



# Research on the Dynamic Effect of Geopolitical Risk on Bulk Commodity Market-Based on Big Data

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**Abstract.** Due to the increasing geopolitical risks, bulk commodity prices have experienced frequent and great fluctuation, which has aroused global concern. The dynamic effect of geopolitical risk on bulk commodity market is still under discussion. This paper clarifies the impact mechanism of geopolitical risks on bulk commodity market from both supply and demand sides, and uses TVP-SV-VAR model to verify it. The results show that geopolitical risk has a significant positive impact on bulk commodity prices due to consumers' panic consumption and pressure in global supply chain. In the short term, the prices of bulk commodity increase sharply in dual sides, and in the medium to long term, the impact of geopolitical risk will change from negative to zero. By comparison, it is also found that the impact of different geographical events on the bulk commodity market varies and some events may have greater impact on supply chain, while others on consumers' decision. Based on the results, it is suggested that the governments should improve emergency management capabilities, stabilize market supply through multiple channels, and calm consumer's sentiment to mitigate the shock by geographical emergencies on the bulk market.

**Keywords:** geopolitical risk; bulk commodities; dynamic effect; big data; time series model

## 1 Introduction

Bulk commodities play a significant role in the national economy and are the basis of economic development [1]. According to the standards of the World Bank's Commodity price Pool, bulk commodities are mainly composed of energy commodities, non-energy commodities and precious metals. These commodities are not only essential in industrial production, but also closely related to people's daily life [2]. Moreover, in recent years, institutional investors have incorporated bulk commodities into their financial asset portfolios, especially after the bursting of the Internet technology stock bubble in 2000. So, the changing of commodity prices will affect the volatility of the entire financial market through index funds. [3].

However, commodity prices are fragile to a variety of factors, including geopolitical conflicts, monetary policy uncertainty and trade frictions [4]. Since the outbreak of the Russia-Ukraine conflict in 2022, commodity prices have experienced a new round of increase. The prices of oil future, precious metals, and gas all experienced a sharp rise, among them, the average price of Henry Hub natural gas futures in 2022 at \$6.52 / MMBTU, up 75.2% year-on-year(<https://www.cmegroup.cn/henryhub>).

The wild swings in commodity prices caused by geopolitical conflicts have attracted worldwide attention. Regulating and stabilizing the commodity price market has become an urgent task for national governments. Therefore, this study focuses on the impact path and dynamic effects of different geopolitical events on the commodity market, and compares the long-term and short-term impacts of different risk events on the commodity market. The findings can reveal both the instant and periodic feedback of commodity market on geographical risks so as to provide more comprehensive implications for governments, enterprises and investors.

## 2 Literature Review

The linkage between geopolitical risk and commodity prices is firstly addressed by Pindyck and Rotemberg [5], who argue that, in general, commodity prices and volatilities are negatively affected by geopolitical issue. It has sparked discussion about the impact of GPR on commodity markets. Gaibulloev and Sandler (2020) analyzed panel data of 18 Western European countries and determined that terrorist acts negatively affect economic growth by causing consumer panic [6]. Qiang Ji(2018)used Garch model to analyze the sensitivity of different products to GPR, and finally concluded that the reason why the sensitivity of fossil energy is higher than that of clean energy is due to the influence of investors' decisions[7]. Ferrer et al. (2018) and Mastroeni et al. (2022) found that most panic due to geopolitical risks among financial market participants can cause commodity prices to fluctuate [8][9]. Fernandes (2022) explored that the uncertainty of the supply side led to the price fluctuation [10]. Solaymani S (2022), by analyzing the supply and demand curve, which argued that the increase in transportation costs and the increase in product input costs caused the rise in agricultural prices [11].

