TURBULENT GLOBAL LANDSCAPE: AN ANALYSIS OF CHINA'S RARE EARTH EXPORTS

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Abstract: *As a key resource for promoting industrial development, climate governance and energy transition, rare earth (RE) has become a new focal point in geopolitical games. This paper incorporates geopolitical risk (GPR) and China's rare earth export (REE) amount into a unified framework and utilizes the rolling-window Granger causality test to investigate their dynamic relationships. The findings demonstrate that GPR transmits positive shocks to REE. This favorable impact implies that geopolitical events can increase countries' concerns about RE supply disruptions and expand their strategic reserves. Then, the rise in demand has played a crucial role in promoting REE. This outcome highlights the importance of GPR in enhancing sustainable REE during turbulent eras. In contrast, REE exhibits a negative impact on GPR. The main reason is that the rise in RE supply alleviates military wars and the tense geopolitical situations caused by resource competition, contributing to the stability of the global geopolitical environment. In the context of worldwide geopolitical turmoil, these findings provide valuable guidance for policymakers and investors to maintain the stability of REE and apply effective risk management methods in responding to GPR impacts.*

Key words: *Rare earth elements; Rare earth exports; Geopolitical risk; Time-varying; Granger causal relation*

JEL: Q21; Q58

Introduction

This article probes China's rare earth export (REE) amount during periods of volatile geopolitical risk (GPR) and further examines whether sustainable REE can be seen as a pivotal strategy for mitigate turbulence. As essential industrial vitamins and strategic resources of the 21st century, the wide application of rare earth elements (RE) holds notable economic and environmental value (Zhang et al., 2022; Liu et al., 2025). On one hand, RE holds a key position in traditional industries (e.g., glass and metallurgy) as well as high-tech industries (e.g., military, defense and medical sectors) (Xu et al., 2024; Zhang et al., 2024a). On the other hand, RE is an indispensable element in clean energy fields, such as new energy vehicles, solar panels and wind power, providing momentum for accelerating the global low-carbon transition (Gao et al., 2024; Liu et al., 2025). In recent years, geopolitical events such as Brexit, the Sino-U.S. trade friction and the Russia-Ukraine conflict have accelerated the fragmentation of the geo-economy and increased the vulnerability of the global RE supply chain. Specifically, geopolitical games and military conflicts can destroy the RE production facilities of supplying countries, block transportation channels and impact the sustainability REE through higher tariffs and shipping costs (Zhou et al., 2022; Zhang et al., 2024b). In addition, the high unpredictability of GPR amplifies investors' concerns about the RE market and prompts them to adopt conservative strategies of delaying investment (Liu et al., 2025), further hinders the rise in REE.

Some studies have investigated the factors influencing the RE market, including economic policy uncertainty (Li et al., 2023), climate policy uncertainty (Wang et al., 2025), renewable energy consumption (Ding et al., 2024; Zhang and Jiang, 2025) and oil price uncertainty (Li et al., 2026). However, the impact of GPR shocks on REE has received little attention. Against the background of the constantly changing global geopolitical landscape, exploring the bidirectional relationship between the two variables can help determine whether GPR is a driving or limiting factor for REE and provide valuable insights for the Chinese government in formulating RE supply policies.

In the global RE industry landscape, China possesses the largest reserves and the most complete industrial chain system (Guo and Liu, 2025; Li et al., 2026). With lenient environmental policies and massive investments, China has controlled 90% of the world's RE refining capacity (Ambrose, 2025). This processing bottleneck strengthens other countries' dependence on RE imports (Fan et al., 2023; Kang et al., 2025) and creates conditions for China to use RE as a tool of geopolitical coercion (Woods, 2025). For example, the outbreak of the 2010 Diaoyu Islands dispute leads China to stop exporting RE to Japan. This diplomatic crisis triggered by a maritime dispute increases global concerns about China's monopoly on RE and exacerbates the rise of GPR (Depraiter and Goutte, 2025). In 2025, China has implemented export control measures on heavy RE as a retaliation against the high tariffs imposed by the U.S. (Li et al., 2026). This move sparks investors' concerns about disruptions in RE trade and leads to significant volatility in the U.S. stock market. Therefore, China can use RE as a political weapon to ease conflicts with other countries. However, China's RE industry faces the dual challenges of sustainable development and supply stability (Diao et al., 2024). On the one hand, incomplete industrial policies and regulatory measures have resulted in a large amount of illegal RE mining activity. Unregulated extraction and processing activities have caused severe environmental damage, including water, soil and air pollution, posing additional risks to biodiversity and human health (Diao et al., 2024). On the other hand, as the largest developing country in the world, China's RE market is highly susceptible to profound impacts from global changes (Li et al., 2025). With the continuous escalation of the limited supply dilemma, geopolitical conflicts and trade protectionism can disrupt RE supply and further complicate China's RE market (Han et al., 2025). Given China's dominant position in the global RE market, examining their correlation can deepen our understanding of GPR's role in shaping the RE market and provide valuable insights for Chinese policymakers to maintain the stability of REE.

