag{B9}$$

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,

$$\begin{aligned}
P_{2,t} &= E_t\left[M_{t+1}P_{1,t+1}\right] \\
&= E_t\left[\exp\left(m_{t+1} + \underbrace{A_1 + B_1 g_{t+1} + C_1 RA_{t+1} + D_1 UC_{t+1} - \phi_{MP} MP_{t+1}}_{\Delta_{t+1}\equiv -rf_{t+1}}\right)\right]. \qquad \text{(B10)}
\end{aligned}$$

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 (B10) can be solved as follows:

$$\begin{aligned}
P_{2,t} &= \exp\left\{\begin{array}{l} E_t(m_{t+1}) + \frac{1}{2}V_t(m_{t+1}) \\ +E_t(\Delta_{t+1}) + \frac{1}{2}V_t(\Delta_{t+1}) \\ +Cov_t(m_{t+1},\Delta_{t+1}) \end{array}\right\} \\
&= \exp\left[A_2 + B_2 g_t + C_2 RA_t + D_2 UC_t - \phi_{MP}MP_t\right]. \qquad \text{(B11)}
\end{aligned}$$

B.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:

$$\begin{aligned}
y_{2,t} &= -\frac{1}{2}\left\{\begin{array}{ll} E_t(m_{t+1}) + \frac{1}{2}V_t(m_{t+1}) & [= -rf_t^* - \phi_{MP}MP_t] \\ +E_t(\Delta_{t+1}) & [1.\ \text{Expectations Hypothesis terms}] \\ +\frac{1}{2}V_t(\Delta_{t+1}) & [2.\ \text{Jensen's inequality term}] \\ +\ Cov_t(m_{t+1},\Delta_{t+1}) & [3.\ \text{Bond term premium channel}] \end{array}\right\}. \\
&= \frac{1}{2}(rf_t^* + \phi_{MP}MP_t) + \frac{1}{2}E_t(rf_{t+1}) - \frac{1}{4}V_t(rf_{t+1}) + \frac{1}{2}Cov_t(m_{t+1}, rf_{t+1}), \qquad \text{(B12)}
\end{aligned}$$

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

$$tp_t = \underbrace{(-m_{2,c}\Delta_{2,c})}_{\eta_{UC}}UC_t + \underbrace{(-m_{2,RA}\Delta_{2,RA})}_{\eta_{RI}}RI_t, \qquad \text{(B13)}$$

which was shown in Section 2.

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

By induction, it can be easily shown that

$$P_{N,t} = \exp\left[A_N + B_N g_t + C_N RA_t + D_N UC_t - \phi_{MP} MP_t\right], \tag{B14}$$

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 (B14) 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.

B.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:

$$r_t^b = \xi_0^b + \boldsymbol{\xi_1^b Y_{t-1}} + \boldsymbol{\xi_2^b}\begin{bmatrix} g_t - E_{t-1}(g_t) \\ RA_t - E_{t-1}(RA_t) \\ UC_t - E_{t-1}(UC_t) \\ MP_t \end{bmatrix}, \tag{B15}$$

where ξ_0^b, $\boldsymbol{\xi_1^b}$, and $\boldsymbol{\xi_2^b}$ are implicitly defined. This equation motivates the four shocks that the paper uses.

B.4 Asset prices: Stock price

B.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,

$$PD_t \;=\; \sum_{n=1}^{\infty} E_t\left[\exp\left(\sum_{j=1}^{n} m_{t+j} + \Delta d_{t+j}\right)\right]. \tag{B16}$$

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

$$F_{n,t} = E_t\left[\exp\left(\sum_{j=1}^{n} m_{t+j} + \Delta d_{t+j}\right)\right], \tag{B17}$$

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:

$$\begin{aligned}
F_{1,t} &= E_t\left[\exp\left(m_{t+1} + \Delta d_{t+1}\right)\right]\\
&= \exp\left\{\begin{array}{ll}
E_t(m_{t+1}) + \frac{1}{2}V_t(m_{t+1}) & \text{[1. Interest rate channel, } = -rf_t^* - \phi_{MP}MP_t\text{]}\\
+E_t(\Delta d_{t+1}) + \frac{1}{2}V_t(\Delta d_{t+1}) & \text{[2. Cash flow channel]}\\
+Cov_t(m_{t+1}, \Delta d_{t+1}) & \text{[3. premium channel (from pure cash flow)]}
\end{array}\right\}\\
&= \exp\left(e_{1,0} + \boldsymbol{e_{1,1}}\begin{bmatrix}g_t & RI_t & UC_t\end{bmatrix}' - \phi_{MP}MP_t\right) \qquad \text{(B18)}
\end{aligned}$$