Previous researches have confirmed that the impact of uncertainty on the market was not constant, but changed over time [12-15]. Extreme events have been shown to increase commodity market volatility, and this effect is time-varying. [16,17]. In view of this time-varying feature, TVP-SV-VAR are widely applied to testify this issue. Cai Yang (2022) demonstrated that the impact of geopolitical risks on market prices was significant in the short term with the time-varying characteristics by establishing TVP-SV-VAR model [18]. Guo Henghu (2023) analyzed the impacts of different events and compared and the results showed that the Sino-US trade conflict has a greater impact on the market than the Russia-Ukraine conflict, which is different from what people expect [19]. Li (2021) also found that geopolitical risks and gold price spillover showed different patterns and ranges. The empirical test demonstrated that

the spillover effect of geopolitical risk on the gold market was on the rise, and would be significantly enhanced in the short term during major geopolitical events [20].

To sum up, the current research has the following characteristics: 1. A variety of models are used to explore the impact of uncertainty on bulk commodities, including quantile method, Garch model and TVP-SV-VAR model. These models have been proved to be able to well verify the time-varying price fluctuations, so the TVP-SV-VAR model is feasible for current research. 2. At present, although scholars use the supply side or demand side to explain the causes of fluctuations, the two sides are not integrated to analyze their impact. 3. some researchers have found the influence of the consumption side, it is still a problem to quantify the influence of the consumption side. Therefore, it is impossible to accurately quantify the effect on the consumption side. This is the focus of this study.

### 3 Data Source and Research Methodology

#### 3.1 Data Resources

**Geopolitical Risk Index.** Caldara (2018) proposed the geopolitical risk index (GPR) by calculating the frequency of terms related to geopolitical risks in ten global mainstream media which is widely accepted and adopted by scholars in the relevant studies. Therefore, this study chooses this index to measure the global geopolitical risk. The data source is uncertainty database(<https://www.policyuncertainty.com>).

**Panic Buying Index.** Panic buying mainly refers to a kind of herding behavior with negative externalities [21]. At present, the method of using keyword search volume to explore people's decisions and behaviors has been applied to finance, medical care and other fields. Some studies on people's response to disease outbreaks through search engine data prove that people's behavioral decisions can be well reflected by the keyword data of search engines [22]. This paper takes the method of measuring social attention index in previous researches for reference and construct the panic buying index (PB), and the specific steps are as follows: 1. Select search engines and keywords; 2. Data integration through algorithm; 3. Calculate the geopolitical risk fear index.

Crawler technology is a program or script that automatically grabs data from the Internet, often referred to as a web crawler or web spider. First of all, the target analysis is carried out. Through the analysis, it is found that the Baidu index data is generated by dynamic loading (JavaScript), and the web content is encrypted. It is difficult to obtain data by direct parsing HTML. The data interface usually returns the data in JSON format through Ajax requests, and it needs to find the valid interface address and parameters. Use the core library to send HTTP requests and simulate browsers to bypass dynamic encryption. The HTML content is parsed and eventually stored using BeautifulSoup. Core steps: 1. Log in the Baidu account, use the browser to log in the Baidu Index, copy the Cookie and User-Agent directly in the code for reuse. 2. Locate the data port. Enter keywords and search on the Baidu index page, observe the XHR

or Fetch request in the network request, and find the interface that returns data. 3. Simulate request to obtain data. Send requests using the Requests library to get the encrypted JSON data. 4. Decrypt the data. Reverse decrypt the data returned by Baidu index. The JS decrypt code can be converted to Python code. The data is stored in a structured format after decryption. The above actions are subject to the terms of service of Baidu Index.

As the world's largest Chinese search engine, Baidu has been in a leading position in terms of market share. Therefore, this paper chooses Baidu as the search engine due to the representativeness of its data. The selection of keywords in the previous research mainly includes subjective word selection and model word selection. Subjective word selection has less work and better effect. Therefore, this paper chose the subjective word selection method. The first type of key keywords were selected to reflect the volatility of the commodity market, which are: "commodity price volatility", "commodity price shock", "commodity price crash" and "commodity price boom". The second type of keywords is selected to reflect the panic of consumers and speculators in the emergency speculation psychology of two keywords, which are "commodity consumption", "commodity long." The panic buying index is crawled through the web crawler data collection method, and the daily data collected are reduced and summarized into monthly data. In order to eliminate heteroscedasticity, the collected data is processed logarithmically to obtain the panic buying index (PB).

