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Kazi Sohag [a], Shaiara Husain [b], Kristina Chukavina [c], Md Al Mamun [d]
[a, c] Ural Federal University, Ekaterinburg, Russian Federation
[b] University of Western Australia, Crawley, Australia
[d] La Trobe University, Bundoora, Australia
[a] https://orcid.org/0000-0002-0976-2357; e-mail: ksokhag@urfu.ru
[b] https://orcid.org/0000-0002-7228-3869
[c] https://orcid.org/0000-0002-0189-2923
[d] https://orcid.org/0000-0002-6540-9195

Policy Uncertainty, Oil Price, Stock Market and Precious Metal Markets Volatility Spillovers in the Russian Economy[1]

The Russian economy is emerging, meaning that natural resources play a dominant role in economic development. Given the considerable volatility in resource prices, we investigate the volatility spillovers among policy uncertainty, international oil prices, exchange rate, stock index and metal prices covering the period of 2 July 2008 to 15 May 2020 for the Russian economy applying Dynamic Connectedness based on Time-Varying Parameter Vector Autoregression (TVP-VAR). Our empirical investigation demonstrates that gold price, Russian policy uncertainty, oil price and stock index are net volatility contributors, whereas palladium, platinum, silver and exchange rate are net volatilities receivers. Market capitalisation and silver market are found to be the highest net contributor and net receiver, respectively. The palladium appears as a net volatility receiver initially, just after the global financial crisis. The Russian economic policy uncertainty appears to be the dominant volatility contributor from 2008 to 2014, but onward it turned to be a net volatility receiver. Over the year 2014, gold price was the prominent volatility contributor to another market when the oil price dropped significantly. The total connectivity of the markets are highly anchored with several exogenous shocks, including economic sanction, adoption of floating exchange rate, oil price plunge. Our empirical findings provide several policy implications to portfolio managers and Russian regional stakeholders.

Keywords: volatility spillovers, TVP-VAR, policy uncertainty, oil price, exchange rate, metal price, gold price, stock index, silver price, Russian Federation

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ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

К. Сохаг [а], Ш. Хусейн [б], К. Чукавина [в], Мд Аль Мамун [г]
[а, в] Уральский федеральный университет, г. Екатеринбург, Российская Федерация
[б] Университет Западной Австралии, Кроули, Австралия
[г] Университет Ла Троба, Бандура, Австралия
[а] https://orcid.org/0000-0002-0976-2357; e-mail: ksokhag@urfu.ru
[б] https://orcid.org/0000-0002-7228-3869
[в] https://orcid.org/0000-0002-0189-2923
[г] https://orcid.org/0000-0002-6540-9195

Влияние эффектов перетекания волатильности на политическую неопределенность, цены на нефть, биржу и рынки драгоценных металлов в российской экономике

Российская экономика — это развивающаяся экономика, природные ресурсы играют доминирующую роль в экономическом развитии страны. Следовательно, на национальную экономику влияет значительная волатильность цен на ресурсы. В статье исследуется влияние эффектов перетекания волатильности на политическую неопределенность, мировые цены на нефть, обменный курс, фондовые индексы и цены на металлы в российской экономике за период со 2 июля 2008 г. по 15 мая 2020 г. Для анализа использована модель векторной авторегрессии с изменяющимися во времени параметрами (TVP-VAR). Проведенное эмпирическое исследование показывает, что цена на золото, политическая неопределенность, цена на нефть и фондовый индекс являются источниками волатильности. В то же время, волатильность влияет на такие факторы, как палладий, платина, серебро и обменный курс рубля. Рыночная капитализация является чистым донором, рынок серебра — чистым получателем. Палладий стал источником чистой волатильности после мирового финансового кризиса. Неопределенность российской экономической политики была основным источником волатильности с 2008 по 2014 гг., однако впоследствии волатильность других факторов оказывала на нее большее влияние. В 2014 г., когда цена на нефть значительно снизилась, цена на золото была основным источником волатильности для других рынков. Полная связанность рынков в значительной степени зависит от ряда экзогенных потрясений, таких как экономические санкции, введение режима плавающего обменного курса, падение цен на нефть. Исходя из представленного анализа, сформулировано несколько рекомендаций для портфельных инвесторов и стейкхолдеров в российских регионах.

Ключевые слова: эффекты перетекания волатильности, TVP-VAR, политическая неопределенность, цена на нефть, обменный курс, цена на металлы, цена на золото, фондовый индекс, цена на серебро, Российская Федерация

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1. Introduction

The Russian economy is emerging where natural resources play a dominant role in economic development (Malle, 2013). The economy is also considered to be endowed with various mineral resources such as oil, natural gas, gold, silver, platinum and palladium. Russia preserves six percent of the world deposit of oil and three percent of global gas deposits[1]. The Russian economy has experienced a steady increment in the corporate income tax earned as the profit share of all the extractive companies ranging from 18.6 % to 22.7 % in response to increasing oil prices over 2005–2013 (Sabitiva, Shavaleyeva, 2015). In addition, Sohag, Gainetdinova and Mariev (2021) documented that an increase in oil price appreciates the Russian rouble. Accordingly, these precious metal resources' price volatilities have significant consequences on fiscal sustainability, eventually affecting Russia's economic growth. Besides, Russia faces economic sanctions, including in oil exploration and production equipment paralysing international oil revenue. The sanctions have resulted in large scale capital outflows leading to the

[1] The Mineral Industry of Russia on the Mineral Resources Program portion of the USGS website. Retrieved from: https://www.usgs.gov/energy-and-minerals/mineral-resources-program.

collapse of the RUR exchange rate in recent times. In this paper, however, we focus on whether economic policy uncertainty partly explains the nature of price volatilities in the precious metals market, stock market and the exchange rate market. With this background, we attempt to analyse the impact of policy uncertainty on explaining the price dynamics in precious metals markets, stock market and exchange rate market in the context of Russia.

