Energy 306 (2024) 132586

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Energy imports in turbulent eras: Evidence from China

Chi-Wei Su [a,b,c], Shengyao Yang [c], Adelina Dumitrescu Peculea [d], Teodora Ioana Biţoiu [d], Meng Qin [e,*]

[a] School of Finance, Yunnan University of Finance and Economics, Kunming, 650221, China
[b] Universidad Antonio de Nebrija, Spain
[c] School of Economics, Qingdao University, China
[d] Department of Economics and Public Policies, National University of Political Studies and Public Administration, Bucharest, 012244, Romania
[e] School of Marxism, Qingdao University, China

ARTICLE INFO

Handling editor: X Zhang

Keywords:
Geopolitical risk
Economic policy uncertainty
Energy import
Quantile-on-quantile

ABSTRACT

The turbulent world situation is an urgent crisis in energy trade and may exacerbate regional energy tensions. This paper measures the links between geopolitical risks (GPR), economic policy uncertainties (EPU) and energy import (EI) from 2005:M3 to 2023:M3. We use the Wavelet-Based quantile-on-quantile (QQ) approach based on China's import statistics for the first time. The results show that both GPR and EPU are important factors affecting EI. We confirm the negative impact of GPR and EPU on EI in the short term, while EI tends to recover in the long run. The result is consistent with the theoretical mechanism that reflects the interrelationship between external uncertainties and EI. As a result, the government should advance diversified energy access options, timely adjustment of energy policies to respond to crises, increase energy reserves and actively undertake energy innovation to reduce external energy dependence.

1. Introduction

A reliable and sustainable energy supply is essential for economic prosperity and national security, but many countries must maintain their national economy through EI because of the uneven distribution of natural resources [1,2]. It is worth noting that many major energy-producing countries, such as the Middle East, face volatile geopolitical situations [2]. Geopolitical unrest and increased EPU are considered factors that may have significant adverse effects on the economy and trade [3,4]. In recent years, regional conflicts have been taking place involving energy as a powerful political tool and threatening resource-poor countries' security [5]. The unstable factor increases the danger of supply disruptions for energy and propels this problem to ascend to influential political agenda [6–8]. Nowadays, greater emphasis must be placed on energy trade security to counter the effects of world instability [9–14]. On this basis, the United Nations Conference on Trade and Development repeatedly focuses on the energy difficulties that GPR may bring. The Russia-Ukraine conflict outbreak 2022 raised global GPR to unprecedented levels [15]. The surge in GPR has exacerbated EPU [16]. This uncertainty represents changes in policy uncertainties related to the economy and is considered one of the influence factors of the market [17]. For GPR, it includes any tensions between the countries and political actors, which can impact the peace process in international relations [18]. Because it may be an essential element affecting the global energy supply chain and the security of energy-importing countries, it is necessary to explore how GPR influences EI [19,20].

GPR usually accompanies EPU, and both are considered external uncertainties when studying the energy market, they are important factors that may have an impact on EI [21–23]. On the one hand, EPU can influence market entities' trade decisions in the process of energy trade, which may raise the negative elements of regional EI [23]. Simultaneously, the increase in EPU impacts investment and income, as well as inflation and exchange rate swings, resulting in a significant negative impact on primary commodities' import demand [24–28]. Although most studies believe that GPR and EPU can suppress energy

Abbreviations: GPR, Geopolitical Risk; EPU, Economic Policy Uncertainty; EI, Energy Import; QQ, Quantile on Quantile; WTI, West Texas Intermediate; COVID-19, Coronavirus Disease 2019; ER, Exchange Rate; PMI, Purchasing Managers' Index.

* Corresponding author.
E-mail addresses: cwsu7137@gmail.com (C.-W. Su), ysy771@163.com (S. Yang), adelina.peculea@snspa.ro (A. Dumitrescu Peculea), teodora.bitoiu@administratiepublica.eu (T. Ioana Biţoiu), meng575316928@126.com (M. Qin).

https://doi.org/10.1016/j.energy.2024.132586
Received 4 June 2024; Received in revised form 12 July 2024; Accepted 24 July 2024
Available online 25 July 2024

trade [29–31], some researchers assume that an increase in EPU can deepen reliance on imported goods in the short term, resulting in promoting EI [24]. In addition, the relationship between uncertainties and energy markets is not static but varies over different periods [32,33]. Considering the important impacts of external uncertainties on energy acquisition and the unclear process of this influence, it is necessary to further research the effects of GPR and EPU on EI.

According to the National Bureau of Statistics of China, this region is the world's second largest economy and the country with the highest industrial added value. China requires a significant amount of energy resources [34], which must be imported to meet the demands of the huge industrial scale in situations where self-sufficiency is not possible [35–38]. In 2018, 2.64 billion tons of oil equivalent[1] energy were produced in this region, but 3.27 billion tons of oil equivalent were consumed in the same year; energy imports account for 19 % of overall consumption, the share of imports is higher for some essential resources, such as crude oil and natural gas, which account for 71 % and 43 % respectively [35]. Given the country's dependence on overseas energy sources, it is necessary to closely monitor the impact of external uncertainties on EI to ensure security of supply. Therefore, the Chinese government attaches great importance to stable geopolitical ecology and has taken corresponding actions[2] [39,40]. Ensuring a secure energy supply from overseas has long been an important agenda for China's development. However, the impact of external uncertainty on EI is still inconclusive, and therefore, the paper's primary purpose is to evaluate this process and draw a comprehensive conclusion.

This article has proposed several contributions. First, we focus on the perspective of EI rather than international energy prices, which reflects the energy access situation in a region more specifically and provides effective policy recommendations [23,30,41,42]. Unlike earlier studies that concentrate on a particular energy product such as crude oil or natural gas [43], in this respect, we focus on the total EI, which is represented by the 27th category of Harmonized System (HS) code, usually be named by HS27, based on China customs statistics [7,44]. This index includes mineral fuels, mineral oils and products of their distillation, bituminous substances, and mineral waxes; it can usually be used to depict the EI of a region [31,45]. Simultaneously, we control the impact of manufacturing growth on EI besides the exchange rate; this allows us to exclude these factors affecting EI and make the result more relevant to China's situation. Finally, most of the past literature has not discussed the relevance of external uncertainty to EI in different time scales. We test the heterogeneity on the short-, medium- and long-term effects of external uncertainty on EI by using the wavelet-based quantile-on-quantile approach so that we can remedy the deficiency and study the subject in greater depth. Our research explains how external uncertainty affects China's overseas energy supply situation against the backdrop of high EI dependency. This has certain reference significance for the government's EI policy formulation. Simultaneously, it helps enterprises avoid risks and reduce the losses caused by external uncertainties.

The rest of this paper is arranged as follows: In the second part, we comb the relevant literature and clarify the influence mechanism between external uncertainty and EI. The third part is about materials and methods. In this paper, we introduce the selection, sources, and trends of the data, as well as the research method and process. The fourth part expounds the empirical results and discusses them. In the last part, we explain the conclusion of this paper and put forward the relevant policy recommendations and shortcomings.

[1] The unit of energy amounts, which is calculated according to the calorific value of standard oil.

[2] For example, China has formed an energy-reliance relationship with nations along the Belt and Road. These countries' energy reserves have reached 52.27 % of the world, equivalent to 758.73 billion tons of standard coal.

2. Literature review

External uncertainty brings significant challenges to the EI. However, there are relatively few studies on the direct relationship between uncertainty risk and EI, and more literature focuses on indirect factors that may affect EI, such as energy price and consumption. Accordingly, the second section is divided into two parts. They each describe the relationship among GPR, EPU and the broader energy system.

2.1. GPR and energy system nexus

GPR is a significant economic influencer and an important force affecting global energy supply chains [18,46]. In this context, Li et al. [31] discover that GPR negatively impacts energy trade, with the inhibitory effect on exports being more significant than that on imports. Some studies emphasise market prices. Bouoiyour et al. [6] demonstrate that GPR influences the international oil price, an essential factor affecting EI. Ivanovski et al. [33] verify that the link between GPR and oil prices is time-varying. Transport is also a necessary part of the energy supply chain. Michail et al. [47] prove that GPR can raise the cost of transportation of liquefied natural gas and liquefied petroleum gas. Khan et al. [30] confirm that when geopolitical conflicts occur, the freight rate of marine trade can affect the energy supply chain. Meanwhile, the geopolitical tensions may result in trade sanctions. Zheng et al. [48] argue that these sanctions have a significant impact on Russia's energy supplies to other countries, with the crude oil trade having the most considerable potential impact, the natural gas trade having the largest direct losses, and the coal trade having the smallest impact. De Rosa et al. [8] conclude that geopolitical turbulence is a significant element posing a threat to the EU's energy supply and security. Furthermore, Umar et al. [11] propose that GPR can impact clean energy commerce in addition to traditional energy sources. Notably, some literature suggests unusual viewpoints. Zhao et al. [49] find that even if geopolitical turmoil leads to a decrease in energy consumption, the ease of the geopolitical situation may also bring about the same result in some developing countries. Yang et al. [50] believe that the impact of GPR on the commodity market is mainly in the short term. Similarly, Barbieri et al. [51] argue that GPR doesn't affect the flow of goods in international trade in the long term, indicating that the impact of war on trade may be short-lived. Zhao [52] discusses the influence of the GPR on the prices of natural resources and finds that this impact is mainly concentrated in the short term.

