Does Monetary Policy Impact International Market Co-Movements?

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ABSTRACT

We investigate the impact of ECB and FED's monetary announcements on the degree of co-movement in the equity and sovereign CDS markets for a large cross-section of countries. The FED's introduction, and to a greater extent relaxation, of unconventionary monetary policy has been accompanied by an increase in international comovement. This effect is particularly pronounced for the group of emerging markets, and for sovereign credit risk. In contrast, the adoption of QE policies by the ECB lead if anything to a decrease in comovement, both within and between developed and emerging markets, including those in the Eurozone. The relation between the global factor and the U.S. market increases during FED meeting days, while the same does hold for the European market during ECB announcements. The response to outside monetary policy shocks relates to a country' degree of openness to the trading of goods and capital flows, but not to the amount of foreign debt, and is observed also for countries with floating exchange rates.

JEL classification: E58, G12, G15
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1 Introduction

Many central banks have introduced quantitative easing (QE) as a new policy tool where they massively buy bonds from market participants with the intent of providing liquidity to the market, reducing the cost of capital, and ultimately fostering economic growth. These policies were introduced by the Federal Reserve in the aftermath of the financial crisis, and by the ECB as a response to the crisis in the Eurozone sovereign bond market. As central banks are still undertaking these measures, a number of studies highlight their effect on bond yields, stock prices, and exchange rates of the developed countries where they are being implemented.[1] However, while QE appears to have produced the desired effect in the home (U.S., and to a much lesser extent Euro) market, several open questions remain with respect to its ultimate effect on global markets. In particular, given the unprecedented size of these interventions it is natural to ask how their introduction (and subsequent unwinding) affects not only domestic markets but more generally the whole international financial system.

In this paper, we contribute to our understanding of the global consequences of revisions in monetary policies by examining to what extent do the ECB and FED policy announcements affect international market comovements. Specifically, we study comovements in the equity and sovereign credit risk (i.e. CDS) markets of a large cross-section of 39 countries, of which 18 developed and 21 emerging markets. While most studies are concerned with the effect of monetary policy news on expected equity returns (see e.g. Lucca and Moench (2015) and Cieslak, Morse, and Vissing-Jorgensen (2019)), we expand the discussion by looking at spillovers that alter the correlation structure of asset prices. We show that central banks', and in particular FED's meetings are associated with significant swings in international market linkages.

Our analysis focuses on the extent of market comovements given its central role in international asset pricing. Changes in the correlation structure reflect changes in the relative importance of local versus global factors, Karolyi and Stulz (1996). A surge in cross-country correlations also

[1] See for example Krishnamurthy and Vissing-Jorgensen (2011), Krishnamurthy, Nagel, and Vissing-Jorgensen (2014) D'Amico et al. (2012), D'Amico and King (2013), Banerjee, Latto, and McLaren (2014), and Li and Wei (2013), Rogers, Scotti, and Wright (2014), Pericoli and Veronese (2016), Eser and Schwaab (2016) among others.

implies a decrease in international diversification benefits. This point is particularly relevant in the most recent period where the search for performance by institutional investors, in particular those focusing on sovereign debt, lead to an increase in the weights associated with emerging markets. Finally, a stronger degree of comovements may generate potential risks associated with the diffusion of local shocks within the entire system, and limit the ability of regulators to keep systemic risk under control.

A distinguishing feature of our study is the analysis of comovements separately within various groups of countries – Eurozone, Developed markets outside the Eurozone, and Emerging countries in different areas – as well as between developed and emerging markets. This approach allows us to assess whether changes in monetary policy have regional effects, global effects, or both. We measure the degree of market comovement by looking at the fraction of overall variance explained by the first principal component of the correlation matrix.[2]

Akin to an event-study approach, we estimate this fraction separately on the days surrounding a given central bank's announcement, and on ex-window days. We then uncover the impact of monetary policy revisions on the correlation structure of asset prices by testing whether the difference in the role of the first principal component between these two subsamples is statistically different from zero based on a bootstrap procedure. To highlight the effect of varying monetary policies, we break down the 2007 to 2015 sample into three periods that were characterized by markedly different central banks' interventions, and further distinguish between announcements generating markedly negative versus positive reactions in the level of yields.

For equity markets, we find that FED's announcements are overall accompanied with a strengthening of return comovements during the 2007-2009 financial crisis and in the following period. This effect is largely confined to emerging markets, and in particular to those in the Asia&Pacific region, which are highly exposed to the U.S. from direct investments or trading of goods. Finally,

[2]Compare Pukthuanthong and Roll (2009) for a study that uses principal component analysis on equity returns, and Longstaff et al. (2011) for evidence of common exposure to global factors on the sovereign CDS market. To be precise, we work on volatility-filtered data as time variation in conditional volatility makes correlation-based tests biased and inaccurate (Forbes and Rigobon (2002)). This issue is especially important for emerging markets, as it is well-known that their equity returns tend to be particularly volatile and subject to structural changes (see e.g. Bekaert and Harvey (1997) and Bekaert and Harvey (2000)). They have also been shown to exhibit variation and heterogeneity in their return asymmetries, see Ghysels, Plazzi, and Valkanov (2016). For these reasons, we pre-filter returns and CDS changes using the asymmetric GARCH model of Glosten, Jagannathan, and Runkle (1993).

during the last June 2013 to November 2015 "tapering" period, we observe stronger comovements within emerging markets, and between developed and emerging, whenever the FED's announcements lead to an increase in the U.S. yield curve. In contrast, ECB's announcements have a positive and significant impact only during the sovereign crisis of 2010-2012. Surprisingly, such an impact is more modest for EMU countries and highest for emerging markets in Europe&MiddleEast. Even more striking is the evidence that during the 2013-2015 period, when the ECB started its QE policies, its impact on equity market comovements is mildly negative, small, and not statistically different from zero. Thus, these policies were not perceived as a global shock in equity markets, not even in the Eurozone.

The results on the pricing of sovereign risk are even more pronounced, as the FED's and ECB's announcements display now an *opposite* effect on market comovements. In particular, ECB's interventions largely induce market "fragmentation", especially in the last QE period and within EMU countries. The effect of FED's announcements on comovements in the sovereign CDS market is extremely large and positive in the last five years. The first hints appear during the massive QE intervention of 2010-2013 within the emerging Asia&Pacific area. In the subsequent period, as the FED starts tapering its unconventional monetary policies, we observe a large and positive impact on market comovements both between and especially *within* the developed and emerging markets, with quite significant heterogeneity in the size of the increase among the different areas.

We dig deeper into these patterns in the correlation structure of the data by separately analyzing factor exposures and the determinants of the first principal component. We find no evidence of changes in the former around announcement days. In contrast, FED's announcements tend to be accompanied with an increase in the role of U.S. equity and (especially) credit risk news in driving the global factor. In contrast, the importance of equity returns and credit spread to Germany does not increase when the ECB announces its policies. We also do not observe a much larger role of exchange rate fluctuations during the announcements.

Overall, the message that emerges from our findings is that central banks' announcements generate pervasive effects on international asset comovements. We thus contribute to the recent

literature that documents a special behaviour of domestic stock markets around central bank meetings (see Lucca and Moench (2015), Cieslak, Morse, and Vissing-Jorgensen (2019), and Kroencke, Schmeling, and Schrimpf (2017)) by showing they also induce time-variation in country correlations. Given that information leaks may dilute the true impact of monetary policy news that is revealed on announcement days,[3] and that our cross-section is large relative to the number of announcements, the statistical power of our tests is limited. Hence, if anything our results should be taken as a lower bound to the overall effect.

Moreover, the FED stands out as having the largest impact, as its monetary policy decisions make U.S. local factors more globally relevant, while the same does not hold for the ECB, a finding that resonates with the evidence in Brusa, Savor, and Wilson (2018). Our results are consistent with the claim that FED news convey additional information on economic prospects that is processed by market participants, as argued by Albuquerque and Vega (2008), or with the FED leading role in experimenting monetary policies that are strongly geared towards stock market reactions, as argued by Brusa, Savor, and Wilson (2018).

The finding that sovereign CDS markets react strongly to FED news also supports the view that its policies affect the market participants' perception of the severity of bad states of the world. This "downside risk channel" (Cieslak, Morse, and Vissing-Jorgensen (2019)) implies that, when the FED starts releasing its accommodating policies in light of better economic outlook, the investors start increasing the likelihood (and price) associated to these states. As sovereign credit markets are especially sensitive to tail risk, FED's actions are felt more heavily. This argument provides an explanation for the spillover effects from FED's unconventional policies to emerging markets' CDS spreads, which reduce the relevance of local sovereign credit risk and potentially erode the ability of local regulators to control such risk.[4]

Our analysis of comovements also serves as an ideal laboratory to advance our understanding on the independence of monetary policy actions around the world. In the standard Mundell-

[3] See Cieslak, Morse, and Vissing-Jorgensen (2019) for evidence that such leaks generate bi-weekly patterns in equity returns.

[4] The FED's and ECB's policies have indeed been accused of having created excessive global liquidity, and thus caused the massive acceleration of capital flows to emerging markets since 2009. Several policymakers in emerging countries, including Raghu Rajan (former Governor of the Bank of India) and Brazil's President Rousseff (2012), have raised concerns that QE policies may generate a monetary tsunami, currency wars, and new protectionism forms around the world.

Fleming frictionless model, a country can attain only two out of three objectives among fixed exchange rates, full capital mobility, and independent monetary policy (the so-called "Mundellian's trilemma"). The recent literature has challenged this claim by arguing that even in the presence of floating exchange rates, revisions in monetary policies of key countries may spillover to other countries' monetary conditions through complex channels such as financial imbalances and market imperfections (see Rey 2015 and 2016). These spillovers are responsible for a global financial cycle in both prices and quantities.

We offer three contributions in this direction. First, we show that the degree of financial and trade openness matter, as open countries exhibit a much higher response to ECB's and especially FED's news compared to closed economies. The effect is stronger in absolute terms for equity markets, and in relative terms (i.e. relative to ex-announcement days) for the sovereign CDS market. Second, we double-sort countries based on the degree of openness and exchange rate anchoring (from Ilzetzki, Reinhart, and Rogoff (2019)) to either the Euro (for ECB announcements) or the USD (for FED announcements). We find that sovereign CDS spreads to closed countries whose currency is anchored to the USD do comove more strongly following FED news, which is consistent with them being unable to maintain a separate policy of output stabilization (as in the standard Mundell-Fleming model). However, open countries with no anchored exchange rate also exhibit a significant surge in market comovements around FED announcements, in both the equity and CDS market. This result is in line with Rey's (2016) argument that floating exchange rates may not be sufficient to prevent from the influence of global factors. Third, we test a possible channel through which monetary autonomy can be jeopardized, namely the incidence of corporate or sovereign debt that is denominated in foreign (Euro or USD) currency. We find no empirical support for this channel, as countries with a lower share of foreign debt exhibit even more pronounced reaction to FED's announcements.

We complement our analysis with a series of robustness checks. Importantly, we also carry a placebo test, where we focus our analysis on the sample of days with a large (positive or negative) equity shock. We find that, while such extreme market moves do impact market comovements

around the world, central bank's (and again, FED's in particular) announcements are still accompanied by a significant differential effect. Thus, our results are not merely capturing a portfolio rebalancing effect, but rather highlight that FED's unconventional monetary policies generate special spillovers over and beyond those already exercised by U.S. news (see Eun and Shim (1989) and Dèes and Galesi (2018)).

The remainder of the paper is organized as follows. Section 2 discusses related literature. Section 3 review the various phases of monetary policy interventions over the last 10 years. We outline our data and methodology in Section 4. Section 5 presents our main empirical results. Section 6 analyzes the global nature of the first principal component and tests for alternative explanations of our results. Section 7 collects a series of robustness checks. Finally, Section 8 offers concluding remarks.

2 Related literature

There is a long-standing debate in the literature about the effects of monetary policy on asset prices. In particular, the role of monetary policy announcements on asset prices has recently received considerable attention (see Cook and Hahn (1989), Bernanke and Kuttner (2005), Gurkaynak, Sack, and Swanson (2005), Ehrmann and Fratzscher (2004), Bjornland and Leitemo (2009), Schmeling and Wagner (2016), Adrian and Liang (2016), Neuhierl and Weber (2016), Boyarchenko, Haddad, and Plosser (2017), Swanson (2017) and Kroencke, Schmeling, and Schrimpf (2017) among others). A strand of this literature looks at stock returns on FOMC announcement days and find a significant impact, larger than macroeconomic announcement days (see Savor and Wilson (2013), Lucca and Moench (2015), Cieslak, Morse, and Vissing-Jorgensen (2019), Brooks, Katz, and Lustig (2018)) and provide evidence of international effects as well (see Brusa, Savor, and Wilson (2018)). Within this context, the literature on QE and near-zero rates has focused on the effect of QE policy measures on interest rates and equity markets in the U.S. and developed European countries. Examples for works in this area are Krishnamurthy and Vissing-Jorgensen (2011), D'Amico

et al. (2012), D'Amico and King (2013), Banerjee, Latto, and McLaren (2014), Li and Wei (2013) and Pericoli and Veronese (2016) and Bulligan and Delle Monache (2018). A few studies explore the impact of QE on Emerging markets, see Fratzscher, Duca, and Straub (2014) Fratzscher, Lo Duca, and Straub (2013) and Chen, Mancini Griffoli, and Sahay (2014). Our paper is complementary to this literature in that we study second (co-)moments, and investigate in which direction and how do monetary policy news spillover to other markets using a factor structure approach.