Figure 1 shows that panic buying index demonstrates a consistent upward trend following geopolitical risk events, which aligns with theoretical predictions.

$$PS = Ln(\alpha_1 + \alpha_2 + \dots + \alpha_6) \tag{1}$$

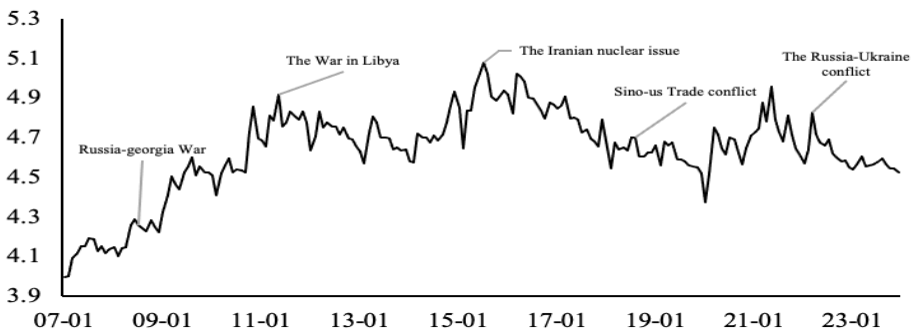


Fig. 1. Panic Buying Index.

**Global Supply Chain Pressure Index.** In order to reflect the impact of geopolitical risks on production capacity and supply chain, this paper selects the Global Supply Chain Pressure Index (GSCPI) as the index of supply chain pressure. The Global Supply Chain Pressure Index is an index released in 2022 that reflects the level of pressure on the global supply chain in terms of spot prices, trading volume, ship utili-

zation, logistics costs, legal risks and other aspects. It is published on the website of the Federal Reserve Bank of New York ([www.newyorkfed.org](http://www.newyorkfed.org)).

**Commodity Price Index.** The CRB index is quantified by the Commodity Bureau of Investigation of the United States through the commodity prices in the international market, which includes three categories of commodities: energy, agricultural and metal commodities respectively.

## 4 Research Results

### 4.1 Descriptive Statistics

In order to better reflect the changes of time series, this paper conducts census-12 seasonal adjustment on each series data, and measures, separates and adjusts the seasonal factors from the actual time series data to make the series more accurately reflect the basic development trend of indicators. According to the statistical results, the geopolitical risk index has a strong dispersion tendency, while the consumer panic buying index has a strong concentration tendency. **Table 1**

**Table 1.** Descriptive Statistics for Variables.

Variables	Std.dev	Mean	Max
Geopolitical risk index (GPR)	28.750	96.765	324.225
Panic BuyingIndex (PB)	0.216	4.631	5.079
Global Supply Chain Pressure Index (GSCPI)	1.139	0.260	4.587
Commodity Prices (CDR)	67.553	456.789	643.290

### 4.2 Test For Stationarity

Since the TVP-SV-VAR model mainly models stationary time series, the stationary test is conducted before the model is established. ADF unit root test is applied, and the results are shown in the **Table 2**.

**Table 2.** ADF Test results.

Variables	ADF Tests	P	Results
GPR	-5.719	0.000	stable
PB	-2.820	0.057	stable
GSCPI	-2.862	0.004	stable
CDR	-1.901	0.331	unstable
DGPR	-13.447	0.000	stable
DPB	-13.224	0.000	stable
DGSCPI	-14.907	0.000	stable
DCDR	-10.041	0.000	stable

The ADF test results show that except the commodity price index, all other variables pass the significance test at the level of 10%. In order to avoid the spurious regression problem and maintain the variable consistency problem, the first-order difference processing is performed on all sequences to generate DGPR, DPB, DGSPI and DCPR sequences. It can be seen from Table 2 that the geopolitical risk index, panic buying index, supply chain pressure index and commodity price index pass the stationarity test at the level of 5% after first-order difference, and each series is stable, so the TVP-SV-VAR model can be constructed.

### 4.3 Analysis of Empirical Results

The optimal lag order of TVP-SV-VAR model is determined by Eviews 8 software. According to the optimal information criterion, order 2 is determined as the optimal lag order (see Table 3).

