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OIL PRICE SHOCKS, ECONOMIC POLICY UNCERTAINTY, AND GREEN FINANCE: A CASE OF CHINA

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Abstract. This study investigates the long- and short-run effects of crude oil price (COP) and economic policy uncertainty (EPU) on China's green bond index (GBI) using the quantile autoregressive distributed lag model. The empirical results show that COP and EPU produce a significant positive and negative influence on GBI in the long-run across most quantiles, respectively, but their short-run counterparts are opposite direction and only significant in higher quantiles. Thus, major contributions are made accordingly and shown in the following aspects. The findings emphasise the importance of understanding how COP and EPU affect China's green bond market for the first time. In addition, both the long- and short-run effects are captured, but long-run shocks primarily drive the green bond market. Finally, time- and quantile-varying analyses are adopted to explain the nexus between COP and EPU to GBI, which considers not only different states of the bond market but also events that occur in different time periods. Some detailed policies, such as a unified and effective green bond market, an early warning mechanism of oil price fluctuation, and prudent economic policy adjustments, are beneficial for stabilising the green finance market.

Keywords: green bond index, crude oil price, economic policy uncertainty, quantile autoregressive distributed lag model.

JEL Classification: C51, E60, Q43.

Introduction

Oil is one of most essential raw materials, it promotes the industrialization process, but triggers concerns related to environmental issues (Chen et al.,2015; Jia et al., 2021). With the growing financial attribute of crude oil, it has been an important influencing factor in

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developing green finance (Balcilar et al., 2020; Lee et al., 2022a). Thus, the linkage between green finance and crude oil price is important and worth discussing (Ouyang et al., 2022). The green financial and crude oil markets experienced an unprecedented shock caused by a sharp rise in uncertainty after the COVID-19 pandemic (Devpura & Narayan, 2020). For example, in May 2020, the oil price plunges to below 20 U.S. dollars per barrel, and reaching the lowest in recent four years. Since 2016, China's green bond market has become the world's largest green bond market with rapid development in the short term. In 2019, the total issuance of Chinese green bonds reached USD 55.8 billion, leading to the country's rankings (Liu et al., 2019, 2022). However, in 2020, a total of 215 domestic green bonds were issued, with a total issuance scale of 222.826 billion yuan, a decrease of 20% compared with the previous year. Among them, the decline in green financial bonds is the most obvious, and the issuance scale has decreased by more than 70% compared with 2019. Although the relationship between oil prices and financial markets or macroeconomic variables has been a hot topic for the past few years (Jiang et al., 2020), the discussion of green finance is largely missing (Zhang, 2018; Broadstock & Cheng, 2019). It is important to use green finance to build a green ecotype society and promote environmentally friendly investments (Liu et al., 2022). As a new green investment product, a green bond is representative of green financial instruments aiming to improve environmental and air quality. Green bonds have been becoming popular as a sustainable financial instrument among market participants who are aware of pollution for energy policies and the potential impact of climate conditions (Tolliver et al., 2020). It is important to explore the interaction between crude oil prices and green finance, which can provide the advantage of a diversified portfolio for green investors and stabilise China's green finance market.

This paper conducts an empirical analysis from China's perspective for the following reasons. First, China is increasingly closely associated with the international market, proposing a "dual circulation" development pattern. To be specific, the connection between the related financial markets and the oil market is increasingly close, and the process of global financial marketisation is deepening (Wu et al., 2020; Guo et al., 2022). Volatility in the oil market could undermine the issuance of green bonds by affecting China's investment in green technologies. Second, China plays a leading role in the innovation process of green finance and has made some achievements. In 2015, China pioneered a relatively complete layout of the system of green finance (Wang & Wang, 2021). On this basis, China continues to improve green finance coverage and capital scale (Lv et al., 2021). For example, green bonds covered 16 secondary industries and issued approximately 18 billion U.S. dollars in green bonds, representing more than 40 percent of the global green bonds issued in 2021. In September 2021, the accumulated green credit balance reached 14.1 trillion yuan in China's twenty-one major commercial banks (Shi et al., 2022). Green finance has obvious environmental benefits, which can promote the saving of more than 400 million tons of coal and reduce CO_2 by approximately 700 million tons yearly (Wang & Wang, 2021). Third, movements in oil prices make the effect of green finance uncertain. Given growing concerns about energy security and environmental pollution, the attractiveness and economic viability of green portfolio management can be affected by fluctuations in oil prices, making market participants shifts towards ethical investments (Reboredo, 2018; Kanamura, 2020). For example, the interest and the incentives of green investments will decrease with the large negative fluctuations in the crude oil market. Conversely, the incentives will increase with an upward movement in oil prices, causing a higher price of green products (Dutta et al., 2020). Thus, in order to provide a reference for the policy adjustments in China's green finance market, it is necessary to learn the association between movements in oil prices and China's green finance market dynamics.

The long- and short-run nexus of crude oil price (COP) and economic policy uncertainty (EPU) with green finance presented by the green bond index (GBI) is discussed through the quantile autoregressive distributed lag (QARDL) model. The major empirical results are shown as follows. First, the long-run parameters of crude oil and economic policy uncertainty are found to be significantly positive and negative on GBI across most quantiles. Second, the short-run parameters are less statistically significant than their long-run counterparts in most quantiles, and the influencing direction is the opposite. This demonstrates that the green bond market is not sensitive to temporary policy incentives or breaking news. Third, using rolling window analysis, the time-varying quantile estimates of long- and short-run parameters, including COP and EPU, present heterogeneous impacts on GBI. Last, the locational asymmetry is discovered for COP and EPU through the Wald test in some periods, which means that their impact on China's GBI is quantile-varying in the long term, indicating critically on the state of the green bond market.

The contributions of this research are highlighted when compared to previous literature. First, China is pursuing green development, and green finance has become a national strategy (Ren et al., 2020; Liu & Xiong, 2022). Being different from traditional finance, green finance more focus on environmental benefits, which makes it become a hot issue and an interesting topic. Second, this paper adds COP and EPU to the empirical framework and compares their heterogeneous impact on GBI. The conventional literature commonly investigates the relevant topic from a single aspect (Huang & Yue, 2020; Abbas et al., 2021; Hau et al., 2022). Therefore, this study extends the empirical analysis from multiple aspects for each pair, and finally obtains fresh and comprehensive results. Third, the relationships between GBI and the other two variables of COP and EPU, may be different under different green bond market scenarios, including booms, financial crises, COVID-19 outbreaks, and stability periods. Therefore, this paper refers to Zhan et al. (2021) and Shahzad et al. (2021), and use QARDL method for comparing each pair of GBI-COP and GBI-EPU from quantile-varying, time-varying, short-run, and long-run aspects.

The remainder is as follows. Section 1 is a literature review and hypothesis development. The QARDL model is introduced in Section 2. Section 3 demonstrates data sources and descriptive analysis. Empirical results are shown in Section 4, and the last section presents conclusions and policy implications.

1. Literature review and hypothesis development

1.1. Oil market and green finance

Our study investigates the relationship between the oil market and green finance dynamics that are affected by the increasing awareness of the influence of energy prices on environmental and green investments (Wen et al., 2014; Inchauspe et al., 2015; Sun et al., 2019; Lee et al., 2022b). Bondia et al. (2016) and Broadstock and Cheng (2019) support that the rising oil price increases incentives, leading to increases in the stock price of green investments. Shah et al. (2018) find an important influence of oil price on renewable energy investment in the U.S. and Norway. Park et al. (2020) show that green assets are vulnerable to oil price impacts, and evoked volatility by these impacts is very durable in the green investment market.