The paper also naturally adds to the vast literature on market integration.[5] This literature looks at a wide array of measures of integration, including cross-country differences in cost of capital (Bekaert and Harvey (2000)), volatilities (Bekaert and Harvey (1997)), and correlations (Goetzmann, Li, and Rouwenhorst (2005)), and the role of global versus local factors in explaining these differences. Principal component analysis has also been recently extensively used as a statistical tool to extract common factors from a cross-section of economic indicators (see e.g. Ludvigson and Ng (2009)) or asset prices, Pukthuanthong and Roll (2009) and Namvar et al. (2016) for equity, and Longstaff et al. (2011) for sovereign CDS and our paper belong to this strand of literature as well. In fact, the ability of few 'global' factors to summarize the full covariance or correlation structure, and conversely the percentage of the variance of individual country movements explained by such factors are commonly utilized as indicators of integration.

From a methodological point of view, our analysis allows for comparison of the impact of ECB and FED monetary policy interventions addressing the relevance of "externalities" originating from a country' monetary policy decision. The main empirical problem in this context is to conduct a natural experiment that can serve as basis for comparison of QE with non-QE periods or of periods when different monetary policy instruments were applied. On this regards, our identification approach builds on the solutions proposed by Rigobon (2003), Rigobon and Sack (2004), Rogers, Scotti, and Wright (2014), Rogers, Scotti, and Wright (2015), and Pericoli and Veronese (2016).

[5] A (very) partial list of studies include see Stulz (1981), Errunza and Losq (1985), Stulz (1987), Cappiello, Engle, and Sheppard (2006), and Kumar and Okimoto (2011), Mauro, Sussman, and Yafeh (2002), Codogno, Favero, and Missale (2003), Geyer, Kossmeier, and Pichler (2004), and Pagano and von Thadden (2004), Remolona, Scatigna, and Wu (2008), Pan and Singleton (2008), Ehrmann et al. (2011), Bernoth and Erdogan (2012), Jotikasthira, Le, and Lundblad (2015)). Volosovych (2011), Dahlquist and Hasseltoft (2013), Carrieri, Errunza and Hogan (2007) and Pukthuanthong and Roll (2009).

3 Monetary policy interventions

The 2007-2009 global financial crisis forced central banks to explore a new universe – a battery of unconventional monetary policy measures that brought interest rates close to their economic lower bound equal to or even slightly less than zero. With cash being a risk-free asset with a zero rate of interest (and only potentially small handling costs), central banks are bound by this rate and cannot lower their policy rates much further to stimulate growth if necessary. Consequently, they started to introduce new intervention tools, such as quantitative easing programs (QE), where central banks massively buy bonds from market participants with the intent of fostering economic growth.

The Fed's initial round of U.S. Treasury bond purchases in late 2009 at a volume of USD 300 billion represented an unprecedented intervention in the market for U.S. government bonds, mortgage backed securities (Large Scale Asset Purchase Program), and provided substantial forward guidance regarding the future direction of its policies. It continued in the second round (the so-called QE2), which started in November 2010, and the Maturity Extension Program announced in September 2011. On September 2012, the FED announced a new USD 40 billion per month, open-ended bond purchasing program of agency mortgage-backed securities (QE3). Moreover, the Federal Open Market Committee (FOMC) announced the aim to maintain the federal funds rate near zero at least through 2015. As a result, the balance sheets U.S central bank reached unprecedented levels. On June 2013, Ben Bernanke announced a "tapering" of some of the Fed's QE policies contingent upon continued positive economic data. As a direct consequence of the announcement, the stock market dropped by approximately 4.3% over the following three trading days, and there was a huge spike in market volatility in emerging markets.

The ECB's monetary intervention as a response to the 2007-2009 crisis and the sovereign crisis of 2010-2012 takes many forms, ranging from the jawboning and formal guidance by its board members, in particular its President, to the injection of liquidity into the major banks in the Euro-zone (the fixed-rate tender, full-allotment) and even to direct purchases of sovereign bonds in the cash markets. During the Euro-zone crisis, the policy interventions by the ECB consisted of (i) the

Security Market Program, initiated in May 2010, (ii) Long Term Refinancing Operations or LTRO, announced and implemented in December 2011, (iii) policy guidance, including the "whatever it takes" speech by Mario Draghi on July 26, 2012 who unveiled the potential for new tools to ease the European sovereign debt crisis, and (iv) Outright Monetary Transactions or OMT, also announced in December 2011. On January 2015, in a dramatic change of policy, ECB announced (and in March 2015 started into) a prolonged period of quantitative easing, with an expected balance sheet expansion of more than Eur 1 trillion in the following 18 months that it has so far prolonged till Dec 2018, with a monthly purchases in public and private sector securities amount that ranges between Eur 40 to 80 billion.[6] Given the size and extraordinary nature of these interventions, that have no precedents in the history of ECB and other modern central banks, their impact on the well-functioning of (domestic and international) capital markets and on real growth are still being questioned.

4 Data and methodology

In Section 4.1, we describe our data for monetary policy announcements and asset prices. In Section 4.2, we outline our empirical methodology and discuss the assumptions underneath our identification approach. Finally, in Section 4.3 we take a first look at the time-series and cross-sectional properties of the dataset.

4.1 Data and variables construction

We look at comovements in the pricing of equity claims and credit derivatives, i.e. CDS contracts. For equity, we use total return indices from Datastream.[7] The indices are denominated in local currency, to avoid contaminating our results with the factor structure in exchange rates (see e.g. Lustig, Roussanov, and Verdelhan (2011)). We construct simple, daily returns. Our source for

[6]For a more detailed description of ECB and FED's interventions, see Fawley and Neely (2013) and Borio and Zabai (2016).

[7]These are the value-weighted 'DS Market' indices that are constructed using all available stocks in a given country. The only exception is Slovakia, for which we use the SAX 16 Index.

CDS contracts is Markit. Markit collects CDS prices via a survey of brokers-dealers and proceeds to clean the data by discarding stale information, outliers, and inconsistent observations. It then reports the daily composite price for each CDS contract for each reference firm in its database. For our analysis, we utilize data for quotations that are denominated in USD and reference the sovereign of a given country.[8] To maximize sample availability, we use the most common restructuring clauses available on a given date (typically, CR or MR). We focus on quotes for the 5-year contract as this is far the most liquid issue. The data coverage varies significantly across countries, starting January 2002. However, it is only after mid-2007 that most of sovereign CDS series depart from zero and exhibit significant time-variation. For this reason, we focus our analysis on the period starting from August, 2007.

Our cross-section consists of a total of 39 countries, which are listed in Table AI. The list is comparable to existing studies on international equity and bond markets (see inter alia Longstaff et al. (2011) and Ghysels, Plazzi, and Valkanov (2016)). The most notable exceptions are Canada, Switzerland, and the U.K. among the Developed markets (as CDS data for these countries is either stale, or starts much later in the sample period), and India for Emerging markets (CDS data does not vary for most of the sample). We further exclude Greece as the CDS quotes are stale at above 10,000 basis points for a prolonged period during 2011-2012. We group countries into 18 Developed and 21 Emerging markets following the classification provided by FTSE.[9] We further contrast the impact of ECB and FED's interventions on the group of the 11 markets that are in the Eurozone (EMU) with that on the 8 developed markets that are not part of it (DM ex-EMU). Finally, we separately analyze the effect on emerging markets based on whether they are located in Europe&MiddleEast (8 countries), Asia&Pacific (5 countries), and Americas (6 countries). We also construct two equally-weighted indices of developed and emerging markets, that we denote respectively "DM Idx" and "EM Idx", to study dynamics *between* the two groups.[10]

Our goal is to measure the effect of monetary policy interventions on market comovements. To

[8]We rely on USD-denominated CDS as these are the most frequently available and liquid contracts. Using Euro-denominated CDS does not, however, alter our findings. In general, given that the currency only pertains to the notional amount, exchange rates fluctuations play a very minor role in CDS contracts with respect to credit risk.

[9]We pool the group of (4) frontier markets with emerging markets, as they are too few to be analyzed separately.

[10]Note that the country equity indices are denominated in local currencies, so these indices do not reflect a feasible equity trading strategy.

identify dates of central banks' interventions, we rely on the list of ECB and FED meetings and announcements that is compiled by Pericoli and Veronese (2016) (see their Appendix Table 4 and 5). This list comprises of all scheduled and unscheduled Governing Council and FOMC meetings, combined with a series of dates where changes in QE policy were announced. In what follows, we refer to such dates simply as meetings. There are a total of 109 ECB meetings and 107 FOMC meetings during the August, 2007 to November 2015 sample period, which are held on week days – mostly, on Thursday for ECB and Wednesday for FOMC. For each of these announcement days, we construct "event windows" which include the day of the meeting, the two days before and the two days after. We refer to these 5-day (-2;+2) windows as "event days". This choice of event window takes into account possible lead-lag effects which may be due to market participants reacting in anticipation of the actual release of information. In addition, the market for credit derivatives is neither centralized nor fully liquid, and therefore it may take some time before the information is fully reflected in CDS prices. In Section 7, we verify that our findings are robust to changes in the event window definition and to using data sampled at the weekly frequency.

4.2 Methodology

A common issue when analysing market data for the evaluation of economic policies (even beyond the focus on monetary policies of this paper) is the identification of structural changes in the underlying data-generating-process. Any of such changes would, in turn, affect the covariance structure of the data, which represents the starting point for all the analyses we perform, and neglecting them would result in inconsistent estimates. To this end, the first step in our approach is to split the full sample over three periods which were characterized by relevant changes in the activities and policies of central banks. The first period runs from August, 2007 to December, 2009 and spans the global financial crisis starting with the tensions in the subprime market and followed by Lehman's default and the interventions by the FED and the ECB. The second period ranges from January, 2010 until May, 2013 and includes the Euro sovereign crisis and the corresponding ECB interventions on one side, and QE2 and QE3 of the FED on the other side. The third and last period

ranges from June, 2013 until November, 2015 and is characterized by the tapering of the FED and, in January 2015, by the beginning of ECB QE program. We separately analyse the impact of FED and ECB announcements within each of these subsamples.

A different concern than the presence of structural breaks is that market players' activity generates variation in volatility *within* a given period. This heteroscedasticity has distortive effects in 'reduced' form approaches such as event studies, as demonstrated by Forbes and Rigobon (2002), and may well lead to inconsistent estimates.[11] For this reason, we pre-filter returns and changes in CDS by time variation in conditional volatility. Specifically, we fit the asymmetric GARCH model of Glosten, Jagannathan, and Runkle (1993) for each series and period, and treat the scaled residuals (i.e, the series scaled by conditional volatility) as our input data. This step guarantees that our measures of comovement reflect only changes in the correlation structure originating from central banks' announcement, and are not contaminated by (or, do not capture) heteroscedasticity or potential heterogeneity in the level of volatilities. We comment on the results when using the raw (unfiltered) series in Section 7.

To proceed, let X_t be the panel of such volatility-filtered equity returns (or CDS changes) for K countries in a given period and consider announcements by a given central bank, be it alternatively the ECB or the FED.[12] We are interested in understanding whether these announcements had a significant impact on the correlation structure of the data. To this end, akin to an event-study approach, we contrast the degree of comovement during all announcement days (denoted by the All subscript), i.e. those falling in the event window of the meetings, with that in the subsample of non-announcement days that fall outside the event window (No subscript). In addition, to capture heterogeneity in the impact of monetary policy "surprises", we look at announcement events that are accompanied by a largely positive or negative reaction on the government bond yield curve. To be precise, we group announcement windows into those that fall below the first tercile ("Low")

[11] Changes in volatility around announcement days play, instead, a key role in the 'structural' approach of Rigobon (2003) and Rigobon and Sack (2004), whose identification strategy actually exploits the presence of heteroscedasticity in the data. The crucial assumption underneath this approach, however, is that the structural model parameters are invariant across periods, which is not going to hold throughout our full sample given the switch between conventional and unconventional policies.

[12] Note that K changes as we carry our analysis on different subset of countries to understand the degree of heterogeneity in comovements across different grouping criteria. To avoid cumbersome notation, we do not introduce separate subscripts for the given period and central bank.

and above the second tercile ("High") of the overall change in the level of yields, which we proxy with the first principal component of the yield curve for the U.S. and Eurozone.

We measure the extent of international comovements by looking at the fraction of overall variance explained by the first principal component of the correlation matrix of the market data (equity returns or changes in CDS spreads). Principal Component Analysis (PCA) has been extensively used in the financial literature as an efficient way of summarizing the joint behavior of several asset classes including fixed income, equity, and exchange rates. See Pukthuanthong and Roll (2009) for a paper that uses PCA on equity returns, and Longstaff et al. (2011) for evidence of common exposure to global factors in the sovereign CDS market.

