The Impact of Geopolitical Risks on Price Volatility of New Energy in China

Lingyin Zhou*, Liping Liu
School of Mathematics and Statistics, Guizhou University of Finance and Economics, Guiyang 550025, China.

Abstract: In recent years, the rise in geopolitical risks has led to significant changes, and the volatility of energy prices has also increased, resulting in numerous challenges for people's daily lives. This paper selects three indicators, GPR, GPA, and GPT, to measure geopolitical risk and uses the GARCH-MIDAS model based on mixed-frequency data to explore the impact of geopolitical uncertainty on the Chinese new energy market. The study shows that geopolitical risk has a positive and significant impact on solar and nuclear energy, while for wind energy, the influence of GPR and GPA on its long-term volatility is not significant, but GPT has a significant impact on the volatility of wind energy. Moreover, the impact of GPT and GPA on the price volatility of new energy is asymmetric, indicating that geopolitical uncertainty is complex and requires further exploration.
Keywords: Geopolitical Risk; GARCH-MIDAS; New Energy

1. Introduction

With the arrival of the new century, geopolitical risks have gradually increased, and geopolitical risk has caused many fluctuations in energy uncertainty, exacerbating the turbulence of the energy market. In recent years, geopolitical uncertainty has been recognized as an important factor affecting economic conditions and asset prices. Geopolitical uncertainty is an important factor affecting the evolution of the international new energy market and trade patterns, and is also one of the reasons for the adjustment of energy policies in various countries around the world.

From domestic research, it can be seen that the long-term and short-term problems of new energy development are interrelated and affected by domestic and international factors. Resource and environmental constraints are further intensifying, and the situation of energy conservation and emission reduction is severe. The degree of external dependence on energy resources is increasing rapidly, and new challenges are arising in the energy sector. Therefore, many scholars at home and abroad have begun to study the impact of geopolitical uncertainty on energy volatility. For example, Lin Boqiang and Li Jianglong established the crude oil price volatility model SWARCH in 2012 and found that sudden political events are the main cause of significant fluctuations in the international crude oil market[1]. Caldara and Iacoviello found in their 2018 study that geopolitical actions have a positive effect on crude oil price volatility, but the impact of geopolitical threats is not significant. Inspired by these studies, more and more scholars are getting involved in related research[2]. For example, Alqahtani and Taillard found in their 2019 study that geopolitical risk does not have a significant impact on crude oil returns[3]. However, in 2020, Cunado et al. used the TVP-SVAR model and found that GPR has a significant inverse effect on crude oil returns[4].

However, traditional same-frequency volatility models, based on the same volatility frequency and limited variable selection, may reduce model accuracy, leading to the loss of valid information in high-frequency oil price data and affecting empirical results. To overcome this limitation and improve estimation accuracy, researchers have used mixed-frequency volatility models. For example, in 2021, Li et al. studied the relationship between geopolitical risk and oil price volatility using a single-factor and two-factor mixed-frequency GARCH-MIDAS model, and found a significant positive effect of geopolitical risk on oil prices[5]. In 2020, Mei et al. used the mixed-data sampling (MIDAS) method proposed by Ghysels et al. in 2005, and found that geopolitical risk had a significant impact on oil price volatility, with GPR effectively predicting short-term oil price fluctuations and GPA effectively predicting long-term oil price fluctuations[6]. Theoretical studies have distinguished energy price fluctuations into long-term and short-term components. Since the outbreak of COVID-19 in 2019, global turmoil has led to significant changes in energy price fluctuations in response to rising geopolitical risk. Building on the foundation laid by domestic and international scholars, we investigate the impact of geopolitical uncertainty on the volatility of three representative new energy commodities - solar energy, nuclear energy, and wind energy.

This article analyzes the impact of geopolitical risk on solar energy, nuclear energy, and wind energy in new energy based on the GARCH-MIDAS model. This study is mainly divided into the following parts: the second part mainly introduces the GARCH-MIDAS model based on mixed-frequency data, the third part introduces the data sources and empirical research, and the final part is the conclusion of this study.

2. GARCH-MIDAS Model

In this paper, the geopolitical risk index is a monthly data, and the price returns of new energy are daily data. If the traditional GARCH model is used to model and analyze, it may lose the effective information in the new energy price returns, resulting in parameter estimation errors and volatility forecasting biases. Therefore, this paper uses the GARCH-MIDAS model applicable to mixed-frequency data research, which incorporates data of different frequencies into the model. The GARCH-MIDAS model is set as follows:

$$r_{i,t}=\mu+\tau_t\delta_{i,t}\varepsilon_{i,t},\ \forall i=1,2,\cdots,N_t \qquad (1)$$

