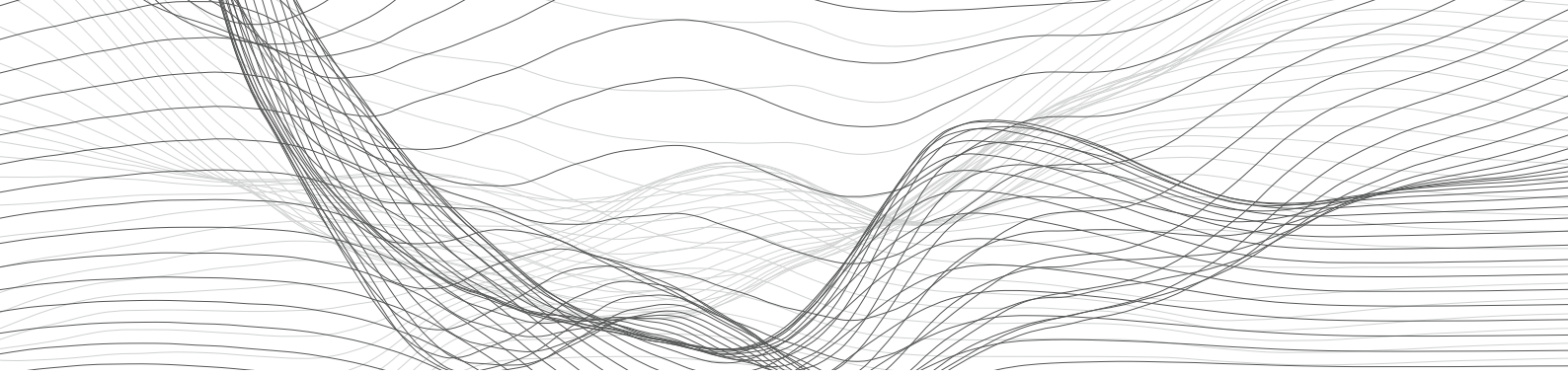

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Stock market evidence on the international transmission channels of US monetary policy surprises*

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Abstract

We decompose unexpected movements in the stock market returns of 40 countries into different news components to assess why expansionary US monetary policy surprises are good news for stock markets. Our results suggest that prior to the zero lower bound (ZLB) period, federal funds rate surprises affect foreign stock markets mainly because such surprises are associated with news about future real interest rates. The effects of forward guidance surprises are negligible. At the

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ZLB, large-scale asset purchases (LSAP) reflect more than commitment to forward guidance. LSAP surprises constitute cash-flow news, while unanticipated forward guidance primarily reflects real interest rate news.

JEL: E44, E52, F36, G15

KEYWORDS: international spillovers, news, monetary policy, stock returns, vector autoregression

1 Introduction

Expansionary US monetary policy surprises tend to be good news for stock markets worldwide (Ammer et al., 2010; Brusa et al., 2019; Ehrmann and Fratzscher, 2009; Jiang et al., 2019; Miranda-Aggripino and Rey, 2018; Thorbecke, 1997; Wongswan, 2009). While this evidence is persuasive, the underlying reasons for foreign stock markets' responses to US monetary policy surprises remain elusive.

In a textbook world, monetary policymakers set the short-term interest rate, influence expectations about future short-term interest rates and thus affect asset prices. However, there is growing evidence, based on high-frequency data, that non-monetary information, e.g., the central bank's growth outlook or risk assessments, is an important part of central bank communication to which financial markets respond (Campbell et al., 2012; Campbell et al., 2017; Cieslak and Schrimpf, 2019; Jarocinski and Karadi, 2019; Kroencke et al., 2019; Nakamura and Steinsson, 2018; Miranda-Aggripino and Ricco, 2019).[1] Indeed, Bernanke and Kuttner (2005) show that federal funds rate surprises affect US stock markets to a large extent through their impact on expectations of future excess returns.

This background raises the question of the channels through which US

[1]Madeira and Madeira (2019) show in a high-frequency event study that even the degree of consent among members of the Fed's Federal Open Market Committee affects stock prices.

monetary policy surprises influence foreign stock markets. Do foreign stock markets respond to US monetary policy surprises because US monetary policy affects expectations of real interest rates? Do they respond because the Fed influences expectations about future cash flows or about future risk premia? Do unconventional monetary policy measures, e.g., large-scale asset purchases (LSAP), affect stock markets through the same channels as conventional measures, such as changes in the federal funds rate?

To shed light on these issues, we build on Bernanke and Kuttner (2005) and extend their analysis by assessing whether US monetary policy surprises occurring in the period from 1991 to 2015 are associated with unexpected stock return movements in 40 developed and emerging economies.[2] Moreover, we combine the vector autoregressive model (VAR) of Bernanke and Kuttner (2005) with the decomposition of unexpected variation in excess returns on US dollar (USD)-denominated stock indices performed by Ammer and Mei (1996). In addition to components reflecting cash-flow news, real interest rate news and news about future excess returns, this decomposition gives us a return component related to real exchange rate news. Hence, we are able to directly evaluate whether the different types of US monetary policy surprises affect expectations about foreign countries' real exchange rates against the USD. Finally, since our sample period covers the zero lower bound (ZLB) period for the fed funds rate, we also take forward guidance and LSAP surprises into account. This allows us to assess whether we observe differences in the impact on foreign stock markets among the three different types of US monetary policy surprises. We employ the proxies of fed funds rate, forward guidance and LSAP surprises proposed by Swanson (2018) in our empirical

[2]We use the MSCI classification of developed and emerging markets as of December 2018 for this distinction and use MSCI standard stock market indices in our empirical analysis. Note that inclusion of a firm's stock in the MSCI indices requires the stock to fulfil certain quality criteria and to offer the opportunity for both domestic and foreign investors to invest in it. Therefore, using the MSCI indices allows us to directly compare evidence for developed markets with that for emerging markets.

analysis.[3]

Distinguishing between the different components of unexpected foreign stock market returns reveals that fed funds rate surprises statistically significantly affect real interest rate news prior to the ZLB period. This is the main channel through which US monetary policy surprises influenced all foreign stock markets from 1991 to 2008. Economically, however, cash-flow and excess return news are by far more important than real interest rate news, but the link between cash-flow and excess return news and US monetary policy surprises is less significant in statistical terms. Forward guidance surprises are only associated with unexpected movements in some of the foreign stock market returns under study. In addition, there is no clear evidence of a particular channel through which forward guidance transmits to foreign stock markets.

In the ZLB period from 2009 to 2015, forward guidance primarily affected foreign stock markets through real interest rate news. We find an association between forward guidance surprises and cash-flow and expected return news for some of the countries under study as well, but the overall statistical significance for these news components is weaker than for real interest rate news. The signs of the responses also vary across countries. Furthermore, our findings suggest that LSAP surprises have an impact on foreign stock markets that goes beyond commitment to forward guidance (Swanson, 2018). LSAP surprises mainly affect foreign stock markets through revisions in expectations about the future stream of dividends (cash-flow news), which are related to the long-term growth prospects of an economy (Ammer and Mei, 1996; Campbell, 1991; Campbell and Vuolteenaho, 2004; Lucas, 1978). LSAP surprises have no impact on real interest rate news.

Moreover, US monetary policy surprises are only weakly associated with revisions in expectations about future real exchange rates. We find that

[3]We are grateful to Eric Swanson for sharing the monetary policy surprise series with us.

LSAP surprises affect stock market returns of emerging markets through real exchange rate news. However, real exchange rate news only explains a small proportion of the unexpected variation in stock market returns. Thus, our findings are in line with the recent event study evidence by Brusa et al. (2019) and suggest that the impact of US monetary policy surprises on foreign stock markets through real exchange rate news is very small. However, this does not mean that the overall exchange rate effects of US monetary policy surprises are negligible. Our results are focused on unexpected movements in stock market returns and not on macroeconomic aggregates.

Overall, our empirical assessments highlight that the link between monetary policy surprises in the US and unexpected stock return movements abroad is significant for developed and emerging markets and for economies with fixed or floating exchange rate systems. The channels, i.e., return news components related to monetary policy surprises, differ between the period before the ZLB and the ZLB period but are similar for both emerging and developed markets. Our analysis, however, provides only little evidence in favour of the recently proposed information effect of Fed communication (Nakamura and Steinsson, 2018). According to the information effect, Fed communication of tightening (loosening) monetary policy constitutes good (bad) news about the economic outlook. We do not find compelling evidence of this effect in our analysis. While the direction of the link between forward guidance surprises and unexpected stock market movements is not clear for some of the countries in our sample, expansionary fed funds rate or LSAP surprises constitute good news for foreign stock markets in the vast majority of cases. Bauer and Swanson (2020) argue that such stock market reactions are inconsistent with an information effect of the Fed's monetary policy communication.

It is beyond the scope of this paper to pinpoint the exact economic and theoretical mechanism underlying our empirical findings. However, we view our results as consistent with an explanation based on the existence of a

global financial cycle. The global financial cycle, i.e., common movements in risky asset prices, cross-border borrowing and lending, and macroeconomic aggregates, appears to be affected by changes in monetary policy in the US, the dominant country in the international financial system (Rey, 2016; Miranda-Aggripino and Rey, 2018). Jiang et al. (2019) rationalize the observation of a global financial cycle with a model in which US monetary policy affects the supply of safe USD-denominated assets. These assets play a central role as collateral for banks worldwide and thus open the door for US monetary policy to influence the risk-bearing capacity of banks across the globe and thus their pricing of risk as reflected in stock prices and returns.

