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Do Methane Gas Prices Interact with Stock Indices?

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A R T I C L E I N F O

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A B S T R A C T

This study investigates the short-term relationship between natural gas prices and stock market index prices for six countries (five of G7 member economies and China) spread on three continents, using the VAR model and the Granger causality test. To achieve this goal was examined the correlation between the stock market indices rates of natural gas (NG), European FTSE 100, DAX 30, CAC 40, American DJI and SP 500, Asian Nikkei 225 and SSEC. These eight daily index values were used for the period February 24, 2022, when the geo-political conflict (Russia-Ukraine) began, to May 27, 2022, when large fluctuations in energy prices were observed. This study tries to answer the question of whether there are concrete links and responses to volatility between the natural gas market and stock indices in six advanced economies in the first three months after the start of the Russia-Ukraine geo-political conflict. According to the results achieved using the VAR model and the Granger causality test, the price of natural gas (NG) is the main cause of the evolution of any of the considered stock indices. Overall, the study provides important insights into the complex dynamics of the energy market and its interactions with the broader economy and financial system.

1. Introduction

The Energy resources are some of the vital natural resources used by countries with input in many economic sectors, including industry, trade, and transportation. They ensure economic stability and enhance national security. The main energy resources commonly used by the countries of the world are oil, natural gas, and coal.

Recently, the importance of natural gas has increased in the global energy market. The natural gas market had developed very quickly and gradually became an important part of the economic system, considering that it is an indispensable resource, including in the residential sector. This evolution was determined because natural gas is cleaner and produces fewer greenhouse emissions than fossil fuels, such as oil and coal. In present we can see the efforts made by countries to increase the use of electric vehicles, and the full transition to the use of electric vehicles, that is planned by 2040 (Akbulaev et al., 2022). For this reason, the demand for electricity generation will increase and an important part of this demand for electricity will be met by natural gas. Also, the demand for natural gas will increase and this evolution may cause an increase of natural gas prices. In the year 2021, natural gas prices quadrupled to record annual levels in Europe (TTF averaging $16/mmBtu) and tripling in the Asian LNG spot market (JKM averaging $18.6/ mmBtu). US Henry Hub prices almost doubled to an average of $3.8/mmBtu in 2021 - the highest annual level since 2014 (Statistical Review of World Energy, 2022).

Companies are currently facing challenges due to fluctuating natural gas prices that could negatively affect the stock market sentiment, and not only (Lin et al, 2019). Geng et al. (2020) in their study point out the presence of a contagion risk between natural gas and stock markets.

These dramatic fluctuations in natural gas prices will affect inevitably two types of behaviour: 1. of companies that use natural gas for production (the price will affect the profit of those companies); 2. residential behaviour regarding the use of natural gas. Thus, we can see that natural gas has gradually become a significant factor that affect economic activity, and that can also affect the natural gas market. For example, an economic recession can reduce industrial production and activity in transport, tourism, etc. This evolution determines implicitly the decrease of demand for natural gas, which in turn can lead to the decrease in the price of natural gas.

Natural gas in power generation increased by 2.6% in 2021, according to Statistical Review of World Energy 2022. Also, global demand for natural gas increased by 5.3% in 2021. Its share of primary energy in

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2021 was unchanged from the previous year at 24%. Demand for natural gas has increased due to its availability, transportation, infrastructure and use as an alternative energy fuel.

According to IEA (2022), 22% of the world's energy is supplied by natural gas, which makes it particularly important in the global energy market (https://www.iea.org/fuels-and-technologies/gas). Therefore, it is necessary to investigate how natural gas correlates with financial markets.

Energy markets have recently suffered important transformations (such as: deregulation of the market, changing the behaviour of energy consumers using renewable energy) and have witnessed a variety of crisis periods, which have affected the relationships between energy commodities and their interactions with stock indices (Ferreira et al., 2022). The effect of energy prices on national economies and financial markets varies depending on the position of the country related to energy stock/reserves, i.e. energy importing or exporting country. Thus, countries that import most of their energy used can be adversely affected by increases in energy prices. When conflict erupts in an area both the oil and gas markets are affected. Gas has more of a regional exposure, being also influenced by physical determinants such as the level of reserves, environmental temperatures (which implies an increase in gas consumption for heating when the environmental temperature is low) or congestion in the system (Zhang et al., 2017).

At the level of 2021, according to Statistical Review of World Energy 2022 (bp Statistical Review of World Energy 2022), imports from Russia via pipelines and LNG accounted for almost 40% of the total consumption of natural gas in the EU. The Russian-Ukrainian geo-political conflict has driven up the price of natural gas and highlighted the EU's dependence on Russian energy. Between February 2021 and February 2022, the price of natural gas increased from 20 to 80 EUR/MWh, with increases up to 180 EUR/MWh, also leading to higher electricity prices (Osička and Černoch, 2022).