Formally, consider a given combination of market (equity or CDS), sample period (three of them), group of countries, and central bank (FED or ECB). Let $\mathcal{R}_i$ be the correlation matrix of X_t separately computed within each subsample of days $i = \{No, Low, High, All\}$. Let L_i denote the matrix of eigenvectors in the spectral decomposition of $\mathcal{R}_i$. We construct principal components as $F_{t,i} = L_i' X_{t,i}$ and look at the fraction of total variance accounted for by the first principal component, which we denote $F1_i$.[13] In what follows, we use the terms principal component and factor interchangeably.

Under the assumption that central bank's announcements are not accompanied by changes in comovements in a given sample period, then $\mathcal{R}_\iota = \mathcal{R}_{No}$, for $\iota = \{Low, High, All\}$. Consequently, the fraction of variance explained by the first principal component should be identical during announcement and non-announcement days. Under this null hypothesis, we expect that the distances

$$\Delta F1 \equiv F1_\iota - F1_{No} \tag{1}$$

should be statistically indistinguishable from zero $\forall \iota$. We test this hypothesis for each time period, central bank, and X_t combination. Given that our sample size may not be sufficiently large to trust

[13] That is, we decompose $\mathcal{R}_i = L_i D_i L_i'$, where D_i denotes the diagonal matrix of eigenvalues. Then, $F1_i = d_{1,i}/K$, where $d_{j,i}$ is the eigenvalue associated with the j-th principal component.

asymptotic approximations, we resort to a bootstrap procedure that takes all features of the data into account. The procedure is detailed in Appendix A.[14]

4.3 A first look at the data

As a prelude to our analysis, we summarize the time-series and cross-sectional properties of equity returns and sovereign CDS spreads in Figure 1. As a mean of comparison, we also plot in the gray area the data for the January, 2006 to August 2007 period that is not used in our analysis.

The top plot of the figure displays the cumulative, equally-weighted average equity return (black thick line) separately computed across EMU countries (left plot), Developed markets ex-EMU (middle plot), and emerging markets (right plot). The vertical dotted lines mark the end of the periods considered. We note broadly similar patterns across groups, with a sharp decline in valuations during the crisis followed by a recovery towards the end of 2010, the turmoil of the European sovereign debt crisis (which is especially pronounced in EMU countries), and the increase in valuations in the last part of the sample reaching levels above the pre-crisis period.

To give a sense of the cross-sectional distribution within countries of a given group, we plot the cross-sectional standard deviation (blue dotted line) on a common scale across the three groups. Overall, the cross-sectional dispersion is much higher for Emerging markets, and shows pronounced spikes exceeding 5% during the major events in the sample. The volatility of EMU countries returns during the sovereign debt crisis is at comparable levels to the 2008-2009 period, and remains high in the last part of the sample. In contrast, the dispersion in returns for developed markets ex-EMU shows a declining trend after 2012 and hovers around lower values. The fact that Emerging markets display rich (heterogeneous) cross-sectional dynamics underscores the potentials for looking at the transmission of monetary policy shocks toward these countries.

The bottom figures plot the time series of equally-weighted average sovereign CDS spread (black thick line). The differences across the three groups of countries are even more pronounced.

[14] In short, the bootstrap generates artificial samples of volatility-scaled X_t, on which we impose the null hypothesis of equal correlation structure. We then simulate artificial announcement and non-announcement dates in a size equal to that observed in a given sample, and compute estimates of the distance in (1) under the null. By repeating the procedure a large number of times, we obtain the empirical confidence interval that we use to assess the significance of our sample estimates.

It is noteworthy that the CDS spreads for EMU countries reached their maximum at 420bps in the middle of the second period, and then calmed down following the ECB intervention reaching values in the 50bps range toward sample end. In contrast, the CDS spread of the other Developed markets has its maximum around 200bps at the peak of credit crisis in 2009, increased to a more modest 100bps level in 2012, and decreased almost steadily thereafter to a level of 30bps. Finally, Emerging markets reach averages above 700bps in 2009 and 300bps in 2012, and are characterized by a distinct upward trend in the later part of the sample to values in the 400 to 500bps range. The figure also shows that for the period preceding August, 2007 CDS spreads are quite close to zero and very sticky, indicating that either sovereign credit risk, the liquidity in the market, or both were very modest.

We summarize the cross-sectional distribution of sovereign CDS spreads by the standard deviation of their changes divided by the average CDS in a given group (blue dotted line). This 'coefficient of variation' is scale-free, and allows us to account for the marked differences in average CDSs. We note that this coefficient is lowest for Developed markets ex-EMU, while EMU countries show cyclical spikes in their dispersion. The variability of CDS spreads for Emerging markets is highest in the last part of the sample, again suggesting that Emerging markets provide a potentially diverse set of countries to examine.

5 Monetary policy and market comovements

Tables 1 and 2 present our main empirical results on the impact of monetary policy announcements on comovements in equity and CDS prices, respectively. Within each table, we report the estimates of the fraction of total variance accounted for by the first principal component $F1$ in the three sample periods considered. In the last two columns of each period, this measure is computed on all announcement and ex-announcement event days.

In the tables, we mark in bold $F1$ estimates whose distance with respect of the non-announcement days ($\Delta F1$) is statistically significant at the 10% level based on the boostrap procedure described

in Appendix A. The analysis is performed by pooling data across all countries, and separately for: the group of EMU countries; developed markets (DM) ex-EMU (Australia, Denmark, Israel, Korea, Japan, Norway, Sweden and the U.S.); all emerging markets (EM); emerging markets in either Europe&MiddleEast, Asia&Pacific, or Americas; and finally, the bivariate system consisting of the developed market and emerging market indices (DM Index & EM Index).

5.1 Results for equity

We begin by discussing the impact of ECB announcements on equity markets' comovements in Panel A of Table 1. A first general trend we observe is that, independently of the release of monetary policy news, international equity linkages were stronger during the global and European sovereign crisis (i.e. Aug2007 to May2013) compared to the most recent period. This difference is present when considering all 39 countries together, at the regional level, and even *between* developed and emerging markets.

Zooming in on the results during the global crisis, the effect of ECB announcements when pooling all meetings is almost muted, as the difference with respect to ex-meeting days is a modest (and statistically insignificant) -0.14% across all countries and -0.18% between developed and emerging countries. However, when the ECB announcement was able to "calm down" the rise in sovereign bond yields ("Low" column) we observe a significant negative impact on equity comovements as the fist principal component accounts for a lower percentage of the total variance than ex-meeting days. The drop is particularly pronounced for emerging markets, and between developed and emerging.

The second period (Jan2010-May2013) is characterized by the European sovereign crisis, where the ECB heavily intervened to avoid the breakup of the Euro area. A few interesting facts are noteworthy. First, the announcements are accompanied by a marked increase in market comovements, with the fraction explained by the first factor being about 4% higher both across all countries as well as between DM and EM. Second, ECB news did *not* significantly impact comovements among EMU countries. Instead, countries ex-EMU and in particular emerging countries strongly

reacted to ECB announcements. The effect is there when the ECB announcement lead to a decrease in yields. It is even more widespread when the announcement was not enough to convince the market that the proposed policy would mitigate sovereign crisis ("High" column), with an increase in $F1$ which is statistically significant among all markets (from 37.21% to 45.76%), between DM and EM (from 86.25% to 92.47%), and especially for DM ex-EMU (by about 10%) and EM (by about 8%). Notably, the latter effect is concentrated in the group of EM Europe&MiddleEast, that is, within countries that are geographically and also commercially highly related to the EMU area.

The last period is dominated by ECB massive QE policy interventions. A striking result that emerges from the table is the modest and overall even negative effect that ECB announcements had on market comovements. The only significant estimate is for the relation between DM and EM when ECB policies resulted in a slight increase in yields, where the first factor explains about 10% less compared to ex-meeting days. This evidence demonstrates that QE actions by the ECB were not perceived as a major global shock and, if anything, lead to a de-coupling between the group of DM and EM equity markets.

The corresponding results for FED announcements are reported in Panel B. We note several differences with respect to Panel A, which are particularly pronounced for emerging countries. First, news from the FED are generally accompanied by an *increase* in the importance of the first factor. This increase is largest during the Global financial crisis period and for emerging markets at 5.90%, and mainly for emerging markets in Europe&MiddleEast (at 7.75%). The increase is significantly significant for all country groups we consider (the exceptions are EMU and DM-ExEMU). However, the impact is quite different if we look across the three yield regimes, as the largest differences are driven by the announcement that were unexpected by the market and are accompanied by a significant change (increase) in the interest rates. There, we observe a 8.53% statistically significant increase in the comovement for all 39 countries, and an even larger 10.60% figure for Emerging markets. Significant differences are also noted for Emerging markets when the FED interventions were effective in reducing interest rates. Co-movement among Emerging markets raise by 10.48%, and for EM Europe&ME by 13.85%. These results reveal that the FED's

announcements significantly altered market comovements both between and within developed and emerging markets. Thus, its announcements are truly perceived as global shocks. Among emerging markets, the change is statistically significant across all geographical areas.

During the second period, which was characterized by FED's QE2 and QE3 interventions, announcements that were accompanied by a drop in the level of rates lead to a significant and across-the-board increase in the degree of comovement of emerging markets in the order of 10%. This result provides empirical support for the concerns of policymakers in these countries that changes in FED's monetary policy spill over to EM in an even amplified manner.

In the last period, when the FED started the QE tapering, the response across All market co-movements appears muted compared to the sample of No announcements. Looking across the separate country groups and yield reactions, however, reveals a richer picture. Announcements associated with a reduction in interest rates are accompanied by a nearly 6% decrease in the importance of the global factor with respect to ex-meeting days, whereas nearly the opposite effect (that is, a 7% increase) is observed during announcements that lead to higher rates. In this latter case, the reaction is amplified for the group of emerging markets, with a nearly one-third increase from 24.45% to 37.61%. This evidence again testifies the large impact of FED's policy decisions on these economies. Notably, whenever significant, the impact of FED news is almost always to *in*crease the linkages between emerging and developed markets, with the fraction accounted for by the global factor increasing by more than 7% (from 79.21% to 86.60%) when pooling across announcements.[15]

5.2 Results for CDS

We next turn to the discussion of market comovements in the CDS market. Panel A of Table 2 reports the impact of ECB announcements on the correlation structure of CDS changes. Looking across the periods, the only across-the-board significant effect is observed during the European sovereign crisis and when ECB announcements were accompanied by an increase in interest rates,

[15]The exception is for the group of EM Asia & Pacific, where an increase in $F1$ is observed when FED announcements lead to lower rates.

namely when the ECB was ineffective in cooling down market tensions. During these days, the fraction accounted for by the first principal component increases by nearly 13% among all countries, and within EMU as well as emerging markets.

In all other period-country-rates combinations, changes in the correlation structure appear to be modest. Some exceptions are observed during the global crisis, when ECB announcements lead to a drop in the importance of the global factor by about 10% across all countries (in the Low subsample), for EM Americas (in the High subsample), and also between the groups of developed and emerging markets.

Taken together, these results indicate that ECB announcements either lead to a general fragmentation (i.e. a decrease in correlations), or to an increase in co-movement when its policy is perceived as ineffective. This result is in line with a fragmentation among core and peripheral countries having different reactions to ECB announcements. Also, the impact on emerging markets, if any, is largely confined to the EM Europe&MiddleEast and EM Americas countries.

The reaction of CDS market comovements to FED announcements is, instead, quite different. In the first period, during the global crisis characterized by Lehman's default and several FED announcements of unconventional monetary policies surrounded by large uncertainty, FED's announcements increase CDS market comovements. However, the differences are mostly not statistically significant. The main exception is for the comovement of the emerging markets, with a large and significant 8% increase which is independent on the yield reaction.

During the second period, when the FED implemented its QE2 and QE3 policies, we again observe a surge in correlations among emerging markets CDS, with a rise in $F1$ by about 10%, but a negative impact on CDS comovements between developed and emerging markets with a reduction of about 7%.

The most striking and significant results for the sovereign CDS market are found in the last period, when the FED starts tapering its QE policies. The degree of comovement in CDS changes among the 39 countries increases substantially, with the first factor explaining an additional 10.13% of the overall variance (from 26.28% to 36.41%). This change is strongly significant, and is mostly

driven by tapering announcements which were followed by a rise in interest rates, when the increase in $F1$ nearly doubles at 19.69%. The impact on CDS market comovement among emerging markets in the High regime is also positive and significant both across all countries (when $F1$ jumps by about a half, from 36.11% to 53.30%) and among the group of EM Americas which are geographically and politically more connected to the U.S. (from 78.57% to 84.74%). For other groups of countries, the impact is also positive and large albeit not significant.