**Table 3.** Results for Lag Order.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1,494.517	NA	55.584	15.369	15.436*	15.396*
1	-1,471.510	44.833	51.732	15.297	15.633	15.433
2	-1,453.128	35.068	50.494*	15.273*	15.877	15.517
3	-1,440.230	24.075	52.154	15.304	16.177	15.658
4	-1,432.767	13.625	56.982	15.392	16.533	15.854
5	-1,424.719	14.362	61.922	15.474	16.883	16.044
6	-1,407.042	30.820*	61.008	15.456	17.135	16.136
7	-1,397.122	16.889	65.142	15.519	17.466	16.307
8	-1,392.053	8.422	73.182	15.631	17.846	16.528

After the order of variables in the model is determined, the MCMC method can be used for model estimation. Ten thousand iterations of simulation, model parameter estimation and empirical process were performed using Ox Metrics6 software. Table 4 shows that the posterior means all fall into the 95% confidence interval. The maximum value of the invalid factor is 139.45, which is far less than the sampling times of 10,000, and the Geweke diagnostic probability is significant at the significance level of 5%. According to the above judgment, the model estimation results are valid.

**Table 4.** Estimation Results of Selected Parameters.

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inef.
sb1	0.023	0.003	0.018	0.030	0.842	62.160
sb2	0.022	0.002	0.018	0.028	0.166	16.710
sa1	0.538	4.381	0.018	4.963	0.241	24.090
sa2	0.128	0.334	0.021	1.246	0.749	161.690
sh1	0.566	0.109	0.367	0.802	0.117	46.850
sh2	0.736	0.266	0.266	1.726	0.561	196.030

#### 4.4 Time-varying Impulse Responses of Geopolitical Risks

The TVP-SV-VAR model focuses on showing the time-varying impact effect in the system caused by the change of the error term, which can be divided into two types: equal-interval impulse response and time-point impulse response. Time intervals of 3, 6, and 12 months are set to represent the short, medium, and long term. The time-point impulse response function is the time-varying impact effect presented inside the system when a positive external shock is applied at a specific time. In terms of the selection of time nodes, three periods are selected to represent the period of rising geopolitical risks caused by potential geopolitical threats and direct actions. August 2008 ( $t=34$ ), April 2018 ( $t=135$ ) and March 2022 ( $t=182$ ) correspond to the three periods of "Russia-Georgia War," "Sino-US trade conflict" and "Russia-Ukraine conflict" respectively.

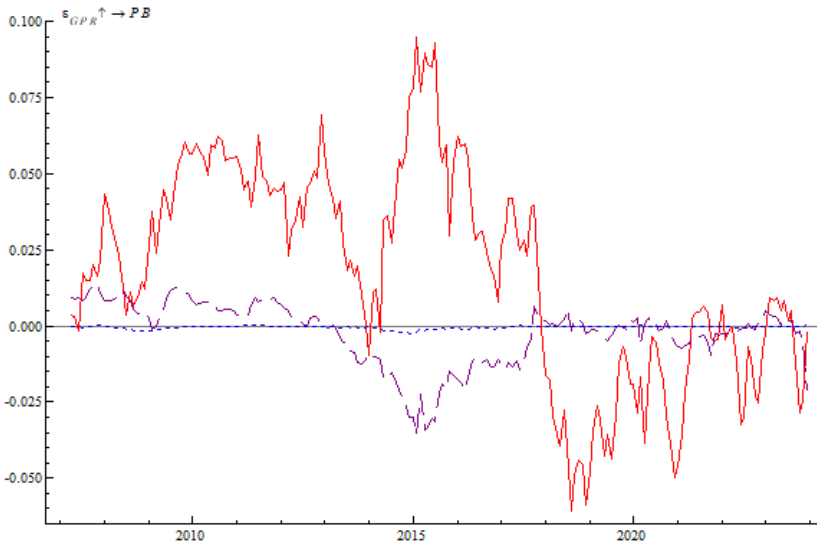


Fig. 2. Time-varying impulses responses from GPR to PB at different lag periods.

