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Tesla under the Russia-Ukraine Conflict: A Short-term Perspective Based on Counterfactual Framework

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Abstract: The ARIMA model has found extensive applications across various domains, including financial time series analysis, weather forecasting, epidemiological forecasting, and market research. Despite its versatility, little attention has been paid to the impact of the ongoing Russia-Ukraine conflict on Tesla Motors. Given the significant influence of Tesla, as a major player in the electric drive vehicle industry, on the global energy landscape, this study aims to utilize the ARIMA model to examine the effect of the Russia-Ukraine conflict on Tesla's sales volume and stock price. The findings of this study may contribute towards mitigating global warming and inspire investment in sustainable energy solutions, including electric vehicles and energy storage issues. Additionally, this study will highlight Tesla's contribution to the global energy landscape and provide a quantitative analysis of investors' preferences for Tesla. Results indicate that the Russia-Ukraine war caused a significant short-term impact on Tesla's stock price. A counterfactual framework was used to compare control and actual sets, revealing a disparity between ideal predictions and the real world. However, Tesla's stock price rebounded in the second month of the war, signifying that this will not significantly affect Tesla's future development. The study also suggests that the disruption of the global supply chain caused by the war and Russia's energy export restrictions resulted in a sharp increase in global oil prices, thereby escalating the cost of gasoline vehicles and leading to a considerable surge in Tesla's sales.

Keywords: TSLA inc., electric vehicle, Russia-Ukraine War, energy sources

1. Introduction

Russia holds a prominent position as a key global exporter of oil, gas, and coal, with a particular emphasis on the energy market. Following the outbreak of the Russo-Ukraine war, there was a short-term decline in the global stock markets. However, recent evidence suggests that there has been an upswing in the stock markets worldwide, especially in the renewable energy sector, in the aftermath of the conflict [1].

Since February 2014, the Russia-Ukraine war has been ongoing following a dispute between the two nations over the official status of Crimea and Donbas. Johannesson and Clowes [2] contend that a primary factor leading to the conflict and Russia's annexation of Crimea is Ukraine's potential to emerge as a direct competitive threat to Russia's energy exports.

The invasion of Ukraine by Russia and the resulting conflict has had detrimental effects on the energy issue. The implementation of physical embargoes and sanctions on Russia has restricted energy flows, leading to a surge in energy prices [3]. The World Bank has predicted that energy costs may increase by more than 50% in 2022, potentially resulting in stagflation, which has not occurred in decades [4]. The region's energy price crisis has been exacerbated by the geopolitical conflict, particularly as the EU depends significantly on energy imports from Russia (approximately 40% of natural gas, 25% of oil, and 50% of coal imported into the EU in 2019). Consequently, there is now a greater incentive for the rapid development of electric vehicles due to their enhanced environmental sustainability [5].

The Russia-Ukraine conflict in 2021-2022 has resulted in a significant increase in oil prices, with rates reaching a historic peak of over 120 US dollars per barrel [6]. This has resulted in the significant economic strain as oil-based vehicles have become more expensive to use. At the same time, the war has spurred the development of electric vehicles.

Tesla's response to the Russia-Ukraine conflict has been swift and comprehensive. They have developed a range of electric trams that are significantly cheaper than their oil-based counterparts. Furthermore, they have invested heavily in research and development to ensure their trams are as efficient and environmentally friendly as possible. This has allowed Tesla to remain competitive with other electric vehicle manufacturers while also providing a viable alternative to oil-based transportation. Although Tesla dominates the American EV market, there is increasing competition. Almost 8% of the market's EV sales are made by Ford, whereas 3.5% are made by GM. Tesla stands out from its rivals thanks to a price reduction [7]. Elon Musk has also stated that Tesla is developing a new base model with a starting price of just £18,000, which is less expensive than the cost of all of their previous models. On March 1, 2023, at the Tesla Investor Day, the technical specifications for this new vehicle will be made public [8]. Tesla has continued to reduce manufacturing costs and lower prices to drive traffic and attention during this period and secure its monopoly in the electric vehicle industry. During this special period, it is very beneficial for Tesla to enter the low-end market and expand their user base.

