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Is the Russian Green Bond Market Strong Enough to Hedge in the Crisis Times?

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Abstract

The scope of this research has two facets. First, we study the spillover effects between the Russian green bonds and the leading capital market's 'indexes before and after the February 2022 events. Second, the identified level of asset connectedness permits to identify portfolio management implications for the analyzed assets. To reveal the spillover effects, we applied the vector autoregressive model and created a synthetic index to capture the dynamics of the green bonds market which included 14 green bond issues between 2021 and 2023 in Russia. We analyze oil & gas, electrical utilities, metals & extraction, chemical sectors collectively referred to as "pollution intensive indexes". The paper contributes by discovering that the total connectedness index (TCI) between Russian green bond market and pollution intensive indexes changed over time and increased after the outbreak of the conflict. Additionally, the paper is novel on revealing the relationship between low hedging effectiveness and hedging ratio of green bond and energy, metals and extraction, sustainability and oil and gas indexes which indicate no need for hedging after February events. The optimal bivariate portfolio weights analysis shows that Russian green bonds market is an outstanding instrument for assets portfolio management during geopolitical conflict. These findings have implications for the government and other stakeholders to manage both the contagion and climate risks during the military conflict.

Keywords: green bonds, Russian capital market, spillover, hedging, economic shocks

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Introduction

The current geopolitical context between Russia and Ukraine, which is determined by the military conflict, caused major structural changes and turbulence in the Russian economy and its capital market. In response to the military conflict, Western countries isolated the Russian economy through sanctions. This policy along with changes in the global and regional energy markets significantly influenced the development path towards sustainability for Russia and rest of the world. Even though the Russian Federation adhered to its sustainable development trajectory, its commitment to achieve the climate targets underwent some tectonic changes, e.g., changes in the legislation design, level of development of the sustainable financial market, access to foreign green technology, international green resources, capabilities, etc. Despite this macroeconomic shock, the Russian green bond market continued its development and increased by 168%[1] since the beginning of the military conflict. Additionally, the Russian capital market experienced crisis dynamics but it stabilized and shifted to a development trend within one year (e.g., the RTS Index increased by 25% in January 2023 compared to February 2022). According to the green finance platform and climate policy database, since the conflict between Russia and Ukraine started, only two regulatory frameworks have been launched (e.g., Decree regarding banned timber-related exports to the EU (2022); Long-term Strategy Russian Federation (2022))[2], while all other policies were implemented before the conflict, which indicates that the priority of sustainable development for the economy was downgraded.

The main scope of this research is to reveal the spillover effects of Russian green bonds towards the main capital market indexes before and after the outbreak of the military conflict, also including the direction of these relationships (either "FROM" or "TO"). It is important to reveal the level of connectedness and to identify the extent to which the Russian green bond market can be used for hedging and portfolio management solutions in the context of macroeconomic shocks. The importance of this research also stems from the fact that the options for hedging against macroeconomic shocks are limited due to Western sanctions on the Russian economy.

Current literature shows that international capital markets were shocked by the geopolitical conflict from the perspective of the general financial market risk and the dynamics of relationships between different capital market assets (e.g., energy companies, etc.) W. Jiang et al. [1] found that during period 2020–2022 the connectedness between traditional, new energy, ESG and green bond markets increased from 19.35% (before February 2022) to almost 30% (after February 2022), showing that there were high transmission forces between these assets for the Chinese economy in the crisis period. O.B. Adekoya and J.A. Oliyide [2] found that the geopolitical crisis increased the connectedness between analyzed capital markets assets during the conflict compared to the preceding period. A similar conclusion was reached by W. Jiang et al. [1], who found that the spillover direction among the assets changed significantly in the crisis period, indicating that investors should change the hedging strategy and portfolio management structure accordingly (e.g., bonds, oil, gold cryptocurrency, etc.). R. Karkowska and S. Urjasz [3] analyzed how the connectedness changed across capital market assets (renewable and non-renewable energy and stock markets), in Europe, US and Asia before and after geopolitical conflict. They found that the US is a net transmitter of spillover, while Europe is a net receiver of the market shocks because European countries were more affected by geopolitical conflict.

To achieve the research objectives, we employed a unique methodological approach for simulating the Russian green bond market through a synthetic index with regard to the price dynamics of all the green bond issuances between January 2021 and December 2023. Further, we have used the F. Diebold and K. Yilmaz's DY model [4] to reveal the connectedness between Russian green bonds and other leading capital market indexes, including pollution-intensive ones (e.g. Electric Utilities, Metals & Mining, Oil & Gas etc.)

First, our findings show that the spillover effects of the Russian green bond market have a different trajectory compared with the other capital market indexes before and after the February 2022 events. The Russian green bond market index is a net receiver of return volatility spillover both in 2021 and 2022 comparing with the other assets that changed their spillover direction. This trajectory change revealed that the green bond market was not significantly affected by the geopolitical conflict.

Even though the structure of the analyzed capital market indexes is different from the existing literature, we found that the value of the connectedness index among the analyzed assets during the crisis period increased from 49.6 to 64.5%. This result validates the idea that during the crisis capital market asset interdependences create a certain dynamic pattern driven by hedging mechanisms and the restructuring of the portfolio management mechanisms. The connectedness index indicates that market inter-relationships between assets have changed, and investors and asset managers should react accordingly.

The study of the spillover effects between capital market assets requires an analysis of the asset risk management implications, hedging and asset portfolio management aspects (e.g., hedging ratio, portfolio weights and hedging effectiveness). Further, as hedging effectiveness measures the risk reduction in the variance of the unhedged position, we found that Russian green bond index demonstrates low values and is statistically significant when the index is in a long position. This aspect, corroborated by the fact that the Russian green bond index is a net receiver of spillover

[1] URL: https://www.moex.com/en / – the figure reflects the market increase in 2022 and 2023 comparing with the green bonds issuance in 2021.

[2] URL: https://climatepolicydatabase.org/

effects, preliminary indicates there is no need for hedging with a short position in other assets when investing in green bonds (long position).

As far as we know, we are the first to analyze the behavior of the Russian green bond market using a synthetic aggregated index before and after the outbreak of the military conflict through the spillover analysis using the DY model. The main conclusion is that the green bonds still represent a reliable asset to hedge in the Russian capital market and are a good instrument to be used in asset portfolio management even during the turmoil period. The remainder of this study is structured as follows: second section highlights the main literature results and existing research gaps, third section develops the data sample and hypotheses, fourth section provides details about the employed methodology, fifth section presents empirical specifications, and sixth section concludes with the findings.

Literature Review

The geopolitical conflict between Russia and Ukraine triggered global macroeconomic shocks that negatively affected many economies and created commercial and financial disturbances between Western and Eastern countries, the Global North, and the Global South. The non-typical military conflict that started between Russia and Ukraine propelled the academia to investigate the effects of such shocks, especially revealing its impact on the sustainable development path assumed by almost all the nations through the 2015 Paris Agreement. Even though Russia was isolated from the Western economies, it continues its efforts to implement its sustainable development agenda, because climate risks and pollution have no borders. As indicated in the existing literature, green bonds are considered a powerful sustainable finance instrument to support the green transition in developed and emerging capital markets. Moreover, green bonds include environmental benefits dividends, which exhibit high liquidity, lower risks, and higher returns in stable macroeconomic contexts [5]. Other papers analyze the nexus between green bonds as instrument for supporting the green transition and other capital market assets during macroeconomic shocks through risk and return spillover effects [e.g. 4]. In other words, the spillover will reveal a complex array of interdependences between the green bond returns and other assets both between and within the capital market indexes.

