BANK OF ENGLAND

Staff Working Paper No. 952
Global spillovers of the Fed information effect

Marco Pinchetti and Andrzej Szczepaniak

November 2021

BANK OF ENGLAND

Staff Working Paper No. 952

Global spillovers of the Fed information effect

Marco Pinchetti[1] and Andrzej Szczepaniak[2]

Abstract

This paper sheds lights on the open economy dimension of the Fed information effect, by evaluating its international spillovers on exchange rates, capital flows, and global economic activity. We provide empirical evidence that in response to unexpected increases in the Federal Funds rate associated with Fed information shocks, the dollar depreciates instead of appreciating. We show that this phenomenon occurs because Fed announcements affect investors' risk appetite. Expansionary Fed information shocks increase investors' risk appetite and drive capital towards foreign markets in pursuit of higher yields. Conversely, contractionary Fed information shocks decrease investors' risk appetite and drive capital towards safe-haven currencies, causing an appreciation of the dollar and safe-haven currencies *vis-à-vis* foreign currencies. We provide evidence that the Fed information effect is associated with large spillovers onto global safe-haven currencies, risk premia, cross-border credit, and ultimately, on global economic activity. These findings highlight the presence of global spillovers of the Fed information effect.

Key words: Monetary policy, information effects, international spillovers, flight to quality, high-frequency identification, sign restrictions, bayesian VAR.

JEL classification: E52, F31, F32, F41, F44.

(1) Bank of England and Centre for Macroeconomics. Email: marco.pinchetti@bankofengland.co.uk
(2) Department of Economics, Ghent University. Email: Andrzej.Szczepaniak@UGent.be

We would like to thank Javier Bianchi, Ambrogio Cesa-Bianchi, Giancarlo Corsetti, Selien De Schryder, Georgios Georgiadis, Alex Haberis, Diego Kanzig, Robert Kollmann, Sevim Kosem, Niklas Kroner, Michele Lenza, Hanno Lustig, Nicolo Maffei-Faccioli, Silvia Miranda-Agrippino, Rigas Oikonomou, Mathieu Parenti, Gert Peersman, Frank Smets, Marco Sorge, Ludwig Straub, Konstantinos Theodoridis, Tomasz Wieladek, Rafael Wouters, and all participants at the seminars in Ghent University, Universite libre de Bruxelles, Universite de Paris Nanterre, the National Bank of Belgium, the Bank of England, the Bank of France, the 8th Belgian Macroeconomics Workshop, the 3rd Cracow University of Economics Workshop on Macroeconomic Research, the Warsaw International Economic Meeting 2020, the Vilnius Winter Meeting 2020, the European Stability Mechanism, the 1st Ventotene Workshop in Macroeconomics, and the European Central Bank for useful comments and suggestions. Andrzej Szczepaniak gratefully acknowledges financial support from Ghent University's Special Research Fund (BOF). The views expressed in this paper are those of the authors, and not necessarily those of the Bank of England or its committees.

The Bank's working paper series can be found at www.bankofengland.co.uk/working-paper/staff-working-papers

Bank of England, Threadneedle Street, London, EC2R 8AH
Email enquiries@bankofengland.co.uk

ISSN 1749-9135 (on-line)

1 Introduction

Fed announcements are events of great importance for global financial markets as the Fed's monetary policy is an important driver of the global financial cycle, as emphasised by Miranda-Agrippino and Rey (2020). Such announcements have sizable effects on global asset prices, including equity prices, bond yields, and exchange rates, and these effects propagate to the global economy.

A large literature thus far has studied the response of global financial markets to Fed announcements, under the assumption that the high-frequency movements in financial markets in response to those announcements are solely attributable to monetary policy measures.[1] However, recent developments in the *central bank information* literature have highlighted the dual nature of central bank communication, stressing the idea that central bank announcements involve a 'policy' component and an 'information' component. This literature, pioneered by Romer and Romer (2000), starts from the idea that central bank communication affects agents' expectations for two main reasons: by communicating the implementation of unexpected monetary policy measures (the *monetary* effect), and by communicating its assessment of the economic outlook, which justifies its policy decision (the *central bank information* effect). Building on the Fed information effect literature, this paper investigates the global impact of information released by the Federal Reserve.

The aim of this paper is to analyse the international transmission of central bank information shocks, highlighting the channels which drive spillovers on exchange rates, capital flows, and the real economy. In this regard, our paper contributes to the literature by providing evidence that Fed non-monetary communication has sizable spillovers onto global financial markets and the global economy.

Information released by the Fed is important for the global economy due to three characteristics of the global economy: the global role of the dollar, the global role of the US financial system, and the quantitative relevance of the US economy for the global economy. First, the dollar has been adopted as an international currency by a large sector of international intermediaries in the trade and the credit sectors. Fluctuations in the value of the dollar associated with news in the US business cycle has spillovers on the value of international debts and credits for non-US firms and banks.[2] Second, the US banking system is worldwide a major source of credit provision[3]. Therefore, news concerning the state of health of the US financial system has the potential to affect credit dynamics at a global level. Third, news concerning the state of demand in the US is important for the global production network.[4]

Our paper exploits state-of-the-art high-frequency methodologies to disentangle the information component from the monetary policy component of central bank communication shocks. To that purpose, our paper adopts the identification scheme developed by Jarociński and Karadi (2020), based on the reaction of equity prices to surprise interest rate changes. In their paper, monetary policy shocks are identified as unexpected increases in the policy rate which results in a decline in equity prices, while central bank information shocks are unexpected increases in the policy rate which results in a rise in equity prices. A positive monetary shock is associated with a policy rate increase, which contracts economic activity and reduces stock prices. On the other hand, a positive central bank information shock is associated with an upward revision of output and

[1] See for instance Rey (2013), Farhi and Werning (2014), Bruno and Shin (2015a), Rey (2016), Miranda-Agrippino and Rey (2020), and Degasperi et al. (2020)

[2] Papers like Goldberg and Tille (2009), Gopinath (2015), Bruno and Shin (2017), and Boz et al. (2017) analyse the importance of the dollar for international trade and credit dynamics.

[3] Kalemli-Ozcan et al. (2013) and Bruno and Shin (2015b) document the prominent role of the US banking sector in the global credit provision.

[4] di Giovanni and Hale (2020) provide evidence that demand shocks induced by changes in the US monetary policy affect the market valuation of global equity

inflation expectations, which increases stock prices and entails expectations of future contractionary policies.

First, we estimate the high-frequency response of the dollar to domestic monetary policy and central bank information shocks, vis-à-vis a panel of 28 floating currencies, including 10 developed market currencies and 18 emerging market currencies. In line with conventional open economy models, a contractionary domestic monetary shock (defined as a policy rate increase which lowers equity prices) triggers an appreciation of the domestic currency. On the other hand, the dollar depreciates in response to a policy rate increase driven by central bank information effects. Such a result, echoed in Stavrakeva and Tang (2019) and Gürkaynak et al. (2020), is in contrast with the conventional view, according to which an interest rate increase must be accompanied by an appreciation of the domestic currency. Furthermore, we find that positive Fed information shocks also depreciate non-dollar safe-haven currencies against both developed and emerging market currencies. In this paper, we argue that this phenomenon occurs because investors revise their assessment about the level of financial risk in the global economy, in response to central bank announcements.

Second, to study the international transmission of US information shocks, we exploit a high-frequency sign-restriction identification approach within a Bayesian VAR to shed light on the propagation and the transmission mechanisms of these shocks. We show that the change in investors' risk appetite causes large spillovers onto global safe-haven currencies, risk premia, cross-border credit, portfolio flows, and ultimately, on global economic activity.

According to our findings, Fed information shocks drive flight-to-quality dynamics. When the Fed reveals negative news about the state of the US economy (and cuts the interest rate), investors and credit institutions respond to concerns of the occurrence of a global recession and move capital from emerging markets to financial *safe havens*, with negative spillovers on foreign economies.[5] Simultaneously, we provide evidence of an increase in risk aversion and the presence of net flows towards safer foreign assets. Meanwhile, when the Fed reveals positive news about the state of the US economy (and raises the interest rate), investors and banks revise their beliefs in favor of a global expansion, and move capital towards the rest of the world, seeking higher yields, with positive spillovers on foreign economies. This occurs as a result of a reduction in investors' risk aversion, associated with a positive central bank information shock. We further provide evidence that these capital flows have real economy spillovers on economic activity in the rest of the world. Such findings suggest that the Fed information effect has global consequences, and affects economic activity in the rest of the world.

We argue that the pattern we highlight in the data can be explained by the interaction of three elements: (i) the presence of a financial risk component in the Fed's communication, (ii) the status of the dollar as a global safe-haven, and (iii) the centrality of the US financial system to the global financial system. These three elements, have to necessarily hold in order to generate the observed pattern.

In order to validate this claim, it is insightful to note that, the absence of one of these three elements would generate implications in contradiction with our findings. First, if Fed communication did not involve a financial risk component, we would not observe that in response to a positive Fed information shock that all global safe-haven currencies depreciate. Second, were the dollar not a safe-haven currency, the triggered capital flows would not be directed to the US and would not entail an appreciation of the dollar. Third, if the US financial system did not act as a global banking sector, news about the risk of the US financial system

[5]We highlight the role of emerging countries in the mechanism description as their financial markets are typically perceived by investors as riskier and display relatively more volatile returns. This channel relies on the implicit assumption that during flight-to-safety-episodes capital tends to flow away from risky assets denominated in foreign currency (although not necessarily denominated in emerging markets currencies). Baele et al. (2019) document the presence of quantitatively relevant outflows from emerging markets to the US during flight-to-safety episodes.

would not have global relevance.

Our findings highlight that standard open economy models are not equipped to comprehensively explain the international spillovers of monetary announcements. First, in standard open economy models,an increase in the domestic interest rate raises the value of the domestic currency, shifting global demand away from domestic goods. Vice versa, a positive interest rate surprise associated with a central bank information shock lowers the value of the dollar shifting global demand towards US goods. Second, the macro-financial literature highlights an international credit channel, operative via the balance sheets of global financial intermediaries. An increase in the US interest rate shrinks the balance sheet and raises the funding cost for the major US global intermediaries, which provide credit at the international level and affect the business cycle of the rest of the world. However, a positive interest rate surprise associated with a central bank information shock expands the balance sheet of major US banks, despite raising their funding costs. Overall, we find the first effect to prevail over the second, resulting in an international credit expansion.