In general, the literature demonstrates a keen interest in assessing the impact of policy uncertainty on various markets in the post-financial crisis period (Antonakakis, Chatziantoniou, Filis, 2013). Specifically, economic policy response changes following the unanticipated oil price shocks. The interplay between the oil price shocks and policy uncertainty influences the financial market by altering expected cash flows and discount rates. The increment in the price of inputs and a substantial reduction in the production process cause inflation and a decline in the investors' expectations regarding the stock market, contributing to the nexus between oil price, policy uncertainty, and financial market (Hamilton, 1996; Sadorsky, 1999). The change in expected discounted cash flows regulates asset price suggested by the economic theories (Williams, 1938; Fisher, 1930; Filis, Degiannakis, Floros, 2011). The firm-level uncertainty regarding investment return is responsible for cyclical fluctuations in aggerate investment in the economy (Elder, Seletis 2010). The firm-level uncertainty affects the investment in oil and other precious metals as these investments are contained in most individual and institutional investors' portfolios (Sari et al. 2010).

The ongoing economic sanctions on Russia have depressed the private sector, resulting in a decline in gross capital formation. This has squeezed down access to global financial markets, thereby reducing capital inflows. The high dependence of a major oil-importing country like Russia on oil revenue makes it even more vulnerable to the extent that it affects financial market by bringing large changes in cash flows in response to even insignificant changes in oil prices and exchange rates (Dabrowski, 2019; Huang et al., 2017). Economic policy uncertainty arises as the Russian government has lost a significant portion of its revenue due to economic sanctions, therefore unable to provide due financial support to the private sector.

We study the volatility transmission mechanism among the oil, gold, silver, palladium, platinum, policy uncertainty, exchange rate and market capitalisation in the context of Russia. Following the literature where spillover impacts have been mostly studied applying different specifications of VAR, we apply a Time-Varying Parameter Vector Autoregression (TVP-VAR) approach to analyse the data span over the period from 2 July 2008 to 15 May 2020. We demonstrate the appropriateness of our methodology by arguing that the TVP-VAR is an upgraded version of VAR which is insensitive to outliers, helps prevent losing observations and is independent of the size of the rolling window (Antonakakis, Chatziantoniou, Gabauer, 2020).

Our analysis highlights that gold price, Russian policy uncertainty, oil price and stock index are net volatility contributors. Since oil is the chief export commodity of Russia, any volatilities in the oil prices contribute to policy uncertainty and market capitalisation by changing the expected cash flows, which also determines the prices of other valuable assets. Mainly gold price co-moves in the same direction with policy uncertainty, oil prices and market capitalisation because the increasing use of gold as an investment asset to combat inflationary pressure and inflationary expectations is a common trend. Any fluctuation in oil prices will tend to influence Russian policy uncertainty, the gold market and market capitalisation in the same direction. These findings are in line with the current literature findings where stock prices have been shown to share a positive relationship with gold prices (Mensi et al., 2014) and oil prices have been shown to be associated with higher stock indices for BRICS countries (Ono, 2011). However, palladium, platinum, silver and exchange rates are found to be net receivers. The exchange rate becomes net receiver as it absorbs any volatility in oil prices since oil prices are denominated in the dollar exchange rate. Market capitalisation and silver market are found to be the highest net contributor and net receiver, respectively.

Anecdotally, there are instances of recent harmonisation among oil prices, metal prices and exchange rate in the context of Russia. However, literature acknowledges that the variation in exchange rates has spillover impacts on global crude oil market and domestic stock returns as well (Sari, Hammoudeh, Soytas, 2010; Bouoiyour et al., 2015; Gavin, 1989; Reboredo, Rivera-Castro, Ugolini, 2016). Among other precious metals, increasing gold use as an investment asset to combat inflationary pressure and inflationary expectations is a common trend. Moreover, the more significant industrial usage of precious metal cousins, including platinum and palladium, is another crucial reason for substituting these metals, leading to coherence among their prices. Individual and institutional investors' portfolios contain both oil and precious metals priced in US dollars; therefore, the dollar exchange rate contributes to both oil and precious metals (Sari, Hammoudeh, Soytas, 2010).

Furthermore, the impact of oil price changes on stock prices has been assessed due to the increment in financial integration among the countries where oil prices volatility has been shown to propagate the stock market through their influence on expected dividends and cash-flows (Jones, Kaul, 1996; El-Sharif et al., 2005). On the contrary, some other studies denote an inverse relationship between stock prices and oil and gas prices for US. and Australia (Huang et al., 1996; Sadorsky, 1999) and Australia (Faff, Brailsford, 1999). However, these researches have been carried out for Canada, Greece, US, UK and the Australian economy. Hence, the interconnections among oil price changes, precious metal prices, policy uncertainty, stock prices, and the exchange rate have been overlooked in the context of Russian economy. Analysing the nexus between these can help contribute to policy formulation and investment strategies for oil-exporting countries like Russia.

Quantifying the impact of uncertainty shocks on macroeconomic activity has been a common research area in recent literature, predominantly using different specifications of VAR approaches (Bloom, 2009; Baker, Bloom, Davis, 2014; Caggiano, Castelnuovo, Figueres, 2013). A substantial amount of literature analyses the spillover impact of US macroeconomic shocks on the business cycle and financial markets at a global context (Kim, 2001; Favero, Giavazzi, 2008). There has also been a comparative discussion between US uncertainty shock and area-specific uncertainty shock by estimating the impact of uncertainty shock on European aggregates (Colombo, 2013). Russia, one of the BRICS economies, is particularly vulnerable to global economic factors as it is a significant recipient of global investment flows and one of the principal consumers of commodities (Mensi et al., 2014). Thence, the impact of policy uncertainty on the Russian economy, which has not been addressed in the literature, is worth studying. The Russian economy has importance in terms of the abundance of its natural resources, and as a result, it is a principal recipient of global investment flows. Russia's policy uncertainty is also of paramount importance due to the reasons mentioned earlier and its promising economic growth. Hence, no previous literature assessed the volatility transmission among the oil prices, exchange rate, political uncertainty, market capitalisation and other precious metals, including gold, silver, palladium, platinum for Russia. We, therefore, claim that our research questions are unprecedented in the literature.