With the development of green finance, the connection between green bonds and the oil market has been paid more attention. Broadstock and Cheng (2019) demonstrate that decreasing oil prices irritate oil demand and thus declines the social responsibility incentive for green investment, which results in a decrease in green bond return. Reboredo et al. (2020) discovered that the fluctuations in oil and the equity market have a crucial effect on the net price undulation impacts of the U.S. and European green bonds. Kanamura (2020) explores the dynamic relationships between green bond returns and crude oil price returns, suggesting green bonds have environmental characteristics. Dutta et al. (2020) examine that oil market fluctuation profoundly influences green assets more than volatility in oil prices across their discoveries on green investments. Naeem et al. (2021) investigate an extremely passive tail dependence between green bonds and crude oil, heating oil, and gasoline, suggesting that price movements in the oil market have an adverse impact on green bond reporting. Lee et al. (2021) indicate oil and green bond prices reciprocally influence each other in a way that any fluctuation in oil prices results in variations in green bond prices and vice versa when these markets are in a weak state. Azhgaliyeava et al. (2022) find the effect of oil supply shocks on the green finance market is significant compared with the impact on the non-green finance market. Lee et al. (2022c) show that the unexpected active fluctuations in oil prices result in an elevation in GPR and a decline in green bond returns. Tian et al. (2022) show that oil price impacts are inactively connected with China's green bond returns. On the contrary, some scholars have paid attention to green bonds' effectiveness in hedging energy assets, such as the oil market. Naeem et al. (2021) indicate that the diversified profits of green bonds in a time-varying context, particularly during the COVID-19 outbreak, have triggered unprecedented volatility in crude oil markets, sending WTI crude futures into negative territory for the first time. Li et al. (2022) find that green bonds have the supreme hedging effect against crude oil, which further study indicates that green bonds decline the risk of energy commodities with the very low tail of the return's distribution. In summary, rising oil prices caused by demand-side shocks increase market uncertainty, leading to lower incentives to invest in green bonds markets, thereby reducing their returns. Therefore, we provide the first hypothesis:

H1: Crude oil price would positively influence the green bond market.

1.2. Economic policy uncertainty and green finance

Green bonds are regarded as a possible way to diversify portfolios, and EPU will largely influence investment yields. Some existing studies discuss the influence of EPU indices on green bonds. Tian et al. (2022) find that the asymmetrical effect of Green bonds by EPU is only reflected in China's market. Pham and Nguyen (2022) show that green bonds are significantly affected by financial and EPU during periods of high uncertainty, especially at the beginning of the COVID-19 pandemic. Wang et al. (2022a) study that only when the connections of clean energy and green bonds are in a bull market will they be sustained to the risk of EPU fluctuation. Pham and Cepni (2022) show that EPU, stock market, and oil markets significantly affect the spillovers between green bonds and investor attention. Boutabba and Rannou (2022) investigate that the relationship between green bonds and uncertainty is time-varying, with a rising connection during periods of higher fluctuation of EPU, such as the conflict between Russia and Ukraine. There is also literature that studies the impact of policy changes in China on green bond development. Zhang et al. (2021a) find in 2016, China's government released the "Guidance on Building Green Financial System" to make clear the definition, incentive mechanism, development direction and risk monitoring measures of China's green finance. Yang et al. (2021) indicate that China's government selected five regions, Zhejiang, Jiangxi, Guangdong, Guizhou, and Xinjiang, to accelerate the regional exploration of green finance in 2017. Liu and Xiong (2022) investigate that by the end of 2020, China's stock of green bonds is 813.2 billion yuan, ranking second in the world. In a word, the decline in returns on green bonds is exacerbated by exogenous shocks to the EPU that undermine corporate confidence in investing in green projects (Pirtea et al., 2019). Thus, this paper provides the second hypothesis:

H2: Economic policy uncertainty would negatively affect the green bond market.

2. Quantile ARDL model

As existing tightly link among COP, EPU and GBI, their links may change under different market conditions. Referring to Cho et al. (2015), the QARDL method can meet our needs for discussing long- and short-run linkages with time-varying and quantile-varying characters. In order to better understand the method, this paper first introduces the traditional ARDL method, which is shown as follows:

$$\Delta Y_t = \alpha + \xi\left(Y_{t-1} - \beta X_{t-1}\right) + \sum_{j=1}^{p-1} \lambda_j \Delta Y_{t-j} + \sum_{j=0}^{q-1} \delta_j \Delta X_{t-j} + \varepsilon_t, \tag{1}$$

where Δ means taking the first difference. Y_t and X_t denotes dependent and independent variables, respectively. ε_t denotes an error term, and p and q indicate lag order. α is a constant to represent intercept. ξ and λ express the speed of adjustment to long-run and short-run equilibrium, separately. β and δ are long- and short-run parameters.

The QARDL method combines the conventional ARDL(p, q) process with the quantile regression method. Therefore, the novel QARDL(p, q) is depicted in the following Equation:

$$\Delta Y_t = \alpha(\tau) + \xi(\tau)\left(Y_{t-1} - \beta(\tau) X_{t-1}\right) + \sum_{j=1}^{p-1} \lambda_j(\tau) \Delta Y_{t-j} + \sum_{j=0}^{q-1} \delta_j(\tau) \Delta X_{t-j} + \varepsilon_t(\tau), \tag{2}$$

where τ is the quantile and ranges from (0, 1). As shown in Eq. (2), the long-run and short-run parameters, $\beta(\tau)$ and $\lambda_j(\tau)$, are not constant and can change with different quantiles. The standard Wald test is also utilised to examine the linear assumption for short- and long-run parameters under different quantiles.

According to Eq. (2), the QARDL(p, q) model is described explicitly in the following form:

$$\Delta GBI_t = \alpha(\tau) + \xi(\tau)\left(GBI_t - \beta^{COP}(\tau)COP_{t-1} - \beta^{EPU}(\tau)EPU_{t-1}\right) + \sum_{j=1}^{p-1}\lambda_j(\tau)\Delta GBI_{t-j} + \sum_{j=0}^{q-1}\delta_j^{COP}(\tau)\Delta COP_{t-j} + \sum_{j=0}^{q-1}\delta_j^{EPU}(\tau)\Delta EPU_{t-j} + \varepsilon_t(\tau), \quad (3)$$

where GBI_t is China's green bond index in period t. COP_t and EPU_t denote crude oil price and economic policy uncertainty in period t, respectively.

The QARDL model performs better because it fully considers both long- and short-term effects, which relies on different quantiles (scenarios) of the dependent variable. Therefore, it has become popular and attracted increasing attention and has been widely utilised in multiple fields, including financial development (Huang et al., 2021), carbon neutrality (Sun et al., 2021), foreign exchange market (Baek, 2021), economic growth (Ikram et al., 2021) and others.

3. Data sources and descriptive analysis

Monthly data covering the period of January 2010 to March 2022 are utilised in this paper. Since 2010, the improving global economic situation has led to the increase of COP. Market players react fiercely to the change in COP, resulting in a great deal of economic uncertainty (Qiu et al., 2012). In the same year, China Central Bank issued 10-year policy financial bonds of 19.52 billion RMB, which was the first green bond in China. To investigate the behaviour of green bonds, we gathered data from China's Green Bond Index (GBI) from the Wind Database, and the index was used in the literature of Tian et al. (2022). The price of crude oil (COP) is the second variable. Following Su et al. (2019) and Wang et al. (2022b), we apply West Texas Intermediate (WTI) crude oil to represent the actual fluctuations in oil prices, with data taken from the Energy Information Administration (EIA). Finally, we adopt the economic policy uncertainty index (EPU), as some extant literature has also used it to represent the continuous economy and policy uncertainties (Ji et al., 2018; Wang et al., 2021). The EPU index for China was first constructed by Baker et al. (2016), which can be found at http://www.policyuncertainty.com.