In order to consistently explain the findings of this paper, additional shocks and frictions are necessary compared to standard New Keynesian models. The exchange rate dynamics we identify are consistent with the response to output volatility shocks in open economy models, in papers like Benigno et al. (2012), Fogli and Perri (2015), and Kollmann (2016). In this class of models, a country-specific rise in output volatility improves the trade balance of the country whose volatility drops, and it depreciates its real exchange rate. This mechanism operates via a precautionary motive: an increase in output volatility pushes agents to increase their savings to insure their consumption, and to invest them into foreign assets. Therefore, our findings can be rationalised through the lenses of models in which the central bank releases information about the volatility of macroeconomic aggregates. Similarly, these findings can be explained by open economy models with signaling and information frictions as Stavrakeva and Tang (2019).

The paper is organised as follows. In Section 2, we review the principal contributions of the existing literature. In Section 3, we describe the identification scheme used. In Section 4, we evaluate how domestic central bank shocks affect domestic exchange rates, whilst in Section 5 we evaluate the global spillovers of the Fed information effect, and discuss the transmission channel at play. In the sixth section, we conclude.

2 Literature review

This paper primarily relates to the literature investigating the international effects of central bank communication shocks. The first attempts to empirically capture the effects of monetary policy communication on the exchange rate date back to the 90s. Eichenbaum and Evans (1995) is the first paper to employ a VAR for investigating the effect of conventional monetary policy on exchange rates, while Kim and Roubini (2000), Faust and Rogers (2003), Farrant and Peersman (2006), and Bjørnland (2009), develop alternative restrictions to improve the identification in the VAR literature. With the introduction of external instrument in macroeconomics, as in Stock and Watson (2012) and Mertens and Ravn (2013), the literature has started to exploit those to circumvent the need to impose theory-based restrictions. Some authors, such as Zanetti and Li (2016), Rogers et al. (2018), Inoue and Rossi (2019), and Dedola et al. (2020), combine high-frequency identification techniques around monetary policy announcements to identify structural VARs and capture the effects of conventional and unconventional monetary policy shocks on domestic and foreign interest rates, as well as on exchange rates.

In this respect, our paper methodologically also relates to the early literature about central bank communication shocks, such as Kuttner (2001), Cochrane and Piazzesi (2002), and Gürkaynak et al. (2005). In open economy these techniques have been more recently applied in papers like Neely (2015), Stavrakeva and Tang (2015), and Glick and Leduc (2018), which perform high-frequency exercises around Fed announcements to capture the effects of conventional and unconventional monetary policies on exchange rates and financial flows. Similarly, high-frequency methodologies have been used in open economy to evaluate the spillovers of conventional and unconventional monetary policies on emerging markets, in papers like Hausman and Wongswan (2011), Chen et al. (2014), Bowman et al. (2015), Dedola et al. (2017), and Fratzscher et al. (2018).

A number of contributions recently focused on the role of the Fed communication policies for the global financial cycle and global credit dynamics. Our paper most closely relates to the work of Passari and Rey (2015), Gerko and Rey (2017), Miranda-Agrippino and Rey (2020), and Degasperi et al. (2020), which show that US monetary policy has sizable global spillovers and is an important driver of the global financial cycle. Due to the important role of credit dynamics in the narrative of our paper, our work connects to Cesa-Bianchi et al. (2018), who highlight the international spillovers of the US credit cycle.

Lastly our paper extends to the open economy the analysis of the recent literature highlighting the role of central bank information effects, such as Nakamura and Steinsson (2018), Jarociński and Karadi (2020), Cieslak and Schrimpf (2019) and Miranda-Agrippino and Ricco (2021). These studies provide empirical evidence that the release of information (or beliefs) about the fundamentals of the economy by the central bank is an important component of market reactions to monetary policy announcements. The literature refers to this channel as the *central bank information effect*. Nevertheless, so far very few studies have investigated the implications of the central bank information effect in an open economy setting. Kerssenfischer (2019) conducts a high-frequency event-study around several ECB monetary policy announcements and finds that the Euro appreciates in response to interest rate increases associated with central bank information shocks identified à la Jarociński and Karadi (2020). Conversely, Franz (2020) finds that the evidence is mixed, and explains the heterogeneities via the role of carry trade flows. Stavrakeva and Tang (2019) and Gürkaynak et al. (2020) highlight that the dollar appreciates in response to expansionary Federal Reserve monetary policy announcements and develop models based on signaling and information frictions to justify such responses. Jarociński (2020) studies the spillovers of central bank information shocks between the US and the Euro Area.

Our paper contributes to the literature by assessing the spillovers generated by the Fed information effect in the global economy, and providing a unifying explanation which is able to consistently reconcile the pattern of capital flows, exchange rates, and investors' behavior.

3 Identification of monetary policy and central bank information shocks

A growing literature has identified the importance of disentangling pure monetary policy from central bank information effects in central bank policy announcements. Following the methodology of Jarociński and Karadi (2020), we decompose US interest rate surprises into two orthogonal series: a pure monetary policy shock and a pure central bank information shock.

Identification is based on a sign-restrictions decomposition whereby a negative co-movement between a short-term policy rate instrument and equity prices is defined as a pure monetary policy shock, and a positive co-movement is defined as a pure central bank information shock, as outlined in Table 1. The policy rate measure and the equity index used are the 3-month Federal Funds Rate futures and the S&P500.

Table 1: Identifying Restrictions for Monetary Policy and Central Bank Information Shocks

	Monetary Policy	Central bank Information
Interest Rate surprise	+	+
Equity Index surprise	–	+

As is standard in the event study literature, we consider a short window around the Federal Reserve policy announcement to ensure clean identification and thus minimise any contamination from non-central bank events. In practice, we consider a 30-minute window. Specifically, for each high-frequency variable, we measure the change in the level 20 minutes after the event minus 10 minutes before the event.

We opt to disentangle monetary policy from central bank information in a stand-alone step so as to use these series as external instruments in the high-frequency empirical exercises which follow. In practice, we replicate the VAR specification of Jarociński and Karadi (2020) for the US, back out the monetary policy and central bank information shocks which are set identified, and we apply the Fry and Pagan (2011) *median target* methodology to preserve the orthogonality of the shocks.

4 The exchange rate response to central bank information shocks

In this section, we estimate the exchange rate response of central bank information shocks using an event study methodology. Given the recent emergence of the literature on central bank information shocks, many questions remain unanswered. Our empirical exercise aims to answer mainly two questions. Firstly, whether exchange rates react differently to central bank information shocks versus monetary policy shocks. Secondly, whether there any difference in the response between developed and emerging market currencies.

In order to shed light on these fundamental questions, we estimate a high-frequency panel model of the following form:

$$y_{i,t} = \alpha_i + \beta\,\mathrm{MP}_{i,t} + \delta\,\mathrm{CBI}_{i,t} + \varepsilon_i \tag{1}$$

where $i = 1, 2, \ldots, N$ and $t = 1, 2, ...T$, and $T \gg N$. $y_{i,t}$ is the daily percentage change in currency i on the date of the monetary policy event, calculated as $y_{i,t} = 100 \times \ln\{p_{i,t}/p_{i,t-1}\}$, where $p_{i,t}$ is the spot exchange rate price at close of pricing on day t.

Our specification makes use of a fully-iterated feasible generalised least squares with cross-section weights and panel-corrected standard errors. This specification accounts for heteroskedasticity among the panels (Solon et al., 2013) and accounts for cross-panel correlation (Moundigbaye et al., 2016).

These three properties of the estimators are crucial, as our sample is likely to feature (i) cross-sectional heteroscedasticity, as the variance of the exchange rate response in each section is likely to be increasing in the intensity of the communication shock, (ii) correlation among cross sections, as exchange rates relative to different US currency pairs are very likely to comove,[6] and (iii) serial correlation within and across cross-

[6]With the exception of safe-haven currencies.

sections, with persistent drops during recessions. Panel estimation techniques based on more simplistic estimators might therefore lead to biased parameter estimates.

As our analysis focuses on how exchange rates in developed markets and emerging markets respond to US monetary policy and information effects, our base currency is USD. Currencies are defined as units of foreign currency which a single unit of home (base) currency can buy. Thus if $y_{i,t} > 0$, the base currency (i.e., the home currency) has appreciated, and otherwise it has depreciated.

In order to classify the selected currency pairs by market type (i.e., developed versus emerging market), we adopt the MSCI markets classification.[7] Furthermore, in our analysis, we only consider floating currencies and hence we exclude currencies which are *de jure* pegged during the sample period under consideration. In order to separate the countries adopting a peg as opposed to a floating exchange rate, we rely on the IMF's Annual Report on Exchange Arrangements Database. Full details on the selected developed markets and emerging markets currencies can be found in Appendix A.

For exchange rate data, we use spot pricing by WM/Reuters Benchmark. Thus $p_{i,t}$ is close of day pricing, occurring at 4pm London time on each date in question. Whenever necessary, we shift our daily window on the date in which the communication event effectively happens. For instance, in the US, the Federal Reserve typically makes announcements at 7pm London time, thus requiring us to calculate the FX change between $t+1$ and t as opposed to t and $t-1$. The MP and CBI variables are defined as in Section 3.

Table 2: Response of USD to monetary policy and information effects

	Developed Economies	Emerging Markets
Monetary Policy	2.90*** (*0.37*)	1.63*** (*0.20*)
Central Bank Information	-1.33** (*0.62*)	-0.58* (*0.32*)

Note: Authors' calculations. Values reported are coefficient estimates from estimated generalised least squares with cross-section weights and standard errors below in parenthesis. Reported standard errors are panel corrected standard errors. Three asterisks indicate 1% significance, two indicate 5%, and one indicates 10%. A positive sign indicates an appreciation of the concerned currency, and a negative sign a depreciation of the concerned currency.

The results from this panel estimation are available in Table 2. In Table 2, we respond to our first question, i.e. whether pure monetary policy shocks behave empirically as conventional theory predicts. On the monetary policy side, what we clearly see is that contractionary monetary policy shocks still have an appreciating effect on exchange rates. That is, if the domestic interest rate rises, then the domestic currency appreciates. We see this holds against both developed and emerging market exchange rates. Thus pure monetary policy shocks identified via sign-restrictions behave empirically as predicted by theory in an open-economy setting.

For US central bank information shocks, however, we provide evidence of the *opposite* effect. That is, a rise in the US interest rate due to a central bank information shock results in a *depreciation* of the USD vis-à-vis both developed and emerging markets currencies.

[7] The MSCI classification is available at this link: https://www.msci.com/market-classification

The hypothesis we raise and empirically validate in this paper is that this phenomenon is a consequence of the fact that the Federal Reserve monetary policy measures are often justified by the assessment of the Fed of the level of financial risk in the US economy, and therefore affect investors' risk appetite, driving flight-to quality dynamics. In turn, investors' risk behavior, is a key driver of exchange rate movements, as documented, inter alia, by Lilley et al. (2019).