Some literature explores GPR and China's energy issues, which has caused a significant energy dilemma [35]. Zhang et al. [53] believe that geopolitical conflict is an essential unstable factor, and reducing dependence on external energy can avoid this impact. Gong et al. [7] argue that the GPR can influence EI and create an energy security issue. Similarly, Wang et al. [2] also raise the negative impact of GPR on China's overseas oil guarantee. Wang et al. [36] point out that when geopolitical events occur in oil-exporting countries, the crude oil supply chain may be disrupted, affecting the production and operation of relevant Chinese enterprises. Nevertheless, some literature still presents different conclusions. Zheng et al. [48] examine the influence of the conflict between Russia and Ukraine; it is believed that China may receive more energy under Western sanctions on Russian energy trade. Wang et al. [54] find that the Russia-Ukraine conflict increases risk spillovers between different markets of this area, including the energy market, but this effect is weak in the long run.

2.2. EPU and energy system nexus

Unstable economic policies, an essential external uncertainty factor, often impact energy markets [22,55,56]. Therefore, Sharma et al. [24] discover that in the long run, EPU considerably lowers the primary product imports of Indian, including energy items. Furthermore, in terms of market price, Yang [57] confirms the impact of EPU on oil market price levels. Similarly, Ahmed et al. [58] investigate the reaction of commodities trade markets to EPU and hold that it can influence the West Texas Intermediate (WTI) crude oil spot price, which serves as the pricing benchmark for the crude oil trading market. Some studies focus on market conditions. Yang et al. [59] argue that stabilising EPU can reduce systemic risks in the international crude oil market, which may significantly impact EI. Chronopoulos et al. (2016) argue that the EPU leads to downsizing projects related to renewable energy. However, the view that EPU negatively affects the energy market is not always accepted. Jalal et al. [43] conclude that EPU has a long-term positive impact on crude oil imports in India. Sharma et al. [24] prove that India's imports of primary commodities, including energy items, have increased in the short term due to the EPU. Mohideen et al. [60] consider the coronavirus disease 2019 (COVID-19) epidemic, an extreme economic event, leads to a 1.5 % increase in demand for renewable energy. Meanwhile, Li et al. (2023) believe that EPU may lead to a positive effect on non-renewable energy consumption for most of the time.

There is also some literature about the relationship between EPU and EI of China. Cheng et al. [61] suggest extreme economic events, such as the Sino-U.S. trade war, have impacted the energy market. When considering the impact of trade policies, Song et al. [23] hold that EPU can affect this country's unit crude oil import cost, meanwhile, GPR and EPU have significant asymmetry in this process. In the study of trade restrictions, Wang et al. [54] find that it has reduced this area's energy consumption demand. High levels of EPU often suppress energy trade, while stable economic policies can promote EI. Zhao et al. [39] investigate the situation of China's resource purchase from countries under the Belt and Road policy and believe that it has significantly increased EI under this framework. Nevertheless, some literature suggests unusual conclusions. Li et al. [62] researched China's resource use during the financial crisis and found that its energy demand increased during this period. Li et al. [63] consider that the increase in EPU can lead to an expansion of traditional energy consumption by domestic enterprises. Yang et al. [64] propose that reducing EPU leads to decreased energy intensity,[3] which may be related to technological progress.

It can be seen that current researchers have paid attention to indirect factors on this topic, such as energy prices, transportation, and trade sanctions, while direct studies on EI are relatively scarce. Most of the literature points to the damaging effects of GPR on energy supplies, but a few studies suggest that there is only weak evidence of this relationship, and there is a lack of long-term connection between them. Compared with GPR, it seems that more literature has proposed the potential positive impact of EPU on the energy market. However, few direct studies still exist on the relationship between EPU and EI. Therefore, further examination is needed to reflect EI changes in a region accurately. Simultaneously, existing literature often fails to explain GPR and EPU's effects on EI under different market conditions and time scales. Therefore, we employ a wavelet-based quantile-on-quantile approach to research correlation among GPR, EPU and EI under different perspectives. This allows us to answer further how external uncertainty affects EI.

3. The interaction mechanism between external uncertainty and EI

In order to introduce the impact of GPR and EPU on EI, we consider GPR and EPU as external uncertainties and further explore their interaction mechanisms [23]. The influence mechanism is shown in Fig. 1. GPR and EPU may affect energy imports in the following ways. At first, as part of international business, energy trade is essential in redistributing natural resources and maintaining global economic operations; external uncertainties may affect the supply and requirement in this market [41,65]. Furthermore, as a widely investment target, energy prices are shocked by hot money [66]. External unpredictable factors can influence energy prices via financial markets [67].

First, rising GPR and increasing global EPU can cause changes in the supply of energy-exporting countries and influence the international energy supply chain, leading to variations in energy prices and an impact on energy imports [30,41,68,69]. Second, external uncertainty can shock the total demand of economies and affect corporate decision-making. The rise in geopolitical risks and frequent changes in economic policies may result in sharp variations in energy prices and an increase in trade risks. Evidence shows that when external uncertainty rises, overall demand falls, negatively affecting economic activity [41]. Simultaneously, if the external uncertainty increases, firms may need to alter their operations to ensure output, resulting in changes in the preventative demand for energy. This may also cause changes in energy prices and impact imports [23]. Furthermore, because energy is a significant investment objective, an increase in external uncertainty can influence multinational investors' decisions, affecting energy prices, which can impact imports [70,71].

Blomberg et al. [72] and Chen et al. [73] propose the Law of one price theory and the asset price theory, respectively, which shows that the exchange rate (ER) can also affect EI, it is expected to consider changes in the exchange rate against the U.S. dollar when analysing energy imports [43]. Meanwhile, manufacturing is the core component of China's economy and is frequently mentioned in energy-related research [74,75]. When studying the relationship between external uncertainty and EI, we consider the influence of exchange rate fluctuations and manufacturing industry growth. We add the RMB to the USD exchange rate and China's manufacturing Purchasing Managers' Index (PMI) as control variables, which reflect the variation of the exchange rate level of the RMB to USD and the growth of China's domestic manufacturing industry, respectively.

4. Methodology

4.1. The quantile-on-quantile approach

Sim and Zhou [76] propose the quantile-on-quantile (QQ) regression; we use it in this paper to assess the relationship among GPR, EPU and EI. This approach, which integrates nonparametric estimation and standard quantile regression techniques, has improved traditional quantile regression. It allows correlations of the independent and dependent variables to be assessed at different quantiles, thus providing a broader and more accurate understanding of the relation of the variables in various circumstances [77,78]. The following non-parametric quantile regression equation is used to start the model we construct:

$$EI_t = \beta^{\theta} U_{t-1} + u_t^{\theta} \tag{1}$$

where EI_t can be used to describe the overall situation regarding imported energy at t period, U_t can be related to GPR and EPU at the time t. The conditional distribution of the θth quantile is EI_t, can be depicted as θ. Furthermore, u_t^{θ} is the error term which conditional θth quantile is equal to zero. Simultaneously, β^{θ} ($\bullet$) is defined as a non-identified function because of its prior information of relationship connecting EI_t and U_t is absence. Therefore, we first linearise β^{θ} ($\bullet$) by a Taylor expansion of first order on the U_t in order to get the equation below:

$$\beta^{\theta}(U_{t-1}) = \beta^{\theta}(U) + \beta^{\theta'}(U)(U_{t-1} - U^{t}) \tag{2}$$

Partial derivatives of $\beta^{\theta}(U)$ with respect to U are depicted by $\beta^{\theta'}$. Nevertheless, this approach reflects a related stretch of the slope parameter in the linear regression model. Furthermore, θ and τ are treated as double indexed in Equation (2), these parameters are presented by $\beta^{\theta}(U)$ and $\beta^{\theta'}(U)$. With this in mind, $\beta^{\theta}(U)$ and $\beta^{\theta'}(U)$ are confirmed as the $\beta(\theta,\tau)$ and $\beta_1(\theta,\tau)$ which stand for functions of θ and τ. As a result, $\beta^{\theta}(U)$ is represented as shown below:

[3] Energy intensity refers to the ratio of energy use to economic output.

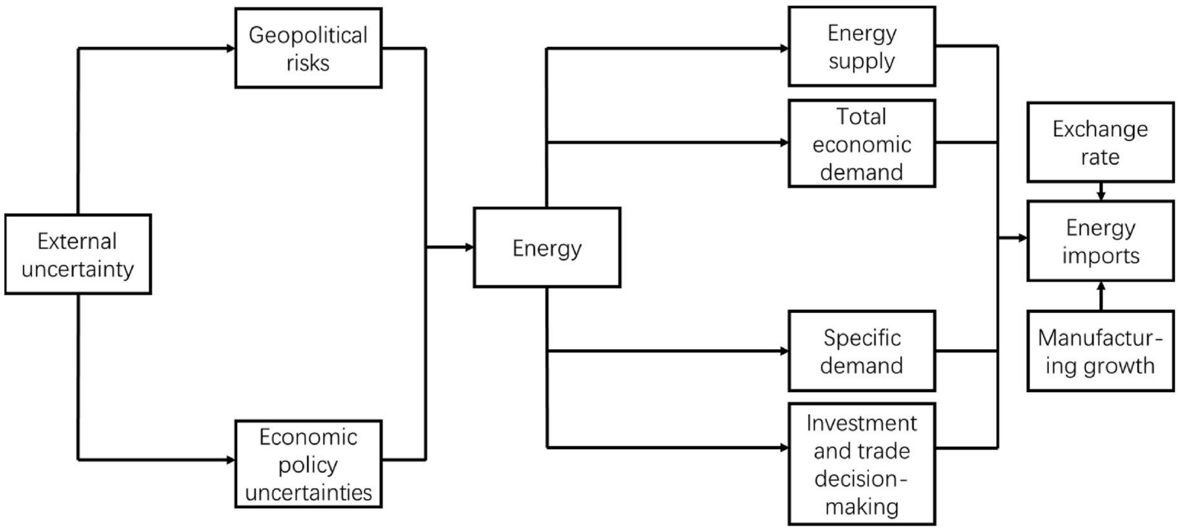

Fig. 1. The impact mechanism of external uncertainty on energy imports.