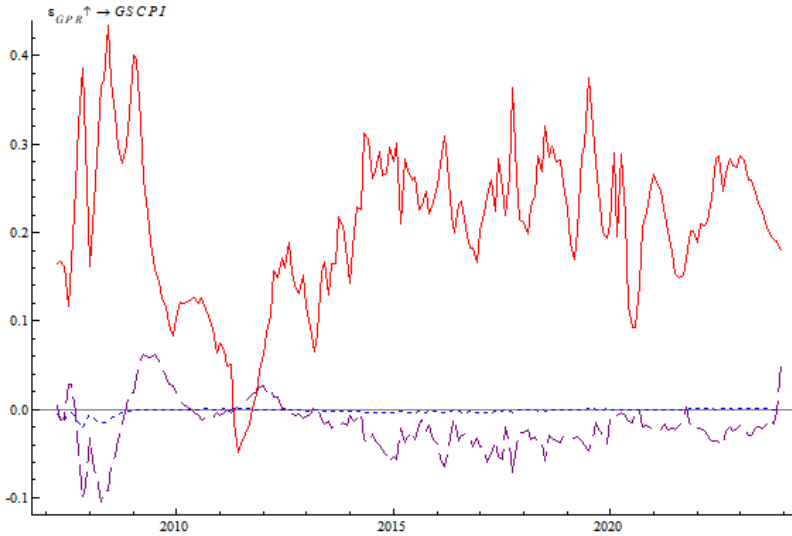
The red, purple, and blue curves in the impulse response graph represent 3, 6, and 12 lag periods, respectively. Figure 2 shows the volatility presented by the PB after applying a positive shock of one unit to geopolitical risk. Overall, the PB shows a positive fluctuation, but a downward trend in a specific period. From 2007 to 2018, the rise of geopolitical risks had a positive impact on the PB, indicating that when geopolitical risks increased sharply during this period, the media could quickly capture this situation and transmit information to the public through the Internet. The continuous dissemination and fermentation of information causes people to worry about the market prospect and produce panic consumption behavior. From 2018 to 2021, the impact of geopolitical risk on the PB showed a negative effect. The possible reasons for this situation include: first, due to the geographical limitations of geopolit-

ical risks, the scope of impact of some events is limited. Second, since the outbreak of COVID-19 in December 2019, media around the world have focused on the epidemic, and the public's attention to international geopolitical risks has declined. At the same time, the government's strict epidemic control measures have reduced the degree of international geopolitical risks, so geopolitical risks have not had the expected effect on the index. But the impact of geopolitical risks on the PB fluctuated more between 2021 and 2023. This is mainly due to the easing of the COVID-19 epidemic and the gradual return of normal production and life order in various countries. In terms of the international situation, the standoff between Russia and NATO in Eastern Europe has been further strengthened. It can be observed in the 12-period lagged image that the volatility of PB is smoother, because the news dissemination has its timeliness. As the timeliness diminishes, its impact decreases too.



**Fig. 3.** Time-varying impulses responses from PB to CDR at different lag periods.

**Fig. 3** shows that a one-unit positive shock of PB is applied to the CDR, and in the short run, an increase in the PB has a clear positive impact on commodity prices. It implies that consumer fear plays a significant role in driving commodity prices up in short time. However, the impact of consumer panic gradually decreases with the increase of time. This is because the consumption caused by panic is transient and explosive. In the short term, panic consumption surges, which has a great positive impact on commodity prices, pushing up the prices. But in the long run, panic consumption would fall, and its impact on commodity prices decreases leading to the falling prices. The results verify the theoretical hypothesis in our theoretical model.



**Fig. 4.** time-varying impulses responses from GPR to GSCPI at different periods.

**Fig. 4** shows the fluctuations in the GSCPI after a one-unit positive shock of GPR. Overall, the GSCPI basically shows positive fluctuations in the short run. When risk increases, production, transportation, and legal costs increase rapidly, leading to an exponential increase in global supply chain stress, which is reflected in reduced supply in the trading market. By focusing on special time nodes, it can be seen that the GSCPI has rose since the Russia-Ukraine conflict in March 2022. As important exporters of commodities, the military conflicts in Russia and Ukraine have led to the blockade of the Black Sea channel and the interruption of the transportation routes of wheat, corn and other agricultural products. The performance of the curve lagged 12 periods is relatively stable because in the long run, the country can reduce the supply gap and reduce the pressure on the supply chain by using the inventory of bulk commodities, seeking other supply sources and opening up other transportation routes.

