MISCELLANEA

Bank i Kredyt 57(4), 2026, 489-520
DOI: 10.5604/01.3001.0055.8611

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The effects of the war in Ukraine on the equity market in Poland

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Submitted: 23 December 2025. Accepted: 8 April 2026.

Suggested citation: Czapkiewicz A., Głodek N., Kopeć D. (2026), The effects of the war in Ukraine on the equity market in Poland, *Bank i Kredyt*, 57(4), 489–520, DOI: 10.5604/01.3001.0055.8611.

Abstract

This study investigates the association between the Russia-Ukraine war and the Polish stock market, distinguishing between energy price exposure and a geopolitical sentiment channel. Using daily data from 1 November 2021 to 31 January 2025 within a GARCH framework, it analyses return dynamics across sectoral indices. Energy-related sectors are more sensitive to oil, gas, and coal price movements, while firms linked to Ukraine appear exposed to gas-market fluctuations. A sentiment proxy based on Google searches for 'Ukraine' is associated with short-term declines in returns, followed by partial reversals, consistent with temporary overreaction, and coincides with movements in energy markets. Robustness checks confirm these patterns. The findings suggest that observed dynamics may be related to both energy-price developments and shifts in investor attention and uncertainty. Energy prices and sentiment factors may be relevant for risk assessment, with short-term reactions informative for trading and risk management.

Keywords: Ukraine war sentiment, energy prices, stock market volatility, OVX, Google Trends

JEL: C58, G15

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1. Introduction

Energy prices, particularly fuel prices, are critical drivers of modern economies. The relationship between energy price fluctuations and financial markets has long drawn scholarly interest due to its far-reaching implications for macroeconomic performance and financial stability. A substantial body of literature has examined the effects of oil price volatility on stock markets (Kling 1985; Hamilton 1996; Jones, Kaul 1996; Sadorsky 1999; Maghyereh, Awartani 2016). However, recent geopolitical developments, most notably the Russia-Ukraine conflict, have expanded the scope of this discussion to include other energy commodities such as natural gas (Belhoula, Mensi, Al-Yahyaee 2024) and coal (Huang et al. 2023). In particular, coal price shocks are increasingly relevant to financial markets due to the growing financialisation of this resource, which has heightened its sensitivity to market volatility.

In energy-dependent countries, fuel price fluctuations can trigger substantial volatility in financial markets (Berezvai 2024). As an energy-importing country, Poland experienced unprecedented fuel price surges in 2022 following the outbreak of the Russia-Ukraine war. These developments created a natural setting to examine how external energy shocks and geopolitical uncertainty transmit to domestic financial markets.

This study evaluates the relationship between global energy prices (WTI, Brent, natural gas, coal), oil market volatility (OVX), domestic fuel prices (PB 95), and the Polish stock market, as well as the role of war-related sentiment associated with the Russia-Ukraine conflict.

Although numerous studies have explored the relationship between energy prices and financial markets, there remains a critical gap in the literature concerning the role of geopolitical sentiment, particularly in the context of the Russia–Ukraine war. Public sentiment plays a key role in amplifying market volatility, as investor behaviour often shifts in response to changes in perceived geopolitical risk. While the existing literature acknowledges the importance of sentiment, a central methodological challenge remains how to effectively measure and quantify it. Tools such as Google Trends allow researchers to track public interest, but there is no standardised method for selecting keywords that avoid duplication or noise. This study addresses this gap by proposing a novel sentiment indicator based on daily search volumes for the single keyword ‘Ukraine’, interpreting increases in search frequency as proxies for heightened concern and negative sentiment.

The objective of this study is to assess the combined effects of global energy price fluctuations and war-related sentiment on the Polish stock market, with particular attention to sectors most vulnerable to geopolitical risk. These include mining (WIG-Mining), energy (WIG-Energy), fuels (WIG-Fuels), and Ukrainian companies listed on the Polish stock market (WIG-Ukraine). The analysis evaluates how fluctuations in the OVX, energy commodity prices, domestic fuel prices, and war-related sentiment affect stock returns and conditional volatility in Poland. To examine these mechanisms, the study develops the following hypotheses:

Hypothesis 1. Energy prices (WTI, Brent, natural gas, coal), domestic fuel prices (PB 95), and oil market volatility (OVX) affect stock market returns and volatility in Poland, with heterogeneous effects across sectors depending on energy exposure.

Hypothesis 2. Increases in Ukraine-related Google search intensity negatively affect Polish stock market returns and increase conditional volatility, both directly and indirectly through energy market dynamics.

Hypothesis 3. The effects of energy prices and Ukraine-related Google search intensity on stock returns remain significant after controlling for index composition effects.

The contribution of this study lies in deepening the understanding of how geopolitical uncertainty and sentiment-driven behaviour interact with energy market dynamics in an energy-dependent economy. By examining these interactions in the context of the Russia-Ukraine conflict, the study provides practical insights for investors, policymakers, and researchers. The findings highlight the broader economic consequences of geopolitical crises and underscore the importance of monitoring sentiment as a determinant of financial market behaviour.

The paper is structured as follows: Section 2 reviews the relevant literature; Section 3 presents the data and the research methodology; Section 4 discusses the results. The paper concludes with a summary of key findings and policy implications.

2. Literature review

Recent studies emphasise that the Russia–Ukraine conflict has significantly affected global energy markets due to Russia's key role as one of the world's largest exporters of fossil fuels (Yag'ya, Yagya 2021). Russia is a major supplier of crude oil, natural gas, and coal, which makes geopolitical developments in the region particularly influential for global commodity markets. Empirical evidence indicates that the outbreak of the conflict triggered sharp increases in oil and natural gas prices and heightened volatility in energy markets (IEA 2021; Mahlstein et al. 2022).

In this context, recent studies highlight the considerable impact of the Russia-Ukraine war on global commodity markets (Balsalobre-Lorente, Sinha, Murshed 2023; Maneejuk, Kaewtathip, Yamaka 2024). In particular, Maneejuk, Kaewtathip, and Yamaka (2024) emphasise the heterogeneous effects of the conflict across different fossil fuel markets. To capture the dynamics of energy prices, empirical analyses frequently employ key benchmark indicators such as the Brent crude oil spot price, natural gas prices (TTF), and global coal prices. These variables have been widely used in previous studies examining developments in fossil fuel markets and their economic consequences (Paiva, Rivera-Castro, Andrade 2018; Joo et al. 2020; Ghabri, Ayadi, Guesmi 2021; Maneejuk et al. 2022).

The relationship between oil price fluctuations and stock market performance has been widely investigated in the financial economics literature. Early contributions by Chen, Roll and Ross (1986), and Jones and Kaul (1996) examined how oil price changes influence stock market returns. Since then, numerous empirical studies have explored this relationship using different methodologies and datasets. Notable contributions include: Antonakakis, Chatziantoniou, Filis (2014), Basher, Haug, Sadorsky (2018), Boldanov, Degiannakis, Filis (2016), Bouri (2015), Maghyereh, Awartani (2016), Shanken Weinstein (2006).

A large body of empirical research suggests that increases in oil prices tend to exert a negative effect on stock market returns (Basher, Sadorsky 2006; Jones, Kaul 1996; Nandha, Faff 2008; Masih, Peters, De Mello 2011; Sadorsky 1999; Tchatoka, Masson, Parry 2019). For example, Cuñado and Pérez de Gracia (2014) used Vector Error Correction Models (VECM) to examine the impact of oil price shocks on stock markets in 12 oil-importing European countries over the period 1973–2011, documenting significant negative effects in most markets. Similarly, Alsalman and Herrera (2015) found that positive oil price innovations reduce aggregate stock returns in the United States.

However, the empirical evidence is not entirely consistent. Several studies report weak or insignificant relationships between oil prices and stock markets (Apergis, Miller 2009; Chen, Roll, Ross 1986; Henriques, Sadorsky 2008; Huang et al. 2012; Sukcharoen et al. 2014). Other research indicates that the relationship may depend on broader macroeconomic conditions and vary over time (Miller, Ratti 2009). For instance, Mollick and Assefa (2013) find that the correlation between oil prices and stock returns changes across economic cycles, with a positive relationship emerging during the post-2008 financial crisis recovery period. Similarly, Silvapulle et al. (2017) report a positive association between oil prices and stock indices in the post-crisis period, suggesting that the strength of oil price effects may vary across different market conditions.

Overall, the empirical evidence suggests that the impact of energy price shocks on stock markets is not uniform and depends on broader macroeconomic and geopolitical conditions. In periods of heightened geopolitical risk, financial markets may react not only to changes in fundamentals such as energy prices, but also to shifts in investor sentiment and perceived uncertainty.

More recent research increasingly emphasises the role of investor sentiment and perceived uncertainty in shaping financial market dynamics. Since sentiment is not directly observable, empirical studies rely on various proxies to capture its effects. Early empirical work frequently employed survey--based indicators such as the University of Michigan Consumer Sentiment Index (UMCSI). Subsequent studies proposed alternative measures based on market indicators and online behaviour. For example, the VIX index has often been interpreted as a proxy for market fear or investor sentiment (Smales 2017). Google Trends search intensity has also been widely used as a high-frequency indicator of investor attention and information demand (Bijl et al. 2016). More recently, researchers have increasingly utilised social media data to capture real-time changes in investor sentiment and market expectations (Al-Nasseri, Menla Ali, Tucker 2021).

Google search data have been successfully applied in various contexts of economic and geopolitical stress. González-Fernández and González-Velasco (2020) developed the Google Sovereign-Risk Sentiment Index (GSSI), based on search volumes for keywords related to sovereign debt crises, and demonstrated that it closely correlates with traditional sovereign risk indicators, particularly during periods of financial stress. Papadamou et al. (2023) further show that pandemic-related search intensity significantly amplifies implied market volatility.

In the context of geopolitical risk, recent studies document that conflict-related search activity can significantly influence financial markets and energy prices (Lohne, Saltvik 2023; Maneejuk, Kaewtathip, Yamaka 2024; Stolbov, Shchepeleva 2025; Da, Engelberg, Gao 2015). A growing body of literature also demonstrates that uncertainty and investor sentiment play an important role in determining stock market performance (Baker, Wurgler 2007; Wang, Su, Duxbury 2022; Caldara, Iacoviello 2022; Baker, Bloom, Davis 2016; Smales 2021). In particular, evidence suggests that investor sentiment during periods of armed conflict can exert a measurable impact on stock returns (Bouteska, Hassan, Safa 2024).

War-related sentiment associated with the Russia-Ukraine conflict has recently attracted increasing scholarly attention. Empirical studies show that conflict-related sentiment affects financial markets in several countries, including Norway (Abakah et al. 2023), the United States (Mino, Williamson 2025), and China (Du 2022).

A key methodological challenge in constructing sentiment indicators based on Google Trends data concerns the selection of appropriate keywords. Previous studies have used a variety of search terms,

including 'Ukraine crisis', 'Russia-Ukraine war', 'Vladimir Putin', 'Russian invasion', 'Russia-Ukraine conflict', 'Russian oil', and 'Russian oil price' (Balsalobre-Lorente, Sinha, Murshed 2023), as well as broader expressions such as 'Ukraine and Russia tensions' (Maneejuk, Kaewtathip, Yamaka 2024). These keywords are typically selected to capture investor attention, which Da et al. (2011) identify as a key precursor of market sentiment.