The remainder of the paper is organized as follows. Section 2 highlights the main contributions of our paper in the context of the related literature. Section 3 provides the background for the decomposition of unexpected stock market returns into different news components. Section 4 introduces the empirical framework to obtain the effects of monetary policy surprises on the news components. Details on the data are outlined in section 5. Section 6 presents the main empirical results, and section 7 concludes. The appendix at the end of the paper provides further details.

2 Main contributions and related literature

The empirical analyses of our paper rely on the VAR models of Campbell (1991) and Ammer and Mei (1996) to decompose unexpected movements in asset returns into components reflecting revisions in expectations about cash flows, expected returns, real interest rates and the real exchange rate. Distinguishing between different news components is important because cash-flow news reflects a revision in expectations about the entire stream of dividends and is thus related to the long-term growth prospects of an economy (Lucas, 1978). Cash-flow news hence has a persistent impact on asset returns. Expected return news has a temporary impact because a capital loss due to

adverse expected return news today will be compensated by the expectation of higher returns in the future (Campbell and Vuolteenaho, 2004).

To link the different return news components to monetary policy surprises, we employ a VAR with exogenous variables that is similar to the empirical framework of Bernanke and Kuttner (2005). However, we do not focus on the US but analyse a sample of 40 developed and emerging markets. Furthermore, we evaluate the responses of different stock return news components to three different types of monetary policy surprises (fed funds rate, forward guidance, and LSAP) because our sample includes the ZLB period during which the Fed resorted to unconventional measures. We thus complement Rogers et al. (2018), who use a VAR framework with exogenously approximated monetary policy surprises related to the different facets of the Fed's monetary policy to study the impact of US monetary policy surprises on bond premia and forward exchange rate premia (relative to USD) in the euro area, Japan and the UK. We focus on stock markets and employ a similar, but slightly different, VAR framework that allows for a detailed distinction between different international transmission channels of US monetary policy, and our sample includes more countries.

Moreover, Paul (2019) uses monetary policy surprises as exogenous variables in a VAR system that includes macroeconomic aggregates as well as US stock and house prices. He shows that fed funds rate surprises are directly interpretable as monetary policy shocks while other monetary policy surprises, e.g., forward guidance, cannot be taken as a direct proxy of monetary policy shocks. This is why, for example, Gertler and Karadi (2015) use monetary policy surprises as an external instrument to identify monetary policy shocks. In this context, it is important to note that we do not attempt to look at monetary policy shocks. We focus on surprises that are, by construction, orthogonal to each other, such that we can assess differences in the responses of the stock return news components to the different surprises. Furthermore, we do not look explicitly at macroeconomic aggregates in our VAR setting,

but we note that the different stock market return news components are interpretable in a macroeconomic way. For example, Ammer and Mei (1996) analyse the cross-country correlations of cash-flow and expected return news between the US and the UK to evaluate the degree of real and financial integration between the two countries. They argue that cash-flow news can be interpreted as news about the real economy, i.e., economic growth, while news about future returns reflects news about the price of risk.

In addition, our paper complements event studies of the effects of US monetary policy on foreign economies' bond and stock markets as well as the responses of foreign exchange rates to US monetary policy surprises (Albagli et al., 2019; Ammer et al., 2010; Ehrmann and Fratzscher, 2009; Hausman and Wongswan, 2011; Swanson, 2019; Wongswan, 2009). Unlike these studies, our monthly VAR estimations allow us to distinguish the effects of monetary policy surprises on different components of asset returns. These components reflect revisions in expectations and are thus not directly comparable to simple changes in stock prices. However, our stock return decompositions have to include short-term real interest rates and real exchange rates directly into the VAR system. Therefore, we need information about consumer price indices. The highest frequency at which these data are available is monthly.

Moreover, our assessment of the link between the three different types of US monetary policy surprises and the four news components of emerging economies' stock market returns gives us a better understanding of the channels through which monetary policy surprises in the US affect emerging markets. This assessment complements studies that assess the impact of US monetary policy on emerging markets' macroeconomic aggregates (e.g., Vicondoa, 2019) and financial markets (e.g., Akinci, 2013; Fratzscher et al., 2018), and it corroborates that monetary policy surprises in the US have important real economic implications for emerging markets.

Finally, our paper contributes to and is consistent with the growing lit-

erature on the emergence of a global financial cycle and its importance for the valuation of assets. Miranda-Aggripino and Rey (2018) show that one global risk factor accounts for non-negligible amounts of the variation in a broad set of risky asset prices around the world. This global factor in asset prices responds to US monetary policy changes. Jiang et al. (2019) provide a theoretical mechanism for this empirical finding. The mechanism is based on the notion that there is special demand for USD-denominated safe assets from financial intermediaries worldwide (e.g., McCauley and McGuire, 2009). US monetary policy, e.g., LSAP, affects the supply of these safe assets, such that the risk-bearing capacity and hence the risk appetite of financial intermediaries are affected. Our results of a statistically significant link between US monetary policy surprises and unexpected variation in the stock market returns of both developed and emerging countries are consistent with this economic mechanism.

3 Economic background: decomposing unexpected variation in stock market returns

Our empirical assessments of the effects of US monetary policy surprises on foreign stock markets are based on a decomposition of unexpected variation in stock market returns into different components. This decomposition relies on a dynamic accounting identity that relates asset returns to expected cash flows and discount rates (Campbell and Shiller, 1988; Campbell, 1991). This accounting identity is based on the two-period version of the present value model that links current stock prices to dividends and returns, i.e.,

$$1 + r_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t} \tag{1}$$

with r, denoting the net return on the stock, P, the stock price excluding dividends, and D, dividends. Equation (1) implies that if stock prices and

dividends are non-stationary, then returns should be stationary. However, stock returns vary at business-cycle frequencies, as risk aversion varies over the business cycle. To allow for time variation in returns, Campbell and Shiller (1988) propose a log-linear approximation of equation (1) around the mean dividend-price ratio. This approximation yields

$$r_{t+1} \approx k + \rho p_{t+1} + (1-\rho)d_{t+1} - p_t \tag{2}$$

in which lower-case letters denote logarithms of the variables. The letter k summarizes the constant terms that result from the Taylor expansion, and $\rho = 1/(1+\exp(d-p))$ is a weight that follows from the log-linearization. This weight depends on the long-run mean of the log dividend-price ratio, d–p, around which equation (1) is linearized. Rearranging equation (2) for the stock price, $p_t \approx k + \rho p_{t+1} + (1-\rho)d_{t+1} - r_{t+1}$ and expanding to the infinite horizon gives a representation of unexpected variation in stock returns. This expansion imposes the condition that discounted stock prices cannot grow forever, $\lim_{j\to\infty} \rho^j p_{t+j} = 0$.

Taking expectations on both sides of the equation gives

$$p_t = \frac{k}{1-\rho} + E_t\left[\sum_{j=0}^{\infty} \rho^j((1-\rho)d_{t+1+j} - r_{t+1+j})\right] \tag{3}$$

with E being the expectation operator conditional on information at time t. Substituting equation (3) into equation (2), Campbell (1991) highlights that unexpected changes in stock returns reflect either news (revisions in expectations) of dividend growth or future discount rates, i.e.,

$$r_{t+1} - E_t r_{t+1} = (E_{t+1} - E_t)\sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j} - (E_{t+1} - E_t)\sum_{j=0}^{\infty} \rho^j r_{t+1+j} \tag{4}$$

To study excess returns, i.e., stock returns in excess of a short-term debt

rate, equation (4) can be rewritten as

$$rx_{t+1} - E_t rx_{t+1} = (E_{t+1} - E_t) \left\{ \sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j} - \sum_{j=0}^{\infty} \rho^j rr_{t+1+j} - \sum_{j=1}^{\infty} \rho^j rx_{t+1+j} \right\} \tag{5}$$

Here, we decompose the discount rate, r, into the short-term real interest rates, rr, and a risk premium term, rx.

For notational convenience, equation (5) can be rewritten as

$$\eta_{t+1}^{T} = \eta_{t+1}^{cf} - \eta_{t+1}^{rr} - \eta_{t+1}^{rx} \tag{6}$$

with $\eta_{t+1}^{T} \equiv rx_{t+1} - E_t rx_{t+1}$ being the unexpected stock market excess return, $\eta_{t+1}^{cf} \equiv (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j}$, being the news of future cash flows (dividends), $\eta_{t+1}^{rr} \equiv (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j rr_{t+1+j}$, being the news of the real interest rate, and finally $\eta_{t+1}^{rx} \equiv (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j rx_{t+1+j}$ being the news of future excess returns, which can be interpreted as a proxy of expected risk premia. Following from this accounting identity, a positive surprise movement in the excess stock market return is associated with positive dividend news, lower than expected real interest rates, lower than expected future excess returns or an arbitrary combination of the three.

Equation (5) also holds for foreign stock returns and can be written as

$$rx_{t+1}^{*} - E_t rx_{t+1}^{*} = (E_{t+1} - E_t) \left\{ \sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j}^{*} - \sum_{j=0}^{\infty} \rho^j rr_{t+1+j}^{*} - \sum_{j=1}^{\infty} \rho^j rx_{t+1+j}^{*} \right\} \tag{7}$$

with asterisk superscripts denoting a foreign variable. Following Ammer and Mei (1996), we focus on the foreign stock return denominated in USD in excess of the US short-term interest rate, frx.