Our narrative hinges on the central role of the US financial sector in the global financial system. Shocks to the US financial system strongly propagate to the global financial system, as it was widely documented for the Lehman Brothers bankruptcy in September 2008.

When the Federal Reserve signals positive news about US economic growth and inflation, investors' risk aversion declines. Higher risk appetite leads capital to flow towards emerging markets in pursuit of higher yields. These financial flows associated to the release of news about the US economy can therefore explain the dollar response. On the other hand, when the Federal Reserve signals weakness in the US economy, investors' risk aversion increases. Higher risk aversion leads investors to readjust their portfolios towards US assets and withdraw from emerging markets on elevated risk-related concerns. In this sense, central bank information shocks for the Federal Reserve likely reflect a *flight to safety* channel for investors. As capital moves from the emerging markets to the US economy, the dollar appreciates. In order to validate this hypothesis, is therefore necessary to analyse investors' risk behavior and capital flows into riskier assets.

4.1 US information shocks, safe haven currencies, and the flight to quality

A first set of evidence for the '*flight to quality*' interpretation of our results is provided by investigating the response of non-dollar safe haven currencies to US monetary policy and central bank information shocks. In this exercise, we test a direct implication of our interpretation. That is, if the Federal Reserve releases relevant information which affects an agent's outlook with respect to the global economy and triggers flight to quality effects, then not only should the dollar appreciate following a US interest rate cut, but so should all safe haven currencies.

We follow the same methodology as previously described and we re-estimate Equation (1), albeit now the independent variables $\text{MP}_{i,t}$ and $\text{CBI}_{i,t}$ are for the US only, and $y_{i,t}$ is a panel of non-dollar safe haven currency pairs. We focus on the response of two established non-dollar safe-haven currencies, the Swiss Franc (CHF) and the Japanese Yen (JPY), and the Euro (EUR),[8] vis-à-vis a panel of emerging market currencies (details in the section A2 of the Appendix).

The results are reported in Table 3. We see that the Swiss Franc, the Japanese Yen, and the Euro all depreciate against emerging market currencies following a rise in the US interest rate, whether due to a Fed monetary policy shock or a Fed information shock. This sheds light on the global nature of the phenomenon which we are describing in this paper, and rules out the possibility that the observed phenomenon purely concerns factors internal to the US. We investigate the response of such currencies vis-à-vis emerging market currencies because we are interested in currency pairs characterised by asymmetric risk levels. In this way, we can assess whether the exchange rate fluctuations are consistent with the hypothesis that in response to Fed information shocks, investors' risk appetite rises, and capital flows from emerging to developed countries and vice versa. The findings in Table 3 confirm the aforementioned hypothesis, with safe-haven currencies

[8] The status of the Euro as a safe-haven currency is sometimes a subject of debate in the literature. For instance, McCauley and McGuire (2009) consider the Euro a safe-haven currency, while Ranaldo and Söderlind (2010) do not. We take an agnostic approach and empirically evaluate its behavior in response to Fed monetary and information shocks. Our results suggest that its behavior, in this dimension, is in line with that of other safe-haven currencies.

depreciating in response to positive Fed information shocks, and therefore suggesting the presence of capital flows from safe havens towards emerging markets. On the other hand, safe-have currencies depreciate vis-à-vis emerging markets currencies in response to Fed monetary policy shock row instead, consistently with the evidence presented in Table 4, whereby the magnitude of the response of developed market currencies vis-à-vis Fed monetary policy shock is greater than the emerging market currencies response.

Table 3: Response of global and safe-haven currencies to Fed monetary and information shocks vis-à-vis emerging market currencies

	Dependent variable:		
	CHF	JPY	EUR
	(1)	(2)	(3)
Monetary Policy Shock	-2.85***	-1.70***	-1.61***
	(0.31)	(0.37)	(0.28)
Central Bank Information	-1.77***	-1.32*	-0.78*
	(0.52)	(0.60)	(0.45)

Note: Authors' calculations. Values reported are coefficient estimates from estimated generalised least squares with cross-section weights and standard errors below in parenthesis. Reported standard errors are panel corrected standard errors. Three asterisks indicate 1% significance, two indicate 5%, and one indicates 10%. A positive sign indicates an appreciation of the concerned currency, and a negative sign a depreciation of the concerned currency.

4.2 Market Volatility, Risk Aversion, and Uncertainty

While the previous section provides evidence for the occurrence of flight to quality behavior for international investors, this section sheds light on the transmission channels. In particular, there are two intrinsically different reasons triggering a flight-to-safety run: (i) a variation in the amount of risk in the economy, or (ii) a variation in agents' risk aversion. These two competing hypotheses lead to different interpretations of our results (see Bekaert et al., 2013 and Bekaert and Hoerova, 2016). On the one hand, the information released by the Fed along with the announcement might act as *insurance* for markets. By discounting the improvement of economic conditions, the level of risk in the economy might endogenously decrease. The other competing hypothesis is that the effect on investors' risk behavior is explained by a confidence channel, i.e. in response to the news released by the Fed, agents become more or less risk averse. We find evidence for the latter interpretation, whereas the former is not supported by the data.

The exercise we conduct in this section exploits the VXO, a common measure of the stock market's expectation of volatility based on S&P 100 index options, which is reflective of the volatility expected by the markets. However, market volatility partially reflects by the price that agents attribute to risk (risk aversion), and partially the amount of risk in the economy (uncertainty). A promising attempt to separate these two components at daily frequency has been recently developed in Bekaert et al. (2019).

The risk aversion index developed in Bekaert et al. (2019) exploits a set of financial assets, such as the detrended earnings yield, corporate return spread (BAA-AAA), term spread (10yr-3mth), equity return realized variance, corporate bond return realized variance, and equity risk-neutral variance, and use them in a structural habit-like model with preference shocks. The obtained index is therefore utility-based, and proxies the time-varying relative risk aversion coefficient of financial investors.

The second component they extract concerns macro-economic uncertainty, which is regarded in the literature as a measure of the amount of risk present in the economy. Their uncertainty index is estimated starting from the monthly conditional variance of industrial production growth exploiting a bad environment-good environment framework and a persistent conditional mean, and projecting it onto the financial instruments used to extrapolate the risk aversion index. Notably, the Bekaert et al. (2019) measure is 81% correlated with the Jurado et al. (2015) macro uncertainty index, and 34% correlated with the geopolitical-economic uncertainty index by Baker et al. (2016).The methodology applies here is similar to the previous high-frequency exercises. We estimate an equation similar to equation (1) exploiting a standard OLS estimator on daily data (close to close).

Table 4 shows that market volatility rises by 7.46% in response to a 1% increase in the policy rate, when the former is associated with a monetary policy shock. However, market volatility drops by more than 10% when associated with an increase in the policy rate expectations associated with a central bank information shock. Global risk aversion - the price of risk on the global markets - rises by 1.26% when the Fed raises its policy rate by 1%, whereas it drops by 2.39% when the policy rate increase is associated with a release of positive news about the US economy. Finally, uncertainty - the amount of risk in the global economy - does not seem to respond to the Fed's policy actions.

Two important pieces of evidence emerge from our analysis. The first is that both monetary policy shocks and Fed information shocks affect market volatility, and do that in different directions. Increases in policy rates associated with monetary policy shocks raise market volatility, whereas expectations of higher (lower) policy rates associated with information releases tend to stabilise (destabilise) the market. The second takeaway is that the increase in realised volatility has to be imputed to the response in investors' risk aversion and not to a change in the level of risk in the global economy. This can be straightforwardly inferred from the fact that, in our high-frequency regressions, monetary policy and Fed information shocks affect global risk aversion, but do not affect global uncertainty.

Table 4: Risk Aversion, Uncertainty, and Market Volatility

	Dependent variable:		
	Risk Aversion	Uncertainty	VXO
	(1)	(2)	(3)
Monetary Policy Shock	1.26***	0.02	7.46***
	(0.35)	(0.05)	(2.03)
Central Bank Information	-2.39***	0.07	-10.31***
	(0.52)	(0.08)	(2.99)

Note: Authors' calculations. Values reported are coefficient estimates from estimated generalised least squares with cross-section weights and standard errors below in parenthesis. Reported standard errors are panel corrected standard errors. Three asterisks indicate 1% significance, two indicate 5%, and one indicates 10%. Positive values indicate an increase in risk aversion, uncertainty, and market-implied expected volatility. Negative values indicate a decrease in risk aversion, uncertainty, and market-implied expected volatility.

Table 5: Flows to Emerging Markets (as a percentage of global GDP, weekly)

	Dependent variable:		
	Total	Equity	Debt
	(1)	(2)	(3)
Monetary Policy Shock	-0.16*	-0.14*	-0.02
	(0.09)	(0.07)	(0.04)
Central Bank Information Shock	0.42***	0.32***	0.09*
	(0.11)	(0.09)	(0.05)

Note: Authors' calculations. Values reported are coefficient estimates from estimated generalised least squares with cross-section weights and standard errors below in parenthesis. Three asterisks indicate 1% significance, two indicate 5%, and one indicates 10%. A positive sign indicates an inflow into emerging markets, and a negative sign an outflow out of emerging markets.

4.3 International Capital Flows

In this sections we provide evidence of the presence of capital flows from the US into riskier assets in response to Fed information shocks. The portfolio reallocation following a central bank information shock, is likely to involve a domestic component, whereby investors reallocate their resources towards riskier asset classes like equities, collateralised mortgages, or derivative products; and an international component whereby investors and financial intermediaries reallocate capital from (to) developed countries to (from) emerging markets.

We provide evidence for international capital flows in response to Fed information shocks using data from the Institute of International Finance (IIF) concerning debt and equity non-resident portfolio flows to emerging markets. The reaction of capital flows has to be studied whilst being aware of the time interval between the investment execution and the settlement of each transaction. This time interval is typically between one and two days. In order to rule out the possibility of missing a part of the market response we consider capital flows at daily frequency. Our results, however, also hold when cumulating the net flows in the 3 days following the announcement.

The IIF capital flow measure considers a comprehensive set of countries, including China, Argentina, Bulgaria, Egypt, India, Brazil, Czech Republic, Lebanon, Indonesia, Chile, Hungary, Morocco, Malaysia, Colombia, Poland, Nigeria, Philippines, Ecuador, Romania, Saudi Arabia, South Korea, Mexico, Russia, South Africa, Thailand, Peru, Turkey, UAE, Venezuela, and Ukraine. As in the previous section, the methodology employed here is similar to Equation (1) and exploits a standard OLS estimator with weekly capital flows data.

