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Abstract

We examine the connectedness in the energy commodities sector and the Russian stock market over the period 2005-2020 using the variance decomposition approach. Our analysis identifies the booms and busts in the correspondence of political and war episodes that are related to spillover effects in the Russian economy, as well as the energy commodities markets. Our findings show that the Russian Oil & Gas and Metals & Mining sectors are net shock contributors of crude oil and have the highest spillovers to other Russian sectors. Furthermore, we disentangle the sources of spillovers that originated from the financial and energy commodity markets and find that a positive change in the energy commodity volatility spillover is associated with an increase in Russian geopolitical uncertainty. Finally, we show that the spread of COVID-19 increases the stock market volatility spillover, whereas it lowers the energy commodity volatility spillover.

Keywords: Spillover Effects, Russian Stock Market, Russian Sectoral Indices, Commodity Markets, International Financial Markets.
JEL classification: C3, C58, E44, G1.

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1 Introduction

Russia represents a major worldwide exporter of crude oil, natural gas, gold and coal. In 2019, the export of these energy commodities amounted to $123 billion (crude oil), $66.2 billion (refined oil products), $24.55 billion (natural gas) and $ 22.09 billion (coal). Russia is the world's third-largest producer of crude oil with an estimated 10 million barrels per day and a share of the world total equal to 11%.[1] Energy commodities are the main drivers of the Russian economy with the Oil & Gas and Metals & Mining sectors representing 42% and 24% of the total stock market capitalisation in December 2020, respectively. Energy exports play a central role in the Russian economy making it vulnerable to price fluctuations and shocks in the commodity markets (e.g., see World Bank, 2018).

The Russian economy is highly engaged in international trade. In 2019, the Russian trade of goods and services with the rest of the world amounted to $674 billion, where almost 50% of such trade involved China, Europe and the United States (United Nations, 2020). The country is considerably exposed to the trade activity of its partners, not only in terms of imports (i.e., machines, automotive and chemicals) and exports (i.e., energy commodities), but also in terms of capital flow restrictions. For instance, Gurvich and Prilepskiy (2015) has found that Western financial sanctions during the period 2014-2017 directly affected Russian state-controlled banks, oil and gas companies. In addition, it had indirect effects on non-sanctioned firms by reducing foreign direct investments.

Several studies have highlighted that Russia is an important player at the geopolitical level. According to Caldara and Iacoviello (2018) and Davis (2016), economic and political crisis, as well as war events that originated in Russia, are linked with episodes of economic uncertainty (e.g., the annexation of Crimea followed by the international sanctions and the Russian financial crisis of 2015). Our study takes a further step in this direction and shows that these events are intertwined with international financial and

[1] Export data have been taken from `https://oec.world/en/profile/country/rus`. *Source*: The Observatory of Economic Complexity (OEC). Crude oil production data have been taken from `https://www.eia.gov/tools/faqs/faq.php?id=709&t=6`. *Source:* International Energy Statistics.

economic crises as well as with the shocks in the commodity markets.

With respect to the previous literature, we contribute in different ways. Firstly, we measure the spillover effects in the Russian stock market, energy commodities and its main trading partners (China, EU and US) caused by shocks in returns and volatility. Secondly, we analyse the importance of the main Russian industrial sectors in terms of shock propagation to international and commodity markets. In particular, we assess the effects that strategic Russian industries, such as Oil & Gas and Metals & Mining, have on major energy commodities. Thirdly, we disentangle the sources of the spillover that originated from the stock and energy commodity markets and find a direct effect of Russian and global geopolitical events on energy commodity volatility spillovers.

We make use of the variance decomposition approach proposed by Diebold and Yilmaz (2009, 2012) which allows us to measure the dynamics and the intensity of the shock transmission. The connectedness across different types of markets and industries represents a central focus in the role of supervision carried out by central banks and the measurement of risk for institutional investors. We consider the period from January 2005 to December 2020 at weekly frequency, which encompasses major recent economic and financial crises, as well as political and war upheavals that affected the Russian economy. The sample also includes the recent crises caused by the outbreak of the COVID-19 pandemic.

Our findings show that the Russian Oil & Gas sector is a net contributor in terms of spillovers that affect crude oil, both in return and volatility. Moreover, we find that the Oil & Gas and Metals & Mining sectors affect gold. Those industries also have the highest spillovers in terms of returns and volatility impacting other Russian sectors. As expected, the Russian market is highly interdependent with the international financial markets.

Through spillover indicators, we identify the booms and busts which occurred in the financial and commodities markets, as well as the political and war episodes that affected the Russian economy. Our findings show that there are both country-specific and international events that provoked spillover in both returns and volatility. In terms of Russian-specific events, we identify: (i) the Russian and Belarus energy disputes in 2007; (ii) the Russian and Ukrainian disputes in 2008-2009; (iii) the Russian industrial crisis in 2013; (iv) the annexation of Crimea by the Russian Federation with the first and second rounds of international sanctions in 2014; (v) the Russian financial crisis in 2015; and (vi) the third round of sanctions against Russia in response to the Annexation of Crimea in 2017. International events involve: (i) the Global Financial Crisis; (ii) the European Debt crisis; and (iii) the oil price plunge in 2015-2016. We also identify large increases in both return and volatility spillovers corresponding with the recent outbreak of the COVID-19 pandemic.

Our analysis assesses the dynamic net contribution of the Oil & Gas and Metals & Mining sectors towards the other variables of interest. Overall, we find that the Oil & Gas net spillover indexes, for both returns and volatility, increase in correspondence with well-identified episodes of the full spillover indexes. These entail the Russian and Belarus energy disputes, the Global Financial Crisis and the first round of international sanctions imposed by the US and the EU. Moreover, we identify one major peak in the net volatility spillover index for the Oil & Gas sector coinciding with the second round of sanctions on Russia imposed by the EU and the US in response to the annexation of Crimea. On the other hand, the increases in Metals & Mining net spillover indexes for both returns and volatility are mainly associated with specific shocks affecting this industry. Interestingly, we find that both the Oil & Gas and Metals & Mining sectors are net shock receivers during the spread of the COVID-19 pandemic.

Finally, we measure the relationship between the estimated rolling spillover indexes and Russian geopolitical uncertainty. We distinguish between local and global events and also include relevant factors, such as the economic and policy uncertainty and the market uncertainty that originated during the COVID-19 pandemic. In this regard, we consider the spillovers that stem from the stock market and the commodity market. Our findings indicate that the variation in the Russian geopolitical uncertainty has a positive impact on the changes in the energy commodity volatility spillover. This confirms that Russian political crises and war episodes influence the spillover mechanism of those commodities in terms of risk. Interestingly, we find that the COVID-19 pandemic has increased the market volatility spillover, whereas it has lowered the commodity spillover. This asymmetry is due to the economic consequence of the pandemic that has triggered the volatility spillover mechanism of the stock markets, which represents a leading indicator for the current and future expectations of the state of the economy.

We believe that our findings provide interesting implications for portfolio risk managers and policymakers. Portfolio risk managers are interested in understanding the drivers of return and volatility spillovers to properly manage the impact of geopolitical uncertainty on the riskiness of their portfolios. Accurate knowledge of return and volatility spillovers between the Russian financial market and the energy commodities during economic and political crises, as well as war events – which are associated with high financial spillover – represents an important element that can benefit portfolio diversification. For instance, our findings indicate that an increase in Russian geopolitical uncertainty has a direct impact on the spillover volatility risk of the energy commodities such as crude oil, natural gas, and coal. In our view, this has direct implications for the asset classes invested in energy and developing markets. On the other hand, policymakers may adopt policy actions in order to ensure financial stability and monitor the effect of the increase in geopolitical risks that may affect energy commodity prices and consequently, inflation dynamics.

The rest of the paper is organised as follows. Section 2 gives a summary of how our paper fits within the literature. Section 3 describes the implemented methodology. Section 4 presents the empirical analyses. Finally, the last section concludes.

2 Relation to Previous Literature

To the best of our knowledge, there are no prior studies that specifically focus on the risk spillovers concerning the Russian stock market and its industrial sectors, with energy commodities and international financial markets.

Our study is related to three branches of the literature. The first branch concerns the studies that investigate the relationship between the BRIC area and emerging countries where Russia is a member of this group. For instance, Mensi et al. (2014) analyse the interdependence between emerging stock markets in BRIC countries and commodity markets. These authors find that there was greater comovement between oil prices and the Russian stock market after the financial crisis. Raza et al. (2016) examine the impact of gold and oil prices and their associated volatilities on the stock markets of emerging economies, including Russia. Their results indicate that the stock markets in the emerging economies are more vulnerable to bad news and events that result in uncertain economic conditions. Hegerty (2016) analyses the spillover effects among commodity prices and output, exchange rates, interest rates and inflation in major emerging markets. His findings show that Russia is highly insulated from fluctuations in world oil prices. Chkili (2016) examines the dynamic relationships between gold and stock markets for the BRIC area and finds that, during major financial crises, gold represents a safe haven against extreme market movements. Korhonen and Ledyaeva (2010) provide evidence that the net effect of oil shocks is positive for Russia as it is an oil producer country, while the effect is mixed for oil-importing countries. Bildirici and Bakirtas (2014) analyse the relationship between the consumption of oil, natural gas and coal, and economic growth in BRIC countries. Their results indicate that there is a bi-directional causality relationship between natural gas energy consumption and economic growth in Russia.

A second branch of the literature related to our paper concerns recent episodes in the international financial markets, as well as political and war upheavals that affected the Russian economy. In this regard, most of the previous studies focus on the impact of international sanctions on the Russian economy related to the recent Ukrainian crisis. Nivorozhkin and Castagneto-Gissey (2016) show that the influence of the world stock markets on the Russian stock market considerably decreased in the aftermath of the Ukrainian crisis. Schmidbauer et al. (2016) find that the sanctions increased the importance of the Russian stock market as a propagator of volatility shocks. Similarly, Ankudinov et al. (2017) show that after the sanctions were introduced, there was a significant increase in the volatility of all Russian sectoral indices due to geopolitical tensions and oil volatility. Hoffmann and Neuenkirch (2017) argue that the introduction of sanctions translated to lower prices on national financial assets. According to these authors, the escalation of the conflict in Ukraine resulted in a 6.5% increase in stock returns variance. Focusing on the sectoral level, Golikova and Kuznetsov (2017) show that the Russian companies most affected were the ones heavily involved in trade and technological supply chains involving the European Union and Ukraine.

The third branch of the literature associated with our paper relates to the international financial market transmission of shocks (see, for example, Chudik and Fratzscher, 2011; Dungey and Martin, 2007; Ehrmann et al., 2011). The country under study in this paper is Russia. Hence, we focus on the interconnectedness of the Russian stock exchange and international financial markets. In this regard, several studies find spillover effects from the Russian market into the Eastern European markets (see, for example, Fedorova and Saleem, 2010; Demiralay and Bayraci, 2015). Recently, Mensi et al. (2016) analyse the spillover effect between the US market and BRICS emerging stock markets. Their results support the hypothesis of decoupling between the US and Russian stock markets during the Global Financial Crisis, indicating that the Russian market has suffered since then. In a different study, Chuliá et al. (2017) show that increases in the uncertainty of the US market have negative effects on emerging markets, including Russia. Ahmad et al. (2018) analyse the dynamic spillovers between BRICS and global markets at a sectoral level and show high inter-country spillovers for the Metal & Mining, Banking, Industrial transportation and Oil & Gas sectors.

In the next section, we present our empirical methodology that allows us to assess the spillover effects between the Russian stock market, its industrial sectors, energy commodities (crude oil, gas and coal) and the main Russian trading partners (United States, Europe and China).

3 Empirical Methodology

In this section, we present the variance decomposition approach proposed in Diebold and Yilmaz (2009, 2012). The variance decomposition is particularly suitable for the purposes of our analysis since it allows us to measure how much of the future uncertainty of a given considered asset (market, sector or commodity) i depends on shocks coming from asset j, at a given horizon. The influence of variable j on the future error variance of variable i is interpreted as a spillover effect, since it involves the dynamic variations of past shocks of j on future shocks of i.[2] The proposed framework is conceptually different from the so-called market comovements, which are based on contemporaneous financial market interdependence, usually proxied by conditional correlation (i.e., Forbes and Rigobon, 2002) or by a set of common risk factors in a static framework (i.e., Bekaert et al., 2009).

The variance decomposition is based on the vector autoregressive process of order p, namely the VAR(p):

$$\mathbf{x}_t = \sum_{l=1}^{p} \mathbf{\Phi}_l \mathbf{x}_{t-l} + \boldsymbol{\varepsilon}_t, \tag{1}$$

where $\mathbf{x_t} = (x_{1,t}, x_{2,t}, \ldots, x_{N,t},)$ is a random vector collecting the series of returns/volatilities for each asset i for $i = 1, 2, \ldots, N$, $\mathbf{\Phi}_l$ is the $(N \times N)$ autoregressive matrix parameters at the l–th lag and $\boldsymbol{\varepsilon} \sim \mathsf{N}(0, \mathbf{\Sigma})$ is the vector of error terms that are assumed to follow a multivariate Gaussian distribution with a variance–covariance matrix $\mathbf{\Sigma}$.