The innovation in foreign excess stock returns can be expressed as

$$frx_{t+1} - E_t frx_{t+1} = (E_{t+1} - E_t)\Big[\sum_{j=0}^{\infty}(\rho^*)^j \Delta d^*_{t+1+j} - \sum_{j=0}^{\infty}(\rho^*)^j rr_{t+1+j} - \sum_{j=0}^{\infty}(\rho^*)^j \Delta q_{t+1+j} - \sum_{j=1}^{\infty}(\rho^*)^j rx^*_{t+1+j}\Big] \tag{8}$$

Here, q represents the real exchange rate, which is denominated in foreign currency as a unit of domestic currency (USD). Again for the purpose of notational convenience, equation (8) can be rewritten as

$$f^T_{t+1} = f^{cf}_{t+1} - f^{rr}_{t+1} - f^q_{t+1} - f^{rx}_{t+1} \tag{9}$$

in which $f^T_{t+1} \equiv frx_{t+1} - E_t frx_{t+1}$ denotes the unexpected foreign stock market excess return denominated in US dollars, $f^{cf}_{t+1} \equiv (E_{t+1} - E_t)\sum_{j=0}^{\infty}(\rho^*)^j \Delta d^*_{t+1+i}$ is the news of future foreign cash flows (dividends), $f^{rr}_{t+1} \equiv (E_{t+1} - E_t)\sum_{j=0}^{\infty}(\rho^*)^j rr_{t+1+j}$ represents the news about the US real interest rate, $f^q_{t+1} \equiv (E_{t+1} - E_t)\sum_{j=0}^{\infty}(\rho^*)^j \Delta q_{t+1+i}$ gives the news about the exchange rate and finally $f^{rx}_{t+1} \equiv (E_{t+1} - E_t)\sum_{j=1}^{\infty}(\rho^*)^j rx^*_{t+1+j}$ denotes the news about future foreign excess returns.

The effect of f^{cf}, f^{rr} and f^{rx} on unexpected excess returns can be interpreted analogously to their corresponding news term in equation (6). The intuition behind the negative sign on exchange rate news f^q is that, ceteris paribus, news about a future USD appreciation must have an adverse impact on the returns of foreign assets denominated in USD.

4 Empirical framework

4.1 The VAR

Estimates of all news terms defined in section 3 can be computed using a VAR that includes the excess return on a stock market and variables that predict returns. In the literature, this has been done by a VAR specification as in

equation (10). For notational flexibility, this process is stated in first order. This notation also represents a higher-order process written as a first-order VAR in companion form

$$z_{t+1} = \Gamma z_t + \epsilon_{t+1} \tag{10}$$

Here, z_{t+1} is a vector of the endogenous variables, Γ denotes the companion matrix and ϵ is an i.i.d. error vector. As we are interested in the effect of monetary policy surprises, abbreviated with ΔM_t^u, on the different news terms, we include the surprise series as exogenous variables in the VAR

$$z_{t+1} = \Gamma z_t + \phi \Delta M_{t+1}^u + \Psi_{t+1}, \tag{11}$$

where ϕ captures the response of the endogenous variables in the VAR to the contemporaneous monetary policy surprises and Ψ_{t+1} is the new error term. This error term is, by construction, orthogonal to our monetary policy surprise series ΔM^u. This splits our baseline error term ϵ_{t+1} in equation (10) into innovations in monetary policy and innovations in all other factors unrelated to monetary policy.

The estimated regression model has the form

$$A(L)y_{t+1} = y_{t+1} - \sum_{l=0}^{p-1} A^{l+1} y_{t-l} - \phi \Delta M_{t+1}^u = \Psi_{t+1} \tag{12}$$

where $A(L)$ is a polynomial of order p and $y_{t+1} = [y_{1,t+1}, y_{2,t+1}, \ldots, y_{K-1,t+1}, y_{K,t+1}]'$ is a column vector with K endogenous variables in the VAR. Thus, the companion matrix is of the form

$$\Gamma = \begin{pmatrix} A_1 & A_2 & \cdots & A_{p-1} & A_p \\ I & 0 & \cdots & 0 & 0 \\ 0 & I & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & I & 0 \end{pmatrix}$$

with I, the identity matrix, and A_i both being matrices of dimensions $(K \times K)$, where $i \in \{1, 2, \ldots, p-1, p\}$. In this case, the left-hand-side vector in equation (10) is $z_{t+1} = [y_{t+1}, y_t, \ldots, y_{t+1-p}, y_{t-p}]'$. As the VAR in equation (11) is also presented in companion form, it can be rewritten as:

$$\begin{pmatrix} y_{t+1} \\ y_t \\ \vdots \\ y_{t+1-p} \\ y_{t-p} \end{pmatrix} = \begin{pmatrix} A_1 & A_2 & \cdots & A_{p-1} & A_p \\ I & 0 & \cdots & 0 & 0 \\ 0 & I & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & I & 0 \end{pmatrix} \begin{pmatrix} y_t \\ y_{t-1} \\ \vdots \\ y_{t-p} \\ y_{t-p-1} \end{pmatrix} + \begin{pmatrix} \Phi & 0 & \cdots & 0 \\ 0 & 0 & \cdots & 0 \\ 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 0 \end{pmatrix} \begin{pmatrix} \Delta m^u_{t+1} \\ 0 \\ \vdots \\ 0 \end{pmatrix} + \begin{pmatrix} \psi_{t+1} \\ 0 \\ 0 \\ \vdots \\ 0 \end{pmatrix},$$

where Φ is a $(K \times s)$-matrix of the monetary surprise coefficients, with s being the number of the surprise series and ϕ being the corresponding matrix in companion form with dimensions $((K * p) \times (K * s))$ such that $\phi \equiv \begin{pmatrix} \Phi & 0 & \cdots & 0 & 0 \\ 0 & 0 & \cdots & 0 & 0 \\ 0 & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & 0 & 0 \end{pmatrix}$.

The vector of monetary policy surprises $\Delta M^u_{t+1} \equiv [\Delta m^u_{t+1}, 0, 0, \ldots, 0]'$ has dimensions $((3*p) \times 1)$, and the error vector $\Psi_{t+1} \equiv [\psi_{t+1}, 0, 0, \ldots, 0]'$ has dimensions $((K * p) \times 1)$.

In the subsequence, we report the results from estimating equation (11) for each of the two sample periods: from 1991 to 2008 (the pre-ZLB period) and from 2009 to 2015 (the ZLB period). Alternatively, one could apply a two-step procedure. Bernanke and Kuttner (2005) argue that vector ΔM^u_{t+1} represents a prediction error from a rational forecast at time t and should therefore be orthogonal to the endogenous variables z_t. Thus, one can obtain consistent estimates of both Γ and ϕ from a two-step estimation. The first step is to run the baseline VAR in equation (10) without the exogenous monetary policy surprises to estimate Γ and to extract ϵ_{t+1}. To obtain an estimate of ϕ, one has to regress the VAR's one-

month-ahead forecast error ϵ_{t+1} in a second step on the monetary policy surprises ΔM^u_{t+1}. Applying the two-step procedure leads to qualitatively similar results as our preferred direct, one-stage estimation of equation (11).

4.2 The news

To estimate the domestic (US) news terms η^T,η^{cf},η^{rr} and η^{rx}, we stack four endogenous variables into the VAR. The first variable in the VAR is the US excess return rx_{t+1}, the second variable is the US real interest rate rr_{t+1}, the third variable is the US yield spread ys_{t+1} and finally the fourth variable is the dividend-price ratio δ_{t+1}.[4] In addition, we include three different exogenous monetary policy surprise series $\Delta M^u_{t+1} = [\Delta i^u_{t+1}, \Delta g^u_{t+1}, \Delta l^u_{t+1}]'$. These series are based on the high-frequency identification proposed by Swanson (2018), with Δi^u_t representing unanticipated changes in the fed funds rate, Δg^u_t representing unanticipated changes in forward guidance and Δl^u representing unanticipated changes in large-scale asset purchases. [5] With $\epsilon_{t+1} \equiv (\phi \Delta M^u_{t+1} + \Psi_{t+1})$ and using Γ and ϕ, one can then calculate the different domestic news terms as follows

$$\eta^T_{t+1} = \lambda_1^{'} \epsilon_{t+1} \tag{13}$$

$$\eta^{rx}_{t+1} = \lambda_1^{'} \rho \Gamma (I - \rho \Gamma)^{-1} \epsilon_{t+1} \tag{14}$$

$$\eta^{rr}_{t+1} = \lambda_2^{'} (I - \rho \Gamma)^{-1} \epsilon_{t+1} \tag{15}$$

$$\eta^{cf}_{t+1} = \eta^T_{t+1} + \eta^{rx}_{t+1} + \eta^{rr}_{t+1}, \tag{16}$$

where ρ is a discount factor. In addition, we define $\lambda_1 = [1, 0, 0, 0]'$ to pick rx and λ_2 in an analogous fashion.

Based on the approach proposed by Ammer and Mei (1996), we stack seven endogenous variables into the VAR for foreign stock market returns to estimate foreign news terms f^T,f^{cf},f^{rr}, f^{rx} and f^q. In addition to the four variables used to es-

[4]The data section presents the exact definitions of the variables.