Our results, in Table 5, suggest that there is robust evidence for Fed information shocks to trigger debt and equity flows towards emerging markets, whereas Fed monetary policy shocks seem to be associated with equity flows only. In the table, positive coefficients indicate the presence of net inflows into emerging markets, and negative coefficients indicate the presence of net outflows from emerging markets. When considering aggregate flows to emerging markets, the response to both shocks turn out to be significant, pointing at the fact that equity flows might be quantitatively more relevant. Quantitatively, a 1% increase in the Fed policy rate associated with a monetary policy shock, entails an equity outflow from emerging markets equivalent to 0.14% of global GDP, and a debt outflow equivalent to 0.02% of global GDP from emerging markets, for a total of approximately 0.16% of global GDP. On the other hand, a 1% increase in the Fed policy rate associated with a central bank information shock triggers an equity inflow equivalent to 0.32% of global GDP, and a debt inflow to emerging markets equivalent to 0.09% of global GDP, otherwise in sum, a total of 0.32% of global GDP. Generally, our results are less pronounced for debt flows compared to equity flows. In Appendix C, a robustness check exploiting cumulative data from the three days following the announcements, qualitatively confirms these results.

Overall, our results seem to support the idea that Fed policy shocks and Fed information shocks have a strong impact, of opposite sign, on international portfolio allocation. Notably, the response of emerging market flows is two to three times larger than the monetary policy response. This fact seems to suggest that news about the US business cycle, capable of affecting the future course of the Fed monetary policy, might be more important for the economic and financial stability of emerging markets than temporary deviations from the Fed's policy rule.

In addition to driving portfolio flows to emerging markets, the decrease in risk aversion associated with central bank information shocks is likely to cause an increase of lending from the US banking sector to the emerging markets. However, credit flows typically respond at a slower frequency to monetary stimuli, therefore, high-frequency techniques cannot be applied in this context.

5 Global spillovers of Fed information shocks

In this section, we study the international propagation of Fed information shocks. Two key questions are at the centre of this section. First, we aim to ascertain whether our flight to quality interpretation is consistent for a larger set of asset classes. Second, we study the propagation of Fed information shocks on international variables, and the rest of the global economy.

5.1 A Bayesian Structural VAR Model

In order to quantitatively assess the spillovers of Fed monetary policy and information shocks, we estimate a Bayesian structural VAR model identified with sign-restrictions, à la Jarociński and Karadi (2020). We employ standard Minnesota priors as in Litterman (1979), a common choice in the Bayesian VAR literature.

Our model is defined by equation (2). The notation m_t indicates a 2×1 vector of high-frequency surprises, where $m_{1,t}$ is the high-frequency surprise in the policy rate around FOMC announcements while $m_{2,t}$ is the high-frequency surprise in equity prices around FOMC announcements, hence m_t takes value 0 in months where no FOMC meeting occurred. The notation y_t is a vector of variables on the US and global economy. The set of considered variables includes the 1-year government bond yield, the S&P 500, US GDP, the US GDP deflator, the Excess Bond Premium, global risk aversion, global GDP, the return on a trade-weighted dollar Index, the US trade balance to GDP ratio, the US Broker-Dealer leverage ratio, and global cross-border credit excluding the US. The model is characterised by the specification described below:

$$\begin{pmatrix} m_t \\ y_t \end{pmatrix} = \sum_{p=1}^{P} \begin{pmatrix} 0 & 0 \\ B^p_{YM} & B^p_{YY} \end{pmatrix} \begin{pmatrix} m_{t-p} \\ y_{t-p} \end{pmatrix} + \begin{pmatrix} 0 \\ c_Y \end{pmatrix} + \begin{pmatrix} u^m_t \\ u^y_t \end{pmatrix} \tag{2}$$

$$\begin{pmatrix} u_t^m \\ u_t^y \end{pmatrix} \sim \mathcal{N}(0, \Sigma)$$

Identification is based on the co-movement between $m_{1,t}$ and $m_{2,t}$. Similarly to as described in Table 1, in the Section 3, a negative co-movement is associated with a monetary policy shock whereas a positive co-movement is associated with a central bank information shock. Posterior draws of the shocks are computed assuming a uniform prior on the space of rotations conditionally on satisfying the sign restrictions, as in Rubio-Ramírez et al. (2010).

Following Jarociński and Karadi (2020), we set p, the number of lags, to 12. The estimation exploits 25 years of macroeconomic data at monthly frequency, from January 1992 to December 2016, and the identification procedure exploits 212 FOMC announcements covering all the length of the estimation sample, in order to identify monetary and central bank information shocks. The reported results are based on 2,000 draws from the Gibbs sampler.

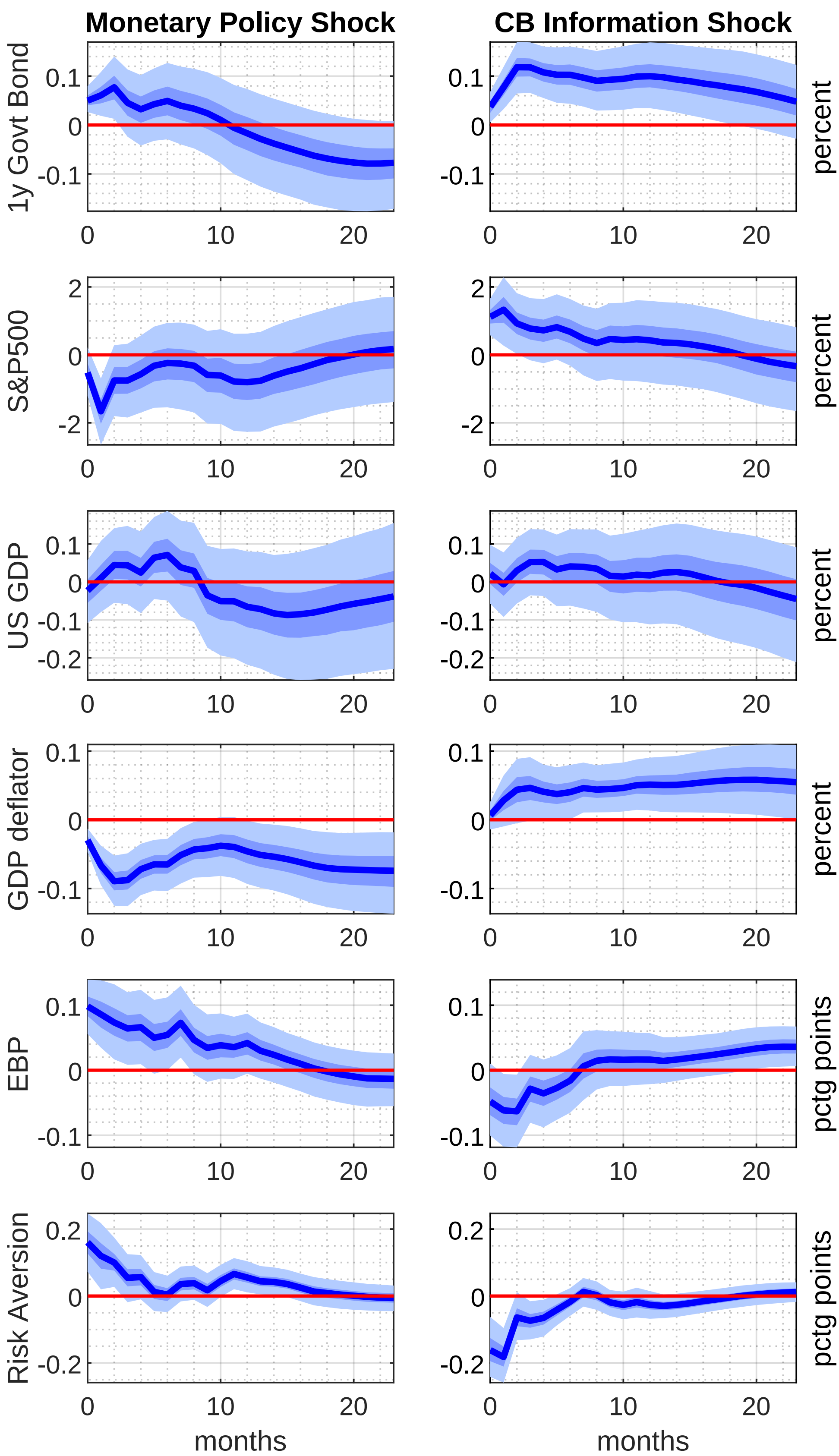
5.2 The Fed information effect and the domestic economy

In Figure 1, we study the effect a 5 basis point rise in the interest rate due to a monetary policy shock (left-hand side) versus a central bank information shock (right-hand side). The magnitude of the shock is quantifiable in 5bp to the Federal funds rate, both in case of a monetary policy shock and in the case of a central bank information shock. By design, due to the nature of our sign restrictions, a 5bp rise in the nominal interest rate associated with a monetary policy shock, has a negative effect on the S&P500 between -0.7% and -2.5%. On the other hand, a 5bp rise in the nominal interest rate associated with a central bank information shock, has a positive effect on the S&P500 of between 0.5% and 1.5%. The estimated size of these effects is much larger than Jarociński and Karadi (2020) (approximately double), and is reminiscent of the evidence in Breitenlechner et al. (2021) that the effects of monetary policy are much larger when the global economy response is take into account, due to the presence of spillbacks, i.e. the domestic consequences of global spillovers.

The response of GDP to both monetary policy and central bank information shocks is weakly significant. In the Appendix, we propose a robustness check using industrial production and CPI rather than GDP and the GDP deflator, and similarly find the response to be small and barely significant for monetary and central bank information shocks. Overall, the response of economic activity proxies to monetary and central bank information shocks seems to be weak. These findings are broadly consistent with Jarociński and Karadi (2020) who find the response of GDP to monetary and central bank information shocks to be weakly significant.

