Higher-Order Risk Premium and Return Spillovers between Commodity and Stock Markets †

Marinela Adriana Finta *

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*Corresponding Author: Department of Accountancy and Finance, Otago Business School, Po Box 56, 9054 Dunedin, New Zealand, Phone: +64 3479 5299; Sim Kee Boon Institute for Financial Economics, Lee Kong Chian School of Business, Singapore Management University, 50 Stamford Road, 178899 Singapore; Emails: marinela.finta@otago.ac.nz, mfinta@smu.edu.sg.

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Abstract

This study examines the spillovers between risk premia and returns of commodity (grain, metal, and energy sectors) and equity markets (the U.S., U.K., Germany, and Japan). Risk premia are defined as the difference between implied volatility, skewness, and kurtosis and their realized moments. Our results show that cross-market and cross-moment spillovers vary over time, and various announcements explain this variation. We uncover the substantial effects of equity markets for commodity markets, and as those of returns for the risk premia. Moreover, we highlight the prominent influence of the metal sector for the other commodity sectors and equity market, and that of skewness risk premia for the returns.

JEL Codes: C58; G01; G15.

Keywords: Return; Volatility; Skewness; Kurtosis; Risk-Neutral; Risk Premium.

1 Introduction

The large investment inflows to commodity markets from financial investors rather than commercial traders ("financialization" process), especially at the beginning of the Global Financial Crisis, have given rise to substantial research on commodities and their relations with equity markets (Christoffersen et al., 2017; Basak and Pavlova, 2016; Henderson et al., 2014; Büyükşahin and Robe, 2014; Cheng and Xiong, 2014; Tang and Xiong, 2012). These studies argue that the increasing exposure of financial traders (e.g., hedge funds) to commodities has led to a high correlation and integration within commodity markets and between them and equity markets. As such, it has made commodities more exposed to shocks coming from financial markets. Our objective is to present new evidence on the risk-return relations between commodity and equity markets by focusing on the volatility and higher-order (skewness and kurtosis) risk premia, namely, the difference between implied and realized moments.

While commercial participants (e.g., farmers, producers, and consumers) use the derivatives markets to hedge against price fluctuations, financial investors also trade for their own reasons such as portfolio diversification and risk management besides facilitating commodity producers' hedging needs (Cheng et al., 2015). Hence, they might trade based on their risk aversion. Indeed, Acharya et al. (2013) and Cheng et al. (2015) emphasize the time-varying risk aversion of financial investors. Moreover, Tang and Xiong (2012) argue that supply and demand no longer determine commodity prices, but rather investors' risk appetite for financial assets. For instance, let us consider an investor who allocates a small share of his investment portfolio to a long position in commodity futures and the rest into equity markets. If equity prices drop, whereas commodity prices remain constant, then the share invested in commodities increases. To rebalance its portfolio, the investor would take a short position on commodities. Therefore, its reduced risk appetite due to changes in the risk-return profile of equity markets affects commodity markets, i.e., equity volatility is being transmitted to them (Cheng and Xiong, 2014). At the same time, the portfolio rebalancing activity might also change the risk-return profiles within and between commodity and equity markets.

Given the above evidence, relations between commodity and equity markets could be better understood by considering their risk premia. By using options and high frequency data to define them as the difference between implied and realized moments, risk premia capture investors' risk aversion. In this paper, we provide new insights about the time-varying risk-return spillovers between commodity and equity markets during the 2008-2016 period. To our knowledge, this study is the first to consider the volatility and higher-order risk premia of commodity and equity markets to examine these relations. Hence, it takes into account three different types of compensation that investors require for bearing the volatility, skewness ("crash risk"), and kurtosis ("tail risk") risks. We use these risk premia to firstly address several research questions. For instance, do the volatility and higher-order risk premia in commodity and equity markets vary over time? Are there cross-market and cross-moment risk premium transmissions between commodity and equity markets? How do these risk premia affect the relationship between commodity and equity returns? To address them, we rely on the approach of Diebold and Yilmaz (2012, 2014) and Greenwood-Nimmo et al. (2015). Particularly, our analysis consists of the eight most liquid commodities from the agricultural, metal, and energy sectors: corn, soybean, wheat, copper, silver, gold, oil, and natural gas. It also includes the equity markets of four advanced economies, i.e., the U.S., U.K., Germany, and Japan.[1] Taking into account the risk premium and return spillovers, we secondly investigate their relationship to various factors, such as the credit and TED spreads, ADS business conditions index (Aruoba et al., 2009), and economic policy uncertainty index(Baker et al., 2016), as well as with the commodity and equity markets' returns and risk premia. In addition, we emphasize the relevance of risk premium-return relations by presenting the summary statistics of several portfolios built on their time-varying sensitivity to prior variables. Finally, we assess the behavior of risk premium-return spillovers around various announcements such as unconventional monetary policy, political and commodity-specific announcements.

Our empirical findings show time variation in the interaction of risk premia, i.e., volatility risk premium (VRP), skewness risk premium (SRP), and kurtosis risk premium (KRP) and returns, both within and across commodity and equity markets. We document substantial within-market and cross-market spillovers, particularly from equity market to commodity sectors. These latter spillovers typically decline and rise following expansionary and political announcements, respectively. Additionally, the cross-metal spillovers matter considerably for both commodity and equity

[1] As proxies for these stock markets, we use the S&P 500, FTSE 100, DAX 30, and NIKKEI 225 indices.

markets. We further show the high influence of the returns to the VRP and higher-order risk premia. Moreover, we emphasize that, in general, SRP has the highest effect on returns. Our discoveries suggest that investors' portfolio rebalancing is related to their volatility and higher-order risk aversion, and then these rebalancing choices affect their risk-return profile. Thereby, many times, the rebalancing might occur during periods of high risk premium spillovers. Furthermore, results reveal an association between our spillovers and macroeconomic and financial variables, and also returns and risk premia of both equity and commodity markets. For instance, while generally, for the credit spread, the ADS index and the SRP of commodity markets there is a negative relationship, for the TED spread, SRP of equity markets, and the VRP of equity and commodity markets (i.e., metal and energy sectors) are positively related to our spillovers. Given these outcomes, we show that investors could construct valuable strategies based on these time-varying relations with returns and risk premia. Our findings also reveal that, generally, expansionary announcements significantly decrease cross-return and cross-risk premium spillovers, whereas contractionary and political announcements lead to increases in them.

Our study adds to the literature on the variance and skewness risk premia of equity markets (Harris and Qiao, 2018; Bali et al., 2019; Bollerslev et al., 2014; Bollerslev et al., 2009). These studies document a positive relation between risk premia and future equity returns. Regarding commodity markets, Finta and Ornelas (2020) also find a positive relation between implied skewness and skewness risk premium, and future returns. We also complement the research of Cipollini et al. (2013), who study variance risk premium in equity markets. Our paper further extends the study of Prokopczuk et al. (2017) on variance risk in commodity markets by considering the higher-order moments and exploring the risk-return relations between commodity and equity markets. Finally, we contribute to the existing studies on commodity and equity markets, pointing to a relationship between their returns, risk premia, and the above factors (Bollerslev et al., 2011; Christoffersen et al., 2017; Wang et al., 2015). For instance, Christoffersen et al. (2017) point out the high commodity volatility when the ADS index and TED spread are low and high, respectively. Moreover, the authors find that commodity volatility is strongly associated with that of the U.S. stock market. The credit and TED spread indicators have been further found to predict equity variance risk premium (Konstantinidi and Skiadopoulos, 2016; Bollerslev et al., 2011).

The article is organized as follows. Section 2 presents the model. Section 3 describes the data. Sections 4 and 5 discuss the empirical findings on the risk premium-return spillovers and their relation to various factors and announcements, respectively. Section 6 concludes the article.

2 Model

To examine the risk premium-return spillovers between commodity and equity markets, we use the well-known variance decompositions approach of Diebold and Yilmaz (2012, 2014). Then we apply the block aggregation of Greenwood-Nimmo et al. (2015). The latter approach allows us to examine the risk premium-return spillovers among groups of commodities and equities (e.g., risk premium-return relations between energy and equity markets), as well as groups of risk premia (e.g., volatility, skewness and kurtosis risk premia of each market are aggregated over both commodity and equity markets).[2]

We start our analysis by recovering the risk premium innovations for all commodity (c) and equity (e) markets using a first-order autoregressive AR(1) model (Menkhoff et al., 2012; Greenwood-Nimmo et al., 2016). Specifically, VRP ($\boldsymbol{v_{ct}}$ and $\boldsymbol{v_{et}}$), SRP ($\boldsymbol{s_{ct}}$ and $\boldsymbol{s_{et}}$) and KRP ($\boldsymbol{k_{ct}}$ and $\boldsymbol{k_{et}}$), where c and e are the commodity and equity markets at daily frequency t. We then estimate the reduced-form vector autoregressive (VAR) model:

$$\boldsymbol{RP_t} = \sum_{i=1}^{p} \boldsymbol{\Psi_i RP_{t-i}} + \boldsymbol{u_t} \tag{1}$$

where $\boldsymbol{RP_t}$ is a $d \times 1$ vector representing the daily risk premia with $d = 4N$ and N being twelve (i.e., eight commodity and four equity markets):

$$\boldsymbol{RP_t} = \Big(\boldsymbol{RP_{ct}}, \boldsymbol{RP_{et}}\Big)' \tag{2}$$

with $\boldsymbol{RP_{ct}} = (\boldsymbol{r_{1t}}, \boldsymbol{v_{1t}}, \boldsymbol{s_{1t}}, \boldsymbol{k_{1t}}, ..., \boldsymbol{r_{ct}}, \boldsymbol{v_{ct}}, \boldsymbol{s_{ct}}, \boldsymbol{k_{ct}})$, $\boldsymbol{RP_{et}} = (\boldsymbol{r_{1t}}, \boldsymbol{v_{1t}}, \boldsymbol{s_{1t}}, \boldsymbol{k_{1t}}, ..., \boldsymbol{r_{et}}, \boldsymbol{v_{et}}, \boldsymbol{s_{et}}, \boldsymbol{k_{et}})$, $c = 8$, $e = 4$ and $\boldsymbol{r_t}$ are the daily returns. The $\boldsymbol{\Psi_i}$ is a $(d \times d)$ matrix for $i = 1, 2, ..., p$ and the reduced-form residuals, $\boldsymbol{u_t} \sim$ N(0, $\boldsymbol{\Omega_u}$). Using Equation (1), we define the h-step ahead generalized

[2]The aggregation approach has also been used by Greenwood-Nimmo et al. (2016).

forecast error variance decomposition that is order-invariant for the returns, VRP, SRP and KRP of each commodity and equity markets as (Pesaran and Shin, 1998):

$$\vartheta_{i\leftarrow j}^{(h)} = \frac{\sigma_{u,jj}^{-1} \sum_{s=0}^{h-1} \left(\boldsymbol{\delta}_{\mathbf{i}}' \boldsymbol{A_s} \boldsymbol{\Omega}_{\mathbf{u}} \boldsymbol{\delta}_{\mathbf{j}} \right)^2}{\sum_{s=0}^{h-1} \boldsymbol{\delta}_{\mathbf{i}}' \boldsymbol{A}_{\mathbf{s}} \boldsymbol{\Omega}_{\mathbf{u}} \boldsymbol{A}_{\mathbf{s}}' \boldsymbol{\delta}_{\mathbf{i}}} \tag{3}$$

where $i, j = 1, ..., d$, $\sigma_{u,jj}$ captures the diagonal element of the reduced-form residuals' covariance matrix $\boldsymbol{\Omega}_{\mathbf{u}}$ and the $(d \times 1)$ selection vector $\boldsymbol{\delta}_{\mathbf{i}}$ is set to one and zero otherwise for its i-th element. We define recursively the matrix $\boldsymbol{A_s}$, i.e., $\boldsymbol{A_s} = \boldsymbol{\Psi_1 A_{s-1}} + \boldsymbol{\Psi_2 A_{s-2}} + ... + \boldsymbol{\Psi_p A_{s-p}}$ with $s = 1, 2, ...$, the $d \times d$ identity matrix $\boldsymbol{A_0}$ and $\boldsymbol{A_s} = 0$ for $s < 0$. $\vartheta_{i\leftarrow j}^{(h)}$ represents the share of the h-step-ahead forecast error variance of commodity or equity market i that is due to shocks occurring in commodity or equity market j.

As Diebold and Yilmaz (2012, 2014), we construct the connectedness matrix $\boldsymbol{C^{(h)}}$ among our returns and risk premia and normalize it's shares such that the sum of rows is equal to one (i.e., $\varphi_{i\leftarrow j}^{(h)} = 100 \times \left(\vartheta_{i\leftarrow j}^{(h)} / \sum_{j=1}^{d} \vartheta_{i\leftarrow j}^{(h)} \right) \%$):

$$\boldsymbol{C}^{(h)} = \begin{bmatrix} \varphi_{1\leftarrow 1}^{(h)} & \varphi_{1\leftarrow 2}^{(h)} & \cdots & \varphi_{1\leftarrow d}^{(h)} \\ \varphi_{2\leftarrow 1}^{(h)} & \varphi_{2\leftarrow 2}^{(h)} & \cdots & \varphi_{2\leftarrow d}^{(h)} \\ \vdots & \vdots & \ddots & \vdots \\ \varphi_{d\leftarrow 1}^{(h)} & \varphi_{d\leftarrow 2}^{(h)} & \cdots & \varphi_{d\leftarrow d}^{(h)} \end{bmatrix} \tag{4}$$

We further define the following spillovers:

$$W_{i\leftarrow i}^{(h)} = \varphi_{i\leftarrow i}^{(h)};\ F_{i\leftarrow \bullet}^{(h)} = \sum_{j=1, j\neq i}^{d} \varphi_{i\leftarrow j}^{(h)};\ T_{\bullet\leftarrow i}^{(h)} = \sum_{j=1, j\neq i}^{d} \varphi_{j\leftarrow i}^{(h)} \text{ and } AS^{(h)} = \frac{1}{d} \sum_{i=1}^{d} F_{i\leftarrow \bullet}^{(h)} \tag{5}$$

where $W_{i\leftarrow i}^{(h)}$ is the within spillover (i.e., the h-step ahead forecast error variance of market i's risk premium that is due to own shocks), $F_{i\leftarrow \bullet}^{(h)}$ and $T_{\bullet\leftarrow i}^{(h)}$ are the cross-market ($from$) and *to* spillovers capturing the effects from all markets to market i and the other way around, and $AS^{(h)}$ is the aggregate risk premium spillover.