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

By induction,

$$\begin{aligned}
F_{N,t} &= E_t\left[\exp\left(m_{t+1}\right)\underbrace{E_{t+1}\left(\exp\left(\sum_{j=1}^{N-1} m_{t+j+1} - \pi_{t+j+1} + \Delta d_{t+j+1}\right)\right)}_{F_{N-1,t+1}}\right]\\
&= \exp\left\{\begin{array}{ll}
E_t(m_{t+1}) + \frac{1}{2}V_t(m_{t+1}) & \text{[1. Interest rate channel, } = -rf_t^* - \phi_{MP}MP_t\\
+E_t(f_{N-1,t+1}) + \frac{1}{2}V_t(f_{N-1,t+1}) & \\
+(m_{2,c}f_{N-1,2,c})UC_t + (m_{2,RA}f_{N-1,2,RA})RI_t & \text{[2. risk premium channel]}
\end{array}\right\}\\
&= \exp\left(e_{N,0} + \boldsymbol{e_{N,1}}\begin{bmatrix}g_t & RI_t & UC_t\end{bmatrix}' - \phi_{MP}MP_t\right). \qquad \text{(B19)}
\end{aligned}$$

Hence, the price-dividend ratio is approximately affine:

$$\begin{aligned}
PD_t &= \sum_{n=1}^{\infty} E_t\left[\exp\left(\sum_{j=1}^{n} m_{t+j} + \Delta d_{t+j}\right)\right]\\
&= \sum_{n=1}^{\infty} F_{n,t}\\
&= \sum_{n=1}^{\infty} \exp\left(e_{n,0} + \boldsymbol{e_{n,1}}\begin{bmatrix}g_t & RI_t & UC_t\end{bmatrix}' - \phi_{MP}MP_t\right), \qquad \text{(B20)}
\end{aligned}$$

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.

B.4.2 Contemporaneous log stock returns

As previously defined, $\boldsymbol{Y_t} = \begin{bmatrix}g_t & RI_t & UC_t & MP_t\end{bmatrix}'$. 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.

$$
\begin{aligned}
r_t^{eq} &= \Delta d_t + \ln\left[\frac{1+\sum_{n=1}^{\infty}\exp\left(e_{n,0}+\boldsymbol{e_{n,1}}\boldsymbol{Y_t}\right)}{\sum_{n=1}^{\infty}\exp\left(e_{n,0}+\boldsymbol{e_{n,1}}\boldsymbol{Y_{t-1}}\right)}\right] \\
&\approx \Delta d_t + \text{const.} + \frac{\sum_{n=1}^{\infty}\exp\left(e_{n,0}+\boldsymbol{e_{n,1}}\bar{\boldsymbol{Y}}\right)\boldsymbol{e_{n,1}}}{\frac{1+\sum_{n=1}^{\infty}\exp\left(e_{n,0}+\boldsymbol{e_{n,1}}\bar{\boldsymbol{Y}}\right)}{\sum_{n=1}^{\infty}\exp\left(e_{n,0}+\boldsymbol{e_{n,1}}\bar{\boldsymbol{Y}}\right)}}\boldsymbol{Y_t} - \frac{\sum_{n=1}^{\infty}\exp\left(e_{n,0}+\boldsymbol{e_{n,1}}\bar{\boldsymbol{Y}}\right)\boldsymbol{e_{n,1}}}{\sum_{n=1}^{\infty}\exp\left(e_{n,0}+\boldsymbol{e_{n,1}}\bar{\boldsymbol{Y}}\right)}\boldsymbol{Y_{t-1}} \\
&= \xi_0^{eq} + \boldsymbol{\xi_1^{eq}}\boldsymbol{Y_{t-1}} + \boldsymbol{\xi_2^{eq}}\begin{bmatrix} g_t - E_{t-1}(g_t) \\ RA_t - E_{t-1}(RA_t) \\ UC_t - E_{t-1}(UC_t) \\ MP_t \end{bmatrix},
\end{aligned}
\tag{B21}
$$

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

B.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:

$$
\begin{aligned}
E_t\left(r_{t+1}^{eq} - rf_t\right) + \frac{1}{2}V_t(r_{t+1}^{eq}) &\approx -Cov_t(m_{t+1}, r_{t+1}^{eq}) \\
&= \underbrace{\left(-m_{2,c}\xi_{2,c}^{eq}\right)}_{\kappa_{UC}} UC_t + \underbrace{\left(-m_{2,c}\xi_{2,RA}^{eq}\right)}_{\kappa_{RI}} RI_t,
\end{aligned}
\tag{B22}
$$

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).