Figure 1 reflects the trends of COP, EPU and GBI. From May to September 2010, affected by the European sovereign debt crisis, COP hovered at a low level. In 2012, the ongoing geopolitical conflicts involving nations that produce oil, including Libya and Yemen, once again promoted the growth of COP. From 2014 to early 2016, events such as the shale oil revolution and the Russia-Ukraine conflict caused the COP to plummet one after another. Since 2016, unexpected interruptions in crude oil supply, such as terrorist attacks in the Middle East, have caused the oil price to fluctuate and rise briefly. In 2020, due to the COVID-19 epidemic and oil price war, COP experienced an unprecedented decline. The EPU also presents a fluctuating trend. In 2011, as the European Union was China's largest trading partner, affected by the European debt crisis, EPU remained high for several consecutive months. Since the second half of 2015, the RMB exchange rate reform policy has been introduced, and the Chinese stock market has collapsed, resulting in high EPU. The trade conflict between

China and the U.S. that began in 2018, the COVID-19 epidemic and the collapse of the US stock market in 2020 have caused the EPU to remain at a high level. Different from COP and EPU, GBI shows an upward trend as a whole. In 2015, the Paris climate agreement stimulated interest in green bonds among investors. The People's Bank of China (PBC) released guidelines for issuing green bonds in China. In 2016, the green bond market was formally created. China's financial market instantly issued a startling 36.2 billion US dollars worth of green bonds, making up 39% of all green bond issuance worldwide. The China Securities Regulatory Commission published guidelines on encouraging the issuing of green bonds in 2017. The PBC and the European Investment Bank launched the green finance plan and decided to cooperate in developing a consistent green bond standard in the same year. The latest list of green bond support projects was released in 2020 by the PBC, the national development and Reform Commission and the China Securities Regulatory Commission together. This series of events have promoted the growth of GBI.

The data description is shown in Table 1. We observe that COP, EPU and GBI's averages are concentrated at the 69.845, 353.056 and 137.360 levels. The standard deviation confirms the greater instability in EPU, and its value reaches 257.475. Moreover, the results for COP, EPU and GBI's skewness are 0.057, 0.788 and 0.140, demonstrating that they have the right skewness. However, the kurtosis shows that they are platykurtic distributed because the value is less than three. Last, as shown from The Jarque-Bera test, they exhibit non-normal distribution markedly at the 1% level.

The ADF unit root test (Dickey & Fuller, 1981), PP unit root test (Phillips & Perron, 1988) and KPSS unit root test (Kwiatkowski et al., 1992) are all utilised to check the stationarity of the GBI, COP and EPU. Table 2 demonstrates that GBI, COP, and EPU are nonstationary at the level. However, these variables become stationary when taking the first difference, which makes autoregressive models appropriate to deal with the links (Zhan et al., 2021). This is an important reason for applying the QARDL model in our paper.

Table 1. Descriptive statistics

	Max	Min	Mean	Median	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
GBI	182.544	100.236	137.360	142.645	24.783	0.140	1.731	10.343***
COP	110.039	16.699	69.845	67.703	22.361	0.057	1.840	8.317***
EPU	970.830	26.144	353.056	269.019	257.475	0.788	2.500	16.738***

Note: *** denotes significance at 1% level.

Table 2. Unit root test

	Level			First difference		
	ADF	PP	KPSS	ADF	PP	KPSS
GBI	0.421	0.513	1.425***	−8.451***	−8.422***	0.115
COP	−1.738	−1.449	0.705**	−8.284***	−7.893***	0.213
EPU	−1.359	−2.466	1.068***	−12.184***	−17.757***	0.063

Note: *** and ** denote significance at 1% and 5% levels, respectively.

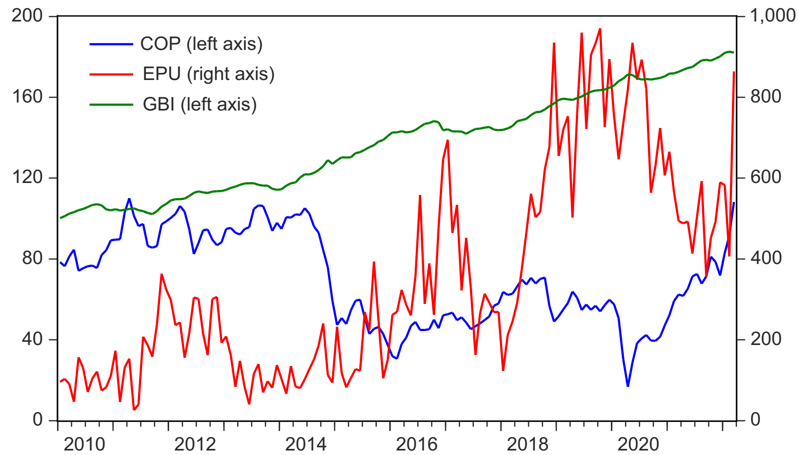

Figure 1. The trends of COP, EPU and GBI

4. Empirical results

4.1. Basic quantile regression

Table 3 points out the long-run parameters of $\beta^{COP}(\tau)$ and $\beta^{EPU}(\tau)$, and short-run parameters of $\delta^{COP}(\tau)$ and $\delta^{EPU}(\tau)$, running in quantiles of 0.05, 0.1,…, 0.95. Referring to the literature of He et al. (2021), the delta test is utilised to compute the *SEs* for the abovementioned parameters in the QARDL model. The optimal lag orders are determined by the Schwarz Information Criteria (SIC), and p and q are both selected as 3.

The long-run parameter of $\beta^{COP}(\tau)$ is statistically positive and significant at 1% and 5% levels across most quantiles. It demonstrates that there exists a long-run influence from COP on GBI under different conditions in the full sample. Meanwhile, parameter values are always positive, indicating rising oil price leads to a better performance of the green bond market. Oil is regarded as the "blood" of industry and plays an important role in industrialisation, thus, oil price fluctuations would obviously impact society and the economy (Hu et al., 2022). For instance, in 2008, the global financial crisis burst, and the oil price sharply fell from over 130 U.S. dollars per barrel to below 40 U.S. dollars per barrel within several months. Similarly, with COVID-19 spreads worldwide, the economy is hit seriously (Zhang et al., 2021b), leading to oil prices plunging below 20 U.S. dollars per barrel. Due to the tight relationship with the oil market, green finance also suffers significant changes. The economic intuition is that when oil prices present a downward trend, motive power and interest in green investment will decline. Oppositely, the upward movement of oil prices would decrease oil needs, which increase the green and sustainable investment, and subsequently produces prosperous demand for green bonds (Lee et al., 2021). In addition, another explanation is that green bonds are regarded as an effective financing tool in supporting energy transition and provide a more diversified investment portfolio to hedge risks (Su et al., 2023). For example, the high oil price is always accompanied by inflation, which may bring devaluation of monetary assets; thus, investors would choose green bonds as hedging assets and increase the performance of the green bond market performance.

The values $\beta^{EPU}(\tau)$ are always negative, demonstrating that rising economic policy uncertainty leads to lower performance in the green bond market. China has suffered rapid economic development since the late 1970s. This significant achievement also implies potential threats, such as an extensive economic growth mode, financial system risk, environmental damage, and low energy utilisation efficiency, which inevitably affect China's EPU (Zhao et al., 2020; Su et al., 2022). The high expectation of increasing EPU negatively influences enterprises' normal economic activities, such as production, investments, and sales, which add external costs and pose obstacles to pursuing green development (Hou et al., 2022). In addition, high EPU brings systemic financial risk and even negatively affects economic fundamentals (Gu et al., 2021). Under these uncertainties, capital costs would increase, translating into high borrowing costs and increasing financial constraints (Wang et al., 2020). In summary, increasing EPU not only reduces enterprises' green financing needs but also exacerbates financing constraints, which subsequently affect the green bond market.