To assess the spillovers among groups of markets, we next apply the generalized framework of

Greenwood-Nimmo et al. (2015) to the connectedness matrix $\boldsymbol{C}^{(\boldsymbol{h})}$ as follows:

$$\mathbf{C}^{(h)} = \begin{bmatrix} \mathbf{G}_{1\leftarrow 1}^{(h)} & \mathbf{G}_{1\leftarrow 2}^{(h)} & \cdots & \mathbf{G}_{1\leftarrow N}^{(h)} \\ \mathbf{G}_{2\leftarrow 1}^{(h)} & \mathbf{G}_{2\leftarrow 2}^{(h)} & \cdots & \mathbf{G}_{2\leftarrow N}^{(h)} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{G}_{N\leftarrow 1}^{(h)} & \mathbf{G}_{N\leftarrow 2}^{(h)} & \cdots & \mathbf{G}_{N\leftarrow N}^{(h)} \end{bmatrix}, \mathbf{G}_{i\leftarrow j}^{(h)} = \begin{bmatrix} \varphi_{r_i\leftarrow r_j}^{(h)} & \varphi_{r_i\leftarrow v_j}^{(h)} & \varphi_{r_i\leftarrow s_j}^{(h)} & \varphi_{r_i\leftarrow k_j}^{(h)} \\ \varphi_{v_i\leftarrow r_j}^{(h)} & \varphi_{v_i\leftarrow v_j}^{(h)} & \varphi_{v_i\leftarrow s_j}^{(h)} & \varphi_{v_i\leftarrow k_j}^{(h)} \\ \varphi_{s_i\leftarrow r_j}^{(h)} & \varphi_{s_i\leftarrow v_j}^{(h)} & \varphi_{s_i\leftarrow s_j}^{(h)} & \varphi_{s_i\leftarrow k_j}^{(h)} \\ \varphi_{k_i\leftarrow r_j}^{(h)} & \varphi_{k_i\leftarrow v_j}^{(h)} & \varphi_{k_i\leftarrow s_j}^{(h)} & \varphi_{k_i\leftarrow k_j}^{(h)} \end{bmatrix} \tag{6}$$

where $i, j = 1, 2, ..., N$. Using Equation (6), we finally define the total within and pairwise spillovers:

$$TW_{i\leftarrow i}^{(h)} = \frac{1}{m}\boldsymbol{e}_{\boldsymbol{m}}'\mathbf{G}_{i\leftarrow i}^{(H)}\boldsymbol{e}_{\boldsymbol{m}} \text{ and } TS_{i\leftarrow j}^{(h)} = \frac{1}{m}\boldsymbol{e}_{\boldsymbol{m}}'\mathbf{G}_{i\leftarrow j}^{(h)}\boldsymbol{e}_{\boldsymbol{m}} \tag{7}$$

with $\boldsymbol{e}_{\boldsymbol{m}}$ being a $m\times 1$ vector of ones and m=4 given our returns and three risk premia (i.e., volatility, skewness and kurtosis). The total aggregate within and cross-market spillovers are similarly defined as in Equation (5). We likewise compute the spillovers among groups of returns and risk premia.

3 Data

We estimate the model from previous Section 2 using daily returns and the AR(1) innovations in VRP, SRP, and KRP for the commodity and equity markets. The analysis is thus done by focusing on the following markets: corn, soybean, wheat, copper, silver, gold, oil, natural gas, and the U.S., U.K., German, and Japanese equity markets. Our data are from Thomson Reuters Tick History and span the period from January 2008 to December 2016. We estimate the implied volatility, skewness, and kurtosis following the well-known model-free approach of Bakshi et al. (2003). The computation of realized moments is done using five-minute returns as in Andersen et al. (2003) and Amaya et al. (2015). We then compute the volatility, skewness, and kurtosis risk premia as the difference between implied and realized moments (Bollerslev et al., 2009). To facilitate the interpretation of empirical findings, although our analyses are estimated using the innovations in risk premia (e.g., $\boldsymbol{v_{ct}}$, $\boldsymbol{s_{ct}}$ and $\boldsymbol{k_{ct}}$; $\boldsymbol{v_{et}}$, $\boldsymbol{s_{et}}$ and $\boldsymbol{k_{et}}$), throughout the paper, we refer to them as being VRP, SRP and KRP.

Table 1 presents the means and standard deviations of the commodity and equity risk premia, as well as their innovations. It also reports these statistics for the commodity and equity returns. Note that copper, oil, and the U.S. stock market have the highest mean returns, whereas oil, natural gas, and wheat returns show the highest volatility. Among our volatility risk premia, the highest mean belongs to copper, natural gas, oil, and the Japanese equity market. Generally, while commodity markets exhibit the highest standard deviation for the VRP and SRP, equity markets display the highest for the KRP. The risk premium innovations show similar characteristics.

INSERT TABLE 1 HERE

4 Empirical findings

In this section, we first present the full sample results. We start the analysis by reporting the connectedness between risk premia, and returns and then exploring the aggregate relations across markets and moments. In particular, the within-market and cross-market spillovers, and the within-moment and cross-moment spillovers. We second discuss the time variation of these risk premium-return relations between commodity and equity markets.

4.1 *Aggregate connectedness between commodity and stock markets*

We initiate our investigation by estimating a VAR (1) model among returns and risk premia of commodity and equity markets. [3] Using Diebold and Yilmaz's (2012, 2014) approach, Table 2 presents the ten-days ahead (48×48) connectedness matrix among returns, volatility risk premia, skewness risk premia, and kurtosis risk premia of commodity and equity markets. Observe that attempting to meaningfully interpret these 2304 elements of Table 2 poses difficulties, especially if looking at these relations over time.

INSERT TABLE 2 HERE

As a solution to better identify these relations, Greenwood-Nimmo et al. (2015) propose a generalized framework relying on block aggregations of Table 2. We further apply this approach that allows a clearer interpretation of the spillovers among groups of markets and risk premia. Table 3

[3] The optimal lag length is selected using the Akaike Information Criterion.

shows the connectedness among aggregate commodity and stock markets across their risk premia and returns, whereas Table 4 shows the total connectedness among aggregate commodity sectors and stock markets across their risk premia and returns.

Table 3 presents the (12 × 12) connectedness matrix among individual commodity and equity markets. Its diagonal captures the within-market effects (i.e., effects due to own-market shocks) and off-diagonal elements record the cross-market spillovers (i.e., impacts from other markets). Note that, although high within-market effects account for around 75% of the German variance to 93% of the copper variance, the cross-market spillovers are also relevant. We document strong bi-directional spillovers within commodities of all three sectors, as well as within equity markets. Specifically, the contribution of corn, soybeans, and wheat to each of the grain sector's commodity variance is between approximately 3% and 6.5%. We find a strong relation between gold and silver, e.g., cross-market effects from each other explain close to 14% of their variance. While cross-market spillovers among equities matter, the Japanese equity market appears to be an exception. The cross-market effects from other equities solely account for around 1% of its variance. Table 3 further reveals the existence of substantial cross-market spillovers between the commodity and equity markets. Observe the important impacts of oil for all commodities and equity markets of the U.S. and Germany. As for the effects to oil, we find that the metal sector (i.e., gold and silver), and the U.S. stock market exhibit the strongest influence on it. Apart from oil's effects, equity markets are also affected by gold.

INSERT TABLE 3 HERE

Table 4 presents the (4 × 4) connectedness matrix among commodity sectors and the equity market. Note that, besides its own effects, the equity market has the highest impacts on commodity sectors, respectively. Specifically, it accounts for around 2%, 4%, and 5% of the forecast variance in grain, metal, and energy sectors. Among commodity sectors, metal and then energy sectors exert the most substantial influence on the equity market.

INSERT TABLE 4 HERE

Our analyses thus far document that the cross-market spillovers among commodities and equities, as well as between them, matter. We observe bi-directional spillovers, especially between metal and energy sectors, and the equity market. Moreover, we point out the strongest influence of the equity market for our commodity sectors.

4.2 *Aggregate connectedness between risk premia and returns*

In the previous section, we discussed the spillovers among groups of markets and emphasized the importance of the equity market for commodity sectors. This section further explores the spillovers among groups of risk premia, namely, volatility risk premia, skewness risk premia, and kurtosis risk premia, and groups of returns. Table 5 presents the connectedness among aggregate risk premia and returns across commodity sectors and the equity market, and Table 6 presents the total connectedness among aggregate risk premia and returns across all markets.

Table 5 reports the (12×12) connectedness matrix with the within-moment effects along the prime diagonal and the cross-moment effects in the off-diagonal entries. Although within-moment effects are of a dominant order between around 60% and 90%, cross-moment effects among commodity sectors and equity markets are relevant as well. We observe high return spillovers among commodity sectors rather than between commodity sectors and equity market. There is, however, a bi-directional return spillover between the energy sector and the equity market. These findings suggest that investors might consider, at the same time, reducing their exposure to commodity sectors. Except for the equity market, remark that commodity sectors' returns are more affected by the own-sector higher-order risk premia, with their impacts being higher than those of the own-sector VRP. These results indicate that investors' aversion towards skewness and kurtosis matters more than that toward volatility risk. As such, the strong spillovers suggest that the rebalancing of their portfolios might occur more often when their compensations for the higher-order risks are high.

Regarding cross-VRP spillovers, we find stronger effects between commodity sectors and the equity market than in the case of returns. Specifically, the cross-VRP effects from the equity market explain more than 2%, 6.5%, and 9% of the grain, metal, and energy sector variances, respectively. We also identify substantial cross-VRP spillovers from metal and energy sectors to the equity market. Examining the cross-SRP and cross-KRP spillovers among commodity sectors and equity market, we document large bi-directional effects between SRP and KRP within the commodity sectors and equity market as well. Specifically, the magnitude of these bilateral spillovers is around

13%, 24%, 32%, and 8% for grain, metal, energy sectors and the equity market, respectively. We further show that own-sector and equity market returns exhibit the highest impacts on high-order risk premia. Such strong spillovers from both commodity and equity returns to SRP and KRP suggest that rebalancing activity due to investors' aversion towards higher-order risks and changes in returns feed back onto the higher-order risk premia.

INSERT TABLE 5 HERE

Table 6 reports the (4×4) total connectedness matrix among returns and risk premia (i.e., VRP, SRP, and KRP). In line with empirical findings presented in Table 5, note the strong influence of returns for the VRP and higher-order premia. As regards the spillovers affecting returns, we find that the SRP spillover has the highest effects on them. We also confirm the large bi-directional spillovers between SRP and KRP.

INSERT TABLE 6 HERE

Overall, we highlight the substantial bi-directional cross-VRP spillovers between commodity sectors and the equity market. Our results point out the bilateral spillovers between returns and higher-order risk premia within commodity sectors and equity markets. Additionally, we underline the high bi-directional spillovers between SRP and KRP.

4.3 *Aggregate connectedness over time*

Previous sections have highlighted the cross-market and cross-moment interactions between commodity and equity markets over the full sample. In this section, we show how these cross-relations vary over time. In particular, we estimate the time variation of risk premia and return spillovers by using a rolling window of 250 trading days with a forecast horizon of 10 trading days. Figures 1 and 2 show the time-varying market (i.e., among commodity sectors and equity market) and moment (i.e., among returns and high-order risk premia) relations as reported in Tables 4 and 6, respectively.

Figure 1 includes four panels for each of the grain, metal and energy sectors, and the equity market. Each of the panels shows three plots of the within-market spillovers (e.g., within-commodity and within-equity effects), the spillover from commodity sectors and equity market (each i-th commodity sector and equity market) to each i-th commodity sector and equity market (commodity sectors and equity market), namely, the $from$ or inward (*to* or outward) spillover, and the spillover effects from each commodity sector and equity market to commodity and equity markets i. The within-market spillovers vary between around 70% and 80%. In particular, we note the low within-commodity effects during the financial crises (i.e., the Global Financial Crisis (GFC) and the European Debt Crisis(EDC)) and the constant within-equity effects. These results reflect the financialization of commodities, namely, investors give more attention to the cross-market effects. Indeed, during this period, there are large cross-market spillovers, primarily until mid-2012. Afterward, their magnitude generally remains constant over the investigation period.

Examining the grain sector's relations, Panel A shows that cross-market effects from commodity and equity markets are higher than those transmitted. Among these cross-market spillovers, the equity market has the strongest impact on the grain sector, with its coefficient varying around 10%. Note that its magnitude exceeds that of metal and energy spillover coefficients, which vary around 7%-8% and 4%-6%, respectively. By contrast, Panel B emphasizes the higher effects of metal to commodity sectors and equity market than vice-versa, especially from mid-2012 to the end of 2013. Once again, the equity market exerts the most substantial influence on the metal sector, whereas grain and energy sectors show similar effects on it. In Panel C, we observe the higher difference between cross-market and energy outward spillovers than in either grain or metal sectors. Moreover, until mid-2012, the cross-market effects from commodity and equity markets have the most substantial impacts to the energy sector. As with spillovers affecting the grain and metal sectors, a high spillover from the equity market is evident, with its coefficient varying between 10% and 15%. Instead, the spillovers from metal and energy sectors fluctuate below 10%. Finally, Panel D highlights the remarkably higher spillover from the equity market to the commodity sectors than the other way around. Among our commodity sectors, the metal sector has the highest effect, especially during the financial crises and from the beginning of 2012 to mid-2013.

INSERT FIGURE 1 HERE

Figure 2 consists of four panels, one panel for returns and one for each of the risk premia (i.e., VRP, SRP, and KRP), each of which contains three plots. The first and second rows of Figure 2 show the within-moment effects, as well as the spillover effect from all moments (each i-th moment) to each i-th moment (all moments), namely, the cross-moment or inward spillover (*to* or outward spillover). The last row presents the contribution of each return and risk premia to return and risk premia i. In general, during the first part of the analysis (i.e., until the beginning of 2010) and starting from 2014, the returns, VRP, and higher-order risk premia are less affected by their own-variable effects. As such, over time, investors consider cross-moment risks.

In line with empirical findings from Table 6, Panel A reveals that, in general, the cross-risk premium effects to returns are slightly smaller than the other way around. It also shows low within-return effects, primarily until mid-2012 indicating the investors' concerns about risks occurring in commodity and equity markets, as shown in Figure 1. In particular, we point out the substantial contribution of higher-order risk premia to the returns, with a higher spillover from SRP than KRP, except for the period from the beginning of 2015 to the end of our analysis. The exception is also the period from the end of 2011 to mid-2013, when VRP displays the highest impact on returns. Considering the VRP spillovers in Panel B, in general, the cross-moment spillover is higher than the outward spillover, and the returns mostly affect the VRP. Note, however, that starting from 2015, again, KRP has the strongest impact on VRP. Finally, Panels C and D show the spillover effects to SRP and KRP, respectively. In line with the return and VRP spillovers, there is a comovement between cross-moment and outward spillovers. Moreover, bi-directional spillovers between SRP and KRP increased considerably (i.e., between the start and end of the sample), from below 20% to above 25%. In addition to these effects, returns have substantial impacts on the higher-order risk premia.