The marginal contributions of this paper can be summarized in three points. First, with the global transition to clean energy and advanced technologies, the importance of RE has become increasingly prominent (Han et al., 2025). In this context, ensuring a sufficient and stable supply of RE has become an important issue. China is a leader in the global RE production and processing sector, and its stable exports play a crucial role in maintaining supply chain security (Li et al., 2026). This paper places GPR and REE within the same analytical framework, which is significant for understanding the factors affecting the stability of RE supply and formulating effective export policies. Second, extant research predominantly delves into the unidirectional impact of GPR on RE prices (Fan et al., 2023; Li et al., 2023) or export amounts (Chen et al., 2025; Islam, 2025). However, the role of REE in GPR has not yet been explored. Therefore, this paper comprehensively examines the bidirectional causal relationship between GPR and REE to fill this research gap. Third, panel regression method and traditional vector autoregression (VAR) model examine the relationship between GPR and REE from a static perspective and cannot assess their nonlinear and time-varying effects. In this paper, the application of the bootstrap rolling-window Granger causality test can capture structural changes and time-varying characteristics caused by external shocks, further addressing the limitations of traditional econometric methods. The findings demonstrate that there is a bidirectional causality between GPR and REE, which is evident across multiple sub-samples. Specifically, GPR exerts a beneficial effect on REE during 2020: M4-2022: M3 and 2022: M9-2024: M2. This reflects that the turmoil caused by GPR helps promote the sustainable REE and RE can serve as a hedge against

geopolitical uncertainties. The negative effect of REE on GPR during 2014: M4-2014: M7 and 2015: M3-2015: M11 indicates that a stable supply of RE has the potential to mitigate geopolitical tensions. In contrast, the decline of REE triggers market concerns about supply disruptions and expands their strategic reserves. Therefore, intensified competition for RE will lead to higher GPR. These conclusions can provide important insights for governments and investors in formulating effective policy measures and risk management strategies.

Basic content

The mechanisms linking GPR and REE are summarized in Figure 1.

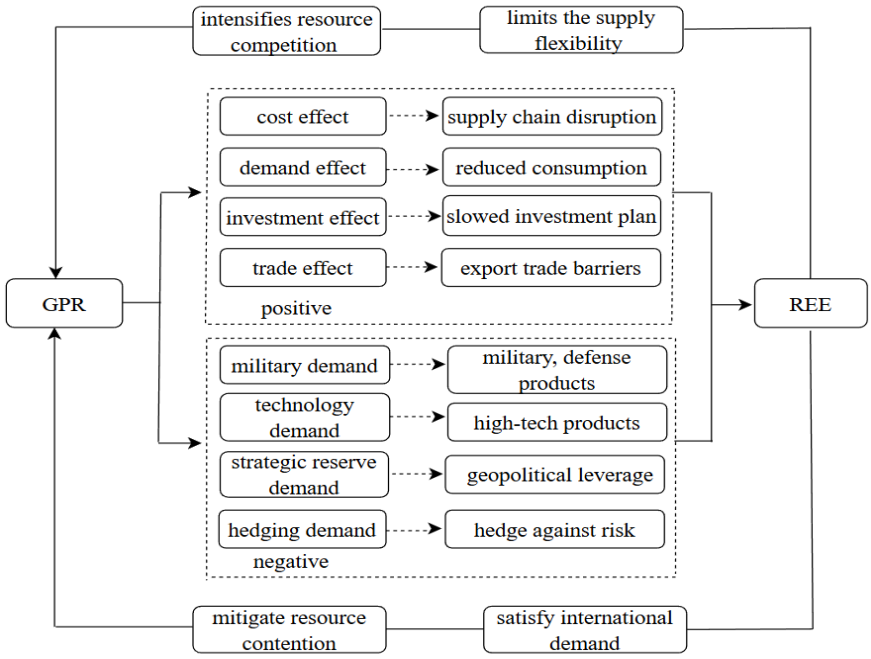


Figure 1. The transmission mechanisms of GPR and REE.
Source: Illustrated by the author