2. Review of Literature

Examination of the connectedness among economic policy uncertainty, precious metal prices, oil prices and macroeconomic indicators (the exchange rate and market capitalisation) is of interest for academics, investors, portfolio managers and policymakers (Yang, 2019). The subject is more critical for an economy like Russian, where hydrocarbon and precious metal revenues play an essential role in the fiscal stance, and, eventually the whole economy.

There exists an extensive group of studies investigating effects of economic policy uncertainty on economic recessions and recoveries, real economic activity and asset pricing models (Baker, Bloom, Davis, 2016; Bloom, 2009; Bloom, 2014; Brogaard, Detzel ,2015), as well as uncertainty spillovers across various countries (Antonakakis, Chatziantoniou, Filis, 2014; Bhattarai, Chatterjee, Park, 2019; Caggiano, Castelnuovo, Figueres, 2020; Colombo, 2013; Klößner, Sekkel, 2014). In this section, we are focusing on the group of studies on volatility spillovers and dynamic connectedness of financial and commodity markets, with the special attention on economic policy uncertainty issues. In terms of methodology, most volatility spillover studies in financial and commodity markets rely on various modifications of generalised autoregressive conditional heteroskedasticity (GARCH) type models, i. e. Vector Autoregressive GARCH, Exponential GARCH, Fractionally Integrated GARCH, Univariate, Bivariate and Multivariate GARCH, Dynamic Conditional Correlation GARCH, etc. (Kang, Ratti, Vespignani, 2017; Basher, Sadorsky, 2016; Mensi et al., 2014; Creti, Joëts, Mignon, 2013; Arouri, Jouini, Nguyen, 2012). Some studies implement D.Y. approach (Diebold and Yilmaz, 2014) considering time and frequency domain (Husain et al., 2019; Baruník, Křehlík, 2017). For instance, Baruník, Kočenda and Vácha (2016b), Mensi et al., (2013), Creti, Joëts and Mignon (2013) and Choi and Hammoudeh, (2010), among others, examine interrelations between commodity and stock markets in a time-varying perspective and find linkages between these assets with increased volatility over time. Gold and silver transmit information to other commodity futures markets (WTI, corn, wheat, and rice) (Kang, McIver, Yoon, 2017), while real oil prices have positive impact on gold (Tiwari, Sahadudheen, 2015). Finally, palladium, gold and platinum are strong contributors to the volatility spillover among crude oil, stock market and other precious metals indices, and crude oil, titanium, steel and silver are net receivers (Husain et al., 2019). Overall, existing research on the relations between commodity and stock markets is limited to the effort of uncovering volatility spillover effects and market co-movements under both time and frequency domain (Ji et al., 2018; Khalfaoui, Boutahar, Boubaker, 2015; Mensi et al. 2013; Arouri, Jouini, Nguyen, 2011; Arouri, Jouini, Nguyen, 2012).

In comparison to the strand of research revealing oil price shock's impact on stock markets or equity markets with the use of GARCH type models, only several studies focused on its impact on metal prices, interest rates and exchange rates with the use of D.Y. extensions (Guhathakurta Dash, Maitra, 2020; Awartani, Aktham, Cherif, 2016; Yang, Zhou 2017; Mandaci, Cagli, Taşkın, 2020). Moreover, prior studies on the interrelations between oil, precious metals and stock market indicators mainly focused on developed economies, with few exceptions (Bouri et al., 2017; Ghosh, Kanjilal, 2016; Raza, et al., 2016; Jain, Biswal, 2016; Sadorsky, 2014).

Considering an aspect of economic policy uncertainty, the existing group of studies does not investigate in details the nature of connectedness between policy uncertainty and oil price shocks. There are only a few recent studies in this context. Focusing on the US market, Yang (2019) postulates that, regarding economic policy uncertainty, the crude oil price is information receiver and that US economic policy uncertainty reflects tremendous significance in the long run. Focusing on dynamic connectedness and spillover effects in oil-importing countries, Wang and Lee (2020) reveal robust results on the impact of fiscal policy uncertainty, exchange rate policy uncertainty, monetary policy uncertainty, and trade policy uncertainty on crude oil returns. Dynamic connectedness between three identified structural oil price shocks and gold price in the presence of economic uncertainty is considered in the study (Mokni et al., 2020); one of the main findings is that economic policy uncertainty has a significant impact on the dynamic connectedness. In addition to the scarcity of existing research regarding dynamic connectedness and policy uncertainty, to the best of our knowledge, there exists no other study in this context of Russian economy applying TVP-VAR model extension of the Diebold and Yilmaz (2014) technique. Our study's primary goal is to fill this gap in the literature by using novel data.

Russia is an important member of BRICS, a major global economic block. It is an important member of oil-exporting countries as one of the biggest energy supplier in Europe (Fang, You, 2014; Filis, Chatziantoniou, 2014; Malik & Umar, 2019). In contrast to extensive international evidence, current literature considering Russian evidence on energy market — stock market nexus is somewhat limited. For example, Fang and You (2014) found that only supply-side oil price shocks have a significant positive effect on the Russian stock market. Huang et al., (2017) showed oil price and exchange rate volatilities across time influence the Russian stock market. Bouoiyour et al. (2015) demonstrated the bidirectional long-run relationship between oil price and real exchange rate, whereas the direct impact of the oil price on the real exchange rate is conditional to various macroeconomic control variables. Overall, there is no evidence of the dynamic linkage among policy uncertainty, stock market, oil price and precious metal markets volatilities spillover in Russian settings.

3. Data and Methodology

3.1. Data and Preliminary Analysis

We utilise the daily data from 2 July 2008 to 15 May 2020 in our empirical setup. Table 1 describes our variables, definition and sources.