Given that the series are stationary in covariance, we can represent the VAR(p) as an

[2] Other approaches have been proposed in the literature. For instance, multivariate GARCH models, such as BEKK (Engle and Kroner, 1995) or DCC (Engle, 2002) have been used in the study of volatility transmission. However, a limitation of those multivariate volatility models is the curse of dimensionality, which leads to an over-proliferation of the parameters to be estimated when the number of series increases and thus, restricts their applicability in small cross-sectional dimensions.

infinity moving average process:

$$\mathbf{x}_t = \sum_{m=0}^{\infty} \mathbf{\Gamma}_m \boldsymbol{\varepsilon}_{t-m} \tag{2}$$

where $\mathbf{\Gamma}_m$ is a recursive matrix $\mathbf{\Gamma}_m = \mathbf{\Phi}_1 \mathbf{\Gamma}_{m-1} + \mathbf{\Phi}_2 \mathbf{\Gamma}_{m-2} + \ldots + \mathbf{\Phi}_p \mathbf{\Gamma}_{m-p}$ for $m > 0$, an $N \times N$ identity matrix for $m = 0$, and equal to zero for $m < 0$.

The matrix $\mathbf{\Gamma}_m$ of the moving average representation allows us to analyse the variance of the forecast error of each variable by identifying the parts that originated from the shocks of all the variables in the system. In this regard, we make use of the generalised forecast error variance decomposition of Koop et al. (1996) and Pesaran and Shin (1998) which is invariant to the ordering of the variables in the VAR. The spillovers represent the cross-variance shares, which are defined as the fractions of the H-step-ahead generalised error variances in forecasting x_i coming from shocks to x_j for $i, j = 1, 2, \ldots, N$, such that $i \neq j$.

The contribution of asset j to asset i's H-step-ahead generalised forecast error variance is:

$$\theta_{ij}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_j)}, \quad H = 1, 2, \cdots, \tag{3}$$

where Σ is the covariance matrix of the vector of error terms $\boldsymbol{\varepsilon}$, σ_{jj} is the standard deviation of the error term ε_i belonging to the jth equation in the system, and e_i is the selection vector with the ith element equal to one and zero, otherwise. Given that, in this framework, the shocks to each variable are not orthogonalized, the contributions to the variance of the forecast error in general does not sum up to one. That is, $\sum_{j=1}^{N} \theta_{ij}(H) \neq 1$. First, each contribution θ_{ij} is normalised by the row sum:

$$\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{j=1}^{N} \theta_{ij}(H)} \tag{4}$$

whereby construction $\sum_{j=1}^{N} \tilde{\theta}_{ij}(H) = 1$ and $\sum_{i=1}^{N} \sum_{j=1}^{N} \tilde{\theta}_{ij}(H) = N$.

The total spillover index is equal to:

$$S(H) = \frac{\sum_{i=1}^{N} \sum_{j \neq i}^{N} \tilde{\theta}_{ij}(H)}{N} \tag{5}$$

Other measures, such as "contribution from others" (FO) and "contribution to others" (TO) and "net spillover contribution" (NSO) can be obtained from normalised contribution values:

$$\text{FO}_i = \frac{\sum_{j=1}^{N} \tilde{\theta}_{ij}(H)}{N}, \; j \neq i, \tag{6}$$

$$\text{TO}_i = \frac{\sum_{i=1}^{N} \tilde{\theta}_{ij}(H)}{N}, \; i \neq j, \tag{7}$$

$$\text{NSO}_i = \text{TO}_i - \text{FO}_i \tag{8}$$

where FO ($i \leftarrow j, \; \forall j = 1, 2, ..., N, \; j \neq i$) shows to what extent variable i receives shocks from all the variables in the system, TO ($i \rightarrow j, \; \forall i = 1, 2, ..., N, \; i \neq j$) represents the shock transmission of variable i to the whole system, and NSO the difference between TO and FO, representing the net spillover contribution of variable i to the system.

4 Empirical Analysis

4.1 Data

We consider the sample period that goes from the second week of January 2005 to the fourth week of December 2020. This period is marked by several episodes of widespread instabilities for oil prices (large fluctuations during 2009-2013 and 2016-2018), natural gas prices (strong increases and plunges during 2007-2010 and 2014-2018) and coal prices (significant variations during 2007-2011 and 2013-2017). In the same period, several major events affected the Russian economy, such as the dispute with Belarus, the dispute with Ukraine, the annexation of Crimea and the subsequent international sanctions, in addition to the three severe crises which occurred viz. the Global Financial Crisis, the

European debt crisis and the Russian financial crisis in January 2015. More recently, the spread of the COVID-19 virus has significantly affected the global economy, as well as the international financial markets due to the negative consequences of general lockdowns and travel limitations.

We set our framework at a weekly frequency and download closing price data from Bloomberg to compute logarithmic returns (Friday-Friday) and volatilities.[3] As Alizadeh et al. (2002), Diebold and Yilmaz (2009) and other similar studies, we compute the weekly volatilities using the estimator of the variance proposed by Garman and Klass (1980):

$$\begin{aligned}\hat{\sigma}^2_{i,t} &= 0.511(H_{i,t} - L_{i,t})^2 - 0.383(C_{i,t} - O_{i,t})^2 \\ &\quad - 0.019[(C_{i,t} - O_{i,t})(H_{i,t} + L_{i,t} - 2O_{i,t}) - 2(H_{i,t} - O_{i,t})(L_{i,t} - O_{i,t})],\end{aligned} \tag{9}$$

where $H_{i,t}$ is the weekly logarithmic high price, $L_{i,t}$ is the weekly logarithmic low price, $O_{i,t}$ is the weekly logarithmic opening price, and $C_{i,t}$ is the logarithmic closing price.[4]

Regarding the international equity markets, we use MSCI indexes for the United States (MXUS), China (MXCN) and the European Union (MXEU). For Russia, we take into consideration the Moscow exchange Russia index (MOEX) and six Russian sectoral indices: Consumers' Goods & Services (MOEXCN), Electric Utilities (MOEXEUP), Financials (MOEXFN), Metals & Mining (MOEXMM), Oil & Gas (MOEXOG) and Telecommunications (MOEXTL). Moreover, we include the Russian Government Bond Index (RGBI).[5] Regarding the commodities, we consider the futures contract at 1 month traded at NYME for Brent crude oil (CO1 comdty), natural gas (NG1 comdty) and gold as a control (GC1 comdty). As a proxy for the global coal industry, we have downloaded the Stowe Global Coal Index. Finally, the forecast horizon is set to four weeks (approx-

[3]The day-of-the-week effect and other anomalies are neglectable with the use of weekly data rather than daily data. See also Geng et al. (2021).

[4]For a given week, the weekly prices have been obtained by taking the maximum among the daily high prices (weekly high price), the minimum among the daily low prices (weekly low price), the opening price of the first available day in a week (weekly opening price), and the closing prices of the last available day in a week (weekly closing price).

[5]The Russian Government Bond Index includes the most liquid government bonds with duration more than one year.

imately one month). Tables 1 and 2 report the descriptive statistics according to the considered period for returns and volatilities, respectively.

4.2 Spillover Analysis for the Full Sample

Tables 3 and 4 provide the estimates of the full-sample analysis for the return and volatility spillovers presented in Section 3. The spillover indexes (SO) for returns and volatility are included in the lower left corners. The off-diagonal column sums (labelled "Contributions to Others", TO) or row sums (labelled "Contributions from Others", FO) give the numerator of the spillover index when totalled across variables. Similarly, the column sums or row sums (including diagonals) give the denominator of the spillover index when totalled across variables.

4.2.1 Return Spillovers

Focusing on oil, Table 3 shows that the return spillover from Brent oil to all Russian sectors (that is, the contribution of the Brent oil on the sum of Consumers' Goods & Services, Electric Utilities, Financials, Metals & Mining, Oil & Gas and Telecommunications) corresponds to 11.2% of the error variance in forecasting 4-week-ahead. As expected, Oil & Gas is the Russian sector that is most affected by Brent oil (3.1%). The effect on MOEX is 2.3%. Interestingly, we find that Brent oil also has an effect on Russian government bonds (2.9%). This result confirms the important role of oil price fluctuations for the fiscal sector of an oil exporting country such as Russia. More specifically, Beidas-Strom and Lorusso (2019) find that lower oil prices mean lower government oil revenues and have negative effects on Russian public finances. Oil & Gas (7.1%) is the Russian sector that mainly affects Brent oil. This result highlights the importance of Russia as a major world oil producer. The contribution of MOEX on Brent oil is 6.1%.

The return spillovers from natural gas to the Russian economy are the lowest compared to all the other commodities. Table 3 shows that the contribution of natural gas on all Russian sectors is only 1.2% of the error variance in forecasting 4-week-ahead. Metals &

Mining and Oil & Gas are the most affected sectors (both with 0.3%). Natural gas also has a low influence on MOEX (less than 1%). As Russia is a major world natural gas producer, Russian sectors have an influence on this specific commodity. In this regard, the contribution of Metals & Mining and Oil & Gas towards natural gas are 1.3% and 1.7%, respectively. MOEX has an influence on natural gas of 1.9%.

Table 3 shows that, among all the commodities considered in our analysis, coal makes the highest contribution to the returns of the Russian sectors (33.8%). More specifically, Metals & Mining and Oil & Gas receive the largest contribution from coal (7.4% and 6.0%, respectively). Similarly, coal has a large influence on MOEX (6.0%). From Table 3, we also observe that Metals & Mining highly affects coal (7.7%) followed by the Oil & Gas sector (7.2%). MOEX has a great influence on coal (8.0%). These results indicate the worldwide importance of Russia as a coal producer.

Gold has low effects on the returns of all Russian sectors (2.6%) and MOEX (less than 1%). The contributions of Metals & Mining and Oil & Gas to gold correspond to 5.8% and 3.2%, respectively. In general, MOEX has a lower influence on gold than on other commodities (3.2%).

In terms of Russian sectors, Oil & Gas and Metals & Mining have the highest return spillovers to others (107.9% and 92.1%, respectively), as well as the strongest contributions to MOEX (14.1% and 10.7%, respectively) and to all other Russian sectors (67.6% and 62.1%, respectively). Interestingly, the Oil & Gas sector has an important influence on Russian government bonds (5.6%).

Analysing the connectedness between international markets and the Russian stock market, Table 3 shows that the MOEX contribution on the sum of US, EU and Chinese stock indexes corresponds to 21.9% of the error variance in forecasting 4-week-ahead. Similarly, EU, US and China have a strong impact on MOEX (6.1%, 4.7% and 4.1%, respectively). The effects of the EU, US and Chinese stock indexes on all Russian sectors are 35.3%, 27.1% and 22.7%, respectively.

Overall, the total Spillover Index is 68.9%. This means that our results quantify important return spillovers among Russian economy sectors, commodities and international markets.

4.2.2 Volatility Spillovers

In terms of volatility spillovers, Table 4 shows that the Brent contribution to all Russian sectors (that is, the Brent contribution to the sum of Consumers' Goods & Services, Electric utilities, Financials, Metals & Mining, Oil & Gas and Telecommunications) corresponds to 3.2% of the error variance in forecasting 4-week-ahead. Hence, Russian sectors are weakly affected by oil. For example, the effects on both Oil & Gas and Telecommunications are less than 1%. Similarly, the effect on MOEX is low (0.6%). However, our findings indicate that Russian sectors influence Brent oil. The same effect is found in Mensi et al. (2017) for the Islamic market. In particular, the sectors that mainly affect Brent oil are Oil & Gas (5.7%) and Metals & Mining (3.7%). The contribution from MOEX to Brent oil is 3.8%.

As for return spillovers, gas has lower effects than the other commodities on the volatility of all Russian sectors (3.2%) and MOEX (less than 1%). Similarly, the effects of the Russian economy on gas are very low. The sectors that mainly affect gas are Financials and Oil & Gas (both around 1%). The contribution of MOEX on gas is only 1.0% of the error variance in forecasting 4-week-ahead.

Table 4 shows that, among our four commodities, coal has the largest volatility spillovers into the Russian economy. Indeed, coal contributes to a 27.6% change in the volatility of all Russian sectors. The most affected sector is Metals & Mining (5.3%). Moreover, coal has an important effect on MOEX (5.2%). Coal contributes to a 4.2% volatility change in Russian government bonds. Interestingly, our empirical results show that the Russian sectors play an important role in terms of coal volatility. In particular, Oil & Gas and Metals & Mining are the sectors with the highest contributions (6.6% and 5.5%, respectively). Overall, MOEX accounts for 6.7% of coal volatility. These results can be explained by the fact that Russia is a major coal producer globally.