The researchers analyzed the spillover effects between green and brown assets, seeking to manage the exposure to idiosyncratic risk determined by climate risks overlapping with macroeconomic shocks [6]. Thus, showing the intensity and direction of risk-return spillover between green bonds and other capital market indexes from the MOEX will allow to build the risk map of the assets [1] and to arrive at the optimal portfolio structure through asset rebalancing by including green bonds as sustainability factors [e.g., 3; 7]. As green bonds are linked to different sustainable development scopes and different industries in the Russian economy, the examination of green bond spillover effects identifies three distinct themes in literature.

First, a certain section of literature focuses on the connectedness between green bonds and other capital market assets during macroeconomic shocks by analyzing the return spillover between the assets before and after the tectonic macroeconomic shift happened. W. Jiang et al. analyzed the level of connectedness and spillover transmission between conventional, new energy, green finance and ESG assets before and after the start of the geopolitical conflict between Russia and Ukraine. Although, the Chinese capital market is far from the epicenter of the conflict, the authors found that the total level of connectedness between assets increased immediately after the conflict had begun. Specifically, it was revealed that green bonds were the net receiver of the spillover effect before the shock and became the net transmitter of spillover after the shock [1]. The COVID-19 pandemic was also considered a macroeconomic shock, albeit with different characteristics; for this reason, academia was comparatively analyzing the level of the green bond spillover effect during different capital market shocks [8–10]. E. Abakah et al. [11] used the S&P green bond index as a proxy to analyze their spillover effect on the blockchain market and other eco-friendly financial assets in the context of macroeconomic instability. They found similar results, namely, that at times of geopolitical instability the level of connectedness between green bonds and other assets is much higher, which makes these assets good instruments for hedging and asset portfolio management, and has similar implications for developed capital markets as well [12].

The second line of research refers to the analysis of green bonds as an instrument of mitigating climate risks used for hedging purposes and portfolio management decisions. Green bonds, as the most important global component of sustainable finance, are highly correlated with the regulatory ecosystem, which is set up either at the country or the regional level [13]. For example, the climate policy uncertainty (CPU) index is an instrument developed by K. Gavriilidis [14], which measures the uncertainty related to climate policies implemented in the US. An analysis of the connectedness between CPU and green bonds reveals the level of risks associated the climate changes and the level of relevant regulatory development in the country – a higher level of CPU will imply a higher level of green bond spillover, and vice versa [15]. Climate risk can be managed properly with green bonds only in those jurisdictions where the level of climate regulatory ecosystem is sufficiently high. To analyze the level of connectedness between green bonds and other assets to reveal the implications on climate risks, studies often include CO_2 emissions or brown energy sources (e.g., Coal) as a proxy. The spillover effect between green bonds and assets that represent climate risks is high, and green bonds are usually the net receivers of these effects [16; 17].

The third theme in literature is the financialization and the decision-making process that derives from the analysis of the spillover effects between green bonds and other capital market assets. It is important to withdraw the maximization factors of economic benefits and long-term value creation and minimize the associated risks, especially those linked to the climate aspects. Different methods of spillover representation, such as: DCC-GARCH and VAR developed by F. Diebold and K. Yilmaz [4], quartile regression model developed by R. Koenker and G. Bassett [18], time-frequency generalized spillover index method and the MVMQ-CAViaR, empirically reveal that green bonds are reliable instruments for hedging and optimal portfolio management [19]. To create an effective hedging structure or to build an optimal portfolio balance between green bonds and other assets, it is important to select the proper assets from a specific capital market. T. Tian et al. [16] found that green bonds can be effectively associated with coal, oil, copper and CHY (the Chinese yuan) in order to reduce significantly the investments risks in the Chinese financial and commodity market. W. Zhang et al. [17] delved into the analysis of the connectedness between green bonds and carbon emission futures and found that a combination of a short position to offset CO_2 emissions and a long position in green bonds is statistically significant, and consequently hedges the risk effectively by taking into account the US and international capital markets indexes. A different approach was developed by L. Pham and H. Do [10], who analyzed the hedging effectiveness of green bonds against the implied volatility to measure the forward-looking market risks in the U.S., European and Chinese stock markets. Overall, it was determined that the level of connectedness between green bonds and other assets is much higher for the US and European than the Chinese capital market in case of forward-looking market risks (e.g., different types of implied volatilities were considered) [20]. Consequently, the optimal portfolio structure and risk management initiatives should also consider cross-market indexes and assets when connecting with the green bonds.

Green bonds create risks and opportunities for national financial markets, and mainly focus on supporting the economies to mitigate and reduce climate risks and strive towards a new economic model based on sustainable development mechanisms. The Russian economy is actively participating in the transition process, despite the geopolitical context, therefore the green bond market is an important capital market enabler for this transition towards the net-zero economy. The spillover analysis shows the connectedness of the green bonds and other capital market assets that allow to mitigate climate risks and are used for hedging and building an optimal capital portfolio structure. This is a research gap in case of the Russian economy. Addressing this gap in the current literature, we have created a synthetic index for capturing the dynamics of the Russian green bond market, aiming to show its return spillover effects on the main indexes from the MOEX.

Data, Variables and Hypotheses

The research uses different data sources to investigate the dynamic causality and spillover effects between the Russian green bond market and other capital market indexes from the Moscow Stock Exchange. To capture the dynamics of the Russian green bond market, a synthetic index was created.

The empirical analysis considers not only the traditional risk spillover between Russian capital market indexes, but also examines the implications of the level of connectedness before and after the outbreak of the military conflict. Moreover, the importance of analyzing the risk and return spillover between green bonds and other Russian capital market indexes is underscored by the fact that the global initiatives towards mitigating climate changes have been threatened and the mechanisms of transition have changed.

Indeed, the conflict between Russia and Ukraine put pressure on the EU and other Western countries' climate agenda due to the energy crisis, global supply chain redesign, sanctions against Russia, etc. The transition towards net-zero economy is supposed to be a collective action undertaken jointly, because climate risks and subsequent global warming do not have any borders. This was the reason for the 2015 Paris Agreement COP-21, which for the first time in the human history aligned the engagement of 196 signatory nations to fight collectively against climate change, bringing together developed and developing countries from the Global South and the Global North.

The current geopolitical conflict changed the roadmap of climate agenda because the global collective initiatives and actions have been broken down. As a result of this geopolitical conflict, Western countries imposed sanctions that decoupled the Russian economy from the global processes that aim to mitigate climate change, with implications on the following: access to Western green technologies, access to the international sustainable financial resources to implement the Russian climate agenda, the implications on the regulatory deployment for climate change (both at national and international levels), or the access to green metals[3].

Considering these aspects, in order to achieve the research objective, 4 categories of indexes from MOEX were used in the analysis: (i) pollution-intensive and climate risk indexes that include the industries with high and negative impact on climate change (Electric Utilities, Metals and Mining, Chemicals, Oil and Gas, Gazprom); (ii) financial sector indexes (Aggregate bond index and Financials); (iii) ESG (Sustainability Vector Index); (iv) digital market index (see Appendix 1). The main reason to include a wide variety of indexes is to reveal the risk and return spillover effect of the green bonds and other capital market assets in the context of geopolitical conflict and economic and financial isolation.