The adverse effects of GPR on REE can be summarized in four points. First, the cost effect. GPR increases transportation costs and transaction costs by disrupting shipping routes and logistics systems (Zhang et al., 2024a; Huang et al., 2025; Sanglier-Contreras et al., 2025). This makes it more difficult for exporting countries to deliver RE products and poses potential risks of supply chain disruption (Mariev and Blueschke, 2025). Second, the demand effect. The turmoil and uncertainty triggered by GPR weaken investor confidence and increase their risk aversion (Zhang et al., 2024b). Therefore, a substantial decrease in global consumption and demand negatively impacts REE. Third, the investment effect. Turbulent geopolitical situations can trigger risk-averse sentiments among companies and investors, leading them to delay or cancel RE-related production activities and investment plans (Zhao et al., 2025). Besides, the worsening of financing difficulties poses a serious threat to the normal production and stable supply of RE (Zhang and Jiang, 2025). Fourth, the trade effect. Rising GPR disrupts trade between supplying countries and importing countries, inhibiting the development of REE trade (Braunstein and Chuchko, 2025; Han et al., 2025). As a result, the strengthening of trade barriers poses a significant threat to REE.

The positive influence of GPR on REE can be attributed to four points. First, the military demand. The military and defense industries have substantial demand for RE during periods of military competition and geopolitical conflicts (Li et al., 2023; Wang et al., 2025), thereby creating favorable conditions for REE growth. Second, the high-tech products demand. The shift from traditional warfare to new forms such as technological embargoes and sanctions will drive the demand for RE in high-tech products (Zhang and Zhu, 2023; Wang et al., 2025). This is conducive to promoting the

sustainable development of the RE industry and growth in exports (Wang et al., 2025). Third, the strategic reserve demand. The high level of GPR can heighten concerns among countries that China may use RE as a geopolitical leverage (Depraiter and Goutte, 2025). This prompts countries to stockpile RE extensively and drives substantial growth in REE. Fourth, the hedging demand. Geopolitical events can undermine the purchasing power and safe-haven value of currencies. As a result, investors channel large amounts of capital into the RE market to hedge against GPR, which facilities the growth of REE (Li et al., 2023). This paradoxical phenomenon indicates that the relationship between GPR and REE is not constant but is influenced by multiple factors. Accordingly, we propose the following research hypothesis:

Hypothesis 1: GPR has an inhibitory effect on REE.

Hypothesis 2: GPR has a promoting effect on REE.

REE exerts a negative influence on GPR. This is because the complexity of RE mining, refining and processing means that only a few RE deposits are economically viable for extraction (Gao et al., 2024; Oka, 2025). Currently, global RE reserves are extremely unevenly distributed, with a few countries controlling a large number of primary deposits (Fan et al., 2023). This unequal distribution of resources enables supplying countries to dominate RE pricing and export amounts (Fan et al., 2023; Oka, 2025), and turns the competition for RE into a central battleground in global geopolitical games (Lin and Zhang, 2025; Mariev and Blueschke, 2025). Accordingly, stable REE supplies are conducive to satisfying the rapid growth of international demand and mitigating geopolitical competition caused by resource contention. However, the decline in REE limits the supply flexibility of importing countries and intensifies competition for RE among nations. This could give rise to new forms of geopolitical conflicts over access to essential RE reserves. Accordingly, this paper proposes the following hypothesis.

Hypothesis 3: REE has an inhibitory effect on GPR.