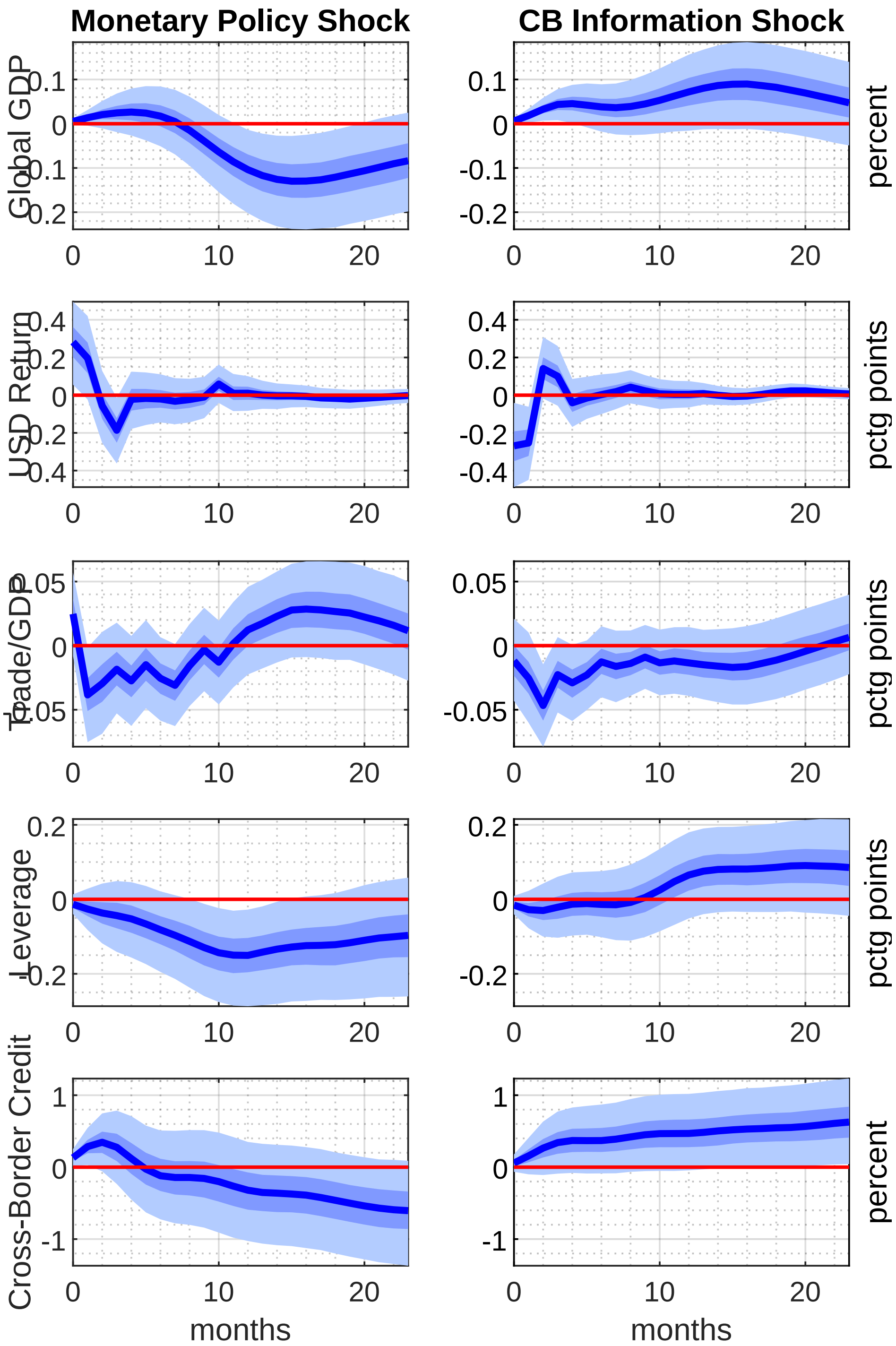
The response of the GDP deflator to a monetary policy shock is significant and persistent, in accordance with the vast literature of New Keynesian models analysing the effect of nominal rigidities. When a monetary shock associated with a 5bp rise in the Federal funds rate hits the economy, inflation drops by between -0.06% and -0.12%. Similarly, in response to a central bank information shock, the response of inflation is significant and persistent. In response to a 5bp rise in the nominal interest rate, inflation rises by between 0% and 0.08%. In our robustness check using CPI inflation, the response to the monetary shock is comparable to our baseline specification, while the response to the central bank information shock is more pronounced. By contrast, in Jarociński and Karadi (2020), the response of the GDP deflator to a monetary shock is smaller, and the response to a central bank information shock is muted.

Figure 1: Estimated responses to US monetary policy and central bank information shocks



The figure displays the estimated dynamic response of US monetary policy and central bank information shocks as identified by our Bayesian SVAR model. Blue lines indicate point estimates, blue areas outline 68% and 90% confidence bands. The shock is associated with a 5bp increase of the 1-year Federal funds rate.

Figure 2: Estimated responses to US monetary policy and central bank information shocks of selected domestic variables and trade-weighted exchange rate indices



The figure displays the estimated dynamic response of US monetary policy and central bank information shocks as identified by our Bayesian SVAR model. Blue lines indicate point estimates, blue areas outline 68% and 90% confidence bands. The shock is associated with a 5bp increase of the 1-year Federal funds rate.

An important variable which can help us evaluate the risk behaviour of the domestic financial markets is the excess bond premium, computed as in Gilchrist and Zakrajsek (2012). In response to a 5bp rise in the nominal interest rate associated with a monetary shock, the US excess bond premium rises between 0.07 p.p. and 0.14 p.p., while a 5bp rise associated with a central bank information shock produces a drop in the excess bond premium between -0.02 p.p. and -0.12 p.p. These estimates are consistent both with our alternative specification using CPI and industrial production, and with estimates from Jarociński and Karadi (2020).

5.3 The Fed information effect and the global economy

Turning to the response of the global variables, we start by analysing the response of a proxy of global risk aversion developed by Bekaert et al. (2019), as we have argued in the previous sections that the investors' risk appetite fluctuations play an important role in the origination of the global spillovers of the Fed information effect. Global risk aversion responds positively to a 5bp rise in the Federal funds rate associated with a monetary shock (from 0.05 to 0.25 p.p.), and negatively to a 5bp rise in the Federal funds rate associated with a central bank information shock (from -0.1 to -0.25 p.p.). These findings are robust to our alternative specification and suggest that investors across the globe become more risk-averse when the Fed tightens monetary policy, and less risk averse when the Fed loosens it. On the other hand, if the Fed rises its interest rate due to an upward revision in its macroeconomic outlook, investors become significantly less risk averse and vice versa.

The second variable we consider is a measure of real global GDP published by the Federal Reserve of Dallas. In response to a 5bp tightening of the Federal funds rate associated with a monetary shock, global output contracts persistently from -0.4% up to -0.24%. Importantly, we find that in response to a 5bp tightening of the Federal funds rate associated with a central bank information shock, global output grows persistently with a peak between 0% to 0.2%.

In order to measure the response of the exchange rate, we consider a trade-weighted measure of the dollar expressed as a monthly return. Our findings indicate that a short-lived rise in the Federal funds rate associated with a monetary shock of 5bp leads to a dollar appreciation from 0.1 p.p. to 0.5 p.p. On the other hand, a rise in the Federal funds rate associated with a central bank information shock leads to a short-lived depreciation of the dollar quantifiable in between -0.1 p.p. to -0.5 p.p. It is important to notice here that, being the variable expressed in differences, a short-lived impact on the return translates into a persistent effect on the level of the variable. Furthermore, a large part of debt contracts in the rest of the world is denominated in dollars. Therefore, when the dollar depreciates, the value of those debts expressed in local currency in the rest of the world shrinks, increasing the borrowing capacity of those countries.

In order to evaluate the role of trade in our story, we analyse the impact of monetary and central bank information shock on the ratio of the US trade balance to GDP. The response of the US trade balance to a 5bp monetary tightening is negative in the short run and positive in the long run, although the response seems weak and practically almost insignificant. On the other hand, the response to a 5p rise in the nominal interest rate associated with a central bank information shock, is persistently negative, and peaks after two months between -0.01 p.p. and -0.07 p.p. The response of trade therefore helps sustaining the global spillovers, as the US tend to import relatively more in response to central bank information shocks.

Finally, we analyse two variables which could help shed light on the credit dimension of our story. The first one is the leverage ratio of the broker-dealers in the United States. This variable is indicative of the leverage of the US financial system and it is shown in papers like Cesa-Bianchi et al. (2018) to be important for explaining global credit dynamics. Our findings indicate that the broker-dealers leverage ratio persistently contracts in response to monetary tightening, and expands slowly but persistently in response to a Fed information shock. In particular, a 5bp rise in the Federal funds rate associated with a monetary shock, implies a reduction in the broker-dealers leverage ratio between -0.1 p.p. and -0.3 p.p. On the other hand, a 5bp rise in the Federal funds rate associated with a central bank information shock, leads to a slow increase in the broker-dealers leverage up to +0.3 p.p., which materialises gradually 10 months after the shock, although it is significant only at the 68% confidence level. We attribute the gradualism of these adjustments to the intrinsic nature of credit negotiations and to the slow expansion in global economic activity. The second credit variable is a measure of the cross-border credit which we obtain by aggregating all international liabilities for all countries excluding the US. This variable therefore captures the cross-border credit received by the global economy, excluding the US. According to our estimates, in response to a 5bp rise in the nominal interest rates, cross border credit initially rises between 0% and 0.8%. then gradually decreases up to between 0% to -1.4%. We interpret the inversion of this response through the overlap of two different effects: the rise in interest payments on previously existing liabilities which contributes to increase the total amount of outstanding liabilities, and the reduction of the credit supply which decreases it. On the other hand, an increase in the Federal funds rate associated with a Fed information shock leads to an increase of cross-border credit to the global economy between 0.05% and 1.2%.

The findings of our BVAR lead us, due to the response of several variables closely tied to agents' risk aversion, to argue that the bulk of the spillovers here identified are driven by the capability of the Fed to affect agents' risk aversion for banks and financial investors, which ultimately drives global credit dynamics and economic activity in the rest of the world. The confidence effect induced by the Federal Reserve leads global banks to lend more in riskier economies, such as emerging economies, ultimately inducing credit-driven real expansions. Papers like Cesa-Bianchi et al. (2018) show that US cross-border lending has sizable spillovers, raising foreign real output and affecting global inflation. Similarly, the increase in investor confidence induced by the Federal Reserve would push banks to lend more in riskier markets, markedly affecting asset prices and resulting in sizable spillovers onto the real economy of those countries.

Overall, the evidence presented here supports the idea that Fed information shocks have spillovers on global economic activity in the rest of the world. When agents extrapolate positive economic news about the US to mean positive news about the global business cycle, we observe agents and banks moving away from safe-haven currencies and move towards other foreign currencies. Simultaneously, we observe real economy spillovers, ultimately leading to an expansion of global economic activity. Vice versa, when the US interest rate declines due to negativity regarding the US economy, global investors and banks become increasingly concerned about global economic conditions and a global slowdown, and take less riskier positions, reallocating capital to financial safe-havens.