To reach the research objective, we utilize data from January 2021 to December 2023 to capture the spillover effect before and after the start of the conflict between Russia and Ukraine. To analyze the risk of contagion and the spillover effect between the Russian green bond market and other capital market assets, the following research hypotheses can be formulated:

[3] URL: https://www.economist.com/finance-and-economics/2023/09/11/how-to-avoid-a-green-metals-crunch

H.1. Assets that offset climate risks are net transmitters of return spillover towards green bonds, and the connectedness strengthens during economic shocks (e.g., COVID-19, geopolitical conflict between Russia and Ukraine) in the emerging capital market [16; 21]. Thus, the level of connectedness between Russia green bonds and the leading capital market indexes will strengthen after February 2022.

H.2. In both developed and emerging capital markets, the green bond index is highly correlated with ESG assets, especially in the periods after macroeconomic shocks [17; 19; 22]. As a result, the Russian green bond market is highly correlated with the MOEX ESG index in the post-conflict period.

H.3. The Russian green bond index is a good hedging instrument against assets with inherent climate risks after the outbreak of the geopolitical conflict and is an important portfolio rebalancing asset for optimal portfolio weights [23].

H.4. The level of connectedness between the Russian green bond index and other capital market assets is time-varying after February 2022, which is characteristic of green bonds in other emerging capital markets [7].

To reveal the dynamic causality and spillovers between the Russian green bond market and other assets from the Moscow Stock Exchange (MOEX), a synthetic green bond index was created from the daily price dynamics of the green bond issuances on MOEX. The weighted average computation included all the green bond issuances denominated in RUB, which allowed to compile an unbiased index that revealed the dynamics of green bonds in the Russian capital market.

Data on green bond issuances and daily price dynamics were sourced from the Cbonds database and MOEX website. We are among the first to aggregate the price dynamics of the Russian green bond market, which is a pioneering effort as there is no evidence that MOEX had created a similar instrument to capture the dynamics of the green bond market. The final green bond index computation included 14 GB issuances denominated in RUB, and the full price index method was used to calculate the synthetic index:

$$I_T = I_{T-1} \sum_{i=1}^{N} \left(W_i^c \cdot \left[\frac{P_{i,T} / 100}{P_{i,T-1} / 100} \right] \right), \quad (1)$$

where I_T is the value of the index during period T; I_{T-1} is the value of the index during period $T-1$; W_i is the GB issue weight; P_i, T is the price of the issue during period T; and P_i, $T-1$ is the price of the issue during period $T-1$.

To increase the accuracy of our results, a stationary series is used in the analysis. Thus, the logarithm calculation of the index return is included in the model of two consecutive prices as follows: $R_t = \ln(P_t) - \ln(P_{t-1})$, where P_t is the price of assets at time t.

To reveal the characteristics of the data included in the analysis, the descriptive statistics is presented in Table 1.

Table 1. Descriptive statistics of return series

	vars	n	mean	sd	median	min	max	skew	kurtosis	ADF	LB(20)
Rus_GB_index	1	743	−0.00004	0.00183	0.00000	−0.01211	0.01607	0.3895	24.9167	−34.6391	516.82
RUABITR	2	741	0.00000	0.00111	0.00003	−0.02288	0.00674	−11.2063	243.3267	−24.8928	97.98
MOEXEU	3	741	−0.00003	0.00285	0.00006	−0.04891	0.02615	−6.1846	128.5264	−34.8737	105.54
MOEXMM	4	741	−0.00004	0.00217	0.00001	−0.03505	0.01801	−5.2700	97.8475	−31.4232	122.59
MOEXCH	5	741	0.00009	0.00233	0.00009	−0.02482	0.03474	3.1827	86.1870	−25.5218	89.19
MOEXFN	6	741	0.00002	0.00277	0.00015	−0.04889	0.01421	−7.4887	131.5320	−28.4184	98.76
MOEXOG	7	741	0.00003	0.00252	0.00015	−0.04290	0.02707	−5.3836	130.6746	−32.9021	152.31
MOEXIT	8	741	−0.00010	0.00419	0.00011	−0.07594	0.01400	−8.1721	144.2175	−28.7019	91.00
GAZP	9	743	−0.00006	0.00545	−0.00004	−0.06376	0.04189	−3.1786	45.4437	−27.7020	71.22
MRSV	10	741	−0.00002	0.00241	0.00012	−0.04144	0.02191	−6.3057	127.7759	−32.5560	149.04

The average value of the analyzed indexes has both positive and negative values that are attributed to the specifics of the sample period: the post-COVID-19 recovery period and the geopolitical conflict between Russia and Ukraine. The negative average returns of the indexes for 2021–2023 is a sign of a bear market, and positive average returns indicate bullish market conditions. Summary statistics reveal that the standard deviation of the synthetic green bond index is low compared with the other indexes (except RUABITR), which indicates that the green bond market exhibits relative stability comparing with the other indexes in the context of macroeconomic turmoil. The results of the augmented Dickey-Fuller test show that the time series are stationary. The RUGBI and MOEXCH series have a positive skewness, which differs from the other indexes. This variance in distribution indicates the index's unique behavior in the context of continuous macroeconomic instability specific for the sample period.

Empirical methodology

The analysis of the connectedness of green bonds with other assets can be undertaken in different ways, often employing multivariate time-series methods. For example, J. Reboredo and G. Uddin [13] used wavelet analysis to study the spillover effects of green bonds across different capital markets, A. Tiwari et al. [7] employed TVP-VAR to reveal the risk of contagion of green bonds, EU Emissions Trading System (EU ETS) and renewable assets; cross-quantilogram analysis was employed by M. Naeem et al. [24] to show the asymmetric spillovers between green bonds and commodities, etc. Among the existing methods used by authors to empirically determine the dynamic causality and spillovers between green bonds and other capital market assets, the method developed by F. Diebold and K. Yilmaz [4] seems to be more comprehensive than the other methods. The method entails the consideration of the generalized vector autoregression (GVAR) and the generalized variance decomposition matrix (GVD) to reveal the relatedness of capital market assets. We used this method in our research because it is much simpler and more intuitive for assessing asset volatility and also represents a methodological approach to various papers that explore the spillover analysis between green bonds and other capital market assets [16; 25]. To evaluate an asset's risk implications that derive from the spillover analysis and asset portfolio management, the following methodological approaches are used: the DCC-GARCH model was utilized to calculate the hedging ratio employing conditional variance and covariance (method proposed by K. Kroner and J. Sultan [26]; and optimal portfolio weights calculation proposed by K. Kroner and V. Ng [27], which is methodologically associated with the computation of asset hedging effectiveness proposed by L. Ederington [28].

To fulfill the research objective, the method developed by F. Diebold and K. Yilmaz [4] is employed to show both the dynamics and static volatility spillover effects between the analyzed assets from the MOEX. The D&Y method implies the following calculation steps:

First, the n-dimensional covariance stationary variable is calculated:

$$y_t = \Phi(L)y_t + \varepsilon_t = \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \ldots + \Phi_p y_{t-p} + \varepsilon_t, \quad (2)$$

where $\Phi(L)$ is an $n \times n$ coefficient matrix and ε_t is a vector of distributed disturbances with the covariance matrix Σ.