Being different from $\beta^{COP}(\tau)$ and $\beta^{EPU}(\tau)$, the parameters of $\delta^{COP}(\tau)$ and $\delta^{EPU}(\tau)$ indicate the short-run effects. We find that the number of statistically significant quantiles is less than that of their long-run counterparts in the full sample. The results show that the influence of COP and EPU on GBI considered in this paper is stronger in the long run. However, there are two distinct features are offered as followings. On the one hand, the significant impacts are mostly located in high quantiles, demonstrating GBI is asymmetrically affected by high COP and EPU. The results infer investors are more sensitive to high uncertainties and more efficiently respond, which is consistent with previous literature by Tian et al. (2022). On the other hand, the values of statistically significant parameters in certain quantiles differ from their long-run parameters. The following aspects can explain the negative relationship between COP and GBI. High oil prices burden enterprises' costs in a short time, making them face business difficulties, and they do not have the capacity and desire to issue green bonds (Wang et al., 2022c). Meanwhile, investors are also cautious and hesitant to invest in green bonds when oil prices are high volatility. In addition, the short-run parameters of EPU are positive. The high EPU brings economic fluctuations and causes public concern; this negative effect needs time to pass to enterprises, but investors are more sensitive to risks and choose green bonds as hedging assets, which boosts the green bond market.

Table 3. Results of quantile autoregressive distributed lag (QARDL) for GBI

	$\alpha(\tau)$	$\xi(\tau)$	$\beta^{COP}(\tau)$	$\beta^{EPU}(\tau)$	$\lambda(\tau)$	$\delta^{COP}(\tau)$	$\delta^{EPU}(\tau)$
0.05	–0.105(0.077)	0.017(0.017)	0.238**(0.112)	–0.794***(0.227)	0.312(0.172)	0.008(0.011)	0.007(0.005)
0.10	–0.029(0.041)	–0.001(0.009)	0.141**(0.069)	–0.567***(0.201)	0.344(0.131)	–0.016(0.018)	0.005(0.004)
0.20	–0.004(0.036)	–0.003(0.008)	0.261***(0.037)	–0.383**(0.201)	0.369(0.102)	–0.011(0.016)	0.002(0.003)
0.30	–0.008(0.036)	0.001(0.007)	0.584***(0.153)	–1.316***(0.413)	0.339***(0.087)	–0.013(0.027)	0.004(0.002)
0.40	0.003(0.037)	0.022** (0.011)	1.233***(0.331)	–2.232***(0.225)	0.358(0.082)	–0.014(0.035)	0.153***(0.013)
0.50	–0.127***(0.035)	0.004(0.007)	0.604**(0.267)	–1.042***(0.388)	0.396***(0.081)	–0.023***(0.005)	0.023***(0.002)
0.60	0.004(0.032)	–0.002(0.007)	1.191***(0.026)	–2.259*(1.228)	0.358***(0.083)	–0.017***(0.05)	0.014**(0.006)
0.70	0.026(0.034)	–0.006(0.008)	1.699***(0.188)	–1.297**(0.562)	0.341*(0.191)	–0.035**(0.006)	0.011*(0.006)
0.80	0.085***(0.031)	–0.012(0.009)	1.098***(0.327)	–1.051***(0.443)	0.251***(0.104)	–0.026**(0.007)	0.022***(0.008)
0.90	0.051(0.045)	–0.017**(0.009)	2.253***(0.393)	–2.795*(1.539)	–0.018**(0.008)	–0.018**(0.008)	0.033**(0.015)
0.95	0.061(0.049)	–0.008(0.011)	1.147***(0.237)	–1.204***(0.146)	0.314**(0.159)	–0.021***(0.007)	0.017***(0.004)

Notes: ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. Standard error (SE) calculated via the delta method is reported in parentheses.

4.2. Rolling window analysis

Structural instabilities are the major issue that needs to be considered in research. The structural breaks possible bring changes in parameters and patterns, thus, the traditional constant relationship among variables is not convincing (Su et al., 2022c). Combined with the rolling window process, the QARDL (3, 3) model, consisting of GBI, COP and EPU, is re-estimated to detect novel and comprehensive empirical results. In the process, a problem of window size needs to be traded off, because a large window size can ensure accuracy, and a small window size can guarantee representativeness. After consideration and comparison, this paper selects 30 months as the window size and utilises the bootstrap method to achieve better precision. Figure 2 and Figure 3 depict the time-varying short-run and long-run parameters, respectively, in quantiles of 0.25, 0.50 and 0.75. In particular, these quantiles sequentially correspond to the bearish, stable, and bullish market situations of green bonds in China, respectively.

As shown in Figure 2, the parameter $\beta^{COP}(\tau)$ is positive and significant at the 5% level across 0.25, 0.50 and 0.75 quantiles in the full sample. However, the rolling estimates drop severely in the year of 2016, losing their significance. One possible explanation is that oil price dropped rapidly and maintained a low level for most time of 2016. The potential reasons can be summarised as followings. The shale oil revolution is rising, and the production capacity of shale oil in the U.S. has achieved 1 million barrels per day, lowering global oil prices (Shakya et al., 2022). Global economic growth slows, leading to a slight energy consumption increase. In 2016, China's GDP growth rate fell below 7% for the first time, and its energy consumption growth rate was 1.3%, which is lower than the average growth rate of the past decade. The Organization of Petroleum Exporting Countries (OPEC) and other exporting countries, such as Russia, declined to reduce oil production and launched a price war against shale oil. All factors affect the global oil market and lead to oil price drops rapidly. Oppositely, green finance ushers in a new opportunity for development. The concept of green finance firstly appears in the 13th Five-year Plan, which marks it has become national strategy. In particular, the issuance scale of green bonds has reached 205.231 billion RMB, and 29 industries such as finance, mining, power, and energy, have issued green bonds. In contrast, the parameter $\beta^{EPU}(\tau)$ is always negative in the quantiles of 0.25, 0.50 and 0.75 throughout the whole sample, except from 2016 to 2018. During the mentioned period, China faced huge uncertainties from home and abroad. RMB joins special drawing rights (SDR), and Trump was elected President of the U.S. in 2016, domestic real estate regulation and Federal Reserve raises interest rates in 2017, Sino-U.S. trade war and the U.S. sanctions for China's technological enterprises in 2018, all incidents affect China's economy, and aggravates the fluctuation of economic policies. However, the green bond market still maintains stable development. For example, at the end of 2017, the issuing amount of green bonds reaches 248.61 billion RMB, with a year-on-year increase of 22.72%. Among them, the green bonds that meet the international definition reach 154.3 billion RMB, ranking second place and accounting for 15% of the global issuance. Figure 3 indicates that the short-run parameters of $\delta^{COP}(\tau)$ and $\delta^{EPU}(\tau)$ are insignificant in the quantiles of 0.25, 0.50 and 0.75 in the full sample. These results are consistent with China's reality that the green bond market is more easily influenced by long-run shocks than short-run shocks. As proven by Pirtea et al. (2021) and Liu et al. (2022), local economic fundamentals, global energy prices, environmental governance, and other long-run factors would have substantial impacts on the development of green bonds.