[5]Appendix A briefly describes the high-frequency identification strategy and section 5 describes how we convert the high-frequency surprises on event days into a monthly time series for the empirical analysis.

timate domestic news terms, we include the foreign stock market excess retun rx^*_{t+1} , the change in the log real exchange rate Δq_{t+1} and the foreign dividend-price ratio δ^*_{t+1}. The variables are ordered such that $z_t = [rx_{t+1}, rx^*_{t+1}, rr_{t+1}, \Delta q_{t+1}, \delta^*_{t+1}, ys_{t+1}, \delta_{t+1}]'$. Again using Γ and ϕ, one can then calculate the different foreign news terms as follows

$$f^T_{t+1} = \Lambda_2^{'} \epsilon_{t+1} \tag{17}$$

$$f^{rx}_{t+1} = \Lambda_2^{'} \rho^* \Gamma (I - \rho^* \Gamma)^{-1} \epsilon_{t+1} \tag{18}$$

$$f^{rr}_{t+1} = \Lambda_3^{'} (I - \rho^* \Gamma)^{-1} \epsilon_{t+1} \tag{19}$$

$$f^{q}_{t+1} = \Lambda_4^{'} (1 - \rho^*)(I - \rho^* \Gamma)^{-1} \epsilon_{t+1} \tag{20}$$

$$f^{cf}_{t+1} = f^T_{t+1} + f^{rx}_{t+1} + f^{rr}_{t+1} + f^{q}_{t+1} \tag{21}$$

Here, we define $\Lambda_2 = [0, 1, 0, 0, 0, 0, 0]'$ to pick rx^* and define Λ_3 and Λ_4 in an analogous fashion.

We need rx^*_{t+1},rr_{t+1} and Δq_{t+1} to estimate the different news components. All of the other variables should be predictors of foreign stock market returns. The choice of variables in our VAR system for all of the foreign (non-US) stock markets reflects our aim of basing the empirical results for developed and emerging markets on similar VAR systems to make the results comparable. That is why, for example, we do not include foreign markets' yield spreads into the system, because data on government bond yields for a sufficiently long time span are not available for most of the emerging markets in our sample. In addition, based on the advice of Engsted et al. (2012), we include foreign stock markets' dividend-price ratios in the VAR systems to address criticism related to the practice of obtaining cash-flow news indirectly from the VAR, which possibly overstates its importance (Chen and Zhao, 2009). Engsted et al. (2012) show that by including the dividend-price ratio (and thus the stock price) into the VAR system, it does not matter whether cash-flow news or discount rate news is obtained directly from the VAR estimates because the dividend-price ratio incorporates information about the stock price level. The stock price level has to be part of the VAR system because the return decomposition only holds conditional on the stock price itself being a part of the

information set. Moreover, we include not only the US stock market return but also the US yield spread and the US dividend-price ratio in the VAR system because Rapach et al. (2013) show that US stock market returns predict foreign stock market returns both in sample and out of sample, whereas foreign stock markets do not lead the US stock market. More generally, their results suggest that US financial market variables observed today are informative about future foreign stock market returns.

4.3 The effect of monetary policy surprises

To assess what news components (revisions in expectations) account for the reaction of foreign stock market excess returns to the US monetary policy surprises, we exploit that the error ϵ_{t+1} from our baseline VAR in equation (10) can be decomposed into innovations in monetary policy ΔM^u_{t+1} and innovations related to all possible factors other than monetary policy. This allows us to rewrite equations (17)-(21), which define how we calculate the different news terms, as follows

$$f^T_{t+1} = \Lambda_2^{'}(\phi \Delta M^u_{t+1} + \Psi_{t+1}) \tag{22}$$

$$f^{rx}_{t+1} = \Lambda_2^{'}\rho^*\Gamma(I - \rho^*\Gamma)^{-1}(\phi \Delta M^u_{t+1} + \Psi_{t+1}) \tag{23}$$

$$f^{rr}_{t+1} = \Lambda_3^{'}(I - \rho^*\Gamma)^{-1}(\phi \Delta M^u_{t+1} + \Psi_{t+1}) \tag{24}$$

$$f^{q}_{t+1} = \Lambda_4^{'}(1 - \rho^*)(I - \rho^*\Gamma)^{-1}(\phi \Delta M^u_{t+1} + \Psi_{t+1}) \tag{25}$$

$$f^{cf}_{t+1} = f^T_{t+1} + f^{rx}_{t+1} + f^{rr}_{t+1} + f^{q}_{t+1} \tag{26}$$

The effect of US monetary policy surprises on the foreign excess stock market return (e.g., total news f^T_{t+1}) becomes

$$\Lambda_2^{'}\phi \Delta M^u_{t+1}. \tag{27}$$

The sources that account for this stock market reaction are the effects of US monetary policy surprises on the news terms that reflect revisions about the discounted sums of expected future excess returns, real interest rates, real exchange rate changes, and cash flows. The response of excess return news to US monetary

policy surprises is

$$\Lambda_2^{'}\rho^*\Gamma(I-\rho^*\Gamma)^{-1}\phi\Delta M_{t+1}^u, \tag{28}$$

the response of real interest rate news is

$$\Lambda_3^{'}(I-\rho^*\Gamma)^{-1}\phi\Delta M_{t+1}^u, \tag{29}$$

the response of real exchange rate news is

$$\Lambda_4^{'}(1-\rho^*)(I-\rho^*\Gamma)^{-1}\phi\Delta M_{t+1}^u, \tag{30}$$

and finally, the response of cash-flow news is

$$\left[\Lambda_2^{'}+\Lambda_2^{'}\rho^*\Gamma(I-\rho^*\Gamma)^{-1}+\Lambda_3^{'}(I-\rho^*\Gamma)^{-1}+\Lambda_4^{'}(1-\rho^*)(I-\rho^*\Gamma)^{-1}\right]\phi\Delta M_{t+1}^u. \tag{31}$$

To make inferences about the statistical significance of the responses of foreign stock markets' news components to US monetary policy surprises, we take into account that the news terms are estimated variables and depend on the VAR parameters. The details are presented in section 6.

5 Data

Our empirical assessments are based on data measured at monthly frequency.[6] The sample period is restricted by the availability of the US monetary policy surprise series. These series start in July 1991 and end in October 2015. The surprises are identified through a high-frequency analysis of various US financial market prices in a narrow time window (30 minutes) around FOMC announcements (Gürkaynak et al., 2005; Swanson, 2018). These surprises are measured on the day of the FOMC announcement, and they are, by construction, orthogonal to each other. To perform the VAR-based decompositions, we have to convert these event-day data

[6]In principle, one could run the VARs at daily frequency. However, to perform our preferred decomposition of unexpected stock market returns, one has to directly include real interest rates and real exchange rates into the VAR system. One needs consumer price indices (CPI) to compute these variables. The highest frequency at which CPI data are available is monthly.

into periodic time series data at the monthly frequency. To do so, we follow Romer and Romer (2004) and Gertler and Karadi (2015) and first calculate the cumulative daily surprise series. In a second step, we take monthly averages of these series. The first differences (month by month) of these series are our measures of US monetary policy surprises converted to the monthly frequency. A negative value of a surprise series reflects surprisingly looser monetary policy in that particular dimension of the monetary policy stance. Monetary policy is then more expansionary than expected. The surprise series are separately estimated for the period from 1991 to 2008, distinguishing between surprises related to the level of the fed funds rate and those related to forward guidance for the fed funds rate's future path, and the period from 2009 to 2015, distinguishing between surprises related to forward guidance and those related to the LSAP. We present the results for these surprise series in the subsequence. Alternatively, one could identify the three surprise series over the full sample period (Swanson, 2018). The qualitative results do not depend on this choice. Figure (1) presents the time series of the monthly surprises series, which all have a mean of 0 and standard deviation of 1. According to Swanson (2018), a one-standard-deviation change in the fed funds rate surprise factor can be thought of as an 8.8-basis-point surprise change in the Fed funds rate, a one-standard-deviation change in the forward guidance surprise factor corresponds to a 6-basis-point change in the Eurodollar futures rate, and a one-standard-deviation change in the LSAP surprise factor roughly corresponds to a 225 billion USD surprise LSAP announcement.[7]

[Figure 1 about here]

We use end-of-month values of USD-denominated MSCI stock market indices to compute log returns on the 40 developed and emerging economies' stock markets in our sample. Using end-of-month values helps to ensure that the (monthly) monetary policy surprises occur before the monthly stock return reaction. We use the MSCI classification to distinguish between developed and emerging markets. Furthermore, inclusion in MSCI market indices requires the stock to fulfil certain quality criteria and the opportunity for both domestic and foreign investors to

[7]For more details see appendix A.

invest in it. Therefore, using the MSCI indices allows us to directly compare evidence for developed markets with evidence for emerging markets. Table (1) provides an overview of the economies under study and the start and end dates of the stock market return data.

The MSCI indices are also used to compute log dividend-price ratios. We compile the log dividend-price ratio as the log of the sum of monthly dividends over the past year minus the log of this month's MSCI price index. Dividend series are obtained from the difference between the returns on the MSCI gross (i.e., total return) index and the returns on the MSCI price index. The MSCI indices are available on the MSCI website.

Excess returns are obtained as the difference between the log stock market return and the one-month US treasury bill rate. The US yield spread is defined as yield on ten-year US government bonds minus the one-month treasury bill rate. US real interest rates are calculated as the one-month treasury bill rate in t minus realized consumer price inflation in month t. Real USD exchange rates are constructed from nominal, bilateral USD exchange rates measured at the end of the month and monthly consumer price indices. The source for the exchange rate, interest rate and consumer prices series is the IMF's International Financial Statistics.

[Table (1) about here]

6 Empirical results

This section presents our main results. We start with a brief description of the outcome of the country-level VAR estimations. Then, we provide our estimates of the responses of the different news components of the US and foreign stock markets to US monetary policy surprises.

6.1 Brief overview of VAR estimation results

The VAR estimates for the US show that past values of the yield spread and the dividend-price ratio forecast US stock market excess returns one month ahead.

The sources of return predictability for the foreign stock markets[8] vary widely. However, US short-term real interest rates and the country's own dividend-price ratio are the variables that most often exhibit forecasting power for foreign stock market returns. The country-specific VAR estimates are not reported to conserve space, but they are readily available upon request.