Overall, the CDS market provides even more clear-cut evidence than equities that the FED's policy plays a relevant role in generating comovements around the world, especially in the last period when it relaxed its QE policies. FED announcements can thus be viewed as a global factor generating spillovers to developed markets, and even more largely so to emerging countries. In contrast, we observe a generally muted response to changes in ECB's policy.

6 What drives market comovements around central bank announcements?

The evidence that FED and ECB interventions have significant (and potentially even opposite) effects on market comovements merits further investigation.

From a statistical viewpoint, changes in the importance of the first factor (i.e. in $F1$) around meeting days can originate from either changes in factor exposures, changes in the 'systematic' nature of the principal components, or both. To see this formally, consider a particular time period and central bank (be it the ECB or the FED). Let $\hat{F}_{t,All} = L'_{No} X_{t,All}$ be the factor we would have observed during All meeting days had the announcement not changed the factor loadings with respect to the non-announcement sample. We can decompose the panel of market data during the

announcement sample as:

$$
\begin{aligned}
X_{t,All} &= L_{All} F_{t,All} \\
&= L_{All} F_{t,All} \pm L_{No} \hat{F}_{t,All} \pm L_{All} \hat{F}_{t,All} \\
&= L_{No} \hat{F}_{t,All} + (L_{All} - L_{No}) \hat{F}_{t,All} + L_{All} \left(F_{t,All} - \hat{F}_{t,All} \right) \\
&= L_{No} \hat{F}_{t,All} + (\Delta L) \hat{F}_{t,All} + L_{All} (\Delta F) \qquad (2)
\end{aligned}
$$

Equation (2) clarifies that if both the factors and the loadings are unaffected by the announcement, so that both ΔL and ΔF are zero, then the first term should be the only one relevant. On the other hand, if monetary policy announcements do affect financial market comovements, this must happen through either changes in factor loadings (the ΔL term), changes in the nature of the factors (the ΔF term), or a combination of the two.

This decomposition allows us to dig deeper into the economic mechanisms through which monetary policy news impact the correlation structure of financial markets. For one, central bank meetings may condensate new information on the state of the economy and act as a conduit towards market participants. This argument would be consistent with the patterns observed in domestic US equity returns around FOMC meetings (see Lucca and Moench (2015) and Cieslak, Morse, and Vissing-Jorgensen (2019)). We refer to this scenario as the "information channel". Alternatively, or possibly concurrently, central banks interventions on reference rates may induce changes in exchange rates. These changes would impact local equity valuations via private sector exposures to the foreign currency, and the pricing of sovereign risk through government bonds issued in those currencies. We call this the "currency exposure channel".

We expect the information channel to affect the systematic nature of the principal component, but not the sensitivity of a country to news. The exposure channel, instead, could impact both factor exposures and the systematic component through the exchange rate. We now therefore use the decomposition in (2) to better understand the driving channel behind our evidence.

6.1 Analysis of factor loadings

We begin by testing for changes in factor loadings, that is, in the exposure of country shocks to the aggregate factors. Our test exploits the fact that, if the two correlation matrices in the non-announcement to announcement sample of central bank j meetings in a given period are identical, then the orthonormality property of eigenvectors implies that:

$$L_\iota' L_N \sim I \qquad \iota = \{Low, High, All\}. \tag{3}$$

This result suggests that changes in the loading structure with respect to the first principal component can be detected by the following statistic:[16]

$$\Delta D = [L_\iota' L_{No}]_{1,1} - 1 \tag{4}$$

where $[.]_{1,1}$ identifies the element in position (i, j).

We find (see Appendix Table AII) that the differences are fairly small and never meet statistical significance. In particular, during the QE period of the ECB and the FED the difference averages at -0.01 for returns and -0.03 CDS changes. We conclude that monetary policy announcements do not result in pronounced shifts in the eigenvector, that is, in the exposure to dominant factor (i.e. the first principal component).

6.2 Analysis of factors

We examine the systematic nature of the first principal component by projecting it onto aggregate factors capturing the impact of news fundamentals or revisions in risk premia, similarly to Longstaff et al. (2011). Our list of factors is confined to market variables that are available on a daily basis, and that are likely to represent global shocks.

Drawing from prior studies, we include the following seven variables: the return to a weighted

[16] For comparability of the principal components we impose that the loading to the first principal component of the first asset is positive in both samples.

average index of exchange rates of the Euro (for ECB meetings) and USD (for FED meetings) against the currencies of a large group of major trading partners[17]; the VIX equity implied volatility index; the equity volatility risk premium, measured by the difference between the VIX and the realized volatility over the past 22 days of daily returns to the S&P500 index; the TYVIX index of implied volatility in the fixed income market, see Mele and Obayashi (2015); the volatility risk premium in the fixed income market, measured by the difference between the TYVIX and the realized volatility over the past 22 days of daily returns to a 10-year bond index; the change in the price of Crude Oil; and the return to the Bloomberg Commodity Index, which comprises of 22 commodity futures. While some of these factors are constructed on the U.S. market, we include them following the argument in Longstaff et al. (2011) that they presumably highly correlate with global-wide shocks.

In line with Longstaff et al. (2011), and following the work of Lucca and Moench (2015) and Cieslak, Morse, and Vissing-Jorgensen (2019) on the role of FED announcements on the US equity market, we augment the set of explanatory variables with the stock market indexes of the US and Germany. We also include their corporate credit risk as measured by the difference between a low grade and high grade corporate bond indexes respectively for the U.S. (for FED meetings) or Germany (for ECB meetings). The scope is to understand whether "local" shocks in the area whose monetary policy is being revised become more globally important. We treat Germany as the representative country for the Eurozone, as in Ang and Longstaff (2013).[18] Structural models of default imply that returns to equity and credit spreads should move in the opposite direction, so we expect their loadings in the regressions to have opposite sign.

Given then relatively high dimensionality of our study, we provide a selected discussion that focuses on the most representative findings, and relegate detailed results in the Online Appendix. In particular, we restrict our attention to the comovements of emerging markets vis-à-vis developed markets when pooling all announcement days. We also report the estimates only for the three factors that are more relevant to distinguish between the price discovery versus currency exposure

[17] The source is the Bank of International Settlements.

[18] Including alternatively an equally weighted average of the equity or credit risk of EMU countries does not alter our conclusions.

stories, namely the stock market, corporate credit risk, and exchange rate factors. All specifications, however, include also the other six control variables listed above.

Table 3 collects the estimates in the regression of the first principal component from the DM and EM indices on the aforementioned variables. In the table, coefficients that are significant at the 10% level are marked in bold. The rightmost columns report the R-squared and the partial R-squared statistics, computed as Shapley-Owen value, capturing the relative contribution of a variable to the overall R-squared. The regressors are standardized to mean zero and unit variance within each sample to ease comparisons.

We start with Panel A of the table that relates equity comovement between DM and EM to our list of regressors during ECB meeting and ex-meeting days. Across all periods, the equity and credit risk variable enter the regression with statistically significant coefficients during meeting days. Interestingly, instead, the Euro exchange rate is relevant only *outside* meetings days. This result gives a first indication that the impact of ECB policies on equity markets is not related to a currency channel. Another striking pattern we note is that the impact of ECB announcements has progressively shifted away from equity return news, as the coefficient on the return to the German market actually decreases in the QE period (compared to ex-meeting days), and so does its partial R-squared. In turn, the credit risk coefficient doubles in magnitude during ECB announcements in that period. A potential explanation for this result is the large effect of ECB interventions on the reduction of banks' as well as sovereign credit risk. Overall, the partial R-squared for the three reported variables is not substantially altered by ECB announcements, which suggests that its unconventional monetary policies did not markedly tilt the nature of global shocks towards European market news.

Panel B of the table reports analogous statistics for FED meetings. The evidence is almost the opposite as that for the ECB in the corresponding periods. Namely, the first two periods are characterized by a decrease in the importance of US equity news on the global factor during announcement days, which is particularly pronounced in the crisis sample. This effect is partly compensated by a more negative (and significant) coefficient on credit risk during the QE, in anal-

ogy to what we observed for the ECB in the third (QE) period. Another difference with the ECB is that the exchange rate (USD) enters now with a large and significant coefficient, which is however largely unaffected by the announcement. In the last Jun2013-Nov2015 period, we observe a sharp increase in the overall R-squared, from 0.36 to 0.51. This effect largely originates from the equity and credit risk factors, whose coefficients are twice as large as in ex-meeting days, and are together responsible for most of the R-squared. Hence, the role of U.S. shocks in driving the global factor becomes stronger as the FED starts tapering its unconventional monetary policy. The same is not true, however, for the USD exchange rate factor, as its coefficient turns smaller and insignificant during announcement days. This result again suggests that equity comovements are not likely on account of a currency channel.

We next turn to the principal component analysis of the sovereign CDS market. In Panel C for ECB announcements, the results broadly mimic those for equity, with some notable differences. First, the role of the Euro exchange rate is now much more pronounced during the European sovereign crisis period. Second, when the ECB started its quantitative easing program in the last part of the sample, the equity, credit risk, and exchange rate factors all enter the regression with a significant loading. However, their contribution in terms of partial R-squared is almost at par with ex-meetings days, and the overall R-squared actually decreases, from 0.42 to 0.36.

The effect of FED monetary policy revisions is presented in Panel D. During the crisis period, FED announcements are associated with a larger regression R-squared, which raises from 0.26 to 0.38 during announcement days. However, this result does not originate from an heightened role of U.S. news on the global factor, as the higher importance of U.S. credit risk (partial R-squared from 0.03 to 0.10) is compensated by a decrease in that of the equity and exchange rate factor (together, from 0.14 to 0.08). This evidence is broadly observed also in the second period, with a slight reduction in the role of U.S. shocks on the global factor. In the tapering period, instead, the impact of US news on the global factor during FED announcement days is felt very strongly. The reported coefficients are up to two to three times larger than those for ex-announcement days, and the R-squared sensibly increases from 0.31 to 0.47. The USD factor stands out with a 0.15 increase

in the partial R-squared, while the US equity return and credit risk account for an additional 0.06. Thus, the stronger degree of comovement in the sovereign CDS market during the tapering period we document in Table 2 comes from a larger impact of U.S. news on the global factor during FED announcement days. In other words, FED announcement are truly perceived as global factors in the equity and even more so sovereign CDS market, as the role of U.S. equity and credit risk in explaining the first principal component raises significantly in the last period.

6.3 Testing for alternative transmission channels

The analysis presented in the previous sections reveals two main results. First, not all the announcements generate an increase of comovements across markets, but only those aimed at reducing the impact of a crisis – i.e. global financial crisis for the US and the sovereign crisis for the ECB – and the tapering of QE by the FED. Periods characterized by large QE implementation, first by the FED and then later on by the ECB, do not result in significant changes in market comovements. In fact, the importance of equity, credit, and currency news is generally stronger when a country's central bank announcements are about tapering compared to implementing QE policies. Second, the increase of co-movement during central banks announcements is associated with an increase in the importance of the U.S. equity and credit risk news, particularly for the sovereign CDS market. The USD exchange rate factor is less relevant for the equity comovements, but does have a role for sovereign CDS shocks in the last period. In this section, we investigate the economic channel that is responsible for these patterns.

Interventions by the FED and the ECB might impact international financial market comovements through adjustments in exchange rates. As some countries load differently on currency risk, these adjustments may generate heterogenous reactions to these central banks' policies. We explore this "currency exposure channel" by using data on currency exposures in international markets available from the BIS. For the analysis on Equity market comovement, we look at the Absolute Net exposure (Claims minus Liabilities) of the banking sector versus Banks and Non-Banks which are denominated in Euro (for ECB) or USD (for FED), scaled by nominal GDP. For

the analysis on Sovereign CDS comovement, we look at the total amount of International debt securities of the General government denominated in Euro (for ECB) or USD (for FED), scaled by nominal GDP Data are quarterly and averaged for each country within each period We group countries in each period into Low and High, where Low (High) means Below (Above) the median country. If the extent of market comovements is on account of different exposures to currency risk at the corporate (for Equity) or sovereign (for CDS) level, we expect countries in the High group to display a stronger reaction to monetary policy news.

The results of this analysis are reported in Table 4. We find that indeed, the group of countries with higher currency exposure do generally present a higher degree of comovement, both for the equity and the CDS market, compared to Low exposure countries. The only exception is in the third period for the CDS market for countries grouped based on Euro exposure. Therefore, the currency exposure channel does affect financial market comovements. However, the degree of comovement for High exposure countries during announcement days is not generally different than that during ex-announcement days. Quite the opposite, most of the significant entries are for countries with a low exposure. As a case in point, FED announcements in the sovereign CDS market in the tapering period are felt quite strongly for countries with a lower relative amount of USD-denominated debt, for which the importance of the first factor increases by a stunning 13% (from 31.13% to 44.34%). As expected, much of this effect is concentrated during days with positive interest rates reaction, where the global factor now accounts for 50% of the overall variability. The same figure is comparable at 49% for High exposure countries, although the change relative to ex-announcement days is smaller. Taken together, this evidence runs contrary to the claim that the changes in comovements that we document are driven by a currency exposure channel.