However, the existing literature has rarely examined the role of war-related sentiment together with energy market dynamics in shaping stock market responses. In particular, relatively little attention has been paid to distinguishing between the direct effects of conflict-related sentiment on financial markets and its indirect effects operating through energy commodity prices. Building on the empirical and theoretical insights discussed above, the study formulates research hypotheses examining the energy-price and geopolitical sentiment channels in the context of the Russia-Ukraine conflict, as detailed in the Introduction.

3. Research methods

3.1. Data

This study utilises daily data covering the period from November 2021 to the end of January 2025, encompassing both the pre-war period and the ongoing phase of the Russia-Ukraine conflict. The analysis focuses on the Polish stock market, energy markets, and war-related sentiment. All daily data are obtained from the EquityRT database unless otherwise specified.

Stock market variables

The analysis focuses on the returns of the WIG index, expressed in US dollars to facilitate comparison with international energy prices and to account for the effects of USD/PLN exchange rate fluctuations. In addition, sectoral indices particularly exposed to risks from the Russia-Ukraine conflict are examined: WIG-Mining, WIG-Fuels, WIG-Energy, and WIG-Ukraine. For comparative purposes, medium- and small-cap indices mWIG40 and sWIG80 are also included. Table 1 provides descriptions of the stock market variables and identifies the markets or exchanges on which they are traded, while Figure 1 shows changes in prices over the study period.

The composition of the WIG index is reviewed quarterly. During each review, some companies may be removed while others are added, and the relative weights of individual companies within the index are updated. To account for these dynamics, changes in constituent weights between September 2021 and December 2024 were calculated. The September 2021 revision preceded the beginning of the study period, while the December 2024 revision represents the last index update before the end of the analysed period.

Figure 2 presents four panels illustrating the 20 largest decreases in constituent weights, the 20 largest increases, as well as the 20 largest debuting and delisted companies. Notable decreases occurred for Allegro and KGHM, while the largest increases were observed for PKN ORLEN and Santander Bank Polska, with ORLEN's growth likely linked to its merger with Lotos and PGNiG. Key debuts included Żabka, whereas significant delistings involved PGNiG and Lotos. Overall, the observed

changes in constituent weights were relatively limited, suggesting that the overall weight structure of the WIG index remained broadly stable during the analysed period. Consequently, these adjustments are unlikely to have materially affected the overall return dynamics of the WIG index.

Energy market variables

To capture financial market uncertainty and geopolitical risk, the analysis incorporates the CBOE Crude Oil Volatility Index (OVX), which measures implied volatility in the crude oil options market. OVX is particularly relevant for oil-importing economies during periods of geopolitical stress. Logarithmic returns of OVX are used to examine shifts in market expectations related to oil price risk.

Energy markets are represented by three major fossil fuel commodities: crude oil, natural gas, and coal. To capture the price dynamics of these markets, this study focuses on widely recognised benchmark indicators: Brent crude oil, Dutch TTF natural gas, and international coal prices – as supported by previous literature (Paiva, Rivera-Castro, Andrade 2018; Joo et al. 2020; Ghabri, Ayadi, Guesmi 2021; Maneejuk et al. 2022). Rather than using spot prices, we analyse futures contracts for West Texas Intermediate (WTI) crude oil, Brent crude oil, TTF natural gas, and coal. Futures prices are favoured for their forward-looking nature, as they incorporate market expectations and investor sentiment. This makes them particularly valuable during periods of heightened geopolitical uncertainty. Moreover, futures markets, especially for crude oil, tend to be more liquid than spot markets, facilitating more accurate price discovery. Consequently, futures contracts provide a robust framework for evaluating the effects of major geopolitical events, such as the Russia-Ukraine conflict, on energy markets and financial stability.

To assess domestic energy market trends, the analysis also includes the average retail price of unleaded petrol (PB 95) in both Polish zloty (PLN) and US dollars (USD), enabling a comparative analysis of local fuel price dynamics relative to global energy markets and currency fluctuations. Table 2 summarises the energy market variables, their descriptions, and the markets on which they are traded, while Figure 3 shows changes in energy commodity prices and retail gasoline prices during the study period.

Sentiment index related to the Russia-Ukraine conflict

The sentiment index related to the Russia-Ukraine war is constructed using Google Trends data, which measures the relative search interest in specific keywords over time, normalised on a scale from 0 to 100. Prior studies analysing sentiment during the conflict have employed various keywords, including 'Ukraine crisis', 'Russia-Ukraine war', 'Vladimir Putin', 'Russian invasion', 'Russia-Ukraine conflict', 'Russian oil', and related terms such as 'Ukraine and Russia tensions'. However, using multiple overlapping terms may lead to redundancy and potential overrepresentation of similar search behaviours, distorting the sentiment signal. To mitigate this, the present study adopts a simplified approach by using only the keyword 'Ukraine'. This term is chosen based on the assumption that increased search activity corresponds to heightened public attention and concern surrounding the conflict.

Google Trends provides daily search data only for intervals up to 269 days. To construct a continuous daily series, the LongTrends Python library is used, which gathers data in successive windows and stitches them together into a consistent series.

The resulting sentiment index is used as an external regressor in the empirical models. To stabilise variance and address potential non-linearity, the logarithm of the sentiment index is used. Robustness checks across different sub-periods confirmed that normalisation (0–100 scaling) does not bias the analysis. Figure 4 presents the search frequency of the keyword 'Ukraine' based on Google Trends data.

3.2. Model

A distinctive feature of our approach is the inclusion of extended regressors – specifically, war-related sentiment, the Oil Volatility Index (OVX), and fuel/energy prices – into both the mean and variance equations of the return-generating models. We explicitly account for both contemporaneous and lagged effects of these external shocks, enabling a richer understanding of their dynamic influence on financial returns and volatility. We adopt a sentiment-augmented GARCH-family framework, where the mean equation is specified as:

$$r_t = \mu + \beta_m x_t + \beta_{lag} x_{t-1} + \eta_t$$

where:

r_t – the asset return at time t,
μ – the constant mean,
x_t – the contemporaneous external regressor (e.g. sentiment or energy price),
x_{t-1} – one-period lag,
$\eta_t = \sigma_t z_t$ – the error term where z_t is an i.i.d. standard normal variable and σ_t is the time-varying conditional standard deviation.

We employ the parsimonious GARCH(1,1) specification to model volatility, given its widespread use and empirical robustness in capturing financial market dynamics (Bollerslev, Chou, Kroner 1992; Hansen, Lunde 2005). In our analysis, we assume that the error term z_t follows a normal distribution. The GARCH(1,1) model incorporates economic sentiment indicators as external regressors in variance equations in following way:

$$\sigma_t^2 = \omega + \alpha \eta_{t-1}^2 + \beta \sigma_{t-1}^2 + \beta_{var} x_t + \beta_{vlag} x_{t-1}$$

To account for potential asymmetric responses in volatility, we extend the model further using the GJR-GARCH(1,1) and EGARCH(1,1) specifications. The GJR-GARCH(1,1) model follows:

$$\sigma_t^2 = \omega + \alpha \eta_{t-1}^2 + \gamma I_{t-1} \eta_{t-1}^2 + \beta \sigma_{t-1}^2 + \beta_{var} x_t + \beta_{vlag} x_{t-1}$$

and $\gamma I_{t-1} \eta_{t-1}^2$ captures the leverage effect, where I_{t-1} is an indicator function equal to 1 if $\eta_{t-1} < 0$ and 0 otherwise, allowing the model to capture asymmetric effects of negative shocks.

The EGARCH(1,1) model is specified as:

$$\sigma_t^2 = \exp\left\{\omega + \alpha\frac{\eta_{t-1}}{\sigma_{t-1}} + \beta_1 \log\sigma_{t-1}^2 + \gamma\left(\left|\frac{\eta_{t-1}}{\sigma_{t-1}}\right| - \sqrt{\frac{2}{\pi}}\right) + \beta_{var}x_t + \beta_{vlag}x_{t-1}\right\}$$

where $\alpha\frac{\eta_{t-1}}{\sigma_{t-1}}$ reflects the leverage effect.

This logarithmic specification inherently allows for leverage effects and ensures that the conditional variance remains positive.

4. Results

4.1. Descriptive statistics

Table 3 presents descriptive statistics for daily logarithmic returns, including the median, mean, standard deviation (SD), skewness, kurtosis, and the observed minimum and maximum values for each variable. Additionally, the table reports p-values for the Augmented Dickey-Fuller (ADF) test for stationarity, the Ljung-Box test for autocorrelation, and the ARCH test for conditional heteroskedasticity.

The statistical characteristics provide insights into the behaviour of the analysed market sectors and energy commodities during the sample period. The WIG index recorded a slightly positive mean return, whereas sectoral indices exhibited negative average returns. Among them, WIG-Energy shows the smallest negative mean return (-0.02). In contrast, WIG-Ukraine displays the most pronounced decrease, with a mean return of -0.10, reflecting the strong exposure of firms linked to the Ukrainian market to geopolitical developments.

Among the analysed energy commodities, natural gas and coal recorded the most negative average returns and the highest volatility, as indicated by their large standard deviations. In contrast, crude oil prices (WTI) exhibit average returns close to zero and comparatively lower volatility. The OVX index stands out with a particularly high standard deviation (5.32), reflecting elevated uncertainty in global energy markets during the analysed period.

The results of the Augmented Dickey-Fuller (ADF) test indicate that all variables are stationary at conventional significance levels. The Ljung-Box test results suggest that most series do not exhibit significant autocorrelation, as indicated by p-values above 0.05. The ARCH test results indicate the presence of conditional heteroskedasticity in several series, which justifies the application of GARCH-type models in the subsequent analysis. However, for WIG-Mining, WIG-Energy, and crude oil prices, the p-values exceed 0.05, indicating weaker evidence of ARCH effects.

Table 4 presents the correlation coefficients between the analysed variables. Due to the very high correlation between WTI and Brent crude oil prices, Brent is excluded from the matrix to avoid redundancy.

The correlation analysis reveals several notable relationships. First, the sectoral indices display strong positive correlations with the aggregate WIG index, particularly WIG-Fuels and WIG-Mining. Second, energy price movements exhibit varying relationships with stock market indices. For example,

natural gas prices show negative correlations with several indices, especially WIG-Ukraine, indicating that gas market shocks may disproportionately affect firms linked to the Ukrainian market. Finally, the USD exchange rate exhibits strong negative correlations with Polish stock indices, suggesting that PLN depreciation tends to coincide with weaker stock market performance.

4.2. The impact of energy market variables on Polish stock market returns

This study evaluates whether developments in global energy markets influence stock market performance on the Polish Stock Market. To capture these effects, we estimate an EGARCH model in which energy commodities, the OVX index, and domestic fuel prices are included as external regressors affecting both the mean and volatility of stock market returns. The EGARCH specification is selected based on the Akaike Information Criterion (AIC), as it outperforms alternative GARCH and GJR-GARCH models.