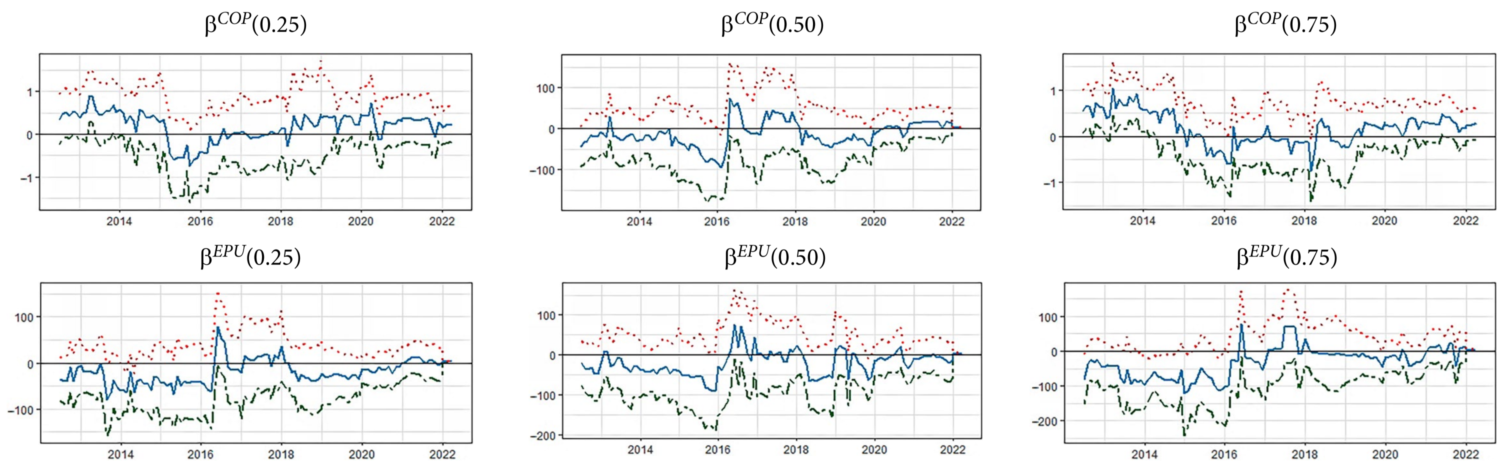

Figure 2. Rolling window estimates for long-run parameters in different quantiles

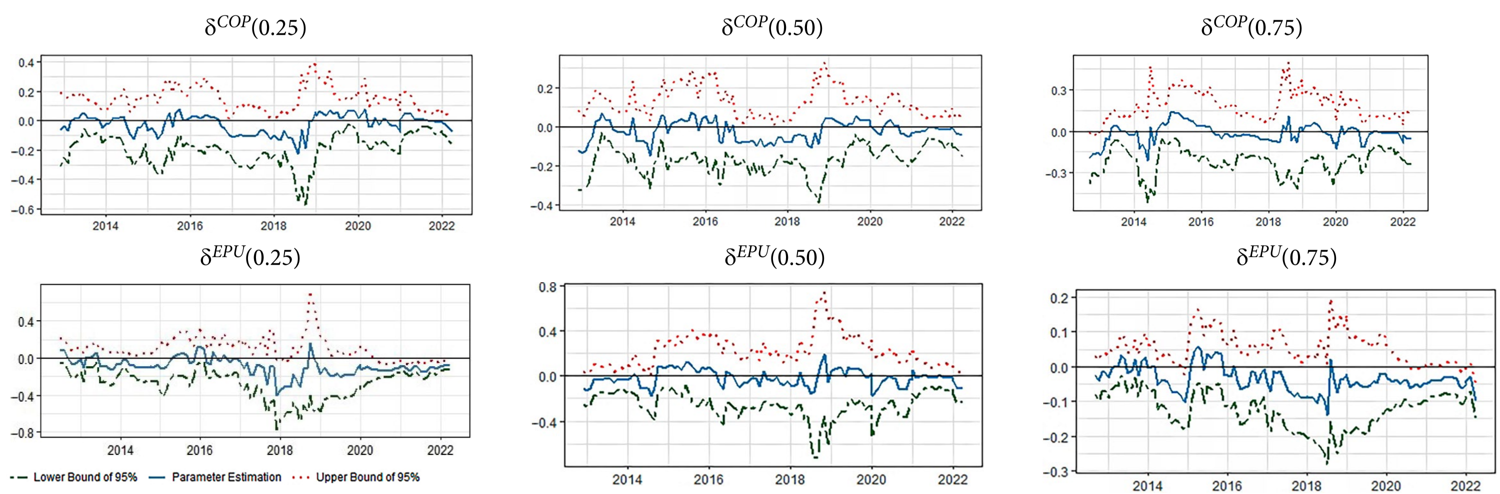

Figure 3. Rolling window estimates for short-run parameters in different quantiles

In contrast, sporadic transient shocks, such as psychological fluctuations, mood swings, and temporary regulatory and other factors, have difficulty affecting the green bond market in the short-run.

4.3. Asymmetric analysis

Due to short-run parameters of COP and EPU are insignificant in the QARDL (3, 3) model, the Wald test is utilised to check asymmetries for long-run parameters of $\beta^{COP}(\tau)$ and $\beta^{EPU}(\tau)$ across quantiles 0.25, 0.50, and 0.75 of GBI. The Wald test not only detects instabilities of intercept and coefficients but also recognises unknown structural breaks (Gudil et al., 2020). The Wald statistic $W(\gamma)$ examines the null hypothesis $H : \gamma(0.25) = \gamma(0.75)$, and the statistic $W^{*}(\gamma)$ examines the null hypothesis $H^{*} : \gamma(0.25) = \gamma(0.50) = \gamma(0.75)$, where γ denotes the parameter under examination. As shown in Figure 4, the p values for both statistics of $W(\beta^{COP})$ and $W^{*}(\beta^{COP})$ are commonly higher than 0.1, except in the period of 2013 to mid-2014. The global oil market confronts difficulties and the price plunges rapidly in the mentioned time. The economic growth of major developed economies is sluggish (Cristea et al., 2022). The shale oil revolution produces shocks in the traditional oil market. The OPEC does not achieve consensus on reducing oil production. All factors result in the mismatch between supply and demand, and further trigger a sharp drop in prices. Meanwhile, China's green finance is at an initial stage of development in this period and owns different responses