The balanced availability of all series determines our sample period. The primarily concerned variable is Russian economic policy uncertainty, which is constructed based on the key economic policy terms in the newspaper articles. We consider market capitalisation, which is the sum of the product of share price times the number of shares outstanding for all listed domestic companies. Anecdotal evidence shows that the stock market is susceptible to policy uncertainty. Since Russia is highly dependent on hydrocarbon exports, we take international oil price, which explains the country's foreign currency reserve, and exchange rate. Exchange rate volatility, which is relatively high in Russia, is sensitive to Russian economic policy, trade and international relations. Due to its plausible role, this study includes daily exchange rate (Rouble/1USD). Figure 1 shows rouble devalued sharply in the mid of 2014 and onward due to imposition of economic sanction. Concurrently, the international price plunged due to thriving US shale oil production and gaining efficiency. Russia is a top-3 country in terms of producing minerals including gold, platinum and palladium and silver. We consider the daily price of gold, platinum and palladium and silver in our price volatility spillover framework. Figure 1 shows that prices of precious metals are soaring overtime, contrary to the

Table 1

Data, definition and sources

Variable	Definition	Source
Policy uncertainty index (PUI)	To measure policy-related economic uncertainty for Russia, we construct an index based on frequency counts of newspaper articles	http://www.policyuncertainty.com/index.html
Market capitalisation (LMC)	The sum of the product of share price times the number of shares outstanding for all listed domestic companies	Bank of Russia https://www.cbr.ru/eng/hd_base/
Oil Price (Oil)	Spot crude oil price in dollars per barrel	Energy Information Administration https://www.eia.gov/
Official exchange rate (EXR)	Average weighted rate (Rouble/US dollar)	Bank of Russia https://www.cbr.ru/eng/hd_base/
Gold Price (Gold)	Reference prices for refined gold per gram	Bank of Russia https://www.cbr.ru/eng/hd_base/
Silver Price (Silver)	Reference prices for refined silver per gram	Bank Russia https://www.cbr.ru/eng/hd_base/
Platinum Price (Platinum)	Reference prices for refined platinum per gram	Bank of Russia https://www.cbr.ru/eng/hd_base/
Palladium price (Palladium)	Reference prices for refined Palladium per gram	Bank of Russia https://www.cbr.ru/eng/hd_base/

oil price, which is partially helping to lower the oil price induced fiscal pressure.

3.2. Econometric Approach

This study applies dynamic connectedness under time-varying parameter vector autoregression (TVP-VAR) approach proposed by Antonakakis and Gabauer (2017) which is an updated version of dynamic connectedness or spillover impact proposed by Diebold and Yılmaz (Diebold and Yılmaz, 2009; Diebold and Yılmaz, 2012; Diebold and Yılmaz, 2014). The current framework includes a changing variance via a stochastic volatility Kalman Filter estimation, along with forgetting factors developed by Koop and Korobilis (2014). Therefore, this approach can overcome the biases that a standard technique often encounters due to arbitrarily selection of rolling window size. It is argued that an arbitrary selection of rolling window size leads an inconsistent parameter and reduces valuable observations. Dynamic connectedness under time-varying parameter vector autoregression (TVP-VAR) approach is also robust in the case of a less frequent and short span of time-series data.

TVP-VAR approach can be exhibited as follows

$$Y_t = \beta_t Y_{t-1} + e_t \; e_t \mid F_{t-1} \sim N(0, S_t), \quad (1)$$

$$\beta_t = \beta_{t-1} + \nu_t \; \nu_t \mid F_{t-1} \sim N(0, R_t), \quad (2)$$

where Y_t indicates a column matrix ($N \times 1$) conditional volatility vector, Y_{t-1} is the lagged conditional vector of Y_t following $N_p \times 1$ order or matrix. β_t is the time-varying coefficient matrix following the $N \times N_p$ dimension. e_t is the vector of error terms following $N \times 1$ dimension along with $N \times N$ time-varying covariance matrix S_t. The vector of the coefficient matrix β_t relies on their respective values β_{t-1} following $N \times N_p$ dimensional residual matrix along with an $N_p \times N_p$ variance-covariance matrix. This approach subsequently measures the generalised connectedness following Diebold and Yilmaz (2014) considering time-varying parameters and error covariances. This framework eventually allows to estimate volatility spillover by utilising generalised impulse response functions (GIRF), and generalised forecast error variance decompositions (GFEVD) suggested by Koop, Pesaran and Potter (1996) and Pesaran and Shin (1998), respectively. Note that, we transform the VAR to its vector moving average (VMA) representation to estimate GIRF and GFEVD following the Wold theorem as follows:

$$Y_t = \beta_t Y_{t-1} + e_t, \quad (3)$$

$$Y_t = A_t e_t, \quad (4)$$

$$A_{0,t} = I, \quad (5)$$

$$A_{i,t} = \beta_{1,t} A_{i-1,t} + \ldots + \beta_{p,t} A_{i-p,t}, \quad (6)$$

where $\beta t = [\beta_{1,t}, \beta_{2,t}, \ldots, \beta_{p,t}]'$ and $A_t = [A_{1,t}, A_{2,t}, \ldots, A_{p,t}]'$, therefore $\beta_{i,t}$ and $A_{i,t}$ are $N \times N$ dimensional parameter matrices.

GIRF exhibits the responses of all respective variables after a shock in variable *i*.

As our model does not follow a structural modelling, we estimate the differences between a *J* — step-ahead forecast in the case if variable *i* is