Table 5 reports the estimation results. The coefficients $\boldsymbol{\beta}_m$, $\boldsymbol{\beta}_{lag}$ measure the contemporaneous and lagged effects of external variables on stock market returns, while $\boldsymbol{\beta}_{var}$, $\boldsymbol{\beta}_{vlag}$ capture their influence on conditional volatility.

The results indicate that global energy markets significantly affect the Polish stock market. For the broad WIG index, oil prices (WTI and Brent) exhibit positive and statistically significant effects on returns, suggesting that increases in oil prices are associated with short-term improvements in market performance. In contrast, natural gas prices show a negative relationship with stock returns, indicating that gas market shocks may exert downward pressure on equity prices.

When the analysis is disaggregated by sector, considerable heterogeneity emerges. WIG-Mining and WIG-Fuels display strong sensitivity to oil prices and domestic fuel prices, reflecting the structural exposure of these industries to developments in energy markets. Coal prices also affect returns in the mining sector, showing the importance of commodity prices for resource-based industries.

The WIG-Energy index also responds to movements in oil prices and fuel prices, although the magnitude of these effects is smaller than for mining and fuel companies. This suggests that electricity and energy utilities are influenced by energy price fluctuations, but their response may be moderated by regulatory and structural factors within the sector.

Overall, the findings provide evidence that energy markets constitute an important transmission channel through which geopolitical shocks may affect the Polish stock market.

4.3. Ukraine sentiment (proxy for war-related investor attention)

In the second stage, we introduce an additional external regressor capturing public attention to the ongoing conflict in Ukraine. This variable, referred to as Ukraine Sentiment, is constructed using Google Trends search intensity for the term 'Ukraine', serving as a proxy for war-related investor attention.

The results reported in Table 6 present the estimated coefficients from the sentiment-augmented EGARCH model, in which Ukraine Sentiment is incorporated as an external regressor in both the mean and variance equations. Overall, the estimates indicate that Ukraine Sentiment plays a statistically significant role in explaining return dynamics across several equity indices and selected commodity

and macro-financial variables. However, its effects vary across asset classes and differ between the mean and volatility equations.

In the mean equation, Ukraine Sentiment is significant for a range of equity indices and energy-related assets, suggesting that changes in war-related search intensity, used as a proxy for public attention, are associated with short-term adjustments in returns. The effects are particularly pronounced in sector-specific indices, indicating stronger sensitivity in markets with higher exposure to geopolitical developments.

Importantly, the WIG-Ukraine index requires a distinct interpretation due to identification constraints. Constituents of this index are directly exposed to developments in Ukraine, implying that Ukraine-related sentiment is not strictly exogenous in this specification. As a result, this case is interpreted as a reference (placebo) specification rather than evidence of a causal transmission channel.[1]

Turning to volatility dynamics, statistically significant effects of Ukraine Sentiment are observed only in a limited set of markets, namely the broad WIG index, the WIG-Ukraine index, and natural gas. In these cases, increased search intensity is associated with changes in conditional volatility, indicating that geopolitical attention contributes to elevated uncertainty.

For energy commodities, Ukraine Sentiment is significant in several mean-equation specifications, although the magnitude and direction of effects vary across markets, reflecting heterogeneous transmission mechanisms within the energy complex. Differences are observed across crude oil, natural gas, and coal markets, suggesting that sensitivity to geopolitical attention depends on the structure and informational role of each market.

Finally, differences emerge in fuel price dynamics depending on currency denomination. Prices expressed in PLN exhibit stronger sensitivity to Ukraine Sentiment compared to USD-denominated series, suggesting that exchange rate movements play an important role in the transmission of geopolitical attention to domestic fuel prices.

Overall, the results indicate that Ukraine Sentiment primarily affects return dynamics in selected markets, while its impact on volatility is more limited and concentrated in specific equity and energy segments. This points to an asset-specific transmission of geopolitical attention rather than a uniform market-wide effect.

4.4. Robustness tests

The WIG index is a capitalisation-weighted index comprising all companies listed on the main market of the Polish stock market, with weights proportional to their free-float market capitalisation. As a result, large firms exert a disproportionate influence on index dynamics. During the analysed period, the index exhibited a relatively high concentration in energy- and commodity-related companies, which may mechanically amplify the sensitivity of aggregate returns to fluctuations in energy markets. Importantly, the composition of the largest energy- and commodity-related firms remained relatively stable throughout the sample period, and no major segment reclassifications affecting these firms

[1] To address potential concerns related to structural breaks in index composition, additional robustness checks are performed using sub-sample estimations before and after September 2023, when Kernel was removed from the index. The results indicate that the statistical significance and qualitative interpretation of sentiment effects remain stable across both sub-periods. Results – pre: β_m = -1.19***, and β_{m-1} = 1.07***; post: β_m = -0.60***, and β_{m-1} = 0.61***.

occurred. Therefore, while sectoral concentration may strengthen the magnitude of the observed relationships, the results are unlikely to be driven by structural breaks or index rebalancing.

Robustness check: mWIG40 and sWIG80

To assess whether the observed relationships reflect broader market dynamics rather than the influence of the largest firms, additional analyses were conducted using mWIG40 and sWIG80, representing medium- and small-cap companies. These indices are less concentrated in energy- and commodity--related firms, allowing examination of whether the impact of energy market variables on stock returns is genuine across market segments. Table 7 presents the estimation results for these indices.

The patterns largely confirm those observed for the broad WIG index: oil prices (WTI and Brent) positively affect returns, the OVX volatility index negatively influences returns, and PB 95 exhibits a strong positive relationship. Gas prices maintain a negative effect. For both mWIG40 and sWIG80, contemporaneous effects dominate, while lagged coefficients are generally smaller and less significant, indicating that most of the market response occurs immediately. Conditional variance results (β_{var}) are consistent with the mean equation, with strongest effects in WIG due to large-cap exposure.

Overall, the results suggest that energy market developments influence medium- and small--cap segments, confirming that the observed effects are not solely a mechanical outcome of index concentration.

Robustness check: WIG-ex

While alternative indices address segmentation effects, the broad WIG may still be mechanically influenced by a few dominant energy and commodity firms. To isolate broader market dynamics, an adjusted WIG series, WIG-ex, was constructed by regressing daily WIG returns on the returns of the largest energy-related companies (PKN Orlen, KGHM, Tauron, and Bogdanka) and using the residuals as the dependent variable. Table 8 shows that even after excluding the direct impact of the largest energy firms, key energy variables remain significant.

Oil prices, gas prices, the OVX index, and PB 95 continue to influence returns. Persistence in the variance equation confirms volatility clustering typical of financial returns. These findings reinforce the robustness of the main results, demonstrating that energy market effects extend beyond the largest firms.

Robustness check: sector weight normalisation

To address potential biases from sectoral concentration in the WIG index, a normalisation procedure was applied. Sectoral returns were weighted by their share in total market capitalisation and rescaled. The normalised returns were re-estimated, with results reported in Table 9.

Normalisation reduces the magnitude of some coefficients, particularly for large-cap sectors, confirming that part of the observed effect reflects index composition. Importantly, many energy--related variables remain statistically significant, including WTI, Brent, OVX, and PB 95. The qualitative structure of the relationships remains unchanged, suggesting that the transmission mechanism from energy markets to the Polish stock market is not an artifact of sectoral concentration but reflects broader macro-financial linkages.

Robustness of Ukraine war sentiment effects across market segments

The war-related sentiment index, based on Google Trends for 'Ukraine', may capture both behavioural and fundamental effects. For companies directly exposed to the conflict, fluctuations may reflect operational and financial prospects, whereas for broader indices (mWIG40, sWIG80), the index captures investor behavioural responses.

Building on the findings reported in Table 10, the sentiment models were re-estimated for mWIG40, sWIG80, and WIG-ex. Table 9 shows that sentiment continues to affect returns across market segments. For medium-sized firms, the effect is significant; for smaller firms, it is weaker. In WIG-ex, the effect persists but is slightly reduced, indicating that large energy firms amplify the response but do not solely drive it. Sector-specific normalised indices reveal a short-term correction pattern: contemporaneous coefficients are partially offset by lagged effects, consistent with market overreaction followed by adjustment. This implies that while sentiment influences returns, its effect is transient and largely absorbed within one trading day.

Overall, the robustness checks confirm that Ukraine war-related sentiment generates measurable responses across the Polish equity market, beyond the mechanical impact of large energy-focused constituents. This is consistent with patterns documented in Table 5 and supports the interpretation that investor attention to geopolitical events affects stock returns at multiple market levels.

5. Discussion

The results of this study highlight several important dynamics in the interaction between geopolitical sentiment (the war in Ukraine) and the Polish financial market.

Descriptive statistics indicate that the broad market recorded slightly positive average returns, whereas sectoral indices such as WIG-Ukraine and WIG-Fuels exhibited weaker performance, reflecting their higher exposure to geopolitical developments. Among energy commodities, natural gas and coal showed the highest volatility, while crude oil prices were comparatively more stable, suggesting heterogeneous risk profiles across energy markets. Correlation analysis confirms pronounced sectoral differences. The WIG-Ukraine index is particularly sensitive to natural gas prices, while mining and fuel-related indices show stronger co-movement with oil prices. In contrast, periods of elevated oil--market uncertainty are associated with weaker stock market performance, indicating that financial markets react negatively to heightened energy risk.

Econometric results corroborate these patterns. For the broad WIG index, oil price increases are associated with positive returns, while OVX and natural gas shocks exert negative effects. Sector-specific responses are more pronounced: WIG-Mining reacts strongly to oil prices, whereas WIG-Ukraine is most affected by natural gas. Coal and domestic fuel prices (PB 95) also influence returns, especially in mining, with lagged coefficients suggesting short-term adjustment dynamics. These findings align with previous studies emphasizing the transmission of geopolitical risk through commodity markets (Caldara, Iacoviello 2022; Silvapulle et al. 2017; Maghyereh, Awartani 2016).

Introducing the Ukraine sentiment index, proxied by Google search intensity, reveals that increased public attention to the conflict negatively affects stock returns in exposed sectors. The effects are particularly strong in mining and fuel-related industries, followed by partial reversals in subsequent

periods. This pattern is consistent with short-term overreaction followed by correction, as documented in behavioural finance literature (Da, Engelberg, Gao 2015).

Energy markets also respond dynamically: initial declines in oil and gas prices are often followed by short-term rebounds, reflecting the propagation of geopolitical attention through commodity markets (Smales 2021; Caldara, Iacoviello 2022). Overall, the broad WIG index shows smaller and less significant effects, suggesting that diversification partially insulates aggregate market returns.

The sentiment effects persist across alternative indices (mWIG40, sWIG80, WIG-ex) and sector-weighted normalised indices, indicating that the response is not solely driven by large energy firms. Medium-sized firms are more sensitive than smaller firms, while WIG-ex shows attenuated but still significant effects. This confirms that investor attention to geopolitical events can influence market dynamics beyond direct exposure, in line with broader research on uncertainty and attention-driven shocks (Baker, Bloom, Davis 2016; Da, Engelberg, Gao 2015).