$$\beta^{\theta}(U_{t-1}) = \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(U_{t-1} - U^{\tau}) \tag{3}$$

Then, we use Equation (3) to replace $\beta^{\theta}(U)$ in Equation (1), in order to achieve the following formula:

$$EI_t = \underbrace{\beta_0(\theta,\tau) + \beta_1(\theta,\tau)(U_{t-1} - U^{\tau})}_{(*)} + u_t^{\theta} \tag{4}$$

Because the β_0 and β_1 are subject to θ and τ, respectively, we can measure the correlation between the two variables at each quantile. The p_{t-1} and p^t need to be substitute for $\hat{p}_{t-1}$ and $\hat{p}^t$ to establish Equation (4). Therefore, the estimation of the coefficients d_0 and d_1 can be solved by the minimisation problem:

$$\min_{b_0,b_1} \sum_{i=1}^{n} \rho_\theta[EI_l - d_0 - d_1(\hat{U}_{t-1} - \hat{U}^{\tau})] \times K\left(\frac{F_n(\hat{U}^{\tau}) - \tau}{h}\right) \tag{5}$$

the function of quantile loss is represented by $\rho_\theta(p)$, there are $\rho_\theta(p) = p(\theta - D(p<0))$. The D stand to functions as a regular indicator. Moreover, $K(\cdot)$ is represented to the Gaussian kernel, and h denotes bandwidth. According to Sim and Zhou [76], we employ $h = 0.05$ as the most suitable in our research.

4.2. The wavelet analysis approach

The QQ method can be combined with wavelet decomposition to improve and perfect our intrinsic conclusion [79]. It can record the information in connection with certain periods and positions in the time-varying data [80]. It enables us to handle the nonstationary time series. Therefore, we construct the dualistic wavelet and transform two specific functions as shown below:

$$\int^{\phi}(t)dt = 1 \tag{6}$$

$$\int^{\psi}(t)dt = 0 \tag{7}$$

ϕ covers low-frequency sections of the series and ψ related to high frequency sections. According to the above equation, the resulting wavelet can be indicated as shown below:

$$\phi_{m,n}(t) = 2^{m/2}\phi(2^m t - n) \tag{8}$$

$$\psi_{m,n}(t) = 2^{m/2}\psi(2^m t - n) \tag{9}$$

where $m = 1,\dots,M$ is related to scale, $n = 1,\dots,2^m$ is related to subsequent translation. The max scales are limited by the size of sample that is $T \geq 2^m$. The integration of the two methods allows testing the effect of one variable on another variable at various periods and their respective different quantiles. Therefore, we can obtain complete and strict results.

5. Data

We employ the monthly data from 2005:M3 to 2023:M3 to test how external uncertainty impacts energy imports (EI). 2005:M3 is the first month of the official implementation of the Kyoto Protocol, which has profoundly affected the world's energy markets [81]. The Chinese government reformed its exchange rate (ER) system in the same year, completing the transition from fixed to floating. That allows ER to capture market factors and enable us to analyse its impact on the energy market [82]. Chinese EI has increased nearly tenfold since 2005:M3, and its energy security has attracted increasing attention as the economy rapidly expands [35,37].

Fig. 2 depicts the trends in Geopolitical risks (GPR) and Economic policy uncertainty (EPU). We can find the world has experienced many uncertainties; the GPR is stable before the Russia-Ukraine conflict, while the EPU tends to show an increasing trend. Geopolitical unrest in the Middle East, such as the Arab Spring in 2011, shocks the region's energy exports [83]. The war in Libya leads to the destruction of energy extraction facilities and almost halts oil production [84]. Uncertainty in Eastern Europe increased with the Ukrainian crisis in 2014. The outbreak of the Russian-Ukrainian war in 2022 pushed the GPR index to its highest level, with the region having long been a significant global exporter of natural gas [15]. In addition to geopolitical conflicts, economic upheaval can also affect energy markets and drive up EPUs. The global financial crisis exacerbated volatility in energy markets in 2008 [85]. The UK Brexit bill passed in 2016 means a renegotiation of energy and climate policy between Britain and the European Union; this leads to increased uncertainty in the energy markets of the associated countries [86]. US-Iran relations were strained in 2017. The following year, the United States announced a new round of sanctions, including restrictions on the transport and trade of their energy resources [87]. The Sino-U.S. trade war that began in 2018 has been proven to have a negative impact on energy trade; this has also resulted in a significant rise in EPU [31]. On the other hand, the COVID-19 epidemic in 2020 has suppressed global enterprise energy demand and the EPU peaked during this period as well [88].

Regarding China's EI, we use the HS27, which includes mineral fuels,

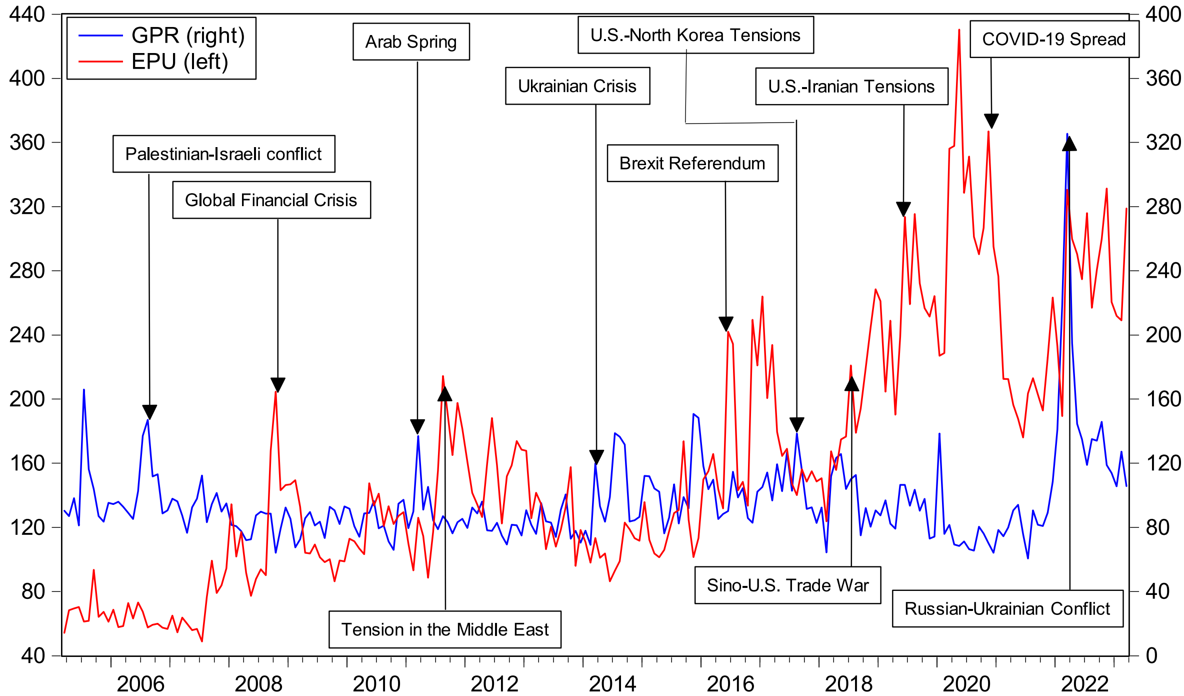

Fig. 2. The trends of GPR and GP.

oils and products of their distillation, bituminous substances, and mineral waxes; the unit is one thousand dollars. This index can reflect a country's overall EI level [31,45]. This part of the data comes from the CSMAR database; it reprinted the statistical data reported by Chinese customs and provided monthly EI sequences under the HS27 code. Furthermore, to assess the geopolitical situation, we use the GPR index developed by Caldara and Iacoviello [89], which covers terrorist attacks, wars, and international tensions affecting international relations [1,6]. We use the EPU indicator constructed by Baker et al. [17] to represent uncertainties of global economy policies, which has a significant dynamic relationship with actual macroeconomic events and is closely linked to international energy trading markets [1,32]. The GPR and EPU data come from economic policy[4] uncertainty websites. Simultaneously, we employ the ER of the RMB to USD and the purchase management index (PMI) of China's manufacturing industry as control variables; these two indicators are frequently employed in energy market analyses [43,75]. The data on ER comes from the Yingwei Caiqing financial information portal,[5] and the data on China's manufacturing PMI comes from the National Bureau of Statistics[6] of China.

According to the descriptive statistics in Table 1, the average values of EI, GPR, EPU, ER and PMI are concentrated at 21110619, 96.025, 159.21, 6.798 and 51.426, respectively. A positive skewness indicates EI, GPR, ER and EPU follow a right-skewed distribution. However, a negative skewness indicates PMI follows a left-skewed distribution. Due to the kurtosis of EI being smaller than 3, they conform to platykurtic distribution, while the kurtosis of GPR, EPU, ER and PMI is greater than 3, which means they comply with leptokurtic distributions. In addition, the results of the Jarque-Bera test indicate that EI, GPR, EPU, ER and PMI are non-normally distributed at the confidence level of 1 %.

Table 1
Descriptive statistics for EI, GPR, EPU, ER and PMI.

	EI	GPR	EPU	ER	PMI
Observations	217	217	217	217	217
Mean	21110619	96.025	159.21	6.798	51.426
Median	20506513	90.37	141.623	6.724	51.1
Maximum	48898861	325.42	430.349	8.277	59.2
Minimum	4889837	60.6	48.875	6.054	35.7
Standard Deviation	10324699	27.248	78.039	0.555	2.736
Skewness	0.508	3.705	0.861	1.079	−1.005
Kurtosis	2.919	27.062	3.143	3.463	10.2
Jarque-Bera	9.41[a]	5731.246[a]	26.976[a]	44.065[a]	505.183[a]

Note.
[a] Denote significance at the 1 % levels.