On the other side, central banks' announcements may act as conduit of new information about domestic economic conditions, which is then processed by each country based on its degree of dependence on external shocks. We therefore test for this "information channel" by looking at a country's degree of financial and trade openness. We consider a country financially close (open) if its Chinn and Ito (2006) index of capital account openness averaged during the sample period is

below (resp., above) the median. A country is closed (open) to the trading of goods if its ratio of import plus export over GDP averaged during the sample period is below (resp., above) the median. Developed and Emerging markets are finally grouped into Closed and Open following the analysis in Martin and Rey (2006) about the relation between openness and outside shocks (crashes).[19] An information story implies Open countries should be more impacted by monetary policy news.

The results of this analysis are reported in Table 5. Also in this case, the analysis shows that countries that are more open do present a higher comovement both for the equity market and the CDS market and for all the periods we consider. The only exceptions are in the first period for the ECB meetings and in the third period for the CDS market regarding the FED announcements. Thus, as expected, a higher degree of openness does result in a larger importance of global shocks. However, when looking at the impact of the central banks' announcements open countries do generally show a larger increase in comovements compared to closed economies. This difference is especially there for equity returns. For the sovereign CDS market, in the third period FED announcements have a significant impact on both closed and open countries, but the difference of the impact with respect to non-announcement days remains much more pronounced for open countries. The result that open countries are more exposed to outside monetary policy announcements lends support to an information channel explanation.

6.3.1 Placebo test

In order to further clarify the provenance of our results, we carry the following "placebo" test. We re-run our analysis only on the subsample of days when the equity market of either Germany (for ECB meetings) or the U.S. (for FED meetings) experienced a large move. Therefore, we restrict our sample only on days when the market experienced a large shock. We define as such days when the equity return is below the first quartile or above the third quartile of the within-period return distribution of the raw (i.e. not volatility-filtered) series.[20] The rationale for this test is to

[19] Namely, Developed markets are classified as open is they are either financially closed and open to trade, or financially open and closed to trade. Emerging markets are classified as closed if they are financially closed.

[20] This definition of a large movement strikes a compromise between isolating returns in the tail of the distribution and allowing a sufficient number of observations to break down meeting days based on the yield reaction.

verify whether our previous results merely originate from equity market shocks being large during announcement days. If markets are priced according to an International CAPM framework, where the international market portfolio is largely represented by US or Euro stocks, large equity moves would lead to portfolio rebalancing and thus correlated changes in prices. If this was the case, once the estimation is conditioned on days with large equity returns we should no longer observe significant differences in the extent of comovements between meetings and ex-meeting dates.

Table 6 collects the fraction of overall variance accounted for by the first principal component of equity returns (Panel A and B) and CDS spreads (Panel C and D) in this subsample. As we can see, the result mimick quite closely those from Table 1 and 2 in terms of magnitude, direction, and statistical significance. Namely, the reaction of equity markets to ECB news is confined to the European sovereign crisis period, and generally shows an increase in comovements, while is muted or even accompanied with "disintegration" in the last period when the ECB carried its QE interventions. For the FED, instead, both the introduction of QE (during Jan2010 to May2013) and its relaxation in the subsequent period have a wider impact. Similarly in the CDS market, the ECB action was accompanied by an increase in comovements only when it generated the undesired effect of increasing rates in the second period, and if anything by a decrease in comovements during the most recent QE period. In contrast, the FED's intervention was felt much strongly especially by emerging countries in the second and in the last "tapering" period.

In sum, we conclude that central bank announcements, and particularly those from the FED, lead to heightened joint market dynamics. Moreover, monetary policy news are felt differently in financial markets and carry additional information than days with similar equity market moves.

7 Robustness tests

We perform an extensive set of checks and additional analyses to confirm and extend our main results along various dimensions. For brevity, we do not tabulate these checks as they are in agreement with our main findings.

Event window: We perform sensitivity analysis with respect to the length and start of the event window. We modify the window so that the start is at the event day, and thus focus on (0,+2). Such a first choice allows verifying the possible role of anticipation. We also consider windows of larger size, defined as (-2,+2) and (0,+4), to capture potentially long-lasting news.

Unfiltered data: Instead of pre-filtering the data by asymmetric volatility, we examine the correlation structure of the raw series. The most striking differences appear in the effect of ECB announcements on the sovereign CDS market, especially for EMU countries where the percentage explained by the first principal component drops by 9.3%. This suggests that while ECB interventions did not significantly affect the correlation structure of EMU asset markets, they nevertheless induced disintegration in the form of heterogeneity in their volatility.

Weekly data: We run our analysis on data sampled at the weekly frequency. Given the international nature of our dataset, working on weekly data guarantees that the information has reached the markets by the end of the observation period thereby solving issues related with differences in time zones. Also, daily variations in CDS prices tend to be small and infrequent, and this staleness may artificially inflate our measures. When dealing with weekly data, we assigning each event to the last open market day of the event week. In that case, the events will last for just a single week. Again, we find that our main conclusions still hold.

Alternative covariance estimator: As an alternative to the use of weekly data to capture markets a-synchronicity, we retain the daily nature of the data but rely on a Newey-West type of estimators that also takes into account one lead/lag effect. We found our main findings remain robust.

Dynamic factor model: As an alternative to the use of Principal Components Analysis where we recover factors from a decomposition of the correlation matrix, we estimate a variation of the latent factor model of Breitung and Eickmeier (2015). The idea is to filter unobservable factors driving the evolution of the cross-section of equity or CDS that are specific to meeting and ex-meeting days. We defer a description of the model we adopt to Appendix B. Even focusing on a different approach for estimating the factors, our main conclusions regarding the impact of ECB and FED policy announcements on market comovements remain valid.

8 Conclusions

How does monetary policy affect the broader economy? As pointed out by Bernanke (2003), answering this question requires an understanding of how policy actions affect both domestic as well as foreign financial markets.

In this paper we show that monetary policy announcements affect market comovements. This effect is much more pronounced for FED's rather than ECB's announcements, and for the sovereign CDS market of Emerging countries during the tapering period. We link this findings to an heightened importance of US equity and credit risk news on the global factors, and provide evidence that such spillovers are mainly on account of the FED being regarded as a conduit of new information.

Our findings have clear policy implications. The fact that FED announcements are perceived as global shocks, especially on sovereign CDS, supports concerns expressed by policymakers in emerging countries: FED monetary policy has a strong impact on the price of sovereign risk on both developed and emerging markets. We do not find a similar result for ECB interventions. This indicates that, at least for FED monetary policy, more coordination is needed at the global level in order to deal with externalities and spillovers. Our findings also beg interesting questions for future research. Equity prices obtain as the present discounted value of future cash flows. Thus, they comprise of both a discount rate (risk premium) and a cash flow ('real') component. Similarly, CDS reflect both the compensation for bearing credit risk and the physical probability of default and recovery rate. Identifying the effect of monetary policy shocks separately on these components would shed further light on the underlying economic mechanisms and enhance the identification of the underlying channel.

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Table 1. Equity market comovements and central bank meetings

This table presents the percentage explained by the first principal component of country stock market returns during ECB (Panel A) and FED (Panel B) meetings. For each central bank, event (meeting) days are from two days prior to two days following an official meeting date. Results are presented when pooling all event days (column 'All'), for ex-event days (column 'No'), and when breaking down the events into those where the change in the first principal component of the Euro (resp., U.S.) yield curve falls either below the first tercile ('Low') or above the second tercile ('High'). Results are reported across: All countries, EMU countries, Developed countries ex-EMU, all Emerging countries, Emerging countries in Europe&Middle East, Emerging countries in Asia&Pacific, Emerging countries in Americas, and two equally-weighted Developed Markets and Emerging Markets indices. Row '$Q(\Delta y)$' reports the tercile (in basis points) of the change in the first principal component of the yield curve. Entries whose difference with the ex-event sample is significant at the 10% level are marked in bold. The full sample consists of daily observations from August, 2007 to November, 2015.

	Aug2007-Dec2009				Jan2010-May2013				Jun2013-Nov2015			
Panel A: ECB meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
All	**34.27**	41.90	42.52	42.66	42.91	**45.76**	41.02	37.21	35.86	29.53	31.82	32.58
EMU	68.19	72.83	72.37	71.98	71.08	75.00	71.55	69.43	73.19	65.74	68.56	68.98
DM ex-EMU	44.09	42.20	48.01	49.05	51.40	**56.55**	49.87	46.98	45.11	39.27	41.57	40.95
EM	**20.91**	30.89	31.26	31.72	**32.60**	**32.35**	28.41	24.72	26.75	21.02	21.77	21.21
EM Europe&ME	**34.34**	48.67	43.85	45.25	**41.70**	**40.51**	**37.60**	32.47	32.12	21.64	24.85	25.53
EM Asia&Pacific	**31.10**	42.74	42.51	43.20	43.12	37.69	39.32	39.45	39.44	34.28	36.62	36.19
EM Americas	45.36	46.52	51.54	47.30	49.65	52.07	45.83	43.66	42.21	44.20	40.68	38.50
DM Idx & EM Idx	**85.61**	91.00	91.22	91.40	90.06	**92.47**	**89.79**	86.25	81.56	**71.54**	77.86	81.64
No. Obs.	55	55	160	470	80	80	230	659	50	50	147	481
$Q(\Delta y)$	-6.98	10.03			-8.05	3.74			-7.20	1.28		
Panel B: FED meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
All	46.59	**49.64**	**45.60**	41.11	42.74	34.47	38.88	38.13	**26.26**	39.17	32.60	32.24
EMU	74.11	73.55	73.42	71.39	73.12	**61.12**	67.89	70.84	62.67	73.79	68.39	69.07
DM ex-EMU	47.45	53.81	48.63	48.75	50.82	45.88	48.42	47.50	**28.71**	48.84	37.74	41.67
EM	**38.03**	**40.14**	**35.45**	29.55	**35.23**	23.28	28.59	24.82	21.70	25.08	21.02	21.45
EM Europe&ME	**56.07**	**53.24**	**49.97**	42.22	**45.82**	31.58	36.72	33.05	22.99	**37.61**	28.21	24.45
EM Asia&Pacific	**50.18**	**51.55**	**47.50**	40.93	**54.91**	33.25	43.45	38.14	**51.49**	34.96	39.42	35.72
EM Americas	53.30	50.25	**51.97**	46.20	51.14	39.20	44.87	43.84	34.74	36.87	35.63	39.66
DM Idx & EM Idx	93.29	**94.35**	**92.98**	90.60	88.40	90.21	**89.73**	86.45	76.12	**92.61**	**86.80**	79.21
No. Obs.	63	60	178	452	70	70	205	684	50	48	138	490
$Q(\Delta y)$	-19.03	9.17			-17.30	1.06			-6.95	9.35		

Table 2. Sovereign CDS comovements and central bank meetings

This table presents the percentage explained by the first principal component of changes in country sovereign CDS spreads during ECB (Panel A) and FED (Panel B) meetings. For each central bank, event (meeting) days are from two days prior to two days following an official meeting date. Results are presented when pooling all event days (column 'All'), for ex-event days (column 'No'), and when breaking down the events into those where the change in the first principal component of the Euro (resp., U.S.) yield curve falls either below the first tercile ('Low') or above the second tercile ('High'). Results are reported across: All countries, EMU countries, Developed countries ex-EMU, all Emerging countries, Emerging countries in Europe&Middle East, Emerging countries in Asia&Pacific, Emerging countries in Americas, and two equally-weighted Developed Markets and Emerging Markets indices. Row '$Q(\Delta y)$' reports the tercile (in basis points) of the change in the first principal component of the yield curve. Entries whose difference with the ex-event sample is significant at the 10% level are marked in bold. The full sample consists of daily observations from August, 2007 to November, 2015.