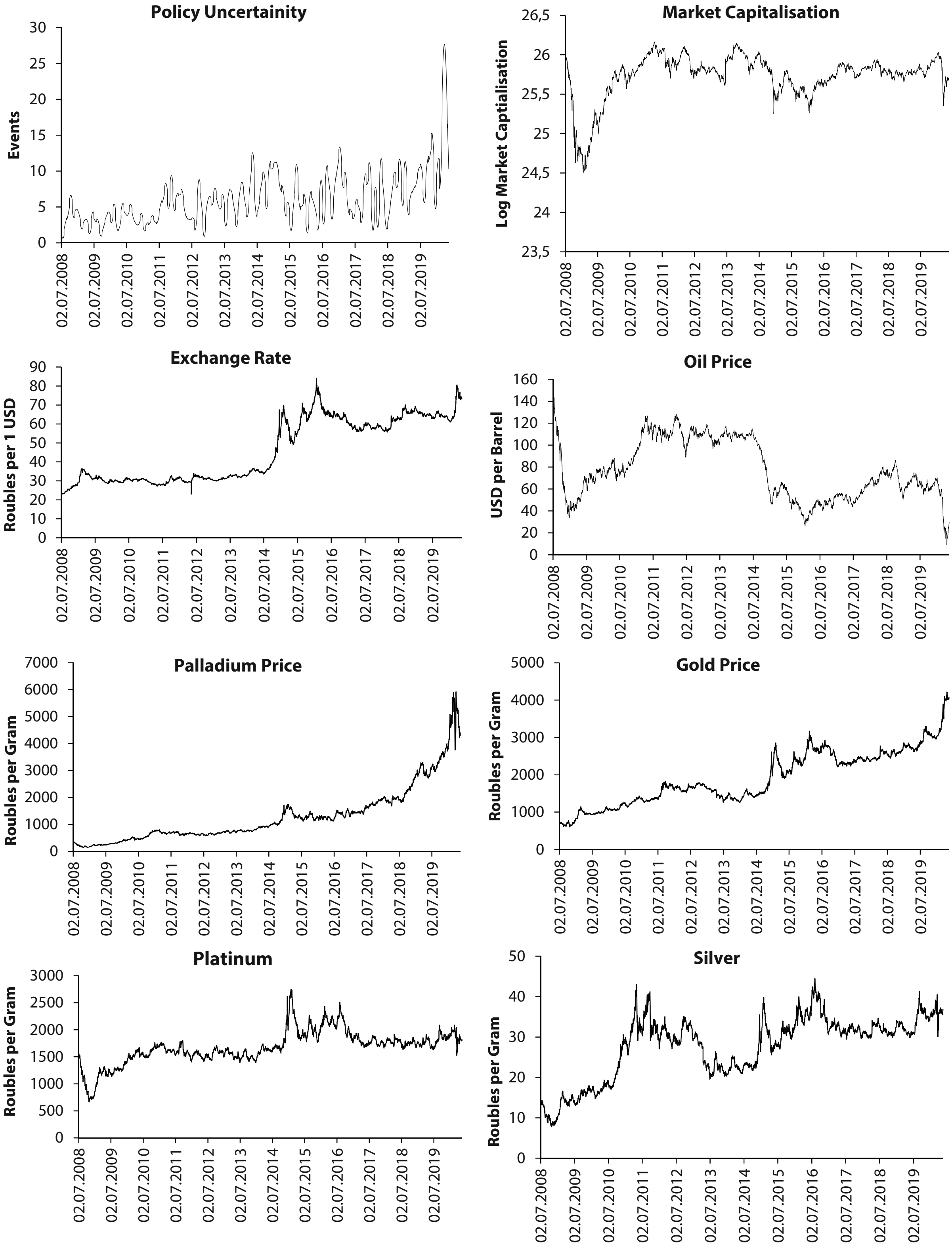

Fig. 1. *Trend Analysis*

shocked as well as not shocked. The difference can be estimated to the shock in variable i, as follows

$$GIR_t\left(J, \delta_{j,t}, F_{t-1}\right) = = E\left(Y_{t+J} \mid e_{j,t} = \delta_{j,t}, F_{t-1}\right) - E\left(Y_{t+J} \mid F_{t-1}\right), \quad (7)$$

$$\psi_{j,t}^{g}\left(J\right) = \frac{A_{J,t} S_t e_{j,t}}{\sqrt{S_{jj,t}}} \frac{\delta_{j,t}}{\sqrt{S_{jj,t}}} \delta_{j,t} = \sqrt{S_{jj,t}}, \quad (8)$$

$$\psi_{j,t}^{g}\left(J\right) = S_{jj,t}^{-\frac{1}{2}} A_{J,t} S_t e_{j,t}, \quad (9)$$

where J indicates the forecast period of time, $\delta_{j,t}$, the selection vector with one on the j^{th} position and zero otherwise, and F_{t-1} the information set until $t-1$. Subsequently, we estimate GFEVD that can be explained as the variance share one variable has on others. The estimated variances are eventually normalised, so that each row added up to one, indicating that all variables together describe 100 % of variable's i forecast error variance. This is estimated as follows

$$\tilde{\phi}^{g}_{ij,t}(J) = \frac{\sum_{t=1}^{J-1} \Psi^{2,g}_{ij,t}}{\sum_{j=1}^{N} \sum_{t=1}^{J-1} \Psi^{2,g}_{ij,t}}, \tag{10}$$

with $\sum_{j=1}^{N} \tilde{\phi}^{N}_{ij,t}(J) = 1$ and $\sum_{i,j=1}^{N} \tilde{\phi}^{N}_{ij,t}(J) = N$. Applying GFEVD, we estimate the total connectedness index by

$$C^{g}_{t}(J) = \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\phi}^{g}_{ij,t}(J)}{\sum_{i,j=1}^{N} \tilde{\phi}^{g}_{ij,t}(J)} 100, \tag{11}$$

$$= \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\phi}^{g}_{ij,t}(J)}{N} 100. \tag{12}$$

This framework of connectedness demonstrates how shocks in a variable spillover to other variables. First, we observe the case where variable i transmits its shock to all other variables j, shown as

$$C^{g}_{i\to j,t}(J) = \frac{\sum_{j=1, i\neq j}^{N} \tilde{\phi}^{g}_{ji,t}(J)}{\sum_{j=1}^{N} \tilde{\phi}^{g}_{ji,t}(J)} 100. \tag{13}$$

Second, we calculate the directional connectedness variable i receives from variables j, called total directional connectedness from others, defined as

$$C^{g}_{i\leftarrow j,t}(J) = \frac{\sum_{j=1, i\neq j}^{N} \tilde{\phi}^{g}_{ij,t}(J)}{\sum_{i=1}^{N} \tilde{\phi}^{g}_{ij,t}(J)} 100. \tag{14}$$

Finally, we subtract total directional connectedness to others from total directional connectedness from others to obtain the net total directional connectedness, which can be interpreted as the 'power' of variable i, or, its influence on the whole variables' network.