Among them, $r_{i,t}$ represents the logarithmic rate of return of the new energy price on the i-th day of the t-th month; μ is the parameter to be estimated; τ_t is the long-term low-frequency component of the volatility; $\delta_{i,t}$ is the high-frequency component of the volatility in the short to medium term; $\varepsilon_{i,t}$ is the random disturbance term. The long-term low-frequency volatility and the short-term high-frequency volatility follow a GARCH(1,1) process:

$$\sigma_{i,t}^2=\tau_t g_{i,t}, \qquad (2)$$

$$\delta_{i,t}=(1-\alpha-\beta)+\alpha\frac{(r_{i-1,t}-\mu)^2}{\tau_t}+\beta\delta_{i-1,t}, \qquad (3)$$

Here, $\sigma_{i,t}^2$ represents volatility, $\alpha+\beta<1$, $\alpha>0$, β is a non-negative number, referring to the MIDAS regression method proposed by Ghysels (2005) and based on the realized volatility $RV_t=\sum_{i=1}^{N_t}r_{i,t}^2$ the long-term component τ_t is characterized as follows:

$$\log\tau_t=m+\theta\sum_{k=1}^{K}\varphi_K(\omega_1,\omega_2)RV_{t-K}, \qquad (4)$$

Among them, K represents the maximum lag order of realized volatility and $\varphi_K(\omega_1,\omega_2)$ represents the weight, i.e:

$$\varphi_K(\omega_1,\omega_2)=\frac{(k/K_r)^{\omega_1-1}(1-k/K_r)^{\omega_2-1}}{\sum_{j=1}^{K_r}(j/K_r)^{\omega_1-1}(1-j/K_r)^{\omega_2-1}}, \qquad (5)$$

To examine the impact of geopolitical risk on the volatility of new energy prices, this paper intends to replace realized volatility (RV) with a geopolitical risk index, and directly incorporate it into the GARCH-MIDAS model:

$$\log\tau_t=m+\theta\sum_{k=1}^{K}\varphi_K(\omega_1,\omega_2)X_{t-K}, \qquad (6)$$

Here, X_{t-K} represents a certain geopolitical risk index (total index, threat sub-index, action sub-index) lagged by k periods relative to the current period (t period), and based on this, a GARCH-MIDAS model incorporating the geopolitical risk index is constructed.

3. Empirical Analysis

3.1 Data Selection and Source

This paper selects the monthly geopolitical risk index from January 1985 to July 2022 as the low-frequency data for measuring geopolitical uncertainty, which is obtained from the website: https://www. matteoiacoviello.com/gprhtm.[1] The daily returns data of solar energy, nuclear energy, and wind energy in the new energy sector are obtained from Tong Hua Shun, ranging from January 1, 2001 to November 25, 2022.

3.2 Geopolitical Uncertainty

This paper uses the monthly Geopolitical Risk (GPR) index proposed by Caldara and Iacoviello (2018) to investigate its impact on the volatility of energy commodities. The index is constructed based on a narrow interpretation of the intensifying geopolitical tensions, such as geopolitical, war, military, and terrorism. The GPR index represents geopolitical risk by the frequency of relevant vocabulary in 11 major international newspapers. In addition, Caldara and Iacoviello (2018) divide the index into two sub-indices, GPA and GPT. Figure 1 shows the changes in the GRP index. The characteristic of the index is that it has several peaks that correspond to key geopolitical events. We found that the highest peak occurred during the invasion of Iraq in 2003. Since then, the increase in the index is related to major terrorist events that occurred in Europe, such as the Madrid bombings in March 2004 and the Paris terrorist attacks in November 2015. The index also increased during the period of Russia's annexation of Crimea and the escalation of ISIS military operations in Iraq and Syria in 2014, and since the outbreak of the COVID-19 pandemic in December 2019. We also analyzed the dynamic changes of the GPT and GPA sub-indices. From Figure 2, we found that GPT and GPA are closely related and have some independent fluctuations. Typically, GPT rises several months before major adverse events occur and remains high until the events happen.