To reduce the impact of heteroscedasticity, we perform logarithmic processing on the EI, GPR and EPU data. We observe the raw data and perform wavelet decomposition[7] to GPR and EPU. The result of wavelet decomposition is shown in Figs. 3 and 4. This process can eliminate signal noise and decompose the GPR and EPU into short- medium- and long-term, which allows the testing of the results for different lengths of time and drawing robust conclusions separately [77]. In the empirical part, we study the original sequences of GPR and EPU and the sequences after wavelet decomposition, and examine the relationship between them and EI. At the same time, we use the QQ method. Therefore, the comprehensive relationship between the variables can be discussed. Finally, we compare the results of QQ and quantile regression, and this robustness test method helps us improve the conclusion's reliability.

6. Empirical results

We can measure the comprehensive relationship among the quantile

[4] The information about GPR and EPU can be obtained at the website (http://policyuncertainty.com/).
[5] The data of ER comes from the website (https://cn.investing.com/).
[6] The data of PMI comes from the website (https://www.stats.gov.cn/).

[7] The GPR and EPU indexes are decomposed into three distinct frequencies using wavelet decomposition methodology, which is 2–4, 8–16, and 32–64, representing the short-, medium-, and long-term, respectively.

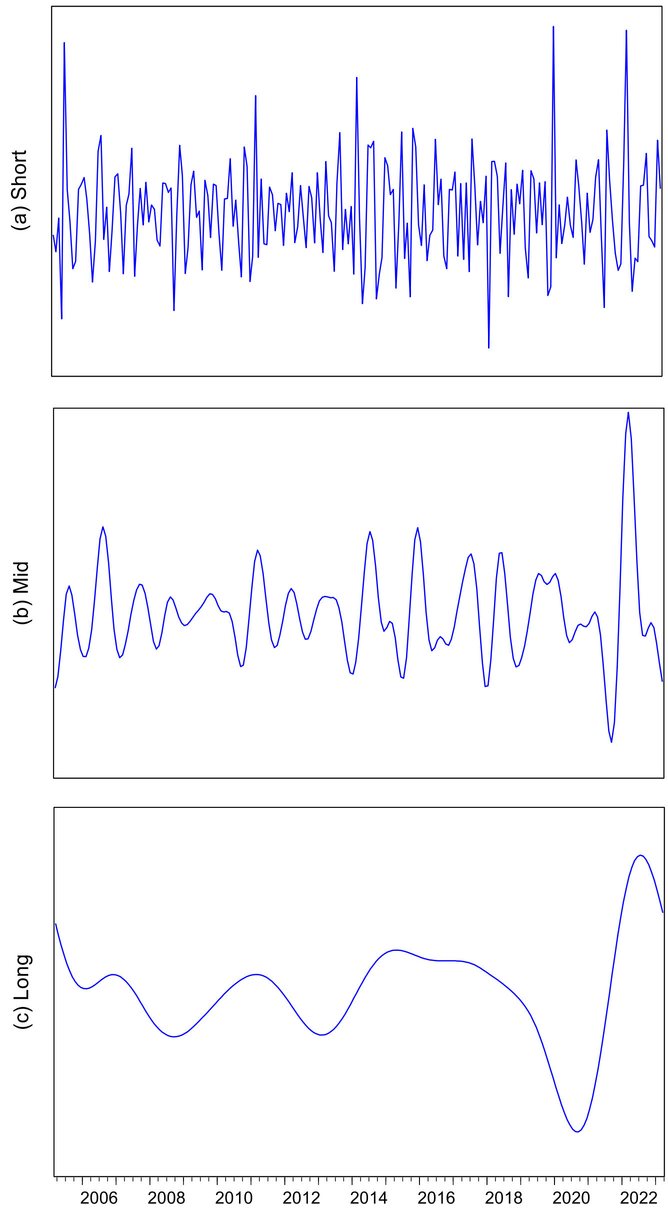

Fig. 3. Time series of GPR that proceeds wavelet decomposition.

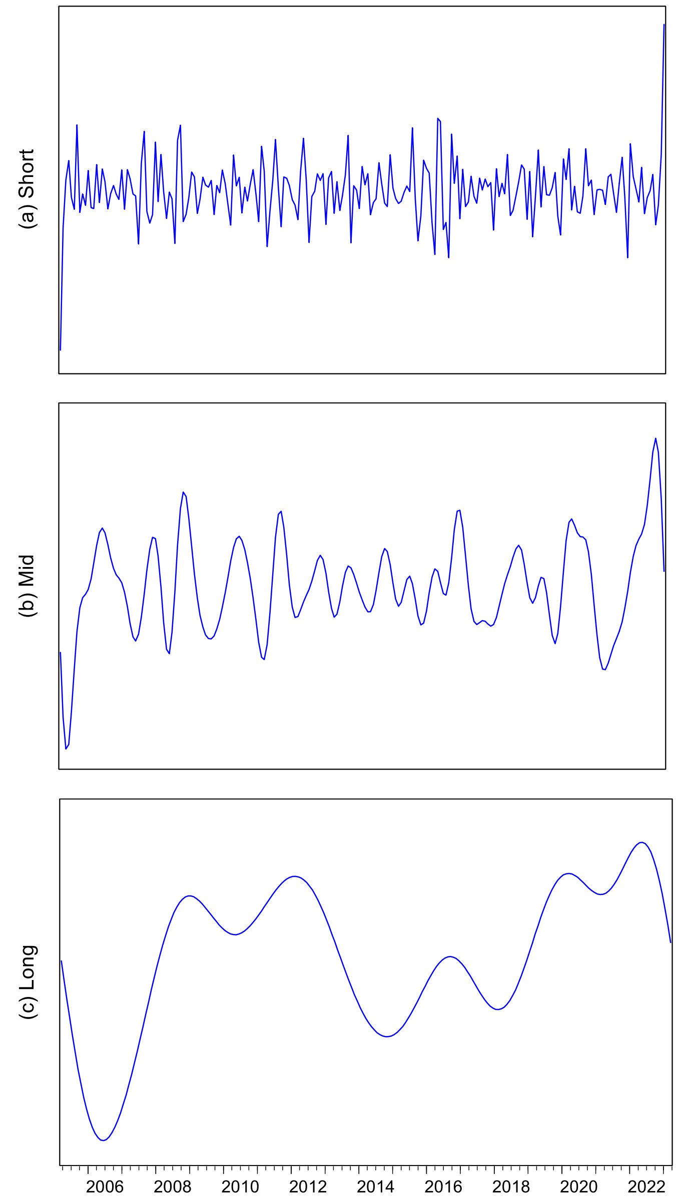

Fig. 4. Time series of EPU that proceeds wavelet decomposition.

of GPR, EPU and EI based on Equation (4), in which the terms of intercept, β_1 (τ, θ) and β_0 (τ, θ) can be defined by two primary parameters. Variations in all factors are related to different GPR, EPU and EI values because they are functions that include the θ and the τ. We evaluate the original time series and the data after the wavelet decomposes based on the QQ method referred to above. Z-axis values identify the impact of GPR and EPU on EI at each quantile with different coefficients. It confirms that the correlation between EI and other influencing factors changes in different time scales. Simultaneously, the resulting robustness can be tested by comparing quantile regression and QQ. We average the parameters of QQ, as $\frac{1}{y}\hat{\beta}_1(\phi, \tau)$ shown, where y is the value of the quantile, and this operation makes the results of QQ can be compared to the quantile regression [90]. This part of the results will be described later. Due to the influence of noise, the results of the two test methods may slightly differ. Furthermore, in order to obtain a comprehensive conclusion, we add the ER and PMI as control variables, respectively.[8]

Fig. 5(a) depicts the effect of GPR on EI in raw data. Lower quantiles are frequently associated with lower values, and the reverse is also true [91]. The results demonstrate that GPR can lower China's overall energy imports, particularly at the mid to high quantiles (0.6–1). This result is in line with the above theoretical mechanism, which means that, on the whole, the more intense geopolitical crisis has a more obvious inhibitory effect on EI. The raw data cannot clearly represent the link between the two variables. We employ Wavelet decomposition to divide the GPR time series into short, medium, and long terms, Fig. 5(b–d) shows the relationship between processed GPR and EI. Fig. 5(b) shows the impact of short-term GPR on EI. The middle and high quantiles of GPR (0.3–0.4, 0.5–0.6, 0.7–0.8) have an almost overall negative effect on EI. This means that GPR, to a high degree, has an inhibitory effect on EI. A growth in GPR can explain why this has an increasing impact on energy

[8] The results are very close after control variables are added, due to space constraints, we do not show the results after adding ER and PMI.