$$C^{g}_{i,t}(J) = C^{g}_{i\to j,t}(J) - C^{g}_{i\leftarrow j,t}(J). \tag{15}$$

If the net total directional connectedness of variable i is positive, it means that variable i influences the network more than being influenced by that. By contrast, if the net total directional connectedness is negative, it means that variable i is driven by the network

4. Results and Discussion

We estimate the volatility spillover effects among several macroeconomic indicators including Russian economic policy uncertainty, exchange rate, stock market and different precious metal markets including gold, silver, platinum and pallidum. Table 4 presents the results highlighting the total volatility of spillover effects. The ith and jth entry in each panel are estimated contribution to the forecast-error variance of variable i coming from market j. The diagonal coefficients of Table 4 present the autoregressive or own lag values effect on the forecast-error variance, while the off-diagonal coefficients present cross-market spillover. The last column of Table 4 reports ith variables receive the magnitude of volatility from the vector jth variables. The third last row of Table 4 highlights the total volatility spillover effect that each variable contributes to other variables. The last row highlights the net volatility contribution of each variable by subtracting total volatility receives from the total volatility contribution, respectively. The net positive values on the last row indicate the net volatility contributors, whereas the negative values represent the net volatility receivers. Our model is explained by 50 % volatility spillover in all the selected markets. Our analysis demonstrates that gold, policy uncertainty, oil and market capitalisation are net volatility contributors whereas palladium, platinum, silver and exchange rate are net volatility receivers. In our model, the stock market and silver market are found to be the highest volatility contributor and receiver, respectively.

Policy uncertainty index (PUI) is influenced by the lagged values of economic policy uncertainty by 67.15 %. Table 4 also shows that the volatility of PUI is the reason for more than 5 % volatility in the foreign exchange rate through the channel of import and export. Our empirical findings support the proposition of Beckmann and Czudaj (2017) who document a strong association between policy uncertainty and exchange rate. The announcement of any economic decision influences the exchange rate as different economic agents react based on either adaptive or rational expectation. PUI also contributes more than 5 % volatility in the stock market. Our estimated result echoes a couple of empirical and seminal

Table 2

Summary Statistics

	PUI	GOLD	EXR	PLATINUM	PALLADIUM	OILPRICE	LMC	SILVER
Mean	6.125189	1919.375	45.94689	1675.560	1290.787	77.02315	25.72614	27.75130
Median	5.349053	1717.890	35.84353	1677.340	930.1950	71.79500	25.78650	30.57000
Maximum	27.67387	4217.370	84.07080	2746.690	5923.000	143.9500	26.16336	44.53000
Minimum	0.630901	602.4700	23.02503	664.7800	144.3200	9.120000	24.50646	7.810000
Std. Dev.	3.713458	732.0766	16.45657	304.1315	1045.014	26.79085	0.287529	7.776761
Skewness	1.995622	0.337800	0.254311	–0.196035	1.752926	0.169180	–1.932899	–0.689269
Kurtosis	10.59746	2.430994	1.353727	4.540158	6.312629	1.876670	7.386406	2.593841
Jarque–Bera	13306.36	140.9566	536.3835	456.3287	4203.120	248.6619	6176.081	373.1365
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	26558.82	8322409.	199225.7	7265228.	5596851.	333972.4	111548.5	120329.6
Sum Sq. Dev.	59778.64	2.32E+09	1173999.	4.01E+08	4.73E+09	3111445.	358.3868	262172.2
Observations	4336	4336	4336	4336	4336	4336	4336	4336

Table 3

TVP-VAR-Static

	Palladium	**Gold**	**Platinum**	**Silver**	**EXR**	**PUI**	**OIL**	**MC**	**FROM**
PALLADIUM	74.322	8.236	14.188	3.158	0.03	0.035	0.025	0.007	25.678
GOLD	6.942	52.903	28.683	11.104	0.264	0.038	0.033	0.033	47.097
PLATINUM	10.773	28.412	52.75	7.942	0.084	0.001	0.029	0.01	47.25
SILVER	3.741	14.861	11.718	69.44	0.052	0.083	0.097	0.008	30.56
EXR	0.016	0.036	0.051	0.013	98.273	0.016	1.459	0.136	1.727
PUI	0.07	0.003	0.027	0.028	0.118	99.601	0.063	0.09	0.399
OIL	0.025	0.14	0.047	0.056	2.278	0.016	96.292	1.146	3.708
MC	0.026	0.026	0.018	0.01	0.152	0.019	0.316	99.433	0.567
Contribution TO others	21.592	51.714	54.731	22.311	2.979	0.208	2.021	1.431	156.987
Contribution including own	95.914	104.617	107.481	91.75	101.252	99.809	98.313	100.864	TCI
Net spillovers	–4.086	4.617	7.481	–8.25	1.252	–0.191	–1.687	0.864	19.623

Table 4

TVP-VAR-Dynamic

	PUI	**STM**	**Gold**	**OIL**	**Palladium**	**Platinum**	**Silver**	**EXR**	**FROM**
PUI	67.152	5.924	4.238	5.362	4.07	3.931	3.908	5.416	32.848
STM	5.225	69.874	3.768	5.929	3.636	3.706	3.405	4.457	30.126
Gold	4.479	4.632	34.078	4.991	14.672	13.925	12.799	10.424	65.922
OIL	5.087	6.786	5.154	60.737	4.644	4.761	4.243	8.588	39.263
Palladium	4.462	4.882	14.13	6.347	40.537	11.238	9.374	9.03	59.463
Platinum	4.955	5.689	15.851	4.972	12.012	38.565	11.417	6.538	61.435
Silver	4.259	5.326	17.123	5.646	7.139	13.547	41.134	5.826	58.866
EXR	5.038	6.991	9.515	10.153	10.766	5.134	4.511	47.892	52.108
Contribution TO others	33.504	40.229	69.779	43.4	56.94	56.242	49.657	50.279	400.032
Contribution including own	100.656	110.103	103.857	104.137	97.477	94.807	90.791	98.171	TCI
Net spillovers	0.656	10.103	3.857	4.137	–2.523	–5.193	–9.209	–1.829	50.004

studies who relate the role of policy uncertainty in translating stock volatilities (Boutchkova et al., 2012; Pastor, Veronesi, 2012; Durnev, 2011; Goodell, Vähämaa, 2013). Prior literature documents that the stock market volatility is sensitive with macroeconomic policies as corporate react in term of their investment decisions. Policy uncertainty has the least influence on silver market volatility, which can be attributed to the fact that its price is relatively low compared to other precious metals and less elastic with any exogenous shocks. Policy uncertainty contributes 33.5 % of volatiles to other variables while its own volatility is contributed by 32.8 %; hence, it appears to be a net contributor. Other market price volatilities significantly influence the economic policy