This analysis uses monthly time series data spanning from 2012: M1 to 2025: M8, so as to detect the complex connection between GPR and REE. The rare earth exports amount[2] is adopted to gauge REE trends in China (Li et al., 2026). GPR refers to the uncertainty and potential threats in international relations caused by factors such as military conflicts, resource competition and geographical locations (Huang et al., 2025; Mariev and Blueschke, 2025). With the increasing complexity of the global geopolitical situation, GPR has emerged as a determinant influencing the fluctuations of REE. In this paper, we adopt the Geopolitical Risk Index developed by Caldara and Iacoviello[3] (2022) as an evaluation indicator of the global geopolitical situation (Huang et al., 2025; Li et al., 2025; Lin and Zhang, 2025). In addition, this paper incorporates CPU and OP as control variables in the empirical analysis. The reason is that the adjustments in climate policy can have a profound impact on the extraction and refining processes of RE, thereby triggering changes in supply quantities. Moreover, the rise in OP drives up demand for clean energy and amplifies the demand for RE, thereby affecting the fluctuations of REE (Li et al., 2025). To this end, we use the Climate Policy Uncertainty Index[4] developed by Gavriilidis (2021) to capture global climate policy trends (Wang et al., 2025). Besides, this paper uses West Texas Intermediate (WTI)[5] as a proxy for global OP fluctuations (Liu et al., 2023). Figure 2 illustrates the trends of GPR and REE.

The bootstrap p-values of GPR on REE are shown in Figure 2. The p-values less than 0.1 indicate that the causal relationship of GPR on REE is significant during this period. The p-values greater than 0.1 imply that GPR does not affect REE. Clearly, GPR Granger causes REE at the 10% level during the periods 2020: M4-2022: M3 and 2022: M9-2024: M2, while no such causal impact is observed in other periods. Figure 3 reports the mean, maximum and minimum values of the impact coefficients

[2] These data are from Wind database.
[3] These data are obtained from the https://www.matteoiacoviello.com/gpr.htm.
[4] These data are from https://www.policyuncertainty.com/.
[5] The data is selected by https://cn.investing.com/currencies/wti-usd.

of GPR on REE. The mean curve lying above zero indicates a positive impact of GPR on REE, and vice versa. During 2020: M4-2022: M3 and 2022: M9-2024: M2, GPR exhibits a positive impact on REE.

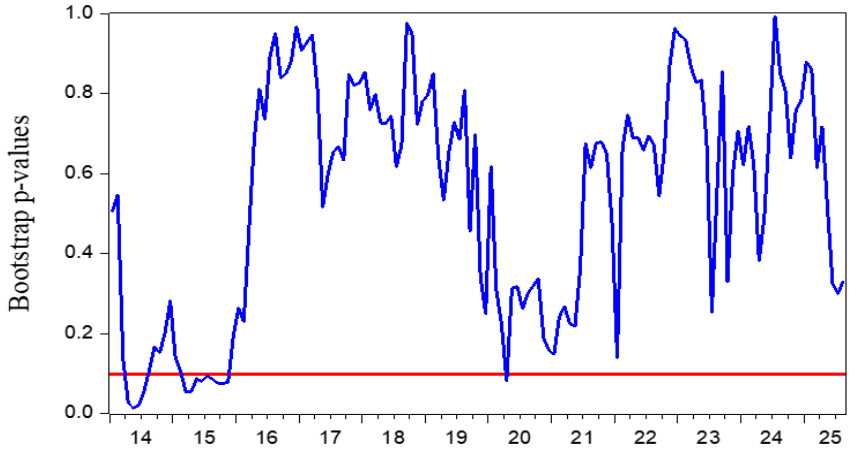


Figure 2. The p-values with no effect of GPR on REE.

Source: Generated using EViews software

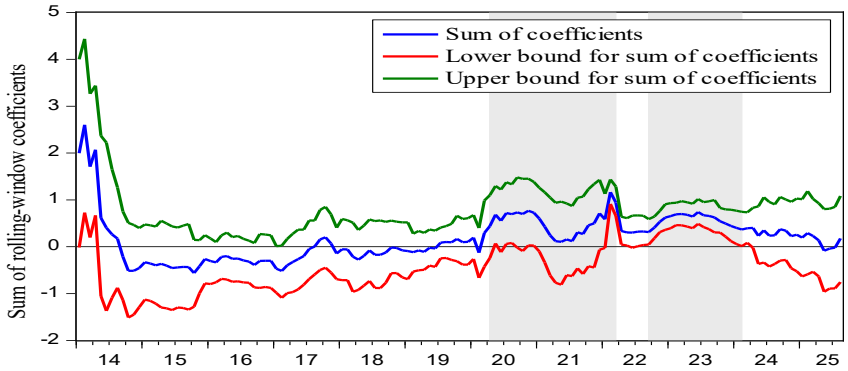


Figure 3. The influence coefficient of GPR on REE.

