Changes In Clean Energy Index Before and After Russia-Ukraine War: Evidence from ARIMA Model

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Abstract. With the outbreak of the Russia-Ukraine War, the geopolitical situation was tense. The uncertainty of the impact of the war crisis and conflict, especially the impact on financial and energy sanctions, reduced the growth expectations of the energy economy. This paper examines the changes in the clean energy index before and after the Russia-Ukraine War, extracts the stock composite index of listed companies in the industry before and after the Russia-Ukraine War, and build ARIMA model to analyze the data, determine and analyze the profitability and stock volatility of the clean energy index before and after the Russia-Ukraine War, investigate how the Russia-Ukraine conflict affects the clean energy index and predicts the future trend of the clean energy index. Interestingly, whether in the ultra-short term, the short term, or the short-medium term, the Russia-Ukraine War has a considerable positive change on the clean energy index. Investment is good, and investors can quickly rebound from the pessimistic mood of the war and reinvest in the market. At the same time, the study predicted the possible future of the clean energy index, analyzed the government's policies to stabilize the response of war shocks to financial markets, and provided investors with relevant management and investment suggestions for "reasonable speculation" profits to avoid the impact of external risk shocks on financial asset returns.

Keywords: Russia-Ukraine War, Clean Energy Index, ARIMA model.

1. Introduction

1.1. Research Background

Since the outbreak of the Russian Ukrainian military conflict on February 24th in 2022, Western countries led by the United States have imposed multiple rounds of severe sanctions on Russia in political, economic, financial, energy, trade, and other fields. Among them, the sanctions against the Russian energy sector have gradually set off an energy crisis in the world since February 24th, posing serious challenges to the pricing levels, energy security and economic growth of countries all over the world, and causing severe reactions in the capital market.

After the outbreak of the Russia-Ukraine conflict, the western countries responded quickly and imposed severe penalties on Russia in the energy field. The United States and the European Union have successively prohibited the technology transfer to Russia in the clean energy industry, prohibited investment in the energy sector, prohibited imports of coal and oil from Russia, and promised to gradually withdraw from Russia's dependence on natural gas. However, with respect to the energy field, Russia's position is critical. Although western sanctions have struck Russian economy, the prices of natural gas, oil, and coal have been pushed up, which has affected the energy security all around the world. In 2021, Russia's average crude oil production was 10 million barrels per day, accounting for around 10% of global crude oil production. Due to the Russia-Ukraine conflict, by the end of April, oil production in Russia has fell by approximately 3 million barrels daily. The international crude oil prices have experienced a significant increase by expansion of the oil gap, from around $80 per barrel at the beginning of 2021, it has significantly increased to a maximum of over $120 per barrel. In terms of financial capital market, the Energy crisis caused energy shortages and rising energy prices, considering divided the index components of major countries around the world by industry and found that due to the rise in oil and gas prices, energy companies have made significant profits, leading energy stock returns in various industries [1].

Clean energy refers to energy that does not produce or only produces a small number of harmful substances during use, including energy from biomass, water, wind, and the sun. With the increasing awareness of environmental protection among people, the development of clean energy is receiving increasing attention. The importance of clean energy is first reflected in environmental protection. The use of traditional energy can produce harmful substances that cause serious pollution to the atmosphere, water quality, and other environments. The use of clean energy can reduce the emissions of these harmful substances, which is beneficial for protecting the ecological environment. Secondly, the development of clean energy also helps to promote sustainable economic development. The development and utilization of clean energy require significant investment in technology, equipment, and manpower, which will create many job opportunities and promote economic development. At the same time, the use of clean energy can reduce environmental pollution, achieving the goal of strengthening the ecological environment while developing the economy. Finally, the scale and influence of the clean energy industry are constantly expanding, supporting the growth of a small energy consumption in clean energy industry, steadily promoting the optimization, and adjusting economic structure, and upgrading of industrial structure.