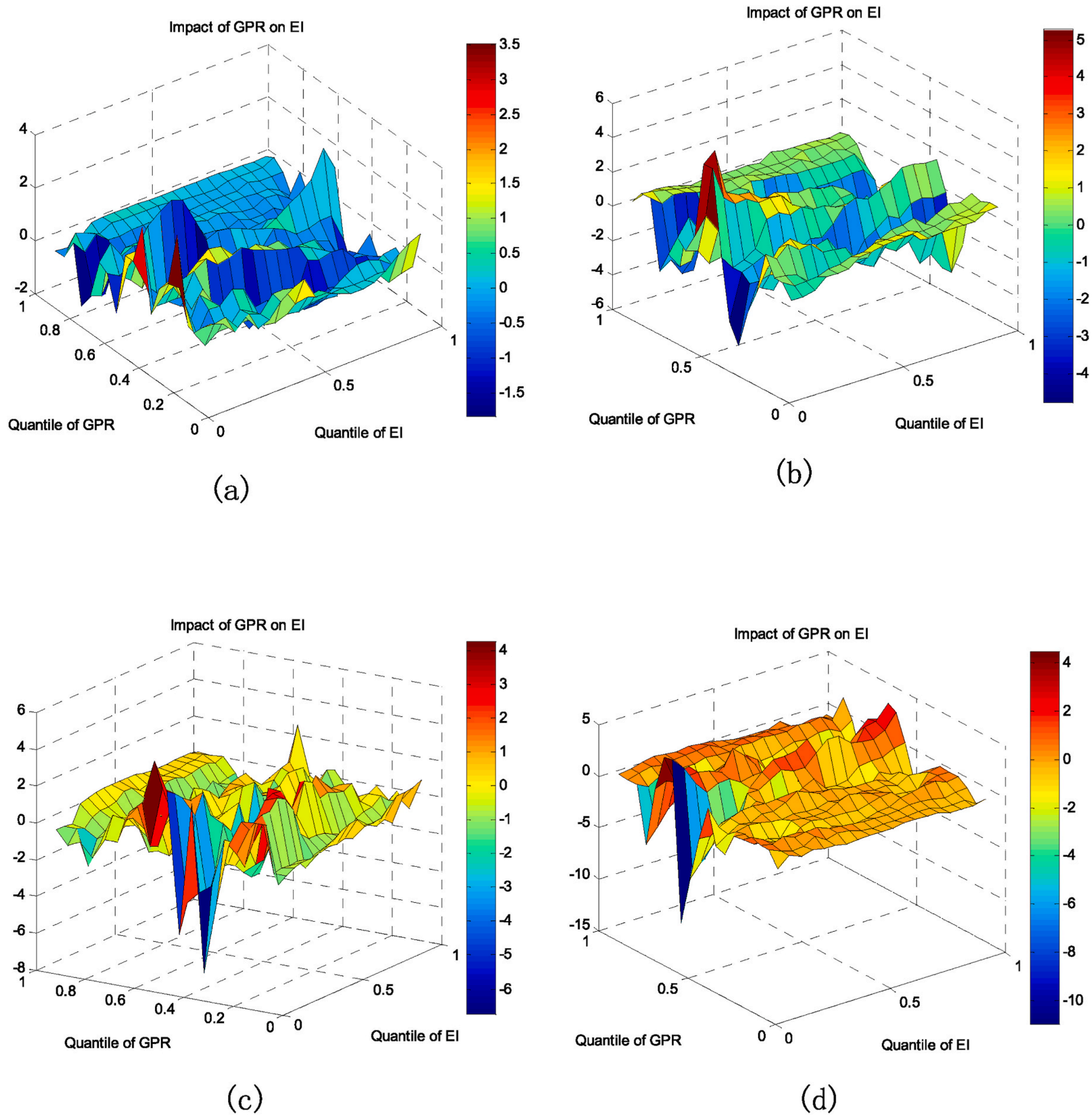

Fig. 5. The coefficients between GPR and EI (The z-axis represents the influence coefficient).

production, international transportation, and the import demand of energy-importing countries, resulting in a decrease in energy imports [23]. This result is in line with the interaction mechanism of the impact of external uncertainty on energy imports. The issue can be explained from an energy supply perspective. Libya is an important energy partner for China; however, its crude oil production suffered a setback during the war in 2011 [92]. According to the Organization of the Petroleum Exporting Countries (OPEC) figures, before January 2011, Libya's crude oil production was 1.6 million barrels per day, but as a result of the war, production plummeted from 375,000 barrels per day in March to only 7000 barrels per day in July. Almost simultaneously, international crude oil prices skyrocket, and the price of natural gas also increases significantly in the short term; this has seriously affected China's EI [23,93,94]. Similarly, the Russia-Ukraine conflict in 2022 has a significant impact on Russia's natural gas exports, while it supplies 19 % of the world's natural gas as a prominent natural gas exporter, this geopolitical conflict also brings changes to China's EI [15]. Furthermore, the mid-term conclusion shown in Fig. 5(c) cannot detect a significant negative impact of GPR on EI, and the long-term demonstrated by Fig. 5 (d) also confirms that GPR has only a short-term impact on EI. This conclusion coincides with the viewpoint of Yang et al. [50] and Zhao [52], which only supports the short-term effect of external uncertainty on energy markets. In the long run, with the implementation of the market stability policy, the market is adjusted, and with the development of financial market confidence, market attitude is alleviated, so import demand should increase [23]. Similarly, Li et al. [31] examine the effect of GPR on energy trade in samples of emerging economies, including China, and think that the inhibitory impact of geopolitical risks on energy imports in emerging economies can disappear within approximately 12–13 months. The above conclusion also demonstrates the reliability of our view.

We can verify the robustness of the conclusion by comparing the results of QQ with quantile regression, as shown in Fig. 6(a–d). This indicates that the results of the two methods are very similar, which reflects that our results are robust. Even if we cannot detect the long-term negative impact of GPR on EI because geopolitical conflicts are a negative factor in energy production and transportation and affect energy demand in various ways, GPR has a significant negative impact on

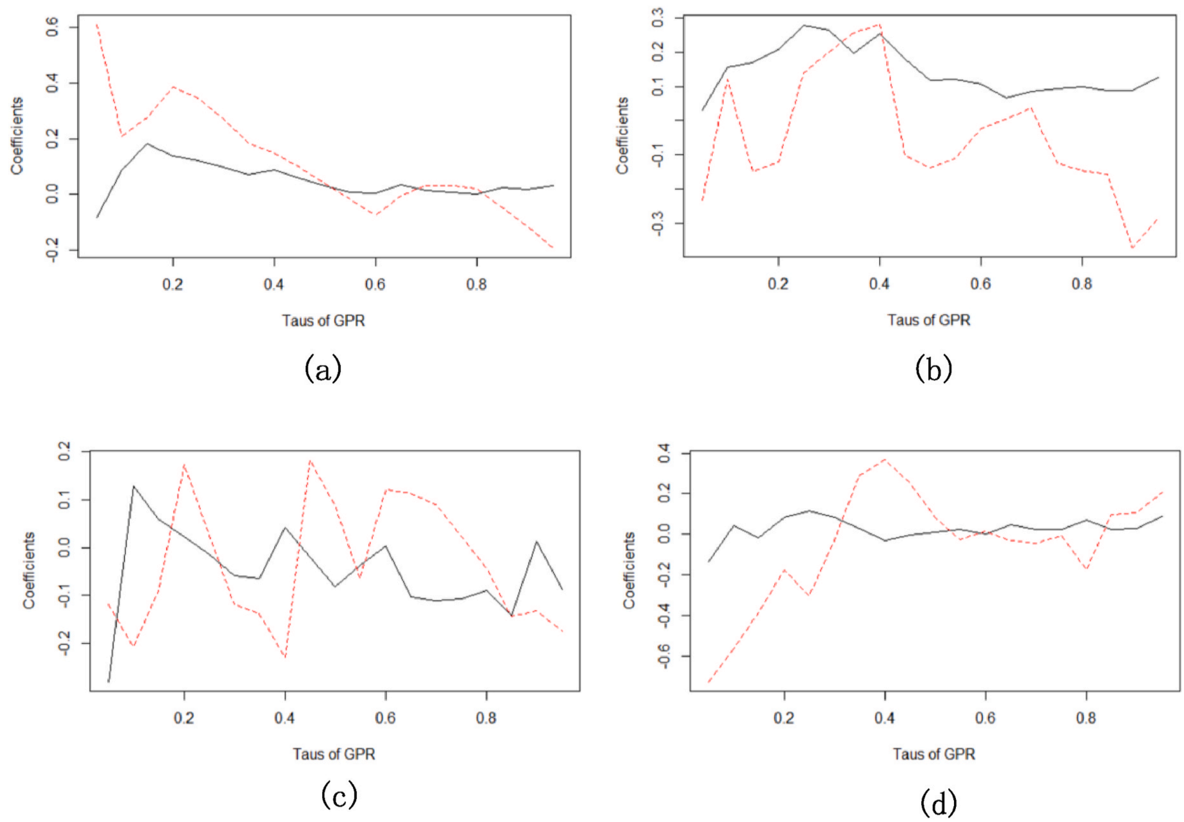

Fig. 6. Quantile Regression (the black line) and QQ estimates (the red line) between GPR and EI.

EI in the short term. After controlling for the effects of ER and PMI separately, we obtain consistent conclusions supported by the influence mechanism of external uncertainty on energy imports.