The impact of the 2021-2022 Russia-Ukraine conflict on Tesla and the global energy landscape has been significant. Tesla's response to the conflict has been prompt, and they have developed a range of environmentally friendly and cost-effective electric vehicles. The conflict has accelerated the global greenhouse effect, resulting in severe climate warming and significant environmental damage. Euronews reports indicate that on the first day of the invasion, the Gaza Equine radiation in the Chernobyl region exceeded the annual limit by 28 times [9]. Moreover, the conflict has led to an increase in the cost of oil-based vehicles, as well as higher levels of air and water pollution. As a result, there has been a growing global awareness of the consequences of climate warming and increased attention to environmental issues. For example, the United Nations has recently accelerated the pace of realizing the "Paris Agreement". The Inflation Reduction Act, the first climate law ever adopted in the United States, will pump an unprecedented $369 billion in public expenditure and tax credits into the American economy over the course of the next ten years to enhance clean energy, clean infrastructure, and climate resilience [10]. This is very beneficial to Tesla's future development. In conclusion, Tesla's response to the Russia-Ukraine War of 2021-2022 has been critical in driving the development of electric vehicles, reducing global emissions, and slowing global warming.

However, due to the direct involvement of Tesla's CEO, Elon Musk, in the Russia-Ukraine conflict by providing satellite technology through Starlink [11], the boundaries of its original civilian use have been breached. This has resulted in Tesla being influenced by politics in international games and trade, and being more passive, leading to significant risks to the development and existence of the global industry. Furthermore, the conflict between Russia and Ukraine has turned into a global trend of enmity, which is expected to hurt Musk's electric vehicle sales company in China and Russia.

This study aims to investigate the impact of the Russia-Ukraine conflict that took place from 2021-2022 on Tesla and the global energy landscape. Specifically, it will examine the effect of the conflict

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on the price of oil, which has risen dramatically, leading to increased costs of using oil-based vehicles and driving the development of electric vehicles. Furthermore, this paper will analyze the economic and environmental consequences of the conflict, and use the ARIMA model to demonstrate the crucial role that Tesla plays in the current global energy landscape.

2. Research Design

2.1. Data Source

The company's operating conditions, assets, liabilities, and revenue for the year are all included in the annual report. It provides particular information about the annual operations of numerous businesses. The annual report contains a wealth of information that is highly representative. In order to apply the ARIMA model to forecast future Tesla car sales, the study retrieved Tesla's monthly sales of electric vehicles during the previous two years from Tesla's 2021 and 2022 annual reports [12]. Because the Russia-Ukraine War would formally start after February 2022, and stop collecting data for the test set at that time. To distinguish between the predicted and actual values, a comparison was made, and data for the comparison set will be collected until February 2023. Additionally, this study examined the impact of the Russia-Ukraine conflict on Tesla's stock price fluctuations, using monthly stock index data for Tesla from 2021 to December 2022 obtained from Yahoo Finance [13]. After applying the ARIMA model differentiation, all data were made stationary. The updated and edited data were analyzed using the ARIMA model in Stata, and models were developed for further exploration.

2.2. Augmented Dickey-Fuller (ADF) Unit Root Test

Verifying the stationarity of the data is the first step before continuing. The p-values of Tesla's stock price and sales in Table 1 after differentiating were all found to be of statistical significance and equal to zero after completing the Augmented Dickey-Fuller (ADF) test in Stata. As a result, the presence of a unit root within the variable can be confidently dismissed. These findings imply that the constructed model based on the data is viable and ultimately, the data is deemed stationary.

Table 1: ADF test.

Variables		t-statistic	p-value
Raw			
	Stock price	-1.961	0.6226
	Sales	-3.706	0.0219
Difference			
	Stock price	-8.752	0.0000
	Sales	-9.723	0.0000

2.3. ARIMA Model

As the Russia-Ukraine War broke out in 2021–2022, this study used the ARIMA model to analyze Tesla's stock price and vehicle sales. An effective method for predicting future values based on historical data is the ARIMA model, which is a common time series analysis tool. Analyzing the time series data's autocorrelation and partial autocorrelation functions yields the model parameters. It is frequently used in time series analysis to forecast future values of a variable based on historical observations. The model is a potent instrument to capture intricate patterns and trends in the data and is usable in diverse fields such as finance, engineering, economics, and social sciences. Autoregressive (AR), moving average (MA), and integrated (I) components make up its basic parts.