Panel A: ECB meetings

	Aug2007-Dec2009				Jan2010-May2013				Jun2013-Nov2015			
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
All	**31.56**	38.93	38.91	41.63	43.40	**56.75**	48.94	44.12	38.42	24.34	25.90	29.38
EMU	48.69	62.53	57.94	56.62	61.16	**76.24**	68.87	65.90	54.83	42.58	45.84	47.17
DM ex-EMU	28.70	38.90	35.64	36.74	41.12	**51.40**	44.74	39.28	30.28	28.51	**25.74**	32.16
EM	45.35	51.20	51.38	53.38	54.12	**63.54**	55.93	51.04	46.99	36.43	36.93	37.75
EM Europe&ME	60.70	69.05	66.65	67.57	71.96	**84.43**	74.76	71.94	57.46	37.62	42.42	38.87
EM Asia&Pacific	68.17	66.21	66.98	69.31	69.87	71.97	70.24	69.59	68.33	66.03	64.92	68.41
EM Americas	78.25	**68.88**	75.39	76.65	**86.83**	80.10	81.21	76.21	81.38	84.04	80.41	78.54
DM Idx & EM Idx	81.53	**67.81**	**77.07**	84.47	74.96	82.49	80.13	79.94	77.79	61.60	66.37	70.44
No. Obs.	55	55	160	470	80	80	230	659	50	50	147	481
$Q(\Delta y)$	-6.98	10.03			-8.05	3.74			-7.20	1.28		

Panel B: FED meetings

Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
All	48.15	47.24	44.01	39.49	45.67	41.73	43.70	46.36	33.10	**45.97**	**36.41**	26.28
EMU	60.72	59.32	58.71	55.93	66.55	64.91	64.36	67.72	49.63	**66.14**	53.72	45.41
DM ex-EMU	38.81	40.71	37.04	36.01	38.61	36.23	39.03	41.76	40.55	43.23	**39.38**	28.80
EM	**59.69**	**60.89**	**58.20**	50.18	57.42	53.97	54.78	51.76	36.15	**53.30**	42.42	36.11
EM Europe&ME	72.46	**76.06**	71.64	65.58	**81.56**	72.99	76.50	71.37	48.75	53.88	46.52	37.45
EM Asia&Pacific	67.10	73.86	69.04	68.64	**75.25**	67.31	71.88	68.80	70.19	73.43	70.79	66.74
EM Americas	**83.59**	78.51	79.81	74.65	80.30	81.02	79.83	77.22	78.87	**84.74**	80.53	78.57
DM Idx & EM Idx	86.26	86.61	85.82	81.01	75.57	73.20	**74.62**	81.70	63.49	76.70	70.41	68.86
No. Obs.	63	60	178	452	70	70	205	684	50	48	138	490
$Q(\Delta y)$	-19.03	9.17			-17.30	1.06			-6.95	9.35		

Table 3. What drives the global factor

This table presents the coefficients from regressing the first principal component (global factor) of the Developed Markets and Emerging Markets indices of equity returns (Panel A and B) and changes in sovereign CDS (Panel C and D) on risk factors. The principal component is constructed from the correlation matrix separately computed on central bank' (ECB in Panel A and C, or FED in Panel B and D) meeting and ex-meeting days. The risk factors are: the return to the German stock market index (r_{Ger}) and the change in the German corporate default spread (DEF_{Ger}) for Panel A and C; the return to the U.S. stock market index (r_{US}) and the change in the U.S. corporate default spread (DEF_{US}) for Panel B and D; the change in the exchange rate of the EUR (for Panel A and C) or USD (for Panel B and D) versus a panel of currencies ($Exch.\ Rate$); and the following list of controls defined in Section 6.2: the VIX equity volatility index, the variance risk premium in the equity market, the TYVIX fixed-income volatility index, the variance risk premium in the fixed-income market, changes in the Oil price, and changes in the value of a commodity index. Coefficients that are significant at the 10% level are marked in bold. The column "R^2" reports the overall R-squared statistic, while the last three columns report the partial R^2 (computed as Shapley-Owen decomposition) for the return, default spread, and exchange rate factors. The full sample consists of daily observations from August, 2007 to November, 2015.

Panel A: Equity markets comovements and ECB meetings

							partial R^2		
Period	Central Bank	r_{Ger}	DEF_{Ger}	Exch.Rate	Controls	R^2	r_{Ger}	DEF_{Ger}	Exch.Rate
Aug2007-Dec2009	ECB	**0.81**	**-0.14**	-0.01	Yes	0.63	0.36	0.07	0.00
	ex-ECB	**0.57**	-0.06	0.01	Yes	0.53	0.26	0.03	0.00
Jan2010-May2013	ECB	**0.70**	**-0.10**	0.06	Yes	0.74	0.31	0.11	0.01
	ex-ECB	**0.63**	**-0.12**	**0.10**	Yes	0.67	0.32	0.07	0.03
Jun2013-Nov2015	ECB	**0.60**	**-0.24**	-0.01	Yes	0.61	0.35	0.10	0.01
	ex-ECB	**0.65**	**-0.11**	**-0.06**	Yes	0.66	0.39	0.05	0.02

Panel B: Equity markets comovements and FED meetings

							partial R^2		
Period	Central Bank	r_{US}	DEF_{US}	Exch.Rate	Controls	R^2	r_{US}	DEF_{US}	Exch.Rate
Aug2007-Dec2009	FED	**0.41**	-0.05	**-0.20**	Yes	0.44	0.08	0.02	0.07
	ex-FED	**0.64**	**-0.06**	**-0.21**	Yes	0.46	0.17	0.02	0.07
Jan2010-May2013	FED	**0.60**	**-0.11**	**-0.34**	Yes	0.64	0.15	0.02	0.17
	ex-FED	**0.63**	-0.04	**-0.34**	Yes	0.61	0.19	0.00	0.15
Jun2013-Nov2015	FED	**0.76**	**-0.27**	-0.07	Yes	0.51	0.23	0.06	0.01
	ex-FED	**0.41**	**-0.13**	**-0.10**	Yes	0.36	0.12	0.02	0.01

Panel C: Sovereign CDS comovements and ECB meetings

							partial R^2		
Period	Central Bank	r_{Ger}	DEF_{Ger}	Exch.Rate	Controls	R^2	r_{Ger}	DEF_{Ger}	Exch.Rate
Aug2007-Dec2009	ECB	-0.31	**0.20**	0.03	Yes	0.33	0.11	0.06	0.00
	ex-ECB	**-0.41**	**0.12**	-0.01	Yes	0.32	0.13	0.03	0.00
Jan2010-May2013	ECB	**-0.23**	**0.24**	**-0.28**	Yes	0.54	0.11	0.11	0.10
	ex-ECB	**-0.35**	**0.29**	**-0.22**	Yes	0.48	0.15	0.13	0.07
Jun2013-Nov2015	ECB	**-0.37**	**0.21**	**0.12**	Yes	0.36	0.16	0.05	0.02
	ex-ECB	**-0.35**	**0.13**	0.02	Yes	0.42	0.15	0.04	0.01

Panel D: Sovereign CDS comovements and FED meetings

							partial R^2		
Period	Central Bank	r_{US}	DEF_{US}	Exch.Rate	Controls	R^2	r_{US}	DEF_{US}	Exch.Rate
Aug2007-Dec2009	FED	-0.15	**0.27**	**0.13**	Yes	0.38	0.03	0.10	0.05
	ex-FED	**-0.31**	**0.14**	**0.29**	Yes	0.26	0.05	0.03	0.09
Jan2010-May2013	FED	**-0.38**	**0.11**	**0.35**	Yes	0.42	0.07	0.02	0.16
	ex-FED	**-0.42**	**0.06**	**0.43**	Yes	0.45	0.10	0.01	0.18
Jun2013-Nov2015	FED	**-0.45**	**0.24**	**0.41**	Yes	0.47	0.09	0.05	0.17
	ex-FED	**-0.15**	**0.12**	**0.11**	Yes	0.31	0.06	0.02	0.02

Table 4. Market comovements and central bank meetings: analysis by currency exposure

This table presents the percentage explained by the first principal component of country stock market returns (panels A and B) and changes in sovereign CDS spread (panels C and D) during ECB (panels A and C) and FED (panels B and D) meetings. For each central bank, event (meeting) days are from two days prior to two days following an official meeting date. Results are presented when pooling all event days (column 'All'), for ex-event days (column 'No'), and when breaking down the events into those where the change in the first principal component of the Euro (resp., U.S.) yield curve falls either below the first tercile ('Low'), between the first and second tercile ('Mid'), or above the second tercile ('High'). In Panel A, the analysis is carried separately on the group of countries with an average absolute net exposure in Euro to GDP that is below ("Low" group) or above ("High" group) the median during the sample period. Panel B reports corresponding analysis when the grouping is based on exposures denominated in USD. In Panel C, the analysis is carried separately on the group of countries with an average amount outstanding of government debt securities denominated in Euro (resp. USD) to GDP that is below ("Low" group) or above ("High" group) the median during the sample period. Panel D reports corresponding analysis when the grouping is based on the amount outstanding denominated in USD. Row '$Q(\Delta y)$' reports the tercile (in basis points) of the change in the first principal component of the yield curve. Entries whose difference with the ex-event sample is significant at the 10% level are marked in bold. The full sample consists of daily observations from August, 2007 to November, 2015.

	Aug2007-Dec2009				Jan2010-May2013				Jun2013-Nov2015			
Panel A: Equity markets comovements and ECB meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
Low Corp Euro Exp	**24.94**	30.04	33.29	32.87	33.28	34.85	30.61	28.34	29.86	25.80	26.43	26.43
High Corp Euro Exp	50.49	57.51	57.17	57.08	57.33	**61.60**	56.75	54.03	48.90	43.38	45.38	45.85
No. Obs.	55	55	160	470	80	80	230	659	50	50	147	481
$Q(\Delta y)$	-6.98	10.03			-8.05	3.74			-7.20	1.28		
Panel B: Equity markets comovements and FED meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
Low Corp USD Exp	**46.49**	**48.25**	**43.46**	36.06	**38.73**	27.63	32.90	32.48	26.58	**39.18**	32.99	30.35
High Corp USD Exp	51.29	54.49	51.34	49.43	49.06	44.53	47.39	46.05	**28.07**	41.78	34.68	36.31
No. Obs.	63	60	178	452	70	70	205	684	50	48	138	490
$Q(\Delta y)$	-19.03	9.17			-17.30	1.06			-6.95	9.35		
Panel C: Sovereign CDS comovements and ECB meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
Low Govn Euro Exp	**32.14**	41.88	41.24	43.55	44.16	**52.68**	47.77	43.94	43.75	37.17	35.16	39.31
High Govn Euro Exp	39.87	47.23	46.68	48.29	51.49	**66.71**	58.62	55.20	40.83	25.16	30.11	31.01
No. Obs.	55	55	160	470	80	80	230	659	50	50	147	481
$Q(\Delta y)$	-6.98	10.03			-8.05	3.74			-7.20	1.28		
Panel D: Sovereign CDS comovements and FED meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
Low Govn USD Exp	46.46	44.71	41.74	38.09	40.85	37.11	38.48	40.93	43.38	**50.01**	**44.34**	31.16
High Govn USD Exp	55.82	55.24	52.33	47.14	54.66	51.96	53.37	56.02	33.39	**49.59**	39.46	34.93
No. Obs.	63	60	178	452	70	70	205	684	50	48	138	490
$Q(\Delta y)$	-19.03	9.17			-17.30	1.06			-6.95	9.35		

Table 5. Market comovements and central bank meetings: analysis by openness

This table presents the percentage explained by the first principal component of country stock market returns (panels A and B) and changes in sovereign CDS spread (panels C and D) during ECB (panels A and C) and FED (panels B and D) meetings. For each central bank, event (meeting) days are from two days prior to two days following an official meeting date. Results are presented when pooling all event days (column 'All'), for ex-event days (column 'No'), and when breaking down the events into those where the change in the first principal component of the Euro (resp., U.S.) yield curve falls either below the first tercile ('Low') or above the second tercile ('High'). The analysis is carried separately on the group of countries that are closed and those that are open to capital flows and the trading of goods. Row '$Q(\Delta y)$' reports the tercile (in basis points) of the change in the first principal component of the yield curve. Entries whose difference with the ex-event sample is significant at the 10% level are marked in bold. The full sample consists of daily observations from August, 2007 to November, 2015.

	Aug2007-Dec2009				Jan2010-May2013				Jun2013-Nov2015			
Panel A: Equity markets comovements and ECB meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
Closed	**36.20**	43.68	43.83	44.62	36.60	37.75	35.21	33.11	30.11	26.44	26.91	27.85
Open	**35.18**	42.42	43.79	42.97	**51.24**	**54.76**	48.61	43.64	42.57	34.18	37.57	38.82
No. Obs.	55	55	160	470	80	80	230	659	50	50	147	481
$Q(\Delta y)$	-6.98	10.03			-8.05	3.74			-7.20	1.28		
Panel B: Equity markets comovements and FED meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
Closed	47.79	50.39	46.30	43.52	37.16	30.31	34.01	33.74	25.12	30.75	27.14	27.62
Open	47.69	**50.71**	**46.98**	41.16	50.30	40.92	45.90	44.73	**31.09**	**48.36**	39.54	38.19
No. Obs.	63	60	178	452	70	70	205	684	50	48	138	490
$Q(\Delta y)$	-19.03	9.17			-17.30	1.06			-6.95	9.35		
Panel C: Sovereign CDS comovements and ECB meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
Closed	**29.24**	35.59	37.34	39.92	36.48	**48.22**	42.29	39.22	42.05	33.46	32.31	36.24
Open	**37.36**	46.22	44.24	46.90	54.32	**67.47**	59.11	53.54	40.13	23.85	26.65	28.50
No. Obs.	55	55	160	470	80	80	230	659	50	50	147	481
$Q(\Delta y)$	-6.98	10.03			-8.05	3.74			-7.20	1.28		
Panel D: Sovereign CDS comovements and FED meetings												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
Closed	44.76	45.43	41.19	38.29	38.27	36.81	37.61	41.16	36.80	**48.96**	**40.84**	33.65
Open	54.77	52.24	49.94	44.45	57.66	50.35	54.10	55.68	34.98	**47.51**	**36.98**	25.32
No. Obs.	63	60	178	452	70	70	205	684	50	48	138	490
$Q(\Delta y)$	-19.03	9.17			-17.30	1.06			-6.95	9.35		

Table 6. Market comovements and central bank meetings: a placebo test

This table presents the percentage explained by the first principal component of country stock market returns (panels A and B) and changes in sovereign CDS spread (panels C and D) during ECB (panels A and C) and FED (panels B and D) meetings. For each central bank, event (meeting) days are from two days prior to two days following an official meeting date. The analysis is confined to days when the German (for ECB meetings) or U.S. (for FED meetings) equity market returns falls either below the first quartile or above the third quartile of its within-period empirical distribution. Results are presented when pooling all event days (column 'All'), for ex-event days (column 'No'), and when breaking down the events into those where the change in the first principal component of the Euro (resp., U.S.) yield curve falls either below the first tercile ('Low') or above the second tercile ('High'). Results are reported across: All countries, EMU countries, Developed countries ex-EMU, all Emerging countries, Emerging countries in Europe&Middle East, Emerging countries in Asia&Pacific, Emerging countries in Americas, and two equally-weighted Developed Markets and Emerging Markets indices. Entries whose difference with the ex-event sample is significant at the 10% level are marked in bold. A dash "-" denotes combinations where the number of days is below the number of countries, and a proper variance-covariance matrix is not defined. The full sample consists of daily observations from August, 2007 to November, 2015.