Focusing on gold, Table 4 shows that it contributes to a 16.1% change in the volatility of all Russian sectors. The sectors that are most affected by gold are Oil & Gas and Metals & Mining and (3.5% and 3.3%, respectively). Moreover, gold accounts for a 3.2% variation in volatility of the MOEX and 2.6% in the volatility of the Russian government bond. The sectors that most affect gold are Metals & Mining and Oil & Gas (7.0% and 6.7%, respectively). MOEX has a substantial effect on the gold price (6.7%). The Russian economy has an important impact on gold, which can be reasoned by the fact that it became a world leader in gold mining in the period 2010-2020.

In terms of Russian sectors, Oil & Gas and Metals & Mining have the strongest effects on MOEX (14.3% and 12.0%, respectively), as well as the highest contributions towards the remaining Russian sectors (68.8% and 69.4%, respectively).

From Table 4, we observe that MOEX has a substantial effect on international markets and contributes to a 20.6% change in volatility of the US, EU and Chinese stock indexes. Similarly, EU, US and Chinese stock indexes have a strong effect on the Russian sectors, corresponding to 34.8%, 29.7.5% and 20.5%, respectively. The EU, US and Chinese stock markets also have a large influence on MOEX (6.1%, 5.1% and 4.3%, respectively).

The volatility spillover index corresponds to 70.0%. This result indicates strong interconnectedness among the volatilities of Russian industrial sectors, energy commodities and international financial markets.

4.2.3 Net Return and Volatility Spillovers

In this section, we determine the net receivers and net contributors to return and volatility spillovers. The net return and volatility spillover indexes (NSO) are obtained by subtracting directional "Contribution to Others" spillovers from directional "Contribution from Others" spillovers. Accordingly, positive (negative) values indicate a source (recipient) of return and volatility to (from) others.

Tables 5 and 6 show that the signs of net effects are very similar in both returns and volatility indexes. The main difference relates to the relative magnitudes and, in general, volatility displays higher values. In particular, we observe that crude oil, natural gas and gold are net receivers of both returns and volatility. Crude oil is the greater receiver of shocks, confirming that it is a cyclical commodity. As argued by Diebold et al. (2018), the demand for this commodity is closely related to global income.[6] On the other hand, coal is the least net contributor of both returns and volatility. Such a result may be explained by the fact that the global coal market price is driven by Australia followed by Mozambique and South Africa (Batten et al., 2019).

Focusing in detail on Russian sectors, we note that four out of six are net contributors to returns and volatility. In terms of returns, the sectors that are net contributors are Financials, Metals & Mining, Oil & Gas and Telecommunications. In terms of volatility, the sectors that are a source of volatility are Electric Utilities, Metals & Mining, Oil & Gas and Telecommunications. For both returns and volatility, the most significant contributors among the six sectors compared to other markets are the Oil & Gas and Metals & Mining sectors, whereas the Consumers' Goods & Services sector is the major receiver.

Turning to international markets, Tables 5 and 6 show that the EU market is a net contributor of both returns and volatility, whereas the Chinese stock exchange is a net receiver of shocks.

Panels (a) and (b) of Figure 1 summarise our main findings about returns and volatility for the full sample, showing the net pairwise directional spillover diagrams. From panel (a) of Figure 1, we observe that MOEX and the Oil & Gas and Metals & Mining sectors are the major contributors of return spillovers, whereas Russian government bonds, crude oil, natural gas, gold, the Consumers' Goods & Services sector, the Electric Utilities sector and the Chinese stock index are net receivers of shocks. From panel (b) of Figure 1, we note that the major contributors of volatility spillovers are the Oil & Gas sector, the Metals & Mining sector, MOEX and the Telecommunication sector. On the other hand, the net receivers are crude oil, natural gas and gold, the Consumers' Goods

[6] In particular, Diebold et al. (2018) refer to the Global Financial Crisis of 2009 when prices of crude oil dropped sharply when faced by the near collapse of global financial markets.

& Services sector, the Financial sector and the Chinese stock index. Once again, our results highlight the important role played by Russia in the commodity sector.

4.3 Rolling-Sample Analysis

The Russian economy, the energy commodities and international markets have experienced several challenging economic and political events during the period 2005-2020. Some of these changes are related to the continuous evolution of financial markets (see, for example, Chuliá et al., 2017; Ahmad et al., 2018; Shen, 2018), as well as commodity markets (see, among others, Baumeister and Kilian, 2016; Kilian and Zhou, 2018). Other episodes relate to booms and busts that occurred in the financial and commodity markets, as well as political unrest and wars that affected the Russian economy over this period (see, for example, Nivorozhkin and Castagneto-Gissey, 2016; Ankudinov et al., 2017). More recently, the outbreak of COVID-19 provides a good example of an unprecedented exogenous shock to international financial markets and economies that could not be predicted and, hence, priced. Clearly, the full sample analysis can mask market turbulences during particular events. As noted by Betz et al. (2016), time variations to observe and monitor the financial system should be taken into account using rolling-window estimates. In this regard, we estimate the models using two-year rolling samples (104 observations). Our aim is to assess the extent and nature of spillover variation over time via the spillover indexes, which we analyse graphically in spillover plots.

4.3.1 Main Episodes Affecting the Return and Volatility Spillovers

Panels (a) and (b) of Figure 2 show the spillover plots for returns and volatility. These spillovers present several spikes associated with major events to the Russian economy, as well as financial and commodity markets.

The first episode that we observe relates to the Russian and Belarus energy disputes that occurred in March and August 2007. The Russian and Belarus energy dispute began when Gazprom[7] demanded an increase in the gas prices paid by Belarus. The dispute escalated in January 2007, when the Russian state-owned pipeline company Transneft stopped pumping oil into the Druzhba pipeline, which runs through Belarus.[8] The dispute worsened again in August 2007, leading Gazprom to announce a cut in gas supply to Belarus by 45% (Zhdannikov, 2007). Our estimates show that the return spillover increased by 3% from January 2007 until August 2007. Similarly, the volatility spillover underwent a 2-percentage point increase from February to March 2007 and it increased by a further 2% in August 2007.

The second episode relates to the Russian and Ukrainian disputes that occurred between January 2008 and March 2009. These disputes started between Ukrainian oil and gas company Naftohaz Ukrayiny and the Russian gas supplier Gazprom over natural gas supplies, prices, and debts. In a few months, these disputes grew beyond simple business disputes into transnational political issues that threatened natural gas supplies in numerous European countries dependent on natural gas imports from Russian suppliers, which are transported through Ukraine.[9] In January 2008, Gazprom warned Ukraine that it would reduce its gas supplies if $1.5 billion in gas debts were not paid (Stern et al., 2009). Panel (b) of Figure 2 shows that the volatility spillover increased by 5% in this period. In December 2008, despite Ukraine's repayment of more than $1 billion of its debt, Gazprom maintained its position, intending to cut the supply of natural gas to Ukraine if it did not fully repay the remainder of $1.67 billion debt in natural gas supplies and an additional $450 million in fines levied by Gazprom (Stern et al., 2009). Panel (b) of Figure 2 shows that, during this period, the volatility spillover increased by 3%. The dispute continued until January 2009 when Gazprom cut off gas supplies to Ukraine. The dispute turned into a full-blown crisis when all Russian gas flows through Ukraine were

[7] Gazprom is a large Russian company founded in 1989, with its business focused on the extraction, production, transport and sale of natural gas. The company is majority owned by the Russian government.

[8] The Druzhba is the world's longest pipeline supplying around 20% of Germany's oil. It also supplies oil to Poland, Ukraine, Slovakia, the Czech Republic and Hungary.

[9] Russia provides around a quarter of the natural gas consumed in the EU. Approximately 80% of those exports travel through pipelines across Ukrainian soil prior to arriving in the EU.

halted for 13 days, completely cutting off supplies to South-east Europe, most of which depends on Russian gas, and partially to other European countries (Stern et al., 2009). The volatility spillover exceeded 80% in March 2009.

The third episode coincides with the effects of the Global Financial Crisis in Russia that started in October 2008. This was a crisis in the Russian financial market, as well as an economic recession that was compounded by political fears after the war with Georgia. Moreover, Russia was hit hard by the decline in the price of many commodities. Russian involvement in the US subprime mortgage crisis contributed to the volatility in Russia's financial system. Panels (a) and (b) of Figure 2 show that the return and volatility spillovers had spectacular spikes in October 2009 registering both 10% increases. In response to the worsening of the crises, in December 2009 the Russian government sold state energy and transport holdings in order to help plug the budget deficit and help improve the nation's aging infrastructure. The state earmarked about 5,500 enterprises for divestment and sold shares in companies that were already publicly traded, including Rosneft, the country's biggest oil producer (World Bank, 2018). During this period, the volatility spillover was above 80%.

The fourth episode corresponds to the European debt crises from March 2011 until January 2012. In March 2011, the failure of European leaders to resolve their disagreements over the Greek debt crisis negatively affected the world credit markets. During this period, the volatility spillover increased by two percentage points. A few months later, in August 2011, significant purchases of Eurozone sovereign bonds took place under the European Central Bank programme. At the same time, Spanish and Italian government bond yields were breached by 6% and the European stock markets suffered further heavy losses due to persistent fears about the world economic outlook. In this period, the volatility spillover saw a substantial increase of 5%. In January 2012, a peak for the Portuguese 10-year governmental interest rates happened after the rating agencies had cut the government credit rating to "non-investment grade". In the same period, Standard & Poor's downgraded France and Austria from AAA rating, as well as lowering their rating for Spain and Italy further (Gibson, 2012). From December 2011 until January 2012, the return spillover increased by two percentage points.

The fifth episode relates to the financial crisis in Cyprus and the low performance of Russian sectors between February and April 2013. In November 2012, the Troika and the Cypriot government agreed on the bailout terms with only the amount of money required for the bailout remaining to be agreed upon. The final agreement was settled in March 2013, with the proposal to close the most troubled Laiki Bank, which helped to significantly reduce the needed loan amount for the overall bailout package. During the same period, in Russia, the dynamics of stock market indices led to a decrease in capitalisation. The last days of March were characterised by the fall of stock market indexes in the banking sector, the power industry, and the chemical and engineering sectors (International Monetary Fund, 2016). Between February and April 2013, our estimates indicate that both the return and volatility spillovers increased by 2%.

The sixth episode is related to the annexation of Crimea by the Russian Federation and the subsequent international sanctions in January and March 2014. The Ukrainian crisis began in November 2013 with protests in Kiev against the president of Ukraine who had suspended an association agreement with the European Union, favouring the prospect of a Russian-led alliance. In January 2014, Russia increased its economic pressure on Ukraine by announcing the suspension of its financial aid commitments to the country. As we can observe from panel (b) of Figure 2, during this period the volatility spillover increased by three percentage points. In February 2014, the anti-government demonstrations in Ukraine culminated in violent clashes with the police, which led to the installation of an interim government. In the aftermath, pro-Russian and anti-revolution protests and activism gripped Crimea and parts of Eastern and Southern Ukraine. At the same time, armed men led to the installation of a pro-Russian government in Crimea declaring Crimea's independence. In March 2014, Russian president Vladimir Putin officially obtained parliamentary authorisation to use force in Ukraine. As a consequence of this aggression, a few days later, US president Barack Obama approved financial sanctions against Russia. Shortly afterwards, the EU introduced its first set of sanctions in the same vein. Panel (b) of Figure 2 shows that this set of events coincided with the sharp increase in the volatility spillover of about 7%.

The seventh episode corresponds to the second round of international sanctions in response to the annexation of Crimea in October and December 2014. This new round of international sanctions coincided with the downing of a Malaysian airliner over separatist-held territory in Ukraine in July 2014. This event exacerbated the confrontation between Russia and Western countries dramatically. In response to this action, the EU imposed financial sanctions against a number of Russian entities supporting actions against Ukraine's integrity. A few days later, the EU decided to extend these sanctions and target the overall economic cooperation and exchanges with Russia. In October 2014, the EU strengthened these sanctions even further in accord with the US. As a consequence, a vast devaluation seized the already weak Ruble (World Bank, 2014). As we can see from panel (b) of Figure 2, in December 2014 the volatility spillover had a spectacular increase of 16%.

The eighth episode coincides with the Russian financial crisis in January 2015. During this period, there was a decline in confidence in the Russian economy which caused investors to sell off their Russian assets, leading to a consequent decline in the value of the Russian Ruble (World Bank, 2015a). The lack of confidence in the Russian economy stemmed from at least two major sources. The first was the fall in the price of oil in 2014. The second was the result of international economic sanctions imposed on Russia following Russia's annexation of Crimea and the Russian military intervention in Ukraine. Panel (a) of Figure 2 shows that, from December 2014 to January 2015, the return spillover increased by 2%.