The AR component models the link between the current observation and a limited number of prior observations, while the MA component models the connection between the current observation and a fixed number of previous forecasting errors, and the I component is employed for differencing the data to establish the time series stationary.

The three components of the ARIMA model—autoregression, differencing, and moving average—are generally written as ARIMA(p,d,q), where p, d, and q represent the respective orders of the AR, I, and MA components. The desired level of predicting accuracy and the data attributes will determine the model order. Maximum likelihood estimation is one of the statistical methods used to estimate the model's parameters, and various metrics, including the Akaike information criterion and mean squared error, are used to assess the model's efficacy. The ARIMA model is widely applied for time series forecasting applications, including weather patterns, stock prices, and product demand. Its ability to capture trends and seasonality implies its suitability for long-term forecasting. Nonetheless, the ARIMA model comes with limitations like the requirement of linearity and stationarity assumptions that are challenging to fulfill in some real-world situations. To sum up, the ARIMA model is a powerful statistical time-series analysis method that forecasts a variable's future values based on past observations. With numerous applications, it can be customized to fit various data types and patterns.

The whole ARIMA model is abbreviated as ARIMA(p, d, q), and its representation is as follows:

$$D_t = c + \emptyset_1 LR_{t-1} + \emptyset_2 LR_{t-2} + \ldots + \emptyset_p LR_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_q \varepsilon_{t-q} \quad (1)$$

In this formula, D_t represents the value of the time series variable at time t, c is a constant, εt represents the error term at time t, $\emptyset_1 \ldots, \emptyset_p$ are coefficients of the AR component, $\theta_1 \ldots, \theta_q$ are the coefficients of the MA component, and p, d, and q are the orders of the AR, I, and MA components, respectively.

The ARIMA model is estimated by fitting the model to the data that are currently available, choosing suitable values for it, and estimating the values of the model parameters using maximum likelihood estimation or other statistical techniques. The time series variable's future values can then be predicted using the model based on historical data and the estimated model parameters.

2.4. The Differencing Component

To achieve stationarity in a time series, the differencing component (I) is utilized. Stationary time series are characterized by consistent mean and variance values over time. The differencing component is represented by I(d), where the value of d signifies the order of differencing. The formula for the I(d) component is expressed as follows:

$$\mathrm{LR_t}' = \mathrm{LR_t} - \mathrm{LR_{t-1}} \quad (2)$$

In this formula, $\mathrm{LR}_t{}'$ represents the differenced time series variable at time t, and $\mathrm{LR}_t - 1$ represents the value of the time series variable at the previous time period. The value of d determines the number of times the time series is different.

2.5. ARMA Model

The autoregressive component (AR) models the relationship between an observation and a fixed number of lagged observations. This component is denoted as AR(p), where p is the order of the model. The formula for the AR(p) component is:

$$\mathrm{LR_t} = \mathrm{c} + \emptyset_1 \mathrm{LR_{t-1}} + \emptyset_2 \mathrm{LR_{t-2}} + \ldots + \emptyset_\mathrm{p} \mathrm{LR_{t-p}} + \varepsilon_\mathrm{t} \quad (3)$$

In this formula, LR_t represents the value of the time series variable at time t, c is a constant, εt is the error term at time t, and $\emptyset_1 \ldots, \emptyset_p$ are the coefficients of the AR component. The value of p determines the number of lagged observations that are included in the model.

The relationship between an observation and a predetermined amount of lag forecast mistakes is modeled by the moving average component (MA). This part is referred to as MA(q), where is the model's order. The MA(q) component's formula is:

$$LR_t = c + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_q \varepsilon_{t-q} \quad (4)$$

In this formula, ε_t represents the error term at time t, and the coefficients of the moving average (MA) component are represented by $\theta_1 \ldots, \theta_q$, and the value of q determines the number of past forecast errors that are included in the model.

3. Empirical Results and Analysis

The ACF and PACF plots are valuable tools in comprehending the structure and dynamics of time series data, encompassing trends, seasonality, and the distribution of the moving average and autoregressive components. Examining these charts can assist in identifying an appropriate model for forecasting future values of the time series.

In this section of the article, it is first necessary to order the first log-return series using the PACF and ACF pairs, the results of which are shown below.