EPU is indispensable in international energy trade and is crucial for EI. Fig. 7(a) depicts the effect of raw data EPU on EI. However, Fig. 7(a) shows a constantly changing trend. The analysis of the original data shows that the relationship between EPU and EI presents different characteristics in different periods. This conclusion can be accepted, and some studies have shown that the relationship between EPU and the energy market is time-varying [32,95]. In order to verify the relationship between them more fully, we further analyse the results after wavelet decomposition. The influence of short-term EPU on EI is depicted in Fig. 7(b), and we discover that EPU in higher quantiles (0.75–0.9) negatively affects EI during the whole period. The short-term findings document a significant suppression of China's EI under dramatic EPU. Similar results appeared in the medium term depicted in Fig. 7(c); we can still see the negative impact of EPU in higher quantiles (0.65–0.7, 0.8–1) on the overall EI (0–1). The above results are reasonable because the EPU's influences on the international trade participant's decisions and possible impacts on currency and inflation rates it is commonly viewed as a significant source of uncertainty in international trade [4,23,24]. Because high quantiles often represent the trend of worsening EPU, the results also indicate that energy imports have been significantly suppressed under high EPU. In this regard, Wang et al. [54] confirm that EPU has overall reduced China's energy consumption; this allows us to explain this phenomenon from a demand perspective through the theoretical mechanisms above mentioned. The extreme EPU affects the socio-economic operation, reduces enterprises' energy demand, and decreases EI. The Sino-U.S. trade war occurred in 2018, with both sides resorting to tariff penalties and significantly increasing EPU. That is believed to have caused a shock in China's energy imports, which coincides with our result [31]. However, in the long-term impact shown by Fig. 7(d), we observe fluctuations on the high quantile (0.7–1). We discover an overall positive effect of EPU on EI at the high quantile of EPU (0.8–1). There is no evidence of negative effects of EPU on EI. This result is different from Sharma et al. [24], which supports the long-term negative impact of EPU on trade. Song et al. [23] support the conclusion to a certain extent when examining China's energy import costs; in contrast to the short to medium-term situation, economic policymakers and market participants generally make corresponding adjustments to adapt to the market in the long run. Similarly, Jalal et al. [43] also embrace the view that expanding economic and monetary policies leads to the long-term positive impact of EPU on EI; for example, the economic stimulus policies after the financial crisis led to an increase in energy imports. In this regard, favourable economic policies enhance EI and improve energy security, and implementing China's Belt and Road policy may help ease its dilemma [96]. In 2015, China imported 4372.1 million tons of standard coal from countries along "the Belt and Road", and the level of guarantee provided by these countries for China's energy security was 58.42 % [39].

Fig. 8(a–d) describes the comparison results of QQ and quantile regression, proving our results are robust. The results reveal that EPU can suppress EI in the short and medium term and tends to play a role in the high quantile while it may have a long-term positive impact on China's EI. After adding ER and PMI, respectively, our conclusions remain unchanged. Compared with GPR, EPU has a longer effect and is more inclined to shock the EI in extreme events such as the Sino-U.S. trade war, but the results for both groups of variables deny their long-term negative impact on the EI of China. In summary, we have drawn a more comprehensive conclusion since we have separately considered the relationship among GPR, EPU and EI in different quantiles and over different periods. Meanwhile, this result has a higher reference value and practical significance because we focus on the real energy access situation. The above results verify the harm of external uncertainty to energy supply and further prove the positive impact of appropriate policy adjustments on EI, which helps to maintain China's energy

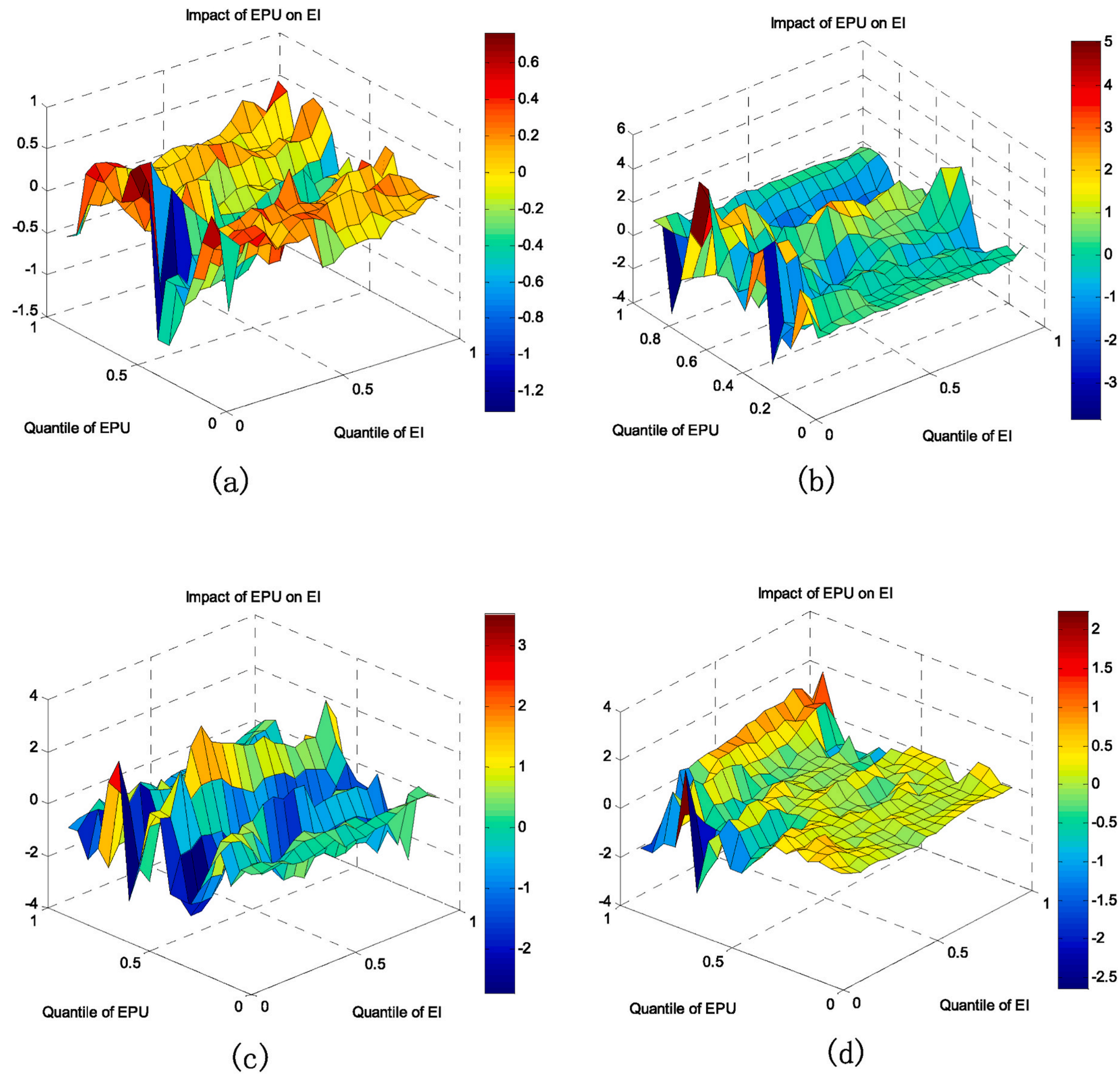

Fig. 7. The coefficients between EPU and EI (The z-axis represents the influence coefficient).

security by preventing and resolving major risks and responding effectively to external environmental changes [54,97].

7. Conclusions and policy implications

7.1. Conclusions

In the past, although there was a lot of literature concerned about the energy market, they mainly studied indirect factors such as price that may affect EI, while direct studies on the relationship between uncertainty risk and EI were relatively lacking. Moreover, their exact relationship is difficult to judge due to the lack of evidence of the connection between the two in different time periods and time domains. Therefore, we first use wavelet decomposition to decompose the GPR and EPU into short-, medium- and long-term series, respectively, and then use quantile-on-quantile regression to explore their specific connections. We find that both GPR and EPU can reduce EI to a certain extent, which is consistent with the interaction mechanism of external uncertainties and energy imports. However, from the perspective of different periods, EPU not only inhibits EI in the short term but also has a significant inhibitory effect in the medium term, so the negative effects of EPU on EI may be longer than GPR. As the time scale lengthens, in the long run, EPU positively impacts EI, which is consistent with Jalal et al. [43] and Song et al. [23], that support EI can rise with market and policy adjustments. In addition, the impact of EPU on EI is mainly concentrated in the high quantile, which confirms the effects of extreme events on EI.

7.2. Policy implications

In light of the above results, the following implications are presented. Firstly, China should take the Belt and Road policy as an opportunity to deepen energy cooperation with countries under this framework and build a diversified overseas energy procurement system. Secondly, as extreme events can have a significant adverse impact on EI in the short term, the Chinese government should increase its energy emergency reserves and improve its ability to respond to emergencies. Thirdly, national energy sectors should establish long-term energy cooperation with relevant countries to reduce uncertainty, and the government must adjust its strategy promptly when problems arise in the energy market. Fourthly, the country should develop its energy to alleviate the energy dilemma, especially in the oil and gas field, as external uncertainty can be transmitted from changes in overseas energy production to EI [98].