Table (2) displays the adjusted R^2 statistics from the return forecasting equation of the country-specific VARs. In the US, for example, depending on the period and whether the exogenous variables are included in the VAR, between 2.0% and 8.6% of the one-month-ahead variation in stock market returns is explained by the variables in the VAR system. This is within the range of the R^2 statistics reported by Campbell (1991) and Bernanke and Kuttner (2005). The US stock market exhibits an average degree of stock return predictability compared with that of the markets in the other countries in our sample. For some, such as Colombia and Indonesia, the variables in the VAR explain more than 10% of one-month-ahead variation in stock market returns while for others, e.g., Japan, there is essentially no evidence of predictability (the R^2 adjusted for the number of regressors falls into negative territory). Overall, foreign stock market returns appear to be approximately equally predictable as US stock market returns.

[about here Table (2)]

Finally, we perform variance decompositions of the unexpected market returns. These decompositions show that cash-flow and excess return news are the most important components of unexpected stock market returns. Real interest rate news is only of minor importance and real exchange rate news contributes virtually nothing to the variation in unexpected stock market returns. Furthermore, we find that expected return news is exceptionally important to understand variation in US stock market returns (Campbell, 1991). However, for the vast majority of the other countries, cash-flow news is the dominant driver of variation in the unexpected stock market returns. This pattern is not unique to our sample of countries or the sample period but has been documented before (e.g., Nitschka, 2010). The details

[8]Standard information criteria suggest that one lag is optimal for all markets' VARs in the pre-ZLB period. The same number of lags is used in the ZLB period.

of the variance decompositions are not reported to conserve space but are available upon request.

6.2 US monetary policy surprises and stock market news

6.2.1 The period of "conventional" monetary policy: July 1991 to December 2008

This section presents the empirical assessment of the link between the different components of the unexpected stock market returns of the 40 countries under study and US monetary policy surprises.

Tables (3) and (4) contain the estimates of the effects of US monetary policy surprises on the different news series defined in equations (27)-(31) for every country in the pre-ZLB period. Statistical significance is assessed using an error resampling bootstrap procedure applied to equation (11). The appendix B provides more details on the bootstrap procedure.

In our sample of developed markets, fed funds rate surprises affect the stock markets of all the developed markets under study through US real interest rate news. This finding is in line with the use of US interest rates as an approximation of a world interest rate (Akinci, 2013; Uribe and Yue, 2006). As seen from the fourth column of table (3), the impact of a one-standard-deviation surprise decline in the fed funds rate varies between 0.6% and 1.2% p.a.. Using the metrics of the size of surprises from Swanson (2018), this finding implies that a surprise lowering of the fed funds rate by 25 basis points (bp) translates into a 1.7% to 3.4% p.a. increase in unexpected, monthly foreign stock market returns.[9]

The responses of expected future cash flows or future excess returns are larger than the real interest rate news reaction, but there is no evidence of statistical significance. This finding explains why total stock market return news appears to be unrelated to the fed funds rate surprises. Moreover, real exchange rate news is

[9]Table (3) gives the coefficients in terms of a one-unit surprise in the Fed funds rate, which corresponds to an 8.8bp change in the first fed funds rate futures contract. Thus, to calculate the effect of a lowering of the fed funds rate by 25 bp, the coefficients in the first five columns must be multiplied by 3.4. See appendix A for more details on Swanson's (2018) metric of the size of the monetary policy surprises.

unrelated to the fed funds rate surprises as well.

Forward guidance surprises only affect the unexpected stock market returns of eight (out of 21) developed stock markets in a statistically significant way. For those countries, we find, again using the metric of surprises provided by Swanson (2018), that a surprise decline in the fed funds rate by 25 bp in one year, implies an increase in unexpected, monthly foreign stock market returns ("Total" in the right panel of table(3)) of up to 75% p.a. (New Zealand). However, the decomposition of the total stock market return news does not reveal the main channel(s) through which forward guidance surprises affect foreign stock market returns. The coefficients that measure the sensitivity of the different news components to forward guidance surprises are statistically indistinguishable from zero.

Taken together, these estimates suggest that surprisingly accommodative US monetary policy constitutes good news for foreign stock markets. US monetary policy surprises primarily affect foreign stock markets through revisions of expectations of future real interest rates. In statistical terms, the link with unexpected stock market return components is stronger for fed funds rate surprises than for forward guidance surprises.

[about here Table (3)]

In our sample of emerging markets, the responses of unexpected stock market returns to US monetary policy surprises are broadly similar to those in their developed market counterparts. Fed funds rate surprises primarily affect emerging markets' stock returns through US real interest rate news. There is no exception. As shown by the estimates presented in table (4), the responses of emerging markets' stock returns to fed funds rate surprises through real interest rate news vary between 0.9% (Hungary) and 1.4% (Mexico) p.a.; i.e., a surprise fed funds rate decline of 25 bp translates into an increase of 2.6% to 4.0% p.a. in unexpected, monthly stock market returns.

Compared with the evidence for developed markets, there is even less evidence of forward guidance surprises affecting emerging markets' unexpected stock returns. Only a few stock market news components reflect a statistically significant sensitivity to forward guidance surprises.

In sum, our evidence highlights that fed funds rate surprises are associated with unexpected stock market returns for all of the countries under study, irrespective of their classification as developed or emerging market or their exchange rate regime. Looser than expected US monetary policy is associated with higher than expected foreign stock market returns.

[about here Table (4)]

6.2.2 "Unconventional" monetary policy surprises: January 2009 to October 2015

The responses of developed and emerging markets to US monetary policy surprises in the period from January 2009 to October 2015 show clear differences from those in the previous period of conventional monetary policy.

Table (5) presents the sensitivities to US forward guidance and LSAP surprises for the different stock return news components of the developed markets under study. These results suggest that forward guidance surprises in the ZLB period are primarily associated with real interest rate news. We find a statistically significant link for 17 of the 21 developed markets, but the magnitudes of the responses are by far smaller than those of the responses to the fed funds rate surprises in the pre-ZLB period. Moreover, the responses show the "wrong" (negative) sign for almost half of the developed markets under study. The significant coefficients range from -0.35% p.a. to 0.29% p.a. Occasionally, forward guidance surprises constitute expected return news or cash-flow news. However, the signs of the responses are not uniform. In some cases, surprisingly loose forward guidance leads to higher expected excess returns, which means that stock prices today have to decline. In other cases, we observe the opposite pattern. For most of the countries under study, there is no statistically significant link at all.

By contrast, the overwhelming majority of the stock market returns of developed markets react to LSAP surprises in a statistically significant way. In these cases, all of the unexpected stock market return responses have the expected sign. Surprisingly loose monetary policy, e.g., in the form of more asset purchases than expected, is associated with an increase in unexpected foreign stock market returns.

This finding applies to 16 of the 21 developed economies in our sample and the significant responses to a surprise one-standard-deviation change in LSAP range from 17% p.a. to 58% p.a. LSAP surprises influence foreign stock markets through cash-flow news, i.e., news about the real economy (Ammer and Mei, 1996). This finding supports Swanson (2018), who argues that LSAP represents more than just the Fed's commitment to its forward guidance (Woodford, 2012). This result also means that LSAP surprises have persistent effects on foreign stock market returns. They influence revisions in expectations about the entire future stream of dividends (Campbell and Vuolteenaho, 2004).

[about here Table (5)]

We observe similar patterns in our sample of emerging markets (see table (6)). Forward guidance surprises are associated with real interest rate news, and, for some countries, cash-flow news. The sizes of the real interest rate news responses to forward guidance surprises are comparable to those of the responses reported for developed markets. LSAP surprises also affect emerging markets' stock returns through revisions in expectations about future cash flows, i.e., the real economy. This is the case for 16 out of the 19 emerging markets under study. The sensitivities of the return news to LSAP surprises have the expected sign (surprisingly more accommodative LSAP is associated with higher unexpected returns). There is only one exception. Finally, we find a statistically significant association between LSAP surprises and emerging stock markets' real exchange rate news. However, revisions in expectations about future real exchange rates contribute little to the overall variation in unexpected stock market returns. This does not mean that the impact of US monetary policy on the real exchange rates of emerging markets is unimportant per se. It is simply relatively small in the context of the stock market return decomposition presented in this paper.

[about here Table (6)]

In sum, these results suggest that developed and emerging stock markets responded similarly to US monetary policy surprises in the ZLB period. Our findings also suggest that LSAP surprises not only signal commitment to forward guidance

but also capture different information that is relevant for stock markets. Moreover, the sensitivities of unexpected stock market return components to US monetary policy surprises do not provide compelling evidence for the information effect in Fed communication (Nakamura and Steinsson, 2018). Most of our estimates suggest that surprisingly accommodative US monetary policy has been associated with good news for foreign stock markets – a feature of the data that appears to be inconsistent with the information effect (Bauer and Swanson, 2020).

7 Conclusions

This paper has used a VAR-based decomposition of unexpected variation in the stock market returns of developed and emerging markets into different news components to assess why foreign stock markets react to US monetary policy surprises.

Our main results highlight that the transmission of US monetary policy surprises to foreign stock markets works through different channels. Prior to the ZLB period, US monetary policy surprises in the form of surprise changes in the fed funds rate affected developed and emerging markets primarily by influencing expectations about future real interest rates. However, we find that at the ZLB, forward guidance and LSAP surprises affected foreign stock markets through different channels. This latter finding highlights that LSAP cannot be viewed only as a signal of commitment to forward guidance.

The main findings of this paper are in line with theory and evidence of a global financial cycle, that is influenced by US monetary policy and affects risky asset prices worldwide. This observation raises the question of whether the effects of US monetary policy surprises on foreign stock markets are stronger or weaker than local monetary policy surprises. Answering this question is beyond the scope of this paper, but shedding light on this issue could help to assess constraints on domestic monetary policy due to the global financial cycle. This question is of particular interest for the emerging markets under study and a fruitful avenue for future research.