INSERT FIGURE 2 HERE

Taken together, our results clearly underline the high impacts from the stock market to commodity sectors, and returns to VRP and higher-order risk premia. We show that among commodity spillovers affecting the equity market, the utmost spillover is from the metal sector. The metal sector also has the highest influence on commodity sectors. With regard to returns, SRP has the highest effect, except toward the beginning of 2015, when generally investors are more concerned about the tail risk (i.e., KRP spillover to other moments is high). Our findings, thus, indicate that investors' aversion towards higher-order risks influences their portfolio rebalancing activity, and then their choices feed back into risk premia and, thus, risk premium spillovers. During our investigation period, we also observe rising bilateral spillovers between SRP and KRP.

5 Aggregate connectedness - various factors and, the equity and commodity markets

In this section, we investigate the relationship between aggregate connectedness and certain factors, including the returns, volatility risk premium, skewness risk premium, and kurtosis risk premium of both commodity and stock markets. We then use this information to build several trading strategies that rely on aggregate connectedness measures. Finally, we explore the behavior of our connectedness measures around several announcements. To undertake this analysis, we compute two time-varying connectedness measures, namely, the aggregate connectedness among markets, and the aggregate connectedness between risk premia and returns. The former and latter measures are computed as the mean of $from$ spillovers in Figures 1 and 2, respectively. Appendix A.1 plots the time-varying aggregate connectedness among markets and the aggregate connectedness between risk premia and returns.

5.1 *Relationship to various factors*

The first part of this section explores how the aggregate connectedness relates to certain factors, such as the credit spread, TED spread, ADS business conditions index and the economic policy uncertainly index (EPU) of Aruoba et al. (2009) and Baker et al. (2016), respectively.[4] It also looks into the connectedness' relationship with commodity and equity returns, and their risk premia. Table 7 reports the ordinary least squares (OLS) regressions in which we regress each of the factors, returns, and risk premia on a constant and each of the high dummies of the aggregate connectedness among markets and aggregate connectedness between risk premia and returns. The high dummies

[4]Data are taken from the St. Louis Federal Reserve Bank website, https://fred.stlouisfed.org except for the EPU index which is from the Baker, Bloom and Davis' website, http://www.policyuncertainty.com.

take a value of one if the aggregate connectedness measures are above their median connectedness over the full sample period, and zero otherwise.

Panel A of Table 7 uncovers a negatively significant relationship between the credit spread and both connectedness measures. The likewise relationship of the ADS with aggregate connectedness between risk premia and returns suggests that, in high connectedness states, business conditions are worse than their average. The positively significant coefficients of the TED spread indicate that a rise in our connectedness measures leads to a high TED spread. Additionally, we emphasize the high positive and negative coefficients of the EPU during times when the aggregate connectedness among markets and between risk premia and returns is high.

Panel B shows that the high connectedness among markets is associated with low and high returns for agricultural commodities and the U.K. stock market, respectively. Finally, Panel C points out the usually positive and significant relationship between the VRP of metal and energy commodities and aggregate connectedness measures. Instead, the VRP of the agricultural sector is negatively related to the aggregate connectedness between risk premia and returns. Concerning equity markets, Panel C displays that their VRP increases with the aggregate connectedness among markets. Examining the SRP, we generally find a positive relationship between our connectedness measures, especially, for the agricultural, gold, and oil markets. Contrary to commodity markets, the SRP of equity markets is negatively associated with connectedness between risk premia and returns. These findings imply that investors would require higher compensation for the equity crash risk when the connectedness between risk premia and returns is high. In general, there is a positive and negative relationship between KRP of commodity markets and the aggregate connectedness among markets and aggregate connectedness between risk premia and returns periods, respectively. Regarding the KRP of equity markets, there is solely a negatively significant relation between the U.S. and connectedness among markets.

INSERT TABLE 7 HERE

5.2 *Portfolios build on connectedness relationship to various factors*

The second part of the Section 5 highlights possible trading strategies relying on the time-varying relationship of aggregate connectedness with both commodity and equity returns, and their risk premia. In addition to the previous two connectedness measures, we consider the aggregate connectedness to returns and risk premia. That is, the $from$ spillover from Panel A of Figure 2 and the mean of $from$ spillovers from Panels B, C and D of Figure 2, respectively. Appendix A.1 displays these time-varying aggregate connectedness indices. We start our investigation by firstly assessing the sensitivity of returns and individual risk premia for each commodity and stock markets to the time-varying aggregate connectedness measures by running OLS regressions as in Table 7. To better capture these relations and their variation over time, we estimate the regressions on the aggregate connectedness indices and use a rolling window size of two years. We secondly, build trading strategies relying on these rolling window coefficients. That is, we buy and sell the top and bottom 25% commodity or equity markets using their exposure of returns and risk premia to our connectedness measures. Thereby, our portfolio consists of three long and short positions with equal weights that we rebalance daily and hold for one month. Table 8 reports the summary statistics for these trading strategies. Specifically, while Panels A and B rely on the aggregate connectedness among markets and aggregate connectedness between risk premia and returns, Panels C and D use the aggregate connectedness to returns and risk premia.

Table 8 underlines in Panels A and B, the positively significant performance of the returns and SRP portfolios presenting a Sharpe ratio of 0.99 and 0.83, respectively. For instance, these portfolios earn an average annual return of circa 13.24% and 10% with volatility around 13.30% and 12%. Apart from the aggregate connectedness among markets and between risk premia and returns, we also control for whether the total spillover from the stock market to the commodity market provides additional information. Appendix A.2 demonstrates that there are no profitable strategies when exploring either the sensitivity of returns or risk premia to the equity spillover to commodity markets. These findings suggest that for a profitable trading strategy, matters the spillover to both commodity and equity markets. Taken together, the above discoveries clearly emphasize the prominence of cross-equity effects for commodity markets besides their own effects and the cross-sector spillovers.[5]

We further separate the aggregate connectedness between risk premia and returns into two measures, namely, aggregate connectedness to returns and aggregate connectedness to risk premia. Panels C and D explore the profitability of various trading strategies, relying on the relationship of commodity and equity returns and risk premia with these connectedness measures. Our findings reveal the high and significant performance of the VRP and KRP portfolios in Panel C and that of the SRP portfolio in Panel D. For example, a trading strategy that buys and sells the mix of commodity and equity portfolio with the highest and lowest VRP delivers annual average returns of 11.61% with a volatility of 15%. Similar strategies on the higher-order portfolios (i.e., SRP and KRP), offer annual returns of 10.35% and 13.49% with a volatility of 12.75% and 12.93%, respectively. In sum, the results confirm once again that it is essential to be aware of the interactions between the returns and higher-order risk premia. By acknowledging them, investors could build profitable trading strategies, as previously shown.

INSERT TABLE 8 HERE

5.3 *Relationship to equity and commodity announcements*

To explain the time-variation in connectedness measures, this subsection looks at changes in their behavior around several equity and commodity announcements, as well as political events.[6] Our analysis primarily focuses on the unconventional monetary policy announcements from the Federal Open Market Committee (FOMC), European Central Bank (ECB), Bank of England (BoE), and the Bank of Japan (BoJ) as proxies for the announcements typically affecting the U.S., U.K., German, and Japanese equity markets. Several studies have shown that monetary policy announcements have significant impacts on equities' implied volatilities and their variance risk premium, as well as on commodity markets (see e.g., Glick and Leduc, 2012; Bekaert et al., 2013; Mamaysky, 2018). Glick and Leduc (2012), for example, highlight that these announcements can affect commodity markets through several channels such as the portfolio-balance, signaling, and exchange-rate

[5] The results also hold when constructing trading strategies solely on commodity markets. These are available on request.

[6] We compute the change in spillovers as the difference between the mean of one month after (post) and prior (pre) to the pooled equity and political announcements (see e.g., Mamaysky, 2018). In general, our results are also robust when using one week or two weeks around the announcements. These findings are available upon request.

channels. Moreover, the authors observe that although commodity prices should usually rise during the looser monetary policy announcements from the FOMC and BoE (i.e., between the end of 2008 and 2010), in fact, prices decline, signaling a lower future economic growth. In this subsection, we thus posit that the effects of unconventional monetary policy announcements can propagate from equity to commodity markets, and hence lead to shifts in our cross-equity, cross-return, and cross-risk premium spillovers. In particular, we expect a reduction and enhancement in these spillovers following the expansionary announcements, and contractionary and political announcements, respectively. We also hypothesize that the behavior of spillovers around expansionary announcements might differ during the crisis and normal periods. Appendix A.3, therefore, classifies expansionary announcements into two groups, namely, from 2009 to 2012 and afterward, and displays the contractionary and political announcements, respectively.

Table 9 documents the effects of expansionary, contractionary, and political announcements on the cross-equity spillovers to grain, metal and energy commodity sectors from Figure 1. We find that cross-equity spillover effects on metal and energy sectors are more sensitive to the expansionary announcements. In particular, these spillovers strengthen and weaken substantially around the expansionary announcements occurring during the GFC and EDC, i.e., between 2009 and 2012, and afterward, respectively. Around the contractionary announcements, instead, there are no significant changes in the cross-equity spillovers to commodity sectors. Our results also uncover that political events led to enhancement in the cross-equity spillovers to grain, metal, and energy sectors.

INSERT TABLE 9 HERE

We further explore the behavior of cross-return and cross-risk premium spillovers around the expansionary, contractionary, and political announcements. Table 10 shows the change in cross-return spillover to each of the risk premia (i.e., VRP, SRP, and KRP from right panels of Figure 2), whereas Table 11 presents the opposite effects. Specifically, it reports the change in spillover effects from VRP, SRP, and KRP to returns from Panel A of Figure 2. The findings in Tables 10 and 11 reveal that generally, expansionary announcements significantly decrease the spillovers from returns to higher-order risk premia (i.e., SRP and KRP), and vice versa. Moreover, contractionary and political announcements usually generate increases in these spillovers. These discoveries suggest that investors might strive to manage their higher-order risk premium-return profile by rebalancing their portfolio, especially around expansionary, contractionary, and political announcements. The exceptions are the spillovers from returns to VRP, and the other way around that significantly rise following the expansionary announcements occurring during the financial crises. In addition, Appendix A.4 presents the change in aggregate connectedness to returns and risk premia following the previous announcements. The results are typically in line with those in Tables 10 and 11. For example, we document a significant reduction in the aggregate connectedness to returns following the expansionary announcements. Instead, contractionary announcements led to a significant rise in aggregate connectedness to risk premia. Finally, political events generate increases in both aggregate connectedness to returns and risk premia.

INSERT TABLE 10 HERE

INSERT TABLE 11 HERE

Besides the above announcements, we include commodity-specific events covering the grain, metal, and energy sectors, such as the monthly releases from the U.S. Department of Agriculture of the World Agricultural Supply and Demand Estimates Report (WASDE), from the World Bureau of Metal Statistics (WBMS), and the U.S. Energy Information Administration of the Short-Term Crude and Natural Gas Outlook report, respectively. When using these announcements, there are no significant shifts in cross-commodity spillovers to the equity market and previous connectedness measures.[7]

6 Conclusion

In this paper, we examine the spillovers between the risk premia and returns of the commodity (i.e., grain, metal, and energy sectors) and equity markets (the U.S., U.K., Germany, and Japan). Using options data and five-minute returns for estimation of implied (i.e., implied volatility, skewness,

[7]As the commodity statements are released monthly, we use one week after and before their release in our estimation. In addition, we control for two days and weeks around release dates. The results are available upon request.

and kurtosis), and realized moments, respectively, we compute the risk premia as the difference between them. By using these measures, we provide new evidence about the relations between three types of compensation that commodity and equity investors require for bearing their risks and their interaction with returns.

Our analysis uncovers several interesting results. First, we document time variation in cross-market and cross-moment spillovers. In particular, we show that during the financial crises until mid-2012, there is an increase in cross-market effects. By contrast, the within-market effects decrease, reflecting the increasing attention given by investors to cross-market spillovers. Specifically, our investigation highlights the significant spillover from stock markets to commodity sectors and the other way around, from mainly the metal sector. In addition, the metal sector has the highest impacts on commodity sectors. Second, we emphasize the strongest influence of returns to VRP and higher-order premia. Regarding the spillovers affecting returns, SRP typically has the highest impact. Note that higher-order risk premia have higher effects on returns than VRP. We further find bi-directional spillovers between SRP and KRP. Third, we uncover a relationship between the high spillover states and various factors (i.e., the credit and TED spreads, ADS, and EPU indices), as well as with returns and risk premia of commodity and equity markets. Moreover, we show that by being aware of these latter relations, investors could build rewarding trading strategies. Finally, our analysis highlights that several announcements explain the substantial changes in cross-equity, cross-return, and cross-risk premium spillovers.

References

Acharya, V. V., Lochstoer, L. A., & Ramadorai, T., 2013. Limits to arbitrage and hedging: Evidence from commodity markets. *Journal of Financial Economics*, 109(2), 441-465.

Andersen, T.G., Bollerslev, T., Diebold, F.X., & Labys, P. 2003. Modeling and forecasting realized volatility. *Econometrica*, 71, 529-626.

Aruoba, S. B., Diebold, F. X., & Scotti, C., 2009. Real-time measurement of business conditions. *Journal of Business and Economic Statistics*, 27(4), 417-427.

Baker, S. R., Bloom, N., & Davis, S. J., 2016. Measuring economic policy uncertainty. *The Quarterly Journal of Economics*, 131(4), 1593-1636.

Bakshi, G., & Madan, D., 2000. Spanning and derivative-security valuation. *Journal of Financial Economics*, 55, 205-238.

Bakshi, G., Kapadia, N., & Madan, D., 2003. Stock return characteristics, skew laws and the differential pricing of individual equity options. *Review of Financial Studies*, 16, 101-143.

Bali, T. G., Hu, J., & Murray, S., 2019. Option implied volatility, skewness, and kurtosis and the cross-section of expected stock returns. *Working Paper*.

Basak, S., & Pavlova, A., 2016. A model of financialization of commodities. *The Journal of Finance*, 71(4), 1511-1556.