For this reason, this study examined short-term correlations between natural gas prices and stock market indices of six countries (USA, Germany, France, UK, Japan and China) on three continents. We chose USA, France, Germany, the United Kingdom and Japan because they are members of the Group of Seven (G7). In addition to the five countries, we also considered China because in 2021 this country's consumption was 9.4% of the total world consumption of natural gas. Another argument is that China's natural gas imports represent 21.2% of total world natural gas imports (bp Statistical Review of World Energy 2022). According to the same report natural gas consumption shares in 2021 were as follows: USA (20.5%), Japan (2.6%), Germany (2.2%), France (1.1%), United Kingdom (1.9%) and China (9.4%); representing 37.7% of the total world consumption. These six countries are big consumers of natural gas. The United States is the most developed capitalist country, a crucial supplier in the natural gas market, but also a giant energy consumer (Ling et al., 2018).

Our objective is to answer the following research questions: What are the interactions between natural gas price and stock indices FTSE 100, DAX 30, CAC 40, American DJI and SP 500, Asian Nikkei 225 and SSEC? Do these markets move together over time? Are there concrete links and responses to volatility between the natural gas market and stock indices in the six economies analyzed in the first three months after the start of the Russia-Ukraine geo-political conflict? How does the direction and magnitude evolve during the period of geo-political conflict?

In the study, daily data were examined for the period 24.02.2022- 27.05.2022. The Vector Autoregressive Model (VAR) was used and the direction of the correlation between the variables was determined by the Granger causality test, to see if natural gas prices have an effect on the indices FTSE 100, DAX 30, CAC 40, American DJI and SP 500, Asian Nikkei 225 and SSEC.

This paper adds to the existing literature three aspects First, there are few studies that analyze the dependence structure between natural gas prices and stock markets, and no studies that analyze the period of the outbreak of geopolitical conflict in Eastern Europe. Second, the paper provides a comprehensive assessment of the effects of the informational connection between the natural gas market and the stock markets, a connection generated by the Russian-Ukrainian conflict. Third, given the different impact of regional natural gas prices, this study selects stock markets in North America, Europe, and Asia to compare their different information spillover effects.

2. Literature review

Because markets have an impact on domestic and international economies and also have an essential role in the process of economic development, many countries around the world pay a lot of attention to the dynamics of energy and capital markets. Thus, the energy and capital markets remain for the global investor community, the attractive destinations for business growth, offering a diverse universe of profitable investment opportunities.

As a representative commodity, energy has often played two major roles in the economy: (1) energy is used to directly support real economic activities; (2) commodity financialization increases the number of investors who tend to view energy commodities only as portfolio diversifiers and hedging investments. These factors strengthened the relationship between energy and financial markets. In portfolio strategy and investor performance, an important role is played by the relationship between the energy market and stocks (Gatfaoui, 2019). Due to the powerful impact of oil and natural gas on the modern global economy, the debate between stock markets and energy markets and the interrelationship between them is a matter of research that has always preoccupied academics and professionals across the globe.

Economies that rely on energy exports (oil, natural gas) usually use their oil/gas revenues to finance their physical and social infrastructure (Emami and Adibpour, 2012). The higher price of energy commodities transfers funds from the energy resource importing economies to the oil/gas exporting economies. If demand in oil/gas of importing economies does not change easily, then the cash flow and total sales of energy sector companies are expected to increase. Thus, the higher profitability of these companies will increase their share price and the stock market will enter a favourable period (Degiannakis et al., 2018). More than that, if demand in oil/gas of importing economies is likely to change mainly due to the substitution of energy resources, then a decrease in cash flow and total turnover of energy sector companies will be observed. As a result, the profitability of the energy sector will decrease, and the stock market will react negatively, and the share price will fall (Kumar et al., 2019).

In the specialized literature we observed an abundance of studies related to the connection between stock market performance and oil prices in different countries and economic regions of the world, and a less research interest dedicated to understanding the relationship between natural gas and stock markets.

Since oil and natural gas contribute significantly to total costs in the manufacturing and transportation sectors, any increase in their costs will lead to the increase the prices. In such a situation, oil and natural gas prices would not have a direct impact on stock prices (Kumar et al., 2019). But considering that rising oil and natural gas prices will increase the cost of production for companies that use oil and gas, that potentially impacting cash flows and bottom-line profits, this will lead to increasing stock prices and pushing the stock market higher (Degiannakis et al., 2018). Otherwise, Cong et al. (2008) opine that higher oil and natural gas prices will lead to cost inflation in oil importing countries and consequently will have a negative impact on financial markets, especially stock markets.

Natural gas prices are more subject to regional and local market conditions (Nick and Thoenes, 2014). There are authors who argue that the natural gas market and the stock market are vulnerable to frequent extreme events, such as financial crisis, economic recession, extreme weather, regional war and so on. For example, Ling et al. (2018) argue that the correlation between the natural gas market and the US stock markets has an asymmetric effect and the dynamic correlation between the natural gas market and stock markets (for China and US) evolves over time and experiences ups and downs according to market conditions.