Source: Generated using EViews software

The positive impact of GPR on REE indicates that tense geopolitical situations enhance the strategic value of RE and promote sustainable growth in exports. The favorable connection between the two variables during 2020: M4-2022: M3 can be summarized in the following three aspects. First, since 2020, the Sino-U.S. trade war has entered a new phase of technological competition (Chang et al., 2025). The U.S. has placed multiple Chinese information and communication technology companies on the entity list and strengthened regulations on semiconductor exports, aiming to curb the development of China's semiconductor industry through the technological war. In response, China enacts the "Export Control Law of the People's Republic of China" in October 2020, aiming to strengthen control over REE as a form of retaliation. The introduction of this policy raises concerns among U.S. defense, new energy and other industries about the RE supply chain. The escalation of Sino-U.S. strategic competition leads GPR to remain at a high level (Wang et al., 2025). Subsequently, the spread of panic increases the global motivation to stockpile RE to prevent the negative effects of supply disruptions (Depraiter et al., 2025). Therefore, the surge in demand triggered by GPR becomes a significant driving force behind China's REE. Second, in March 2021, the leaders of the U.S., Japan, India and Australia have reached a strategic partnership, aiming to accelerate the development of RE refining technology and establishing self-sufficient mining and refining plans. Moreover, the U.S. attempts to accelerate the development of a new RE supply chain to reduce dependence on imports from China and counter its dominance in the global RE market. As geopolitical competition continues

to escalate, the strategic assets nature of RE has been unprecedentedly reinforced. With the global RE supply shortage intensifying, the further increase in demand amplifies the positive impact of GPR on REE. Third, thanks to its unique physical and chemical properties, RE is widely used in clean technologies such as solar panels, electric vehicles and energy storage systems (Ding et al., 2024; Vivoda et al., 2025). In the post-pandemic era, the transition to green and clean energy has created new investment opportunities for RE mining (Li et al., 2023; Wang et al., 2025). Therefore, the importance of RE as a key low-carbon transition asset has become increasingly prominent (Zhang et al., 2025; Zhang and Jiang, 2025). In this context, countries have expanded their procurement and reserves of RE to avoid supply disruptions caused by high GPR, leading to a rising trend in REE (Ye et al., 2023; Wang et al., 2025).

During the period of 2022: M9-2024: M2, the positive impact of GPR on REE can be explained by the following three points. First, the outbreak of the Russia-Ukraine conflict has intensified global tensions, weakened the stability of the international environment and pushed the GPR to a historic high of 318.95 in March 2022 (Liu et al., 2023). To maintain military capabilities and strengthen national security, countries invest heavily in defense spending to enhance their military capabilities (Li et al., 2023). As crucial raw materials for advanced defense technologies and military products, the increased stockpiling of RE drives sustainable growth in demand (Islam, 2025). Second, the ongoing escalation of the Russia-Ukraine crisis and long-term unrest in the Middle East have further complicated the geopolitical situation and triggered a dilemma of crude oil supply shortages. With the global economic recovery, industrial production and transportation development have increased the demand for crude oil (Huang et al., 2025). The intensifying supply-demand conflict has caused a significant rise in international OP, leading the WTI price to reach $95 per barrel on September 19, 2023. The rise in OP highlights the risk-hedging attribute of oil in turbulent environments, which motivates a large number of investors to pour funds into the crude oil futures market (Li et al., 2026). Due to the close cost correlation between extraction, refining, and processing of RE and oil, investors have also developed strong expectations for the rise in RE prices, which significantly boosts REE (Li et al., 2026). Third, the continuing intensification of the internal conflict in Myanmar causes a complete halt in local RE mining and forces closures along the China-Myanmar border. As Myanmar is a major global supplier of heavy RE concentrates, its production halt has led to a significant gap in the global supply of heavy RE. As a result, purchases of heavy RE concentrates from China by various governments have stimulated the growth of REE. Therefore, the above conclusions validate Hypothesis 2, which underscores that GPR can stimulate huge demand for RE from investors and increase strategic reserves, thereby exerting a positive impact on REE.