Bekaert, G., Hoerova, M., & Lo Duca, M., 2013. Risk, uncertainty and monetary policy. *Journal of Monetary Economics*, 60, 771-788.

Bollerslev, T., Tauchen, & Zhou, H., 2009. Expected stock returns and variance risk premia. *Review of Financial Studies*, 22, 4463-4492.

Bollerslev, T., Gibson, N., & Zhou, H., 2011. Dynamic estimation of volatility risk premia and investor risk aversion from option-implied and realized volatilities. *Journal of Econometrics*, 160, 235-245.

Bollerslev, T., Marrone, J., Xu, L. & Zhou, H., 2014. Stock return predictability and variance risk premia: Statistical inference and international evidence. *Journal of Financial and Quantitative Analysis*, 49(3), 633-661.

Büyükşahin, B., & Robe, M. A., 2014. Speculators, commodities and cross-market linkages. *Journal of International Money and Finance*, 42, 38-70.

Cipollini, A., Lo Cascio, I., & Muzzioli, S., 2013. Wavelet analysis of variance risk premium spillovers. *Working Paper*, University of Modena and Reggio Emilia.

Cheng, I. H., & Xiong, W., 2014. Financialization of commodity markets. *Annual Review of Financial Economics*, 6(1), 419-441.

Cheng, I. H., Kirilenko, A., & Xiong, W., 2015. Convective risk flows in commodity futures markets. *Review of Finance*, 19(5), 1733-1781.

Christoffersen, P., Lunde, A., & Olesen, K., 2017. Factor structure in commodity futures return and volatility. *Journal of Financial and Quantitative Analysis*, 1-74.

Diebold, F., & Yilmaz K., 2012. Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, 28, 57-66.

Diebold, F., & Yilmaz, K., 2014. On the network topology of variance decompositions: Measuring the connectedness of financial firms. *Journal of Econometrics*, 182, 119-134.

Finta, M. A., & Ornelas, J. R. H., 2020. Commodity return predictability: Evidence from implied variance, skewness and their risk premia. *Working Paper*.

Glick, R., & Leduc, S., 2012. Central bank announcements of asset purchases and the impact on global financial and commodity markets. *Journal of International Money and Finance*, 31(8), 2078-2101.

Greenwood-Nimmo, M. J., Nguyen, V. H., & Shin, Y., 2015. Measuring the connectedness of the global economy. *Working Paper*, Mimeo, University of Melbourne.

Greenwood-Nimmo, M., Nguyen, V. H., & Rafferty, B., 2016. Risk and return spillovers among the G10 currencies. *Journal of Financial Markets*, 31, 43-62.

Harris, R. D. & Qiao, F., 2018. Moment risk premia and the cross-section of stock returns. *Working Paper*.

Henderson, B. J., Pearson, N. D., & Wang, L., 2014. New evidence on the financialization of commodity markets. *The Review of Financial Studies*, 28(5), 1285-1311.

Konstantinidi, E., & Skiadopoulos, G., 2016. How does the market variance risk premium vary over time? Evidence from S&P 500 variance swap investment returns. *Journal of Banking and Finance*, 62, 62-75.

Mamaysky, H., 2018. The time horizon of price responses to quantitative easing. *Journal of Banking and Finance*, 90, 32-49.

Menkhoff, L., Sarno, L., Schmeling, M., & Schrimpf, A., 2012. Carry trades and global foreign exchange volatility. *Journal of Finance*, 67, 681-718.

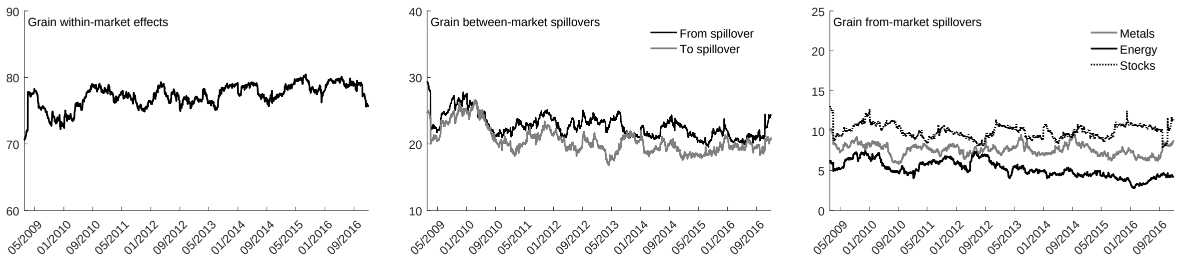
Prokopczuk, M., Symeonidis, L., & Simen, C. W., 2017. Variance risk in commodity markets. *Journal of Banking and Finance*, 81, 136-149.

Tang, K., & Xiong, W., 2012. Index investment and the financialization of commodities. *Financial Analysts Journal*, 68(5), 54-74.

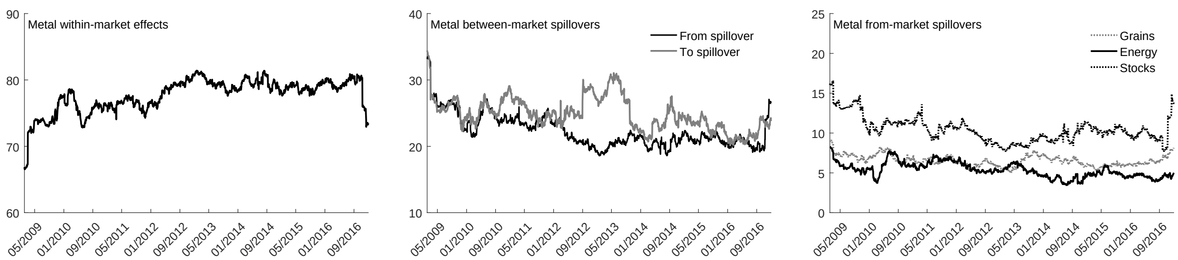
Wang, Y., Zhang, B., Diao, X. & Wu, C., 2015. Commodity price changes and the predictability of economic policy uncertainty. *Economics Letters*, 127, 39-42.

Figure 1: Time-Varying Connectedness between Commodity and Stock Markets

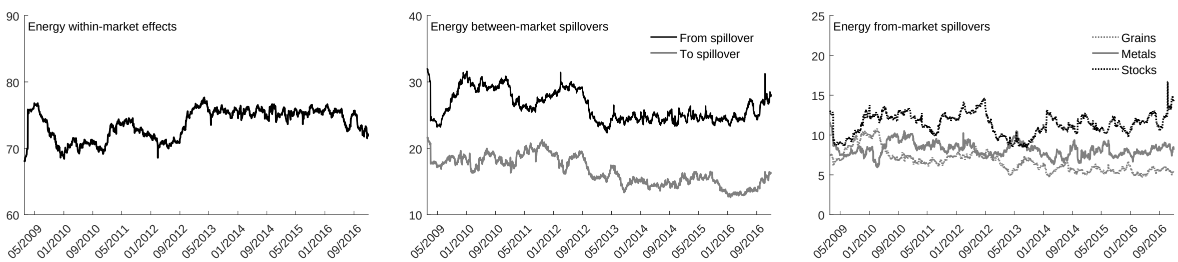
Panel A: Grain Relations



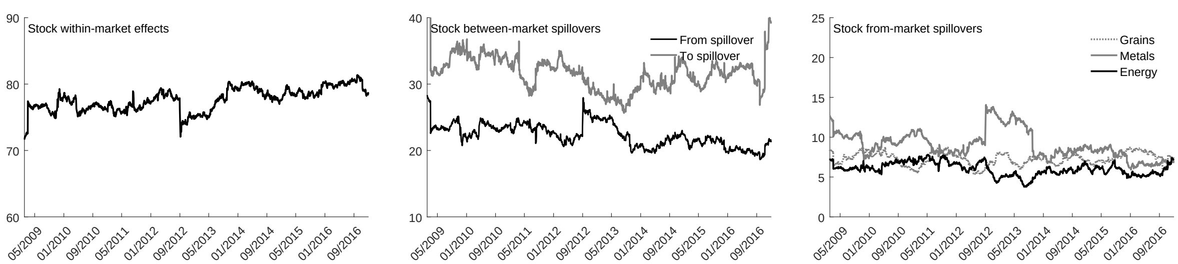
Panel B: Metal Relations



Panel C: Energy Relations



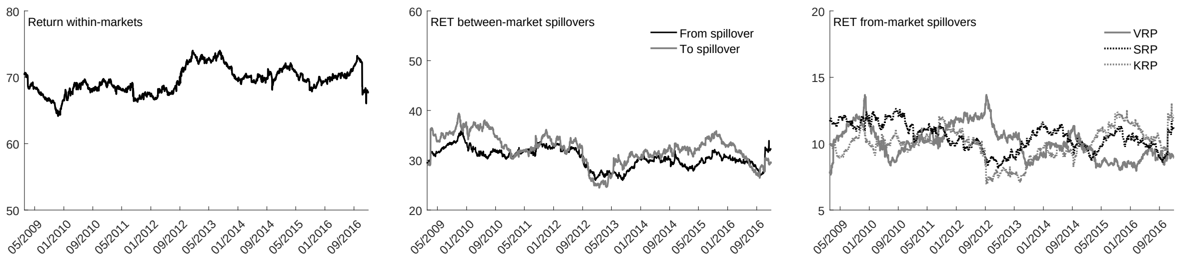
Panel D: Stock Relations



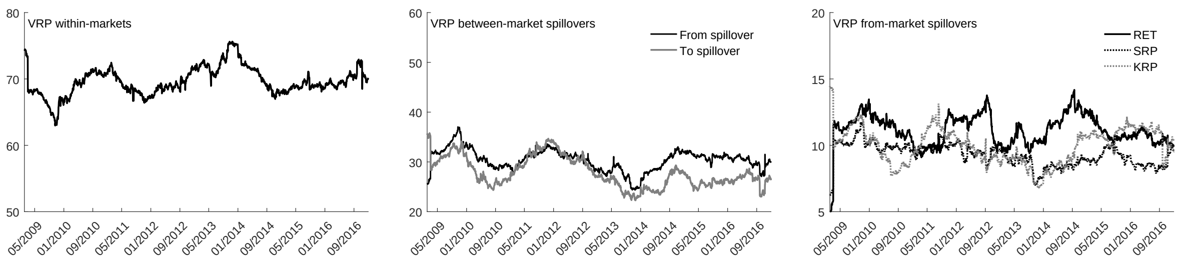
Note: This figure shows the rolling window risk premium relations between commodity (i.e., grain, metal, and energy sectors) and stock market (i.e., the U.S., U.K., German, and Japanese markets). We use the block aggregation approach of Greenwood-Nimmo et al. (2015) that relies on the connectedness matrix of Diebold and Yilmaz (2012, 2014). The connectedness matrix is estimated using a rolling window length of 250 trading day with a forecast horizon of ten trading days. The figures capture the share of variance of the commodity and stock markets that is due to their own and other shocks. The $from$ (to) spillover shows the total spillover from all commodity and stock markets (each of the commodity and stock markets i) to each of the commodity and stock markets i (all commodity and stock markets).

Figure 2: Time-Varying Connectedness between Risk Premia and Returns

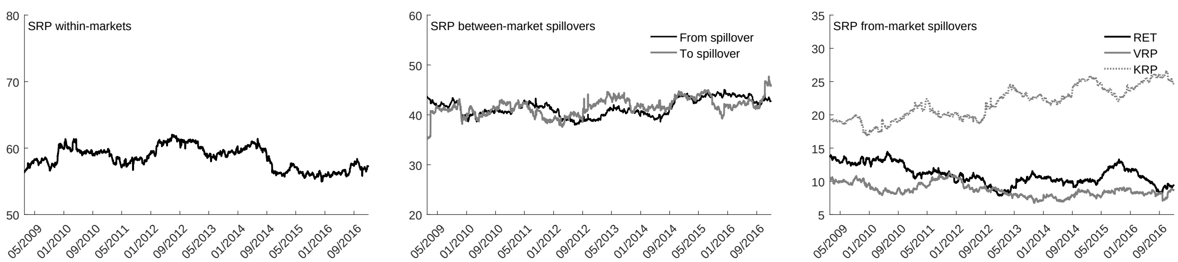
Panel A: Return Relations



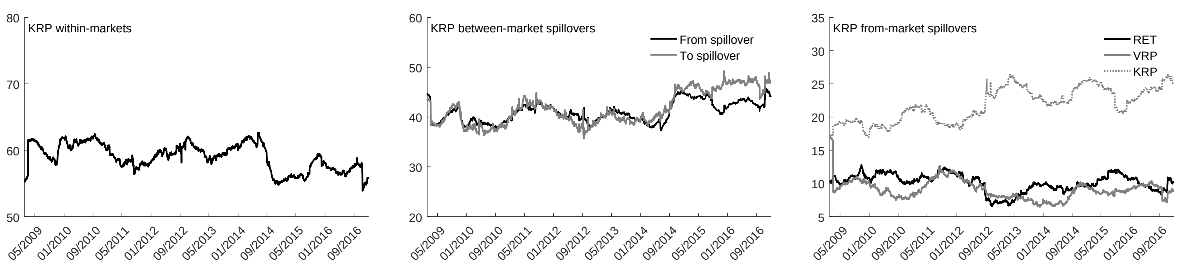
Panel B: Volatility Risk Premium Relations



Panel C: Skewness Risk Premium Relations



Panel D: Kurtosis Risk Premium Relations



Note: This figure shows the rolling window relations between risk premia (namely, volatility risk premium (VRP), skewness risk premium (SRP), and kurtosis risk premium (KRP)), and returns (RET). We use the block aggregation approach of Greenwood-Nimmo et al. (2015) that relies on the connectedness matrix of Diebold and Yilmaz (2012, 2014). The connectedness matrix is estimated using a rolling window length of 250 trading day with a forecast horizon of ten trading days. The figures capture the share of variance of the risk premia and returns that is due to their own and other shocks. The *from* (*to*) return spillover shows the total spillover from all risk premia (all market returns) to all market returns (all risk premia). The other *from* (*to*) spillovers are defined likewise.