Second, the moving average of yi is calculated by using VAR:

$$y_i = \Psi(L)\varepsilon_t = \Psi_0\varepsilon_t + \Psi_1\varepsilon_{t-1} + \ldots + \Psi_h\varepsilon_{t-h} + \ldots, \quad (3)$$

where vector Ψ_h represents an $n \times n$ polynomial matrix with lag h (h-step-ahead error variance in forecasting y_i). Next, the generalized forecast error variance decomposition (GFEVD) is calculated:

$$\theta_{ij}^{H} = \frac{\sum_{h=0}^{H-1}\left(e_i^{'}\Psi_h \Sigma e_j\right)^2}{e_j^{'}\Sigma e_j \bullet \sum_{h=0}^{H-1} e_i^{'}\left(\Psi_h \Sigma \Psi_h^{'}\right)e_i} = \frac{1}{\sigma_{jj}} \bullet \frac{\sum_{h=0}^{H-1}\left(\left(\Psi_h \Sigma\right)_{ij}\right)^2}{\sum_{h=0}^{H-1}\left(\Psi_h \Sigma \Psi_h^{'}\right)_{ii}}, \quad (4)$$

where σ_{jj} is standard deviation of the error term for the j-th equation and e_j is the vector with the j-th element which is 1 and the rest being 0. The j-th series' contribution to the forecast error variance of the variable i at the horizontal h is equal to θ_{ij}^{H} .

The above equation is normalized for every entry of the matrix with variance decomposition by the raw sum:

$$C^H = \frac{\sum_{i,j=1, i\neq j}^{n} \bar{\theta}_{ij}^{H}}{\sum_{i,j=1}^{n} \bar{\theta}_{ij}^{H}} \bullet 100 = \frac{1}{n} \sum_{i,j=1, i\neq j}^{n} \bar{\theta}_{ij}^{H} \text{v} \bullet 100. \quad (5)$$

In the last stage, the directional spillover (TO/FROM) is determined from variable i to variable j and vice-versa (TO/FROM), which also includes the net spillover position of variable i as a difference between the other two as follows:

$$C_{i\rightarrow\bullet}^{H} = \frac{1}{n}\sum_{j=1, j\neq i}^{n} \bar{\theta}_{ji}^{H} \bullet 100 \quad \text{(TO)} \quad (6)$$

$$C_{i\leftarrow\bullet}^{H} = \frac{1}{n}\sum_{j=1, j\neq i}^{n} \bar{\theta}_{ij}^{H} \bullet 100 \quad \text{(FROM)} \quad (7)$$

$$C_{i,net}^{H} = C_{i\rightarrow\bullet}^{H} - C_{i\leftarrow\bullet}^{H} \quad \text{(NET)} \quad (8)$$

At this stage the spillover matrix is obtained to determine the directional spillover between the Russian green bond index and the rest of the analysed assets, thus methodologically supporting the validation of Hypothesis 1 and 2. The F. Diebold and K. Yilmaz [4] method is used to determine both static and dynamic spillover effects. Both methodological approaches provide empirical results that have a complementary role in analyzing the level of connectedness between the Russian green bond market and capital market indexes.

Bilateral hedging ratio and portfolio weights

The calculation of the spillover and the analysis of the connectedness among the assets is often used to determine the hedging performance of the target assets compared to other assets and lead to portfolio rebalancing. To validate hypothesis 3, the following methodological approach is defined. First, the model developed by K. Kroner and J. Sultan [26] is employed in the research. To calculate the optimal hedging ratio, the estimation of conditional variance and covariance from DCC-GARCH is utilized as follows:

$$\beta_{ijt} = h_{ijt} / h_{jjt}, \quad (9)$$

where h_{ijt} represents the conditional covariance of asset i and asset j, and h_{jjt} is the conditional variance of asset j. Next, the model developed by K. Kroner and V. Ng [27] is employed to determine the optimal portfolio weights (W_{ijt}) as follows:

$$W_{ijt} = \frac{h_{jjt} - h_{ijt}}{h_{iit} - 2h_{ijt} + h_{jjt}}, \quad (10)$$

where W_{ijt} represents the weight of asset i in a 1-dollar portfolio of two assets i and j at time t, while the weight of the asset W_{jit} is $(1 - W_{jit})$.

In the last stage we calculate the hedging effectiveness of the determined portfolio weights and the hedging ratio, which were calculated earlier by following the methodology developed by L. Ederington [28].

$$HE_{ijt} = 1 - \left[\left(Var\left(r_{\beta ijt}\right), Var\left(r_{wijt}\right)\right) / Var\left(r_{unhedged}\right)\right], \quad (11)$$

where

$$r_{wijt} = W_{ijt}x_{it} + W_{ijt}x_{jt} \quad (12)$$

$$r_{\beta ijt} = x_{it} - \beta_{jit}x_{jt}. \quad (13)$$

The $(Var(r_{\beta ijt}), Var(r_{wijt}))$ denotes the hedged portfolio variance of the optimal hedging ratio or the optimal portfolio weight. Var (unhedged) represents the variance of the unhedged position between variable i and variable j.

Empirical Results

In the last five years, the Russian capital market experienced a unique development characterized by post-COVID-19 market specifics, geopolitical conflict with Ukraine, marked by the cancel culture with a multitude of sanctions [29]. Currently the Russian economy and its capital market are adapting to the new reality and at the same time keeping up the development pace and striving towards sustainable development, like other emerging capital markets [30; 31]. The geopolitical conflict between Russia and Ukraine turned to be a macroeconomic shock, especially for Western economies (e.g., EU countries) and Asian countries, as it changed the flow of energy supply factors (e.g., natural gas, oil, etc.) and affected logistics and global supply.

Given these aspects, empirical research reveals the risk and spillover effect between green bonds and other capital market indexes on the Moscow Stock Exchange. This analysis intends to show the benefits of green bonds for hedging and optimal portfolio asset management reasons, as well as their propensity for the sustainable development of Russian economy since green bonds turned to be one of the main drivers for sustainable development in other economies [e.g. 22; 32].

Static connectedness

To analyze comparatively the risk and return volatility spillover between the Russian green bond market and other indexes, static spillover connectedness is calculated across the following periods: 2021–2023 (the sample period); Jan. 2021 – Jan. 2022 (post-COVID-19 period); Jan. 2022 – Dec. 2023 (geopolitical period for Russian economy and its capital market). Thus, we follow the methodological approach proposed by [3; 8] to show a comparative analysis within different time periods for hedging and portfolio management reasons.

The post-COVID-19 period was marked by the restoration of economic stability and growth in different sectors of activity that were affected in the entire global economy, including Russia, during the pandemic. Thus, by employing vector autoregressive models (VAR) proposed by F. Diebold and K. Yilmaz, we determine the total connectedness index between the Russian green bond index and other assets before the geopolitical conflict started. As the period was still marked by post-COVID effects, the TCI amounted to 49,61% (Table 2), which is considered to be high compared with the pre-pandemic period [2; 11]. The analysis demonstrates that many countries, including the Russian Federation were involved in sustainable development processes at different levels (e.g., regulatory, capital market structuring, strategic environment projects, etc.).