	Aug2007-Dec2009				Jan2010-May2013				Jun2013-Nov2015			
Panel A: ECB meetings, Equity returns												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
All	-	-	50.55	49.39	**52.86**	**53.30**	49.66	45.03	-	-	38.41	39.18
EMU	78.11	78.10	79.19	77.62	**82.10**	81.00	79.32	76.42	79.17	72.59	76.40	76.83
DM ex-EMU	49.43	48.93	54.05	54.58	57.49	63.72	57.93	55.82	56.99	42.62	50.12	46.91
EM	**29.57**	37.11	38.65	37.46	**41.84**	**38.82**	35.85	30.70	32.04	23.64	26.14	25.37
EM Europe&ME	41.51	54.32	48.42	51.10	**49.54**	**50.02**	45.67	39.84	38.41	28.22	30.26	29.11
EM Asia&Pacific	35.93	48.01	50.36	43.15	40.66	41.89	41.11	42.01	44.57	36.89	40.47	39.03
EM Americas	47.40	51.30	57.42	54.77	**62.12**	58.46	55.60	50.00	46.11	40.66	42.60	42.64
DM Idx & EM Idx	89.78	92.89	93.82	93.74	93.54	**96.19**	**93.58**	89.97	85.72	**74.00**	82.22	86.86
No. Obs.	23	28	81	235	40	48	120	324	28	22	71	243
Panel B: FED meetings, Equity returns												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
All	40.63	-	45.27	46.42	44.81	-	43.81	45.24	-	-	38.60	36.44
EMU	72.16	74.90	74.10	75.60	75.61	**68.32**	74.32	76.74	**65.38**	78.64	73.62	73.00
DM ex-EMU	**40.90**	54.12	44.53	53.98	50.01	**44.17**	**48.27**	55.34	**31.86**	54.66	41.01	46.37
EM	31.03	**48.69**	36.30	33.81	**38.71**	27.56	33.83	30.27	22.41	29.10	25.50	24.17
EM Europe&ME	51.76	**57.74**	50.18	45.08	**48.72**	37.43	43.31	38.81	**22.19**	**42.51**	**33.98**	26.31
EM Asia&Pacific	47.96	**59.55**	48.98	43.90	**56.15**	32.89	43.50	38.74	**52.04**	35.01	42.59	36.95
EM Americas	52.25	57.74	55.68	53.16	55.30	46.94	51.78	51.51	38.65	38.26	41.07	45.15
DM Idx & EM Idx	90.35	95.07	92.24	92.55	88.72	91.83	91.91	90.81	83.73	**94.04**	**91.29**	83.95
No. Obs.	40	33	105	211	46	35	116	328	31	28	75	239
Panel C: ECB meetings, CDS changes												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
All	-	-	44.96	47.43	48.05	**61.98**	54.84	49.19	-	-	26.90	33.84
EMU	55.26	60.75	62.00	62.49	65.28	**79.47**	72.89	69.24	51.74	51.08	50.60	51.95
DM ex-EMU	32.62	43.60	40.95	42.20	41.57	**55.09**	48.43	40.74	33.34	33.88	**26.64**	35.25
EM	59.83	54.45	57.56	58.69	57.79	**68.72**	61.75	56.68	42.32	40.60	38.83	42.45
EM Europe&ME	74.75	70.79	72.18	72.25	76.17	**87.57**	81.39	77.49	50.53	40.87	38.82	43.23
EM Asia&Pacific	73.94	69.72	68.75	69.99	69.31	73.24	71.17	70.46	68.99	67.03	**64.60**	71.38
EM Americas	84.28	73.16	80.57	81.12	**90.39**	85.01	86.05	80.51	81.59	86.46	82.64	79.84
DM Idx & EM Idx	86.58	**68.22**	78.57	86.95	76.27	86.52	83.12	84.52	71.99	63.02	67.03	74.63
No. Obs.	23	28	81	235	40	48	120	324	28	22	71	243
Panel D: FED meetings, CDS changes												
Countries	Low	High	All	No	Low	High	All	No	Low	High	All	No
All	49.66	-	45.26	43.09	46.60	-	45.81	51.55	-	-	**40.99**	30.27
EMU	63.69	66.57	62.26	59.98	**64.22**	67.82	**64.61**	72.22	51.55	**69.40**	56.45	49.22
DM ex-EMU	41.49	39.42	37.98	41.92	42.53	34.61	41.14	44.53	43.60	**49.62**	**41.37**	31.46
EM	61.55	63.28	59.53	53.94	59.04	50.56	55.96	56.79	41.21	**56.94**	47.54	40.34
EM Europe&ME	75.58	**78.48**	73.40	66.75	82.09	68.56	76.32	75.13	50.22	57.68	50.23	43.68
EM Asia&Pacific	67.80	75.29	68.21	68.83	**76.70**	63.36	72.15	69.56	73.62	75.73	72.21	67.65
EM Americas	86.66	81.80	83.76	80.29	84.50	83.55	84.19	82.18	80.35	**88.52**	83.03	81.72
DM Idx & EM Idx	84.04	89.59	84.84	84.14	**72.20**	77.73	**75.92**	84.41	68.00	82.66	76.69	72.17
No. Obs.	40	33	105	211	46	35	116	328	31	28	75	239

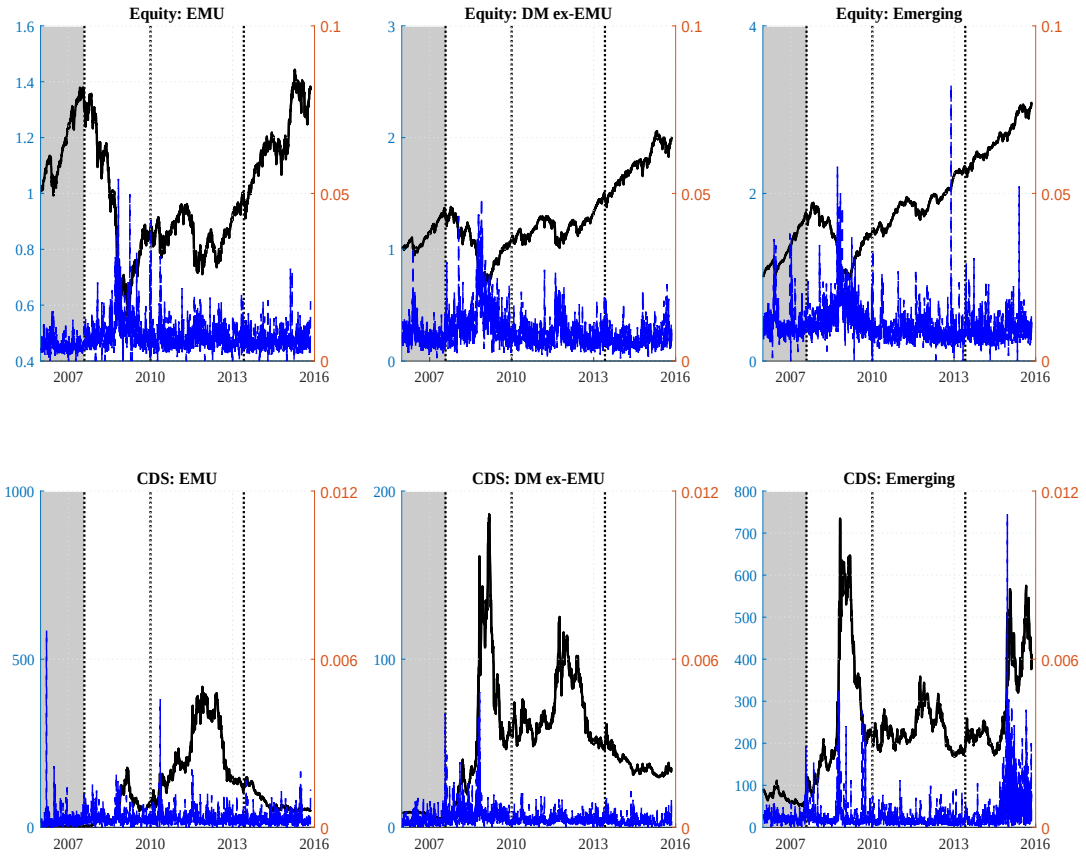

Figure 1. Equity and Sovereign CDS Spreads. The top three figures plot the time-series pattern of cumulative equally-weighted average equity returns (black thick line, left Y axis) and the cross-sectional standard deviation (blue dotted line, right Y axis) separately computed across EMU countries (left plot), Developed markets ex-EMU (middle plot), and Emerging markets (right plot). The bottom figures plot the time-series pattern of equally-weighted average sovereign CDS spread (black thick line, left Y axis) and the ratio between the cross-sectional standard deviation of changes in sovereign CDS spreads and the average sovereign CDS spread (blue dotted line, right Y axis) separately computed across EMU countries (left plot), Developed markets ex-EMU (middle plot), and Emerging markets (right plot). The vertical dotted lines mark the end of the subsamples considered. The full sample is daily observations from January, 2006 to November, 2015. The gray area marks the January, 2006 to August 2007 period that is not used in our analysis.

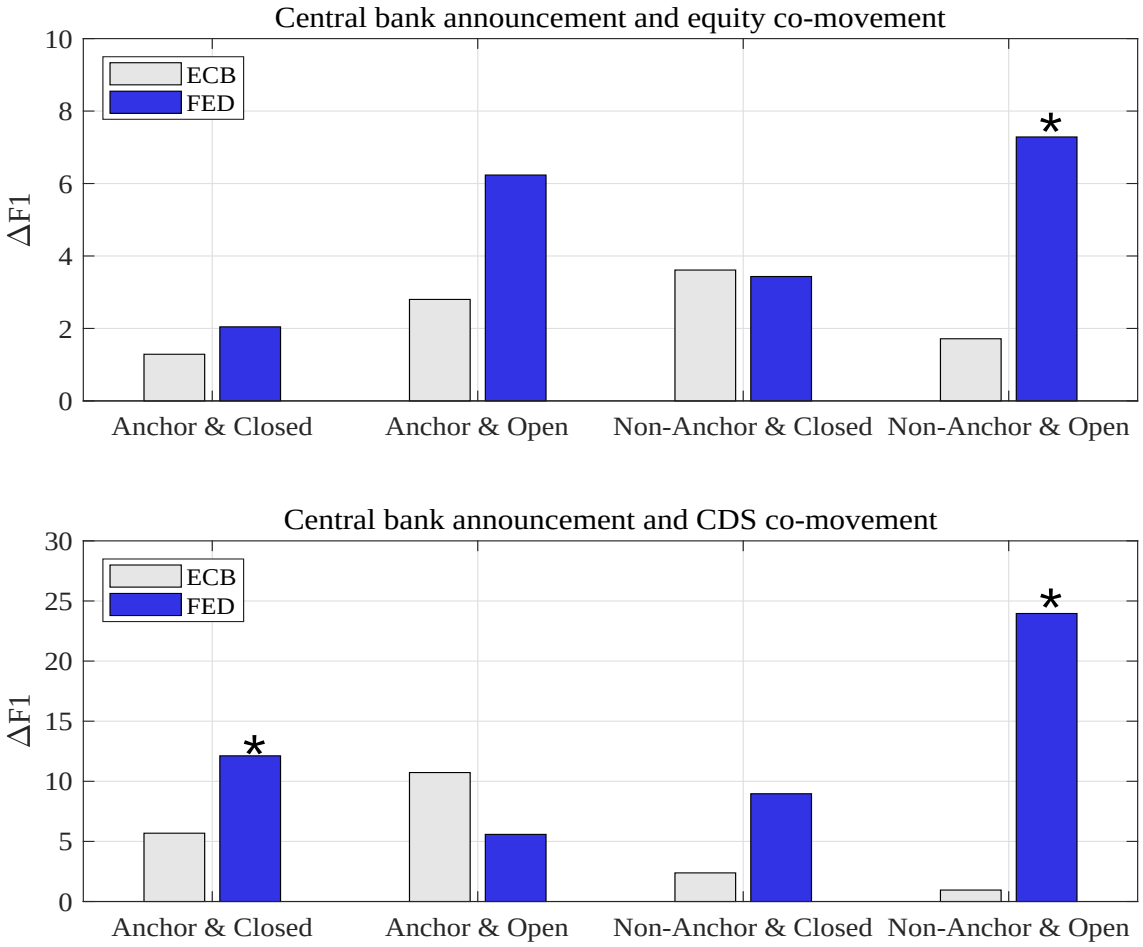

Figure 2. Anchoring and Openness. This figure reports the difference in the percentage explained by the first principal component, $\Delta F1$ of country stock market returns (top panel) and changes in sovereign CDS spread (bottom panel) between meeting days when either the ECB announcements lower the level of yields (ECB Low, grey bars) or FED announcements increase the level of yields (FED High, blue bars) and days with No announcement, over the period Jun2013 to Nov2015. The results are reported for countries grouped according to currency anchoring and openness. Anchored countries are those whose currency is explicitly or implicitly pegged to the Euro (for ECB announcements) or USD (for FED announcements). Countries are classified as Open/Closed as in Table 5. For each central bank, event (meeting) days are from two days prior to two days following an official meeting date. 'ECB Low' events are those where the change in the first principal component of the Euro yield curve falls below the first tercile. 'FED High' events are those where the change in the first principal component of the Euro yield curve falls above the second tercile ('High'). Entries that are significant at the 10% level are marked with an asterisk.