1.2. Research Gap

Considering that previous data and studies are unclear, will the outbreak of war factors affect the development of green finance such as clean energy index in the face of significant external risks? Therefore, to make up for the exploration gap in this field, this paper will further clarify and investigate "whether the Russia-Ukraine War has a substantial change on the clean energy index".

In the period after the outbreak of the war, the task of developing the clean energy industry and green financial economy has attracted worldwide attention. This paper demonstrates that even during the harsh war, human beings still try the best to make our world a better place to live and make green finance growth for our better life.

1.3. Structure

The following components are organized as follows: The second section is a literature review, including the investigation on the causes and implications of the Russia-Ukraine conflict and how the Russia-Ukraine war has brought changes to the stock markets. The third part, looking for data sources, detecting data stability and establishing models, with specific images and data as assistance, focuses on analyzing the effect of the Russia-Ukraine conflict on the clean energy index. The fourth section will use the obtained relevant data for ARIMA model analysis, and additional analysis will be conducted on the prediction of the clean energy index, the volatility of the renewable energy index, and the behavior of market participants. In the fifth section, the empirical analysis results are utilized to display the influence of the Russia-Ukraine war and a series of world clean energy control restrictions in the financial market and expounds the impact of the clean energy dispute on the stock market from multiple perspectives. Finally, the sixth section draws conclusions and makes predictions for three time periods: ultra-short term, short term, and short-middle term, during different periods, to providing innovative and feasible suggestions for the future development of the clean energy.

2. Literature Review

2.1. Definition and Development

The start invasion of Russia was marked in February 2022. Geopolitical tensions between different nations caused by the conflict led to decreased global growth expectations as uncertainty about the changes of the crisis on the global financial market [2]. This investigation begins by finding a reason why Russia and Ukraine start a war. Researchers recognize that countries are involved in conflicts to safeguard their energy resources or to retain their regional clout [3], while other countries maintain their rights that claims to have difficulty managing more colonial resources or common resources or aimed to value in an equal manner [4].

2.2. Important Results

The Russia-Ukraine conflict is undoubtedly the most important war since the World War II, which has had a serious repercussion on financial markets worldwide. Since its inception, the cumulative anomalous returns on global financial stock markets have been negative, with important heterogeneity effects [5]. In this regard, Boungou and Yati é [6] also pointed out that during the entire conflict period, the stock returns of 94 countries worldwide were negative.

Under the assumption of an efficient market, stock prices often immediately adjust to any unexpected situations without overreacting [7]. Logical individuals often carefully evaluate different opportunities and outcomes with the information they possess to make effective decisions according to the argument. All available information is supposed to be reflected by the stock prices. Inversely, behavioral theory contradicts these assumptions, stating that the reaction of investors to news about geopolitical conflicts and risks could be overreacted [8]. In this regard, Muhammad Umar [9] advised that the significance assumption of risk decision-making should be considered. The predominance of conflict distorts the goal probability of the outcome and changes the weight of decision-making, especially in situations where there is a possibility of conflict. Considering these complex issues, we will take the Russia-Ukraine dispute as evidence to investigate these points.

2.3. Summary

In general, the investigating into the causes, process and change of the Russia-Ukraine conflict has been relatively in-depth, while the changes of the Russia-Ukraine dispute in the financial market, on the clean energy index especially, there are still relatively few studies conducted. Predicting the future growth of clean energy in capital market is a challenging. Therefore, this investigation looks forward to filling the research gap in this field by using empirical data to prove the changes of the Russia-Ukraine dispute on the current and future different terms of development of clean energy index in financial market.

3. Research Design

3.1. Data Source

This research utilizes the search engine Choice Financial Terminal to search and obtain the comprehensive index of listed stocks in the industry in conjunction with East Money Information [10] and find out the closing price of the clean energy index from December 31 in 2012, to June 20 in 2023, which are downloaded respectively by daily, weekly, and monthly data. And set the outbreak day by Russia-Ukraine conflict, February 24th in 2022, as T0. As the source of data foundation for empirical analysis, this investigation studies the impact of the Russia-Ukraine dispute on the clean energy index. Generating a logarithmic series of closing prices and a logarithmic rate of return series, updating the edited data by using Stata analysis, and building a model for further exploration.