Gatfaoui (2016) investigates the relationship between the US natural gas market and US stock markets and shows that the links between these markets are unstable over time. Furthermore, the degree of risk appetite of investors was demonstrated to affect the volatility of stock returns (Kim et al, 2014) and cause fluctuations in the crude oil and natural gas markets. Thus, some authors found that the risk appetite of stock investment can have a significant influence on crude oil and natural gas markets (Sari et al., 2010). That means, changes in the economic benefits of the natural gas market can be reflected in the stock market, functioning as a barometer of economic activity (Sari et al., 2010).

Due to its useful policy implications at the micro and macro levels, the dependence between energy and capital markets has been the focus of substantial empirical research and debate for many years. In investigating this relationship, a wide range of econometric models and techniques have been applied. Ewing et al. (2002) analyzed the spread of volatility between oil and natural gas markets using the GARCH model. Acaravci et al. (2012) investigated the long-term relationship between natural gas prices and stock prices using the vector error correction model, developed by Johansen and Juselius (1990). The Granger causality analysis presented by Acaravci et al. (2012) show an indirect impact of gas prices on stock prices through industrial production. They used quarterly data from EU-15 countries, and found that gas prices, industrial production growth and stock prices have a long-run equilibrium relationship in about 33% of the sample. Kumar et al. (2019) showed that there is no long-run cointegration between natural gas and stock prices in India, using various multivariate generalized autoregressive conditional heteroskedasticity (MGARCH) models with and without skewness. A significant transmission between the S&P 500 and commodity markets was revealed by Mensi et al. (2013) that employed the VAR-GARCH model to investigate the return and volatility spread of commodities such as energy, food, and gold, in relation to the S&P 500.

The work of Ling et al. (2018) investigates the transmission of risks between the natural gas market and the stock markets from China and US over the period from 1994 to 2016. The authors used this period because was characterized by the appearance of successive crises and turbulent episodes, such as natural hazards, financial crisis, economic turbulence, regional war etc. which have a significant influence on the dynamic correlation between these two markets from China and US.

The links between the prices of six commodities and stock market returns, using data from six South American economies, was investigated by Johnson and Soenen (2009) who found an influence of energy (oil and gas) prices in the stock markets of Argentina, Brazil, and Peru.

From the literature studied we found that a little attention was paid to the link between natural gas and the stock market. Among the first studies developed is that of Boyer and Filion (2007) which provides evidence of Canadian oil and gas firms with a positive correlation between increases in gas prices and stock returns. Gjerde and Saettem (1999) and Basher and Sadorsky (2006) also present evidence of a positive direct impact of energy prices on stock prices in Norway and 21 emerging markets, respectively. The price of natural gas positively influences the stock market due to the substitution mechanism between oil and natural gas. In contrast, Benkraiem et al. (2018) in their study reveal a negative relationship between the price of natural gas and the S&P500 index in the short term. Their study is consistent with the study of Sadorsky (1999) that present the evidence of a significant negative relationship between the stock market index and the price of oil, natural gas in the long run.

Several studies have reported mixed findings on the relationship between energy prices and stock indices. Thus, Kumar and colleagues (2019) found that: (1) empirical evidence that crude oil and natural gas prices have a positive impact on stock indices in the short term; (2) over the long term, crude oil prices have a negative influence on stock indices. Also, the results of the Granger causality test of Acaravci et al. (2012) imply an indirect Granger causality relationship between these two variables, while detecting a significant long-run relationship between stock prices and natural gas prices.

Few studies explore the natural gas and stock market relationship across continents; some authors compared only a few states, for example the USA and some European countries (Oberndorfer, 2009; Grieb, 2015; Ordu and Soytaş, 2016; Boyer and Filion, 2007; Gatfaoui, 2016); other authors have considered sectoral or regional stock indices in relation to energy prices in European economies (Arouri et al., 2012), G-7 economies (Lee et al., 2012), the US economy (Broadstock and Filis, 2014) or only in the MENA region (Mohanty et al., 2011).

Thus, there are several reasons that determined our choice of stock indices from six economies on three continents: first, the limited existing literature on the relationship between natural gas and stock indices on the three most important continents provides inconsistent findings. Therefore, further in-depth study on the correlation between the two markets is necessary. Second, each of the seven stock market indices on the three continents reacts differently to the geo-political conflicts in certain regions of the globe - in the case of our study, the analysis is carried out for the first three months of the Russian-Ukrainian conflict. Third, recurring episodes of the 2008 financial crisis led to high levels of uncertainty in the global economy and high volatility in energy prices, a prevailing situation that convinced investors to look for alternative investment securities and move to other continents.

In the recent years, investors should be aware of how fluctuations in natural gas, crude oil and electric utility stock indices affect risk and value of their investment portfolios. In this direction, our study is important in helping the investors interested in investing in the capital markets, in their decision-making process.