Table 1: Summary Statistics

		Corn	Soybeans	Wheat	Copper	Silver	Gold	Oil	Natural Gas	U.S.	U.K.	Germany	Japan
RET	Mean	−0.0005	−0.0004	−0.0009	0.0004	0.0000	−0.0001	0.0003	−0.0004	0.0001	−0.0002	−0.0002	−0.0003
	Std. Dev.	0.0145	0.0121	0.0168	0.0109	0.0139	0.0077	0.0168	0.0169	0.0099	0.0078	0.0124	0.0121
VRP	Mean	0.0041	0.0029	0.0011	0.0129	0.0040	0.0031	0.0045	0.0050	0.0035	0.0031	0.0007	0.0049
	Std. Dev.	0.0053	0.0035	0.0051	0.0092	0.0032	0.0018	0.0033	0.0037	0.0028	0.0024	0.0021	0.0026
SRP	Mean	0.0617	−0.0183	0.0957	−0.0456	−0.0046	−0.0353	0.0079	0.0816	−0.3701	−0.1890	−0.0792	−0.1698
	Std. Dev.	0.2124	0.1944	0.1993	0.2539	0.1398	0.1679	0.1176	0.0977	0.1184	0.0997	0.1006	0.1221
KRP	Mean	0.1422	0.1682	0.1320	0.2182	0.0908	0.1401	0.1092	0.0650	0.1006	−0.2434	−0.2546	−0.2900
	Std. Dev.	0.1661	0.1302	0.1575	0.2005	0.1355	0.1531	0.0865	0.0918	0.1906	0.2080	0.1446	0.3874
VRP	Mean	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Innovations	Std. Dev.	0.0022	0.0017	0.0022	0.0030	0.0016	0.0007	0.0013	0.0012	0.0011	0.0010	0.0007	0.0010
SRP	Mean	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	−0.0000	0.0000	−0.0000	−0.0000
Innovations	Std. Dev.	0.0905	0.0859	0.0887	0.1031	0.0499	0.0520	0.0411	0.0428	0.0448	0.0378	0.0315	0.0446
KRP	Mean	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	−0.0000	−0.0000	0.0000	−0.0000
Innovations	Std. Dev.	0.0574	0.0513	0.0559	0.0730	0.0437	0.0478	0.0323	0.0330	0.0833	0.0820	0.0501	0.1346

Note: This table presents the means and standard deviations (Std. Dev.) for daily risk premia and their innovations (i.e, volatility, skewness, and kurtosis) of the commodity (i.e., corn, soybeans, wheat, copper, silver, gold, oil, and natural gas) and equity markets (i.e., the U.S., U.K., German, and Japanese markets). We estimate the daily implied moments following Bakshi et al. (2003) and realized moments using five-minute returns as in Andersen et al. (2003) and Amaya et al. (2015). Following Bollerslev et al. (2009), we compute the daily risk premia (i.e., the volatility risk premium (VRP), skewness risk premium (SRP), and kurtosis risk premium (KRP)), as the difference between implied and realized moments. As Menkhoff et al. (2012) and Greenwood-Nimmo et al. (2016), we then recover the risk premium innovations from an AR (1) model.

Table 2: Connectedness between Risk Premia and Returns

To\From		Corn RET	Corn VRP	Corn SRP	Corn KRP	Soybeans RET	Soybeans VRP	Soybeans SRP	Soybeans KRP	Wheat RET	Wheat VRP	Wheat SRP	Wheat KRP	Copper RET	Copper VRP	Copper SRP	Copper KRP	Silver RET	Silver VRP	Silver SRP	Silver KRP	Gold RET	Gold VRP	Gold SRP	Gold KRP
Corn	RET	53.91	0.03	3.47	1.81	13.91	0.04	0.40	0.49	16.97	0.04	1.30	1.41	0.01	0.02	0.07	0.00	0.81	0.04	0.01	0.03	0.47	0.02	0.02	0.02
	VRP	0.05	89.99	0.19	1.10	0.02	0.72	0.18	0.24	0.08	1.72	0.17	0.15	0.11	0.07	0.07	0.18	0.18	0.23	0.06	0.03	0.16	0.84	0.06	0.18
	SRP	4.61	0.12	71.45	17.52	0.69	0.18	0.19	0.26	1.38	0.02	0.19	0.01	0.02	0.05	0.06	0.01	0.11	0.05	0.27	0.30	0.20	0.04	0.09	0.17
	KRP	2.39	0.87	17.77	72.02	0.06	0.15	0.60	0.53	0.71	0.10	0.12	0.19	0.00	0.42	0.05	0.00	0.21	0.02	0.32	0.23	0.23	0.09	0.21	0.26
Soybeans	RET	16.41	0.03	0.50	0.39	62.41	0.00	1.48	1.97	8.83	0.01	0.36	0.95	0.15	0.01	0.16	0.01	0.91	0.01	0.08	0.10	0.60	0.04	0.07	0.00
	VRP	0.02	0.72	0.11	0.21	0.01	88.32	0.08	1.76	0.04	1.62	0.01	0.00	0.02	0.13	0.03	0.51	0.02	0.51	0.08	0.06	0.02	0.75	0.01	0.01
	SRP	0.63	0.03	0.19	0.47	1.46	0.08	88.70	3.55	0.18	0.09	0.65	0.41	0.09	0.14	0.00	0.18	0.41	0.05	0.02	0.16	0.11	0.06	0.00	0.03
	KRP	0.73	0.10	0.09	0.38	2.76	1.69	3.68	86.39	0.45	0.18	0.25	0.30	0.06	0.06	0.19	0.00	0.03	0.05	0.01	0.02	0.09	0.07	0.04	0.01
Wheat	RET	17.70	0.04	1.09	0.54	7.96	0.02	0.19	0.19	56.31	0.20	3.67	4.73	0.01	0.22	0.09	0.09	1.00	0.01	0.03	0.09	0.63	0.05	0.10	0.11
	VRP	0.28	1.63	0.03	0.11	0.08	0.96	0.06	0.13	0.32	84.37	0.43	3.06	0.06	0.19	0.20	0.05	0.23	0.50	0.01	0.08	0.34	0.75	0.29	0.07
	SRP	1.76	0.30	0.19	0.06	0.41	0.00	0.62	0.20	4.70	0.36	71.88	16.61	0.01	0.11	0.02	0.08	0.02	0.03	0.23	0.10	0.02	0.06	0.01	0.03
	KRP	1.79	0.18	0.01	0.19	1.05	0.00	0.33	0.28	5.77	2.50	15.52	69.28	0.04	0.08	0.01	0.13	0.04	0.02	0.05	0.00	0.02	0.06	0.15	0.14
Copper	RET	0.20	0.01	0.09	0.03	0.17	0.00	0.08	0.08	0.04	0.17	0.04	0.06	94.71	0.03	0.06	0.04	0.01	0.17	0.02	0.02	0.42	0.12	0.03	0.31
	VRP	0.05	0.07	0.02	0.39	0.01	0.13	0.12	0.07	0.17	0.07	0.09	0.03	0.02	90.25	0.03	3.25	0.30	0.34	0.14	0.03	0.12	0.13	0.02	0.00
	SRP	0.22	0.14	0.53	0.01	0.22	0.04	0.00	0.13	0.09	0.04	0.05	0.01	0.04	0.03	89.83	0.23	0.73	0.09	0.12	0.10	0.41	0.12	0.30	0.29
	KRP	0.00	0.22	0.02	0.00	0.01	0.51	0.18	0.01	0.11	0.05	0.11	0.16	0.29	3.21	0.30	89.90	0.22	0.10	0.02	0.08	0.07	0.10	0.16	0.13
Silver	RET	0.80	0.02	0.16	0.17	0.53	0.00	0.08	0.04	0.86	0.13	0.01	0.02	0.01	0.04	0.40	0.13	48.92	0.16	2.81	3.89	29.04	0.12	1.67	2.51
	VRP	0.08	0.36	0.06	0.01	0.00	0.50	0.01	0.02	0.01	0.48	0.04	0.08	0.33	0.30	0.12	0.08	0.07	85.10	0.06	1.20	0.06	2.55	0.02	0.03
	SRP	0.03	0.02	0.20	0.08	0.06	0.00	0.01	0.01	0.02	0.02	0.05	0.03	0.01	0.02	0.05	0.06	3.22	0.04	54.47	30.80	1.81	0.13	2.99	3.49
	KRP	0.03	0.02	0.20	0.08	0.06	0.01	0.01	0.04	0.04	0.03	0.05	0.02	0.05	0.01	0.05	0.04	4.11	0.72	29.01	51.53	2.44	0.21	3.71	4.46
Gold	RET	0.53	0.00	0.15	0.15	0.37	0.01	0.08	0.03	0.67	0.19	0.01	0.03	0.24	0.03	0.23	0.08	30.09	0.04	1.67	2.41	50.67	0.07	2.70	4.29
	VRP	0.07	0.50	0.08	0.05	0.09	0.63	0.01	0.06	0.11	0.67	0.04	0.09	0.10	0.22	0.13	0.03	0.01	1.17	0.19	0.40	0.20	75.16	0.22	0.25
	SRP	0.00	0.10	0.09	0.14	0.06	0.01	0.08	0.07	0.07	0.01	0.00	0.03	0.03	0.01	0.11	0.01	1.73	0.04	2.94	3.85	2.87	0.02	53.44	32.15
	KRP	0.02	0.06	0.12	0.23	0.00	0.02	0.05	0.02	0.06	0.01	0.02	0.10	0.01	0.00	0.06	0.01	2.63	0.01	3.32	4.45	4.28	0.07	30.96	51.40
Oil	RET	2.32	0.03	0.10	0.04	1.86	0.04	0.03	0.26	1.59	0.01	0.03	0.03	0.04	0.06	0.87	0.25	4.01	0.20	0.22	0.26	2.62	0.09	0.13	0.11
	VRP	0.14	0.45	0.11	0.00	0.19	0.32	0.03	0.07	0.18	0.65	0.08	0.09	0.17	0.19	0.15	0.03	0.17	0.88	0.05	0.01	0.26	1.36	0.05	0.15
	SRP	0.15	0.02	0.03	0.01	0.08	0.11	0.04	0.02	0.36	0.04	0.02	0.03	0.05	0.10	0.38	0.15	0.81	0.09	0.11	0.20	0.76	0.16	0.19	0.20
	KRP	0.16	0.02	0.04	0.04	0.17	0.05	0.11	0.03	0.42	0.05	0.27	0.03	0.01	0.19	0.35	0.24	0.77	0.13	0.16	0.15	0.80	0.23	0.18	0.13
Natural Gas	RET	0.38	0.20	0.11	0.08	0.45	0.00	0.00	0.00	0.47	0.06	0.12	0.06	0.02	0.21	0.18	0.22	0.17	0.00	0.01	0.04	0.10	0.02	0.22	0.19
	VRP	0.09	0.17	0.00	0.00	0.16	0.23	0.02	0.12	0.02	0.43	0.11	0.02	0.15	0.40	0.30	0.16	0.05	0.91	0.02	0.01	0.07	1.65	0.04	0.01
	SRP	0.03	0.22	0.12	0.18	0.05	0.07	0.01	0.11	0.08	0.01	0.03	0.03	0.03	0.11	0.06	0.16	0.06	0.01	0.02	0.00	0.06	0.02	0.05	0.04
	KRP	0.00	0.25	0.08	0.06	0.04	0.08	0.04	0.04	0.08	0.03	0.04	0.01	0.05	0.02	0.03	0.06	0.07	0.02	0.00	0.01	0.06	0.00	0.03	0.03
U.S.	RET	0.79	0.00	0.02	0.08	0.39	0.00	0.01	0.05	0.51	0.13	0.02	0.04	0.21	0.18	0.29	0.38	0.57	0.38	0.01	0.01	0.05	0.22	0.08	0.16
	VRP	0.02	0.15	0.03	0.01	0.06	0.30	0.03	0.09	0.12	0.33	0.08	0.03	0.07	0.01	0.06	0.13	0.11	0.20	0.04	0.08	0.01	2.62	0.04	0.05
	SRP	0.08	0.13	0.11	0.03	0.05	0.03	0.23	0.02	0.19	0.06	0.04	0.13	0.12	0.09	0.03	0.19	0.05	0.08	0.07	0.17	0.06	0.45	0.05	0.04
	KRP	0.08	0.09	0.08	0.16	0.16	0.09	0.06	0.07	0.03	0.11	0.09	0.00	0.00	0.07	0.02	0.02	0.01	0.06	0.22	0.31	0.01	0.20	0.02	0.02
U.K.	RET	0.14	0.05	0.05	0.06	0.13	0.08	0.06	0.02	0.08	0.09	0.08	0.04	0.13	0.09	0.10	0.10	0.34	0.04	0.03	0.04	0.08	0.72	0.05	0.02
	VRP	0.19	0.17	0.02	0.03	0.23	0.29	0.00	0.04	0.09	0.22	0.07	0.13	0.06	0.12	0.07	0.02	0.54	0.29	0.03	0.11	0.06	5.54	0.02	0.06
	SRP	0.17	0.02	0.16	0.03	0.09	0.03	0.01	0.22	0.15	0.03	0.01	0.19	0.08	0.04	0.12	0.07	0.13	0.25	0.15	0.11	0.36	0.03	0.12	0.08
	KRP	0.09	0.24	0.06	0.16	0.07	0.13	0.18	0.41	0.04	0.14	0.01	0.01	0.02	0.05	0.31	0.13	0.04	0.22	0.03	0.08	0.27	0.10	0.17	0.15
Germany	RET	0.16	0.03	0.20	0.05	0.10	0.17	0.14	0.13	0.24	0.05	0.23	0.07	0.13	0.03	0.09	0.32	0.21	0.05	0.01	0.03	0.21	1.01	0.29	0.27
	VRP	0.24	0.19	0.00	0.04	0.14	0.77	0.01	0.03	0.02	0.95	0.23	0.13	0.44	0.32	0.06	0.04	0.08	0.72	0.04	0.07	0.09	3.26	0.03	0.11
	SRP	0.05	0.10	0.05	0.04	0.16	0.12	0.33	0.14	0.09	0.15	0.20	0.01	0.05	0.05	0.07	0.03	0.04	0.09	0.40	0.37	0.06	0.18	0.11	0.16
	KRP	0.04	0.06	0.01	0.05	0.03	0.36	0.07	0.26	0.06	0.10	0.00	0.15	0.02	0.14	0.35	0.06	0.18	0.38	0.66	0.73	0.11	0.52	0.73	0.41
Japan	RET	0.14	0.04	0.03	0.11	0.07	0.15	0.00	0.03	0.02	0.08	0.03	0.03	0.07	0.15	0.25	0.60	0.05	0.51	0.05	0.07	0.08	0.52	0.05	0.22
	VRP	0.03	0.29	0.06	0.27	0.06	0.37	0.02	0.02	0.02	0.56	0.07	0.05	0.12	0.23	0.02	0.00	0.07	1.04	0.00	0.11	0.05	2.92	0.05	0.01
	SRP	0.08	0.09	0.17	0.19	0.14	0.20	0.17	0.01	0.00	0.08	0.09	0.09	0.05	0.07	0.10	0.11	0.01	0.27	0.02	0.02	0.01	0.07	0.15	0.06
	KRP	0.30	0.06	0.48	0.65	0.13	0.02	0.46	0.40	0.25	0.75	0.12	0.12	0.22	0.07	0.04	0.10	0.16	0.15	0.09	0.08	0.23	0.07	0.08	0.06