The ninth episode relates to the plunge in the oil price between August 2015 and February 2016. In August 2015, the Moscow Interbank Currency Exchange (MICEX) decreased due to the plunge in the oil price. This fall strongly affected Russian stock market quotations (World Bank, 2015b). Panel (b) of Figure 2 shows that, during this period, the volatility spillover had a large increase of about 5%. In January 2016, the sharp fall in the oil price led to a significant weakening of the Ruble and increased market uncertainty. Moreover, upside risks to the inflation target of the Central Bank of Russia (CBR) limited the space for monetary easing. The Russian Federal State Statistics Service (ROSSTAT) estimated a fall in GDP of 3.7% (World Bank, 2016a). Between December 2015 and February 2016, the return spillover increased by four percentage points. In April 2016, the rating agency Fitch affirmed Russia's long-term foreign and local currency rating at "BBB-" with a negative outlook. Fitch was concerned about Russian structural weaknesses, low growth potential and geopolitical tensions (World Bank, 2016b). From January to April 2016, the volatility spillover increased by 2%.

The tenth episode corresponds with the plunge of international markets that followed the presidential election of the Republican Donald Trump. Futures for the Standard & Poor's 500 stock index decreased by 5%. International stock markets were initially apprehensive about Trump's anti-trade rhetoric. As we can observe from panel (b) of Figure 2, the return spillover increased by 2% at the end of November 2016.[10]

The eleventh episode is associated with the additional international sanctions levied against Russia in response to the annexation of Crimea in August 2017. The US president Donald Trump signed a bill imposing new measures against Russia at the beginning of August 2017. Moscow retaliated against the new sanctions, ordering the US to cut its diplomatic staff in Russia by 60%, obliging the embassy to make many of the Russian staff redundant (Borger, 2017). Panel (b) of Figure 2 shows that the volatility spillover increased by two percentage points over this period.

The last episode is related to the COVID-19 outbreak in mid-March 2020. Between February and March 2020, the international financial markets experienced several crashes, registering the largest drop of around 13% on the 16*th* of March 2020. Central banks have responded with asset purchase programs to ensure financial stability. In Russia, the pandemic began to spread in the same period and venues and parks were turned into

[10]For more details, please see the article "Why Stock Markets, Initially Shaken, Went Up After Trump's Victory" (https://www.nytimes.com/2016/11/10/business/dealbook/stock-markets-election.html).

temporary hospitals. As a consequence, the government decided to impose generalised lockdowns, air travel restrictions, and border checkpoints, including on the Belarus border. The numerous measures that were adopted in order to contain the spread of the virus, combined with the disruption to global oil markets, induced a significant economic contraction.[11] Panels (a) and (b) of Figure 2 show that the return and volatility spillovers had striking increases in March 2020, soaring by 7% and 15%, respectively.

4.3.2 The Net Contribution of the Oil & Gas and Metals & Mining Sectors

From the full sample analysis, we observed that Oil & Gas and Metals & Mining play an important role in terms of energy commodities, international financial markets and other Russian sectors. In this section, we analyse the time-variations of the net return and volatility spillover indexes for both these Russian industries.

Oil & Gas Sector. We start by focusing on the return spillover index, indicating the net effects of the Oil & Gas industry on the other variables in panel (a) of Figure 3. We observe that such spillover reaches its largest values in two main periods: from January 2007 to May 2008 and from February 2016 to August 2017. During these two periods, the net return spillover index exceeded 25%.

As we described above, between January 2007 and September 2009 the Russia-Belarus and Russia-Ukraine energy disputes caused interruptions in Russian gas supply to the rest of Europe. These disputes coincided with an upturn in global aggregate demand for natural gas which, in turn, induced an increase in the gas price (International Energy Agency, 2008). Moreover, during 2008, the Oil & Gas sector benefited from large capital inflows which induced strong growth in investment and productivity in this sector (International Monetary Fund, 2008).

The second period of high values of the net return spillover index goes from February

[11] In 2020, the Russian economy lost 3.1% of its GDP (International Monetary Fund, 2021) while the price of oil plunged in March and April 2020, achieving a minimum of US$20 per barrel (International Monetary Fund, 2021).

2016 to August 2017. In this period, the oil and gas extraction sector suffered from low investment and high indebtedness of oil companies. Upstream and downstream sectors, such as drilling and transportation (dominated by state-owned companies Transneft and Russian Railways), performed very poorly. The fall in the revenues from the Oil & Gas sector led to a general decline in fiscal receipts for the Russian government with lowered dividend payments from state-owned enterprises and banks linked to the Oil & Gas industry (International Monetary Fund, 2016).

Turning to the volatility spillover index indicating the net effects of Oil & Gas industry, panel (b) of Figure 3 shows that this spillover reaches high values in the following periods: from January to March 2008, from April 2009 to September 2010, and from December 2013 to March 2014. In these three periods, the net volatility spillover index reached a percentage above 25%.

As we described above, the period that goes from January 2007 to October 2007 was characterised by the Russian and Belarus energy disputes. Moreover, from April 2009 to October 2010 the performance of the Oil & Gas sector contracted by 7% due to the ongoing effects of the Global Financial Crisis in Russia. At the same time, the crude oil price plunged due to the drops of both world aggregate and oil market-specific demands[12] and the price of natural gas fell due to the economic downturn in Europe.[13]

The third period (from December 2013 to March 2014) coincides with the first round of international sanctions imposed by the US and the EU. These sanctions were imposed in response to Russia's actions in Crimea and developments in Eastern Ukraine. Transactions conducted in the US and the EU involving major state-owned Russian banks and Oil & Gas companies were prohibited. Moreover, sanctions included a ban on exports of high-technology goods for use in the Russian Oil & Gas industry.

We also observe one spectacular peak in the volatility index in December 2014. This episode corresponds with a considerable fall in the sale of Russian oil and gas coinciding

[12]See Lorusso and Pieroni (2018) for a detailed analysis concerning the causes of the plunge in the oil price during this period.

[13]For more details refer to International Energy Agency (2009).

with the second round of sanctions imposed by the EU and the US on Russia in response to the annexation of Crimea (International Monetary Fund, 2016).

Interestingly, we note that from April 2020 until the end of our sample, the volatility spillover index assumes negative values. This means that the Oil & Gas sector is a net receiver of volatility. As discussed above, this period relates to the spread of the COVID-19 pandemic.

Metals & Mining Sector. Panels (a) and (b) of Figure 4 show the return and volatility spillover indexes, measuring the net contributions of the Metals & Mining industry on all the other variables of our analysis.

Focusing on the returns, we note that the net spillover assumes the highest values in two main periods: from January 2008 to September 2009, and from October 2011 to December 2013. The net return spillover index assumes values higher than 20% during these two periods. In the first period, the Metals & Mining sector experienced a strong increase of its role in financial markets. High-rated companies in this sector issued bonds at interest rates and maturities that were more favourable than commercial bank loans (International Monetary Fund, 2007 and PwC, 2011). The period that goes from October 2011 to December 2013 coincided with a serious crisis related to the Russian mining sector. The crises started at the end of 2010 and continued in 2011 and 2012. During this period, the four major Russian mining companies (Norilsk Nickel, Polyus Gold, Alrosa and Uralkali) significantly underperformed and their stock prices lost value despite record profits. This crisis was mainly caused by a lack of confidence in the Metals & Mining industry which was related to higher expected costs and lower capital investments (PwC, 2013).

We also observe that between March 2020 and October 2020 the net return spillover on Metals & Mining becomes a net receiver in correspondence with the COVID-19 outbreak.

Turning to the net spillover index for volatility indicating the contribution of Metals & Mining on MOEX, we note that such index assumes the largest values in the following periods: from September 2008 to March 2010, from October 2010 to August 2011 and from September 2013 to March 2014. The first period largely coincides with the wave of financialization experienced by companies in the Metals & Mining sector that we described above. During this period, aggregate revenues for the overall sector rose by $40 billion with strong corporate revenues attributable to higher commodities production and sales. The second period largely corresponds to the beginning of the crisis in the Metals & Mining sector as we explained above. The last period (between September 2013 and March 2014) is related to a significant increase in production companies in the Metals & Mining sector. The free cash flow for the four major Russian mining companies was positive and a mix of productivity measures, Ruble devaluation and lower input costs boosted their margins (PwC, 2015).

4.4 The Relationship between Spillover Indexes and Geopolitical Risks

In this section, we aim to measure the relationship between the estimated spillover indexes (return and volatility) and Russian geopolitical uncertainty. In this regard, we decompose each series of the spillover index obtained from the rolling-window estimates in order to disentangle the sources of the spillover that originated from the stock and commodity markets.[14]

The total spillover index, S^{TOT}, at time t can be disentangled and expressed as fol-

[14] The authors are indebted to an anonymous reviewer for providing insightful comments and directions for additional work, which has resulted in this section.

lows:[15]

$$
\begin{aligned}
S_t^{\mathrm{TOT}} &= \frac{1}{N}\sum_{i=1}^{N}\sum_{j\neq i}^{N}\tilde{\theta}_{ij,t} \\
&= \sum_{k=1}^{K}\left(\frac{1}{N}\sum_{i=1}^{N}\sum_{j\neq i}^{N}\tilde{\theta}_{ij,t}\mathbb{I}_{j=k}\right) \\
&= \sum_{k=1}^{K} S_t^k
\end{aligned}
\tag{10}
$$

where $\tilde{\theta}_{ij,t}$ is the normalised contribution (see Section 3), $k = \{1, \ldots, K\}$ is the set of the K defined (sub)groups and $\mathbb{I}_{j=k}$ is the indicator function for the membership of the asset j in the subset k. In the following analysis, we define the stock market group (MKT, $k = 1$) and the energy commodity market group (COM, $k = 2$).

Accordingly, the total spillover index S^{TOT} can be decomposed as follows:

$$
S_t^{\mathrm{TOT}} = S_t^{\mathrm{MKT}} + S_t^{\mathrm{COM}} \tag{11}
$$

where S_t^{MKT} and S_t^{COM} are the total spillovers originating from the stock market and the commodity market groups, respectively.[16] Figure 5 shows that the disentangled spillovers for returns and volatility, S_t^{MKT} and S_t^{COM}, exhibit different patterns in both cases. The energy commodity spillover tends to assume higher values in correspondence with Russian specific events, such as the dispute with Belarus, the dispute with Ukraine, the Russian financial crises and during the international sanctions that followed the annexation of Crimea.[17] On the other hand, the stock market spillover increases during international crises such as the Global Financial Crisis, the European debt crisis and the crisis generated by the COVID-19 pandemic.

We aim to measure the relationship between the total spillover indexes and geopolitical

[15] We simplify the notation by removing the time horizon H as discussed in equation (5), in Section 3, since we are in the post-estimation step where H has already been set.

[16] Gold is included in the stock market group because it is not an energy commodity, whereas it is widely used as an alternative investment vehicle to hedge against global uncertainty.

[17] The oil price plunge between August 2015 and February 2016 contributes to increasing this spillover.

risks by distinguishing between Russian and global events, including other relevant factors that could exert an impact on these indexes. In this regard, we consider the Russian geopolitical risk index (GPR RUSSIA) and the global geopolitical risk index (GPR) developed by Caldara and Iacoviello (2018). Those uncertainty indexes are built on the frequency of keywords related to geopolitical tensions in international newspapers and are available on a monthly basis.

As additional controls, we include the Russian economic policy uncertainty index (EPU RUSSIA) and the global economic policy uncertainty index (EPU) proposed by Baker et al. (2016) to account for policy-related economic uncertainty. Furthermore, to control for the impact of the financial market, we include the OFR financial stress index (FSI) developed by the US Department of Treasury (Monin, 2019). This index measures the level of systemic financial stress, such as abrupt disruptions and other financial events that may impact the normal functioning of the financial markets (i.e., the Global Financial Crises and the European sovereign debt crises). Given that the sub-components of the index are also available for macro-regions, we consider the sub-indexes for the developed and emerging markets to account for market regional effects.[18] Finally, we consider the infectious disease equity market volatility tracker (EMV) (Baker et al., 2020) to control for the effect of the COVID-19 pandemic, which has represented an exogenous shock to the financial system. The EMV index quantifies the news related to infectious disease outbreaks in the financial markets.

To measure if changes in these variables provide information about the future changes of the spillover indexes and to avoid capturing contemporaneous variations due to economic and financial stress, we lag the independent variables of one period (one month). A similar approach has also been adopted in Chau and Deesomsak (2014).[19] Finally, we aggregate the weekly spillover indexes by averaging them since the uncertainty indicators

[18] The subcomponents of the index are available for three macro-regions: the US, other advanced economies, and emerging markets. Since the sum of the three provides the total index, we aggregate the US and other advanced economies to obtain the developed component.