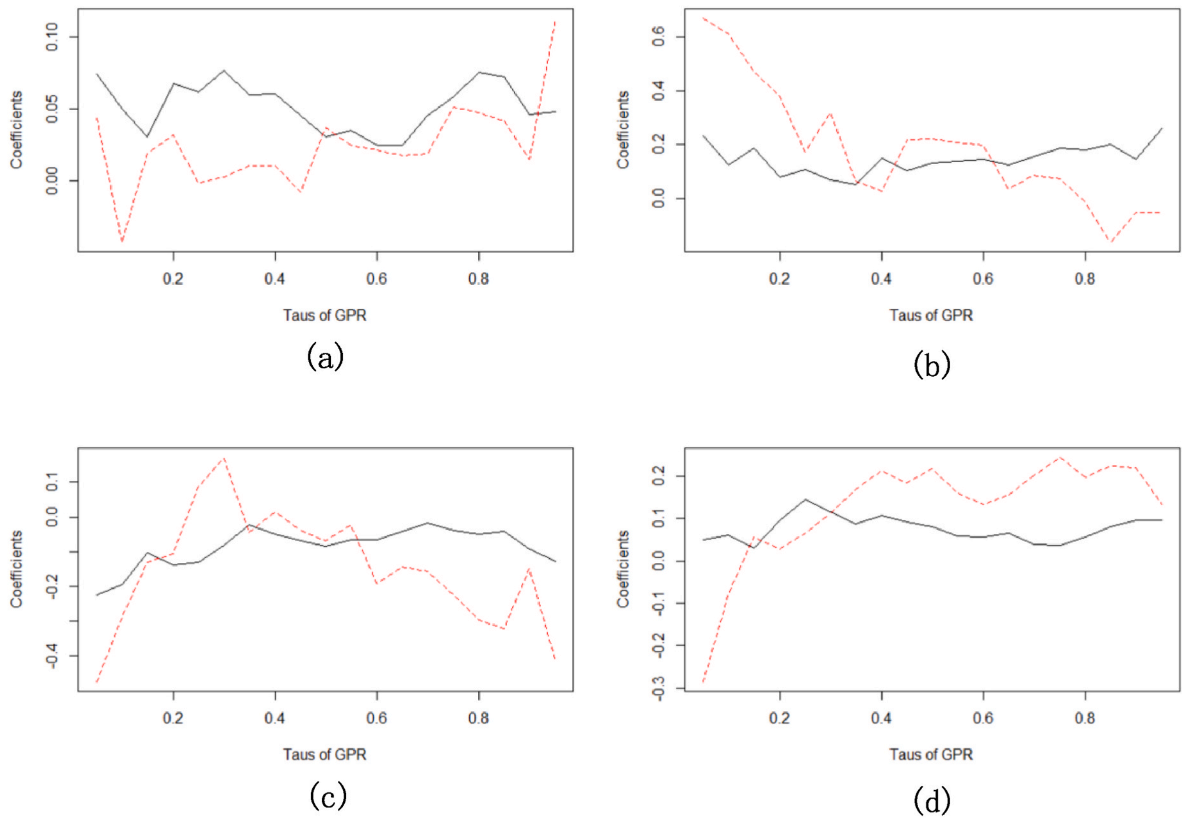

Fig. 8. Quantile Regression (the black line) and QQ estimates (the red line) between EPU and EI.

7.3. Limitations and future directions

This paper has some shortcomings that need to be remedied in future studies. Firstly, we have neglected to distinguish between fossil and renewable energy sources, which may lead to heterogeneous results due to the differences in their endowment qualities. In addition, this study can be extended to a larger number of countries to reveal differences in the response to external uncertainty across different types of countries.

CRediT authorship contribution statement

Chi-Wei Su: Data curation, Conceptualization. **Shengyao Yang:** Writing – original draft, Visualization. **Adelina Dumitrescu Peculea:** Investigation, Methodology. **Teodora Ioana Biţoiu:** Resources, Writing – review & editing. **Meng Qin:** Resources, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

[1] Su CW, Khan K, Umar M, Zhang W. Does renewable energy redefine geopolitical risks? Energy Pol 2021;158:112566.
[2] Wang KH, Su CW, Umar M. Geopolitical risk and crude oil security: a Chinese perspective. Energy 2021;219:119555.
[3] Carney Mark. Uncertainty, the economy and policy. London: Speech, Bank of England; 2016. June 30.
[4] Al-Thaqeb SA, Algharabali BG. Economic policy uncertainty: a literature review. J Econ Asymmetries 2019;20:e00133.
[5] Zhou E, Wang X. Dynamics of systemic risk in European gas and oil markets under the Russia–Ukraine conflict: a quantile regression neural network approach. Energy Rep 2023;9:3956–66.
[6] Bouoiyour J, Selmi R, Hammoudeh S, Wohar ME. What are the categories of geopolitical risks that could drive oil prices higher? Acts or threats? Energy Econ 2019;84:104523.
[7] Gong X, Sun Y, Du Z. Geopolitical risk and China's oil security. Energy Pol 2022;163:112856.
[8] De Rosa M, Gainsford K, Pallonetto F, Finn DP. Diversification, concentration and renewability of the energy supply in the European Union. Energy 2022;253:124097.
[9] Barlow P, van Schalkwyk MC, McKee M, Labonté R, Stuckler D. COVID-19 and the collapse of global trade: building an effective public health response. Lancet Planet Health 2021;5(2):e102–7.
[10] Fang Y, Shao Z. The Russia-Ukraine conflict and volatility risk of commodity markets. Finance Res Lett 2022;50:103264.
[11] Umar M, Riaz Y, Yousaf I. Impact of Russian-Ukraine war on clean energy, conventional energy, and metal markets: evidence from event study approach. Resour Pol 2022;79:102966.
[12] Su CW, Qin M, Chang HL, Ţăran AM. Which risks drive European natural gas bubbles? Novel evidence from geopolitics and climate. Resour Pol 2023;81:103381.
[13] Qin M, Hu W, Qi X, Chang T. Do the benefits outweigh the disadvantages? Exploring the role of artificial intelligence in renewable energy. Energy Econ 2024;131:107403.
[14] Qin M, Su AH, Li R, Su CW. Speculation, climate or pandemic: who drives the Chinese herbal medicine bubbles? China Econ Rev 2024;102213.
[15] Orhan E. The effects of the Russia-ukraine war on global trade. Journal of International Trade, Logistics and Law 2022;8:141–6.
[16] Shen L, Hong Y. Can geopolitical risks excite Germany economic policy uncertainty: rethinking in the context of the Russia-Ukraine conflict. Finance Res Lett 2023;51:103420.
[17] Baker SR, Bloom N, Davis SJ. Measuring economic policy uncertainty. Q J Econ 2016;131(4):1593–636.
[18] Caldara D, Iacoviello M. Measuring geopolitical risk. Am Econ Rev 2022;112(4):1194–225.
[19] Cui L, Yue S, Nghiem XH, Duan M. Exploring the risk and economic vulnerability of global energy supply chain interruption in the context of Russo-Ukrainian war. Resour Pol 2023;81:103373.
[20] Meyer KE, Fang T, Panibratov AY, Peng MW, Gaur A. International business under sanctions. J World Bus 2023;58(2):101426.