To\From		Oil RET	Oil VRP	Oil SRP	Oil KRP	Natural Gas RET	Natural Gas VRP	Natural Gas SRP	Natural Gas KRP	U.S. RET	U.S. VRP	U.S. SRP	U.S. KRP	U.K. RET	U.K. VRP	U.K. SRP	U.K. KRP	Germany RET	Germany VRP	Germany SRP	Germany KRP	Japan RET	Japan VRP	Japan SRP	Japan KRP
Corn	RET	2.16	0.03	0.15	0.13	0.31	0.05	0.08	0.06	0.62	0.01	0.12	0.06	0.07	0.26	0.03	0.06	0.19	0.07	0.04	0.01	0.02	0.08	0.05	0.03
	VRP	0.06	0.55	0.03	0.08	0.24	0.19	0.10	0.12	0.06	0.22	0.08	0.07	0.10	0.10	0.05	0.21	0.06	0.22	0.01	0.05	0.04	0.38	0.17	0.03
	SRP	0.07	0.06	0.03	0.05	0.08	0.01	0.45	0.20	0.01	0.00	0.24	0.08	0.03	0.02	0.21	0.05	0.06	0.01	0.09	0.06	0.04	0.04	0.06	0.08
	KRP	0.06	0.01	0.02	0.03	0.14	0.18	0.43	0.19	0.10	0.01	0.09	0.08	0.02	0.04	0.04	0.14	0.15	0.03	0.07	0.04	0.16	0.24	0.04	0.18
Soybeans	RET	2.08	0.06	0.06	0.17	0.38	0.01	0.05	0.05	0.39	0.14	0.04	0.06	0.05	0.39	0.03	0.01	0.20	0.05	0.15	0.07	0.01	0.01	0.05	0.03
	VRP	0.04	0.40	0.02	0.05	0.03	0.46	0.13	0.11	0.04	0.46	0.05	0.03	0.09	0.38	0.11	0.06	0.11	1.08	0.21	0.41	0.11	0.51	0.03	0.03
	SRP	0.17	0.13	0.09	0.03	0.15	0.11	0.06	0.18	0.07	0.07	0.09	0.18	0.01	0.05	0.03	0.16	0.08	0.01	0.41	0.07	0.00	0.00	0.02	0.16
	KRP	0.34	0.04	0.20	0.09	0.01	0.10	0.20	0.11	0.06	0.15	0.00	0.05	0.04	0.21	0.12	0.09	0.08	0.07	0.16	0.20	0.01	0.02	0.01	0.02
Wheat	RET	1.72	0.12	0.33	0.39	0.38	0.02	0.10	0.08	0.48	0.13	0.11	0.03	0.15	0.19	0.02	0.06	0.20	0.02	0.19	0.03	0.03	0.11	0.00	0.02
	VRP	0.11	0.74	0.01	0.08	0.07	0.44	0.08	0.02	0.13	0.50	0.07	0.11	0.00	0.26	0.01	0.18	0.22	1.66	0.01	0.12	0.08	0.72	0.16	0.00
	SRP	0.04	0.08	0.07	0.14	0.12	0.01	0.05	0.06	0.08	0.15	0.03	0.07	0.07	0.10	0.02	0.04	0.29	0.34	0.21	0.05	0.02	0.00	0.11	0.02
	KRP	0.02	0.11	0.05	0.03	0.16	0.00	0.34	0.27	0.07	0.03	0.13	0.02	0.03	0.10	0.24	0.10	0.10	0.10	0.05	0.14	0.01	0.03	0.12	0.12
Copper	RET	0.02	0.11	0.03	0.00	0.06	0.18	0.06	0.06	0.32	0.13	0.17	0.00	0.03	0.02	0.21	0.01	0.17	0.79	0.03	0.04	0.34	0.12	0.03	0.19
	VRP	0.09	0.21	0.11	0.25	0.33	0.42	0.14	0.04	0.27	0.01	0.23	0.07	0.13	0.15	0.08	0.05	0.04	0.68	0.05	0.17	0.14	0.27	0.03	0.17
	SRP	1.30	0.22	0.48	0.48	0.37	0.05	0.10	0.17	0.56	0.13	0.17	0.06	0.10	0.86	0.17	0.13	0.12	0.02	0.13	0.40	0.07	0.01	0.07	0.05
	KRP	0.22	0.11	0.28	0.30	0.25	0.04	0.20	0.07	0.46	0.21	0.20	0.02	0.08	0.15	0.07	0.11	0.52	0.06	0.02	0.09	0.44	0.01	0.08	0.07
Silver	RET	3.28	0.10	0.59	0.60	0.13	0.03	0.08	0.06	0.78	0.04	0.01	0.01	0.28	0.44	0.14	0.06	0.24	0.03	0.02	0.03	0.01	0.03	0.15	0.31
	VRP	0.00	1.01	0.01	0.05	0.01	0.96	0.08	0.13	0.48	0.34	0.03	0.09	0.08	0.39	0.06	0.14	0.22	1.35	0.19	0.53	0.58	1.27	0.26	0.16
	SRP	0.19	0.19	0.07	0.15	0.04	0.04	0.05	0.04	0.02	0.05	0.04	0.05	0.09	0.01	0.13	0.06	0.01	0.06	0.33	0.17	0.01	0.05	0.01	0.51
	KRP	0.22	0.14	0.17	0.18	0.03	0.06	0.06	0.09	0.00	0.07	0.13	0.10	0.03	0.12	0.12	0.11	0.04	0.07	0.29	0.12	0.13	0.12	0.10	0.60
Gold	RET	2.22	0.23	0.62	0.69	0.08	0.02	0.07	0.05	0.14	0.04	0.01	0.01	0.03	0.08	0.21	0.15	0.19	0.01	0.06	0.03	0.08	0.02	0.09	0.15
	VRP	0.02	0.92	0.04	0.13	0.03	1.47	0.01	0.00	0.23	1.99	0.21	0.02	0.08	6.35	0.22	0.19	0.21	3.59	0.05	0.37	0.08	3.22	0.01	0.10
	SRP	0.20	0.02	0.13	0.22	0.09	0.05	0.05	0.09	0.08	0.10	0.05	0.01	0.04	0.03	0.07	0.09	0.30	0.03	0.10	0.04	0.12	0.03	0.04	0.13
	KRP	0.11	0.03	0.11	0.14	0.13	0.01	0.04	0.09	0.16	0.22	0.03	0.02	0.02	0.14	0.03	0.08	0.23	0.04	0.12	0.05	0.09	0.04	0.04	0.12
Oil	RET	60.12	1.42	6.84	5.01	2.64	0.22	0.34	0.21	4.09	0.60	0.08	0.10	0.23	0.85	0.13	0.02	1.09	0.20	0.29	0.00	0.21	0.08	0.01	0.00
	VRP	1.76	75.37	0.95	0.01	0.28	1.39	0.02	0.02	0.84	3.84	0.29	0.05	0.03	3.35	0.05	0.05	0.11	4.55	0.03	0.08	0.05	1.02	0.01	0.06
	SRP	6.96	0.70	60.34	24.90	0.50	0.07	0.22	0.10	0.64	0.23	0.03	0.03	0.16	0.30	0.01	0.16	0.14	0.06	0.13	0.02	0.05	0.01	0.07	0.03
	KRP	5.18	0.07	25.83	62.19	0.17	0.12	0.10	0.03	0.36	0.09	0.09	0.03	0.08	0.15	0.04	0.31	0.06	0.02	0.17	0.05	0.01	0.01	0.08	0.03
Natural Gas	RET	3.28	0.27	0.55	0.22	74.81	0.11	8.02	7.80	0.31	0.14	0.05	0.01	0.19	0.04	0.20	0.11	0.10	0.01	0.09	0.01	0.24	0.00	0.06	0.06
	VRP	0.25	1.50	0.10	0.14	0.07	84.39	1.10	0.09	0.13	1.34	0.20	0.17	0.06	0.65	0.05	0.14	0.08	2.69	0.06	0.29	0.07	1.24	0.01	0.01
	SRP	0.33	0.04	0.27	0.10	5.80	0.70	54.08	36.03	0.10	0.14	0.24	0.05	0.03	0.01	0.11	0.12	0.03	0.05	0.05	0.02	0.04	0.06	0.02	0.02
	KRP	0.21	0.01	0.11	0.02	5.68	0.12	36.97	54.73	0.07	0.12	0.06	0.01	0.04	0.05	0.15	0.17	0.03	0.04	0.08	0.05	0.04	0.02	0.05	0.07
U.S.	RET	4.46	1.02	0.77	0.38	0.24	0.08	0.02	0.07	63.55	7.66	2.11	1.11	0.63	5.04	0.07	0.46	6.12	0.24	1.00	0.17	0.04	0.12	0.02	0.01
	VRP	0.67	2.56	0.18	0.04	0.11	0.77	0.19	0.19	6.54	53.27	2.99	0.60	1.09	12.26	0.08	0.22	2.97	8.26	0.39	0.09	0.43	1.31	0.02	0.10
	SRP	0.05	0.23	0.20	0.36	0.07	0.10	0.08	0.08	2.87	4.22	75.48	10.19	0.10	1.05	0.09	0.40	0.53	0.79	0.17	0.02	0.28	0.05	0.03	0.06
	KRP	0.12	0.05	0.04	0.03	0.00	0.12	0.07	0.07	1.34	0.88	10.20	76.24	0.23	0.29	0.31	4.92	1.19	0.21	0.03	0.06	0.05	0.11	0.42	1.05
U.K.	RET	0.18	0.07	0.11	0.06	0.04	0.06	0.03	0.01	1.01	2.10	0.12	0.08	78.59	3.62	0.02	0.05	8.83	1.29	0.56	0.14	0.29	0.05	0.00	0.09
	VRP	0.17	1.22	0.09	0.08	0.02	0.50	0.03	0.15	3.85	6.71	0.81	0.27	0.60	64.50	0.06	0.65	2.10	8.77	0.37	0.01	0.11	0.51	0.00	0.04
	SRP	0.10	0.13	0.08	0.06	0.15	0.09	0.14	0.15	0.08	0.09	0.20	0.35	0.75	0.04	90.05	0.96	0.24	0.01	2.65	0.11	0.42	0.17	0.13	0.18
	KRP	0.02	0.04	0.23	0.40	0.09	0.15	0.09	0.20	0.49	0.42	0.17	5.25	0.08	0.95	0.70	78.68	0.32	1.14	0.20	5.78	0.38	0.05	0.84	0.24
Germany	RET	1.00	0.11	0.15	0.03	0.07	0.07	0.06	0.05	5.53	3.27	0.42	0.94	5.91	8.29	0.02	0.23	55.97	5.52	7.16	0.63	0.26	0.02	0.02	0.04
	VRP	0.22	3.00	0.05	0.00	0.11	1.50	0.04	0.05	2.66	8.65	0.53	0.25	1.00	17.28	0.02	0.67	4.42	47.40	0.60	0.19	0.12	3.23	0.01	0.01
	SRP	0.29	0.04	0.16	0.18	0.04	0.11	0.11	0.06	1.11	0.64	0.21	0.05	1.23	2.42	1.33	0.36	8.94	1.02	69.93	8.46	0.05	0.12	0.06	0.04
	KRP	0.04	0.08	0.05	0.10	0.05	0.32	0.04	0.08	0.23	0.26	0.02	0.06	0.15	0.67	0.06	2.01	0.96	0.52	9.58	78.66	0.19	0.31	0.04	0.04
Japan	RET	0.29	0.10	0.13	0.12	0.46	0.08	0.09	0.07	1.81	0.87	0.24	0.08	1.62	3.24	0.24	0.47	1.71	0.20	0.11	0.22	83.36	0.19	0.94	0.01
	VRP	0.13	1.15	0.12	0.04	0.00	0.97	0.08	0.02	2.71	4.56	0.43	0.16	0.43	5.00	0.17	0.15	3.49	6.00	0.66	0.29	0.60	64.73	1.04	0.60
	SRP	0.01	0.01	0.09	0.12	0.05	0.05	0.02	0.01	0.07	0.09	0.03	0.50	0.13	0.05	0.01	1.27	0.05	0.03	0.06	0.05	0.98	1.53	89.52	3.04
	KRP	0.00	0.06	0.16	0.28	0.14	0.11	0.18	0.40	0.02	0.13	0.20	1.10	0.44	0.30	5.50	10.16	0.14	0.50	1.21	1.47	0.37	0.64	2.40	69.00

Note: This table presents the full sample connectedness between risk premia (namely, volatility risk premium (VRP), skewness risk premium (SRP), and kurtosis risk premium (KRP)) and returns (RET) of the commodity (i.e., corn, soybeans, wheat, copper, silver, gold, oil, and natural gas) and stock markets (i.e., the U.S., U.K., German, and Japanese markets). We use the approach of Diebold and Yilmaz (2012, 2014) and compute the connectedness matrix using a forecast horizon of ten trading days. The connectedness matrix captures the share of variance of commodity and stock markets' risk premium and return that is due to their own and other shocks.