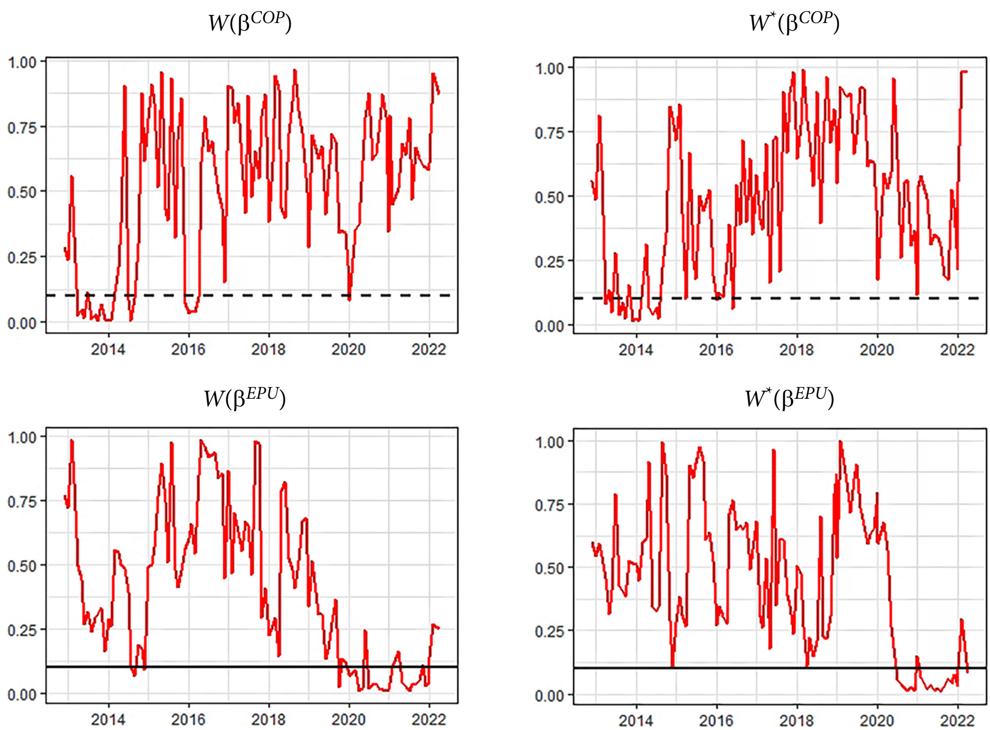

Figure 4. Wald tests of constancy of rolling quantile parameter estimates

to external shocks such as oil price volatility (Hu et al., 2022; Yan et al., 2022). Besides, the *p values* for both statistics $W(\beta^{EPU})$ and $W^{*}(\beta^{EPU})$ are observed to be lower than 0.1 since the year 2020, meaning that the null hypothesis is not able to accept during the mentioned time. It is noteworthy that the location asymmetry in the long-run effects of China's EPU on the green bond index occurred during the COVID-19 pandemic. The virus ravages cause dramatic turbulence in the economy, such as the stock market (Wang et al., 2022d), commodity market (Chen et al., 2022) and real estate market (Huang et al., 2022). China has had to implement policies such as city lockdowns and tax reductions to curb the pandemic and stimulate economic development. These measures consequently increase China's EPU to the highest point in the country's history.

Conclusions

This study discusses the long- and short-run effects of crude oil price and economic policy uncertainty on the green bond index, combining the QARDL model with China's realities. In general, the GBI is more susceptible to the long-run effects of COP and EPU in our full sample, and their linkages are of quantile- and time-varying characteristics. In detail, from the aspects of time period and bond market situation, the fluctuation of crude oil price is found to have significant influence on the green bond index. Meanwhile, economic policy uncertainty negatively affects the green bond market, and locational asymmetry only exists during the period of the COVID-19 outbreak and its spread. However, the short-run effects of COP and EPU on GBI are less significant and concentrated in high quantiles. One possible explanation is that the green bond market in China is mainly influenced by long-run policy support and economic fundamentals rather than temporary shocks and breaking news.

Some relevant policy implications are provided for all market participants based on our empirical findings. First, in order to avoid shocks from the oil market and economic policy uncertainties, policy makers are supposed to set up mechanisms for emergency. Besides, in view of the fluctuations of oil prices and economic policy uncertainties, the 'one size fits all' practices and policies should be prevented, and a multi-combination portfolio can be considered to resist risks. Second, with regards to green portfolio managers and investors, the nonlinear transmission mechanism and causality between oil prices and green finance should be considered when making hedging and portfolio decisions. In order to enhance accuracy in green bond market, it is essential learn from variations of oil price or changes in economic policy. Last, in order to guarantee a better system of green bond market, a complete legal liability system is necessary to build. Professionals in environmental protection should participate with financial regulators and bond broker in rules making. In particular, clear monitoring process and green criteria are beneficial for attracting green bond investor, and reduce issuers' additional costs.

References

Abbas, M. G., Wang, Z., Bashir, S., Iqbal, W., & Ullah, H. (2021). Nexus between energy policy and environmental performance in China: The moderating role of green finance adopted firms. *Environmental Science and Pollution Research*, *28*, 63263–63277. https://doi.org/10.1007/s11356-021-15195-5

Azhgaliyeva, D., Kapsalyamova, Z., & Mishra, R. (2022). Oil price shocks and green bonds: An empirical evidence. *Energy Economics*, *112*, 106108. https://doi.org/10.1016/j.eneco.2022.106108

Baek, J. (2021). A new look at the oil prices and exchange rates nexus: A quantile cointegrating regression approach to South Korea. *Applied Economics*, *53*(56), 6510–6521. https://doi.org/10.1080/00036846.2021.1946475

Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *The Quarterly Journal of Economics*, *131*(4), 1593–1636. https://doi.org/10.1093/qje/qjw024

Balcilar, M., Gupta, R., Wang, S., & Wohar, M. E. (2020). Oil price uncertainty and movements in the US government bond risk premia. *North American Journal of Economics and Finance*, *52*, 101147. https://doi.org/10.1016/j.najef.2020.101147

Bondia, R., Ghosh, S., & Kanjilal, K. (2016). International crude oil prices and the stock prices of clean energy and technology companies: Evidence from non-linear cointegration tests with unknown structural breaks. *Energy*, *101*, 558–565. https://doi.org/10.1016/j.energy.2016.02.031

Boutabba, M. A., & Rannou, Y. (2022). Investor strategies in the green bond market: The influence of liquidity risks, economic factors and clientele effects. International *Review of Financial Analysis*, *81*, 102071. https://doi.org/10.1016/j.irfa.2022.102071

Broadstock, D. C., & Cheng, L. T. (2019). Time-varying relation between black and. green bond price benchmarks: Macroeconomic determinants for the first decade. *Finance research letters*, *29*, 17–22. https://doi.org/10.1016/j.frl.2019.02.006

Chen, H., Xu, C., & Peng, Y. (2022). Time-frequency connectedness between energy and nonenergy commodity markets during COVID-19: Evidence from China. *Resources Policy*, *78*, 102874. https://doi.org/10.1016/j.resourpol.2022.102874

Chen, W., Huang, Z., & Yi, Y. (2015). Is there a structural change in the persistence of WTI–Brent oil price spreads in the post-2010 period? *Economic Modelling*, *50*, 64–71. https://doi.org/10.1016/j.econmod.2015.06.007

Cho, J. S., Kim, T., & Shin, Y. (2015). Quantile cointegration in the autoregressive distributed-lag modeling framework. *Journal of Econometrics*, *188*(1), 281–301. https://doi.org/10.1016/j.jeconom.2015.05.003

Cristea, M. S., Pirtea, M. G., Suciu, M. C., & Noja, G. G. (2022). Workforce participation, ageing, and economic welfare: New empirical evidence on complex patterns across the European Union. *Complexity*, *2022*, 7313452. https://doi.org/10.1155/2022/7313452

Devpura, N., & Narayan, P. K. (2020). Hourly oil price volatility: The role of COVID-19. *Energy Research Letters*, *1*(2), 13683. https://doi.org/10.46557/001c.13683

Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, *49*(4), 1057–1072. https://doi.org/10.2307/1912517

Dutta, A., Jana, R. K., & Das, D. (2020). Do green investments react to oil price shocks? Implications for sustainable development. *Journal of Cleaner Production*, *266*, 121956. https://doi.org/10.1016/j.jclepro.2020.121956

Gu, K., Dong, F., Sun, H., & Zhou, Y. (2021). How economic policy uncertainty processes impact on inclusive green growth in emerging industrialized countries: A case study of China. *Journal of Cleaner Production*, *322*, 128963. https://doi.org/10.1016/j.jclepro.2021.128963

Gudil, D. I., Sarwat, S., Sharif, A., & Jermsittiparsert, K. (2020). How oil prices, gold prices, uncertainty and risk impact Islamic and conventional stocks? Empirical evidence from QARDL technique. *Resources Policy*, *66*, 101638. https://doi.org/10.1016/j.resourpol.2020.101638

Guo, Y., Chen, Y. H., Lo, K. L., & Mi, J. J. (2022). The influence of international crude oil price on the crude oil spot price in China. *Procedia Computer Science*, *199*, 1144–1151. https://doi.org/10.1016/j.procs.2022.01.145

Hau, L., Zhu, H., Sun, W., & Yu, K. (2022). Flight-to-quality or not? Evidence from China's green bond and green equity markets during COVID-19 crisis. *Applied Economics Letters*. https://doi.org/10.1080/13504851.2022.2083059

He, X., Mishra, S., Aman, A., Shahbaz, M., Razzaq, A., & Sharif, A. (2021). The linkage between clean energy stocks and the fluctuations in oil price and financial stress in the US and Europe? Evidence from QARDL approach. *Resources Policy*, *72*, 102021. https://doi.org/10.1016/j.resourpol.2021.102021