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Tables

Table 1: Country overview and sample dates

Developed stock markets			
country	acronym	start date	end date
United States of America	USA	July 1991	October 2015
Australia	AUS	July 1991	October 2015
Austria	AUT	July 1991	October 2015
Belgium	BEL	July 1991	October 2015
Canada	CAN	July 1991	October 2015
Denmark	DNK	July 1991	October 2015
Finland	FIN	July 1991	October 2015
France	FRA	July 1991	October 2015
Germany	DEU	July 1991	October 2015
Ireland	IRL	July 1991	October 2015
Israel	ISR	February 1993	October 2015
Italy	ITA	July 1991	October 2015
Japan	JPN	July 1991	October 2015
Netherlands	NLD	July 1991	October 2015
Norway	NOR	July 1991	October 2015
Portugal	PRT	July 1991	October 2015
Spain	ESP	July 1991	October 2015
Sweden	SWE	July 1991	October 2015
Switzerland	CHE	July 1991	October 2015
United Kingdom	GBR	July 1991	October 2015
Emerging stock markets			
Brazil	BRA	July 1991	October 2015
Chile	CHL	July 1991	October 2015
Colombia	COL	February 1993	October 2015
Czech Republic	CZE	May 1995	October 2015
Egypt	EGY	April 1995	October 2015
Greece	GRC	July 1991	October 2015
Hungary	HUN	June 1995	October 2015
India	IND	February 1993	October 2015
Indonesia	IDN	July 1991	October 2015
Korea	KOR	July 1991	October 2015
Malaysia	MYS	July 1991	October 2015
Mexico	MEX	July 1991	October 2015
Pakistan	PAK	March 1993	October 2015
Peru	PER	February 1993	October 2015
Philippines	PHL	July 1991	October 2015
Poland	POL	May 1993	October 2015
South Africa	ZAF	February 1993	October 2015
Thailand	THA	July 1991	October 2015
Turkey	TUR	July 1991	October 2015

Table 2: Country VAR estimation: adjusted R^2 in % from the return forecasting equation

	pre-ZLB period		ZLB period	
country	incl. exo.	excl. exo.	incl. exo.	excl. exo.
USA	4.72	4.46	35.43	36.83
AUS	0.79	-2.19	12.65	12.76
AUT	9.16	7.75	6.85	3.10
BEL	10.15	9.45	6.82	3.82
CAN	2.40	0.99	18.36	17.45
DNK	4.17	3.16	4.04	-0.28
FIN	6.53	7.20	12.40	-0.24
FRA	0.44	0.17	8.65	3.39
DEU	-0.65	-0.04	12.37	2.02
IRL	12.03	10.42	3.10	-3.53
ISR	-0.68	-0.89	16.61	16.13
ITA	0.80	0.75	9.11	-0.19
JPN	-0.62	-0.63	-4.62	-2.91
NLD	5.55	4.73	9.41	2.92
NZL	3.97	2.06	3.32	4.78
NOR	3.04	2.51	3.34	4.34
PRT	1.12	2.09	13.26	14.93
ESP	-1.52	-1.08	9.94	4.20
SWE	0.21	-0.42	15.25	10.24
CHE	1.43	0.56	5.53	3.63
GBR	4.66	3.41	8.21	5.95
BRA	-0.73	-0.83	12.19	10.61
CHL	0.25	0.36	3.71	3.92
COL	12.69	10.49	11.13	12.08
CZE	1.66	1.06	23.27	3.73
EGY	7.94	8.61	9.45	7.85
GRC	1.36	1.31	9.63	5.44
HUN	2.52	2.12	11.58	8.29
IND	1.41	2.28	10.03	7.93
IDN	10.57	7.08	17.39	12.52
KOR	4.82	4.44	19.88	3.50
MYS	0.67	1.55	18.95	13.30
MEX	-0.50	-0.72	11.76	10.10
PAK	-1.82	-0.70	17.93	17.60
PER	1.00	-0.32	10.69	10.39
PHL	3.76	1.92	4.32	5.61
POL	-3.53	-2.51	11.44	3.56
ZAF	-0.88	-1.70	14.54	11.07
THA	-1.25	-1.60	7.01	6.29
TUR	0.76	0.78	8.96	5.65

Notes: This table presents the R^2 statistics (adjusted for the number of regressors) of the VAR equation that forecasts the respective country's stock market return in excess of the US t-bill rate in the pre-ZLB and ZLB period with (incl. exo) as well as without (excl. exo) exogenous variables. The sample periods run from July 1991 to the end of 2008 (the pre-ZLB period) and from January 2009 to October 2015 (the ZLB period). Table (1) gives the start and end dates of the sample for each country and explains the country acronyms. We use the MSCI classification of developed and emerging stock markets. We choose a lag length of one month for all countries.

Table 3: Reaction of stock market news to US monetary policy surprises from 1991 to 2008: developed markets

	Fed funds rate surprise					Forward guidance surprise				
	Total	CF	ER	RIR	RFX	Total	CF	ER	RIR	RFX
USA	-3.27	0.03	2.83	0.47***		-3.56	-1.29	1.99	0.28	
AUS	0.67	5.58	4.36	0.62***	-0.07	-14.46**	-15.56**	-3.22	1.52	0.60**
AUT	10.56	21.54	10.36	0.74***	-0.11	-17.68**	-30.85**	-14.08	0.77	0.13
BEL	5.41	11.50*	5.65	0.60***	-0.16	-12.58*	-14.56	-2.37	0.19	0.19
CAN	-5.29	-0.06	4.26	1.04***	-0.07*	-6.44	-5.72	0.12	0.43	0.17***
DNK	-8.57	-8.77	-1.01	0.88***	-0.07	-1.49	-5.99	-4.86	0.28	0.07
FIN	2.08	14.88	11.75	1.21***	-0.15	-7.29	-8.77	-1.63	0.03	0.12
FRA	0.36	8.64	7.36	1.03**	-0.11	-7.71	-7.52	-0.25	0.33	0.11
DEU	0.80	5.30	3.66	0.93***	-0.09	-5.33	-3.94	1.08	0.22	0.09
IRL	0.51	10.04	8.89	0.79***	-0.15	-12.11*	-16.88	-5.96	0.87	0.31
ISR	-10.25	-5.66	3.66	0.92***	0.01	-0.17	0.06	-0.03	0.34	-0.08
ITA	6.15	12.24	5.37	0.89**	-0.17	-11.31*	-13.10	-2.09	0.09	0.21*
JPN	5.19	2.36	-3.69	0.74***	0.12**	-9.93	-9.21	-0.04	0.85	-0.09
NLD	-1.71	5.42	6.53	0.77***	-0.16	-7.80	-8.37	-0.83	0.10	0.16
NZL	8.80	9.57	0.06	0.75***	-0.04	-17.95**	-22.37**	-5.10	0.23	0.46
NOR	-7.83	-1.00	6.15	0.79***	-0.12	-4.63	-7.80	-3.72	0.41	0.15
PRT	1.00	3.88	2.32	0.75***	-0.19	-1.41	0.19	1.14	0.20	0.26
ESP	-0.86	2.22	2.42	0.90***	-0.23	-5.22	-2.36	2.57	0.08	0.21
SWE	-11.88	-5.01	5.94	1.04***	-0.12	0.29	-3.09	-3.65	0.10	0.16
CHE	6.58	9.38	1.62	1.23***	-0.05	-10.79**	-8.28	2.41	0.06	0.04
GBR	1.30	6.46	4.54	0.82***	-0.20*	-8.66**	-8.18*	-0.11	0.30	0.28

Notes: This table presents estimates from equation (11)), i.e., the coefficients that link unexpected variation in stock market returns ("Total") and their components reflecting news about future cash flows ("CF"), expected excess returns ("ER"), expected US real interest rates ("RIR") and USD real exchange rate changes ("RFX") to US monetary policy surprises in the form of fed funds rate and forward guidance surprises. The sample period runs from July 1991 or the earliest date for which foreign stock market data are available to December 2008. This table reports the results for the developed markets under study. Table (1) gives the start and end dates of the sample for each country and explains the country acronyms. We use the MSCI classification of developed and emerging stock markets. ***, ** and * denote significance of the regression coefficients at the 1%, 5% and 10% level based on the empirical distribution of the VAR coefficients from 10000 bootstrap samples. The coefficient estimates are linked through: Total = CF - ER - RIR - RFX.