3. Data and methodology

3.1. Data set

In this study, the correlation between the rates of the Natural Gas NG, European FTSE 100, DAX 30, CAC 40, American DJI and SP 500, Asian Nikkei 225 and SSEC stock markets indices was examined. These eight indices daily data were used for the period February 24, the date when the Russian-Ukrainian geopolitical conflict began, to May 27, 2022. The period included large price fluctuations observed in energy prices (Figure 1). The data for our study were provided by https://www.cnbc.com and https://www.bloomberg.com/.

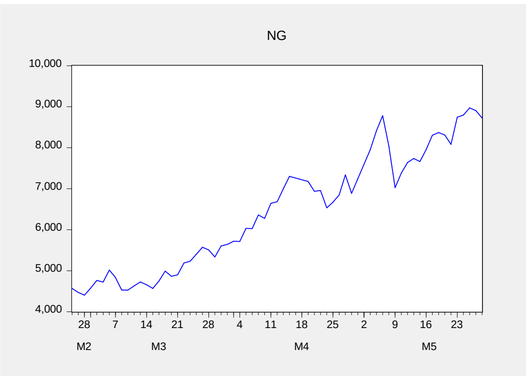

Figure 1. Natural gas price during February 24/2022- May 27/2022

To examine the correlation between the variables, the Vector autoregressive model was used. The direction of the correlation between the variables was determined by the Granger causality test. For econometric analysis we used the statistical package EViews.

3.2. Methodology

The first step is to decide the method used to choose the right model in studying the correlation between NG prices and stock market indices. Thus, an ordinary time series analysis will be appropriate if all the variables are stationary; if they are not stationary, a cointegration analysis, like vector autoregressive (VAR) model, will be the appropriate model to test this correlation. The analysis will start with some stationarity tests, after that the VAR model and the Granger causality test are explained.

3.3. Stationarity tests

In time series analysis, the concept of stationarity holds significant importance, as many analytical tools, statistical tests, and models rely on it for their effectiveness. Therefore, the ability to determine whether a time series is stationary is crucial, the goal being to determine, with a high level of confidence, that a series is generated by a stationary process.

The Dickey-Fuller test is the first statistical test to examine the presence of a unit root in an autoregressive model of a time series and determine if the process is stationary. The original test is designed for a simple lag-1 AR model, and it serves to test the null hypothesis that a unit root exists. There are three versions of the test available, which vary in the unit root process model they evaluate.

1. Test for a unit root:

$$\Delta y_i = \delta y_i - 1 + u_i \qquad (1)$$

2. Test for a unit root with drift:

$$\Delta y_i = a_0 + \delta y_i - 1 + u_i \qquad (2)$$

3. Test for a unit root with drift and deterministic time trend:

$$\Delta y_i = a_0 + a_1 * t + \delta y_i - 1 + u_i \qquad (3)$$

Selecting the appropriate version of the Dickey-Fuller test is a crucial decision, that can have a significant impact on the test's size and power. The extensions of the Dickey-Fuller test have been developed in order to accommodate more complex models and data. These extensions include: (1) the Augmented Dickey-Fuller (ADF), which supports the modelling of time trends and uses autoregressive models of any order p; (2) the Phillips-Perron test (PP), which provides robustness to unspecified autocorrelation and heteroscedasticity, and (3) the ADF-GLS test, which utilizes local detrending of data to address constant and linear trends.

The augmented Dickey-Fuller (ADF) test is utilized to examine whether a time series dataset has a unit root and the presence of unit roots can result in non-stationarity. If the null hypothesis is rejected, it indicates that the alternate hypothesis is valid (i.e., the data is stationary). The ADF statistic, which is employed in the test, is a negative number, and the strength of rejection of the hypothesis that a unit root exists at a particular level of confidence increases as the value of the statistic becomes more negative.

For detecting the presence of a unit root, the KPSS test (Kwiatkowski et al., 1992) can be used. In contrast to the Dickey-Fuller tests, the KPSS test hypothesizes stationarity around a mean or a linear trend in the null hypothesis, while the alternative hypothesis assumes the presence of a unit root. The test employs linear regression, dividing the series into three components: a deterministic trend (βt), a random walk (rt), and a stationary error (εt), and uses a regression equation:

$$xt = rt + \beta t + \varepsilon t \qquad (4)$$

A stationary dataset will have a constant intercept, that indicates the series is stationary around a fixed level. As a result, the KPSS test is frequently employed to supplement Dickey-Fuller-type tests.

3.4. Vector Autoregressive Model

The possibility of endogeneity can bias traditional multilinear model estimates. At this point, the vector autoregressive (VAR) model is a suitable model designed to deal with endogeneity problems that will be applied. At the end, there will be as many equations as the number of variables. Thus, the effect of each variable on other variables can be tested. The VAR model will use the following systems of equations for the two variables (Syzdykova and Azretbergenova, 2021).

VAR analysis requires determining the optimal lag length. In the above equations, m refers to the optimal lag. Depending on the information criteria, the appropriate lag length is selected. Likelihood Ratio (LR), Final Prediction Error (FPE), Hannan-Quinn (HQ), Schwarz (SIC), Akaike (AIC) are the information criteria we will use. The lower the information criteria of the model, the more appropriate the lag length used in that model. However, information criteria alone are not sufficient to decide the optimal lag length. Serial correlation is a very critical problem in VAR analysis, as the VAR model includes the lagged value of the dependent variable. Therefore, before determining the optimal lag, model results with that lag should be tested for serial correlation. The appropriate lag length can only be chosen after it has been found that the error terms are not serially related.