Hou, D., Chan, K. C., Dong, M., & Yao, Q. (2022). The impact of economic policy uncertainty on a firm's green behavior: Evidence from China. *Research in International Business and Finance*, *59*, 101544. https://doi.org/10.1016/j.ribaf.2021.101544

Hu, J., Wang, K., Su, C., & Umar, M. (2022). Oil price, green innovation and institutional pressure: A China's perspective. *Resources Policy*, *78*, 102788. https://doi.org/10.1016/j.resourpol.2022.102788

Huang, S., Sadiq, M., & Chien, F. (2021). The impact of natural resource rent, financial development, and urbanization on carbon emission. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-021-16818-7

Huang, T., & Yue, Q. (2020). How the game changer was generated? An analysis on the legal rules and development of China's green bond market. *International Environmental Agreement: Politics, Law and Economics*, *20*, 85–102. https://doi.org/10.1007/s10784-019-09460-9

Huang, W., Lan, C., Xu, Y., Zhang, Z., & Zeng, H. (2022). Does COVID-19 matter for systemic financial risks? Evidence from China's financial and real estate sectors. *Pacific-Basin Finance Journal*, *74*, 101819. https://doi.org/10.1016/j.pacfin.2022.101819

Ikram, M., Xia, W., Fareed, Z., Shahzad, U., & Rafique, M. Z. (2021). Exploring the nexus between economic complexity, economic growth and ecological footprint: Contextual evidences from Japan. *Sustainable Energy Technologies and Assessments*, *47*, 101460. https://doi.org/10.1016/j.seta.2021.101460

Inchauspe, J., Ripple, R. D., & Trück, S. (2015). The dynamics of returns on renewable. Energy companies: A state-space approach. *Energy Economics*, *48*, 325–335. https://doi.org/10.1016/j.eneco.2014.11.013

Ji, Q., Liu, B. Y., Nehler, H., & Uddin, G. S. (2018). Uncertainties and extreme risk spillover in the energy markets: A time-varying copula-based CoVaR approach. *Energy Economics*, *76*, 115–126. https://doi.org/10.1016/j.eneco.2018.10.010

Jia, Z., Wen, S., & Lin, B. (2021). The effects and reacts of COVID-19 pandemic and international oil price on energy, economy, and environment in China. *Applied Energy*, *302*, 117612. https://doi.org/10.1016/j.apenergy.2021.117612

Jiang, Y., Feng, Q., Mo, B., & Nie, H. (2020). Visiting the effects of oil price shocks on exchange rates: Quantile-on-quantile and causality-in-quantiles approaches. *North American Journal of Economics and Finance*, *52*, 101161. https://doi.org/10.1016/j.najef.2020.101161

Kanamura, T. (2020). Are green bonds environmentally friendly and good performing assets? *Energy Economics*, *88*, 104767. https://doi.org/10.1016/j.eneco.2020.104767

Kwiatkowski, D., Phillips, P., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationary against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics*, *54*(1–3), 159–178. https://doi.org/10.1016/0304-4076(92)90104-Y

Lee, C. C., Li, X., Yu, C. H., & Zhao, J. (2022a). The contribution of climate finance towards environmental sustainability: New global evidence. *Energy Economics*, *111*, 106072. https://doi.org/10.1016/j.eneco.2022.106072

Lee, C. C., Xing, W., & Lee, C. C. (2022b). The impact of energy security on income inequality: The key role of economic development. *Energy*, *248*, 123564. https://doi.org/10.1016/j.energy.2022.123564

Lee, C. C., Tang, H., & Li, D. (2022c). The roles of oil shocks and geopolitical. uncertainties on China's green bond returns. *Economic Analysis and Policy*, *74*, 494–505. https://doi.org/10.1016/j.eap.2022.03.008

Lee, C., Lee, C., & Li, Y. (2021). Oil price shocks, geopolitical risks, and green bond market dynamics. *North American Journal of Economics and Finance*, *55*, 101309. https://doi.org/10.1016/j.najef.2020.101309

Li, Z., Kuo, T. H., Siao-Yun, W., & Vinh, L. T. (2022). Role of green finance, volatility and risk in promoting the investments in Renewable Energy Resources in the post-covid-19. *Resources Policy*, *76*, 102563. https://doi.org/10.1016/j.resourpol.2022.102563

Liu, C., & Xiong, M. (2022). Green finance reform and corporate innovation: Evidence from China. *Finance Research Letters*, *48*, 102993. https://doi.org/10.1016/j.frl.2022.102993

Liu, S. Q., Qi, H. J., & Wan, Y. L. (2022). Driving factors behind the development of China's green bond market. *Journal of Cleaner Production*, *354*, 131705. https://doi.org/10.1016/j.jclepro.2022.131705

Liu, X., Wang, E., & Cai, D. (2019). Green credit policy, property rights and debt financing: Quasinatural experimental evidence from China. *Finance Research Letters*, *29*, 129–135. https://doi.org/10.1016/j.frl.2019.03.014

Lv, C., Bian, B., Lee, C. C., & He, Z. (2021). Regional gap and the trend of green finance development in China. *Energy Economics*, *102*, 105476. https://doi.org/10.1016/j.eneco.2021.105476

Naeem, M. A., Bouri, E., Costa, M. D., Naifar, N., & Shahzad, S. J. H. (2021). Energy markets and green bonds: A tail dependence analysis with time-varying optimal copulas and portfolio implications. *Resources Policy*, *74*, 102418. https://doi.org/10.1016/j.resourpol.2021.102418

Ouyang, Z. S., Liu, M. T., Huang, S. S., & Yao, T. (2022). Does the source of oil price shocks matter for the systemic risk? *Energy Economics*, *109*, 105958. https://doi.org/10.1016/j.eneco.2022.105958

Park, D., Park, J., & Ryu, D. (2020). Volatility spillovers between equity and green bond markets. *Sustainability*, *12*(9), 3722. https://doi.org/10.3390/su12093722

Pham, L., & Cepni, O. (2022). Extreme directional spillovers between investor attention and green bond markets. *International Review of Economics & Finance*, *80*, 186–210. https://doi.org/10.1016/j.iref.2022.02.069

Pham, L., & Nguyen, C. P. (2022). How do stock, oil, and economic policy uncertainty influence the green bond market? *Finance Research Letters*, *45*, 102128. https://doi.org/10.1016/j.frl.2021.102128

Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*(2), 335–346. https://doi.org/10.1093/biomet/75.2.335

Pirtea, M. G., Noja, G. G., Cristea, M., & Panait, M. (2021). Interplay between environmental, social and governance coordinates and the financial performance of agricultural companies. *Agricultural Economics – Czech*, *67*, 479–490. https://doi.org/10.17221/286/2021-AGRICECON

Pirtea, M. G., Sipos, G. L., & Ionescu, A. (2019). Does corruption affects business innovation? Insights from emerging countries. *Journal of Business Economics and Management*, *20*(4), 715–733. https://doi.org/10.3846/jbem.2019.10160

Qiu, C., Colson, G., Escalante, C., & Wetzstein, M. (2012). Considering macroeconomic indicators in the food before fuel nexus. *Energy Economics*, *34*(6), 2021–2028. https://doi.org/10.1016/j.eneco.2012.08.018

Reboredo, J. C. (2018). Green bond and financial markets: Co-movement, diversification and price spillover effects, *Energy Economics*, *74*, 38–50. https://doi.org/10.1016/j.eneco.2018.05.030

Reboredo, J. C., Ugolini, A., & Aiube, F. A. L. (2020). Network connectedness of green bonds and asset classes. *Energy Economics*, *86*, 104629. https://doi.org/10.1016/j.eneco.2019.104629