Robustness tests confirm that the observed effects hold across market segments. Medium- and small-cap indices (mWIG40, sWIG80; Table 7) show similar patterns: positive oil price effects, negative OVX effects, and significant PB 95 influence, with smaller lagged coefficients indicating rapid adjustment. Excluding large energy firms (WIG-ex; Table 8) slightly reduces the effects but confirms that sectoral concentration amplifies rather than creates them. Normalised sector-weighted indices (Table 9) further support these findings, with key variables remaining significant. Finally, Ukraine sentiment (Table 10) affects returns across all segments, with contemporaneous negative effects followed by positive lagged coefficients, highlighting the transient but measurable impact of geopolitical attention.

6. Conclusion

This study examines the relationships between geopolitical sentiment related to the war in Ukraine, Polish stock market performance and energy commodity prices. Stock returns are positively correlated with crude oil prices but negatively affected by oil market volatility (OVX) and increases in natural gas and coal prices. Sectoral differences are evident: WIG-Ukraine is particularly sensitive to natural gas, while WIG-Mining responds strongly to oil prices, reflecting energy dependence.

GARCH model results suggest that both oil market volatility and war-related sentiment, proxied by Google Trends, are associated with stock returns dynamics. Periods of heightened war-related attention are followed by short-term declines in stock prices and subsequent partial reversals. Energy prices show heterogeneous patterns, with oil and gas declining initially and partially recovering, while coal exhibits a more persistent downward movement.

The analysis is consistent with H1 (energy-price channel): energy price fluctuations are associated with stock return dynamics, with sector-specific patterns. It is also consistent with H2 (geopolitical sentiment channel): war-related sentiment is associated with short-term declines in returns, particularly in energy- and commodity-intensive sectors. Finally, the results are in line with H3: the effects of energy prices and geopolitical sentiment remain observable even after controlling for index composition effects.

From a practical perspective, investors should consider both energy market dynamics and geopolitical sentiment when assessing risk, as short-term market reactions can create opportunities for tactical trading or risk management. This study, however, has some limitations: it focuses on

a single country and relies on search activity as a proxy for investor sentiment, which may not fully capture nuanced market perceptions, and using only one search term may introduce measurement noise. Overall, the findings demonstrate that geopolitical sentiment, even when measured narrowly via Google Trends, has short-term effects on equity markets, particularly in energy-sensitive sectors. Future research could explore multi-country settings or alternative sentiment measures to validate and extend these findings.

References

Abakah E.J.A., Adeabah D., Tiwari A.K., Abdullah M. (2023), Effect of Russia-Ukraine war sentiment on blockchain and FinTech stocks, *International Review of Financial Analysis*, 90.

Alsalman Z., Herrera A.M. (2015), Oil price shocks and the U.S. stock market: Do sign and size matter?, *The Energy Journal*, 36(3), 171–188.

Al-Nasseri A., Menla Ali F., Tucker A. (2021), Investor sentiment and the dispersion of stock returns: evidence based on the social network of investors, *International Review of Financial Analysis*, 78, 101910.

Antonakakis N., Chatziantoniou I., Filis G. (2014), Dynamic spillovers of oil price shocks and economic policy uncertainty, *Energy Economics*, 44, 433–447, DOI: 10.1016/j.eneco.2014.05.007.

Apergis N., Miller S.M. (2009), Do structural oil-market shocks affect stock prices?, *Energy Economics*, 31(4), 569–575, DOI: 10.1016/j.eneco.2009.03.001.

Baker M., Wurgler J. (2007), Investor sentiment in the stock market, *Journal of Economic Perspectives*, 21(2), 129–152.

Baker S.R., Bloom N., Davis S.J. (2016), Measuring economic policy uncertainty, *The Quarterly Journal of Economics*, 131(4), 1593–1636, DOI: 10.1093/qje/qjw024.

Basher S.A., Haug A.A., Sadorsky P. (2018), The impact of oil-market shocks on stock returns in major oil-exporting countries, *Journal of International Money and Finance*, 86, 264–280, DOI: 10.1016/j.jimonfin.2018.05.003.

Basher S.A., Sadorsky P. (2006), Oil price risk and emerging stock markets, *Global Finance Journal*, 17(2), 224–251, DOI: 10.1016/j.gfj.2006.04.001.

Balsalobre-Lorente D., Sinha A., Murshed M. (2023), Russia-Ukraine conflict sentiments and energy market returns in G7 countries: discovering the unexplored dynamics, *Energy Economics*, 125, 106847, DOI: 10.1016/j.eneco.2023.106847.

Belhoula M.M., Mensi W., Al-Yahyaee K.H. (2024), Dynamic speculation and efficiency in European natural gas markets during the COVID-19 and Russia-Ukraine crises, *Resources Policy*, 98, 105362.

Berezvai Z., Helfrich D. (2024), The impact of a short-term fuel price cap on market prices after its removal: evidence from Hungary, *Energy Strategy Reviews*, 54, 101472, DOI: 10.1016/j.esr.2024.101472.

Bijl L., Kringhaug G., Molnár P., Sandvik E. (2016), Google searches and stock returns, *International Review of Financial Analysis*, 45, 150–156, DOI: 10.1016/j.irfa.2016.03.015.

Boldanov R., Degiannakis S., Filis G. (2016), Time-varying correlation between oil and stock market volatilities: evidence from oil-importing and oil-exporting countries, *International Review of Financial Analysis*, 48, 209–220, DOI: 10.1016/j.irfa.2016.10.002.

Bollerslev T., Chou R.Y., Kroner K.F. (1992), ARCH modeling in finance: a review of the theory and empirical evidence, *Journal of Econometrics*, 52(1–2), 5–59, DOI: 10.1016/0304-4076(92)90064-X.

Bouri E. (2015), Oil volatility shocks and the stock markets of oil-importing MENA economies: a tale from the financial crisis, *Energy Economics*, 51, 590–598, DOI: 10.1016/j.eneco.2015.09.002.

Bouteska A., Hassan M.K., Safa M.F. (2024), Investor sentiment and stock markets during the war in pandemic time, *International Journal of Accounting and Information Management*, 34(1), 57–87, DOI: 10.1108/IJAIM-02-2024-0073.

Caldara D., Iacoviello M. (2022), Measuring geopolitical risk, *American Economic Review*, 112(4), 1194–1225, DOI: 10.1257/aer.20191823.

Chen N.F., Roll R., Ross S. (1986), Economic forces and the stock market, *The Journal of Business*, 59(3), 383–403, DOI: 10.1086/296344.

Cuñado J., Pérez de Gracia F. (2014), Oil price shocks and stock market returns: evidence for some European countries, *Energy Economics*, 42, 365–377, 10.1016/j.eneco.2013.10.017.

Da Z., Engelberg J., Gao P. (2011), In search of attention, *The Journal of Finance*, 66(5), 1461–1499.

Da Z., Engelberg J., Gao P. (2015), The sum of all FEARS investor sentiment and asset prices, *Review of Financial Studies*, 28(1), 1–32, DOI: 10.1093/rfs/hhu072.

Du Q. (2022), Volatility in Chinese and European stock markets under the "Black Swan" of the Russia-Ukraine war: an empirical test based on the GARCH family models and investor sentiment, in: *Proceedings of the 2022 2nd International Conference on Economic Development and Business Culture (ICEDBC 2022)*, Atlantis Press.

Ghabri Y., Ayadi A., Guesmi K. (2021), Fossil energy and clean energy stock markets under COVID-19 pandemic, *Applied Economics*, 53(43), 4962–4974, DOI: 10.1080/00036846.2021.1912284.

González-Fernández M., González-Velasco C. (2020), A sentiment index to measure sovereign risk using Google data, *International Review of Economics & Finance*, 69, 406–418, DOI: 10.1016 /j.iref.2020.05.011.

Hamilton J.D. (1996), This is what happened to the oil price-macroeconomy relationship, *Journal of Monetary Economics*, 38(2), 215–220.

Hansen P.R., Lunde A. (2005), A forecast comparison of volatility models: Does anything beat a GARCH(1,1)?, *Journal of Applied Econometrics*, 20(7), 873–889, DOI: 10.1002/jae.800.

Henriques I., Sadorsky P. (2008), Oil prices and the stock prices of alternative energy companies, *Energy Economics*, 30(3), 998–1010, DOI: 10.1016/j.eneco.2007.11.001.

Huang A.Y., Cheng C.-M., Hu W.-C., Chen C.-C. (2012), Oil prices and stock prices of alternative energy companies: time varying relationship with recent evidence, *Journal of Economics and Management*, 8(2), 221–258.

Huang H., Zhao J., Liu H., Ren S., Liu M., Liu H., An F., Guo Y., An H. (2023), Research on the crisis propagation in the global coal trade under the Russia-Ukraine conflict, *Scientific Reports*, 13, 15954.

IEA (2021), *Net Zero by 2050*, International Energy Agency, https://www.iea.org/reports/net-zero-by-2050.

Jones C.M., Kaul G. (1996), Oil and the stock markets, *The Journal of Finance*, 51(2), 463–491, DOI: 10.1111/j.1540-6261.1996.tb02691.x.

Joo K., Suh J.H., Lee D., Ahn K. (2020), Impact of the global financial crisis on the crude oil market, *Energy Strategy Reviews*, 30, 100516, DOI: 10.1016/j.esr.2020.100516.

Kling J.L. (1985), Oil price shocks and stock-market behavior, *Journal of Portfolio Management*, 12(1), 34–39.

Lohne S.D., Saltvik S.M.A. (2023), *The invasion of Ukraine and stock returns*, master's thesis, University of Stavanger, https://nva.sikt.no/registration/01990524870d-f5a55f51-9078-4d58-9692-d63e2c4ed03d.

Maghyereh A., Awartani B. (2016), Oil price uncertainty and equity returns, *Journal of Financial Economic Policy*, 8(1), 64–79, DOI: 10.1108/JFEP-06-2015-0035.

Mahlstein K., McDaniel C., Schropp S., Tsigas M. (2022), Estimating the economic effects of sanctions on Russia: an allied trade embargo, *The World Economy*, 45(11), 3344–3383, DOI: 10.1111/twec.13311.

Maneejuk P., Kaewtathip N., Jaipong P., Yamaka W. (2022), The transition of the global financial markets' connectedness during the COVID-19 pandemic, *The North American Journal of Economics and Finance*, 63, 101816.

Maneejuk P., Kaewtathip N., Yamaka W. (2024), The influence of the Ukraine-Russia conflict on renewable and fossil energy price cycles, *Energy Economics*, 129, 107218, DOI: 10.1016/j.eneco.2023.107218.

Masih R., Peters S., De Mello L. (2011), Oil price volatility and stock price fluctuations in an emerging market: evidence from South Korea, *Energy Economics*, 33(5), 975–986, DOI: 10.1016/j.eneco.2011.03.015.

Miller J., Ratti R. (2009), Crude oil and stock markets: stability, instability, and bubbles, *Energy Economics*, 31(4), 559–568, DOI: 10.1016/j.eneco.2009.01.009.