3.5. Granger Causality Test

VAR models describe the joint generation process of several variables over time. That they can be used for investigating relationships between the variables. Granger causality (Granger, 1968) is one type of relationship between time series, that can be summarized as follows: if the addition of information from a second time series enhances the accuracy of forecasting the first time series, and then the second time series is said to have a causal impact on the first. Specifically, two autoregressive models are fitted to the first time series, with and without including the second time series, and the improvement of the prediction is measured by the ratio of the variance of the error terms. Thus, the null hypothesis for GC is that no explanatory power is added by jointly considering the lagged values of y and x as predictors. In this sense, the null hypothesis that x does not cause y is rejected if coefficients for the lagged values of x are significant, i.e., Granger called a variable x causal for a variable y if the lagged values of x are helpful for improving forecasts of y (y at future times).

4. Results and Discussions

4.1. Descriptive Summary of All Prices and Return Series Data

Table 1 presents the unit root test for all the prices and returns series data. The ADF and KPSS test results presented in Table 1 show that the null hypothesis of non-stationarity is rejected at a 5% level of significance in each of the returns series, but each of the price series becomes stationary from the first difference.

Table 1. Unit root tests of stock markets indices and natural gas price and price returns.

Variables	Level Data (t-Value)				First Difference Data	
	ADF (Return)	KPSS (Return)	ADF (Price)	KPSS (Price)	ADF (Price)	KPSS (Price)
NGN2	-6.29**	0.04**	4.43	0.24	-6.52**	0.08**
FTSE 100	-3.99**	0.04**	-2.42	0.71	-3.99**	0.04**
DAX	-4.36**	0.04**	3.08	0.46	-4.35**	0.04**
CAC 40	-4.10**	0.05**	3.01	0.63	-4.10**	0.04**
DJI	-2.96**	0.07**	2.17	1.19	-2.96**	0.07**
SP500	-2.62	0.09**	1.88	1.21	-2.62	0.09**
Nikkei 225	-3.65**	0.06**	1.87	0.60	-3.73**	0.06**
SSEC	-4.05**	0.03**	-7.97*	0.33	-4.02**	0.04**

Note: ** Denotes statistical significance < 5% level. Source: Own calculation.

From the applied unit root test results, we can see that all variables included in the analysis consist of stationary data. The first condition for searching for cointegration among variables is that all variables have the same order of integration. Therefore, we can see a cointegration between the variables of natural gas (NG) prices and FTSE 100, DAX 30, CAC 40, DJI, SP 500, Nikkei 225 and SSEC. Thus, a VAR model can be used with all the variables, without taking the first or second differences of the prices of all the variables included in this study.

Table 2 presents the results of summary statistics. The JB statistic is statistically significant at the 1% level, indicating that all the returns series have skewness and excess kurtosis. These results indicates that the returns series do not come from a normally distributed population, and according to the JB statistics, all return series are violations of normality assumptions. These results imply that it is necessary to consider their asymmetric distributions.

Table 2. Statistical properties of our data series.

Return Variables	Min.	Max.	Std.	Skewness	Kurtosis	JB
NGN2	-14.47	8.93	4.17	-0.97	1.99	20.35***
FTSE 100	-3.60	3.77	1.26	-0.07	1.46	5.69***
DAX	-4.61	7.34	1.85	0.69	3.13	30.69***
CAC 40	-5.22	6.65	1.86	0.39	2.34	15.96***
DJI	-3.69	2.74	1.40	-0.51	0.12	2.79***
SP500	-4.21	2.90	1.70	-0.41	-0.29	2.02***
Nikkei 225	-3.03	3.79	1.48	0.18	-0.17	0.39***

Return Variables	Min.	Max.	Std.	Skewness	Kurtosis	JB
SSEC	-5.41	3.37	1.63	-0.97	-1.94	18.1***

Note: *** Denotes statistical significance at the 1% level. Source: Own calculation.

4.2 Lag length selection

The first step consists of determine the appropriate lag length. In the Table 3, the lag length is determined according to different models.

Table 3. Information Criteria for Lag Length Selection.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2894.768	NA	9.60e+35	105.5552	105.8472	105.6681
1	-2579.957	526.5930	1.08e+32	96.43480	99.06258*	97.45099
2	-2529.380	69.88884	2.02e+32	96.92289	101.8865	98.84235
3	-2455.874	80.18824	2.15e+32	96.57723	103.8766	99.39996
4	-2340.146	92.58202*	8.19e+31*	94.69623*	104.3314	98.42223*

Source: Own calculation.

Information criterion statistics show that the appropriate lag length is 4, because four out of five information criteria selected the model with lag 4 as the appropriate model.