Table 2. Static connectedness between assets in 2021, %

	RUGBI	RUABITR	MOEXEU	MOEXMM	MOEXCH	MOEXFN	MOEXOG	MOEXIT	GAZP	MRSV	FROM
RUGBI	90.45	0.52	2.83	2.09	0.31	1.56	0.55	0.56	0.78	0.34	9.55
RUABITR	0.84	81.31	2.74	3.3	3.34	1.65	0.87	0.83	1.54	3.58	18.69
MOEXEU	1.07	1.03	33.97	9.07	4.18	7.51	10.41	5.18	6.94	20.64	66.03

	RUGBI	RUABITR	MOEXEU	MOEXMM	MOEXCH	MOEXFN	MOEXOG	MOEXIT	GAZP	MRSV	FROM
MOEXMM	0.51	1.73	10.83	40.28	5.1	5.29	5.12	5.52	1.53	24.1	59.72
MOEXCH	0.14	0.91	7.11	7.7	60.22	2.68	4.14	1.53	2.65	12.91	39.78
MOEXFN	0.07	1.02	9.61	5.42	1.72	41.45	8.62	10.25	5.56	16.3	58.55
MOEXOG	0.03	0.52	10.76	4.89	2.56	7.99	34.38	5.49	13.3	20.09	65.62
MOEXIT	0.09	0.41	5.78	6.6	0.94	12.49	5.59	53.8	2.44	11.87	46.2
GAZP	0.25	0.79	9.7	3.29	2.41	7.85	16.14	5.42	42.55	11.6	57.45
MRSV	0.12	1.02	15.54	15.26	5.43	10.14	14.54	6.21	6.19	25.54	74.46
TO	3.13	7.94	74.91	57.62	25.98	57.16	65.97	40.98	40.93	121.43	496.05
NET	−6.43	−10.75	8.88	−2.1	−13.8	−1.39	0.35	−5.22	−16.52	46.98	49.61

A detailed analysis of the connectedness between the assets shows that "to" volatility connectedness varies between 3.13 and 121.43%, while the "from" connectedness between the assets varies from 9.55 to 74.46%. This level of connectedness indicates that the level of return spillover transmission is much higher compared with the level of spillover received [1; 8]. As the spillover analysis includes capital market indexes from different sectors of activity, which are divided into high (e.g., MOEXEU, MOEXMM, MOEXCH) and low pollution impact (e.g., MOEXFN, IT), the results shows that most of the indexes are net receivers of the risk and return spillover except electricity and utilities, and MRSV, which are net transmitters. The net transmitting effects of the volatility spillover of the Russian green bond market, which records only −6.43% and MRSV, which transmits a net spillover effect of 46.98%, indicate that in the post-COVID period the propensity of the Russian capital market towards sustainable development was high. A decomposition analysis of the spillover receiving factors shows that the Russian green bond market receives spillover effects from the following sectors of activity: MOEXEU (2.83%), MOEXMM (2.09), MOEXFN (1.56%) and GAZP (0.78%), which are pollution-intensive industries except the financial sector. The analysis of the opposite spillover direction indicates that the green bond market sends the spillover effect to the following capital market indexes: MOEXEU (1.07%), RUABITR (0.84%), MOEXMM (0.51%) and GAZP (0.25%). The net spillover effects indicate that green bonds in the Russian capital market were good instruments for hedging between two macroeconomic shocks, which is in line with the existing literature about emerging capital markets [1; 33].

The period after the outbreak of the conflict between Russia and Ukraine had changed the structure of the internal capital market. In the short-term, the Russian capital market has been characterized by high volatility and uncertainty, and massive outflow of capital. For example, in the first few weeks after February 24, 2022, the RTS Index went down by approximately 50% compared with January 2022 values (https://www.moex.com/en/index/RTSI). The empirical results show that the return volatility spillover changed its trajectory and structure during the onset of the cancel culture. The total connectedness index went up from 49.61 to 64.58% (Table 3). The first implication of this tectonic geopolitical change indicates that the macroeconomic shock is much higher than during the COVID-19 pandemic, which is also supported by R. Karkowska and S. Urjasz [3]. Moreover, the isolation of the Russian economy and Russian capital market through cancel culture has led to the dominance of certain sectors of activity over others through the spillover effects. For example, before the outbreak of the conflict MOEXMM and MOEXFN were net receivers and MOEXOG had very little spillover implications, while after the start of the conflict, the following indexes turned to be net positive and strong return spillover transmitters: MOEXMM (6.99%), MOEXFN (11,41%) and MOEXOG (24.54%).

Table 3. Detailed static connectedness between assets in 2022–2023, %

	RUGBI	RUABITR	MOEXEU	MOEXMM	MOEXCH	MOEXFN	MOEXOG	MOEXIT	GAZP	MRSV	FROM
RUGBI	93.62	0.87	0.74	1.08	1.11	0.39	0.78	0.46	0.08	0.85	6.38
RUABITR	0.28	48.04	11.09	7.13	0.63	7.14	9.12	4.76	1.75	10.06	51.96

	RUGBI	RUABITR	MOEXEU	MOEXMM	MOEXCH	MOEXFN	MOEXOG	MOEXIT	GAZP	MRSV	FROM
MOEXEU	0.16	5.26	22.07	12.34	3.1	12.6	13.99	8.43	5.61	16.44	77.93
MOEXMM	0.22	3.49	12.16	22.23	3.44	12.06	14.07	8.98	4.72	18.63	77.77
MOEXCH	1.32	1.95	6.65	6.69	45.46	7.31	10.64	6.96	2.99	10.04	54.54
MOEXFN	0.1	3.16	11.86	11.71	3.37	22.44	14.22	11.73	5.61	15.79	77.56
MOEXOG	0.18	4.35	12.09	12.31	4.59	13.06	19.62	9.06	7.64	17.1	80.38
MOEXIT	0.2	2.55	9.73	10.63	3.71	14.07	12.02	26.93	6.14	14	73.07
GAZP	0.02	1.34	8.69	7.73	2.7	9.1	14.16	8.12	35.54	12.61	64.46
MRSV	0.17	4.08	13.25	15.15	4.02	13.24	15.91	9.64	6.36	18.2	81.8
TO	2.65	27.05	86.26	84.76	26.65	88.97	104.92	68.15	40.9	115.52	645.84
NET	−3.73	−24.9	8.34	6.99	−27.89	11.41	24.54	−4.91	−23.56	33.72	64.58

Comparing with the period before the conflict, the return volatility spillover of the Russian green bond market after the outbreak of the conflict was reduced, thus it received only 6.38% from the other assets and transmitted only 2.65% of the spillover effects to the other assets. These aspects indicate the green bond market turned out to be a good instrument for hedging [e.g., 16] during the macroeconomic shock instigated by the Russia-Ukraine conflict and cancel culture. Thus, the green bond market receives the spillover effects mainly from the MOEXCH (1.11%), MOEXMM (1.08%), MOEXEU (0.74%), MOEXOG (0.78%) for pollution-intensive industries, which validates Hypothesis 1. The GB index sends the spillover effects consistently to the MOEXCH (1.32%), and to a much smaller extent - to the MOEXMM (0.22%), MOEXOG (0.18%) and MOEXIT (0.20%). The results also indicate that RUGBI receives return spillover volatility from the ESG index of 0.85% and sends only 0.17%, thus supporting Hypothesis 2, which states that it is highly correlated. Additionally, it was found that these results are in line with the existing literature about the spillover effects of green bonds in emerging countries during macroeconomic shocks, which indicates that the Russian GB market also creates good premises for hedging and portfolio management. When comparing the volatility spillover of GB with that of other assets from the analysis, we see that the top 3 least volatile assets are RUGBI, RUABITR, MOEXCH and GAZP. This supports the idea that, despite Russia's striving to adhere to the sustainable development model, pollution-intensive businesses are still dominant, which is typical for an oil exporting country.

The total spillover index across the entire sample period (2021–2023), which is equal to 62.26%, is specific to those capital market conditions that persist during macroeconomic shocks, which is the case for both Russia and Western countries. The empirical results reveal that the green bond market index receives the spillover effects from MOEXEU (0.78%), MOEXMM (1.25%), MOEXOG (0.64%) and MRSV (0.68%) and send them only to MOEXMM and MOEXCH. Even though both internal and external markets were affected by the cancel culture against Russian Federation, the green bond market shows a certain stability, which validates the main idea that, as for other economies, it is a reliable and stable hedging and portfolio management instrument.