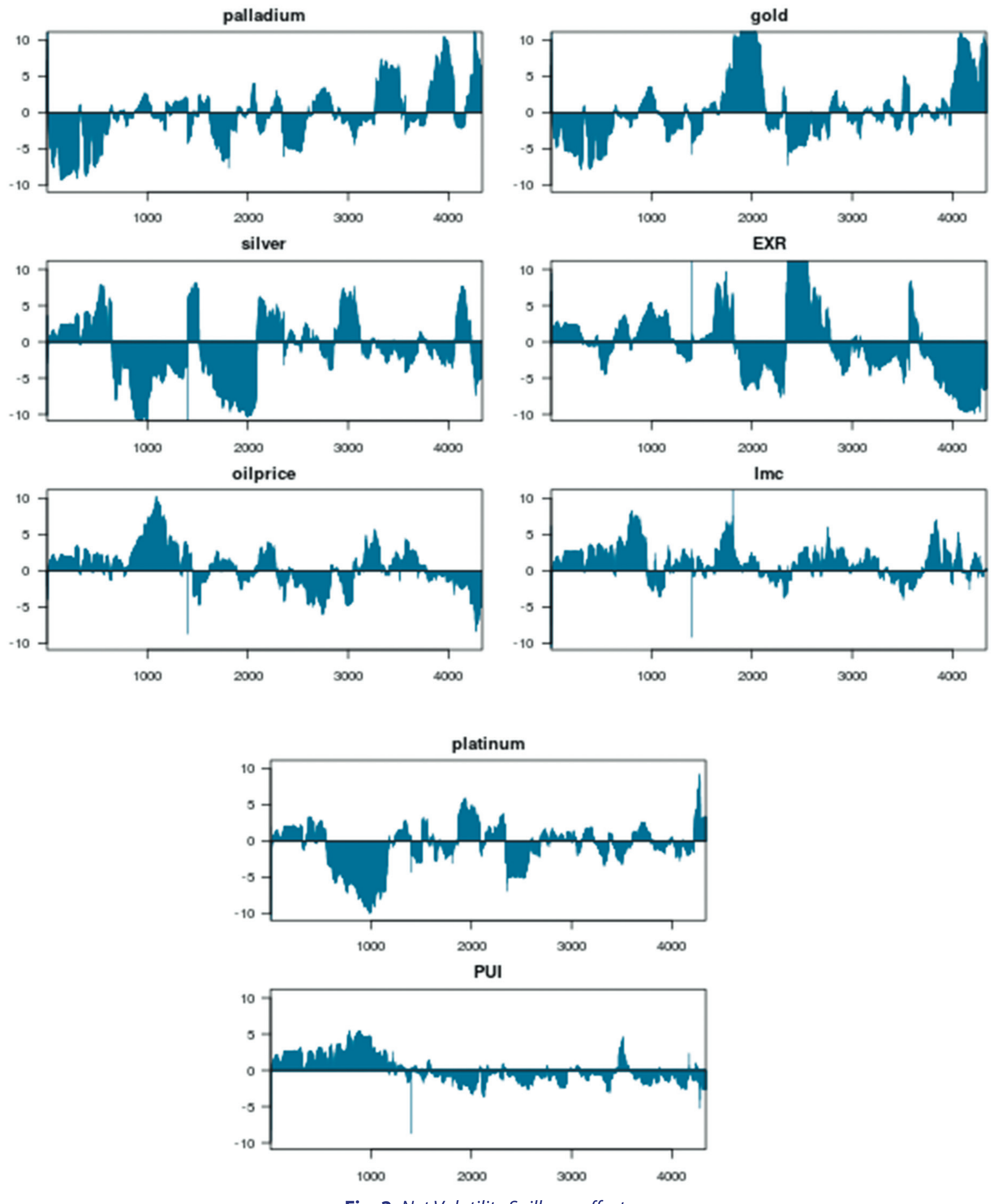

Fig. 2. *Net Volatility Spillover effect*

since the Russian government requires to accommodate inevitable changes in other markets, especially oil price and exchange rate. Our propositions are reflected by pairwise assessment as Table 4 shows PUI is the net contributor of volatility spillovers to mainly precious metal prices including gold, platinum and silver.

In contrast, Russian PUI in influenced by the stock market, oil price, palladium price and exchange rate volatiles. Our findings provide an insight that Russian policy is influenced by the international oil price rather than its ability to influence. Although Russia is one of the biggest oil-producing countries with relatively lower extraction and refinery cost, Russia has less influence against its rival due to OPEC curtail and their aligned oil-exporting countries. Nevertheless, we believe that Russian policy uncertainty is influenced by both the demand-driven and supply-driven oil price shocks unlike OPEC countries (Baumeister, Peersman, 2013; Hamilton, 2009; Kilian, 2009; Lippi, Nobili, 2012)

Stock market (STM) appears to be the highest net volatility contributor (10.10 %) to the other markets. Table 4 reports that STM influences the volatility of other respective variables about 40.229 % while it is influenced by 30.12 % from the rest of the seven variables. STM mostly influences policy uncertainty, exchange rate and oil price, as well as STM is influenced by them. The highest and lowest volatility contribution of STM is found to be 6.99 % towards exchange rate and 4.63 % towards the gold market. On the contrary, oil marker has the strongest influence and palladium has the least influence on STM.