3.2. Weak Stationarity Test

Before building the model, a stationarity test needs to be performed where the model was initially thought not smooth. Having run the stationary test by entering the data into Stata, we cannot find many patterns in first-order difference, although the data looks stable but not significant.

After second-order difference, the first hypothesis rules out that the model is stable and practicable since Table 1 makes it evident that the p-value for the log-returns is 0, which is less than 0.1.

Table 1 Weak stationarity test

Variables	t-statistic	p-value
Raw		
Daily	-1.327	0.8810
Weekly	-1.560	0.8425
Monthly	-1.725	0.7398
1st order difference		
Daily	-32.925	0.0000
Weekly	-13.994	0.0000
Monthly	-6.4950	0.0000
2nd order difference		
Daily	-57.67	0.0000
Weekly	-26.112	0.0000
Monthly	-10.459	0.0000

3.3. ARIMA Model Setting

The principle of the ARIMA model is to investigate the objects and time of observation at different time points. Predicting the change trend of the research object after the observation time point based on the historical change relationship before potential. In the ARIMA (p, d, q) model, AR represents the autoregressive process, where the number of autoregressive terms is denoted by p; MA represents the method of moving average, and the amount of moving average terms is q; d represents the number of variations required to make the sequence stable, and its mathematical expression is as follows:

$$\left(1-\sum_{i=1}^{p}\emptyset iL^{i}\right)(1-L)^{d}X_{t}=\left(1+\sum_{i=1}^{q}\theta_{i}L^{i}\right)\varepsilon_{t} \quad (1)$$

Homogeneity can be denoted as a difference operator:

$$\nabla^{2}y_{t}=\nabla(y_{t}-y_{t-1})=y_{t}-2y_{t-1}+y_{t-2} \quad (2)$$

For delay operators, there are:

$$y_{t-p}=B^{p}y_{t}\ ,\ \forall p\geq 1 \quad (3)$$

Conclusion that:

$$\nabla^{k}=(1-B)^{k} \quad (4)$$

ARMA (p, q) model:

$$\lambda(B)(\nabla^{d}y_{t})=\theta(B)\epsilon_{t} \quad (5)$$

Among them, $\lambda(B)=1-\lambda_{1}B-\lambda_{2}B^{2}-\cdots-\lambda_{P}B^{P}$ which called white noise sequence denoted as ARIMA (p, d, q) [11].

4. Results and Analysis

4.1. Order Selection

In this section, the log-return series can be ordered by using the PACF and ACF pairings, the results of which are illustrated in figure 1:

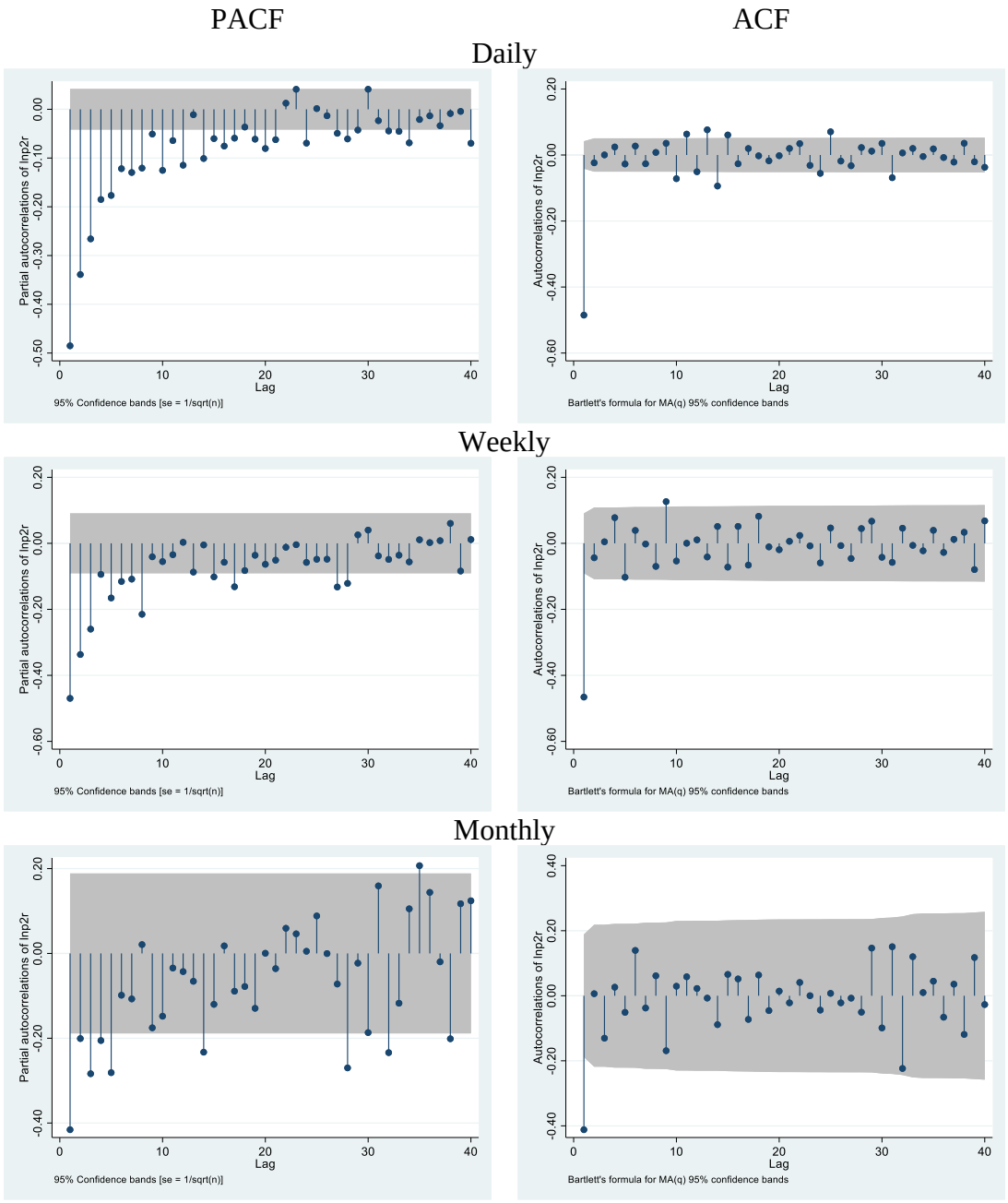


Figure 1 PACF and ACF

Photo credit: Original

The 95% confidence interval for AR(p) in PACF and MA(q) in ACF is denoted by the region defined by y=2 standard error. In daily data, the fixed order outcome in the first row in Figure 1, 8th is the first portion beyond the x-axis., the 9th order is not that significant, so P has an order of 8. Similarly, the p value is 8 in weekly data and p is of order 5 in monthly data.

The value of d depends on the number of differences, and second-order differences find a clear pattern, so the number of d is equal to 2.

4.2. Residual Test

After estimating the order of the model ARIMA, we perform a white noise test on the residual sequence, which mainly focusing on the p-value, the results can be seen as bellowed in table 2 and prediction for actual and fitted value in figure 2.