Figures 4 and 5 illustrate the bootstrap p-values and impact directions of REE on GPR, respectively. During the periods 2014: M4-2014: M7 and 2015: M3-2015: M11, there are causal relationships between REE and GPR at the 10% level. Two negative impacts of REE on GPR can be observed during these periods.

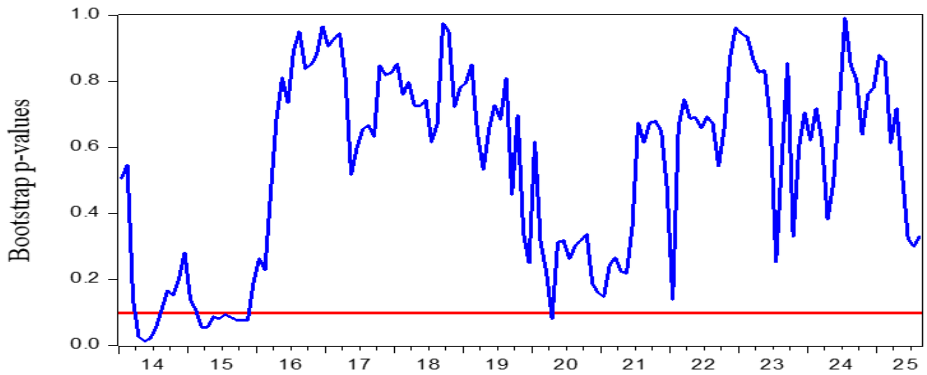
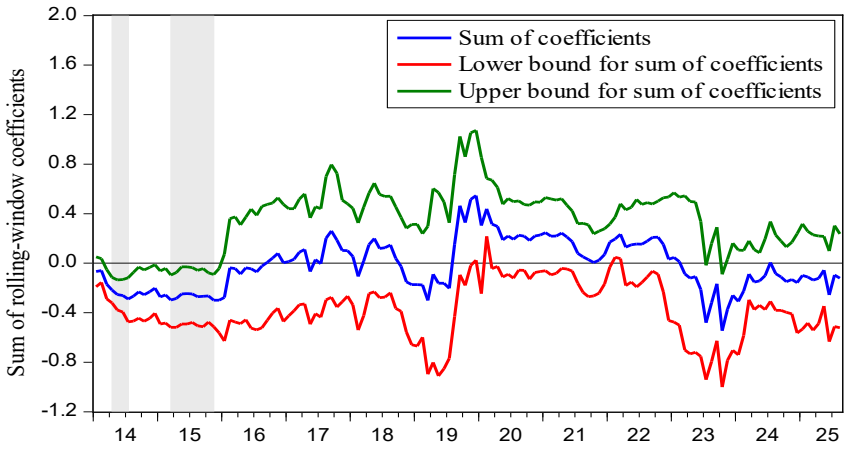


Figure 4. The p-values with no effect of REE on GPR.

Source: Generated using EViews software

Figure 5. The influence coefficient of REE on GPR.



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In the time frame 2014: M4-2014: M7, under the dual influences of rising environmental protection costs and WTO trade disputes, REE shows a significant downward trend. On February 13, 2014, China's Ministry of Industry and Information Technology issues the "Promotion Plan for Cleaner Production Technology in the Rare Earth Industry". The policy aims to decrease pollutant emissions by improving the level of cleaner production in the RE sector. The implementation of this policy increases production costs for enterprises and reduces their operational profits, posing a significant barrier to the growth of REE. On March 26, 2014, the WTO rules that China's restrictions on REE violates trade rules (Xu et al., 2024; Kang et al., 2025). In response, China appeals to the WTO regarding the RE trade dispute on April 17, 2014. During this period, the escalation of trade friction prompts China to increase its strategic reserves of RE and significantly decrease export quotas. This intensifies western governments' criticism of China using RE as a trade weapon and deepens mutual distrust. Besides, international disputes over RE increase concerns in various countries about China being the sole supplier. As a result, western countries led by the U.S. accelerate import diversification and promote supply chain security strategies in an attempt to lower the heavy dependence on China's imports. These moves heighten international competition for RE and threaten the security of China's political environment. Therefore, the reduction of REE boosts the growth of GPR, which confirms the negative impact between the two variables.