[21] Kisswani KM, Elian MI. Analyzing the (a)symmetric impacts of oil price, economic policy uncertainty, and global geopolitical risk on exchange rate. J Econ Asymmetries 2021;24:e00204.
[22] Wang Y, Wei M, Bashir U, Zhou C. Geopolitical risk, economic policy uncertainty and global oil price volatility —an empirical study based on quantile causality nonparametric test and wavelet coherence. Energy Strategy Rev 2022;41:100851.
[23] Song Y, Zhang X, Hu G. Relationships among geopolitical risk, trade policy uncertainty, and crude oil import prices: evidence from China. Resour Pol 2023;82: 103555.
[24] Sharma C, Paramati SR. Does economic policy uncertainty dampen imports? Commodity-level evidence from India. Econ Modell 2021;94:139–49.
[25] Qin M, Su CW, Wang Y, Doran NM. Could "digital gold" resist global supply chain pressure? Technol Econ Dev Econ 2024;30(1):1–21.
[26] Su CW, Liu X, Qin M, Umar M. Is the uncertainty economic policy an impediment or an impetus to technological innovation? Emerg Mark Finance Trade 2024;1–15.
[27] Su CW, Lv S, Qin M, Norena-Chavez D. Uncertainty and credit: the chicken or the egg causality dilemma. Emerg Mark Finance Trade 2024:1–19.
[28] Su CW, Yang S, Ren YS. Economic policy uncertainty and company stock prices: empirical evidence from blockchain companies. Finance Res Lett 2024;65:105547.
[29] Hassan S, Shabi S, Choudhry T. Asymmetry, uncertainty and international trade. 2018. No. 2018-24.
[30] Khan K, Su CW, Tao R, Umar M. How do geopolitical risks affect oil prices and freight rates? Ocean Coast Manag 2021;215:105955.
[31] Li F, Yang C, Li Z, Failler P. Does geopolitics have an impact on energy trade? Empirical research on emerging countries. Sustainability 2021;13(9):5199.
[32] Lyu Y, Tuo S, Wei Y, Yang M. Time-varying effects of global economic policy uncertainty shocks on crude oil price volatility: new evidence. Resour Pol 2021;70: 101943.
[33] Ivanovski K, Hailemariam A. Time-varying geopolitical risk and oil prices. Int Rev Econ Finance 2022;77:206–21.
[34] Sun YF, Yu S, Zhang YJ, Su B. How do imports change the energy consumption of China? An analysis of its role in intermediate inputs and final demands. Energy 2023;270:126947.
[35] Zou C, Pan S, Hao Q. On the connotation, challenge and significance of China's "energy independence" strategy. Petrol Explor Dev 2020;47(2):449–62.
[36] Wang KH, Xiong DP, Mirza N, Shao XF, Yue XG. Does geopolitical risk uncertainty strengthen or depress cash holdings of oil enterprises? Evidence from China. Pac Basin Finance J 2021;66:101516.
[37] Yu LL, Li Z. Research on China's energy external dependence and energy strategy. E3S Web of Conferences 2021;245:01047.
[38] Qin M, Su CW, Qiu L, Lobonţ OR. Are there digital tech bubbles in China? Technol Econ Dev Econ 2024;30(3):603–26.
[39] Zhao Y, Liu X, Wang S, Ge Y. Energy relations between China and the countries along the Belt and Road: an analysis of the distribution of energy resources and interdependence relationships. Renew Sustain Energy Rev 2019;107:133–44.
[40] Bega F, Lin B. China's belt & road initiative energy cooperation: international assessment of the power projects. Energy 2023;270:126951.
[41] Zhang Z, Wang Y, Xiao J, Zhang Y. Not all geopolitical shocks are alike: identifying price dynamics in the crude oil market under tensions. Resource Policy 2023;80: 103238.
[42] Qin M, Zhu Y, Xie X, Shao X, Lobonţ OR. The impact of climate risk on technological progress under the fourth industrial era. Technol Forecast Soc Change 2024;202:123325.
[43] Jalal R, Gopinathan R. Time-frequency relationship between energy imports, energy prices, exchange rate, and policy uncertainties in India: evidence from wavelet quantile correlation approach. Finance Res Lett 2023:103980.
[44] Lin B, Wang T. Forecasting natural gas supply in China: production peak and import trends. Energy Pol 2012;49:225–33.
[45] Xu HC, Wang ZY, Jawadi F, Zhou WX. Reconstruction of international energy trade networks with given marginal data: a comparative analysis. Chaos, Solit Fractals 2023;167:113031.
[46] Wang M, Su Y. How Russian-Ukrainian geopolitical risks affect Chinese commodity and financial markets? Finance Res Lett 2023;56:104179.
[47] Michail NA, Melas KD. Geopolitical risk and the LNG-LPG trade. Peace Econ Peace Sci Publ Pol 2022;28(3):243–65.
[48] Zheng S, Zhou X, Tan Z, Zhang H, Liu C, Hao H, Hu H, Cai X, Yang H, Luo W. Preliminary study on the global impact of sanctions on fossil energy trade: based on complex network theory. Energy for Sustainable Development 2022;71:517–31.
[49] Zhao W, Zhong R, Sohail S, Majeed MT, Ullah S. Geopolitical risks, energy consumption, and CO2 emissions in BRICS: an asymmetric analysis. Environ Sci Pollut Control Ser 2021;28(29):39668–79.
[50] Yang C, Niu Z, Gao W. The time-varying effects of trade policy uncertainty and geopolitical risks shocks on the commodity market prices: evidence from the TVP-VAR-SV approach. Resour Pol 2022;76:102600.
[51] Barbieri K, Levy JS. Sleeping with the enemy: the impact of war on trade. J Peace Res 1999;36(4):463–79.
[52] Zhao J. Time-varying impact of geopolitical risk on natural resources prices: evidence from the hybrid TVP-VAR model with large system. Resour Pol 2023;82: 103467.
[53] Zhang HY, Ji Q, Fan Y. An evaluation framework for oil import security based on the supply chain with a case study focused on China. Energy Econ 2013;38:87–95.
[54] Wang F, Wu M. How does trade policy uncertainty affect China's economy and energy? J Environ Manag 2023;330:117198.
[55] Qamruzzaman M, Karim S, Jahan I. Nexus between economic policy uncertainty, foreign direct investment, government debt and renewable energy consumption in 13 top oil importing nations: evidence from the symmetric and asymmetric investigation. Renew Energy 2022;195:121–36.
[56] Dagar V, Dagher L, Rao A, Doytch N, Kagzi M. Economic policy uncertainty: global energy security with diversification. Econ Anal Pol 2024;82:248–63.
[57] Yang L. Connectedness of economic policy uncertainty and oil price shocks in a time domain perspective. Energy Econ 2019;80:219–33.
[58] Ahmed MY, Sarkodie SA. COVID-19 pandemic and economic policy uncertainty regimes affect commodity market volatility. Resour Pol 2021;74:102303.
[59] Yang L, Hamori S. Systemic risk and economic policy uncertainty: international evidence from the crude oil market. Econ Anal Pol 2021;69:142–58.
[60] Mohideen MM, Ramakrishna S, Prabu S, Liu Y. Advancing green energy solution with the impetus of COVID-19 pandemic. J Energy Chem 2021;59:688–705.
[61] Cheng NFL, Hasanov AS, Poon WC, Bouri E. The US-China trade war and the volatility linkages between energy and agricultural commodities. Energy Econ 2023;120:106605.
[62] Li F, Song Z, Liu W. China's energy consumption under the global economic crisis: decomposition and sectoral analysis. Energy Pol 2014;64:193–202.
[63] Li X, Li Z, Su CW, Umar M, Shao X. Exploring the asymmetric impact of economic policy uncertainty on China's carbon emissions trading market price: do different types of uncertainty matter? Technol Forecast Soc Change 2022;178:121601.
[64] Yang Z, Hong J. Trade policy uncertainty and energy intensity: evidence from Chinese industrial firms. Energy Econ 2021;103:105606.
[65] Kilian L. Not all oil price shocks are alike: disentangling demand and supply shocks in the crude oil market. Am Econ Rev 2009;99(3):1053–69.
[66] Joëts M. Heterogeneous beliefs, regret, and uncertainty: the role of speculation in energy price dynamics. Eur J Oper Res 2015;247(1):204–15.
[67] Alqahtani A, Bouri E, Vo XV. Predictability of GCC stock returns: the role of geopolitical risk and crude oil returns. Econ Anal Pol 2020;68:239–49.
[68] Chen SS, Hsu KW. Reverse globalization: does high oil price volatility discourage international trade? Energy Econ 2012;34(5):1634–43.
[69] Cunado J, Gupta R, Lau CKM, Sheng X. Time-varying impact of geopolitical risks on oil prices. Defence Peace Econ 2020;31(6):692–706.
[70] Zhang YJ, Yan XX. The impact of US economic policy uncertainty on WTI crude oil returns in different time and frequency domains. Int Rev Econ Finance 2020;69: 750–68.
[71] Benlagha N, Karim S, Naeem MA, Lucey BM, Vigne SA. Risk connectedness between energy and stock markets: evidence from oil importing and exporting countries. Energy Econ 2022;115:106348.
[72] Blomberg SB, Harris ES. The commodity-consumer price connection: fact or fable? Economic Policy Review 1995;1(3).
[73] Chen YC, Rogoff KS, Rossi B. Can exchange rates forecast commodity prices? Q J Econ 2010;125(3):1145–94.
[74] Lin B, Chen G. Energy efficiency and conservation in China's manufacturing industry. J Clean Prod 2018;174:492–501.
[75] Lin B, Su T. Monetary policy drives economic prosperity: innegligible influence of energy. 2021.
[76] Sim N, Zhou H. Oil prices, US stock return, and the dependence between their quantiles. J Bank Finance 2015;55:1–8.
[77] Umar M, Su CW, Rizvi SKA, Shao XF. Bitcoin: a safe haven asset and a winner amid political and economic uncertainties in the US? Technol Forecast Soc Change 2021; 167:120680.
[78] Su CW, Wei S, Wang Y, Tao R. How does climate policy uncertainty affect the carbon market? Technol Forecast Soc Change 2024;200:123155.
[79] Khan K, Su CW, Zhu MN. Examining the behaviour of energy prices to COVID-19 uncertainty: a quantile on quantile approach. Energy 2022;239:122430.
[80] Gencay R, Selcuk, Whitcher B. An introduction to wavelets and other filtering methods in finance and economics. San Diego, CA: Academic Press; 2002.
[81] Frei CW. The Kyoto protocol—a victim of supply security?: or: if Maslow were in energy politics. Energy Pol 2004;32(11):1253–6.
[82] Zeileis A, Shah A, Patnaik I. Testing, monitoring, and dating structural changes in exchange rate regimes. Comput Stat Data Anal 2010;54(6):1696–706.
[83] Bahgat G. The impact of the Arab spring on the oil and gas industry in North Africa–a preliminary assessment. J N Afr Stud 2012;17(3):503–14.
[84] Ali I, Harvie C. Oil and economic development: Libya in the post-Gaddafi era. Econ Modell 2013;32:273–85.
[85] Jebabli I, Kouaissah N, Arouri M. Volatility spillovers between stock and energy markets during crises: a comparative assessment between the 2008 global financial crisis and the COVID-19 pandemic crisis. Finance Res Lett 2022;46:102363.
[86] Muinzer TL, Jenkins KE, McCauley DA, Little GM. Energy justice beyond borders? Exploring the impact of Brexit on Ireland's all-island energy market. Electr J 2022; 35(10):107218.
[87] Chaziza M. The impact of US sanctions on Iran's engagement and integration in the Belt and Road Initiative. Digest of Middle East Studies 2020;29(2):167–82.
[88] Jiang P, Van Fan Y, Klemeš JJ. Impacts of COVID-19 on energy demand and consumption: challenges, lessons and emerging opportunities. Applied energy 2021;285:116441.
[89] Caldara D, Iacoviello M. Measuring geopolitical risk. International Finance Discussion Paper, 2018 2018;(1222):1–66.
[90] Qin M, Su CW, Umar M, Lobonţ OR, Manta AG. Are climate and geopolitics the challenges to sustainable development? Novel evidence from the global supply chain. Econ Anal Pol 2023;77:748–63.
[91] Razzaq A, Wang YF, Chupradit S, Suksatan W, Shahzad F. Asymmetric inter-linkages between green technology innovation and consumption-based carbon emissions in BRICS countries using quantile-on-quantile framework. Technol Soc 2021;66:101656.

[92] Liao S, Wang F, Wu T, Pan W. Crude oil price decision under considering emergency and release of strategic petroleum reserves. Energy 2016;102:436–43.
[93] Verleger PK. Rising crude oil prices: the link to environmental regulations. Bus Econ 2011;46(4):239–48.
[94] Nick S, Thoenes S. What drives natural gas prices? — a structural VAR approach. Energy Econ 2014;45:517–27.
[95] Li ZZ, Su CW, Moldovan NC, Umar M. Energy consumption within policy uncertainty: considering the climate and economic factors. Renew Energy 2023; 208:567–76.
[96] Madani S. The BRI and its implications for China's energy security: the four as model perspective. Int J Energy Econ Pol 2021;11(4):549–59.
[97] Ang BW, Choong WL, Ng TS. Energy security: definitions, dimensions and indexes. Renewable and sustainable energy reviews 2015;42:1077–93.
[98] Mănescu CB, Nuno G. Quantitative effects of the shale oil revolution. Energy Pol 2015;86:855–66.