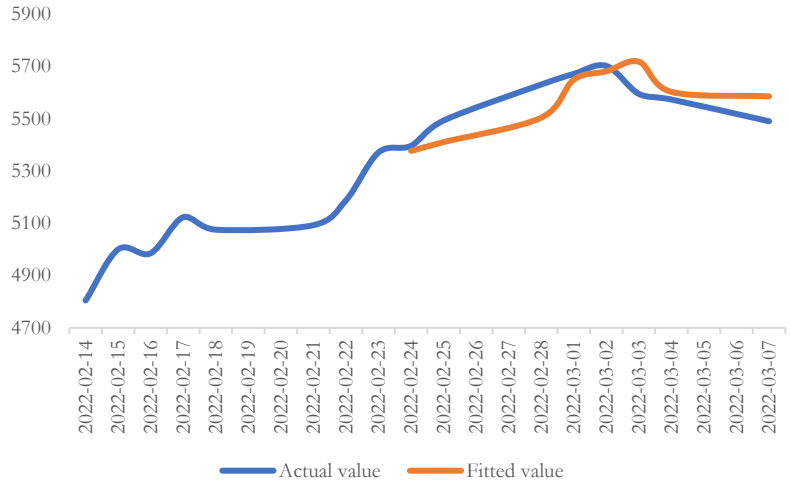
Table 2 Residual test

Model	Portmanteau (Q) statistic	Prob > chi2
Daily ARIMA (8, 2, 1)	65.4654	0.0067
Weekly ARIMA (8, 2, 1)	38.5662	0.5348
Monthly ARIMA (5, 2, 1)	24.7866	0.9716

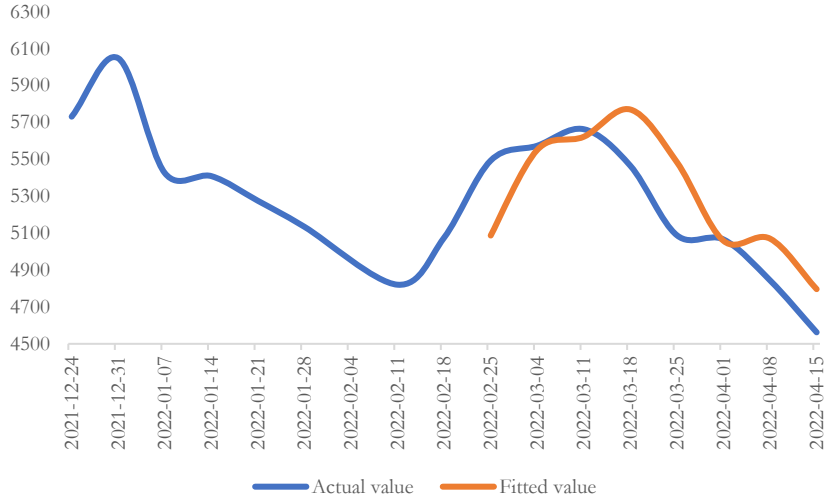
By residual testing, assuming the original hypothesis, the original sequence is white noise. In daily data, prob=0.0067<0.1, rejecting the original hypothesis does not have high data accuracy but the analysis is based on the estimated outcomes of the model, as a rough trend of the control group, rather than precise prediction.

In weekly and monthly data, prob>0.1, accepting the original assumption that white noise sequence is a stationary time series, without periodicity, trend, and autocorrelation.

Daily



Weekly



Monthly

Figure 2 Actual and fitted value.

Photo credit: Original

As tables and graphs described above, it is assumed that the actual values which represents by the blue line are our established control group, and the fitted values which show by orange line are our experimental group predicted by modeling. Both the control group and the experimental group are positive branches, which proves that the Russia-Ukraine conflict has a positive and significant change on the clean energy index.

4.3. Theoretical Explanation

From the perspective of ultra-short term daily data, within 5 days after the outbreak of the war against Russia and Ukraine, the impact of the conflict was positive for the rise of the clean energy index. From February 24 to March 2 in 2022, only within 5 days, the average growth difference divided by the average fitted value was 0.98%, showing a short-term positive trend. It is interesting that after an ultra-short term positive, it immediately reverses, and the difference shows a negative number, indicating the expected decline in the clean energy index. However, the magnitude of the decline is still higher than the original value, which perfectly explains the "overreaction" effect of the financial market. Overall, after 5 days of rising and 3 days of falling, the index has risen by 0.05% totally, showing a relatively slight effect of "overreaction".