6 Conclusion

In this paper, we present evidence that, the Fed information effect results in an anomalous response of the dollar exchange rate vis-à-vis the rest of the world, and material international spillovers on cross-border credit and global output.

We show that not all interest rate surprise are equal in open economy. Fed information shocks behave markedly differently to Fed monetary policy shocks in an open-economy setting. A rise in the nominal interest rate associated with a monetary shock, entails an *appreciation* of the dollar. However, a rise in the nominal interest rate associated with a central bank information shock, entails a *depreciation* of the dollar vis-à-vis other currencies, and other safe-haven currencies vis-à-vis other currencies. This result is at odds with conventional macroeconomic theory, which predicts that a rise in the US interest rate should appreciate the dollar. Furthermore, we find that Fed information shocks have real economy spillovers. A positive Fed information shock results in an expansion of global cross-border credit and global output.

In our view, the global effects of Fed information shocks can be interpreted through the lens of *flight to quality* effects. When the Federal Reserve reveals positive news about the state of the US economy, investors revise their expectations accordingly. The upward revision of investors' expectations lead them to adopt a more risky behavior, and to therefore investors reallocate the geographical composition of their portfolios towards the rest of the global economy, in order to seek higher yields from riskier assets. Hence, we observe that the dollar depreciates and a net inflow of capital into emerging markets. Such capital inflows ultimately have real economy spillovers, resulting in an increase in output in the rest of the world. Vice versa, when the Federal Reserve signals weakness in the US economy, the concerns of a global recession lead investors to reallocate their portfolios towards global safe havens, and in particular towards the US. Hence, the dollar appreciates.

We argue that three elements are crucial to this mechanism, and necessary to comprehensively explain the pattern in the data: (i) the presence of financial risk information in the Fed's announcements, (ii) the role of the dollar as a global safe-haven, and (iii) the centrality and the relevance of the US financial sector for the global economy.

Our findings suggest that evaluating the global spillovers of the Fed information effect is essential to quantify the exchange rate dynamics in response to central bank announcements. Empirical analyses which neglect the information component of central bank communication will tend to overestimate the exchange rate dynamics implied by monetary announcements, and therefore overestimate the effectiveness of monetary stimuli.

References

BAELE, L., G. BEKAERT, K. INGHELBRECHT, AND M. WEI (2019): "Flights to Safety," *The Review of Financial Studies*, 33, 689–746.

BAKER, S. R., N. BLOOM, AND S. J. DAVIS (2016): "Measuring Economic Policy Uncertainty," *The Quarterly Journal of Economics*, 131, 1593–1636.

BEKAERT, G., E. C. ENGSTROM, AND N. R. XU (2019): "The time variation in risk appetite and uncertainty," Working Paper 25673, National Bureau of Economic Research.

BEKAERT, G. AND M. HOEROVA (2016): "What do asset prices have to say about risk appetite and uncertainty?" *Journal of Banking Finance*, 67, 103–118.

BEKAERT, G., M. HOEROVA, AND M. LO DUCA (2013): "Risk, uncertainty and monetary policy," *Journal of Monetary Economics*, 60, 771 – 788.

BENIGNO, G., P. BENIGNO, AND S. NISTICÒ (2012): "Risk, monetary policy, and the exchange rate," *NBER Macroeconomics Annual*, 26, 247–309.

BJØRNLAND, H. C. (2009): "Monetary policy and exchange rate overshooting: Dornbusch was right after all," *Journal of International Economics*, 79, 64–77.

BOWMAN, D., J. M. LONDONO, AND H. SAPRIZA (2015): "U.S. unconventional monetary policy and transmission to emerging market economies," *Journal of International Money and Finance*, 55, 27–59.

BOZ, E., G. GOPINATH, AND M. PLAGBORG-MØLLER (2017): "Global Trade and the Dollar," NBER Working Papers 23988, National Bureau of Economic Research, Inc.

BREITENLECHNER, M., G. GEORGIADIS, AND B. SCHUMANN (2021): "What goes around comes around: How large are spillbacks from US monetary policy?" Working Papers 2021-05, Faculty of Economics and Statistics, University of Innsbruck.

BRUNO, V. AND H. S. SHIN (2015a): "Capital flows and the risk-taking channel of monetary policy," *Journal of Monetary Economics*, 71, 119–132.

——— (2015b): "Cross-Border Banking and Global Liquidity," *Review of Economic Studies*, 82, 535–564.

——— (2017): "Global Dollar Credit and Carry Trades: A Firm-Level Analysis," *Review of Financial Studies*, 30, 703–749.

CESA-BIANCHI, A., A. FERRERO, AND A. REBUCCI (2018): "International credit supply shocks," *Journal of International Economics*, 112, 219–237.

CHEN, J., T. M. GRIFFOLI, AND R. SAHAY (2014): "Spillovers from United States Monetary Policy on Emerging Markets; Different This Time?" IMF Working Papers 14/240, International Monetary Fund.

CIESLAK, A. AND A. SCHRIMPF (2019): "Non-monetary news in central bank communication," *Journal of International Economics*, 118, 293–315.

COCHRANE, J. H. AND M. PIAZZESI (2002): "The Fed and Interest Rates - A High-Frequency Identification," *American Economic Review*, 92, 90–95.

Dedola, L., G. Georgiadis, J. Gräb, and A. Mehl (2020): "Does a big bazooka matter? Quantitative easing policies and exchange rates," Tech. rep.

Dedola, L., G. Rivolta, and L. Stracca (2017): "If the Fed sneezes, who catches a cold?" *Journal of International Economics*, 108, 23–41.

Degasperi, R., S. S. Hong, and G. Ricco (2020): "The Global Transmission of U.S. Monetary Policy," *The Warwick Economics Research Paper Series (TWERPS) 1257, University of Warwick, Department of Economics*.

di Giovanni, J. and G. B. Hale (2020): "Stock Market Spillovers via the Global Production Network: Transmission of U.S. Monetary Policy," CEPR Discussion Papers 15404, C.E.P.R. Discussion Papers.

Eichenbaum, M. and C. L. Evans (1995): "Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates*," *The Quarterly Journal of Economics*, 110, 975–1009.

Farhi, E. and I. Werning (2014): "Dilemma Not Trilemma? Capital Controls and Exchange Rates with Volatile Capital Flows," *IMF Economic Review*, 62, 569–605.

Farrant, K. and G. Peersman (2006): "Is the Exchange Rate a Shock Absorber or a Source of Shocks? New Empirical Evidence," *Journal of Money, Credit and Banking*, 38, 939–961.

Faust, J. and J. H. Rogers (2003): "Monetary policy's role in exchange rate behavior," *Journal of Monetary Economics*, 50, 1403–1424.

Favara, G., S. Gilchrist, K. F. Lewis, and E. Zakrajšek (2016): "Updating the Recession Risk and the Excess Bond Premium," FEDS Notes 2016-10-06, Board of Governors of the Federal Reserve System (U.S.).

Fogli, A. and F. Perri (2015): "Macroeconomic volatility and external imbalances," *Journal of Monetary Economics*, 69, 1–15.

Franz, T. (2020): "Central Bank Information Shocks and Exchange Rates," Discussion papers, Deutsche Bundesbank.

Fratzscher, M., M. L. Duca, and R. Straub (2018): "On the International Spillovers of US Quantitative Easing," *Economic Journal*, 128, 330–377.

Fry, R. and A. Pagan (2011): "Sign Restrictions in Structural Vector Autoregressions: A Critical Review," *Journal of Economic Literature*, 49, 938–960.

Gerko, E. and H. Rey (2017): "Monetary Policy in the Capitals of Capital," *Journal of the European Economic Association*, 15, 721–745.

Gilchrist, S. and E. Zakrajsek (2012): "Credit Spreads and Business Cycle Fluctuations," *American Economic Review*, 102, 1692–1720.

Glick, R. and S. Leduc (2018): "Unconventional Monetary Policy and the Dollar: Conventional Signs, Unconventional Magnitudes," *International Journal of Central Banking*, 14, 103–152.

Goldberg, L. and C. Tille (2009): "Macroeconomic interdependence and the international role of the dollar," *Journal of Monetary Economics*, 56, 990–1003.

Gopinath, G. (2015): "The International Price System," NBER Working Papers 21646, National Bureau of Economic Research, Inc.

GÜRKAYNAK, R. S., B. SACK, AND E. SWANSON (2005): "Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements," *International Journal of Central Banking*, 1.

GÜRKAYNAK, R., H. KARA, B. KISACIKOĞLU, AND S. S. LEE (2020): "Monetary Policy Surprises and Exchange Rate Abnormalities," *mimeo*.

HAUSMAN, J. AND J. WONGSWAN (2011): "Global asset prices and FOMC announcements," *Journal of International Money and Finance*, 30, 547–571.

INOUE, A. AND B. ROSSI (2019): "The effects of conventional and unconventional monetary policy on exchange rates," *Journal of International Economics*, 118, 419–447.

JAROCIŃSKI, M. (2020): "Central bank information effects and transatlantic spillovers," Working Paper Series 2482, European Central Bank.

JAROCIŃSKI, M. AND P. KARADI (2020): "Deconstructing Monetary Policy Surprises—The Role of Information Shocks," *American Economic Journal: Macroeconomics*, 12, 1–43.

JURADO, K., S. C. LUDVIGSON, AND S. NG (2015): "Measuring Uncertainty," *American Economic Review*, 105, 1177–1216.

KALEMLI-OZCAN, S., E. PAPAIOANNOU, AND F. PERRI (2013): "Global banks and crisis transmission," *Journal of International Economics*, 89, 495–510.

KERSSENFISCHER, M. (2019): "Information effects of euro area monetary policy: New evidence from high-frequency futures data," Discussion Papers 07/2019, Deutsche Bundesbank.

KIM, S. AND N. ROUBINI (2000): "Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach," *Journal of Monetary Economics*, 45, 561 – 586.

KOLLMANN, R. (2016): "International business cycles and risk sharing with uncertainty shocks and recursive preferences," *Journal of Economic Dynamics and Control*, 72, 115–124.

KUTTNER, K. N. (2001): "Monetary policy surprises and interest rates: Evidence from the Fed funds futures market," *Journal of Monetary Economics*, 47, 523–544.

LILLEY, A., M. MAGGIORI, B. NEIMAN, AND J. SCHREGER (2019): "Exchange Rate Reconnect," *NBER Working Papers, National Bureau of Economic Research, Inc*.

LITTERMAN, R. B. (1979): "Techniques of forecasting using vector autoregressions," Tech. rep.