Table 3: Aggregate Connectedness between Commodity and Stock Markets

		Grains			Metals			Energy		Stocks			
To\From		Corn	Soybeans	Wheat	Copper	Silver	Gold	Oil	Natural Gas	U.S.	U.K.	Germany	Japan
Grains	Corn	84.32	4.67	6.13	0.29	0.72	0.76	0.88	0.71	0.46	0.36	0.29	0.41
	Soybeans	5.26	86.08	3.58	0.43	0.63	0.48	0.99	0.53	0.47	0.46	0.84	0.26
	Wheat	6.47	3.12	84.93	0.35	0.61	0.71	1.01	0.55	0.53	0.40	0.93	0.39
Metals	Copper	0.51	0.44	0.32	93.06	0.62	0.68	1.05	0.63	0.75	0.59	0.84	0.52
	Silver	0.58	0.35	0.47	0.43	79.03	13.81	1.74	0.47	0.56	0.57	0.93	1.07
	Gold	0.58	0.40	0.53	0.33	13.74	77.18	1.45	0.57	0.83	1.95	1.36	1.09
Energy	Oil	0.92	0.85	0.97	0.81	2.06	1.85	84.41	1.62	2.85	1.48	1.75	0.43
	Natural Gas	0.50	0.36	0.40	0.54	0.35	0.65	1.85	92.63	0.79	0.53	0.92	0.51
Stocks	U.S.	0.46	0.41	0.48	0.47	0.59	1.02	2.79	0.57	79.81	6.81	5.56	1.03
	U.K.	0.41	0.50	0.35	0.38	0.61	1.96	0.76	0.47	5.50	80.08	8.13	0.87
	Germany	0.33	0.75	0.67	0.55	1.01	1.89	1.38	0.69	6.20	10.41	74.99	1.14
	Japan	0.75	0.56	0.59	0.55	0.68	1.16	0.70	0.69	3.25	7.30	4.04	79.74

Note: This table presents the aggregate connectedness between commodity (i.e., corn, soybeans, wheat, copper, silver, gold, oil, and natural gas) and stock markets (i.e., the U.S., U.K., German, and Japanese markets). We use the block aggregation approach of Greenwood-Nimmo et al. (2015) that relies on the connectedness matrix of Diebold and Yilmaz (2012, 2014). The aggregate connectedness matrix captures the share of variance of the commodity and stock markets that is due to their own and other shocks. The variance decompositions are estimated using a forecast horizon of ten trading days.

Table 4: Total Aggregate Connectedness between Commodity and Stock Markets

To\From	Grains	Metals	Energy	Stocks
Grains	94.85	1.66	1.56	1.93
Metals	1.39	92.96	1.97	3.68
Energy	2.00	3.12	90.25	4.63
Stocks	1.57	2.71	2.01	93.72

Note: This table presents the total aggregate connectedness between commodity (i.e., grain, metal, and energy sectors) and stock market. We use the block aggregation approach of Greenwood-Nimmo et al. (2015) that relies on the connectedness matrix of Diebold and Yilmaz (2012, 2014). The aggregate connectedness matrix captures the share of variance of the commodity and stock markets that is due to their own and other shocks. The variance decompositions are estimated using a forecast horizon of ten trading days.

Table 5: Aggregate Connectedness between Risk Premia and Returns

		Grains				Metals				Energy				Stocks			
To\From		RET	VRP	SRP	KRP	RET	VRP	SRP	KRP	RET	VRP	SRP	KRP	RET	VRP	SRP	KRP
Grains	RET	84.80	0.14	4.16	4.16	1.53	0.14	0.21	0.15	2.34	0.10	0.26	0.29	0.81	0.49	0.28	0.15
	VRP	0.30	90.02	0.42	2.25	0.38	1.33	0.27	0.39	0.18	0.93	0.12	0.15	0.35	2.16	0.32	0.43
	SRP	5.27	0.39	78.02	13.03	0.33	0.19	0.23	0.35	0.21	0.14	0.25	0.21	0.25	0.27	0.51	0.34
	KRP	5.24	1.92	12.79	76.52	0.24	0.29	0.34	0.27	0.24	0.14	0.41	0.24	0.27	0.34	0.36	0.39
Metals	RET	1.40	0.18	0.23	0.20	84.70	0.26	3.19	4.56	1.93	0.22	0.48	0.49	0.87	0.58	0.38	0.33
	VRP	0.19	1.14	0.16	0.27	0.40	85.07	0.31	1.76	0.16	1.66	0.13	0.20	0.85	6.54	0.48	0.69
	SRP	0.25	0.13	0.34	0.17	3.62	0.17	68.08	23.66	0.73	0.19	0.29	0.38	0.50	0.46	0.44	0.57
	KRP	0.11	0.31	0.25	0.22	4.70	1.48	22.53	67.33	0.32	0.13	0.29	0.29	0.74	0.42	0.40	0.49
Energy	RET	3.54	0.17	0.20	0.24	3.48	0.29	0.81	0.53	70.42	1.01	7.88	6.62	3.23	0.96	0.45	0.16
	VRP	0.39	1.12	0.18	0.16	0.43	2.69	0.31	0.19	1.19	81.32	1.09	0.13	0.69	9.35	0.35	0.42
	SRP	0.37	0.23	0.12	0.19	0.88	0.24	0.41	0.39	6.80	0.76	57.46	30.57	0.60	0.43	0.33	0.23
	KRP	0.43	0.24	0.29	0.11	0.87	0.30	0.38	0.31	5.62	0.16	31.51	58.49	0.34	0.25	0.35	0.36
Stocks	RET	0.69	0.22	0.22	0.18	0.53	0.98	0.33	0.55	1.69	0.40	0.34	0.20	78.81	10.43	3.26	1.18
	VRP	0.31	1.14	0.16	0.21	0.42	4.32	0.11	0.19	0.36	2.92	0.20	0.14	8.28	78.11	2.05	1.08
	SRP	0.32	0.27	0.39	0.28	0.25	0.42	0.34	0.35	0.19	0.19	0.22	0.26	4.45	3.08	82.49	6.51
	KRP	0.32	0.54	0.41	0.61	0.32	0.51	0.68	0.54	0.12	0.23	0.21	0.39	1.65	1.84	7.97	83.68

Note: This table presents the aggregate connectedness between risk premia (i.e., volatility risk premium (VRP), skewness risk premium (SRP), and kurtosis risk premium (KRP)), and returns (RET) of the commodity (i.e., grain, metal, and energy sectors) and equity markets. We use the block aggregation approach of Greenwood-Nimmo et al. (2015) that relies on the connectedness matrix of Diebold and Yilmaz (2012, 2014). The aggregate connectedness matrix captures the share of variance of the risk premia and returns that is due to their own and other shocks. The variance decompositions are estimated using a forecast horizon of ten trading days.

Table 6: Total Aggregate Connectedness between Risk Premia and Returns

To\From	RET	VRP	SRP	KRP
RET	85.28	4.94	5.24	4.55
VRP	4.28	91.79	1.71	2.22
SRP	5.97	2.08	74.58	17.37
KRP	4.98	2.46	17.85	74.72

Note: This table presents the aggregate connectedness between risk premia (i.e., volatility risk premium (VRP), skewness risk premium (SRP), and kurtosis risk premium (KRP)), and returns (RET). We use the block aggregation approach of Greenwood-Nimmo et al. (2015) that relies on the connectedness matrix of Diebold and Yilmaz (2012, 2014). The aggregate connectedness matrix captures the share of variance of the risk premia and returns that is due to their own and other shocks. The variance decompositions are estimated using a forecast horizon of ten trading days.

Table 7: Relationship to Various Factors, Returns and Risk Premia

		Connectedness among markets	Connectedness between risk premia and returns
Panel A: Various factors			
	Credit spread	-0.310^{***}	-0.126^{***}
		(-5.19)	(-2.80)
	Ted spread	0.047^{**}	0.041^{**}
		(1.97)	(2.16)
	ADS	-0.050	-0.119^{*}
		(-0.62)	(-1.90)
	EPU	58.98^{***}	-19.35^{***}
		(9.74)	(-3.09)
Panel B: Returns			
Commodity	EW Commodity	-0.0003	0.0001
		(-1.07)	(0.48)
	Corn	-0.0015^{***}	0.0004
		(-2.53)	(0.60)
	Soybeans	-0.0011^{***}	-0.00001
		(-2.33)	(-0.01)
	Wheat	-0.0017^{**}	0.0008
		(-2.09)	(1.06)
	Copper	0.0001	0.0002
		(0.26)	(0.42)
	Silver	0.0005	-0.0001
		(0.85)	(-0.21)
	Gold	0.0002	-0.0002
		(0.54)	(-0.47)
	Oil	0.0009	0.0003
		(1.50)	(0.55)
	Natural Gas	0.0003	-0.0004
		(0.39)	(-0.57)

(continued)

Table 7 (continued): Relationship to Various Factors, Returns and Risk Premia

		Connectedness among markets	Connectedness between risk premia and returns
Panel B: Returns			
Equity	EW Equity	0.0003	−0.0001
		(1.17)	(−0.27)
	U.S.	0.0001	0.00001
		(0.47)	(0.02)
	U.K.	0.0005*	−0.0001
		(1.84)	(−0.34)
	Germany	0.0006	−0.0001
		(1.12)	(−0.13)
	Japan	−0.0001	−0.0001
		(−0.18)	(−0.30)
Panel C: Risk premia			
VRP	EW Commodity	0.0015***	−0.0004
		(5.31)	(−1.43)
	Corn	−0.0001	−0.0019***
		(−0.19)	(−2.64)
	Soybeans	0.0012***	−0.0017***
		(2.80)	(−4.28)
	Wheat	−0.0007	−0.0030***
		(−1.15)	(−5.19)
	Copper	0.0087***	0.0025**
		(7.10)	(2.08)
	Silver	0.0008***	0.0001
		(2.39)	(0.34)
	Gold	0.00001	0.0003*
		(0.06)	(1.87)
	Oil	0.0022***	0.00002
		(6.21)	(0.07)
	Natural Gas	−0.0002	0.0004
		(−0.36)	(0.82)

(continued)

Table 7 (continued): Relationship to Various Factors, Returns and Risk Premia

		Connectedness among markets	Connectedness between risk premia and returns
Panel C: Risk premia			
VRP	EW Equity	0.0009***	0.0003
		(4.36)	(1.46)
	U.S.	0.0017***	0.0004
		(5.25)	(1.18)
	U.K.	0.0009***	0.0002
		(3.94)	(1.03)
	Germany	0.0001	−0.0005**
		(0.47)	(−2.20)
	Japan	0.0007***	0.0011***
		(2.59)	(3.85)
SRP	EW Commodity	0.0315***	0.0200*
		(2.76)	(1.77)
	Corn	−0.0286	0.0541*
		(−0.97)	(1.77)
	Soybeans	0.1050***	0.0437*
		(3.96)	(1.72)
	Wheat	0.0713***	−0.019
		(2.56)	(−0.68)
	Copper	−0.0485	0.0436
		(−1.36)	(1.23)
	Silver	0.0269	−0.0063
		(1.25)	(−0.3)
	Gold	0.0404	0.0544***
		(1.58)	(2.12)
	Oil	0.0658***	0.0069
		(4.51)	(0.48)
	Natural Gas	0.0195	−0.0177
		(1.46)	(−1.38)

(continued)

Table 7 (continued): Relationship to Various Factors, Returns and Risk Premia

		Connectedness among markets	Connectedness between risk premia and returns
Panel C: Risk premia			
SRP	EW Equity	0.0130	−0.0245***
		(1.51)	(−2.87)
	U.S.	0.0884***	−0.0257*
		(6.15)	(−1.79)
	U.K.	0.0097	−0.0261**
		(0.72)	(−2.00)
	Germany	−0.0281*	0.0114
		(−1.90)	(0.81)
	Japan	−0.0182	−0.0578***
		(−1.06)	(−3.30)
KRP	EW Commodity	0.0353***	−0.0293***
		(4.43)	(−3.61)
	Corn	0.035	−0.0085
		(1.42)	(−0.34)
	Soybeans	0.0672***	−0.0257
		(3.67)	(−1.44)
	Wheat	0.0477**	−0.0038
		(2.02)	(−0.16)
	Copper	−0.0359	−0.1083***
		(−1.48)	(−4.21)
	Silver	0.0873***	−0.0293
		(4.44)	(−1.51)
	Gold	0.0445*	0.0116
		(1.93)	(0.51)
	Oil	0.0431***	−0.0366***
		(3.91)	(−3.29)
	Natural Gas	−0.0062	−0.0334***
		(−0.49)	(−2.79)

(continued)

Table 7 (continued): Relationship to Various Factors, Returns and Risk Premia

		Connectedness among markets	Connectedness between risk premia and returns
Panel C: Risk premia			
KRP	EW Equity	−0.0246	−0.0069
		(−1.09)	(−0.31)
	U.S.	-0.0711^{***}	−0.0106
		(−2.78)	(−0.42)
	U.K.	0.015	−0.0102
		(0.48)	(−0.34)
	Germany	0.0211	0.0094
		(0.95)	(0.43)
	Japan	−0.0632	−0.0161
		(−1.06)	(−0.28)

Note: This table shows the relationship of connectedness measures with the macroeconomic, financial, and risk premium factors. That is, it displays the individual regressions of each of these factors on a constant and each of the high dummies of the aggregate connectedness among markets and aggregate connectedness between risk premia and returns. Panel A presents the results for the macroeconomic and financial factors, namely, credit spread, TED spread, Aruoba, Diebold and Scotti (2009) business conditions index (ADS), and economic policy uncertainty index (EPU). Panel B presents the results for the risk premium factors (i.e., the volatility risk premium (VRP), skewness risk premium (SRP), and kurtosis risk premium (KRP)) of the U.S., U.K., German and Japanese stock markets. In addition, we compute an equally weighted variable (EW) for each of the risk premia and markets (i.e., a separate EW portfolio for commodity and equity markets). ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 8: Portfolio Return Statistics using Aggregate Connectedness

Criteria	Mean	Std. Dev.	Skew.	Kurt.	Sharpe	t-stat<>0
Panel A: Aggregate connectedness among markets						
Returns	13.24%	13.30%	−0.03	4	0.99	2.24**
VRP	−5.02%	15.06%	−0.12	4.47	−0.33	−0.86
SRP	−1.00%	13.81%	0.17	4.75	−0.07	−0.16
KRP	4.22%	12.34%	0.12	5.42	0.34	0.79
EW	−2.10%	6.91%	−0.14	5.1	−0.3	−0.71
Panel B: Aggregate connectedness between risk premia and returns						
Returns	1.28%	14.98%	0.19	4.49	0.09	0.2
VRP	−3.38%	15.04%	−0.56	6.07	−0.23	−0.52
SRP	10.00%	12.07%	0.18	5.21	0.83	1.87*
KRP	−1.03%	12.19%	−0.3	5.24	−0.08	−0.19
EW	−2.10%	6.91%	−0.14	5.1	−0.3	−0.71
Panel C: Aggregate connectedness to returns						
Returns	-2.81%	15.72%	0.3	4.32	-0.18	-0.37
VRP	11.61%	15.00%	0.06	4.53	0.77	1.67*
SRP	7.51%	13.10%	0.01	4.09	0.57	1.26
KRP	13.49%	12.93%	-0.1	4.96	1.04	2.51***
EW	-2.10%	6.91%	-0.14	5.1	-0.3	-0.71
Panel D: Aggregate connectedness to risk premia						
Returns	-0.90%	14.37%	0.02	3.92	-0.06	-0.15
VRP	-4.72%	15.37%	-0.53	5.86	-0.31	-0.7
SRP	10.35%	12.75%	0.16	4.8	0.81	1.87*
KRP	-1.98%	11.61%	-0.26	5.42	-0.17	-0.4
EW	-2.10%	6.91%	-0.14	5.1	-0.3	-0.71

Note: This table presents the portfolio return statistics (mean, standard deviation, skewness, kurtosis and Sharpe ratio) using the aggregate connectedness measures. That is, based on the reaction of returns and individual risk premia (i.e., volatility risk premium (VRP), skewness risk premium (SRP) and kurtosis risk premium (KRP)) for each of our commodity and stock markets to these connectedness measures. In addition, we consider the sensitivity of an equal-weighted (EW) variable to the connectedness measures. Panels A and B use the aggregate connectedness among markets and aggregate connectedness between risk premia and returns. These measures are computed as the mean of $from$ spillovers from Figures 1 and 2, respectively. Panels C and D use the aggregate connectedness to returns (i.e., the $from$ spillovers to returns from Panel A of Figure 2) and aggregate connectedness to risk premia (i.e., the mean of $from$ spillovers to risk premia from Panels B, C and D of Figure 2). We use the block aggregation approach of Greenwood-Nimmo et al. (2015) that relies on the connectedness matrix of Diebold and Yilmaz (2012, 2014). The aggregate connectedness matrix captures the share of variance of the commodity and stock markets that is due to their own and other shocks. The variance decompositions are estimated using a forecast horizon of ten trading days and our portfolios use a one month holding period.