From the perspective of short-term weekly data, the short-term predicted data is basically consistent with the ultra-short-term data. It is good and profitable in the short term to be purchased by investors. A few weeks later, due to the reversal of market reaction, it decreases slightly. However, the scarcity of clean energy, such as the monopoly on oil, accounts for 1/3 of world exports still causes the financial market overreacted and investors purchased too much. Overall, the Russia-Ukraine conflict has a positive change on the clean energy index.

From the perspective of short- middle monthly data，One week after sharply shock, the clean energy index had an important positive, up to 8.7% critically, an amazing rate of return on investment. As expected, by analyzing from financial fundamentals, with the prolongation of the war, Russia's competition for clean energy, such as increased oil control efforts have increased. there are factors of overreaction afterwards, and after the reversal, there is still a significantly positive trend in the short-medium term.

5. Discussion

The Russia-Ukraine war is undoubtedly the most important shock since World War II, which has had a serious influence on global financial markets. Since its inception, the global financial stock market has presented a negative cumulative unusual return, which has a significant heterogeneous impact. However, this paper concluded that the huge external risk event impact of the Russia-Ukraine

conflict has a positive impact on the stock market and the clean energy index. In addition, the efficient market theory states that stock prices often immediately adapt to any unexpected event without overreacting. Rational decision-makers often assess numerous possibilities and outcomes considering the available information to make well-informed and wise choices. In this research forecast, investors will take the decision of active purchase based on the scarcity and monopoly of clean energy, as well as the increased control over clean energy and competition for scarce resources in the Russia-Ukraine conflict. The capital market overreacted in the ultra-short, short term and short-medium term. Russia-Ukraine conflict exactly has a positive and significant impact on the clean energy index.

According to the results of this paper, in the face of such a big external impact of the Russia-Ukraine conflict, policy makers had to make a series of policies to cope with the shock of external risks on the financial market. The first goal is to ensure that clean energy supply is ensured in the short term, even in crises, strikes, or special circumstances. The second goal is sustainability. This means that humans may provide energy that does not threaten Earth's life in the future. Unfortunately, the reliance on renewable energy is an exception in most countries around the world, and energy policy makers are trying to find sustainable energy to make life on Earth safer and more sustainable. The third goal is an appropriate price. The government has provided additional financial resources, and some countries have benefited greatly from the rise of the clean energy index. Therefore, these countries are interested in prolonging the war, but the real interest lies in stabilizing their prices within the appropriate range of importing and exporting countries, which helps to achieve balance in the financial market.

As far as investors are concerned, in the face of the huge external impact of the Russia-Ukraine War, there are unexpected risks. At the same time, there are also "reasonable speculation" profits through rational allocation of financial assets, or to avoid the impact of external risks on asset returns. To avoid the pessimistic sentiment in the financial market caused by the trauma of war, rational analysis of the expected trend of the financial market should be conducted. Evaluate from various aspects such as government support, shareholder mentality, business operation model, and time dimension. The Russo-Ukrainian War has greatly stimulated the rise and fall of clean energy in the world. In the short and medium term, some good assets will be suppressed during the war. If the fundamentals are not broken and the business model operates normally, it is time to pick up cheap chips.

6. Conclusion

Due to Russia's invasion of Ukraine, the world's financial markets have suffered tremendous losses, yet renewable energy companies have benefited. The key factor is that financiers anticipated the demand for alternative energy sources. This paper observes and analyzes how the clean energy index respond to Russian Ukraine invasion war with the use of quantitative modeling technique, by building ARIMA model to investigates the changes of the clean energy index before and after the Russian-Ukrainian war. The gathered information shows an improvement in the anomalous returns linked to the clean energy index. Moreover, the period of short-middle term is one of the renewable energy markets to respond to conflict. The influence was also greatest on short-to-middle term days, which was positive investment return rate, and concludes that the clean energy index will be affected positively by Russian Ukraine in the ultra-short and short term, while change is significant in the short-middle term in the future development. The Russian-Ukrainian War has been going on for a long time. Maybe more data are needed to collect, explore, and predict whether the investment is good in the later period. It is also possible that the prolonged war cycle may lead to market volatility and instability, which is the direction for further research in this paper.

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