[19] In the study of Chau and Deesomsak (2014), the spillover index is used as a covariate to measure its impact on the future state of the economy.

are expressed at a monthly frequency. Hence, we estimate the following model:

$$\begin{aligned}\Delta S^l_{m,t} = \beta^l_{0,m} &+ \beta^l_{1,m}\Delta \text{ GPR RUSSIA}_{t-1} + \beta^l_{2,m}\Delta \text{ GPR}_{t-1} + \beta^l_{3,m}\Delta \text{ EPU RUSSIA}_{t-1} \\ &+ \beta^l_{4,m}\Delta \text{ EPU}_{t-1} + \beta^l_{5,m}\Delta \text{ FSI DEVELOPED}_{t-1} \\ &+ \beta^l_{6,m}\Delta \text{ FSI EMERGING}_{t-1} + \beta^l_{7,m}\Delta \text{ EMV}_{t-1} + \varepsilon^l_{m,t}\end{aligned} \tag{12}$$

where $\Delta S^l_{m,t}$ is the change in the spillover index with $l = \{\text{TOT}, \text{MKT}, \text{COM}\}$ and $m = \{\text{RET}, \text{VOL}\}$.

Given that the total spillover index ($S^{\text{TOT}}_{m,t}$) is the sum of the two sub-spillovers indexes ($S^{\text{MKT}}_{m,t}$ and $S^{\text{COM}}_{m,t}$), it follows that $\beta^{\text{TOT}}_{i,m} = \beta^{\text{MKT}}_{i,m} + \beta^{\text{COM}}_{i,m}$. Consequently, we can decompose the impact of the uncertainty indicators for the total and each marginal source of spillovers.

The estimation results for the six models ($l \times m$) are shown in Table 7. Regarding the spillover index on returns, we see that the EPU index has a significant and positive effect on the total spillover (column 1). If we examine the impact of EPU on the marginal sources of the total spillover (columns 2 and 3), we see that EPU has a positive and statistically significant effect on the stock market group, but it does not affect the energy commodity group. This result indicates that changes in global policy and economic uncertainty have a direct effect on the financial markets by amplifying their role in spreading future shocks at one month horizon.

Focusing on the financial stress index, we note that FSI for developed and emerging countries have opposite effects on the total spillover (column 1). Both these effects are statistically significant. Our estimated results show that the FSI for developed countries increases the spillover of the commodity market group, yet it lowers that of the stock market group (columns 2 and 3). Moreover, we find that the FSI index for emerging markets has a positive and significant effect on the stock market group. This finding is not surprising since Russia is member of the BRICS countries and this confirms that it is more exposed to an increase in the financial stress of emerging economies.

If we examine the impact of EPU on the marginal sources of the total spillover (columns 2 and 3), we see that EPU has a positive and statistically significant effect on the stock market group, yet it does not affect the energy commodity group. This result indicates that changes in global policy and economic uncertainty have a direct effect on the financial markets by amplifying their role in spreading future shocks at one month horizon.

We note that changes in the GPR index do not exert an impact on the total spillover. However, if we look at the disaggregated sources of the total spillover, we can see that GPR has a negative and significant effect on the future energy commodity spillover. Since the GPR reflects heterogeneous geopolitical risks, this implies that an increase in global risks reduces the transmission mechanism of the energy commodities in spreading future shocks at one month horizon. Notably, the Russian GPR, the Russian EPU and the infectious disease EMV index do not exert any impact on future return spillovers.

The results are different when we analyse the volatility spillover indexes. In particular, we see that changes in the Russian GPR have a significant and positive impact on future changes in the energy commodity volatility spillover (column 6). This is a very interesting finding since it confirms that Russian political crises and war episodes influence the volatility spillover mechanism of the energy commodities in terms of risk. This result complements the previously discussed analyses on the dynamic of the spillovers and unveils the strong connection between Russian geopolitical events and the energy commodity market. It is also worth noting that this effect is not observed in the total spillover, as well as the stock market spillover. This evidence suggests that the sphere of influence of Russian geopolitical risks is largely limited to the energy commodities.[20]

Finally, we focus on the EMV index, which is clearly related to the outbreak of pandemic diseases. At first glance (column 4), the EMV does not seem to have a statistical impact on the total volatility spillover index. If we look at the marginal source of

[20]As a robustness check, we have performed a regression by extending the lag up to three months. Results remain unchanged and are available upon request to the authors.

spillovers, we find that this is due to the opposite effect that the EMV exerts on the stock and energy commodity markets. As it can be viewed in columns 5 and 6, EMV has a significant and positive impact on the market volatility spillover, whereas it is significant and negative for the energy commodity spillover.

We interpret this asymmetry as being the consequences of the prolonged lockdowns and travel limitations that have induced an abrupt change in growth perspectives. These, in turn, have triggered the volatility spillover mechanism of the stock markets. The result is not surprising since the stock market, rather than the commodity market, represents the leading indicator of the current and future expectations of the economy. For instance, Farid et al. (2021) provide evidence that the (US) stock market is the largest transmitter of volatility spillovers to commodity markets.

5 Conclusion

Recently, the Russian economy has undergone substantial changes and most of its industrial sectors have experienced the process of financialization. At the same time, the Russian economy continues to be heavily dependent on energy commodities production. In addition, the COVID-19 pandemic has generated a dramatic crisis due to the negative consequences of general lockdowns and travel limitations.

In this paper, we examine the connectedness between the energy commodities produced in Russia (crude oil, natural gas, coal and gold) and the Russian stock market, including its six main sectors. We make use of the variance decomposition approach proposed by Diebold and Yilmaz (2009) and Diebold and Yilmaz (2012), which allows us to measure dynamics and intensity in shock transmission. Our analysis includes the major episodes related to the booms and busts that occurred in the financial and commodity markets, as well as the political unrest and wars that have affected the Russian economy.

Our findings indicate spillover effects, both in returns and volatilities, from the Russian Oil & Gas and Metals & Mining sectors to energy commodities, such as crude oil and gold. In particular, we find that these Russian energy sectors are net transmitters, rather than receivers, to the energy commodities. Interestingly, our estimated results show that episodes such as the Russian energy disputes with Belarus and Ukraine represent trigger events of shock transmission.

Our dynamic net contribution analysis shows that the Oil & Gas sector had the highest spillover effects during the Belarus energy disputes, the Russia-Ukraine crisis, the Global Financial Crisis and the first two rounds of international sanctions. On the other hand, increases in the net spillover indexes of both returns and volatility for Metals & Mining are mainly associated with specific shocks of this industry.

The empirical approach we have adopted enables us to disentangle the aggregate spillovers in returns and volatility into specific spillovers that originated from the financial and commodity markets. In this respect, we analyse the effects of Russian and global geopolitical events on such spillovers. We find that a positive change in the energy commodity volatility spillover is associated with Russian-specific events (i.e., Russian political crises and war episodes), whereas the stock market spillover assumes high values during international crises. Finally, we show that the spread of COVID-19 increases the stock market volatility spillover, whereas it lowers the energy commodity spillover.

We believe that our empirical findings provide meaningful insights for investors, as well as for policymakers. In particular, we have shown how wars, energy disputes, geopolitical tensions, and the COVID-19 pandemic have impacted Russian sectors and financial markets and changed their normal functioning. Without any doubt, economic and (geo)political stability provide a better environment for investors reducing uncertainties and risks in the commodities and financial markets.

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Table 1: Descriptive statistics, Returns, January 2005 - December 2020

	CONS	UTILS	FIN	MET	OILGAS	TLC	MOEX	GAS	GOLD	BRENT	GOV	COAL	US	EU	CN
Mean	0.00257	0.00098	0.00258	0.00281	0.00237	0.00099	0.00213	-0.00104	0.00180	0.00021	0.00035	-0.00056	0.00142	0.00045	0.00177
Median	0.00363	0.00199	0.00318	0.00340	0.00381	0.00219	0.00323	-0.00229	0.00351	0.00322	0.00026	0.00324	0.00261	0.00318	0.00399
Max	0.13694	0.24981	0.28274	0.27555	0.34470	0.16719	0.35424	0.24651	0.12346	0.31352	0.10021	0.23112	0.11672	0.12443	0.17762
Min	-0.19089	-0.28738	-0.24770	-0.35121	-0.25096	-0.28253	-0.27770	-0.28600	-0.10141	-0.29714	-0.07501	-0.31837	-0.20116	-0.24373	-0.22293
St. Dev.	0.03009	0.04292	0.04130	0.04520	0.04108	0.03734	0.03956	0.06760	0.02520	0.04997	0.01057	0.04943	0.02520	0.02675	0.03524
Skewness	-0.55362	-1.00761	-0.20556	-0.63882	-0.22586	-0.90821	-0.24614	0.02387	-0.34369	-0.52230	0.12291	-0.70602	-1.10521	-1.77684	-0.34754
Kurtosis	8.72757	11.57324	9.11462	14.34981	13.86644	9.28269	16.07105	3.90877	4.91360	9.71218	24.18120	8.35746	12.75799	17.14073	6.69603

Notes: Returns are measured weekly, Friday-to-Friday. The labels in the table are as follows. CONS: Russian stock index for the Consumers' Goods & Services sector. UTILS: Russian stock index for the Electric Utilities sector. FIN: Russian stock index for Financial companies. MET: Russian stock index for the Metals & Mining sector. OILGAS: Russian stock index for the Oil & Gas sector. TLC: Russian stock index for Telecommunication companies. MOEX: Moscow exchange Russia index. GOV: Russian Government Bonds. US: US stock market index. EU: EU stock market index. CN: Chinese stock market index.

Table 2: Descriptive statistics, Volatilities, January 2005 - December 2020

	CONS	UTILS	FIN	MET	OILGAS	TLC	MOEX	GAS	GOLD	BRENT	GOV	COAL	US	EU	CN
Mean	0.02248	0.02984	0.03318	0.03184	0.03099	0.02870	0.02993	0.05848	0.02159	0.04148	0.00557	0.02494	0.01796	0.01938	0.02695
Median	0.01856	0.02399	0.02540	0.02457	0.02440	0.02324	0.02309	0.05062	0.01866	0.03589	0.00333	0.01734	0.01411	0.01554	0.02206
Max	0.11725	0.26909	0.36446	0.23021	0.28153	0.24312	0.26015	0.22711	0.11296	0.36774	0.07179	0.21618	0.14012	0.11584	0.20818
Min	0.00040	0.00504	0.00231	0.00325	0.00252	0.00117	0.00259	0.01994	0.00301	0.00846	0.00000	0.00000	0.00332	0.00000	0.00000
St. Dev.	0.01491	0.02409	0.02725	0.02481	0.02485	0.02159	0.02473	0.02844	0.01217	0.02695	0.00712	0.02536	0.01425	0.01351	0.01877
Skewness	2.42395	3.65447	4.63515	3.12338	4.01160	3.98014	3.92747	1.75618	2.26535	4.70573	4.20535	3.35866	3.54740	2.82757	3.50031
Kurtosis	10.94742	24.46350	41.71297	17.54581	28.29523	28.15092	26.73080	7.83984	11.72231	43.11111	27.32187	19.12247	22.03989	15.56803	22.91478

Notes: Volatilities are for Monday-to-Friday returns. The labels in the table are as follows. CONS: Russian stock index for the Consumers' Goods & Services sector. UTILS: Russian stock index for the Electric Utilities sector. FIN: Russian stock index for Financial companies. MET: Russian stock index for the Metals & Mining sector. OILGAS: Russian stock index for the Oil & Gas sector. TLC: Russian stock index for Telecommunication companies. MOEX: Moscow exchange Russia index. GOV: Russian Government Bonds. US: US stock market index. EU: EU stock market index. CN: Chinese stock market index.