Table 9: Change in Cross-Equity Spillovers around Events

		Spillover from equity market to		
		Grain sector	Metal sector	Energy sector
Panel A: Expansionary announcements				
	Pre	9.76	10.11	11.94
All	Post	9.70	10.14	11.87
	Diff	−0.05	0.03	−0.06
		(−0.69)	(0.33)	(−0.65)
	Pre	9.73	10.74	12.17
From 2009 to 2012	Post	9.67	10.97	12.36
	Diff	−0.07	0.24***	0.19**
		(−1.18)	(3.33)	(2.15)
	Pre	9.77	9.62	11.76
Others	Post	9.73	9.48	11.50
	Diff	−0.05	−0.14*	−0.26***
		(−0.48)	(−1.74)	(−2.45)
Panel B: Contractionary announcements				
	Pre	10.11	9.56	10.34
	Post	10.13	9.58	10.27
	Diff	0.02	0.02	−0.07
		(0.26)	(0.22)	(−0.60)
Panel C: Political announcements				
	Pre	9.25	9.24	11.69
	Post	9.97	10.47	12.64
	Diff	0.72***	1.23***	0.95***
		(7.60)	(8.52)	(6.47)

Note: This table presents the change in cross-equity spillover to each of the commodity sectors (namely, grain, metal and energy sectors), from right panels of Figure 1. Panels A, B and C show the effects of expansionary, contractionary, and political announcements, respectively. We report the change in spillovers, i.e., the difference between one month after (post) and prior (pre) to the pooled announcements from Appendix A.3. The numbers in parentheses are t-statistics. ***, ** and * denote significance at 1%, 5% and 10% levels.

Table 10: Change in Cross-Return Spillovers around Events

		Spillover from returns to		
		VRP	SRP	KRP
Panel A: Expansionary announcements				
	Pre	11.40	10.59	10.06
All	Post	11.70	10.41	9.77
	Diff	0.30***	−0.17***	−0.29***
		(3.68)	(−2.55)	(−3.44)
	Pre	11.45	11.62	11.43
From 2009 to 2012	Post	12.03	11.53	11.27
	Diff	0.58***	−0.08	−0.16***
		(6.54)	(−1.34)	(−2.93)
	Pre	11.36	9.78	8.99
Others	Post	11.44	9.54	8.60
	Diff	0.08	−0.24***	−0.39***
		(1.06)	(−3.39)	(−3.84)
Panel B: Contractionary announcements				
	Pre	11.38	10.57	9.85
	Post	11.28	10.84	9.98
	Diff	−0.09	0.27***	0.13***
		(−1.19)	(3.72)	(1.80)
Panel C: Political announcements				
	Pre	10.72	10.22	9.77
	Post	10.31	10.38	10.45
	Diff	−0.40***	0.15***	0.68***
		(−7.83)	(3.24)	(9.44)

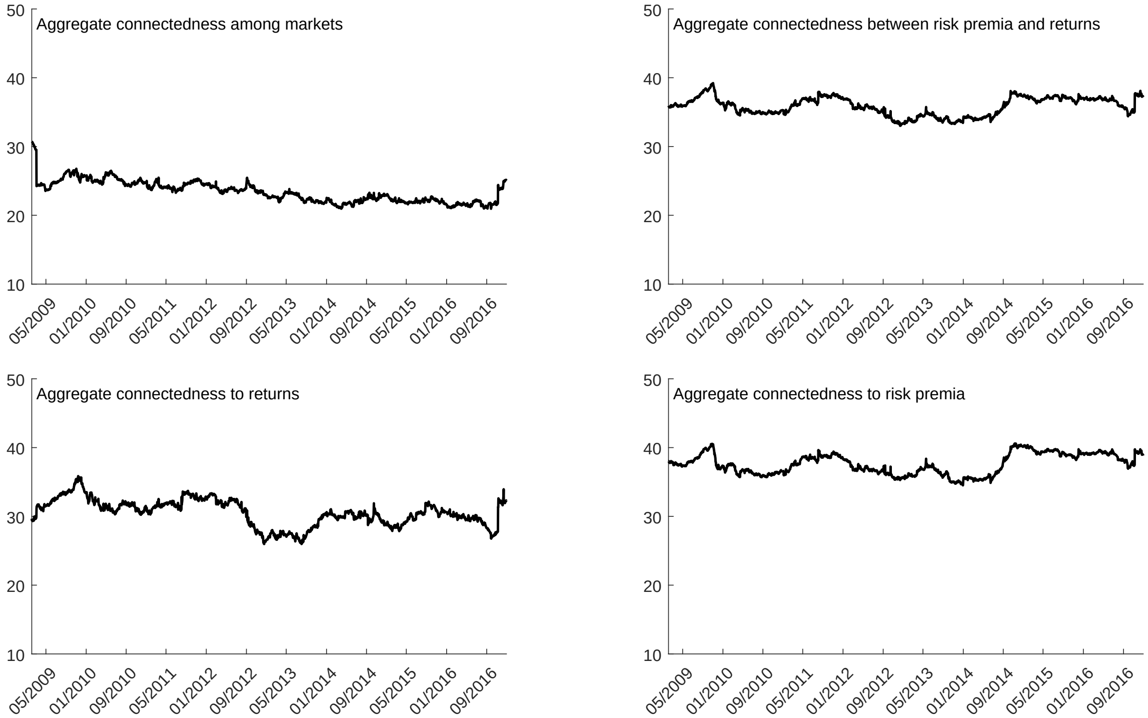
Note: This table presents the change in the cross-return spillover to each of the risk premia (namely, volatility risk premium (VRP), skewness risk premium (SRP), and kurtosis risk premium (KRP)), from right panels of Figure 2. Panels A, B and C show the effects of expansionary, contractionary, and political announcements, respectively. We report the change in spillovers, i.e., the difference between one month after (post) and prior (pre) to the pooled announcements from Appendix A.3. The numbers in parentheses are t-statistics. ***, ** and * denote significance at 1%, 5% and 10% levels.

Table 11: Change in Cross-Risk Premium Spillovers around Events

		Spillover from risk premia to returns		
		VRP to returns	SRP to returns	KRP to returns
Panel A: Expansionary announcements				
	Pre	10.68	10.13	9.95
All	Post	10.76	9.89	9.54
	Diff	0.07	-0.24^{***}	-0.40^{***}
		(1.02)	(−4.19)	(−5.18)
	Pre	11.01	10.88	10.68
From 2009 to 2012	Post	11.25	10.63	10.40
	Diff	0.24^{***}	-0.25^{***}	-0.28^{***}
		(4.06)	(−4.73)	(−4.83)
	Pre	10.43	9.54	9.38
Others	Post	10.38	9.32	8.88
	Diff	−0.05	-0.22^{***}	-0.50^{***}
		(−0.64)	(−3.81)	(−5.52)
Panel B: Contractionary announcements				
	Pre	9.38	9.76	10.31
	Post	9.35	10.12	10.18
	Diff	−0.03	0.36^{***}	−0.13
		(−0.63)	(5.25)	(−1.59)
Panel C: Political announcements				
	Pre	8.99	9.75	10.21
	Post	8.99	10.48	11.20
	Diff	0.00	0.73^{***}	0.99^{***}
		(−0.10)	(13.10)	(12.02)

Note: This table presents the change in cross-risk premium spillover (namely, volatility risk premium (VRP), skewness risk premium (SRP), and kurtosis risk premium (KRP)), to returns (RET), from Panel A of Figure 2. Panels A, B and C show the effects of expansionary, contractionary, and political announcements, respectively. We report the change in spillovers, i.e., the difference between one month after (post) and prior (pre) to the pooled announcements from Appendix A.3. The numbers in parentheses are t-statistics. ***, ** and * denote significance at 1%, 5% and 10% levels.

Appendix A.1: Time-varying Aggregate Risk Premium Connectedness



Note: This figure shows the time-varying aggregate connectedness among markets and aggregate connectedness between risk premia and returns. The aggregate risk premium connectedness among markets is computed as the mean of *from* spillovers from Figure 1. Aggregate risk premium connectedness between risk premia and returns is computed as the mean of *from* spillovers from Figure 2. Aggregate connectedness to returns is the *from* spillover from Panel A of Figure 2. Finally, the aggregate connectedness to risk premia is defined as the mean of *from* spillovers from Panels B, C and D of Figure 2. We use the block aggregation approach of Greenwood-Nimmo et al. (2015) that relies on the connectedness matrix of Diebold and Yilmaz (2012, 2014). The variance decompositions are estimated using a forecast horizon of ten trading days.

Appendix A.2: Portfolio Return Statistics using Aggregate Connectedness to Commodity Markets

Criteria	Mean	Std. Dev.	Skew.	Kurt.	Sharpe	t-stat<>0
Returns	6.74%	13.69%	0.05	4.74	0.49	1.14
VRP	−3.80%	13.76%	−0.16	4.39	−0.28	−0.65
SRP	4.04%	13.45%	0.22	4.66	0.3	0.74
KRP	7.54%	13.01%	0.07	5.91	0.58	1.32
EW	−2.10%	6.91%	−0.14	5.1	−0.3	−0.71

Note: This table presents the portfolio return statistics (mean, standard deviation, skewness, kurtosis and Sharpe ratio) using the aggregate connectedness to commodity markets. That is, based on the reaction of returns and individual risk premia for each of our commodity and stock markets to the aggregate spillovers $from$ equity markets to commodity markets. In other words, we consider mean of $from$ spillovers from Panels A, B and C of Figure 1. We use the block aggregation approach of Greenwood-Nimmo et al. (2015) that relies on the connectedness matrix of Diebold and Yilmaz (2012, 2014). The aggregate connectedness matrix captures the share of variance of the commodity and stock markets that is due to their own and other shocks. The variance decompositions are estimated using a forecast horizon of ten trading days and our portfolios use a one month holding period.

Appendix A.3: Equity Announcements

Panel A: Expansionary announcements - 2009 to 2012
FOMC-QE 2-November 3, 2010
FOMC-Maturity extension (Operation Twist)-September 21, 2011
FOMC-Maturity extension (Operation Twist)-June 20, 2012
ECB-Covered bond purchase program (CBPP1)-July 2, 2009
ECB-Securities Markets Program (SMP)- May 10, 2010
ECB-Covered bond purchase program (CBPP2)-November 3, 2011
ECB-Installment of the QE-July 11, 2012
BoE-QE 2-October 6, 2011
Panel B: Expansionary announcements - other
FOMC-QE 3-September 13, 2012
FOMC-Extension of the QE 3-December 12, 2012
ECB-Outright Monetary Transactions (OMT)-September 6, 2012
ECB-Asset-backed securities purchase program (ABSPP)-November 21, 2014
ECB-Public sector purchase program (PSPP)-March 9, 2015
ECB-Corporate sector purchase program (CSPP)-June 8, 2016
BoJ-Quantitative and qualitative easing-April 3, 2013
BoJ-Launch of an additional QE-September 21, 2016
Panel C: Contractionary announcements
Taper tantrum-May 22, 2013
FOMC's Monetary policy normalization-September 17, 2014
Fed increases interest rates-December 16, 2015
Bund tantrum-May 7, 2015
ECB-Mario Draghi's announcement-December 3, 2015
Panel D: Political events
The U.K. European Union Referendum Act of 2015-May 28, 2015
The U.K. referendum-June 23, 2016
The U.S. presidential election-November 7, 2016

Note: This table presents the mainly unconventional monetary policy announcements from the Federal Open Market Committee (FOMC), European Central Bank (ECB), Bank of England (BoE) and the Bank of Japan (BoJ). It also reports several political events.

Appendix A.4: Change in Aggregate Connectedness to Returns and Risk Premia around Events

		Aggregate connectedness to returns	Aggregate connectedness to risk premia
Panel A: Expansionary announcements			
	Pre	30.76	37.65
All	Post	30.19	37.64
	Diff	-0.57^{***}	0.01
		(-6.02)	(-0.05)
	Pre	32.57	37.73
From 2009 to 2012	Post	32.28	37.83
	Diff	-0.29^{***}	0.10
		(-3.63)	(1.62)
	Pre	29.35	37.58
Others	Post	28.57	37.50
	Diff	-0.78^{***}	-0.08
		(-7.55)	(-1.33)
Panel B: Contractionary announcements			
	Pre	29.45	38.29
	Post	29.65	38.85
	Diff	0.20	0.56^{***}
		(1.60)	(4.96)
Panel C: Political announcements			
	Pre	28.95	38.73
	Post	30.67	39.33
	Diff	1.72^{***}	0.60^{***}
		(12.39)	(7.65)

Note: This table presents the change in aggregate connectedness to returns and risk premia from Appendix A.1. Aggregate connectedness to returns is the *from* spillover from Panel A of Figure 2. The aggregate connectedness to risk premia is defined as the mean of *from* spillovers from Panels B, C and D of Figure 2. Panels A, B and C show the effects of expansionary, contractionary and political announcements, respectively. We report the change in connectedness measures, i.e., the difference between one month after (post) and prior (pre) to the pooled announcements from Appendix A.3. The numbers in parentheses are t-statistics. ***, ** and * denote significance at 1%, 5% and 10% levels.