MCCAULEY, R. N. AND P. MCGUIRE (2009): "Dollar appreciation in 2008: safe haven, carry trades, dollar shortage and overhedging," *BIS Quarterly Review*.

MERTENS, K. AND M. O. RAVN (2013): "The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States," *American Economic Review*, 103, 1212–1247.

MIRANDA-AGRIPPINO, S. AND H. REY (2020): "U.S. Monetary Policy and the Global Financial Cycle," *Review of Economic Studies*, 87, 2754–2776.

MIRANDA-AGRIPPINO, S. AND G. RICCO (2021): "The Transmission of Monetary Policy Shocks," *American Economic Journal: Macroeconomics*, 13, 74–107.

MOUNDIGBAYE, M., W. REA, AND W. R. REED (2016): "More Evidence On "Which Panel Data Estimator Should I Use?"," Working Papers in Economics 16/18, University of Canterbury, Department of Economics and Finance.

NAKAMURA, E. AND J. STEINSSON (2018): "High-Frequency Identification of Monetary Non-Neutrality: The Information Effect," *The Quarterly Journal of Economics*, 133, 1283–1330.

NEELY, C. J. (2015): "Unconventional monetary policy had large international effects," *Journal of Banking & Finance*, 52, 101–111.

PASSARI, E. AND H. REY (2015): "Financial Flows and the International Monetary System," *Economic Journal*, 0, 675–698.

RANALDO, A. AND P. SÖDERLIND (2010): "Safe Haven Currencies," *Review of Finance*, 14, 385–407.

REY, H. (2013): "Dilemma not trilemma: the global cycle and monetary policy independence," *Proceedings - Economic Policy Symposium - Jackson Hole*, 1–2.

——— (2016): "International Channels of Transmission of Monetary Policy and the Mundellian Trilemma," *IMF Economic Review*, 64, 6–35.

ROGERS, J. H., C. SCOTTI, AND J. H. WRIGHT (2018): "Unconventional Monetary Policy and International Risk Premia," *Journal of Money, Credit and Banking*, 50, 1827–1850.

ROMER, D. H. AND C. D. ROMER (2000): "Federal Reserve Information and the Behavior of Interest Rates," *American Economic Review*, 90, 429–457.

RUBIO-RAMÍREZ, J. F., D. F. WAGGONER, AND T. ZHA (2010): "Structural Vector Autoregressions: Theory of Identification and Algorithms for Inference," *Review of Economic Studies*, 77, 665–696.

SOLON, G., S. J. HAIDER, AND J. WOOLDRIDGE (2013): "What Are We Weighting For?" NBER Working Papers 18859, National Bureau of Economic Research, Inc.

STAVRAKEVA, V. AND J. TANG (2015): "Exchange rates and monetary policy," Working Papers 15-16, Federal Reserve Bank of Boston.

——— (2019): "The Dollar During the Great Recession: US Monetary Policy Signaling and The Flight To Safety," CEPR Discussion Papers 14034, C.E.P.R. Discussion Papers.

STOCK, J. H. AND M. W. WATSON (2012): "Disentangling the Channels of the 2007-2009 Recession," NBER Working Papers 18094, National Bureau of Economic Research, Inc.

ZANETTI, F. AND W. LI (2016): "The Effect of Monetary Policy Shocks in the United Kingdom: an External Instruments Approach," Economics Series Working Papers 812, University of Oxford, Department of Economics.

Appendix A: Classification and choice of currencies

To classify currencies by 'developed markets' versus 'emerging markets', we make use of the MSCI Market Classification Framework. We refer the reader to their methodology document[9] for further details.

For illustrative purposes, developed markets and emerging markets are listed in Table A1.

Table A1: All MSCI Developed and Emerging Markets

MSCI Developed Markets		
Australia	Israel	Sweden
Canada	Japan	Switzerland
Denmark	New Zealand	United Kingdom
Euro area countries	Norway	United States
Hong Kong	Singapore	

MSCI Emerging Markets		
Argentina	India	Russia
Brazil	Indonesia	Saudi Arabia
Chile	Malaysia	South Africa
China	Mexico	South Korea
Colombia	Pakistan	Taiwan
Czech Republic	Peru	Thailand
Egypt	Philippines	Turkey
Greece	Poland	United Arab Emirates
Hungary	Qatar	

For reference, Euro area countries in the developed markets table comprises: Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, and Spain.

However, for developed and emerging markets, we filtered out some currencies for different reasons. For example, Denmark has its currency pegged to the Euro, and hence we cannot include the Danish Krone in our analysis. Equally, the Hong Kong dollar is pegged to the USD, and so likewise we cannot include it. Similarly we exclude Singapore as it is pegged to a basket of develop markets currencies. For emerging markets, we exclude currencies which are *de jure* pegged to another currency or basket of currencies. For illustrative purposes, this includes the Chinese Yuan and the Saudi Riyal, as they are pegged to the USD, and Greece, as its currency is the Euro. Information on whether a currency is pegged is obtained from the IMF's Annual Report on Exchange Arrangements Database. This database provides a long timeline of currency arrangements, and whether they are *de jure* or *de facto* pegged or floating, and whether it is a free float or managed float. We refer the reader to the IMF database for specifics on each currency. Ultimately, all currencies we include in our analysis are defined as either *de jure* or *de facto* floating, whether it be free floating or managed floating (whereby managed floating is not due to having an active exchange rate policy to maintain said country's currency in-line with another).

Subsequently, the currencies we make use of in our analysis are included in Table A2.

[9]Link: https://www.msci.com/documents/1296102/1330218/MSCI_Global_Market_Framework_2019.pdf

Table A2: Currencies included in our analysis

Developed Markets		
Australia	Japan	Switzerland
Canada	New Zealand	United Kingdom
Euro area countries	Norway	United States
Israel	Sweden	

Emerging Markets		
Argentina	Indonesia	Russia
Brazil*	Malaysia	South Africa*
Chile	Mexico*	South Korea*
Colombia	Peru	Taiwan*
Czech Republlic	Philippines	Thailand*
India*	Poland	Turkey

Note: All developed markets currencies listed in Table A2 are included in both the panel and the SVAR analysis. All emerging markets currencies listed in Table A2 are included in the panel analysis whereas only currencies marked with an asterisk (*) are included in the SVAR analysis; this is because they have a much longer history of data available which is preferable for tracing out time series dynamics.

Appendix B: Data and Sources

Table B1: High-Frequency Regressions - Data and Sources

Data	Source	Description
3-month Fed Funds Future Surprises	Jarociński and Karadi (2020)	3-month Fed Funds Future Surprises within a 30-minute window around FOMC announcements from 1990 to 2016.
S&P 500 Surprises	Jarociński and Karadi (2020)	S&P 500 Surprises within a 30-minute window around FOMC announcements from 1990 to 2016.
Global Risk Aversion	Bekaert et al. (2019)	Utility-Based Risk Aversion at daily frequency, computed from a set of variables including detrended earnings yield, corporate return spread (Baa-Aaa), term spread (10yr-3mth), equity return realized variance, corporate bond return realized variance, and equity risk-neutral variance.
Global Uncertainty	Bekaert et al. (2019)	Daily uncertainty measure computed from the monthly conditional variance of industrial production growth with a realistic Bad Environment-Good Environment innovation framework and a persistent conditional mean, projected onto the financial instruments used to span the Risk Aversion index.
VXO	Chicago Board Options Exchange	CBOE S&P 100 Volatility Index, Not Seasonally Adjusted, Daily Frequency, Close Price.
Emerging Market Flows	Institute of International Finance (IIF)	Daily and weekly data on non-resident portfolio flows to emerging markets (2005-2016). Included countries are China, Argentina, Bulgaria, Egypt, India, Brazil, Czech Republic, Lebanon, Indonesia, Chile, Hungary, Morocco, Malaysia, Colombia, Poland, Nigeria, Philippines, Ecuador, Romania, Saudi Arabia, South Korea, Mexico, Russia, South Africa, Thailand, Peru, Turkey, UAE, Venezuela, and Ukraine.

Table B2: BVAR - Data and Sources

Data	Source	Description
3-month Fed Funds Future Surprises	Jarociński and Karadi (2020)	3-month Fed Funds Future Surprises within a 30-minute window around FOMC announcements from 1990 to 2016.
S&P 500 Surprises	Jarociński and Karadi (2020)	S&P 500 Surprises within a 30-minute window around FOMC announcements from 1990 to 2016.
Effective Federal Funds Rate	Federal Reserve Bank of New York	Effective Federal Funds Rate set by the Federal Reserve.
S&P 500	S&P Dow Jones Indices LLC	Monthly average of the S&P 500, an index of the stocks of 500 leading companies in the US economy, representative of the large capitalisation U.S. equity market, in logs.
US Real GDP	U.S. Bureau of Economic Analysis	Inflation-adjusted annual level of the US economic output. Seasonally adjusted, interpolated to monthly frequency via cubic spline interpolation, and expressed in logs.
Global Real GDP	Federal Reserve of Dallas	Inflation-adjusted annual level of the global economy output (excluding the US). Seasonally adjusted, interpolated to monthly frequency via cubic spline interpolation, and expressed in logs.
US Real Industrial Production	U.S. Bureau of Economic Analysis	Inflation-adjusted monthly index of real output for all facilities located in the U.S. in manufacturing, mining, and electric and gas industries, monthly, seasonally adjusted, deflated with the US CPI, expressed in logs.
Global Real Industrial Production	Federal Reserve of Dallas	Inflation-adjusted monthly index of real output for all facilities located in all countries excluding the US in manufacturing, mining, and electric and gas industries, monthly, seasonally adjusted.
US GDP Deflator	U.S. Bureau of Economic Analysis	Level of prices of all new goods and services produced by labor and property located in the U.S. Seasonally adjusted, interpolated to monthly frequency via cubic spline interpolation, and expressed in logs.
US CPI	U.S. Bureau of Labor Statistics	Inflation measure derived from tracking the changes in the weighted-average price of a basket of common goods and services.
Excess Bond Premium	Favara et al. (2016)	Monthly Excess Bond Premium as in Gilchrist and Zakrajsek (2012).
Global Risk Aversion	Bekaert et al. (2019)	Utility-Based Risk Aversion at daily frequency, computed from a set of variables including detrended earnings yield, corporate return spread (Baa-Aaa), term spread (10yr-3mth), equity return realized variance, corporate bond return realized variance, and equity risk-neutral variance (1990-2016)
VXO	Chicago Board Options Exchange	CBOE S&P 100 Volatility Index, Not Seasonally Adjusted, Monthly Average.
USD Return	Board of Governors of the Federal Reserve System	Monthly return of a weighted average of the foreign exchange value of the U.S. dollar against the currencies of a broad group of major U.S. trading partners.
Trade Balance-to-GDP	U.S. Bureau of Economic Analysis	Seasonally adjusted trade balance divided by nominal GDP, interpolated to monthly frequency using a cubic spline interpolation.
Broker-Dealers Leverage Ratio	FRB flow of funds	Leverage of the financial intermediaries in the US, calculated by dividing financial assets by equity.
Cross-Border Credit	BIS	Foreign liabilities (all instruments, in all currencies, in all countries except the US) of all BIS reporting banks vis-à-vis all sectors deflated by US consumer price inflation, similarly to Cesa-Bianchi et al. (2018).