Table 3: Spillover table, returns of Russian sectors, commodities and main international markets, January 2005 - December 2020

	CONS	UTILS	FIN	MET	OILGAS	TLC	MOEX	GAS	GOLD	BRENT	GOV	COAL	US	EU	CN	FO
CONS	23.78	8.87	8.61	7.84	9.08	9.50	10.58	0.13	0.19	1.31	2.15	4.99	4.16	5.48	3.32	76.22
UTILS	7.57	20.59	9.39	8.49	9.43	9.80	11.38	0.11	0.22	1.69	2.97	4.96	4.03	5.83	3.52	79.41
FIN	6.63	8.03	19.51	8.09	10.32	9.21	13.46	0.13	0.21	1.67	1.90	5.49	4.95	6.25	4.14	80.49
MET	5.52	7.38	7.93	19.33	11.50	7.66	13.51	0.31	1.07	1.55	1.14	7.40	5.22	5.90	4.57	80.67
OILGAS	5.99	7.26	9.03	10.13	17.20	8.45	15.65	0.35	0.73	3.07	2.13	6.01	4.30	5.94	3.74	82.80
TLC	7.13	9.00	9.40	8.18	10.09	20.37	11.76	0.17	0.21	1.95	3.07	4.93	4.43	5.91	3.40	79.63
MOEX	6.21	7.85	10.61	10.72	14.07	8.91	15.44	0.32	0.57	2.33	2.00	6.08	4.71	6.13	4.05	84.56
GAS	1.24	0.50	0.50	1.34	1.66	0.82	1.85	82.87	0.49	2.45	0.84	2.52	1.71	0.66	0.56	17.13
GOLD	0.77	1.31	0.98	5.82	3.19	1.57	3.24	0.25	69.43	3.63	0.24	5.18	0.72	0.38	3.28	30.57
BRENT	2.50	3.61	3.54	3.33	7.09	4.46	6.14	1.20	2.08	37.29	2.80	9.73	5.84	6.84	3.55	62.71
GOV	3.71	5.71	4.41	2.59	5.64	7.00	5.69	0.14	0.33	2.85	49.64	2.64	2.51	4.99	2.16	50.36
COAL	3.21	4.29	5.58	7.73	7.19	4.96	8.04	0.61	1.63	5.13	1.41	20.89	9.81	9.63	9.90	79.11
US	2.98	3.93	5.49	6.15	5.79	4.92	6.90	0.51	0.44	3.41	1.23	10.77	23.38	16.47	7.61	76.62
EU	3.89	5.63	6.22	6.21	6.94	5.92	7.90	0.13	0.23	3.27	2.04	9.31	14.52	20.58	7.22	79.42
CN	3.20	4.16	5.74	6.29	5.91	4.57	7.12	0.16	1.26	2.39	1.68	12.57	9.02	9.53	26.39	73.61
TO	60.56	77.53	87.43	92.91	107.92	87.77	123.21	4.53	9.67	36.71	25.60	92.58	75.93	89.92	61.02	1033.29
SO	68.89%															

Notes: The underlying variance decomposition is based upon a weekly VAR, identified using the generalised variance decomposition. The *(i, j)*-th value is the estimated contribution to the variance of the 4-week-ahead stock returns forecast error of variable i coming from innovations of variable j. The labels in the table are as follows. CONS: Russian stock index for the Consumers' Goods & Services sector. UTILS: Russian stock index for the Electric Utilities sector. FIN: Russian stock index for Financial companies. MET: Russian stock index for the Metals & Mining sector. OILGAS: Russian stock index for the Oil & Gas sector. TLC: Russian stock index for Telecommunication companies. MOEX: Moscow exchange Russia index. GOV: Russian Government Bonds. US: US stock market index. EU: EU stock market index. CN: Chinese stock market index. SO: The Spillover Index. FO: Contribution from Others. TO: Contribution to others.

Table 4: Spillover table, volatility of Russian sectors, commodities and main international markets, January 2005 - December 2020

	CONS	UTILS	FIN	MET	OILGAS	TLC	MOEX	GAS	GOLD	BRENT	GOV	COAL	US	EU	CN	FO
CONS	25.60	8.71	4.41	8.47	7.53	8.98	8.12	0.41	1.52	0.46	4.33	4.98	6.62	7.47	2.39	74.40
UTILS	5.72	19.58	5.59	10.58	10.80	10.67	11.33	0.48	2.44	0.40	3.94	4.93	5.18	5.52	2.84	80.42
FIN	4.87	7.53	22.85	10.05	10.99	9.94	13.24	0.98	3.07	0.35	3.31	2.84	3.03	3.94	3.02	77.15
MET	5.06	8.46	6.70	19.16	11.75	8.98	13.46	0.51	3.32	0.28	2.70	5.28	4.69	5.55	4.11	80.84
OILGAS	4.18	8.21	6.41	11.10	16.30	9.71	14.74	0.52	3.45	0.99	3.69	4.73	5.43	6.26	4.30	83.70
TLC	5.27	9.51	6.35	10.02	11.45	18.63	11.98	0.29	2.34	0.71	3.94	4.83	4.77	6.10	3.80	81.37
MOEX	4.57	8.29	7.46	11.95	14.28	9.87	15.66	0.59	3.19	0.59	2.94	5.15	5.11	6.06	4.29	84.34
GAS	0.41	0.22	1.38	0.55	1.01	0.33	1.00	90.49	1.20	1.48	0.29	0.18	0.84	0.39	0.22	9.51
GOLD	1.60	4.74	3.24	6.97	6.70	5.57	6.65	0.72	34.72	1.08	1.80	5.70	7.16	8.26	5.09	65.28
BRENT	1.24	2.34	1.05	3.67	5.74	3.30	3.79	0.88	2.87	50.61	2.54	2.20	11.64	6.76	1.37	49.39
GOV	4.72	7.97	4.02	6.30	8.12	9.62	6.95	0.16	2.64	0.97	30.81	4.20	5.41	5.55	2.55	69.19
COAL	2.67	4.83	1.76	6.21	6.62	5.48	6.74	0.16	4.10	0.76	1.74	29.45	11.16	10.52	7.79	70.55
US	3.34	4.79	2.05	5.98	6.83	5.75	6.61	0.17	4.54	2.30	2.20	8.38	25.05	15.86	6.14	74.95
EU	3.76	5.60	2.39	5.25	6.99	6.04	6.93	0.04	5.05	1.82	2.41	8.08	15.47	23.96	6.20	76.04
CN	2.15	3.98	2.88	5.09	7.52	5.19	7.10	0.05	4.98	0.40	2.83	10.55	10.05	10.03	27.19	72.81
TO	49.56	85.18	55.70	102.18	116.35	99.45	118.65	5.96	44.70	12.59	38.65	72.04	96.55	98.27	54.10	1049.93
SO	70.00%															

Notes: The underlying variance decomposition is based upon a weekly VAR, identified using the generalised variance decomposition. The *(i, j)*-th value is the estimated contribution to the variance of the 4-week-ahead stock volatility forecast error of variable *i* coming from innovations of variable *j*. The labels in the table are as follows. CONS: Russian stock index for the Consumers' Goods & Services sector. UTILS: Russian stock index for the Electric Utilities sector. FIN: Russian stock index for Financial companies. MET: Russian stock index for the Metals & Mining sector. OILGAS: Russian stock index for the Oil & Gas sector. TLC: Russian stock index for Telecommunication companies. MOEX: Moscow exchange Russia index. GOV: Russian Government Bonds. US: US stock market index. EU: EU stock market index. CN: Chinese stock market index. SO: The Spillover Index. FO: Contribution from Others. TO: Contribution to others.

Table 5: Net directional spillovers, returns of Russian sectors, commodities and main international markets, January 2005 - December 2020

	CONS	UTILS	FIN	MET	OILGAS	TLC	MOEX	GAS	GOLD	BRENT	GOV	COAL	US	EU	CN
CONS	0.00	1.30	1.98	2.32	3.09	2.38	4.37	-1.11	-0.58	-1.19	-1.56	1.78	1.18	1.58	0.12
UTILS	-1.30	0.00	1.36	1.11	2.17	0.80	3.53	-0.38	-1.09	-1.91	-2.74	0.67	0.10	0.21	-0.64
FIN	-1.98	-1.36	0.00	0.17	1.29	-0.19	2.84	-0.37	-0.77	-1.87	-2.51	-0.08	-0.54	0.03	-1.60
MET	-2.32	-1.11	-0.17	0.00	1.37	-0.51	2.79	-1.03	-4.75	-1.78	-1.45	-0.32	-0.93	-0.30	-1.73
OILGAS	-3.09	-2.17	-1.29	-1.37	0.00	-1.64	1.58	-1.31	-2.46	-4.02	-3.52	-1.18	-1.49	-1.00	-2.17
TLC	-2.38	-0.80	0.19	0.51	1.64	0.00	2.85	-0.65	-1.35	-2.51	-3.93	-0.03	-0.49	-0.01	-1.18
MOEX	-4.37	-3.53	-2.84	-2.79	-1.58	-2.85	0.00	-1.53	-2.67	-3.81	-3.69	-1.96	-2.20	-1.78	-3.07
GAS	1.11	0.38	0.37	1.03	1.31	0.65	1.53	0.00	0.24	1.25	0.70	1.91	1.19	0.53	0.40
GOLD	0.58	1.09	0.77	4.75	2.46	1.35	2.67	-0.24	0.00	1.55	-0.08	3.55	0.28	0.15	2.01
BRENT	1.19	1.91	1.87	1.78	4.02	2.51	3.81	-1.25	-1.55	0.00	-0.05	4.60	2.42	3.57	1.16
GOV	1.56	2.74	2.51	1.45	3.52	3.93	3.69	-0.70	0.08	0.05	0.00	1.23	1.29	2.95	0.48
COAL	-1.78	-0.67	0.08	0.32	1.18	0.03	1.96	-1.91	-3.55	-4.60	-1.23	0.00	-0.96	0.32	-2.68
US	-1.18	-0.10	0.54	0.93	1.49	0.49	2.20	-1.19	-0.28	-2.42	-1.29	0.96	0.00	1.95	-1.41
EU	-1.58	-0.21	-0.03	0.30	1.00	0.01	1.78	-0.53	-0.15	-3.57	-2.95	-0.32	-1.95	0.00	-2.31
CN	-0.12	0.64	1.60	1.73	2.17	1.18	3.07	-0.40	-2.01	-1.16	-0.48	2.68	1.41	2.31	0.00
Net	-15.66	-1.88	6.95	12.24	25.13	8.14	38.66	-12.60	-20.90	-26.01	-24.77	13.47	-0.69	10.51	-12.59
Conclusion	Net-rec.	Net-rec.	Net-contr.	Net-contr.	Net-contr.	Net-contr.	Net-contr.	Net-rec.	Net-rec.	Net-rec.	Net-rec.	Net-contr.	Net-rec.	Net-contr.	Net-rec.

Notes: A positive (negative) value indicates that i is a net transmitter (receiver) of shocks from j. The labels in the table are as follows. The last row indicates whether each asset is a net receiver or spreader. CONS: Russian stock index for the Consumers' Goods & Services sector. UTILS: Russian stock index for the Electric Utilities sector. FIN: Russian stock index for Financial companies. MET: Russian stock index for the Metals & Mining sector. OILGAS: Russian stock index for the Oil & Gas sector. TLC: Russian stock index for Telecommunication companies. MOEX: Moscow exchange Russia index. GOV: Russian Government Bonds. US: US stock market index. EU: EU stock market index. CN: Chinese stock market index. SO: The Spillover Index. FO: Contribution from Others. TO: Contribution to others.

Table 6: Net directional spillovers, volatility of Russian sectors, commodities and main international markets, January 2005 - December 2020

	CONS	UTILS	FIN	MET	OILGAS	TLC	MOEX	GAS	GOLD	BRENT	GOV	COAL	US	EU	CN
CONS	0.00	2.99	-0.46	3.41	3.35	3.71	3.55	0.00	-0.08	-0.78	-0.40	2.32	3.28	3.71	0.24
UTILS	-2.99	0.00	-1.94	2.12	2.59	1.16	3.04	0.26	-2.30	-1.93	-4.02	0.10	0.38	-0.08	-1.14
FIN	0.46	1.94	0.00	3.34	4.58	3.59	5.78	-0.41	-0.17	-0.71	-0.71	1.08	0.97	1.55	0.14
MET	-3.41	-2.12	-3.34	0.00	0.65	-1.04	1.51	-0.05	-3.65	-3.38	-3.60	-0.93	-1.29	0.30	-0.98
OILGAS	-3.35	-2.59	-4.58	-0.65	0.00	-1.74	0.46	-0.50	-3.25	-4.75	-4.44	-1.89	-1.41	-0.73	-3.22
TLC	-3.71	-1.16	-3.59	1.04	1.74	0.00	2.11	-0.04	-3.23	-2.60	-5.68	-0.65	-0.98	0.06	-1.39
MOEX	-3.55	-3.04	-5.78	-1.51	-0.46	-2.11	0.00	-0.40	-3.47	-3.20	-4.02	-1.59	-1.50	-0.88	-2.81
GAS	0.00	-0.26	0.41	0.05	0.50	0.04	0.40	0.00	0.47	0.59	0.13	0.02	0.68	0.35	0.17
GOLD	0.08	2.30	0.17	3.65	3.25	3.23	3.47	-0.47	0.00	-1.79	-0.84	1.60	2.62	3.21	0.11
BRENT	0.78	1.93	0.71	3.38	4.75	2.60	3.20	-0.59	1.79	0.00	1.58	1.43	9.33	4.94	0.97
GOV	0.40	4.02	0.71	3.60	4.44	5.68	4.02	-0.13	0.84	-1.58	0.00	2.46	3.21	3.14	-0.28
COAL	-2.32	-0.10	-1.08	0.93	1.89	0.65	1.59	-0.02	-1.60	-1.43	-2.46	0.00	2.79	2.43	-2.77
US	-3.28	-0.38	-0.97	1.29	1.41	0.98	1.50	-0.68	-2.62	-9.33	-3.21	-2.79	0.00	0.39	-3.91
EU	-3.71	0.08	-1.55	-0.30	0.73	-0.06	0.88	-0.35	-3.21	-4.94	-3.14	-2.43	-0.39	0.00	-3.83
CN	-0.24	1.14	-0.14	0.98	3.22	1.39	2.81	-0.17	-0.11	-0.97	0.28	2.77	3.91	3.83	0.00
Net	-24.84	4.76	-21.45	21.34	32.64	18.08	34.30	-3.55	-20.59	-36.79	-30.53	1.49	21.60	22.23	-18.71
Conclusion	Net-rec.	Net-contr.	Net-rec.	Net-contr.	Net-contr.	Net-contr.	Net-contr.	Net-rec.	Net-rec.	Net-rec.	Net-rec.	Net-contr.	Net-contr.	Net-contr.	Net-rec.