Mino D., Williamson C. (2025), *Sentiment and volatility in financial markets: a review of BERT and GARCH applications during geopolitical crises,* DOI: 10.48550/arXiv.2510.16503.

Mollick A., Assefa T.A. (2013), U.S. stock returns and oil prices: the tale from daily data and the 2008–2009 financial crisis, *Energy Economics*, 36, 1–18, DOI: 10.1016/j.eneco.2012.11.021.

Nandha M., Faff R. (2008), Does oil move equity prices? A global view, *Energy Economics*, 30(3), 986–997, DOI: 10.1016/j.eneco.2007.09.003.

Paiva A.S.S., Rivera-Castro M.A., Andrade R.F.S. (2018), DCCA analysis of renewable and conventional energy prices, *Physica A: Statistical Mechanics and its Applications*, 490, 1408–1414, DOI: 10.1016/j.physa.2017.08.052.

Papadamou S., Fassas A.P., Kenourgios D., Dimitriou D. (2023), Effects of the first wave of COVID-19 pandemic on implied stock market volatility: international evidence using a Google Trend measure, *The Journal of Economic Asymmetries*, 28, e00317, DOI: 10.1016/j.jeca.2023.e00317.

Sadorsky P. (1999), Oil price shocks and stock market activity, *Energy Economics,* 21(5), 449–469, DOI: 10.1016/S0140-9883(99)00020-1.

Shanken J., Weinstein M.I. (2006), Economic forces and the stock market revisited, *Journal of Empirical Finance*, 13(2), 129–144, DOI: 10.1016/j.jempfin.2005.09.001.

Silvapulle P., Smyth R., Zhang X., Fenech J.-P. (2017), Nonparametric panel data model for crude oil and stock market prices in net oil importing countries, *Energy Economics*, 67, 255–267, DOI: 10.1016/j.eneco.2017.08.017.

Smales L.A. (2017), The importance of fear: investor sentiment and stock market returns, *Applied Economics*, 49(34), 3395–3421.

Smales L.A. (2021), Geopolitical risk and volatility spillovers in oil and stock markets, *The Quarterly Review of Economics and Finance*, 80, 358–366.

Stolbov M., Shchepeleva M. (2025), A sentiment-based financial stress index for Russia, *Borsa Istanbul Review*, 25(2), 350–359, DOI: 10.1016/j.bir.2025.01.007.

Sukcharoen K., Zohrabyan T., Leatham D., Wu X. (2014), Interdependence of oil prices and stock market indices: a copula approach, *Energy Economics*, 44, 331–339, DOI: 10.1016/j.eneco.2014.04.012.

Tchatoka F.D., Masson V., Parry S. (2019), Linkages between oil price shocks and stock returns revisited, *Energy Economics*, 82, 42–61, DOI: 10.1016/j.eneco.2018.02.016.

Wang W., Su C., Duxbury D. (2022), The conditional impact of investor sentiment in global stock markets: a two-channel examination, *Journal of Banking & Finance*, 138, 106458, DOI: 10.1016 /j.jbankfin.2022.106458.

Yag'ya V., Yagya T. (2021), Geography of oil and gas of the Russian Federation in the world markets, in: R. Bolgov, V. Atnashev, Y. Gladkiy, A. Leete, A. Tsyb, S. Pogodin (eds.), *Proceedings of Topical Issues in International Political Geography*, Springer, DOI: 10.1007/978-3-030-58263-0_21.

Appendix

Table 1

Stock market variables: descriptions and trading venues

Variable	Description	Market/exchange
WIG	Broad stock market index	Polish stock market
mWIG40	Medium-cap index	Polish stock market
sWIG80	Small-cap index	Polish stock market
WIG-Mining	Sectoral index – mining companies	Polish stock market
WIG-Fuels	Sectoral index – fuel companies	Polish stock market
WIG-Energy	Sectoral index – energy utilities	Polish stock market
WIG-Ukraine	Index of Ukrainian-affiliated companies listed on WSE	Polish stock market

Note: all indices are based on daily closing prices, and returns are expressed in USD to capture both international financial market dynamics and the effect of currency fluctuations on domestic stock performance.

Source: own study.

Table 2

Energy market variables: descriptions and trading venues

Variable	Description	Market/exchange
WTI	WTI crude oil futures	NYMEX (ICE US)
Brent	Brent crude oil futures	ICE Futures Europe
GAS	Dutch TTF natural gas futures (benchmark contract)	ICE Futures Europe
Coal	Coal futures (benchmark contract)	ICE Futures Europe
OVX	CBOE Crude Oil Volatility Index	CBOE
PB95	Retail gasoline price at gas stations	Poland

Notes:
All futures contracts (WTI, Brent, GAS, Coal) used in this study are front-month contracts. 'Front-month' refers to the nearest expiry futures contract, which is typically the most liquid and representative of current market prices.

Source: own study.

Table 3
Descriptive statistics of daily returns and diagnostic tests

Variable	Median	Mean	SD	Skewness	Kurtosis	Minimum	Maximum	ADF (p val.)	Ljung-Box (p val.)	ARCH (p val.)
WIG	0.02	0.01	1.76	-0.36	8.01	-13.2	7.83	0.01	0.3	0.01
WIG-Mining	0.02	-0.03	2.85	0.01	4.8	-14.85	12.26	0.01	0.16	0.34
WIG-Ukraine	-0.07	-0.10	3.39	-3.96	69.27	-50.68	16.75	0.01	0.9	0.01
WIG-Fuels	0.01	-0.04	2.3	-0.12	4.76	-9.14	10.17	0.01	0.1	0.01
WIG-Energy	-0.09	-0.02	2.31	0.4	5.6	-9.25	14.02	0.01	0.69	0.03
sWIG80	0.14	0.01	1.26	-0.97	9.84	-10.17	5.75	0.01	0.01	0.01
mWIG40	0.15	0.01	1.69	-0.61	11.20	-14.35	9.04	0.01	0.23	0.01
OVX	-0.35	-0.02	5.32	0.62	9.35	-31.12	36.78	0.01	0.58	0.01
WTI	0.16	0.01	2.4	-0.79	6.38	-13.44	8.26	0.01	0.66	0.23
Brent	0.18	0.01	2.28	-0.82	6.73	-14.11	8.43	0.01	0.35	0.55
GAS	-0.08	-0.06	6.26	0.22	9.02	-35.24	41.28	0.01	0.12	0.01
Coal	0.01	-0.04	3.77	0.49	22.91	-22.71	32.62	0.01	0.23	0.01
PB 95	-0.06	-0.01	1.14	0.45	7.62	-5.85	7.53	0.01	0.01	0.01
PB 95 (PLN)	0.01	0.01	0.9	0.58	11.93	-4.93	5.96	0.01	0.01	0.01
USD	-0.04	0.01	0.74	0.01	5.07	-4.3	2.82	0.01	0.11	0.01

Notes:
The table reports descriptive statistics for daily logarithmic returns of all variables over the sample period.
Mean, median, standard deviation, minimum and maximum are expressed in percentage points.
ADF denotes the Augmented Dickey-Fuller test for stationarity, Ljung-Box refers to the test for autocorrelation, and ARCH denotes the test for conditional heteroskedasticity.

Source: own study.

Table 4
Correlation matrix

WIG	1													
mWIG40	0.94	1												
sWIG80	0.87	0.87	1											
WIG-Mining	0.75	0.67	0.64	1										
WIG-Ukraine	0.55	0.60	0.57	0.34	1									
WIG-Fuels	0.76	0.67	0.63	0.67	0.34	1								
WIG-Energy	0.68	0.67	0.62	0.53	0.32	0.62	1							
OVX	-0.21	-0.19	-0.20	-0.18	-0.12	-0.18	-0.12	1						
WTI	0.14	0.09	0.08	0.31	-0.03	0.28	0.11	-0.2	1					
GAS	-0.22	-0.25	-0.25	-0.08	-0.35	-0.09	-0.09	0.05	0.12	1				
Coal	-0.05	-0.09	-0.08	0.04	-0.16	0.06	0.08	0.04	0.2	0.34	1			
PB 95	0.45	0.43	0.47	0.38	0.24	0.39	0.35	-0.11	0.11	-0.12	0.07	1		
PB 95 (PLN)	-0.03	-0.05	-0.04	0.04	-0.06	0.06	0.02	-0.02	0.12	0.01	0.13	0.76	1	
USD	-0.73	-0.73	-0.77	-0.53	-0.44	-0.52	-0.51	0.14	-0.02	0.21	0.04	-0.62	0.04	1

Source: own calculations.

Table 5
The importance of energy market variables in modelling Polish stock market returns

	μ	β_m	$\beta_{m,-1}$	ω	α	β	γ	β_{var}	$\beta_{var,-1}$	AIC
WIG										
OVX	0.01	**-0.06*** **	**-0.03*** **	0.03*	-0.07***	0.97***	0.07	-0.01	0.02	3.82
WTI	0.01	**0.14*** **	0.04	0.03	-0.07	0.97***	0.12	-0.02	0.03	3.83
Brent	0.02	**0.13*** **	**0.05***	0.03***	-0.07***	0.97***	0.11*	-0.02	0.03	3.84
GAS	0.01	**-0.04****	0.01	0.02***	-0.07***	0.98***	0.05***	**0.01***	**-0.01***	3.84
Coal	0.01	-0.01	**-0.04****	0.03***	-0.08***	0.97***	0.09	0.01	-0.01	3.86
PB 95	0.03**	**0.86*** **	**-0.19*** **	0.03***	-0.07**	0.97***	0.14***	-0.08	0.06	3.58
WIG-Mining										
OVX	-0.04**	**-0.09*** **	**-0.04*** **	0.01***	-0.01	0.99***	0.04***	0.01	0.01	4.86
WTI	0.01***	**0.35***	**0.07*** **	0.01***	-0.04***	0.99***	-0.03***	**-0.03*** **	**0.04*** **	4.78
Brent	-0.07	**0.32*** **	**0.07*** **	0.01***	-0.03***	0.99**	-0.03	**-0.06*** **	**0.07****	4.79
GAS	-0.01	0.02	-0.03	0.44	-0.04	0.79	0.11	0.01	0.01	4.93
Coal	0.01***	**0.01*** **	**-0.04*** **	0.01***	-0.03***	0.99***	-0.03***	**0.02*** **	**-0.02*** **	4.87
PB 95	-0.05	**1.13*** **	**-0.28****	0.01***	-0.02*	0.99***	0.04***	-0.05	0.06	4.71
WIG-Fuel										
OVX	-0.05	**-0.07*** **	-0.02	0.22	-0.03	0.86***	0.22	0.01	0.01	4,28
WTI	-0.04	**0.25*** **	**0.14*** **	1.26	-0.04	0.19	0.34***	0.02	0.01	4.39
Brent	-0.06	**0.25*** **	**0.13*** **	0.08***	-0.03	0.95***	0.14***	0.01	-0.01	4.38
GAS	-0.05	-0.03	**0.02***	0.02***	-0.05**	0.99***	0.03***	**0.01****	-0.01	4.43
Coal	-0.04	0.03	0.04	0.57	-0.07	0.65**	0.29***	**0.03****	-0.02	4.46
PB 95	-0.04	**0.93*** **	**-0.21****	0.36	-0.03	0.75	0.31*	-0.04	0.01	6.01
WIG-Energy										
OVX	-0.02	**-0.05*** **	-0.03	0.06***	-0.06**	0.97***	0.04	**0.03***	-0.02	4.35
WTI	-0.03	**0.1*** **	0.02	0.04***	-0.05**	0.98***	0.02***	0.01	0.02	4.47
Brent	-0.02	**0.09****	0.01	2.56	-0.09	-0.55	0.08	0.01	-0.03	4.36
GAS	-0.02	-0.02	0.01	0.6	-0.05	0.64*	0.24***	0.01	0.01	4.49
Coal	-0.02	0.03	-0.01	0.71	-0.07	0.57	0.22***	0.02	-0.01	4.49
PB 95	-0.03	**0.81*** **	**-0.21****	0.04***	-0.07***	0.98***	0.01***	0.03	-0.02	4.33
WIG-Ukraine										
OVX	-0.11	**-0.03****	**-0.03***	0.11	-0.12	0.96***	0.32**	-0.01	0.01	4.62
WTI	-0.02	0.05	0.11	0.09***	-0.1	0.97***	0.3	-0.02	0.04	4.63
Brent	-0.01	0.04	**0.11****	0.07***	-0.07	0.98***	0.25**	0.03	0.02	4.61
GAS	-0.04**	**-0.03*** **	0.01	0.09	-0.04	0.96***	0.24**	**0.03*** **	**-0.03*** **	4.56
Coal	-0.10**	-0.01	**-0.02****	0.12*	-0.12	0.95***	0.34**	0.01	-0.02	4.64
PB 95	-0.15***	**0.59*** **	**-0.11*** **	0.12	-0.08	0.95***	0.31**	-0.11	0.08	4.57