By analyzing the static spillover effects between the Russian green bond market and other indexes that reflect both pollution-intensive and non-pollution-intensive businesses, we can conclude that Russian green bonds market was less volatile and turned to be a good instrument for hedging against macroeconomic shocks and climate risks. This aspect indicates that even though Russian economy is struggling with sanctions and cancel culture, it continues its movement towards achieving the sustainable development goals and climate targets. Moreover, the results send strong signals to the regulators that the Russian green bond market is effective and needs further regulatory assistance to strengthen its future development.

Dynamics spillover effects

Static connectedness analysis between the green bonds and other capital market indexes reveals volatility spillover over a certain period, which is a limitation of this method. To address this drawback in the research, we employed rolling-window analysis to delve deeper into the analysis of the connectedness between assets, which changes over time, especially during tectonic macroeconomic shifts. For this reason, the D&Y method was used to analyze the dynamic volatility spillover for the entire period to identify the exact timing of the changes in the assets' connectedness, because we used the calendar timing split in the static spillover representation. Following the existing literature, we used a 100-day rolling window with a horizon forecast period of 100 days. Figure 1 shows the dynamics of the total connectedness index for 2021–2023, thus indicating a more accurate representation of the return volatility spillover before and after the outbreak of the conflict between Russia and Ukraine.

Static analysis of the 2021–2023 period produces a total connectedness index of 62.26%, which indicates high spillover effects between green bonds and other capital market assets, but relevant information is still missing. A detailed analysis of the dynamic connectedness index indicates that the maximum connectedness between assets has been achieved not at the start of the conflict or immediately after, but in December 2022, when it reached the value of 90%. The main argument for this dynamic is that the capital market needed some time to absorb the new realities and adjust correspondingly. Moreover, we witnessed a decrease of the total connectedness index in mid-2023 (e.g., it reached about 51%), which reveals more stable capital market conditions compared with 2022 in the new era of cancel culture for Russian economy. Thus, Hypothesis 4 is validated, indicating that connectedness between green bonds and other capital market assets is time-varying and requires special attention from investors and policymakers. The importance of the dynamic net spillover analysis has two important implications: first, investors should adjust the hedging strategy and portfolio management structure more often during macroeconomic shocks as the capital market conditions change more dynamically. Second, policymakers should revise and update the existing regulatory framework to make the market more agile and resilient to the new macroeconomic context determined by the cancel culture market state.

Figure 1. Dynamic Total Connectedness Index, 2021–2023

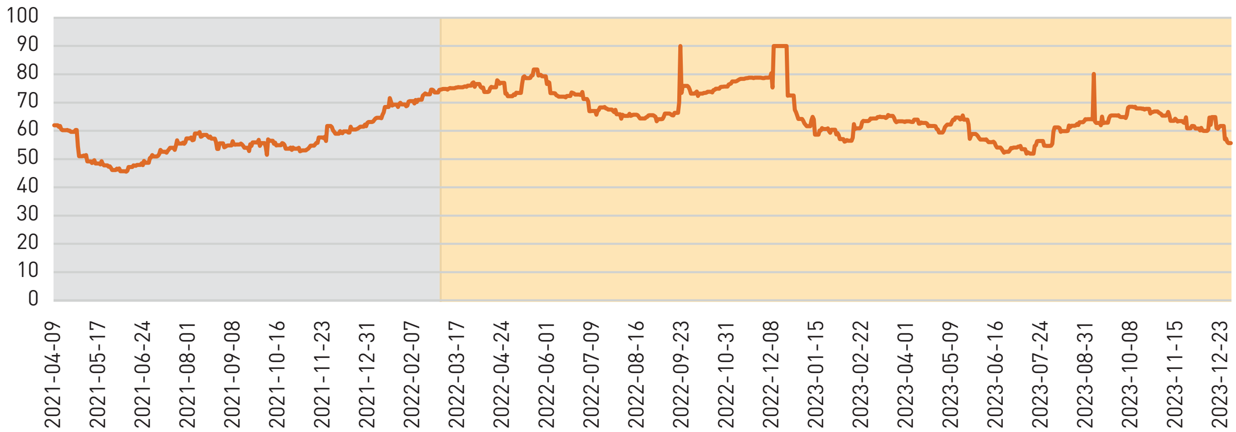
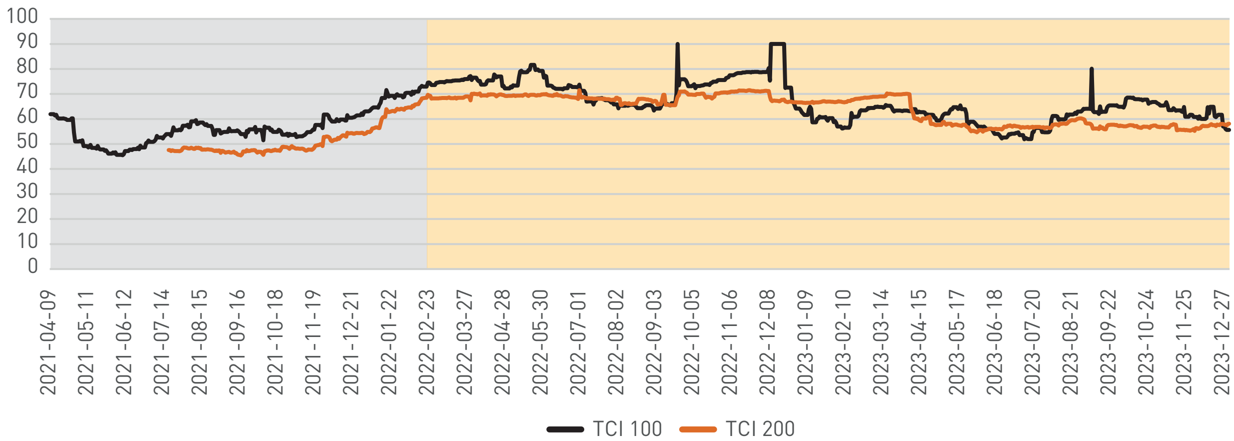


Figure 2. Dynamic TCI calculated using the D&Y method with rolling windows (100, and 200 days)



Robustness check

To assess the robustness of the results, it will be necessary to validate the dynamic net spillover since it contains more information about the market's responsiveness to macroeconomic shocks as it is time-varying. For this reason, the method proposed by W. Jiang et al. [1] is used. As in the calculation and representation of the dynamic spillover index, 100 days were used as the parameter for varying rolling windows, while for robustness check purposes we extend this period to 200 days. The main reason is to test the pattern of the total connectedness index compared to the one calculated by using the 100-day rolling windows because the volatility spillover is sensitive to the changes in the analyzed period. Figure 2 illustrates robustness analysis, and as is apparent, even though two different rolling windows were used, the dynamics of the total connectedness index does not change significantly and maintains its trend across the analyzed period. Additionally, both rolling windows' representations capture the moment of the outbreak of the military conflict and the stabilization of the TCI in 2023, when the Russian economy stabilized under the new cancel culture conditions. An extended analysis illustrated in Table 4 indicated the minimum, maximum, and average TCI values for different rolling time windows in each period. Small differences are shown between different times periods, indicating that the obtained results are robust.