Notes: A positive (negative) value indicates that i is a net transmitter (receiver) of shocks from j. The last row indicates whether each asset is a net receiver or spreader. The labels in the table are as follows. CONS: Russian stock index for the Consumers' Goods & Services sector. UTILS: Russian stock index for the Electric Utilities sector. FIN: Russian stock index for Financial companies. MET: Russian stock index for the Metals & Mining sector. OILGAS: Russian stock index for the Oil & Gas sector. TLC: Russian stock index for Telecommunication companies. MOEX: Moscow exchange Russia index. GOV: Russian Government Bonds. US: US stock market index. EU: EU stock market index. CN: Chinese stock market index. SO: The Spillover Index. FO: Contribution from Others. TO: Contribution to others.

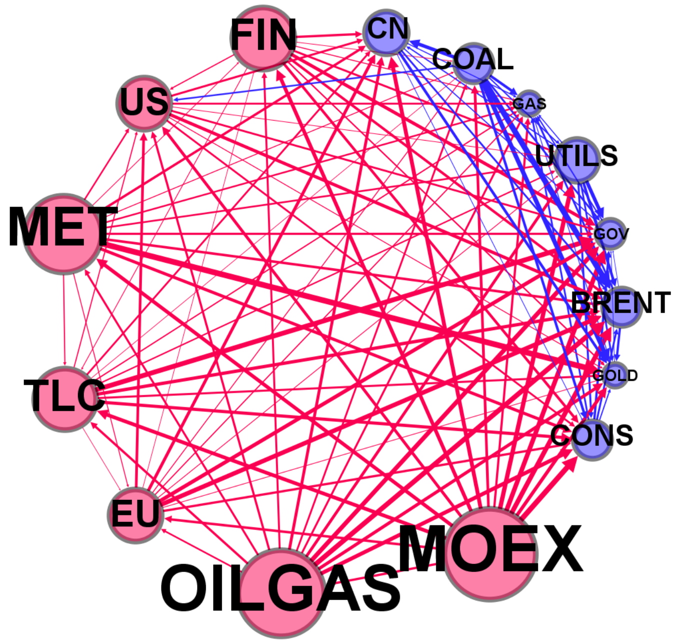
Table 7: The impact of changes in geopolitical risks, economic uncertainty and infectious disease outbreaks on the spillover indexes.

	Returns			Volatility		
Δ *Spillover Index*	(1) TOT	(2) MKT	(3) COM	(4) TOT	(5) MKT	(6) COM
Δ GPR RUSSIA (1)	0.0001	-0.0015	0.0015	0.0107	0.0056	0.0050**
	(0.0043)	(0.0045)	(0.0017)	(0.0100)	(0.0096)	(0.0023)
Δ GPR (1)	-0.0057	-0.0036	-0.0022**	-0.0134	-0.0113	-0.0021*
	(0.0075)	(0.0068)	(0.0011)	(0.0123)	(0.0116)	(0.0011)
Δ EPU RUSSIA (1)	-0.0014	-0.0016	0.0002	-0.0007	-0.0003	-0.0004
	(0.0011)	(0.0011)	(0.0004)	(0.0020)	(0.0020)	(0.0005)
Δ EPU (1)	0.0051*	0.0043*	0.0008	0.0010	-0.0004	0.0014
	(0.0029)	(0.0024)	(0.0011)	(0.0059)	(0.0058)	(0.0013)
Δ FSI DEVELOPED (1)	-0.2110*	-0.3293***	0.1183**	-0.3047	-0.2501	-0.0546
	(0.1133)	(0.1077)	(0.0576)	(0.2639)	(0.2515)	(0.0651)
Δ FSI EMERGING (1)	2.8763***	3.4939***	-0.6177	3.1365	2.5754	0.5610
	(1.0243)	(0.9043)	(0.5159)	(2.2809)	(2.1779)	(0.5730)
Δ EMV (1)	0.0574	0.0534	0.0040	0.0773	0.1116**	-0.0343**
	(0.0478)	(0.0469)	(0.0105)	(0.0617)	(0.0560)	(0.0139)
Observations	166	166	166	166	166	166
R-squared	0.1576	0.1267	0.1227	0.1033	0.1074	0.0572

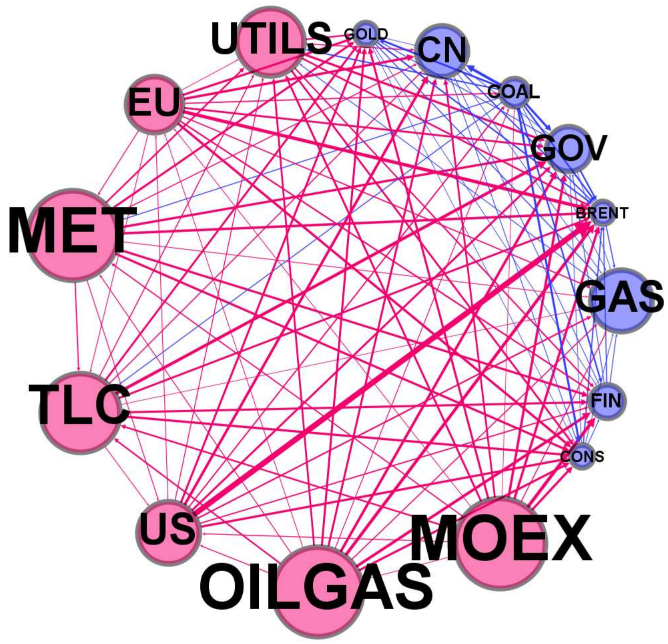
Notes: We distinguish between the total spillover (TOT), stock market spillover (MKT), and the energy commodity market spillover (COM). GPR RUSSIA indicates the Russian geopolitical risk index. GPR denotes the global geopolitical risk index. EPU RUSSIA is the Russian economic uncertainty index. EPU represents the global economic uncertainty index. EMV indicates the infectious disease equity market volatility tracker. FSI DEVELOPED corresponds to the financial stress index for developed countries. FSI EMERGING denotes the financial stress index for emerging countries. Δ denotes the change in a given variable from the previous period. "(1)" in the covariate indicates that the variable is lagged of one period (one month). Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 1: Diagram of Net Pairwise Directional Spillovers

Panel (a): Return Spillover



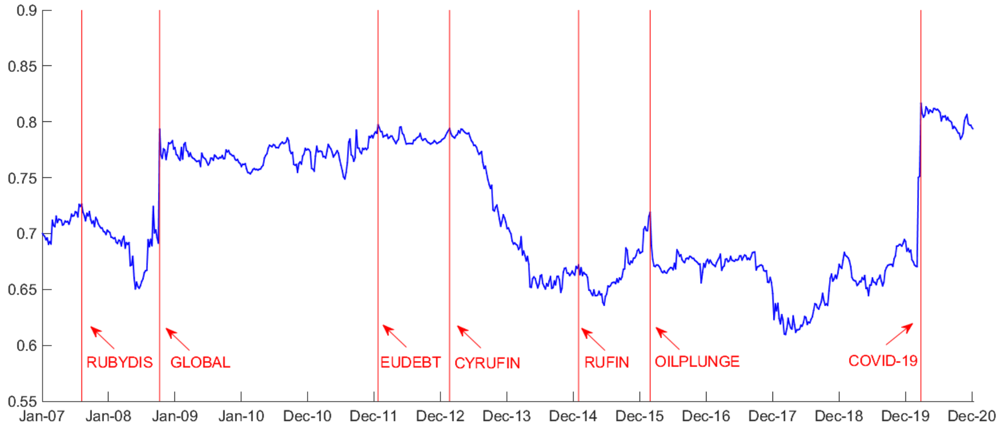
Panel (b): Volatility Spillover



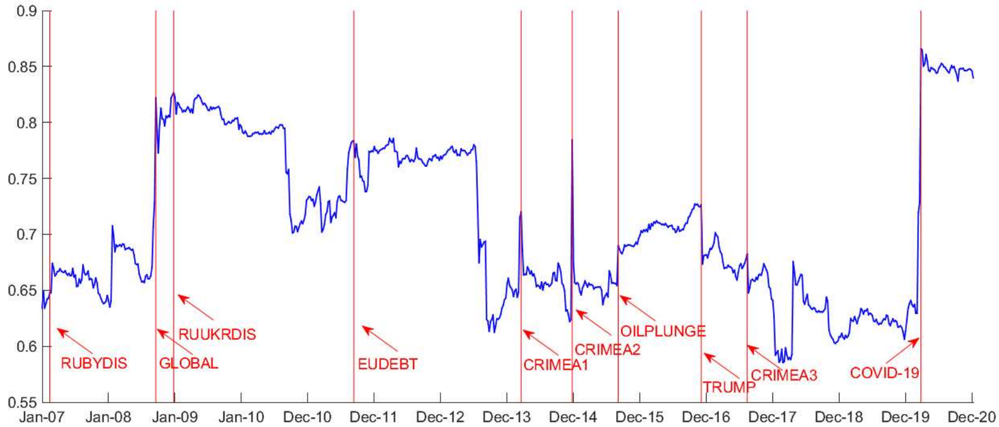
Notes: The size of a node highlights the magnitude of a net transmission/reception TO or FROM other variables. The red (blue) colour of a node shows that a variable is a net transmitter (receiver) in the system. The edge size underscores the magnitude of the pairwise spillover. The labels in the table are as follows. CONS: Russian stock index for the Consumers' Goods & Services sector. UTILS: Russian stock index for the Electric Utilities sector. FIN: Russian stock index for Financial companies. MET: Russian stock index for the Metals & Mining sector. OILGAS: Russian stock index for the Oil & Gas sector. TLC: Russian stock index for Telecommunication companies. MOEX: Moscow exchange Russia index. GOV: Russian Government Bonds. US: US stock market index. EU: EU stock market index. CN: Chinese stock market index.