It is seen in Figure 2 that the estimated VAR (4) model satisfies the stability conditions. Considering Figure 2, we can find that the inverse roots of the autoregressive characteristic polynomial are distributed within the unit circle.

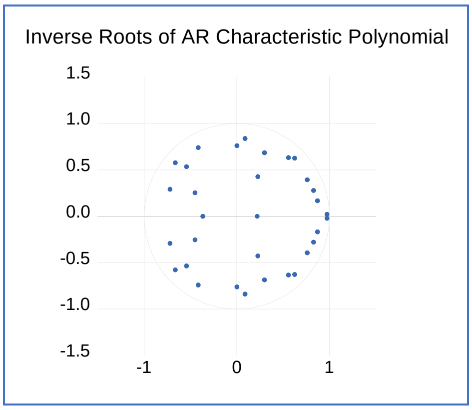

Figure 2. The stability graph for the VAR Method

4.3 VAR model

The regression results of the VAR model with lag 4 in the analysis are in Table 4. Statistics inside parentheses are the standard error of estimate.

Table 4. VAR Model Regression Results

	NGN2	FTSE100	DAX	CAC_40	DJI	SP500	NIKKEI 225	SSEC
NGN2	0.107249 (0.17870)	-0.196157 (0.05090)	-0.467342 (0.05047)	-0.237886 (0.00302)	-0.981067 (0.00252)	-0.153023 (0.00470)	-0.371316 (0.03436)	-0.021459 (0.01454)
FTSE100	1.427555 (1.37444)	0.079304 (0.42990)	-0.192898 (1.20347)	-0.002734 (0.56158)	2.345957 (2.55747)	0.196090 (0.38995)	-0.437983 (1.95633)	0.075123 (0.26565)
DAX	0.829311 (0.75505)	-0.167328 (0.23617)	-0.398284 (0.66112)	-0.151036 (0.30850)	-0.991108 (1.40494)	-0.108083 (0.21422)	1.682183 (1.07471)	-0.078100 (0.14593)
CAC 40	-3.041599 (1.65421)	0.253479 (0.51741)	0.986348 (1.44843)	0.337196 (0.67588)	1.031065 (3.07803)	0.158526 (0.46933)	-3.739804 (2.35454)	0.171238 (0.31972)
DJI	0.247376 (0.19086)	-0.301212 (0.05353)	-0.796576 (0.00980)	-0.429634 (0.00056)	-0.039736 (0.91336)	0.029211 (0.03927)	1.503987 (0.09868)	0.007695 (0.09487)
SP500	-0.181643 (3.08849)	2.286982 (0.96603)	5.552465 (2.70430)	2.878951 (1.26191)	0.954579 (5.74684)	0.003817 (0.87626)	-8.265657 (4.39605)	-0.072034 (0.59694)
NIKKEI225	0.137974 (0.15906)	0.040604 (0.04975)	0.090620 (0.13927)	0.084522 (0.06499)	0.145367 (0.29597)	0.033418 (0.04513)	-0.123195 (0.22640)	0.034611 (0.03074)

	NGN2	FTSE100	DAX	CAC_40	DJI	SP500	NIKKEI 225	SSEC
SSEC	-1.255559 (1.00779)	0.336147 (0.31522)	0.937622 (0.88243)	0.432904 (0 41177)	0.093889 (1.87523)	-0.074197 (0.28593)	-0.786324 (1.43446)	-0.225118 (0.19478)
C	-7143.718 (11438.5)	3565.290 (3577.78)	13912.41 (10015.6)	3251.816 (4673.59)	-4986.742 (21283.9)	-1362.998 (3245.30)	-498.7044 (16281.2)	1713.311 (2210.81)
R-squared	0.986172	0.928635	0.892462	0.897250	0.936466	0.956836	0.935915	0.948943
Adj. R-squared	0.966059	0.824832	0.736044	0.747796	0.844053	0.894052	0.842701	0.874679
Sum sq. resids	1234719.	120797.2	946635.7	206124.4	4274971.	99388.77	2501495.	46124.46
S.E. equation	236.9042	74.09982	207.4341	96.79509	440.8139	67.21363	337.2007	45.78828
F-statistic	49.03100	8.946104	5.705616	6.003522	10.13345	15.24010	10.04047	1637682
Log likelihood	-353.5647	-289.6413	-346.2584	-304.3364	-387.7179	-284.2768	-372.9809	10.76964
Akaike AIC	14.05690	11.73241	13.79121	12.26678	15.29883	11.53734	14.76294	11.97404
Schwarz SC	15.26130	12.93681	14.99561	13.47118	16.50323	12.74174	15.96734	3171.956
Mean dependent	6326.582	7417.594	14030.57	6451.478	33698.50	4301.500	26726.05	129.3428
S.D. dependent	1285.208	177.0474	403.7518	192.7426	1116.262	206.4955	850.2085	1713.311

Source: Own calculation.