The gold market appears to be the highest total (69.77 %) and third-largest net (3.85 %) volatility contributor to other concerning markets. Table 4 shows that the gold market is the reason for 14.13 %, 15.851 % and 17.123 % volatility in palladium, platinum and silver markets, respectively. In contrast, gold price volatility is explained mainly by palladium price, exchange rate and policy uncertainty. About 34.07 % price volatility of the gold market price is influenced by its own lagged price. Russia's oil export meets around 12 % of global oil demand. Thus, international oil price plays an important role in the Russian balance of payment, exchange rate and other markets. Oil price contributes 43.4 % volatility to the other markets. Interestingly, our time-varying analysis shows that oil price net contributor influences the Russian policy uncertainty. Either way, oil price and exchange rate appear to be the highest volatility contributors of each other.

Russian exchange rate (EXR) is sensitive to the countries' geopolitical issues as exchange rate with USD climbed up from roughly from 35 RUB to 65 RUB per 1 USD. Our empirical analysis shows that EXR is a net volatility receiver. Russia faces economic sanctions including in oil exploration and production equipment and services which aggravates large scale capital outflows leading to the collapse of the RUR exchange rate in 2014–2015. Interestingly, EXR has a net spillover effect on economic policy uncertainty (5.416 – 5.038 = 0.378), gold price (10.424 – 9.515 = 0.909), platinum price (6.538 – 5.134 = 1.404) and silver price (5.826 – 4.511 = 1.315). EXR receives net volatility spillover from the stock market (4.457 – 6.991 = = –2.534), oil price (8.588 – 10.153 = –1.565) and palladium price (9.030 – 10.766 = 1.736). Our empirical findings are in harmony with prior literature, where they document that a variation in exchange rates has spillover impacts on global crude oil market and domestic stock returns as well (Sari, Hammoudeh, Soytas, 2010; Bouoiyour et al., 2015; Gavin, 1989; Reboredo, Rivera-Castro, Ugolini, 2016).

Figure 2 reports the net volatility spillover effect of each market. The figure shows that palladium appears as a net volatility receiver at the beginning, just after the global financial crisis. Over the year 2014, gold price was the prominent volatility contributor to another market when the oil price dropped significantly. Russian exchange rate often receives the volatility spillover from the other market, consistent with (Sohag et al., 2021). Interestingly, Russian economic policies are often induced by the other markets.

5. Conclusion

The world economy is characterised by an unnatural fluctuation due to various market connectedness, financial crisis, policy uncurtaining, pandemic, endogenous and economic policy uncertainty. In this study, we examined the dynamic connectedness among economic policy uncertainty, international oil price, exchange rate, stock market index and the prices of various precious metals in the context of the Russian economy. To this end, we applied a dynamic connectedness volatility spillover approach under time-Varying Parameter Vector Autoregression (TVP-VAR) framework to analyse daily data for the period from 2 July 2008 to 15 May 2020. The conducted research yielded several interesting findings. Stock market volatility is found to be the main volatility spillover contributor to other markets considered in this study. Our empirical investigation demonstrates that economic policy uncertainty is the smallest net volatility spillover contributor to other markets. Besides, the international oil price and gold price appear to be net volatility spillover contributors. In contrast, our analysis highlights that silver, platinum and palladium markets, as well as exchange rate, are net volatility receivers from stock, gold and international oil price market as well as economic policy uncertainty. The silver market is found to be the main net volatility spillover receiver.

Our empirical findings can be helpful to portfolio managers for hedging purposes as well as the Russian economy, primarily focusing on natural resource extracting regions. For instance, the gold price is a useful hedge against the silver price as we found the gold price is the highest volatility contributor to the silver price. Russian economic policy uncertainty also highly influences the Moscow stock exchange and exchange rate; thus, the policy stability is vital to stabilize the respective indicators.

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About the authors

Kazi Sohag — PhD in Economics, Academic Head of the Laboratory for International and Regional Economics, Graduate School of Economics and Management, Ural Federal University; https://orcid.org/0000-0002-0976-2357 (Ekaterinburg, 620075, Russian Federation; e-mail: ksokhag@urfu.ru).

Shaiara Husain — PhD Scholar, Department of Economics, University of Western Australia; https://orcid.org/0000-0002-7228-3869 (Crawley, Perth, 6009, Australia; e-mail: shaiara.husain@research.uwa.edu.au).

Kristina Chukavina — Masters in Economics, Senior Lecturer, Graduate School of Economics and Management, Ural Federal University; https://orcid.org/0000-0002-0189-2923 (Ekaterinburg, 620075, Russian Federation; e-mail: k.v.chukavina@urfu.ru).

Md Al Mamun — PhD in Finance, Lecturer, Department of Economics and Finance, La Trobe University; https://orcid.org/0000-0002-6540-9195 (Bundoora, Melbourne, 3086, Australia; e-mail: M.AlMamun@latrobe.edu.au).

Информация об авторах

Сохаг Кази — кандидат экономических наук, научный руководитель, Лаборатория международной и региональной экономики, Институт экономики и управления, Уральский федеральный университет; https://orcid.org/0000-0002-0976-2357 (Российская Федерация, 620075, г. Екатеринбург; e-mail: ksokhag@urfu.ru).

Хусейн Шайара — аспирант, экономический факультета, Университет Западной Австралии; https://orcid.org/0000-0002-7228-3869 (Австралия, 6009, г. Перт, Кроули; e-mail: shaiara.husain@research.uwa.edu.au).

Чукавина Кристина — магистр экономики, старший преподаватель, Институт экономики и управления, Уральский федеральный университет; https://orcid.org/0000-0002-0189-2923 (Российская Федерация, 620075, г. Екатеринбург; e-mail: k.v.chukavina@urfu.ru).

Аль Мамун Мд — PhD в области финансов, преподаватель, кафедра экономики и финансов, Университет Ла Троба; https://orcid.org/0000-0002-6540-9195 (Австралия, 3086, г. Мельбурн, Бандура; e-mail: M.AlMamun@latrobe.edu.au).

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