Appendix

A Bootstrap procedure

We rely on the following bootstrap to assess the statistical significance of the differences in the measures of comovements across announcement and non-announcement days. The procedure is applied to a given asset (equity or CDS spreads) and period/central bank combination. Let T be the total number of days in that period. The procedure is organized in the following steps:

1. We estimate the covariance matrices Σ, Σ_A, and Σ_N on the full sample and separately on the event (announcement) and non-event days.

2. We compute the Cholesky decomposition of these matrices, and multiply event and non-event days by the inverse of the Cholesky matrix of the corresponding covariance matrices. This procedure gives us scaled uncorrelated shocks across both the A and N samples, which we then pool together.

3. We draw random samples of size T from these shocks using a stationary bootstrap with average sample size equal to 4. The bootstrap is made to preserve the conditional properties of the data, such as unfiltered heteroskedasticity or other forms of dependence, that are still present in the (unconditionally) scaled shocks. The shocks are sampled jointly in the cross-section of countries.

4. We multiply this new artificial dataset by the Cholesky matrix of the full-sample covariance matrix Σ. This step imposes the null hypothesis of equal correlation structure in the two periods.

5. We then draw a random set of announcement days equal to the actual number of announcements the period, and construct our (-2;+2) event window.

6. Finally, we compute the distance in (1) for this random sample.

We repeat steps 3 to 6 for 2,500 times, and use the empirical distribution of the Δs to construct the confidence interval under the null hypothesis.

B Latent Factor Model

As a further robustness check, we estimate on our data a latent factor model inspired by the multi-level factor model of Breitung and Eickmeier (2015). We assume that our variables of interest X_t have a common dynamic behavior, which is driven by two sets of latent factors:

$$X_t = \mu_i + \beta'_{A,i} F_{A,t} + \beta'_{N,i} F_{No,t} + \varepsilon_{i,t}. \tag{5}$$

The factors included in $F_{A,t}$ appear only during announcement periods while the factors included in $F_{No,t}$ are active in non-announcement periods. Differently from Breitung and Eickmeier (2015) we do not include a global factor appearing both on announcements and non-announcements.

We estimate the model using the approach suggested by Breitung and Eickmeier (2015) that consists of iterating between two least squares estimation steps: the first conditions on the factors

in order to estimate the loadings vectors $\beta_{A,i}$ and $\beta_{No,i}$; the second steps conditions on the loadings to estimate the latent factors. We also include a normalization step to ensure we obtain orthonormal factors in both announcement and non-announcement periods. For further details on the estimation approach, see Breitung and Eickmeier (2014 and 2015).

Given the estimated factors and the corresponding loadings, we look at the fraction of variance explained by the factors for both the announcement and non-announcement period. Since the fraction of explained variance is country-specific, we focus on the median across countries and group Emerging Markets together. We assume the presence of three latent factors in the two sub-samples.[21] Table AIII reports the corresponding results.

For equity, in the first and second period we do not observe large changes when contrasting announcement and non-announcement samples. In the third period, both ECB and FED interventions seem to drive a limited increase in comovements, while in the fourth period we observe more heterogeneity, with a decrease in comovements on EM during both central banks announcements. Turning to sovereign CDS, we observe that the fraction of total variance explained by the latent factors is higher in the second and third periods, coherently with the analyses on correlation in the main text. Moreover, we do see a different impact in the role played by the ECB and the FED. While the former seems to decrease market comovements in the fourth period for the CDS case (the change is negative for all country groups), FED's announcements drive comovements up as reflected by the sharp increase in the fraction of variance explained by the latent factors. In the third period, both ECB and FED interventions reduce comovements for both EMU and EM markets, with a much larger impact by the FED. Overall, the message that emerges from the table lines up quite closely with that from Section 5.

[21] We also consider the presence of a single factor. Patterns appear in a more clear way when we introduce three factors, thus suggesting that a single period-specific common factor (one for announcement and one for non-announcement) is not sufficient to capture the latent behavior (and heterogeneity) of the markets.

Table AI. Country list and classification

This table presents the list of 39 countries in our sample, their classification into Developed or EM markets, their geographical classification, and the EMU dummy which is 1 for countries in the Eurozone and 0 otherwise. The classification is based on FTSE. In the analysis, we pool the group of frontier markets with emerging markets, as they are too few to be analyzed separately.

Country	Developed/Emerging	Location	EMU
Australia	Developed	Asia&Pacific	0
Austria	Developed	Europe&ME	1
Belgium	Developed	Europe&ME	1
Brazil	Emerging	Americas	0
Bulgaria	Emerging	Europe&ME	0
Chile	Emerging	Americas	0
China	Emerging	Asia&Pacific	0
Colombia	Emerging	Americas	0
Croatia	Emerging	Europe&ME	0
Czech Rep.	Emerging	Europe&ME	0
Denmark	Developed	Europe&ME	0
Finland	Developed	Europe&ME	1
France	Developed	Europe&ME	1
Germany	Developed	Europe&ME	1
Ireland	Developed	Europe&ME	1
Israel	Developed	Europe&ME	0
Italy	Developed	Europe&ME	1
Japan	Developed	Asia&Pacific	0
Korea	Developed	Asia&Pacific	0
Malaysia	Emerging	Asia&Pacific	0
Mexico	Emerging	Americas	0
Morocco	Frontier	Africa	0
Netherlands	Developed	Europe&ME	1
Norway	Developed	Europe&ME	0
Pakistan	Emerging	Asia&Pacific	0
Peru	Emerging	Americas	0
Philippines	Emerging	Asia&Pacific	0
Poland	Emerging	Europe&ME	0
Portugal	Developed	Europe&ME	1
Romania	Frontier	Europe&ME	0
Russia	Emerging	Europe&ME	0
S. Africa	Emerging	Africa	0
Slovakia	Frontier	Europe&ME	1
Spain	Developed	Europe&ME	1
Sweden	Developed	Europe&ME	0
Thailand	Emerging	Asia&Pacific	0
Turkey	Emerging	Europe&ME	0
U.S.	Developed	Americas	0
Venezuela	Frontier	Americas	0

Table AII. Analysis of factor loadings

This table presents estimates of the ΔD test for orthonormality of the first eigenvector between the announcement and non-announcement samples, equation (4). The distance is computed on equity returns (Panel A and B) and changes in sovereign CDS spreads (Panel C and D) in correspondence to either ECB (Panel A and C) or FED (Panel C and D) announcements. Results are reported across the three periods considered, when pooling all event days (column 'All') as well as for the Low and High meeting days as defined in Table 1, for: All countries, EMU countries, Developed countries ex-EMU, and Emerging countries, and between DM and EM. Bold numbers denote entries that are significant at the 10% level.

Panel A: Equity markets comovements and ECB meetings

Countries	Low	High	All	Low	High	All	Low	High	All
All	-0.03	-0.02	0.00	-0.01	-0.01	-0.01	-0.03	-0.02	-0.01
EMU	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00
DM ex-EMU	0.00	-0.02	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00
EM	-0.04	-0.03	-0.01	-0.03	-0.03	-0.01	-0.04	-0.04	-0.01

Panel B: Equity markets comovements and FED meetings

Countries	Low	High	All	Low	High	All	Low	High	All
All	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.04	-0.01	-0.01
EMU	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
DM ex-EMU	0.00	-0.01	0.00	-0.01	-0.01	0.00	-0.32	-0.01	-0.01
EM	-0.02	-0.01	-0.01	-0.03	-0.05	-0.01	-0.10	-0.04	-0.02

Panel C: Sovereign CDS comovements and ECB meetings

Countries	Low	High	All	Low	High	All	Low	High	All
All	-0.02	-0.01	0.00	-0.01	-0.01	0.00	-0.04	-0.09	-0.03
EMU	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01	-0.05	-0.01
DM ex-EMU	-0.05	-0.08	-0.02	0.00	-0.01	-0.01	-0.13	-0.30	-0.05
EM	-0.01	-0.01	0.00	-0.01	0.00	0.00	-0.02	-0.02	-0.01

Panel D: Sovereign CDS comovements and FED meetings

Countries	Low	High	All	Low	High	All	Low	High	All
All	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.08	-0.02	-0.03
EMU	-0.01	0.00	0.00	-0.01	0.00	0.00	-0.01	-0.04	-0.01
DM ex-EMU	-0.03	-0.01	-0.01	-0.02	-0.02	-0.01	-0.03	-0.02	-0.03
EM	-0.01	-0.01	0.00	-0.01	0.00	0.00	-0.05	-0.03	-0.02

Table AIII. Dynamic factor model

This table presents the median fraction of the variance explained by the three latent factors in the dynamic factor model described in Appendix B across four groups of countries. The factors are filtered from the cross section of either equity (Panel A and B) or sovereign CDS changes (Panel C and D) during central bank' (ECB in Panel A and C, or FED in Panel B and D) meeting and ex-meeting days.

	Aug2007-Dec2009			Jan2010-May2013			Jun2013-Nov2015		
Panel A: Equity markets comovements and FED meetings									
Countries	ECB	ex-ECB	Δ	ECB	ex-ECB	Δ	ECB	ex-ECB	Δ
All	69.70	60.00	*9.70*	69.70	51.10	*18.60*	35.80	31.00	*4.80*
EMU	90.30	87.80	*2.50*	89.90	86.60	*3.40*	84.90	83.40	*1.50*
DM ex-EMU	83.50	82.00	*1.50*	85.00	76.80	*8.20*	70.10	70.50	*-0.40*
EM	83.60	80.90	*2.70*	87.40	81.20	*6.20*	78.50	80.00	*-1.50*
Panel B: Equity markets comovements and FED meetings									
Countries	FED	ex-FED	Δ	FED	ex-FED	Δ	FED	ex-FED	Δ
All	67.00	59.90	*7.10*	70.70	53.60	*17.10*	43.50	30.20	*13.30*
EMU	86.90	86.70	*0.10*	89.10	86.70	*2.50*	85.70	83.70	*2.10*
DM ex-EMU	87.00	81.10	*5.90*	85.70	76.40	*9.30*	69.70	70.40	*-0.70*
EM	85.10	78.30	*6.80*	82.30	81.70	*0.60*	70.30	81.60	*-11.20*
Panel C: Sovereign CDS comovements and ECB meetings									
Countries	ECB	ex-ECB	Δ	ECB	ex-ECB	Δ	ECB	ex-ECB	Δ
All	43.80	60.70	*-17.00*	61.50	50.50	*11.00*	16.50	28.80	*-12.20*
EMU	84.50	78.20	*6.30*	63.90	73.70	*-9.80*	38.10	52.00	*-13.90*
DM ex-EMU	70.10	55.10	*15.00*	83.20	65.50	*17.70*	39.90	57.00	*-17.00*
EM	76.70	61.10	*15.60*	54.10	57.50	*-3.40*	19.30	39.60	*-20.20*
Panel D: Sovereign CDS comovements and FED meetings									
Countries	FED	ex-FED	Δ	FED	ex-FED	Δ	FED	ex-FED	Δ
All	54.30	56.50	*-2.30*	55.40	51.90	*3.60*	52.60	22.30	*30.40*
EMU	83.40	78.30	*5.00*	46.30	73.60	*-27.40*	78.10	36.20	*41.90*
DM ex-EMU	60.20	56.10	*4.00*	67.60	71.70	*-4.10*	72.80	51.10	*21.70*
EM	67.30	62.10	*5.20*	40.80	57.70	*-16.90*	64.10	31.10	*33.10*