Switching to the sub-sample period 2015: M3-2015: M6, REE experiences a significant growth. On May 1, 2015, the newly implemented tax reform reduces the cost burden on RE enterprises and stimulates the expansion of production scale (Mancheri et al., 2019). Meanwhile, the cancellation of export quotas and tariffs results in increasing China's RE supply (Mancheri et al., 2019). As a result, the sharp drop in RE prices triggers a purchasing frenzy for RE in various countries (Zhang et al., 2025). In addition, the surge in REE significantly hampers global GPR. First, the end of the RE trade dispute demonstrates China's good image of adhering to WTO rules, creating favorable conditions for easing tensions with the U.S., Japan and the European Union and improving multilateral trade relations. Second, the growth of REE has effectively reduced the risk of production halts caused by severe dependence on RE in sectors such as defense, new energy vehicles and high-tech industries due to supply disruptions, laying a foundation for ensuring corporate production. Moreover, a stable RE supply contributes to alleviating global concerns over supply interruptions and reducing geopolitical maneuvers triggered by resource competition. Third, the expansion of REE has led to a sharp drop in global prices, delaying the process of Western countries establishing a supply chain independent of China's RE. This forces them to rely more on China in the global RE supply chain and maintain cooperative trade relations, thereby reducing GPR triggered by direct confrontation.

Therefore, the above analysis confirms Hypothesis 3, which highlights that the growth of REE can foster a more peaceful international political environment.

To verify the robustness of the empirical results, this paper adopts an alternative proxy variable to replace GPR for robustness testing. Specifically, the Geopolitical Risk Threat Index (GPRT) is used as a proxy variable for GPR. At the same time, we log-transform the GPRT to prevent potential biases caused by heteroscedasticity.