Appendix C: Additional Results and Robustness Checks

Table 6: Global Risk Aversion [Bekaert et al. (2013)]

	Dependent variable:
	Global Risk Aversion
Monetary Policy	43.91***
	(12.84)
Central Bank Information	-42.15**
	(19.13)

Note: Authors' calculations. Values reported are coefficient estimates from ordinary least squares, standard errors are below in parenthesis. Three asterisks indicate 1% significance level, two indicate 5%, and one indicates 10%. A positive sign indicates a higher risk aversion, a higher uncertainty, or a higher volatility, and a negative sign indicates a lower risk aversion, a lower uncertainty, or a lower volatility.

Table 7: Risk Appetite [Miranda-Agrippino and Rey (2020)]

	Dependent variable:
	Risk Appetite
Monetary Policy	-37.67***
	(8.42)
Central Bank Information	26.69**
	(12.55)

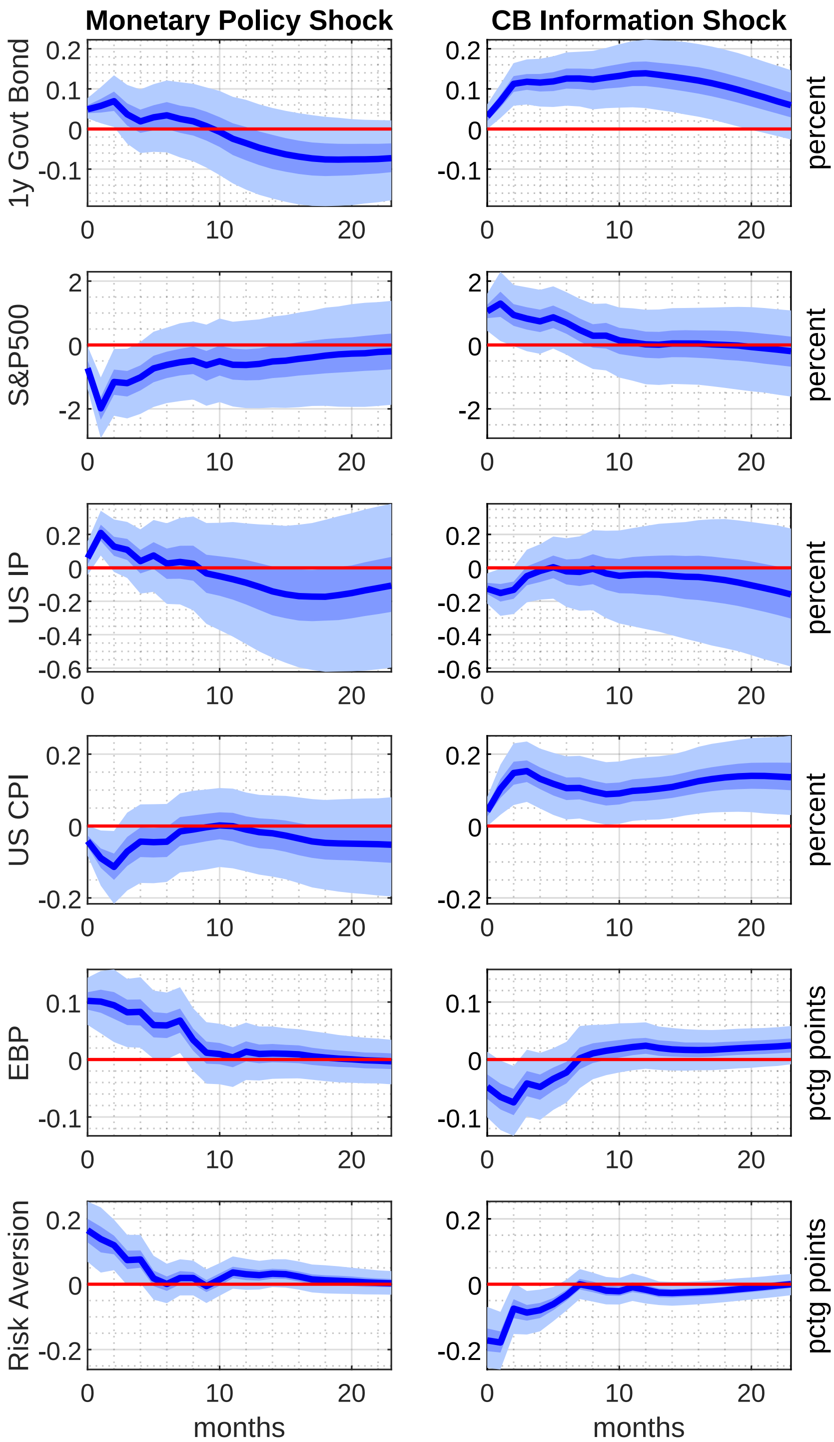
Note: Authors' calculations. Values reported are coefficient estimates from ordinary least squares, standard errors are below in parenthesis. Three asterisks indicate 1% significance level, two indicate 5%, and one indicates 10%. A positive sign indicates a higher risk aversion, a higher uncertainty, or a higher volatility, and a negative sign indicates a lower risk aversion, a lower uncertainty, or a lower volatility.

Table 8: Flows to Emerging Markets (cumulative change during the three days following the announcement, as a percentage of global GDP)

	Dependent variable:		
	Total	Equity	Debt
	(1)	(2)	(3)
Monetary Policy Shock	-0.13***	-0.12***	-0.01
	(0.05)	(0.04)	(0.02)
Central Bank Information Shock	0.13**	0.07	0.06**
	(0.06)	(0.05)	(0.02)

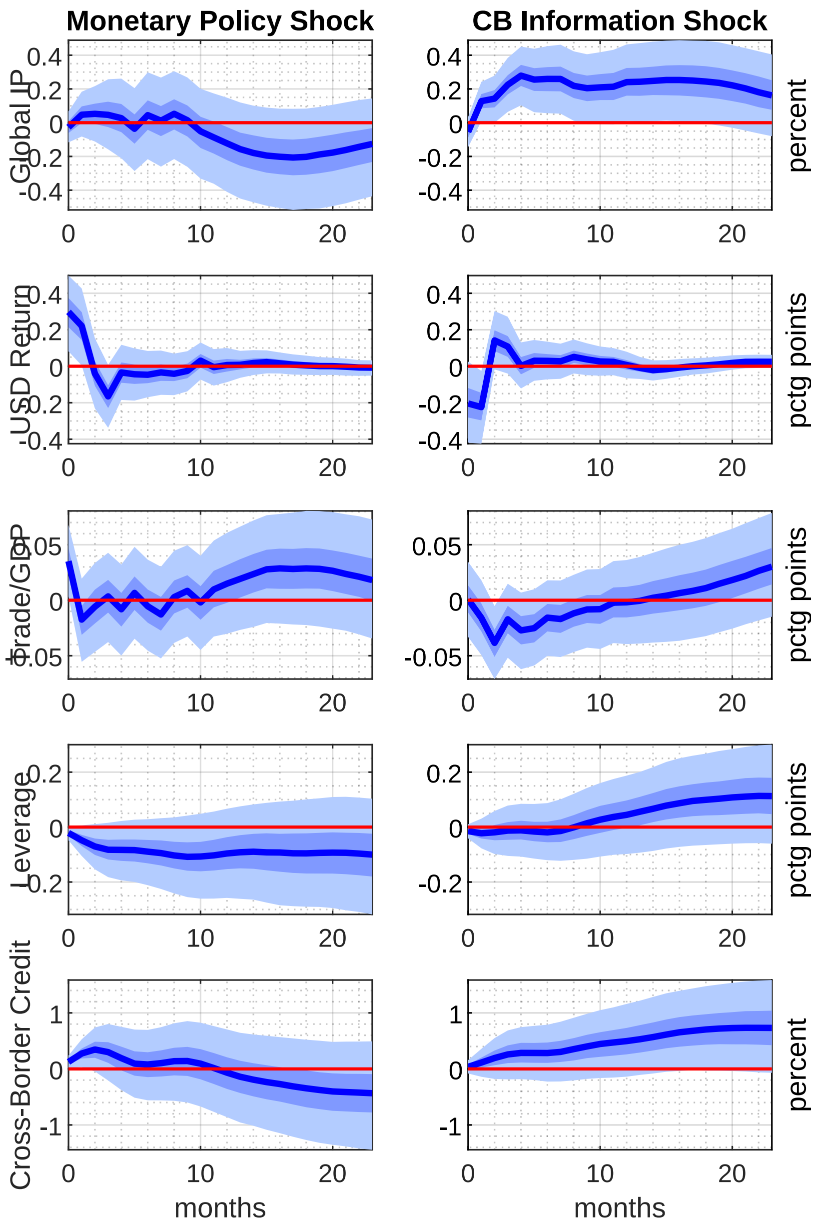
Note: Authors' calculations. Values reported are coefficient estimates from ordinary least squares, standard errors are below in parenthesis. Three asterisks indicate 1% significance level, two indicate 5%, and one indicates 10%. A positive sign indicates an inflow into emerging markets, and a negative sign an outflow from emerging markets.

Figure 3: Estimated responses to US monetary policy and central bank information shocks



The figure displays the estimated dynamic response of US monetary policy and central bank information shocks as identified by the sign restrictions identification scheme. Blue lines indicate point estimates, blue areas outline 68% and 90% confidence bands. This version includes Industrial Production and the CPI Inflation as opposed to GDP and the GDP deflator. The shock is associated with a 5bp increase of the 1-year Federal funds rate.

Figure 4: Estimated responses to US monetary policy and central bank information shocks



The figure displays the estimated dynamic response of US monetary policy and central bank information shocks as identified by our Bayesian SVAR model. Blue lines indicate point estimates, blue areas outline 68% and 90% confidence bands. This version includes Industrial Production and the CPI Inflation as opposed to GDP and the GDP deflator. The shock is associated with a 5bp increase of the 1-year Federal funds rate.