Regarding the logarithmic order of Tesla stocks, the PACF and ACF help to derive the lag order of AR (p) and MA (q). In Figure 1, combined with Tesla's IPO date of June 2010 [14], it is more appropriate to choose the first part beyond the critical value as

PACF ACF

Tesla stock price

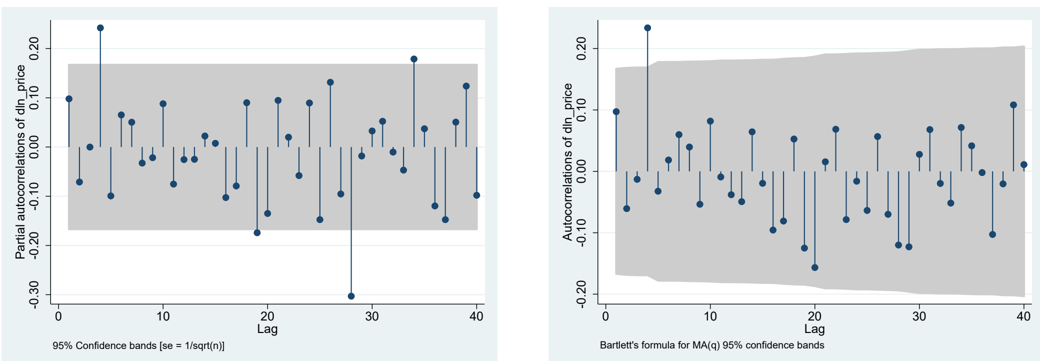

Figure 1: PACF and ACF of Stock price. (Photo credit: Original)

The AR(p) and MA(q) models have fixed orders that can be determined by examining the first portion of the ACF and PACF plots. As shown in Figure 1, both plots exceed the critical value at lag 4, indicating that the values of p and q are both 4 and that the orders of the AR(p) and MA(q) models are also 4. Consequently, it can be inferred that the initial four forecasts are increasingly accurate. With each succeeding cycle, the precision of the model's prediction experiences a gradual diminution. Therefore, the deployment of an ARMA(4,4) model would inevitably result in a decreasing level of

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accuracy in prognosticating the number of forthcoming time intervals that exceed four. This phenomenon is consistent with the predictive attributes of the ARIMA model.

PACF ACF

Tesla sales

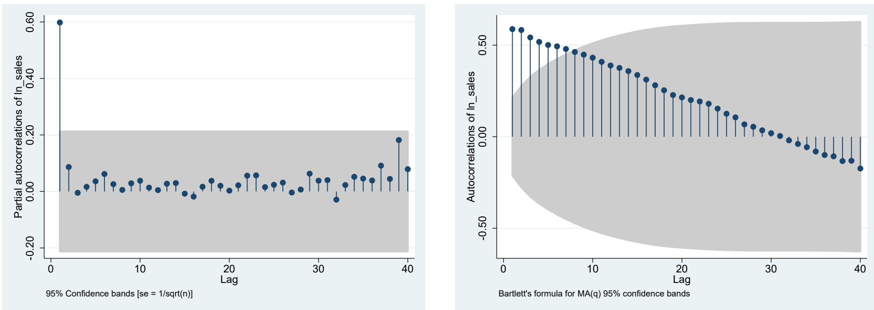

Figure 2: PACF and ACF of Tesla Sales. (Photo credit: Original)

The analysis depicted in Figure 2 adheres to the utilizing monthly sales data of Tesla vehicles starting in 2021 [15]. According to the findings, the initial portion of the autocorrelation function (ACF) and partial autocorrelation function (PACF) beyond the critical value, which both have a value of 7 (as shown in Figure 2), suggests that the fixed orders for the autoregressive AR(p) and moving average (MA(q)) models should be 7, with the values of p and q being identical. This indicates that the forecast accuracy for the first seven periods is progressively improving, followed by a reduction in accuracy, which is consistent with the predictive nature of the ARIMA model.

Notes: The dependent variable, PACF, and ACF of the logarithmic return on the two semiconductor stocks are plotted on the Y-axis, while the time lag order is plotted on the X-axis. The 95% confidence interval for AR(p) and MA is the region between $y = -0.1$ and $y = 0.1$.