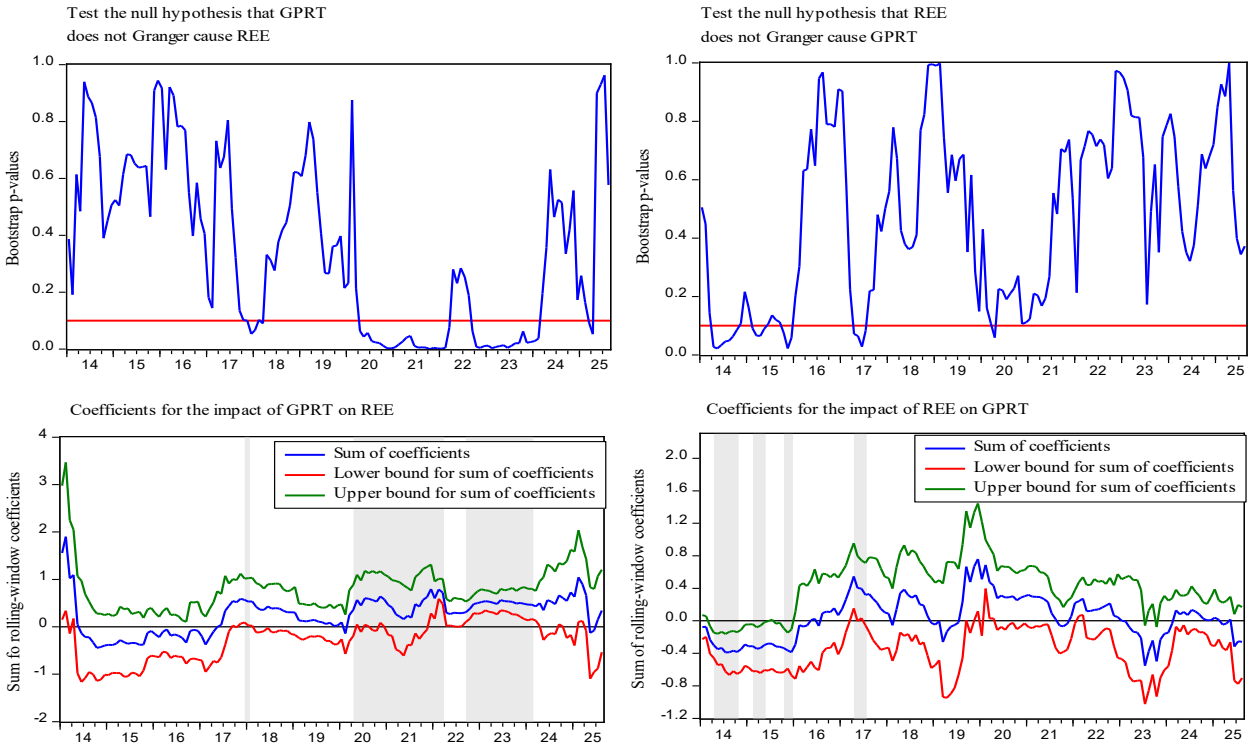

Figure 6. The results between GPRT and REE.

Source: Generated using EViews software

Figure 6 reports that GPRT exerts a significant promotion effect on REE during 2017: M12-2018: M1, 2020: M4-2022: M3 and 2022: M9-2024: M2. REE exhibits negative links to GPRT during 2014: M4-2014: M10, 2015: M2-2015: M5 and 2015: M10-2015: M12. Moreover, there is a favorable relationship from REE to GPRT during 2017: M4-2017: M7. These outcomes are largely consistent with Figures 3-6, confirming the robustness of the empirical findings in this paper.

3. Conclusions

In the context of the global transition to clean energy and a low-carbon economy, RE has become a central battlefield for resource competition and geopolitical rivalry among countries. Therefore, this paper examines the complex linkages and dynamic relationships between GPR and REE over time. To address the limitations of existing research that overlooks their bidirectional causal relationship, this study uses both full-sample and sub-sample methods. We find that the effects between GPR and RE vary across different time points. During the periods of 2020: M4-2022: M3 and 2022: M9-2024: M2, GPR produces a favorable shock to REE. The reason is that escalating geopolitical tensions raise global concerns about the vulnerability of RE supply chains and strengthen the strategic significance of RE in the defense and renewable energy industries. Therefore, the fervent rush to purchase and stockpile has created favorable conditions for expanding the sustainable export of China's RE. On the contrary, REE is negatively correlated with GPR. During 2014: M4-2014: M7, the reduction of REE intensifies international competition for RE and increases the complexity of the geopolitical environment. During 2015: M3-2015: M11, the stable and sustainable REE is conducive to improving

multilateral trade relations, delaying new RE supply chains construction and paving the way for geopolitical stability.

Based on the above research findings, this analysis presents some concrete and meaningful policy measures for governments and investors. First, the positive correlation between GPR and REE highlights the safe-haven value of RE during turbulent times. Thus, investors can dynamically adjust their investment portfolios and asset allocations according to changes in global GPR. In a volatile geopolitical environment, investors can view RE as a hedge to avoid significant losses caused by heightened GPR. In addition, this positive effect implies that GPR can predict future fluctuations of REE. To this end, governments should establish early warning systems for REE fluctuations and integrate GPR into monitoring systems, so as to avoid negative impacts on the RE market caused by geopolitical turmoil. Second, the negative effect of REE on GPR confirms the significant role of a stable REE in reducing geopolitical games and military conflicts triggered by resource competition. Therefore, China should assume its responsibility as the world's largest RE exporter, regulating RE exports under the premise of safeguarding national security to maintain the security of the global supply chain. Furthermore, China should vigorously promote the efficient utilization of the RE, minimizing pollution emissions and environmental damage caused by the mining and refining processes, thereby achieving sustainable use of RE. Third, various governments should encourage enterprises and research institutions to increase investment in RE technologies through tax incentives and financial subsidies, so as to enhance domestic mining and processing capabilities. Moreover, recovering RE from electronic products and industrial waste provides an energy-efficient and sustainable solution. Therefore, governments should increase investment in recycling technologies and alternative materials projects to achieve the sustainable use of RE. Fourth, against the backdrop of accelerating energy transition and climate governance, the demand for RE in various countries is expected to show a rapid growth trend. To this end, governments should strengthen the security of RE supply through diversifying imports channels, establishing strategic reserve plans and technological innovation cooperation. Furthermore, governments should actively expand international cooperation and diversify sources of RE imports by building open and collaborative trade partnerships, in order to reduce the risks caused by supply disruptions.

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