Table 4: Reaction of stock market news to US monetary policy surprises from 1991 to 2008: emerging markets

	Fed funds rate surprise					Forward guidance surprise				
	Total	CF	ER	RIR	RFX	Total	CF	ER	RIR	RFX
BRA	-15.71	-9.88	4.70	1.00***	0.12	-0.07	0.72	0.82	-0.10	0.07
CHL	-9.21	-11.18	-3.05	1.05***	0.03	1.99	1.26	-0.77	-0.04	0.08
COL	-9.90	-21.39**	-12.68**	0.92***	0.28*	-13.19	-17.88	-4.85	0.13	0.03
CZE	-6.57	-1.95	3.82	0.84***	-0.04	-8.37	-19.62	-11.64	0.25	0.14
EGY	1.52	-0.22	-2.79	0.89***	0.16	-9.28	-13.54	-4.25	0.14	-0.15
GRC	12.67	20.06**	6.80	0.82***	-0.22	-14.42*	-18.39*	-4.28	0.11	0.20
HUN	2.82	12.75	9.12	0.85***	-0.05	-18.42	-33.81	-16.00	0.43	0.17**
IND	1.20	6.65	4.50	1.01**	-0.06	-5.80	-14.60	-9.15	0.29	0.06
IDN	-16.99	-40.46	-24.91	1.15***	0.30	-21.27	-29.11	-8.17	0.11	0.21
KOR	-8.39	-5.21	1.96	1.17***	0.04	-8.43	-16.00	-7.72	0.07	0.07
MYS	-4.60	-7.90	-4.57	1.22***	0.06	4.25	2.92	-1.28	-0.01	-0.03
MEX	-5.49	-3.70	0.45	1.39***	-0.05	-7.78	-9.44	-1.47	-0.32	0.12
PAK	0.89	7.00	5.62	0.74***	-0.24	0.09	-13.64	-13.85	-0.13	0.24
PER	-1.38	-2.32	-1.96	0.94***	0.09**	-17.34*	-17.37	0.00	0.04	-0.07*
PHL	1.36	-4.89	-7.48	1.17***	0.07	-19.65**	-7.51	12.06**	0.06	0.01
POL	1.51	0.48	-1.79	0.80***	-0.03	4.08	1.94	-2.63	0.39	0.11
ZAF	-2.03	-0.52	0.94	0.80***	-0.23	-12.79	-13.92	-1.58	0.17	0.28
THA	-9.38	-17.54	-9.52	1.13***	0.23	-8.42	-4.83	3.75	-0.05	-0.11
TUR	-4.74	-0.48	3.45	0.97***	-0.16	-15.94	-24.02	-8.48	-0.02	0.41*

Notes: This table presents estimates from equation (11)), i.e., the coefficients that link unexpected variation in stock market returns ("Total") and their components reflecting news about future cash flows ("CF"), expected excess returns ("ER"), expected US real interest rates ("RIR") and USD real exchange rate changes ("RFX") to US monetary policy surprises in the form of fed funds rate and forward guidance surprises. The sample period runs from July 1991 or the earliest date for which foreign stock market data are available to December 2008. This table reports the results for the emerging markets under study. Table (1) gives the start and end dates of the sample for each country and explains the country acronyms. We use the MSCI classification of developed and emerging stock markets. ***, ** and * denote significance of the regression coefficients at the 1%, 5% and 10% level based on the empirical distribution of the VAR coefficients from 10000 bootstrap samples. The coefficent estimates are linked through: Total = CF - ER - RIR - RFX.

Table 5: Reaction of stock market news to US monetary policy surprises from 2009 to 2015: developed markets

	Forward guidance surprise					Large scale asset purchases				
	Total	CF	ER	RIR	RFX	Total	CF	ER	RIR	RFX
USA	0.71	-0.24	-0.96	0.00**		-3.42	-2.73*	0.21	0.48	
AUS	-4.84	-3.60	0.56	0.28	0.40	-19.36*	-4.57	14.37	0.21***	0.21**
AUT	-6.17	-3.75	2.47*	0.02**	-0.07	-36.95*	-15.28**	21.07	0.68	-0.08
BEL	0.07	0.47	0.61*	-0.29***	0.08	-19.32	-7.03*	12.00	0.15	0.14
CAN	-2.57	-0.94	1.47*	0.21	-0.04	-16.85*	-7.42**	8.73	0.73	-0.03*
DNK	-4.53	-4.50	-0.02	0.02*	0.03	-27.40	-19.56*	7.17	0.65	0.02
FIN	-21.81	-28.08**	-6.34	-0.05***	0.12	-57.55***	-57.66***	-0.82	0.56	0.15
FRA	-1.29	-4.87	-3.54*	-0.07***	0.04	-28.03*	-18.70**	8.72	0.56	0.05
DEU	-0.76	-7.88	-7.10*	0.01***	-0.02	-36.49**	-33.83***	1.99	0.65	0.02
IRL	-11.56	-12.26	-0.67	-0.02**	-0.01	-38.62**	-29.98**	7.97	0.60	0.06
ISR	9.58	4.50	-5.36*	0.29**	0.00	-3.61	-1.67	1.06	1.03	-0.14
ITA	-4.79	-11.54	-6.94*	-0.04***	0.23	-44.89**	-39.19**	4.74	0.58	0.38
JPN	-3.60	6.46	9.70	0.11**	0.24	-8.77	1.71	9.31	0.93	0.24
NLD	1.68	-0.13	-2.12	0.04**	0.27	-25.63	-14.38	10.29	0.66	0.29
NZL	-6.85	-9.09*	-2.50	-0.04**	0.29	-13.27	-9.05**	3.86	0.37	-0.01**
NOR	-13.30	-10.39*	2.53	0.14***	0.24	-19.07	-9.13**	9.82	0.04	0.08*
PRT	-7.94	-14.60	-6.76*	-0.12***	0.21	-11.44	-8.35	2.31	0.49	0.29
ESP	-3.11	0.20	2.57	0.43	0.31	-38.44**	-13.94*	23.30	0.96	0.24
SWE	-4.32	-3.16	1.50	-0.35***	0.02	-29.69**	-9.07***	20.31	0.15	0.17**
CHE	1.15	-2.41	-3.70	-0.12**	0.25	-14.72	-11.98*	2.08	0.51	0.16
GBR	-1.79	2.15	3.41	0.53	0.00	-18.18	-3.11*	14.32	0.85	-0.11

Notes: This table presents estimates from equation (11)), i.e., the coefficients that link unexpected variation in stock market returns ("Total") and their components reflecting news about future cash flows ("CF"), expected excess returns ("ER"), expected US real interest rates ("RIR") and USD real exchange rate changes ("RFX") to US monetary policy surprises in the form of forward guidance and LSAP surprises. The sample period runs from January 2009 to October 2015. This table reports the results for the developed markets under study. Table (1) gives the start and end dates of the sample for each country and explains the country acronyms. We use the MSCI classification of developed and emerging stock markets. ***, ** and * denote significance of the regression coefficients at the 1%, 5% and 10% level based on the empirical distribution of the VAR coefficients from 10000 bootstrap samples. The coefficient estimates are linked through: Total = CF - ER - RIR - RFX.

Table 6: Reaction of stock market news to US monetary policy surprises from 2009 to 2015: emerging markets

	Forward guidance surprise					Large scale asset purchases				
	Total	CF	ER	RIR	RFX	Total	CF	ER	RIR	RFX
BRA	-19.17	-15.12**	3.95	-0.14*	0.24*	-33.36**	-10.29***	22.80	0.35	-0.08**
CHL	-4.94	-8.98	-3.91	-0.17**	0.04	-17.33	-12.83**	4.45	0.16	-0.11
COL	-6.60	-8.81	-2.56	0.05***	0.31	-16.86	-1.43**	14.18*	0.86	0.38**
CZE	-12.46	-22.62	-10.24	-0.04**	0.12	-60.68***	-66.59***	-7.05	0.73	0.41*
EGY	-18.52	-13.51*	4.87	0.08**	0.06	-32.53**	-21.32***	10.18	0.91	0.12*
GRC	-11.17	-2.40	8.65	0.00**	0.12	-60.67*	-11.67*	48.32	0.64	0.04
HUN	-15.24	-9.11	5.94	0.13**	0.06	-47.59*	-18.42**	28.22	0.77	0.18*
IND	-0.68	-3.48	-2.80*	-0.04**	0.04	-26.65*	-4.82**	20.97	0.84	0.01
IDN	-8.39	-10.66	-2.72*	0.18**	0.26**	-37.30**	-20.78***	15.34	0.91	0.27***
KOR	-31.32**	-23.29**	7.56	0.28	0.19***	-62.96***	-37.21***	24.20	1.27*	0.28***
MYS	-17.35*	-6.89*	10.09	-0.01**	0.38*	-26.90**	10.38***	37.48	-0.23	0.02**
MEX	1.12	0.78	-0.28*	-0.07**	0.01	-17.65	-1.82**	15.29	0.51	0.03
PAK	-3.89	3.85	7.53	0.03**	0.18	-18.09	4.68	21.79	0.61	0.37
PER	-18.12	-16.45	1.44	0.08**	0.15**	-23.97*	-9.61**	13.17	0.85	0.34***
PHL	2.48	3.93	1.28	0.11***	0.05	-8.09	-1.89	5.21	0.89	0.10
POL	-14.29	-20.18*	-6.09	-0.12**	0.31	-50.96***	-42.80***	7.03	0.50	0.62**
ZAF	-16.34	-12.37**	3.65	0.13**	0.19	-30.26**	-16.82***	12.67	0.62	0.15***
THA	-0.52	-0.72	-0.58	0.22**	0.16	-19.05	-9.84**	8.26	0.77	0.18**
TUR	-7.90	-7.97	-0.17*	0.04***	0.06	-39.25**	-19.79***	18.48	0.78	0.21**

Notes: This table presents estimates from equation (11)), i.e., the coefficients that link unexpected variation in stock market returns ("Total") and their components reflecting news about future cash flows ("CF"), expected excess returns ("ER"), expected US real interest rates ("RIR") and USD real exchange rate changes ("RFX") to US monetary policy surprises in the form of forward guidance and LSAP surprises. The sample period runs from January 2009 to October 2015. This table reports the results for the emerging markets under study. Table (1) gives the start and end dates of the sample for each country and explains the country acronyms. We use the MSCI classification of developed and emerging stock markets. ***, ** and * denote significance of the regression coefficients at the 1%, 5% and 10% level based on the empirical distribution of the VAR coefficients from 10000 bootstrap samples. The coefficent estimates are linked through: Total = CF - ER - RIR - RFX.