The results of a Vector Autoregression (VAR) model regression analysis developed indicate that changes in natural gas prices are significantly related to changes in market indices. The negative sign of the effect indicates that there is an inverse relationship between natural gas prices and the indices, meaning that an increase in natural gas prices tends to cause a decrease in the indices and vice versa.

Natural gas prices have a strong effect on global stock market indices such as European FTSE 100, DAX 30, CAC 40, American DJI and SP 500, Asian Nikkei 225, and SSEC for several reasons:

(1) natural gas is a key energy source for many industries, including manufacturing, transportation, and power generation. As a result, changes in natural gas prices can significantly impact the cost of production, transportation, and electricity generation, which can have impact on the profits and overall performance of companies in these industries, results supported by Degiannakis et al. (2018) in their study. This can in turn affect the value of stocks in these industries, and have impact the stock market indices.

(2) natural gas prices are influenced by a variety of factors, including weather patterns, supply and demand dynamics, and geopolitical events. These factors can create uncertainty and volatility in the natural gas markets, which can lead to fluctuations in the stock markets. This result is in line with Ling et al. (2018) study; they examined the transmission of risk between the natural gas market and the stock markets of China ans USA over a 22-year period from 1994 to 2016; this period was marked by several crises and turbulent episodes, which significantly impacted the correlation between the natural gas market and the Chinese and American stock markets.

(3) natural gas prices are often correlated with other commodities such as oil and coal. Changes in these prices can also impact the cost structure of many industries, and hence, impact stock market indices, as sustain Kim et al. (2014).

(4) natural gas is a major input cost for the energy sector, which accounts for a significant portion of the global economy. As a result, changes in natural gas prices can significantly impact the earnings and profitability of energy companies, which can in turn affect the value of their stocks and the overall performance of the stock market indices.

(5) the changes in natural gas prices can also impact the cost of heating and cooling for households and businesses, which can impact consumer spending and overall economic activity. This, in turn, can impact the performance of industries and sectors that are dependent on consumer spending, such as retail, leisure, and hospitality, which can then affect the value of their stocks and the broader stock market indices.

(6) natural gas prices can also be influenced by geopolitical events, such as tensions between major natural gas producing and consuming countries, which can create uncertainty in the markets and lead to fluctuations in the stock market indices.

All these means that the impact of the price of natural gas is very strong on the economy and business. Natural gas is used as a substitute for oil and is an alternative investment product for hedging, speculation, or diversification purposes.

Our results are consistent with the results of previous studies between natural gas prices and stock prices (Ling et al., 2018; Degiannakis et al., 2018; Kim et al., 2014; Bilgin et al., 2015 and Acaravci et al., 2012).

4.4 Granger Causality Test

The Granger causality method was employed to investigate the causal relationships between variables, this statistical test assesing whether one time series can be used to forecast another. If the probability value is lower than a specified α level, then the hypothesis is rejected at that level. Table 5 presents the outcomes of the

Granger causality test, which sheds light on the direction of the correlation between natural gas and stock market indices.

Table 5. Granger Causality Test Results

Null Hypothesis:	F-Statistic	Prob.
CAC40 does not Granger Cause NGN2	0.44770	0.7736
ÑGN2 does not Granger Cause CAC40	0.59899	**0.0051**
DAX does not Granger Cause NGN2	0.36362	0.8334
NGN2 does not Granger Cause DAX	0.49538	**0.0491**
DJI does not Granger Cause NGN2	4.52177	0.0033
NGN2 does not Granger Cause DJI	0.84127	**0.0045**
FTSE100 does not Granger Cause NGN2	0.99828	0.4171
NGN2 does not Granger Cause FTSE100	1.14580	**0.0057**
Nikkei225 does not Granger Cause NGN2	0.68422	0.2065
NGN2 does not Granger Cause Nikkei225	0.30031	**0.0462**
SP500 does not Granger Cause NGN2	4.29983	0.0045
NGN2 does not Granger Cause SP500	1.05851	0.0066
SSEC does not Granger Cause NGN2	0.75404	0.5605
NGN2 does not Granger Cause SSEC	0.74108	**0.0589**

Source: Own calculation.

According to the results of the Granger causality test, on short- term, the Natural Gas price represents the cause of the FTSE 100 (P = 0.0057 <5%), or DAX 30 (P = 0.0491 <5%), or CAC 40 (P = 0.0051 <1%), or DJI (P = 0.0045 < 1%), or SP 500 (P = 0.0066 < 1%), or Nikkei 225 (P = 0.0462 <5%), or SSEC (P = 0.0589 <10%).

According to the Granger causality test results, the natural gas price affects the stock indices. The p-value of the test statistics for the DJI, SP500, FTSE100 and CAC40 is lower than the 1% significance level. As a result, it can be said that the Granger causality test results confirmed the findings of the VAR analysis in the first three months since the Russian-Ukrainian geo-political conflict began.