Notes:
*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.
Coefficients in bold correspond to statistically significant parameters in both the mean and variance equations.

Source: own study.

Table 6
The role of Ukraine sentiment in modelling Polish stock market returns and energy market variables

	μ	β_m	$\beta_{m,-1}$	ω	α	β	γ	β_{var}	$\beta_{var,-1}$	AIC
Stock market										
WIG	0.05	**-0.65*** **	**0.59*** **	0.13	-0.07***	0.78***	0.08	0.59	**-0.46*** **	3.83
WIG-Mining	-0.09	**-1.18*** **	**1.24*** **	0.01**	-0.02	0.99***	0.04***	0.07	-0.07	4.88
WIG-Ukraine	0.01	**-1.37*** **	**1.28*** **	0.23	0.01	0.73	0.37	**0.71** **	-0.32	4.49
WIG-Fuel	-0.09	**-0.74***	**0.79** **	0.26*	-0.04	0.82***	0.22**	0.38	-0.32	4.44
WIG-Energy	-0.09	**-0.59*** **	**0.7*** **	0.55*	-0.05	0.61***	0.17**	0.3	-0.17	4.46
Factors related to global energy commodity prices										
OVX	0.71***	**0.48*** **	**-1.21*** **	0.34	0.11**	0.91***	0.32	-0.09	0.03	5.98
WTI	-0.09	**-0.55** **	**0.73*** **	0.04***	-0.02	0.97***	0.12***	0.04	-0.01	4.48
BRENT	-0.18***	**-0.31*** **	**0.7*** **	0.04***	0.01	0.96***	0.14***	-0.01	0.04	**4.36**
GAS	0.32***	**-0.9*** **	**0.27*** **	0.23	0.1*	0.92***	0.39***	**0.46***	**-0.4***	6.14
COAL	0.15***	**-0.26*** **	**-0.18*** **	1.04*	-0.12	0.4	0.16	-0.13	0.68	**5.13**
Macroeconomic factors related to Poland										
PB 95 USD	0.01	**-0.38*** **	**0.38*** **	-0.4***	-0.1*	0.28**	0.34***	0.26	0.4	2.86
PB 95 PLN	-0.04***	**0.02*** **	**0.07*** **	-0.08	0.05	0.9***	0.38***	0.15	-0.08	2.18
USD/PLN	-0.03	**0.34***	-0.28	-0.16	0.04	0.87***	0.07	0.19	-0.09	2.12

Notes:
*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.
Coefficients in bold correspond to statistically significant parameters in both the mean and variance equations.

Source: own study.

Table 7
The importance of energy market variables in modelling mWIG40 and sWIG80 returns

	μ	β_m	$\beta_{m,-1}$	ω	α	β	γ	β_{var}	$\beta_{var,-1}$	AIC
mWIG40										
OVX	0.01	**-0.04*** **	**-0.03** **	0.04*	-0.10**	0.96***	0.10**	0.00	0.02	3.70
WTI	0.01	**0.11*** **	0.03	0.04	-0.11**	0.95***	0.14**	-0.02	0.02	3.71
Brent	0.02	**0.10** **	0.04	0.04	-0.10	0.96***	0.13	-0.01	0.03	3.72
GAS	0.01	**-0.04** **	0.00	0.03***	-0.09***	0.97***	0.08**	**0.01***	-0.01	3.71
Coal	0.01	-0.02	-0.04	0.04	-0.11	0.96	0.12	-0.01	0.01	3.73
PB 95	0.05	**0.76*** **	**-0.12*** **	0.03*	-0.11***	0.95***	0.18***	-0.09	0.06	3.46
sWIG80										
OVX	0.03	**-0.04*** **	**-0.03*** **	0.02	-0.12	0.93**	0.09	0.02	0.01	3.11
WTI	0.04	**0.07*** **	0.04	0.02	-0.12	0.93**	0.11	-0.04	0.04	3.14
Brent	0.04	**0.06** **	0.05	0.02	-0.12	0.93	0.10	-0.03	0.04	3.15
GAS	0.01***	**-0.03*** **	0.00	0.00*	-0.07***	0.99***	-0.04	**0.02** **	**-0.02*** **	3.10
Coal	0.04	**-0.02***	**-0.03** **	0.03	-0.15*	0.90***	0.11**	0.01	0.01	3.16
PB 95	0.06**	**0.60*** **	**-0.08*** **	0.00	-0.12**	0.93***	0.17***	**-0.14** **	0.10*	2.84

Notes:
*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.
Coefficients in bold correspond to statistically significant parameters in both the mean and variance equations.

Source: own study.

Table 8
The importance of energy market variables in modelling returns of WIG-ex

	μ	β_m	$\beta_{m,-1}$	ω	α	β	γ	β_{var}	$\beta_{var,-1}$	AIC
WIG excluding major energy-related companies										
OVX	0.00	**-0.03****	-0.02	0.03***	-0.08***	0.97***	0.09**	-0.01	0.02	3.87
WTI	0.01	0.00	0.02	0.03***	-0.06**	0.97***	0.09**	-0.02	0.04**	3.87
Brent	0.15***	-0.09	0.10	0.00***	-0.02***	1.00***	-0.04***	**-0.03*****	**0.05*****	3.88
GAS	-0.01	**-0.04*****	0.00	0.03***	-0.07***	0.98***	0.10**	0.01	-0.01	3.85
Coal	0.01	-0.02	**-0.04***	0.02***	-0.06**	0.98***	0.09	0.01	0.00	3.87
PB 95	0.05	**1.02*****	**-0.23*****	0.03*	-0.08**	0.96***	0.23***	-0.06	0.04	3.45

Notes:
*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.
Coefficients in bold correspond to statistically significant parameters in both the mean and variance equations.

Source: own study.

Table 9

The importance of energy market variables in modelling sector-weighted Polish stock market returns

	μ	β_m	$\beta_{m,-1}$	ω	α	β	γ	β_{var}	$\beta_{var,-1}$	AIC
WIG-Mining normalised										
OVX	0.01**	**-0.01***	**0.01***	-0.02***	-0.01	0.99***	0.04***	0.01	0.00	-0.35
WTI	0.01***	**0.03***	**0.01***	-0.01***	-0.03***	1.00***	-0.02**	**-0.05***	**0.06***	-0.43
Brent	0.00	0.03	0.00	-0.01***	-0.03**	1.00***	-0.03*	**-0.04***	**0.06***	-0.42
GAS	0.00	0.00	0.00	0.01***	-0.02	1.00***	-0.02***	**0.01***	**0.00***	-0.33
Coal	0.01***	**0.01***	0.00	-0.01	-0.02	1.00	-0.03***	0.01	**-0.01***	-0.34
PB 95	0.00	**0.08***	**-0.02****	-0.02***	-0.02*	0.99***	0.04***	-0.05	0.06	-0.50
WIG-Fuel normalised										
OVX	0.00	**-0.01***	0.00	-0.51	-0.03	0.86***	0.22	0.01	0.01	-0.88
WTI	0.00	**0.02***	0.01	-0.21	-0.02	0.94***	0.15	0.01	-0.02	-0.92
Brent	0.00	**0.02***	**0.01***	-0.18	-0.03	0.95***	0.14	0.00	-0.01	-0.90
GAS	0.00	0.00	0.00	0.01**	-0.03	1.00	-0.03***	0.01	-0.01	-0.87
Coal	0.01***	0.00	0.00	-0.01***	-0.04***	1.00***	-0.03***	**0.03***	**-0.03***	-0.86
PB 95	0.00	**0.07***	**-0.02***	-0.04***	-0.04**	0.99***	0.04***	-0.05	0.03	-1.02
WIG-Energy normalised										
OVX	0.00	**0.01***	0.00	-0.19***	-0.06**	0.97***	0.04***	**0.03***	-0.02	-2.73
WTI	0.00	**0.01***	0.00	-0.12***	-0.05***	0.98***	0.02	0.00	0.02	-2.71
Brent	0.00	**0.01****	0.00	-0.11***	-0.05**	0.98***	0.01***	-0.01	0.03	-2.71
GAS	0.00	0.00	0.00	-0.16***	-0.06***	0.97***	0.04***	0.00	0.00	-2.70
Coal	0.00	0.00	0.00	-0.14***	-0.05***	0.97***	0.02*	0.02	-0.02	-2.71
PB 95	0.00	**0.02***	**-0.01****	-0.13***	-0.07***	0.98***	0.01*	0.03	-0.02	-2.85
WIG-Ukraine normalised										
OVX	0.00	**0.01****	**0.01***	-0.46***	-0.12*	0.96***	0.32**	-0.01	0.00	-9.13
WTI	0.00	0.00	0.00	-0.34**	-0.10	0.97***	0.30	-0.02	0.04	-9.12
Brent	0.00	0.00	0.00	-0.25**	-0.07	0.98***	0.25**	0.03	0.02	-9.14
GAS	0.01***	**0.01***	0.00	-0.42***	-0.04	0.96***	0.24***	**0.03***	**-0.03***	-9.19
Coal	0.01*	0.00	**0.01****	-0.53***	-0.12*	0.95***	0.34**	0.00	-0.01	-9.12
PB 95	0.00	0.00	0.00	-0.58	-0.07	0.95***	0.35	-0.11	0.07	-9.18

Notes:
*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.
Coefficients in bold correspond to statistically significant parameters in both the mean and variance equations.