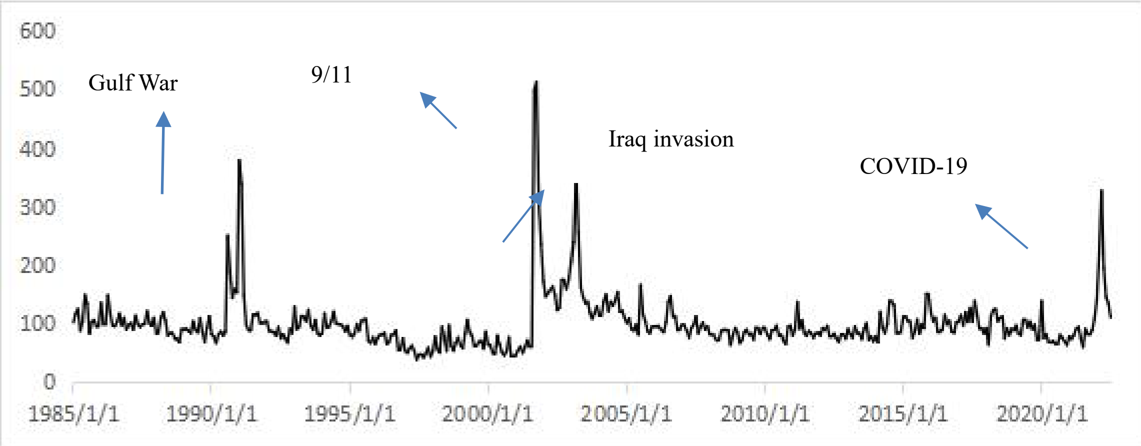

Fig.1. The Historical Evolution of the GPR Index

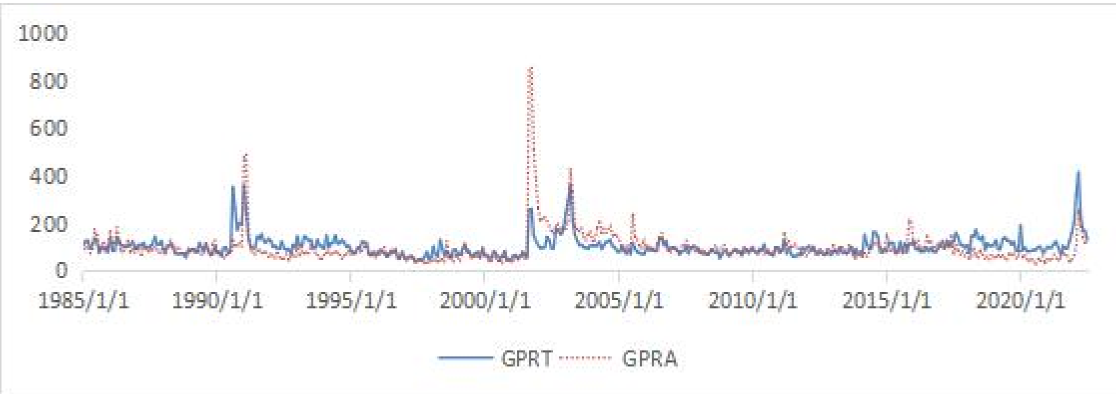

Fig.2. The Historical Evolution of GPT and GPA

3.3 Empirical Results Analysis

The GARCH-MIDAS model was employed by incorporating high-frequency daily returns of new energy and low-frequency geopolitical uncertainty variables. The results are shown in Table 1.

Table 1 Estimation Results of the Model

	Solar Energy			Wind Energy			Nuclear energy		
	GPR	GPT	GPA	GPR	GPT	GPA	GPR	GPT	GPA
α	0.1227 (0.0184**)	0.124 (0.0253**)	0.1218 (0.0353**)	0.2927 (0.328**)	0.0629 (0.0449**)	0.3416 (0.1094**)	0.0992 (0.0247**)	0.0977 (0.0296**)	0.112 (0.0207**)
β	0.7992	0.8072	0.8176	0.6505	0.9361	0.5844	0.8529	0.8553	0.8367

	(0.000***)	(0.000***)	(0.000***)	(0.0527*)	(0.000***)	(0.0143**)	(0.000***)	(0.000***)	(0.000***)
m	-7.1536 (0.000***)	-7.1155 (0.000***)	-7.0909 (0.000***)	-6.6816 (0.000***)	-9.1472 (0.000***)	-6.658 (0.000***)	-7.34 (0.000***)	-7.3446 (0.000***)	-7.3003 (0.000***)
θGPR	0.0444 (0.0062***)			-0.001 (0.9857)			0.0174 (0.0252**)		
θGPT		0.0053 (0.5737)			0.0176 (0.026***)			0.0134 (0.0265**)	
θGPA			-0.0054 (-0.8782)			0.055 (0.2054)			0.0142 (0.0222**)
ωGPR	1.001 (0.0043***)			2.6774 (0.004***)			6.9625 (0.000***)		
ωGPT		4.589 (0.2108)			1.0751 (0.0519*)			6.2218 (0.000***)	
ωGPA			2.1157 (0.000***)			1.0076 (0.009***)			9.7243 (0.000***)

Note: Robust standard errors are shown in parentheses; *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively;