The Russian-Ukrainian geopolitical conflict has the potential to affect the relationship between natural gas prices and stock indices for several reasons: (1) the conflict involves two countries: Russia (producer) and Ukraine (with the massive gas transport network), and the conflict has the potential to disrupt natural gas supplies and pipelines, which can lead to supply shortages and price fluctuations; (2) the conflict has geopolitical implications that can affect global energy markets and investor sentiment. For example, sanctions on Russia or disruptions to global natural gas supplies can lead to increased uncertainty and volatility in the energy markets, which can then spill over into the broader stock market indices; (3) the conflict can impact the economic and political stability of the region, which can affect consumer and investor confidence. This can lead to changes in consumption patterns, investment decisions, and overall economic activity, which can then impact the performance of the stock market indices. Overall, the Russian-Ukrainian conflict can create a range of economic and geopolitical risks that can impact the relationship between natural gas prices and stock indices. It is important to note, however, that the exact nature and extent of these effects can be difficult to predict and can be influenced by a range of factors beyond the conflict itself.

Natural gas prices can have a direct effect on stock prices. First, energy is a significant cost item for companies that has the direct potential to erode profit margins. Second, natural gas prices can affect stock prices through the macroeconomic channel. Considering these findings, we can conclude that there is a Granger causality relationship between stock returns and natural gas price increases. Increases in natural gas prices have an impact on industrial production growth, and industrial production growth influences stock returns. Stock indices are subject to the fluctuations in the price of natural gas, which is a widely traded global commodity. An increase in the price of natural gas can result in a corresponding decrease in these indices.

Attention to the economic significance of the transmission of energy prices to stock markets can enable financial experts to make more complex financial decisions. However, caution should be exercised before generalizing these results as it is essential to differentiate between natural gas importing and natural gas exporting countries.

Overall, the interplay between natural gas prices and global stock market indices is complex and can be influenced by a wide range of economic, political, and environmental factors. As a result, investors and analysts closely monitor natural gas prices as an important indicator of the health and direction of the global economy.

The findings suggest that fluctuations in natural gas prices have important implications for the broader economy and financial markets, particularly during periods of energy market disruption. As natural gas is a widely traded commodity with global supply and demand factors, its price movements can have significant impacts on both energy producers and consumers, as well as financial market participants.

6. Conclusions

Countries around the world closely monitor the dynamics of energy and capital markets for several reasons. These two markets continue to play an important role in the process of economic development due to their major impact on many aspects of the domestic and international economy. For the global investment community, energy and capital markets remain attractive destinations for business growth, offering a diverse range of profitable investment opportunities. These markets also provide cues that can help policymakers analyze the determinants of macroeconomic performance and thus better explain the uncertainty that lies ahead.

The relationship between energy and capital market indicators is very important for investors as it can affect their diversification decisions. In this study, the correlations between natural gas prices and European FTSE 100, DAX 30, CAC 40, American DJI and SP 500, Asian Nikkei 225 and SSEC stock markets indices were examined. In this study, the correlation between natural gas prices and stock prices was studied for six countries (five of G7 member economies and China) on three continents. Daily data between 24.02.2022- 27.05.2022, representing the first three month of the Russian-Ukrainian geo-political conflict, were considered. Vector autoregressive model was used and the direction of the correlation between variables was determined by the Granger causality test.

The goal of this study was to investigate the short-term relationship between natural gas prices and stock prices for seven stock indices during the first three months of the Russian-Ukrainian geo-political conflict, which generated an explosion in the price of natural gas.

According to the results of the VAR model and Granger causality test, the natural gas (NG) price represents the main cause of the evolution of all the considered stock indices. On the other hand, the Granger causality test results have confirmed the findings of the VAR analysis. Another conclusion is that natural gas is much more closely related to the S&P 500 than to the SSEC, a conclusion reached by He et al. (2020). The findings of this paper are aligned with the research implications of Ling et al. (2018), Degiannakis et al. (2018), Kim et al. (2014) and Bilgin et al. (2015). Similar evidence was also found by Acaravci et al. (2012).

The result obtained from this study shows that energy and capital market investors should carefully follow both natural gas price changes and stock market indices during geopolitical conflicts period. Although the results provided some valuable information regarding the correlation between stock market indices and natural gas prices, it would be useful to analyze other periods and compare the results with the findings of this study. In other words, an extended analysis, at least compared to the economic and financial crisis periods, will help to see whether the results in question are specific to the periods used or whether they can be generalized. Apart from this, although the findings of this study are generalized, since many factors affect the capital markets, investors should not forget that the dynamics in the capital markets may change.

This study brings original contributions to the finance and energy literature. This paper is one of the first who examine the relationship between natural gas prices and stock prices in the first three months of the Russian-Ukrainian geo-political conflict. Although the relationship between oil prices and financial indicators is well documented, a limited number of studies examine the relationship between natural gas prices and stock prices. Furthermore, although the limited literature examining the link between stock prices and natural gas prices focuses on the direct channel, we focus on the indirect channel through which natural gas prices appear to influence stock prices. Therefore, financial managers will need to consider the macroeconomic consequences of changes in natural gas prices, in addition to focusing on the variation in cost and profit levels because of changes in natural gas prices.

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