Table 4. Dynamics of the Total Connectedness Index across different rolling windows

	Min	Max	Average	Median	SD
TCI 100	46	90	64	63	8.87
TCI 200	45	71	61	61	7.88

Hedging and portfolio management

The analysis of the interconnectedness between green bonds and other Russian capital market indexes implies subsequent actions for hedging and optimal portfolio management decisions. For these reasons investors and asset managers will utilize the information provided by the analysis of asset spillover between green bonds and pollution-intensive industries to construct optimal portfolio weights and hedging strategies to minimize the risks and maximize portfolio returns as proposed by G. Markowitz (1952), while internalizing sustainability drivers. Besides the cancel culture that tectonically changed the structure of the Russian economy, the risk of climate change persists, therefore Russian Federation should continue its engagement in international programs with climate targets. Moreover, in the context of economic and political sanctions, the country should continue its adherence and participation to the international initiative for sustainable development and climate change, in order to not allow Russia to lose its competitiveness through sustainability. Thus, to reveal the contribution of the newly designed Russian Green Bond index for climate risk mitigation and designing portfolio weights, a bivariate portfolio was constructed as illustrated in Tables 5 and 6.

Methodologically, the analysis shows the relationships between the hedging ratio, portfolio weights and hedging effectiveness across all 3 examined periods for each RUGBI pair.

Table 5 illustrates the values of hedging ratios and corresponding hedging effectiveness for the sample period 2021–2023, the period before and after the outbreak of the geopolitical conflict. During the sample period, the hedging ratio varies between 9.9 and 32.8, which means that for a $1 long position in green bonds, the index equates a cost that varies between 10 and 33 cents in a short position of paired assets. In our research we invoke bivariate portfolio analysis from Panel B, when green bonds are equated to a long position. Even though the hedging effectiveness is low, it is statistically significant at 1%, indicating that the portfolio ratio effectively reflects its usability. The 3% hedging effectiveness that is statistically significant at 1% was identified showing paired indexes with the Russian green bond index: MOEXEE, MOEXFN, MOEXMM, MRSV that ultimately seems to be a good combination for hedging. A rough analysis of the hedging ratio in each sub-period shows that before the conflict the Russian green bond market was not supposed to be efficient for hedging, but the situation changed significantly after the eruption of the conflict. Thus, with a hedging effectiveness that varies between 5 and 7% and is statistically significant at 1%, both pollution-intensive and non-pollution-intensive industries turned to be effective for hedging: MOEXEU, MOEXFN, MOEXIT, MOEXMM, MOEXOG, MRSV.

Table 5. Optimal hedging ratio (HR) and hedging effectiveness (HE) index

Pair indexs	2021–2023 HR	2021–2023 HE	2021 HR	2021 HE	2022–2023 HR	2022–2023 HE
Panel A						
GAZP/RUGBI	0.0057	–0.01	0.0000	0.00	0.0097	–0.02
MOEXCH/RUGBI	0.0144	–0.07	0.0030	0.00	0.0298	–0.09
MOEXEU/RUGBI	0.0240	0.11	0.0840	–0.09	0.0255	0.12
MOEXFN/RUGBI	0.0247	0.09	–0.0031	0.00	0.0365	0.10
MOEXIT/RUGBI	0.0126	0.03	–0.0110	–0.02	0.0244	0.01
MOEXMM/RUGBI	0.0325	0.04	0.1040	–0.20	0.0278	0.04
MOEXOG/RUGBI	0.0188	0.05	–0.0248	0.00	0.0408	0.05
MRSV/RUGBI	0.0284	0.06	0.0246	–0.02	0.0347	0.07
RUABITR/RUGBI	0.3998	0.20	–0.0024	0.00	0.6857	0.22

Pair indexs	2021–2023 HR	2021–2023 HE	2021 HR	2021 HE	2022–2023 HR	2022–2023 HE
Panel B						
RUGBI/GAZP	0.3004	0.00	–0.0005	0.00***	0.3908	0.01
RUGBI/MOEXCH	0.0999	–0.02***	0.0093	0.00**	0.1668	–0.01***
RUGBI/MOEXEU	0.1718	0.03***	0.0524	0.01***	0.2694	0.05***
RUGBI/MOEXFN	0.2233	0.03***	–0.0082	0.00***	0.3172	0.06***
RUGBI/MOEXIT	0.3280	0.02***	–0.0349	0.00**	0.5099	0.07***
RUGBI/MOEXMM	0.1976	0.03***	0.0812	0.00***	0.2068	0.05***
RUGBI/MOEXOG	0.1583	0.02***	–0.0296	0.00***	0.3120	0.05***
RUGBI/MRSV	0.1911	0.03***	0.0214	0.00***	0.2717	0.06***
RUGBI/RUABITR	0.1175	–0.03***	–0.0003	0.00	0.1871	–0.17***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Note: Panel B displays the hedging position of RUGBI paired with each of the analyzed assets. This configuration involves taking a $1 long position in RUGBI and simultaneously establishing a short position in another asset with a corresponding value in USD. Panel A illustrates the converse scenario, depicting the hedging of a $1 long position for each asset, paired with a short position in RUGBI with a corresponding value in USD.

The empirical analysis shows that the reverse direction of the hedging methodology, where the Russian green bond market is supposed to be in a short position paired with other assets in a long position, is not efficient due to the low parameter value for the hedging ratio and being statistically non-significant.

Continuing the analysis that derives from the calculation of the level of connectedness between green bonds and other capital market assets, we should determine portfolio weights and the corresponding hedging effectiveness of the Russian green bond market paired with other indexes. Table 6 illustrates the results of the analysis for all periods in question. The portfolio weights are empirically studied using the bivariate relationship analysis. The results reveal that the Russian green bond market plays an important role in the construction of optimal portfolio weights in both short and long positions in a bivariate relationship with the analyzed assets for the entire period, as well as separately for 2021 and 2022–2023. As it can be seen, the hedging effectiveness parameter is high and is statistically at 1% for almost all the pairs, but the level of effectiveness changes across different periods. Thus, MOEXMM, MOEXCH and MOEXFN were found to be good, paired assets for optimal portfolio weights for all 3 periods, while oil and gas and the sustainability index were a good option for optimal portfolio weights in connection with the Russian green bond index only in 2021 and the entire sample period.

Table 6. Optimal portfolio weights (PW) and hedging effectiveness (HE) index

Index pair	2021–2023 PW	2021–2023 HE	2021 PW	2021 HE	2022–2023 PW	2022–2023 HE
Panel A						
RUGBI/RUABITR	0.29	0.67*	0.21	0.94***	0.25	0.51
RUGBI/MOEXEU	0.77	0.61***	0.50	0.72	0.87	0.47***
RUGBI/MOEXMM	0.75	0.55***	0.55	0.70***	0.82	0.41***
RUGBI/MOEXCH	0.74	0.62***	0.60	0.66***	0.79	0.53***
RUGBI/MOEXFN	0.77	0.58***	0.64	0.63***	0.84	0.47***
RUGBI/MOEXOG	0.75	0.54***	0.60	0.67***	0.83	0.33***

Index pair	2021–2023 PW	2021–2023 HE	2021 PW	2021 HE	2022–2023 PW	2022–2023 HE
RUGBI/MOEXIT	0.84	0.47***	0.73	0.50***	0.91	0.27***
RUGBI/GAZP	0.90	0.43***	0.83	0.31***	0.94	0.46***
RUGBI/MRSV	0.74	0.57***	0.51	0.74***	0.83	0.40***
Panel B						
RUABITR/RUGBI	0.71	0.12***	0.79	–0.39***	0.75	0.06***
MOEXEU/RUGBI	0.23	0.84***	0.50	0.10***	0.13	0.85***
MOEXMM/RUGBI	0.25	0.68***	0.45	0.29***	0.18	0.68***
MOEXCH/RUGBI	0.26	0.76***	0.40	0.32***	0.21	0.78***
MOEXFN/RUGBI	0.23	0.81***	0.36	0.49***	0.16	0.83***
MOEXOG/RUGBI	0.25	0.76***	0.40	0.42***	0.17	0.74***
MOEXIT/RUGBI	0.16	0.90***	0.27	0.60***	0.09	0.90***
GAZP/RUGBI	0.10	0.93***	0.17	0.75***	0.06	0.95***
MRSV/RUGBI	0.26	0.75***	0.49	0.26***	0.17	0.75***

*** p<0.01, ** p<0.05, * p<0.1.
Note: Panel A displays the hedging position of RUGBI paired with each of the analyzed assets. This configuration involves taking a $1 long position in RUGBI and simultaneously establishing a short position in another asset with a corresponding value in USD. Panel B illustrates the converse scenario, depicting the hedging of a $1 long position for each asset, paired with a short position in RUGBI with a corresponding value in USD.