Figures

Figure 1: Monetary policy surprises 1991-2015

Notes: This figure depicts the monthly time series of monetary policy surprises (Fed funds rate, forward guidance and large-scale asset purchases (LSAP)). The series are based on the high-frequency identification of Swanson (2018) and identified separately for the periods from July 1991 to December 2008 (Fed funds rate and forward guidance) and from January 2009 to October 2015 (forward guidance and LSAP).

A Measuring monetary policy surprises with high-frequency data

In our analysis, we use the three US monetary policy surprise series from Swanson (2018). Here, we briefly describe the approach used to identify these three factors over the full sample period. The three factors correspond to surprises in the fed funds rate, forward guidance and LSAP. A more detailed and comprehensive description of the approach can be found in Swanson (2018).[10] A similar identification can be obtained separately for the sample periods of rather conventional (1991 to 2008) and rather unconventional (2009 to 2015) monetary policy. Our main empirical results use the separately identified surprises. The qualitative results are not sensitive to this choice and the general approach to identify the surprise series is the same.

The identification of monetary policy surprises relies on collecting all price changes of federal funds futures (current and next-month maturities), Eurodollar futures (2−, 3− and 4−quarters maturites) and treasury bond yields (2−, 5−, and 10−year maturities) on the dates of every FOMC announcement between July 1991 and October 2015 within a 30-minute window bracketing each announcement. The price changes of these assets are then gathered in a $T \times n$ matrix X, where T is the number of FOMC announcements in the covered sample period and n the number of assets. These data may then be generated by a factor model such as

$$X = F\Lambda + \epsilon, \tag{32}$$

with F being a $T \times k$ matrix of $k \leq n$ latent factors, Λ being a $k \times n$ matrix of loadings of asset price responses on the k factors, and ϵ being a $T \times n$ matrix of white noise residuals. Then, the goal is to identify three factors that correspond to surprises in (1) the fed fund rates, (2) forward guidance, and (3) LSAP. Principal component analysis shows that the first three principal components of X explain 94% of the total variance of X. These three principal components are unlikely to have the desired structural interpretation, so one needs an alternative factor model

[10] See section 2 and appendix A in Swanson (2018) for more details.

producing the same ϵ with factors $\tilde{F}$ reflecting surprise changes in the federal funds rate, forward guidance, and LSAP. Such an alternative factor model can be represented by $X = \tilde{F}\tilde{\Lambda} + \epsilon$, where $\tilde{F} \equiv FU$, $\tilde{\Lambda} \equiv U'\Lambda$ and U is any 3×3 orthogonal matrix. Three restrictions are required to identify U and the ones used by Swanson (2018) are as follows: (1) LSAP have no effect on the current federal funds rate, (2) forward guidance has no effect on the current federal funds rate, and (3) the LSAP factor is as small as possible in the pre-ZLB period between 1991 and 2008. This then allows one to uniquely identify $\tilde{F}$, with the first column corresponding to surprise changes in the federal funds rate, the second column to surprise changes in forward guidance, and the third column to surprise changes in LSAP.

The resulting estimates of the structural loading matrix $\tilde{\Lambda}$ are directly taken from Swanson (2018) and depicted in table 7. The table reveals that the fed funds rate surprise factor loads with 8.8 on the first fed funds rate future (MP1). Thus, a one-standard-deviation change in the fed funds rate surprise factor can be thought of as an 8.8-basis-points surprise change in the fed funds rate. The structural loading of the forward guidance surprise factor on the fourth Eurodollar futures contracts (ED4) is 6.0. A one-standard-deviation change in the forward guidance surprise factor can hence be thought of as an 6-basis-points change of the expected fed funds rate one year ahead. Finally, Swanson (2018) suggests, based on some estimates in the literature, that a one-standard-deviation change in the LSAP surprise factor roughly corresponds to a 225 billion USD surprise LSAP announcement.

Table 7: Estimated effects of conventional and unconventional monetary policy announcements on interest rates 1991-2015

	MP1	MP3	ED2	ED3	ED4	TR2y	TR5y	TR10y
Δ FFR	8.78	6.22	5.55	5.21	4.43	3.68	2.04	0.95
Δ FG	0.00	1.21	4.16	5.32	6.02	4.85	5.09	3.92
Δ LSAP	0.00	0.85	1.42	1.37	1.04	-0.32	-3.71	-5.68

Notes: This table is taken directly from Swanson (2018). The coefficients in the table correspond to elements of the structural loading matrix $\tilde{\Lambda}$, in basis points per standard deviation change in the monetary policy instrument. MP1 and MP2 denote scaled changes in the first and third federal funds futures contracts, respectively; ED2, ED3, and ED4 denote changes in the second through fourth Eurodollar futures contracts; and TR2y, TR5y, and TR10y denote changes in 2-, 5-, and 10-year treasury yields.

B Details on the bootstrap procedure

In this section, we present the bootstrap procedure used to compute the standard errors of the VAR coefficients in equation (10) based on error resampling. In a first step, we run our VAR $z_t = \Gamma z_{t-1} + \phi \Delta M_t^u + \Psi_t$ with T observations to estimate the companion matrix $\widehat{\Gamma}$ and to extract the estimated residuals Ψ. For each bootstrap sample i, we draw T random numbers $r_s^{(i)}$, $s = 1, \ldots, T$, between 1 and T, with replacement. We then generate a series of bootstrapped errors $\hat{\Psi}_t^{(i)}$, where the sth row of $\hat{\Psi}_t^{(i)}$ is given by the $r_s^{(i)}$th row of the original $\hat{\Psi}$. The bootstrap sample $z^{(i)}$ is then defined as follows

$$z_t^{(i)} = \widehat{\Gamma} z_{t-1} + \hat{\phi} \Delta M_t^u + \hat{\Psi}_t^{(i)}, \quad \forall t \in \{1..., T\} \tag{33}$$

We repeat this resampling procedure 10,000 times. With 10,000 bootstrap samples of z in hand we re-estimate the VAR and store the corresponding companion matrices $\widehat{\Gamma}^{(i)}$ and exogenous variables coefficient matrix $\hat{\phi}^{(i)}$. Then, we compute the bootstrapped effect of US monetary policy surprises on the foreign excess stock market return (e.g. total news f_{t+1}^T)

$$\Lambda_2^{'} \hat{\phi}^{(i)} \Delta M_{t+1}^u, \tag{34}$$

on excess return news

$$\Lambda_2^{'} \rho^* \widehat{\Gamma}^{(i)} (I - \rho^* \widehat{\Gamma}^{(i)})^{-1} \hat{\phi}^{(i)} \Delta M_{t+1}^u, \tag{35}$$

real interest rate news

$$\Lambda_3^{'} (I - \rho^* \widehat{\Gamma}^{(i)})^{-1} \hat{\phi}^{(i)} \Delta M_{t+1}^u, \tag{36}$$

real exchange rate news

$$\Lambda_4^{'} (1 - \rho^*) (I - \rho^* \widehat{\Gamma}^{(i)})^{-1} \hat{\phi}^{(i)} \Delta M_{t+1}^u, \tag{37}$$

and finally, cash-flow news

$$\left[\Lambda_2^{'}+\Lambda_2^{'}\rho^*\widehat{\Gamma}^{(i)}(I-\rho^*\widehat{\Gamma}^{(i)})^{-1}+\Lambda_3^{'}(I-\rho^*\widehat{\Gamma}^{(i)})^{-1}+\Lambda_4^{'}(1-\rho^*)(I-\rho^*\widehat{\Gamma}^{(i)})^{-1}\right]\hat{\phi}^{(i)}\Delta M_{t+1}^{u} \tag{38}$$

for each bootstrap sample i. The resulting empirical distributions of the effects on the different news terms are then used to draw inferences about the statistical significance of the sensitivities of the return news to US monetary policy surprises.

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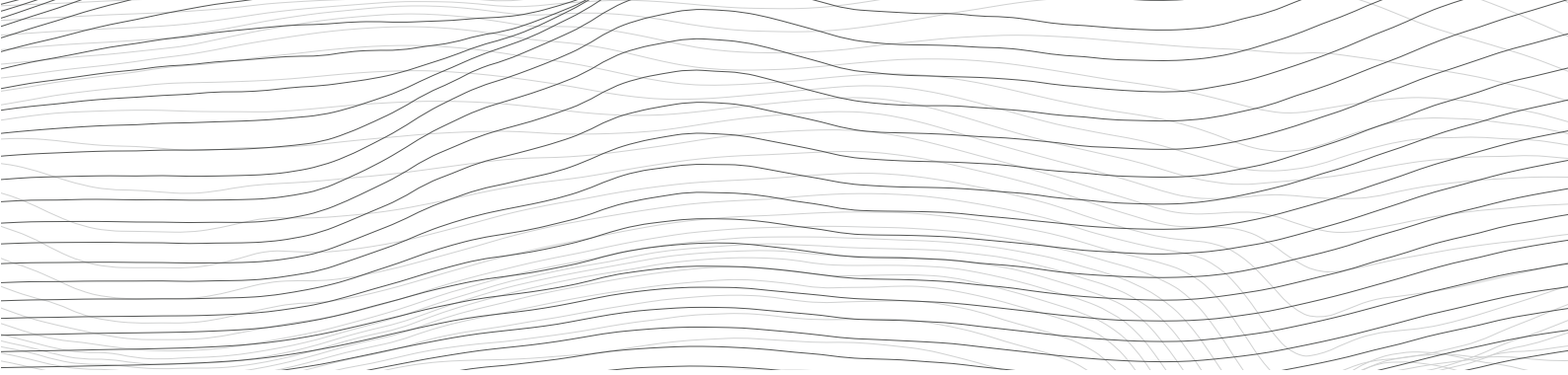

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