Ren, X., Shao, Q., & Zhong, R. (2020). Nexus between green finance, non-fossil energy use, and carbon intensity: Empirical evidence from China based on a vector error correction model. *Journal of Cleaner Production*, *277*, 122844. https://doi.org/10.1016/j.jclepro.2020.122844

Shah, I. H., Hiles, C., & Morley, B. (2018). How do oil prices, macroeconomic factors and policies affect the market for renewable energy? *Applied energy*, *215*, 87–97. https://doi.org/10.1016/j.apenergy.2018.01.084

Shahzad, S. J. H., Hurley, D., & Ferrer, R. (2021). U.S. stock prices and macroeconomic fundamentals: Fresh evidence using the quantile ARDL approach. *International Journal of Finance & Economics*, *26*(3), 3569–3587. https://doi.org/10.1002/ijfe.1976

Shakya, S., Li, B., & Etienne, X. (2022). Shale revolution, oil and gas prices, and drilling activities in the United States. *Energy Economics*, *108*, 105877. https://doi.org/10.1016/j.eneco.2022.105877

Shi, J., Yu, C., Li, Y., & Wang, T. (2022). Does green financial policy affect debt-financing cost of heavy-polluting enterprises? An empirical evidence based on Chinese pilot zones for green finance reform and innovations. *Technological Forecasting and Social Change*, *179*, 121678. https://doi.org/10.1016/j.techfore.2022.121678

Su, C., Chen, Y., Hu, J., Chang, T., & Umar, M. (2023). Can the green bond market enter a new era under the fluctuation of oil price? *Economic Research-Ekonomska Istraživanja*, *36*(1), 536–561. https://doi.org/10.1080/1331677X.2022.2077794

Su, C., Li, W., Umar, M., & Lobonţ, O. (2022). Can green credit reduce the emissions of pollutants? *Economic Analysis and Policy*, *74*, 205–219. https://doi.org/10.1016/j.eap.2022.01.016

Su, C., Pang, L., Tao, R., Shao, X., & Umar, M. (2022c). Renewable energy and technological innovation: Which one is the winner in promoting net-zero emissions? *Technological Forecasting and Social Change*, *182*, 121798. https://doi.org/10.1016/j.techfore.2022.121798

Su, C. W., Wang, X. Q., Tao, R., & Oana-Ramona, L. (2019). Do oil prices drive agricultural commodity prices? Further evidence in a global bio-energy context. *Energy*, *172*, 691–701. https://doi.org/10.1016/j.energy.2019.02.028

Sun, C., Ding, D., Fang, X., Zhang, H., & Li, J. (2019). How do fossil energy prices affect the stock prices of new energy companies? Evidence from Divisia energy price index in China's market. *Energy*, *169*, 637–645. https://doi.org/10.1016/j.energy.2018.12.032

Sun, Y., Duru, O. A., Razzaq, A., & Dinca, M. S. (2021). The asymmetric effect eco-innovation and tourism towards carbon neutrality target in Turkey. *Journal of Environmental Management*, *299*, 113653. https://doi.org/10.1016/j.jenvman.2021.113653

Tian, H., Long, S., & Li, Z. (2022). Asymmetric effects of climate policy uncertainty, infectious diseases-related uncertainty, crude oil volatility, and geopolitical risks on green bond prices. *Finance Research Letters*, *48*, 103008. https://doi.org/10.1016/j.frl.2022.103008

Tolliver, C., Keeley, A. R., & Managi, S. (2020). Drivers of green bond market growth: The importance of Nationally Determined Contributions to the Paris Agreement and implications for sustainability. *Journal of Cleaner Production*, *244*, 118643. https://doi.org/10.1016/j.jclepro.2019.118643

Wang, X., Li, J., & Ren, X. (2022a). Asymmetric causality of economic policy uncertainty and oil volatility index on time-varying nexus of the clean energy, carbon and green bond. *International Review of Financial Analysis*, *83*, 102306. https://doi.org/10.1016/j.irfa.2022.102306

Wang, K. H., Liu, L., Li, X., & Oana-Ramona, L. (2022b). Do oil price shocks drive unemployment? Evidence from Russia and Canada. *Energy*, *253*, 124107. https://doi.org/10.1016/j.energy.2022.124107

Wang, K., Zhao, Y., Jiang, C., & Li, Z. (2022c). Does green finance inspire sustainable development? Evidence from a global perspective. *Economic Analysis and Policy*, *75*, 412–426. https://doi.org/10.1016/j.eap.2022.06.002

Wang, Z., Dong, Y., & Liu, A. (2022d). How does China's stock market react to supply chain disruptions from COVID-19? *International Review of Financial Analysis*, *82*, 102168. https://doi.org/10.1016/j.irfa.2022.102168

Wang, X., Luo, Y., Wang, Z., Xu, Y., & Wu, C. (2021). The impact of economic policy uncertainty on volatility of China's financial stocks: An empirical analysis. *Finance Research Letters*, *39*, 101650. https://doi.org/10.1016/j.frl.2020.101650

Wang, X., & Wang, Q. (2021). Research on the impact of green finance on the upgrading of China's regional industrial structure from the perspective of sustainable development. *Resources Policy*, *74*, 102436. https://doi.org/10.1016/j.resourpol.2021.102436

Wang, Z., Li, Y., & He, F. (2020). Asymmetric volatility spillovers between economic policy uncertainty and stock markets: Evidence from China. *Research in International Business and Finance*, *53*, 101233. https://doi.org/10.1016/j.ribaf.2020.101233

Wen, X., Guo, Y., Wei, Y., & Huang, D. (2014). How do the stock prices of new energy and fossil fuel companies correlate? Evidence from China. *Energy Economics*, *41*, 63–75. https://doi.org/10.1016/j.eneco.2013.10.018

Wu, K., Zhu, J., Xu, M., & Yang, L. (2020). Can crude oil drive the co-movement in the international stock market? Evidence from partial wavelet coherence analysis. *North American Journal of Economics and Finance*, *53*, 101194. https://doi.org/10.1016/j.najef.2020.101194

Yan, L., Wang, H., Athari, S. A., & Atif, F. (2022). Driving green bond market through energy prices, gold prices and green energy stocks: evidence from a non-linear approach. *Economic Research-Ekonomska Istraživanja*, *35*(1), 6479–6499. https://doi.org/10.1080/1331677X.2022.2049977

Yang, Y., Su, X., & Yao, S. (2021). Nexus between green finance, fintech, and high-quality economic development: Empirical evidence from China. *Resources Policy*, *74*, 102445. https://doi.org/10.1016/j.resourpol.2021.102445

Zhan, Z., Ali, L., Sarwat, S., Godil, D. I., Dinca, G., & Anser, M. K. (2021). A step towards environmental mitigation: Do tourism, renewable energy and institutions really matter? A QARDL approach. *Science of the Total Environment*, *778*, 146209. https://doi.org/10.1016/j.scitotenv.2021.146209

Zhang, D. (2018). Energy finance: Background, concept, and recent developments. *Emerging Markets Finance and Trade*, *54*(8), 1687–1692. https://doi.org/10.1080/1540496X.2018.1466524

Zhang, K., Li, Y., Qi, Y., & Shao, S. (2021a). Can green credit policy improve environmental quality? Evidence from China. *Journal of Environmental Management*, *298*, 113445. https://doi.org/10.1016/j.jenvman.2021.113445

Zhang, F., Narayan, P. K., & Devpura, N. (2021b). Has COVID-19 changed the stock return-oil price predictability pattern? *Financial Innovation*, *7*(1), 1–10. https://doi.org/10.1186/s40854-021-00277-7

Zhao, X., Meng, X., Zhou, Y., & Li, P. (2020). Policy inducement effect in energy efficiency: An empirical analysis of China. *Energy*, *211*, 118726. https://doi.org/10.1016/j.energy.2020.118726