Panel B from Table 6 illustrates the reverse relationship between RUGBI and other MOEX indexes. Thus, for a $1 long position in pollution-intensive indexes and a short RUGBI position that is equivalent in USD dollars, it is demonstrated that for almost all the indexes the short position in US dollar equivalent is lower than $1, varying between 0.1 and 0.71 cents, while the hedging effectiveness is statistically significant and varies between 12 and 93%. For this reason the optimal portfolio weight strengthened after the outbreak of the conflict. Moreover, only GAZP and MOEXIT show higher value parameters across all the periods. After the conflict started, the highest (e.g., above 80%) hedging effectiveness was demonstrated by the MOEXEU, MOEXFN, MOEXIT and GAZP.

To conclude, the RUGBI should be included in a hedging strategy and portfolio management, but tailored to specific macroeconomic conditions in a prudent manner. This is because the analyzed period was characterized by instabilities marked by the post-COVID-19 pandemic period of economic recovery and the outbreak of the military conflict between Russia and Ukraine that triggered another macroeconomic shock. It offered the optimal hedging strategy to include energy, financial, materials and mining and sustainability indexes. In terms of optimal portfolio weights, RUGBI can be combined with almost every capital market asset, but asset managers and investors should be careful to change the investment strategy every time when the economy goes through instabilities periods.

Conclusions

The cancel culture against Russian economy emerged after the outbreak of the military conflict with Ukraine and transformed the national economy and its capital market into the "new normal" state, signifying turbulence with direct impact on its anticipated national sustainable development targets. This conflict created a macroeconomic shock to the global economy that still persists, having changed the climate agenda for many nations, especially because of the energy crisis that has intensified. Given the importance of the new normal and the impact of cancel culture for the Russian economy, there has been a surge in research of spillover effects in the emerging financial markets, especially in reference to green bonds as the key driver in promoting sustainable development. The paper intends to reveal the return spillover effect between the Russian green bond market and other capital market indexes, both pollution and non-pollution intensive, before and after the outbreak of the military conflict. To capture the dynamics of the Russian green bond market, a synthetic index is introduced, leveraging the F. Diebold and K. Yilmaz [4] model to investigate the conditional mean connectedness between the Russian green bond index and leading capital market indexes.

The subsequent implications of the spillover analysis during macroeconomic shocks refer to the investors' and asset managers' decisions for asset hedging and determining optimal portfolio structures.

First it was discovered that the level of connectedness between the Russian green bond index pollution intensive assets was still high in the post-COVID-19 pandemic period (e.g., 2021), indicating that this category of sustainable finance was a good instrument for mitigating climate risks. The green bond index was the net receiver of the spillover effects compared with the other assets, which apparently provided a good option for hedging, especially important for Electricity and Utility, Oil and Gas, Chemicals and Materials, and Mining sectors. Additionally, it was found that the level of connectedness of the green bond index and Sustainability Vector Index is low, indicating that the ESG index is not a good option for constructing a hedging strategy, which is contrary to the existing literature. The level of connectedness between green bonds and the ESG asset is increasing after the outbreak, thus being the only assets where the return volatility spillover is rising, which makes the asset a good option for hedging.

After the military conflict started, the level of connectedness between green bonds and Russian leading capital market indexes increased, indicating that the Russian capital market reacted to the new normal determined by the cancel culture. The Russian green bond index still remains a return volatility spillover receiver in relation to the high-pollution capacity indexes, which creates good prerequisites for hedging and building an optimal asset portfolio structure. These findings are strengthened by the hedging ratio and portfolio weight analysis. In this research, the DCC-GARCH was employed together with the methods developed by K. Kroner and V. Ng [27] and L. Ederington [28] to find the best bivariate asset combination with the Russian green bond index across different time periods. Thus, it was found that the optimal hedging ratio is obtained for a $1 long position in RUGBI and a short position in the leading capital market indexes with high pollution impact (e.g., Oil and Gas, Mineral and Mining etc.). Even though hedging effectiveness is low, the values are statistically significant at 1%, therefore, it is best to include the RUGBI in the hedging strategy after the outbreak of the conflict (e.g., 2022–2023). In regard to the optimal portfolio weights between RUGBI and other capital market assets, asset bivariate analysis indicates that green bonds play an important role in constructing the optimal structure to maximize the return and minimize the costs. Thus, the conclusion is supported by the high value of hedging effectiveness, which is also statistically significant.

The research has some limitations. First the representativeness of the Russian green bond market reflected in the synthetic index is still low because of the low number of green bond issuances marketed in 2021–2023. Second, for some green bonds low liquidity might affect the correctness of the level of volatility of the Russian green bond market, which may also ultimately affect the spillover effects on the assets. Further analysis is still required in this regard.

This study has several implications. First, the volatility spillover direction between RUGBI and leading Russian capital market indexes can help investors and asset managers to expand their portfolio management decisions and hedging strategies to Moscow Stock Exchange. This aspect will support the subsequent development of the Russian green bond market that will accelerate the transition of the Russian economy towards a sustainable development model. Second, policymakers can draw valuable insights for designing or consolidating the sustainable finance regulatory frameworks. Russian policy-related factors might support some strategic sustainable development projects, stimulating the production of a renewable energy system, supportive policies for conventional energy sources, and the financialization of energy markets.

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Appendix 1. Description of capital markets indexes and variables

Group of Indexes	Index ID	Index Name	Description
Financial	RUABITR	Aggregate bond index	MOEX Aggregate Bond Index is a broad-based benchmark that measures the performance of the entire Russian bond market. It consists of most liquid Russian government bonds (OFZ), municipal, subfederal and corporporate bonds with duration more than 1 year
Pollution – Energy	MOEXEU	Electric Utilities	The sector capitalization-weighted indices calculated based on prices of the most liquid shares of Russian issuers admitted to trading in PJSC-MOEX
Pollution – NonEnergy	MOEXMM	Metals & Mining	
Pollution – NonEnergy	MOEXCH	Chemicals	
Financial	MOEXFN	Financials	
Pollution – Energy	MOEXOG	Oil&Gas	
Other	MOEXIT	IT	
Pollution – Energy	GAZP	Gazprom	The share price of the company with the highest market capitalization on the MOEX
ESG	MRSV	Sustainability Vector Index	The ESG index with calculation base including shares of companies, which show the best dynamics of indicators in the field of sustainable development and corporate social responsibility. The index was awarded the UNCTAD ISAR HONOURS-2019 award

Source: Moscow Exchange.

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