Source: own study.

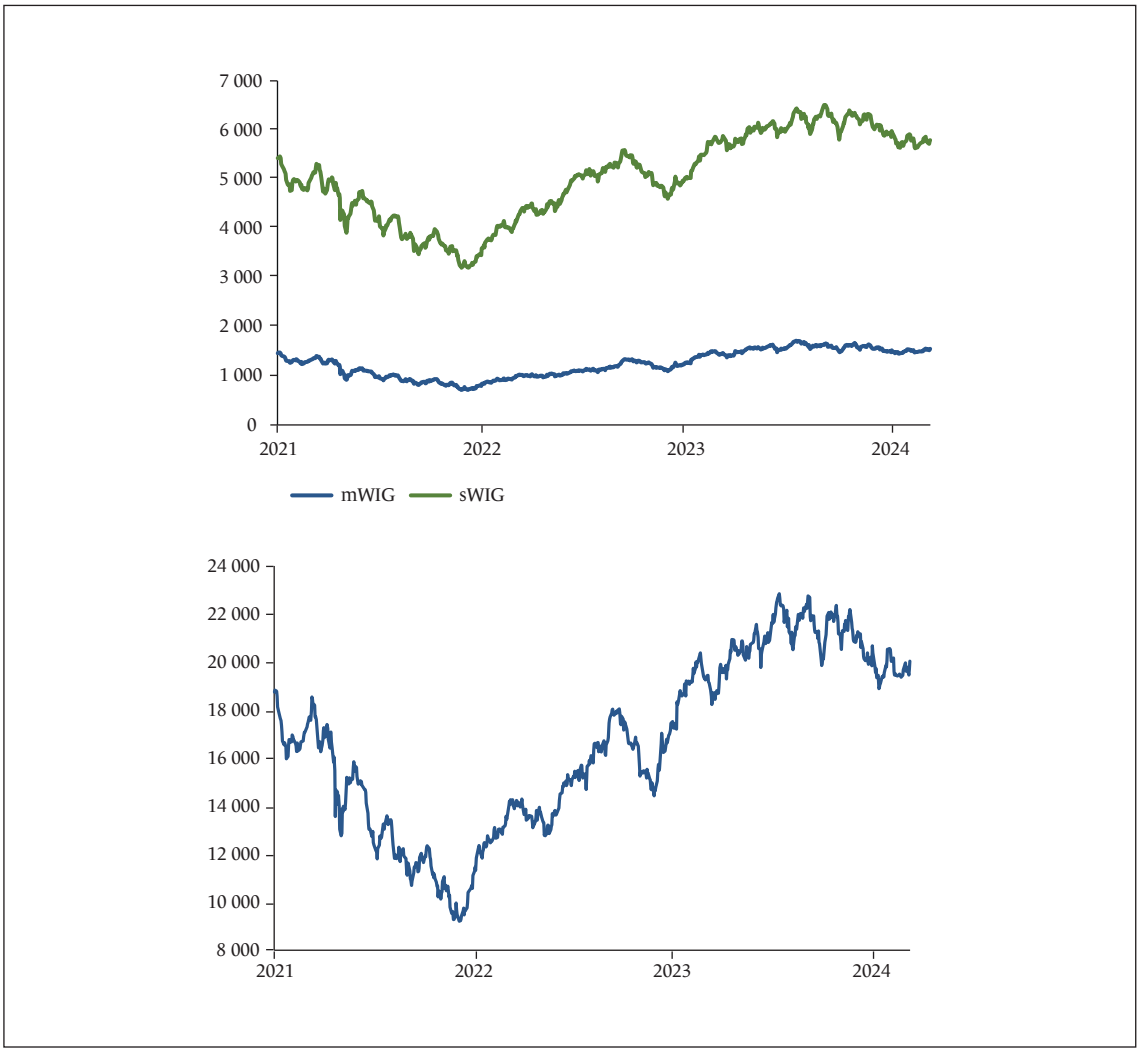
Table 10
The impact of Ukraine war sentiment on alternative Polish stock market indices

	μ	β_m	$\beta_{m,-1}$	ω	α	β	γ	β_{var}	$\beta_{var,-1}$	AIC
mWIG40_USD	0.06	**-0.66*** **	**0.60*** **	0.10	-0.11***	0.79	0.08	0.58	**-0.46*** **	3.70
sWIG80_USD	0.06	**-0.39** **	**0.36** **	-0.05	-0.22***	0.47	0.08	**0.78***	**-0.48** **	3.12
exWIG_USD	0.11	**-0.80*** **	**0.60*** **	0.03	-0.05	0.93***	0.06	0.20	-0.13	3.85
WIG_ ENERGY_N	0.00	**-0.02*** **	**0.02*** **	-2.25*	-0.05	0.61***	0.17**	0.30	-0.17	-2.71
WIG_FUELS_N	-0.01	-0.05	**0.06** **	-0.68	-0.04	0.82***	0.22**	0.38	-0.32	-0.84
WIG_MINING_N	-0.01	**-0.09*** **	**0.09*** **	-0.02***	-0.02	0.99***	0.04***	0.07	-0.07	-0.33
WIG_UKRAINE_N	0.00	0.00	**0.01*** **	-3.33	0.00	0.74	0.36	**0.70** **	-0.33	-9.26

Notes:
*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.
Coefficients in bold correspond to statistically significant parameters in both the mean and variance equations.

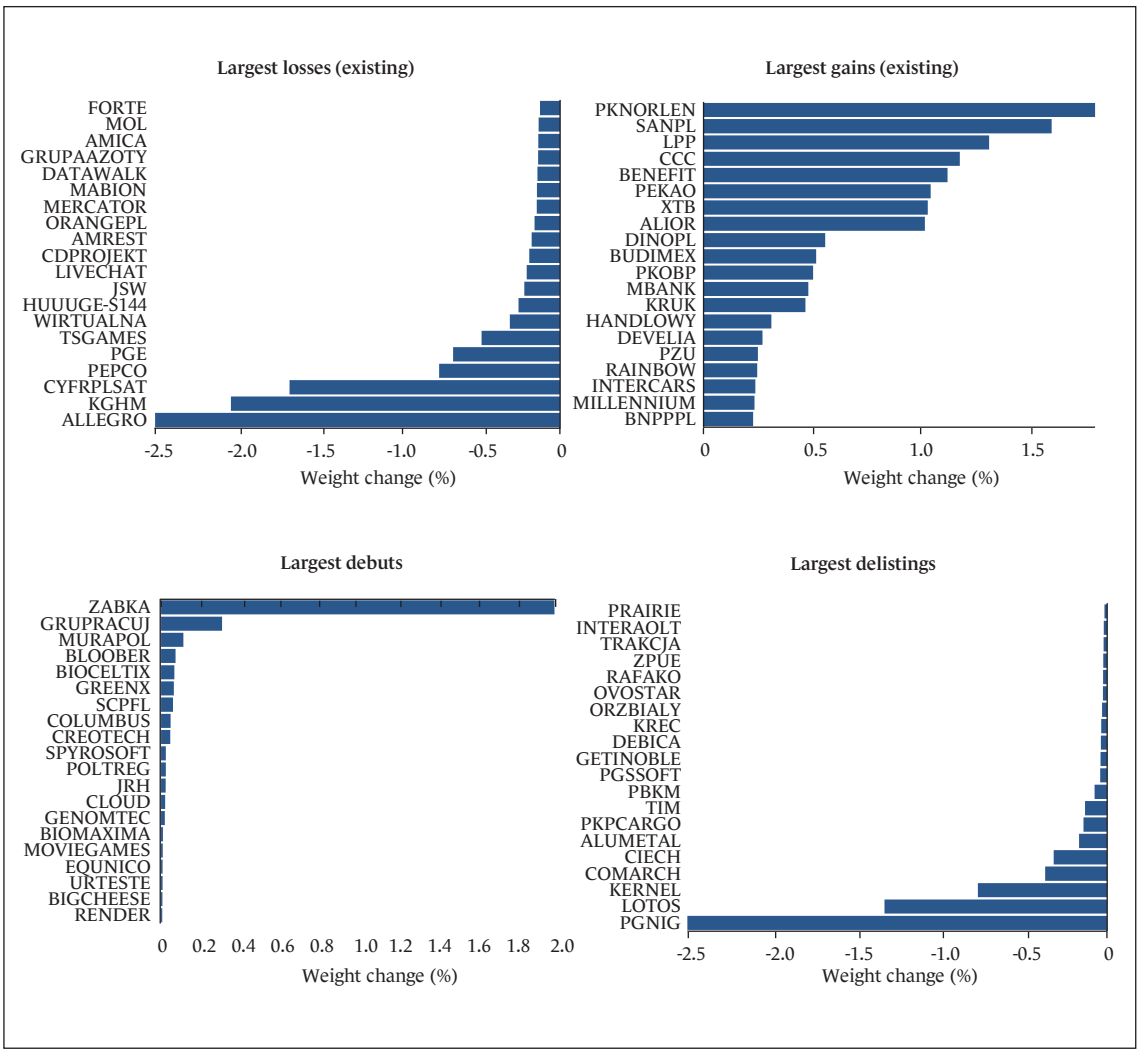
Source: own study.

Figure 1
mWIG/sWIG index (top panel) and WIG index (bottom panel)