3.1. Residual Test

Following the residual test, it was found that the P-values of both the stock price model and the sales model was high, thereby accepting the null hypothesis. This indicates that both sequences adhere to the false column of white noise. Consequently, both models are deemed highly suitable for future predictions.

Table 2: Residual test.

Model	Portmanteau (Q) statistic	Prob > chi2
Stock price	29.8239	0.8801
Sales	30.1808	0.8701

3.2. Empirical Results

The objective of the current study is to assess the influence of the Russia-Ukraine Conflict on Tesla's stock price and vehicle sales, identifying whether the effect is good or negative using quantitative methodologies. Specifically, the research question is addressed from two perspectives: (1) the difference between the control group and the actual group of Tesla's stock price and the comparison of the stock rise and fall before and after the war, and (2) the difference between the control group and the actual group of Tesla's car sales and the comparison of sales before and after the war. In order to understand how sensitive the company is to geopolitical risks and to guide future strategic decisions, this study will examine how the Russia-Ukraine War has affected Tesla's business.

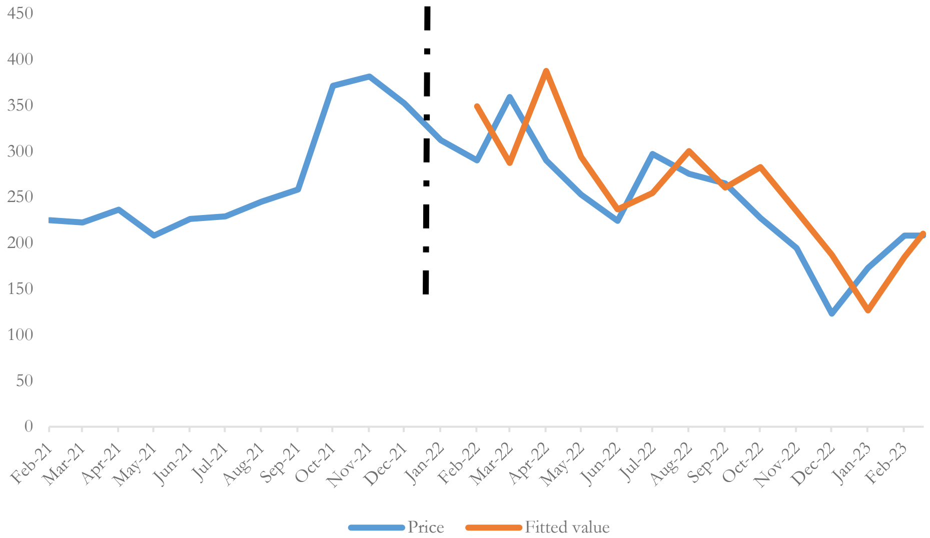

Figure 3: Changes in TSLA. Inc stock price. (Photo credit: Original)

In this research, the Autoregressive Integrated Moving Average (ARIMA) model is utilized to examine how the conflict between Russia and Ukraine has affected Tesla's sales and stock price, as demonstrated in Figure 3. The investigation begins by analyzing the historical data of Tesla's stock price to identify typical variations and detect any exceptional instances linked to the war. Afterward, two sets of data are generated, namely, the forecast and actual test, for comparison.

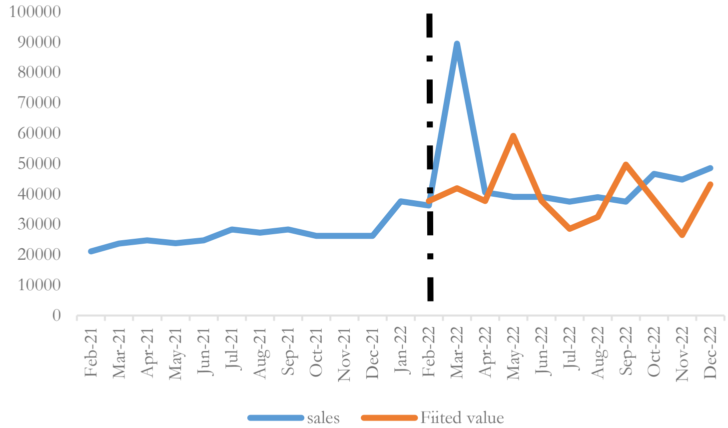

Figure 4: Changes in Tesla monthly sales. (Photo credit: Original)

The results reveal that in the four months preceding the war, Tesla's stock price was significantly affected, decreasing by an average of $-31 per share. However, in the second month of the conflict, the stock price experienced a robust resurgence as investors realized their overreaction. Figure 4 of the study discloses that the global supply chain disruption caused by the war, coupled with constraints on Russia's energy exports, triggered a rapid escalation in global oil prices, consequently increasing the cost of oil vehicles. As a result, Tesla's sales recorded a significant boost. The forecast for the

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upcoming seven periods indicates a mean monthly sales growth rate of 16.5%, which is a remarkably high value.