Table 1 shows that geopolitical risk has a significant positive impact on price volatility of solar and nuclear energy. Based on the sign of coefficient θ, the estimated values are positive and significant for both solar and nuclear energy, indicating that an increase in geopolitical risk intensifies price volatility of these two types of energy. Although geopolitical risk has no significant impact on price volatility of wind energy, coefficient θ is significant for wind energy, suggesting that an increase in geopolitical risk still amplifies price volatility of wind energy. Additionally, we find that GPA and GPT indices have asymmetric impacts on long-term energy volatility. Specifically, in the study of the impact of geopolitical risk on price volatility of wind energy, GPT has no significant effect, while GPA has a significant positive effect on price volatility of wind energy. However, for solar energy, θ is significant, indicating that an increase in the GPR index has a significant impact on solar energy price fluctuations, while θ based on the GPT and GPA models are not significant, indicating that specific geopolitical risk factors causing solar energy price fluctuations require further research. For wind energy, θ is not significant, which may be due to the relatively large and complex risk factors included in the overall index, which interferes with the regression results, and requires further precise identification of the influencing factors on new energy price fluctuations. When using sub-indices to measure geopolitical risks separately in order to isolate the specific risks causing new energy price fluctuations, it is found that based on the θGPT, θGPA is not significant, indicating that wind energy price fluctuations are caused by adverse geopolitical threats rather than geopolitical practices. The above conclusions demonstrate the necessity of paying attention to geopolitical risks, and compared with geopolitical events, geopolitical threats can more accurately identify the impact of risk.

4. Conclusion

In this paper, we developed a GARCH-MIDAS model to analyze the impact of geopolitical uncertainty on the volatility of energy commodities such as solar energy, wind energy, and nuclear energy, and attempted to capture the explanatory power of geopolitical uncertainty. We found that GPR has a significant positive impact on the long-term volatility of solar and nuclear energy. As geopolitical uncertainty increases, the volatility of solar and nuclear energy also changes. However, for wind energy, the effect of θ is not significant, while in the GPT model, θ is significant, indicating the complexity of geopolitical risk. In addition, we also explored the performance of the two components of GPR, and the results showed that the impact of GPT and GPA on new energy is asymmetric.

4.1 Policy Recommendations

Based on theoretical research and empirical testing results, the following policy recommendations are now proposed to promote the normal operation of the new energy market trading mechanism in China and further reduce the price fluctuations of solar energy, wind energy, and nuclear energy.

4.2 Strengthening the Policy Guiding Function

Firstly, relevant government departments should strongly support investment in and use of new energy, and stabilize the situation to avoid the rise of geopolitical risks, thereby preventing sharp fluctuations in new energy prices and maintaining their long-term stability. National managers should actively expand the supply channels of new energy, strengthen transportation safety management, maintain transmission safety, ensure the adequacy and timeliness of new energy supply, to avoid situations where rareness results in high prices, thereby controlling price increases. In addition, a risk warning mechanism for the price fluctuations of new energy could be established to objectively judge the new situation of geopolitical uncertainty in China and establish an energy security protection system.

4.3 Rational Judgment by Investors in the Financial Market

In the financial investment market, investors should focus on the differences in the sensitivity of different types of new energy to geopolitical risks. Investors trading wind energy pay more attention to geopolitical threats, while investors trading nuclear energy need to simultaneously consider both geopolitical threats and the realization of geopolitical events. Risk managers should focus on the specific impact of geopolitical risks on new energy price fluctuations, so as to effectively respond to new energy price fluctuations caused by increased geopolitical risks.

References

[1] Lin BQ, Li JL. Volatility of Crude Oil Prices and Domestic and International Contagion Effects. [J] Financial Research, 2012(11):1-15.

[2] Caldara D, Iacoviello M. Measuring Geopolitical Risk[R]. FRBInternational Finance Discussion Paper, No.12222, 2018.

[3] Alqahtani A, Taillard M. Global Energy and Geopolitical Risk:Behavior of Oil Markets [U]. International Journal o f Energy Sector Management, 2019, 14(2): 358-371.

[4] Cunado Juncal, Gupta Rangan, Lau Chi Keung Marco, Sheng Xin. Time-Varying Impact of Geopolitical Risks on Oil Prices[J]. Defence and Peace Economics, 2019.

[5] Li Z, Shi Q, Bu L. Is Geopolitical Risk a Factor Affecting International Crude Oil Price Volatility? An Analysis Based on the GARCH-MIDAS Model. [J] World Economic Research, 2021, (11): 18-32+135.

[6] Mei D, Ma F, Liao Y, Wang L. Geopolitical Risk Uncertainty and Oil Future Volatility: Evidence from Midas Models[J]. Energy Economics, 2020, 86: Article 104624.

Introduction to the first author(Corresponding author):Zhou Lingyin (1998-12—), female, Han nationality, Nayong, Guizhou, bachelor degree, postgraduate student, School of Statistics, Guizhou University of Finance and Economics, research direction: Financial statistics and Risk Management.

Introduction to the second author:Liu Liping (1984-11—), female, Han nationality, born in Shandong Province, Doctor's degree, professor and master's supervisor of Guizhou University of Finance and Economics, research direction: Quantitative analysis of Finance.