Figure 2: The Spillover Index, January 2005 - December 2020

Panel (a): Return Spillover



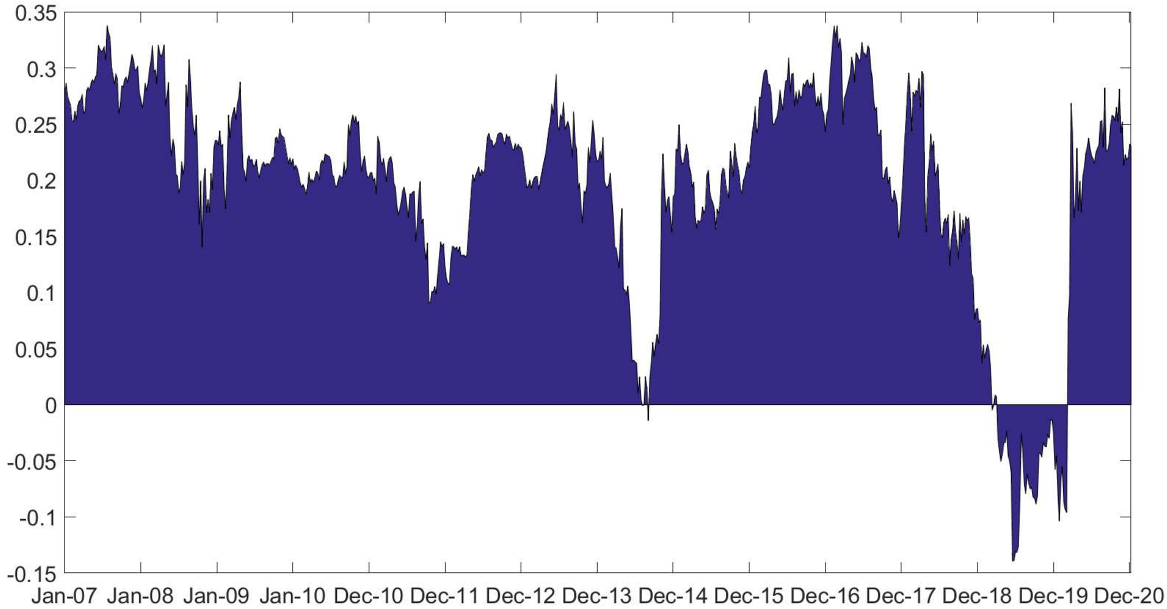
Panel (b): Volatility Spillover



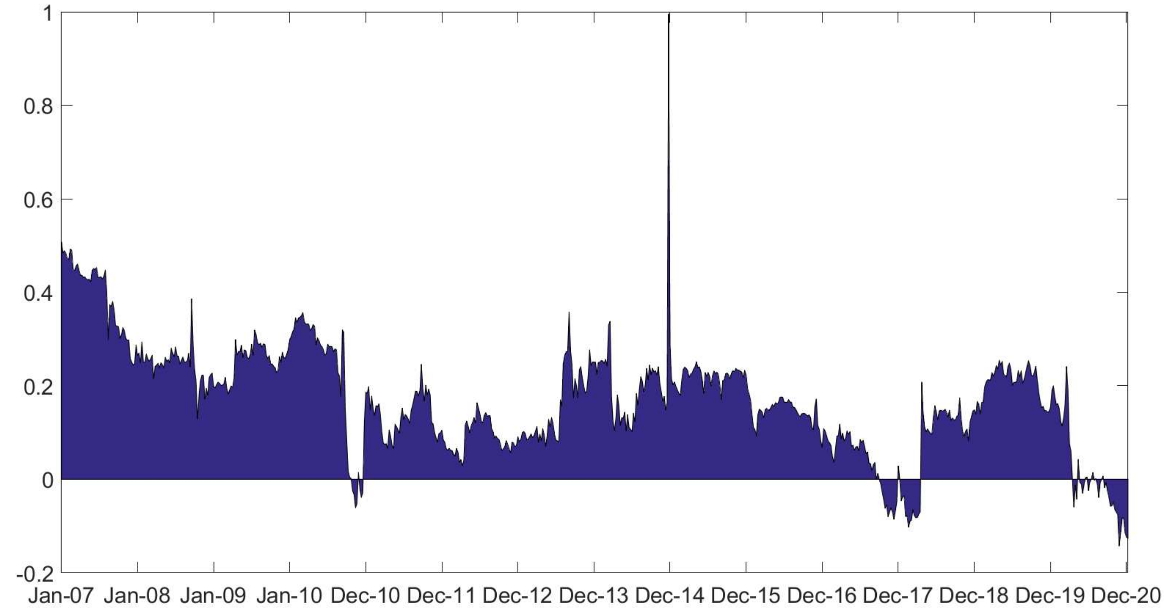
Notes: The returns and volatility spillover indexes are defined as the sums of all variance decomposition "contributions to others", estimated using two-year rolling windows (104 observations). The labels in the figures are as follows. RUBYDIS: Russia and Belarus dispute. GLOBAL: Global Financial Crisis. EUDEBT: European Debt Crises. CYRUFIN: Cyprus financial crisis and low performance of Russian sectors. RUFIN: Russian financial crisis. OILPLUNGE: Oil price plunge. RUUKRDIS: Russia and Ukraine dispute. CRIMEA1: Annexation of Crimea and 1st round of international sanctions. CRIMEA2: 2nd round of international sanctions. CRIMEA3: 3rd round of international sanctions. TRUMP: Presidential election of the Republican Donald Trump. COVID-19: Outbreak of the COVID-19 pandemic.

Figure 3: Net Spillover of the Oil & Gas Sector, January 2005 - December 2020

Panel (a): Return Spillover



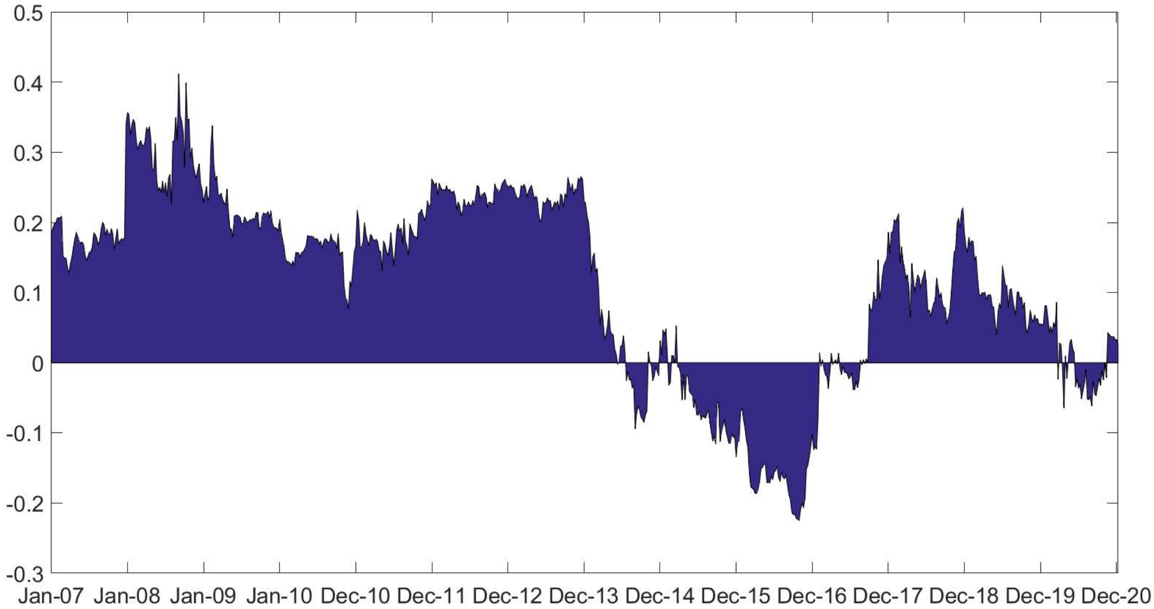
Panel (b): Volatility Spillover



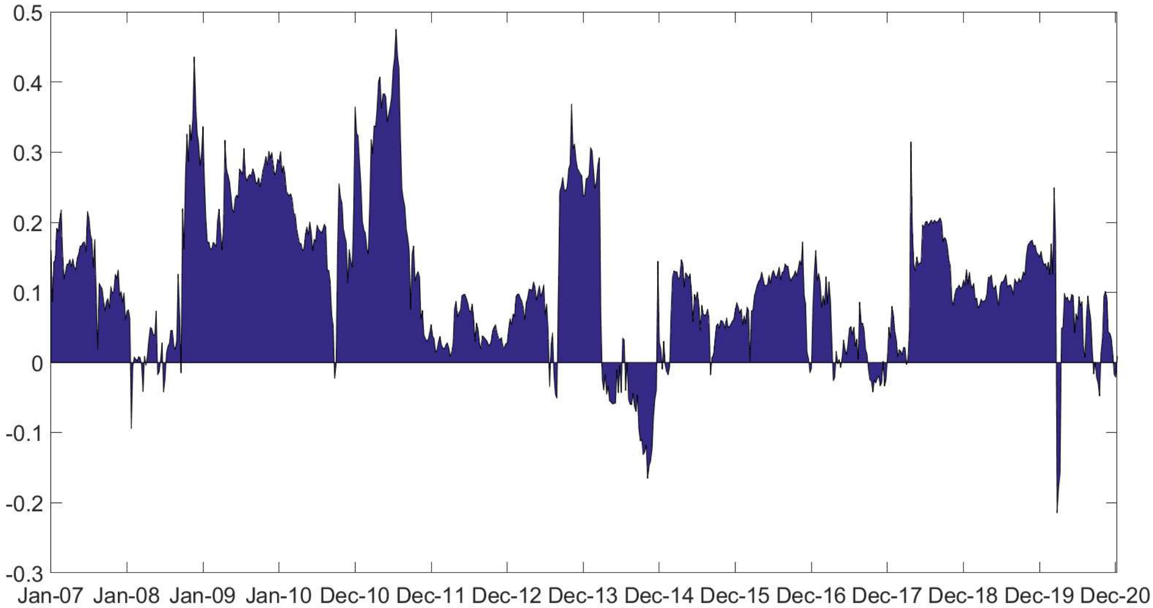
Notes: The Net Spillover (NSO) is computed as the difference between the "contribution from others" (FO) and "contribution to others" (TO). The spectacular peak in panel (b) corresponds to the second round of international sanctions on Russia (December 2014).

Figure 4: Net Spillover of the Metals & Mining Sector, January 2005 - December 2020

Panel (a): Return Spillover



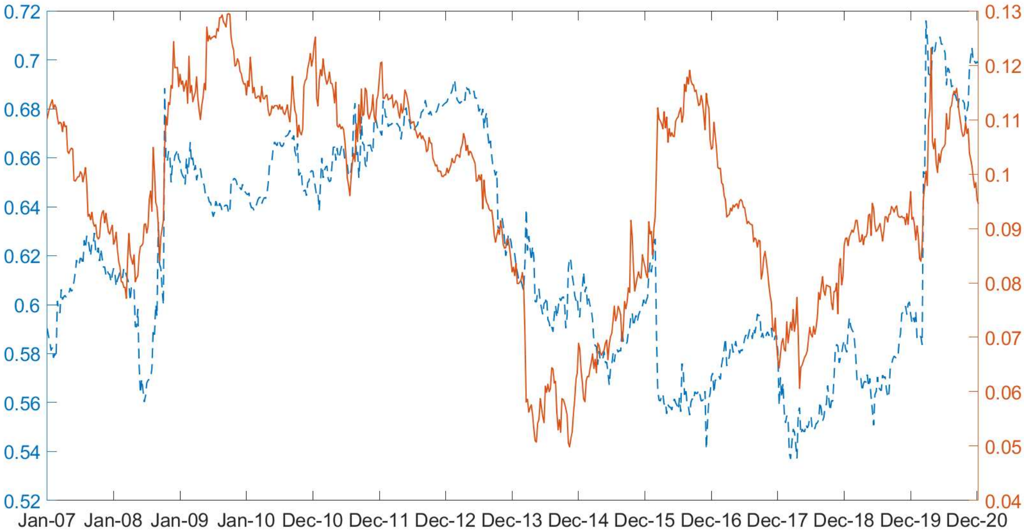
Panel (b): Volatility Spillover



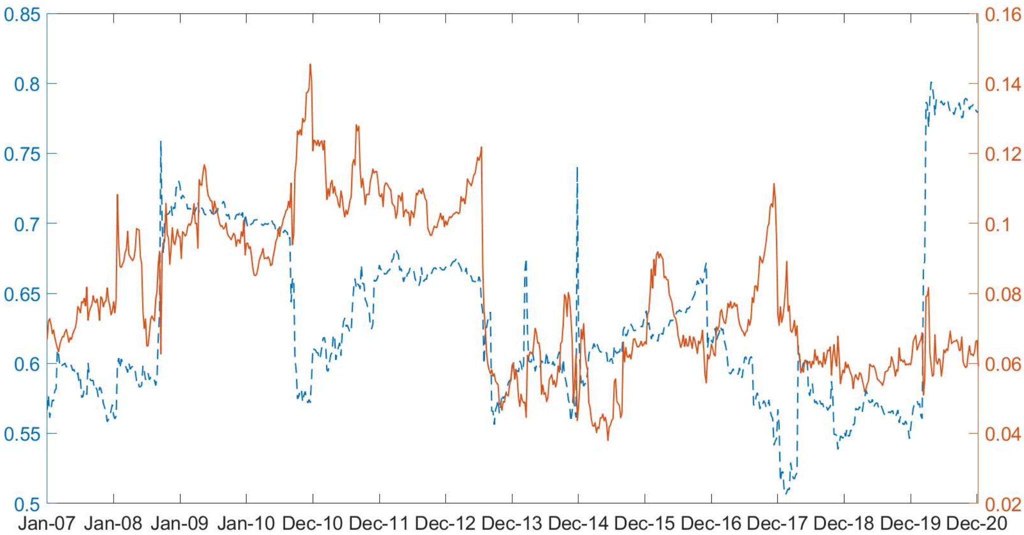
Notes: The Net Spillover (NSO) is computed as the difference between the "contribution from others" (FO) and "contribution to others" (TO).

Figure 5: The disentangled Spillover Index, January 2005 - December 2020

Panel (a): Return Spillover



Panel (b): Volatility Spillover



Notes: The blue dashed line indicates the stock market total spillover (S_t^{MKT}) on the left axis, whereas the orange solid line represents the energy commodity total spillover (S_t^{COM}), on the right axis.