The present study's outcomes demonstrate that the ARIMA model can effectively predict Tesla's stock price and car sales during the 2021-2022 Russia-Ukraine War. The findings reveal that Tesla's car sales and stock prices were adversely impacted during the conflict. However, this impact was transient, and soon after the war, Tesla's sales and stock price showed a prompt recovery.

4. Discussion

The ongoing conflict between Russia and Ukraine has resulted in a surge in global oil prices, consequently leading to an increase in the cost of gasoline-powered vehicles. As a result, this situation has presented an opening for electric vehicle manufacturers such as Tesla to meet the escalating demand for their products.

Tesla's success in this area is due to its commitment to innovation and sustainability, providing consumers with an alternative to gasoline-powered vehicles. As a result, Tesla's stock price has risen significantly in recent months, reflecting the growing demand for its products. Furthermore, the company has reported strong sales figures, with many consumers opting to purchase Tesla vehicles as a way to reduce their dependence on gasoline.

However, It's crucial to keep in mind, though, that the rise in interest in electric cars also reflects the need for sustainable transportation alternatives and the rising concern over environmental effects.

The rise in demand for Tesla's products due to the increase in gasoline prices is a positive sign for both the company and the wider electric vehicle industry. It highlights the potential for electric vehicles to disrupt the traditional automobile market and reduce our reliance on fossil fuels.

5. Conclusion

The ARIMA model is a commonly used statistical tool for time series analysis that can help identify trends, seasonal patterns, and other characteristics of a dataset. In this study, the ARIMA model is utilized to analyze Tesla's historical stock price data and identify any deviations from normal patterns that may be attributed to the Russia-Ukraine War. The model can also help predict future trends and patterns in the data. By using the ARIMA model, the study aims to provide insights into the short-term effects of the conflict on Tesla's stock price and revenue. The data is then used to develop a model that forecasts Tesla's stock price and another model that forecasts its sales using the ARIMA model. The accuracy of the model is validated by comparing expected and actual stock prices. The study has revealed that the Russia-Ukraine Conflict had a significant short-term effect on Tesla's stock price. Additionally, a counterfactual framework was used to compare the control set and the actual set, highlighting the disparity between predicted outcomes and real-world results. In the first four months before the war officially broke out, Tesla's stock price was greatly affected, declining by an average of $-31 per share. However, in the second month of the war, Tesla's stock price rebounded strongly as investors realized their overreaction. According to the study, the war's disruption of the world's supply chain and restrictions on Russia's energy exports prompted global oil prices to rise quickly and the price of oil-powered vehicles to climb, which led to a sharp jump in Tesla's sales. A very high number of 16.5% for the average monthly sales growth rate is predicted for the following seven periods, which is a very long period.

In conclusion, this study emphasizes the significance of using the ARIMA model to evaluate the impact of the Russia-Ukraine Conflict on Tesla's sales volume and stock price. The analysis conducted through this model provides valuable insights into the economic and environmental effects of the conflict on the global energy landscape, as well as the role of Tesla in promoting sustainable energy solutions and electric vehicles. The findings of this study underscore the importance of understanding the impact of geopolitical events on the stock market and the need for further research in this area. The results of this study can help reduce global warming and support further investments in electric vehicles and sustainable transportation options. Additionally, this research provides insights into the future development trend of automobiles and proves Tesla's crucial role in the global energy landscape. Finally, this study confirms investors' highly optimistic quantitative analysis of Tesla.

Moving forward, continued investment in sustainable transportation solutions will be critical to addressing the environmental challenges we face. Tesla, with its focus on innovation and sustainability, is well-positioned to continue to grow and innovate in this space.

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