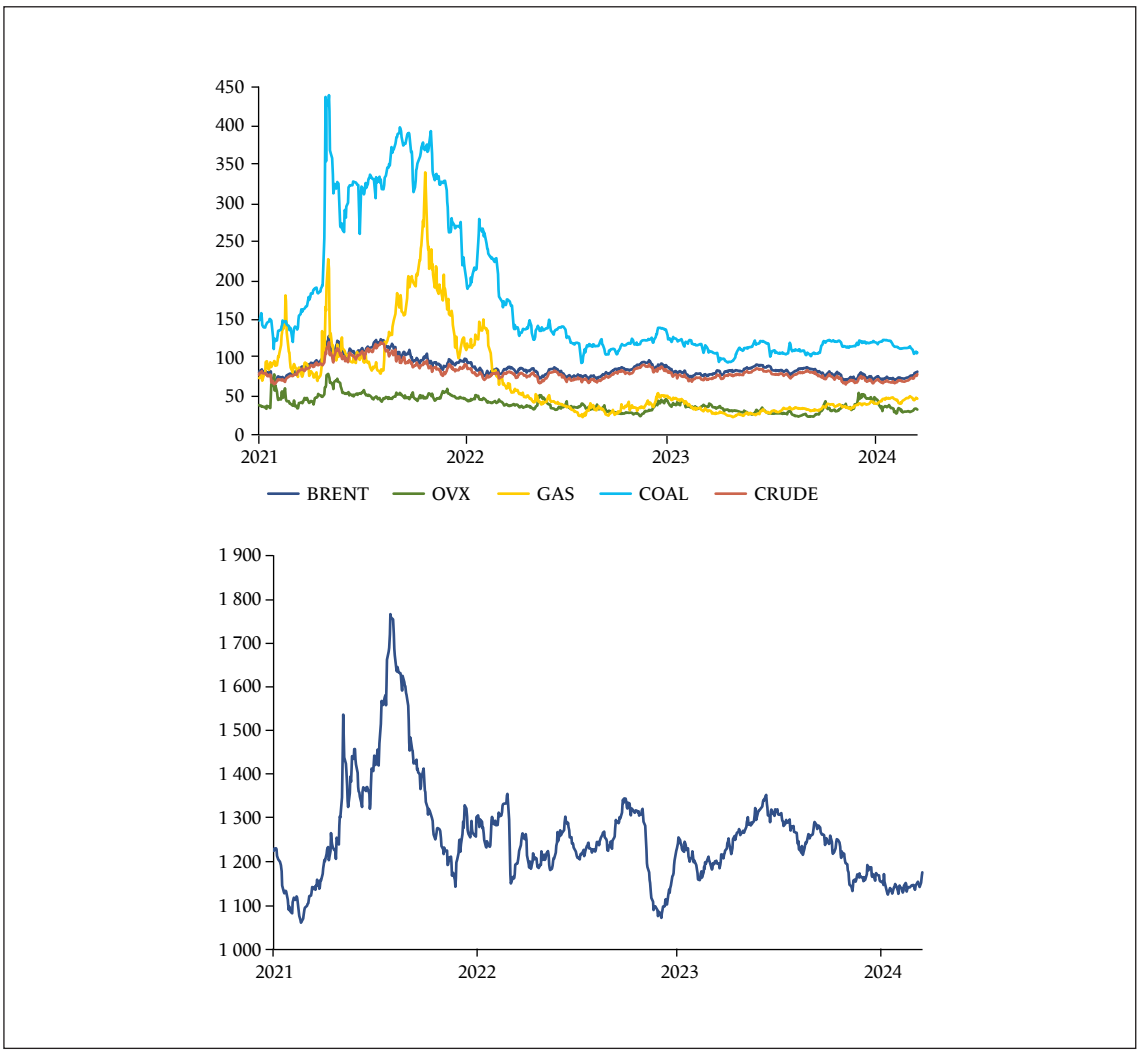
Source: own study.

Figure 2
Changes in the composition of the WIG index between 2021 and 2024



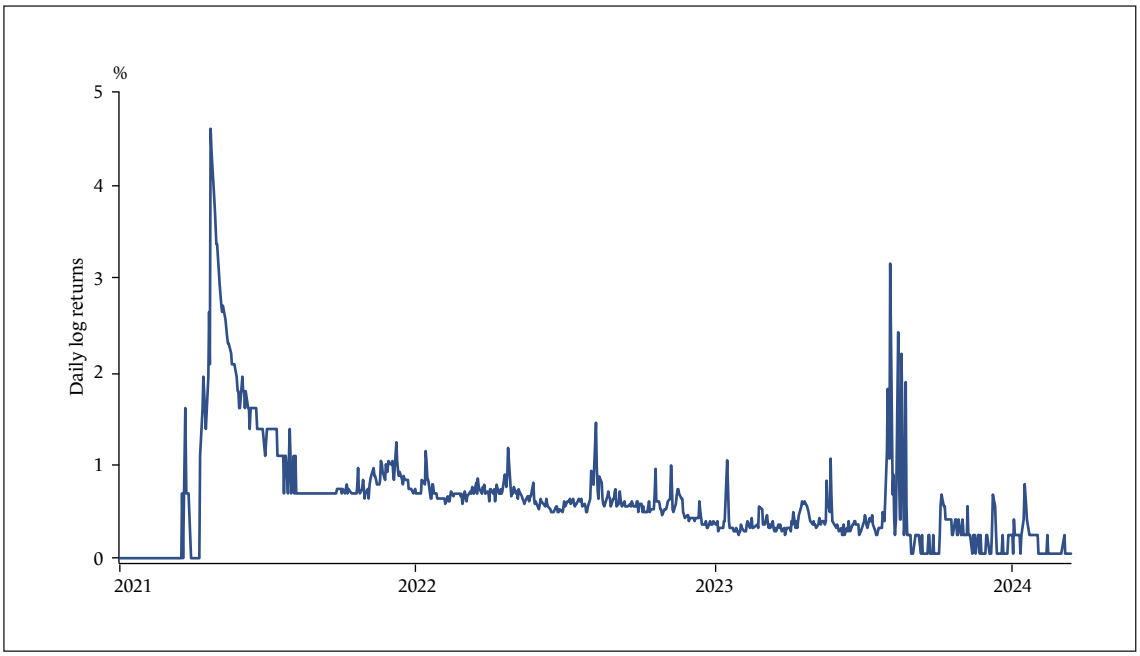
Source: own study.

Figure 3
Energy commodity futures prices and Crude Oil Volatility Index (top panel) and retail gasoline prices (bottom panel)



Source: own study.

Figure 4
The search frequency of the keyword ‘Ukraine’ based on Google Trends data



Source: own study.

Wpływ wojny w Ukrainie na rynek akcji w Polsce

Streszczenie

Celem badania jest określenie, w jaki sposób wojna rosyjsko-ukraińska wpłynęła na polski rynek kapitałowy, a w szczególności uwzględnienie roli zmian cen energii oraz nastrojów geopolitycznych. Konflikt zbrojny doprowadził do gwałtownych zmian cen surowców energetycznych, wzrostu niepewności oraz podwyższonej zmienności na światowych rynkach finansowych.

Przyjęto założenie, że wpływ wojny na rynek akcji realizuje się przede wszystkim za pośrednictwem dwóch wzajemnie powiązanych kanałów transmisji. Pierwszym z nich jest kanał cen energii, obejmujący zmiany światowych cen ropy naftowej, gazu ziemnego i węgla, krajowych cen paliw oraz zmienność rynku ropy. Drugim jest kanał nastrojów geopolitycznych, odzwierciedlający wzrost zainteresowania informacjami dotyczącymi wojny w Ukrainie. Nastroje te mogą oddziaływać na decyzje inwestorów zarówno bezpośrednio – przez wzrost awersji do ryzyka i zmianę oczekiwań – jak i pośrednio, za pośrednictwem reakcji zachodzących na rynkach energii.

Na tej podstawie sformułowano trzy hipotezy badawcze.

Hipoteza 1. Zmiany cen ropy WTI i Brent, gazu ziemnego, węgla, krajowych cen benzyny PB 95 oraz indeksu zmienności rynku ropy OVX wpływają na stopy zwrotu i zmienność polskiego rynku akcji. Siła i kierunek tego oddziaływania różnią się między sektorami w zależności od ich ekspozycji na koszty energii.

Hipoteza 2. Wzrost zainteresowania hasłem „Ukraina" w wyszukiwarce Google wiąże się ze spadkiem stóp zwrotu oraz wzrostem zmienności warunkowej na polskim rynku akcji. Wpływ ten może występować zarówno bezpośrednio, przez zmianę zachowań inwestorów, jak i pośrednio, za pośrednictwem rynku energii.

Hipoteza 3. Zależności między cenami energii, nastrojami związanymi z wojną a stopami zwrotu pozostają istotne także po uwzględnieniu wpływu składu i struktury analizowanych indeksów giełdowych.

Analizę empiryczną przeprowadzono na podstawie danych dziennych obejmujących okres od listopada 2021 r. do stycznia 2025 r. Zakres czasowy obejmuje zarówno miesiące poprzedzające rozpoczęcie pełnoskalowej inwazji Rosji na Ukrainę, jak i okres trwania konfliktu. Sytuację na polskim rynku kapitałowym oceniono na podstawie indeksu WIG oraz wybranych indeksów sektorowych. Warunki panujące na światowych rynkach energii opisano za pomocą cen kontraktów terminowych na ropę naftową, gaz ziemny i węgiel oraz indeksu OVX. Krajowe uwarunkowania energetyczne odzwierciedlono przy wykorzystaniu detalicznych cen benzyny PB 95 w Polsce. Jako przybliżoną miarę nastrojów geopolitycznych zastosowano dane Google Trends dotyczące częstotliwości wyszukiwania hasła „Ukraina".

Do analizy zależności pomiędzy badanymi zmiennymi wykorzystano model EGARCH, rozszerzony o zewnętrzne zmienne objaśniające. Umożliwiło to jednoczesne badanie wpływu poszczególnych czynników na stopy zwrotu oraz na zmienność warunkową rynku. W modelach uwzględniono zarówno efekty bieżące, jak i opóźnione, co pozwoliło lepiej uchwycić dynamiczny charakter reakcji rynku kapitałowego.

Istotnym elementem badania były testy odporności. W celu ograniczenia ryzyka, że uzyskane zależności wynikają wyłącznie ze specyficznej struktury indeksu WIG, analizę rozszerzono o indeksy mWIG40 i sWIG80. Dodatkowo skonstruowano zmodyfikowany indeks WIG, z którego wyłączono największe spółki reprezentujące sektor energetyczny i wydobywczy. Przeprowadzono również dodatkowe estymacje dla alternatywnych indeksów giełdowych, aby sprawdzić trwałość zależności związanych z nastrojami geopolitycznymi.

Wyniki badania wskazują, że sytuacja na światowych rynkach energii ma duże znaczenie dla zachowania polskiego rynku akcji. Zmiany cen surowców energetycznych oraz wzrost zmienności rynku ropy oddziałują zarówno na stopy zwrotu, jak i na poziom ryzyka rynkowego. Istotny okazał się również wpływ nastrojów związanych z wojną. Wzrost zainteresowania tematyką Ukrainy wiąże się ze zmianami stóp zwrotu i zmienności, przy czym część tego efektu jest przenoszona za pośrednictwem rynku energii.

Uzyskane rezultaty potwierdzają zatem, że wojna rosyjsko-ukraińska wpływa na polski rynek kapitałowy dwoma głównymi kanałami: przez ceny energii oraz przez nastroje geopolityczne. Wyniki testów odporności wskazują jednocześnie, że obserwowanych zależności nie można wyjaśnić wyłącznie dominującym udziałem dużych spółek energetycznych i wydobywczych w strukturze podstawowych indeksów.

Z praktycznego punktu widzenia wyniki sugerują, że inwestorzy powinni uwzględniać w ocenie ryzyka nie tylko zmiany cen surowców energetycznych, lecz także zmiany nastrojów związanych z wydarzeniami geopolitycznymi. Informacje dotyczące wojny mogą wywoływać zauważalne reakcje rynku w krótkim okresie, wpływając zarówno na poziom ryzyka, jak i na bieżące decyzje inwestycyjne.

Interpretując wyniki, należy jednak wziąć pod uwagę ograniczenia badania. Analiza koncentruje się na jednym rynku krajowym, a nastroje geopolityczne są mierzone pośrednio, za pomocą intensywności wyszukiwań w Google Trends. Miara ta nie odzwierciedla bezpośrednio opinii i oczekiwań inwestorów, lecz stanowi przybliżenie poziomu zainteresowania i niepewności związanej z przebiegiem wojny.

Słowa kluczowe: sentyment wojny w Ukrainie, ceny energii, zmienność rynku akcji, indeks OVX, Google Trends