**Fig. 5** shows the price volatility characteristics of commodities after applying a one-unit positive shock of GSCPI to CDR. In the short term, regardless of the year, the increase in the supply chain stress index has directly led to a positive impact on commodity prices. The degree of influence showed a decreasing trend over time, but the effect was always positive. On the one hand, it proves that the market has a strong sensitivity to the supply side, and the operation of the commodity market depends on the stability of the supply chain. On the other hand, with the abundance of supply channels and suppliers, the impact of supply chain pressure on commodities is also weakened to a certain extent. In the medium term, we can observe that the impact of supply chain pressure on the market has sharply weakened, and even has a negative impact on the market. This corresponds to the theoretical analysis above, that is, as other suppliers quickly fill the gap in the market, it will have a cooling effect on prices. Eventually, on a long-term scale, the market almost returns to its original price structure.

To sum up, the results of equally spaced impulse responses are basically consistent with the theoretical analysis in this paper. Commodity prices are volatile because of supply and demand conflicts caused by consumer panic and supply chain pressures, and rising geopolitical risks will cause volatility at both ends of supply and demand. When geopolitical risks rise sharply, consumer panic tends to rise in the short term. Due to the timeliness of the message, this effect diminishes in the long run. On the other hand, the supply chain pressure index will rise in the short term, resulting in increased positive fluctuations in commodity prices, and this impact will weaken in the long term as inventory replenishment and other supply sources open up.

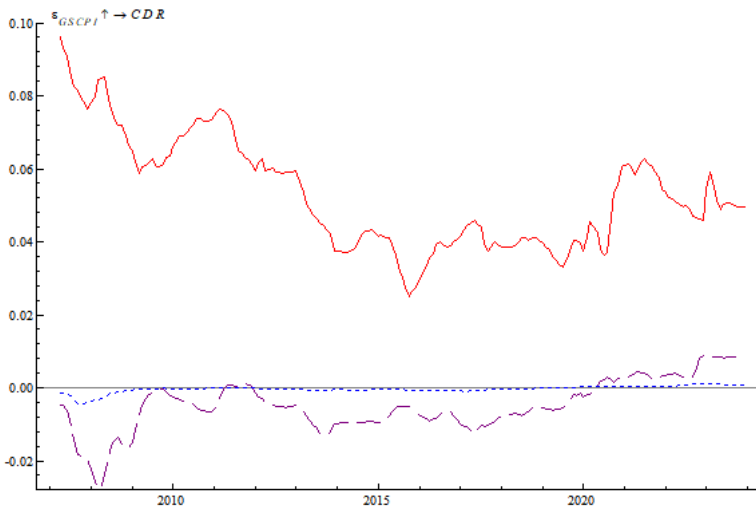


Fig. 5. time-varying impulses responses from GSCPI to CDR at different periods.

## 5 Conclusions

This paper establishes a theoretical model to explain the impact mechanism of geopolitical risks on bulk commodity prices and applied a 4-variable TVP-SV-VAR model to test the impact. The theoretical analysis reveals that geopolitical risk may cause panic consumption and supply pressure, leading to the fluctuation of bulk commodity market. And the impact of geopolitical risk may vary at different time. The empirical results verify this dynamic relationship. The results show that the increase of geopolitical risk will cause the increase of supply chain pressure and consumer panic consumption in the short and medium term, resulting in positive price fluctuations. However, in the long run, with the weakening of the timeliness of information and the supply and supplement of multiple channels, the influence degree gradually weakens to 0. Different types of geopolitical risk events will cause different degrees of impact, the Sino-US trade war has a greater impact on panic consumption behavior, while the Russia-Georgia war has a more obvious impact on the supply side due to its geographical significance.

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