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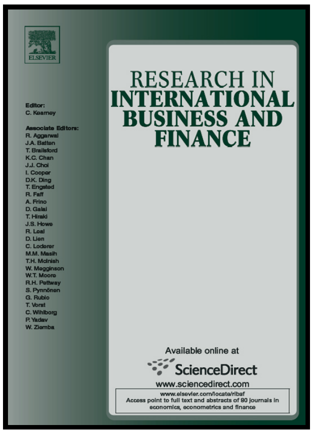

PII: S0275-5319(24)00179-X

DOI: https://doi.org/10.1016/j.ribaf.2024.102386

Reference: RIBAF102386

To appear in: *Research in International Business and Finance*

Received date: 29 March 2024
Revised date: 17 April 2024
Accepted date: 23 April 2024

Please cite this article as: Shusheng Ding, Anqi Wang, Tianxiang Cui, Anna Min Du and Xinmiao Zhou, Commodity Market Stability and Sustainable Development: The Effect of Public Health Policies, *Research in International Business and Finance,* (2024) doi:https://doi.org/10.1016/j.ribaf.2024.102386

Commodity Market Stability and Sustainable Development: The Effect of Public Health Policies

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Abstract

This study explores the influence of public health policies on commodity market volatility during public health emergencies, such as pandemics, using data from China and the US. We investigate how stringent public health measures can mitigate the effects of pandemics on the

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stability of commodity markets by stabilizing domestic demand and supply of natural resources. Our findings highlight the interconnectedness between commodity market stability and oil production, showing that firms increase their oil inventories in response to oil market volatility as a precautionary measure. This action, in turn, affects the amount of oil available for production, impacting oil consumption and extraction rates. We demonstrate that stability in the oil market significantly influences not only oil consumption but also has broader implications for sustainable development, green asset markets, and carbon emissions.

Key words:

Public health policy; Commodity market stability; Commodity price volatility; Impulse response function

JEL classification: E65 I18 Q02

1. Introduction

As the pandemic broke in 2019, the policies of Public Health Emergency (PHE) against this pandemic varied across countries. Social distancing and travel restriction policies were relaxed as the pandemic progressed, especially for the U.S. and other European countries in the second year of the pandemic (see Bickley et al., 2021; Gunay and Kurtulmuş, 2021; Popkova et al., 2021; Ashraf and Goodell, 2022; Ashraf et al., 2022). The relatively open public health policy system based on herd immunity represented by the U.S. and other European countries. In contrast, China has a relatively strict public health policy to control the spread of the pandemic.

How do two different public health policies affect financial market stability, such as commodity market stability, in different ways? This comparison of the two different public health policies can provide a sustainable policy formulation for commodity market risk management. In fact, the key element of sustainable resource extraction is to stabilize commodity market prices and build a prudent consumption and production schedule (Yang et al., 2022). The shock of the pandemic to the oil market in early 2020 put heavy pressure on oil storage, resulting in negative oil prices and high oil market volatility, which caused the commodity market instability, leading to unnecessary resource depletion because of limited storage capacity (Ma et al., 2021). Furthermore, high oil volatility may also jeopardize economies pursuing sustainable goals (Corbet et al., 2020; Jia et al., 2021). As a result, commodity market stability plays a pivotal role in sustainable development since oil market instability may interrupt sustainable goal achievement.

Therefore, this study attempts to examine how two different public health policies affect the impact of pandemic conditions on commodity market volatilities. We use the Vector Autoregression (VAR) model to demonstrate that different public health policies have led to different responses of the commodity market to pandemic conditions, thus affecting commodity market stability. We further scrutinize the effect of oil market stability on oil consumption and production and discuss the implications for sustainable development.

Commodity market volatility has exhibited high level of sensitivity to the changing environment (Bhar and Hammoudeh, 2011; Ding et al., 2023; Xu et al., 2023), and the pandemic has acted as a vital element impacting commodity market volatility (Ahmed and Sarkodie, 2021; Khan et al., 2022; Iuga et al., 2024). The oil market has also been considerably impacted by emergencies, such as ransomware attacks (Goodell and Corbet, 2023) and supply chain interruptions caused by pandemics (Yang et al., 2023). As a consequence, the close relationship between commodity market volatility and pandemics has been well documented, and thus, policies related to pandemics can either increase or mitigate the impact of pandemics on commodity market volatility. In fact, commodity prices can be influenced by a number of external factors, such as market financialization (Ding et al., 2021), trading factors, like speculation (Huchet and Fam, 2016), other commodity market prices (Ding and Zhang, 2020), and order imbalances (Ding et al., 2022). On this basis, our paper furnishes the literature with an up-to-date investigation into the impact of public health policies on commodity prices and commodity market volatility. The relief of high commodity market volatility, especially energy market volatility, also navigates investment to green assets and renewable energies (Dutta et al., 2020; Zhao et al., 2021).

Therefore, this paper intends to compare two different public health policies in two countries to demonstrate the different impacts of pandemics on commodity market volatility as a result of different policies. The contribution of our paper is threefold. Firstly, we investigate the impact of new increases in the number of pandemic cases on commodity market volatility by comparing two countries with different public health policies. Second, we further scrutinize the effect of commodity market volatility on commodity consumption and production by using the oil market as an example. We show that commodity market volatility shocks, which are commodity market instabilities, have significant impacts on commodity demand and supply. Finally, we introduce the carbon futures market as a vital element of the sustainable development of natural resources, which is usually neglected in the literature. It has been documented that the carbon market positively affects the excess returns of corporate participants (Wen et al., 2020), which can further permeate into policy reform and sustainable plans for carbon emissions (Andersson, 2018; Wu et al., 2013). The introduction of the carbon market into our VAR model also sheds the insights into the effect of commodity market volatility on sustainable development.

Our paper investigates two natural resource sectors' responses to the increasing rate of the pandemic, namely, the metal natural resource markets and the energy natural resource markets. Compared with the response of US commodity market volatilities, the response of Chinese commodity market volatilities tends to be moderate. The increase rate of the shock caused by the pandemic shifted the Chinese metal market volatilities within a small range.

In fact, commodity prices can be influenced by a number of external factors, such as market financialization (Ding et al., 2021), and trading factors, such as speculation (Huchet and Fam, 2016) and order imbalance (Ding et al., 2022). Regarding the metal natural resource markets, the copper market is more sensitive to the case increase rate than is the gold market in both China and the US. As public health policies are quite different in China and the US, the impact of the pandemic on commodity market volatility can reflect natural resource demand under different pandemic policies in these two countries (Zhang et al., 2022). In particular, the demand and supply of copper were substantially disrupted during the pandemic (Ahmed and Sarkodie, 2021; Ryter et al. 2021). The moderate response of the Chinese copper market might be attributed to the rapid recovery of the domestic supply and demand of copper under strict public health policies (He and Small, 2021). Therefore, we demonstrate that a strict public health policy can help to stabilize the domestic demand and supply of natural resources, which can lessen the impact of the pandemic on commodity markets.

We also demonstrate that sustainable natural resource development is highly relevant to oil market volatility by showing the effect of oil market volatility. Firms respond to high oil volatility by enriching their oil inventories as a buffering cushion, which reduces the total amount of oil that can be put into the production process resulting from this precautionary savings effect. The market stability of oil has a heavy impact on oil consumption and extraction since oil market volatility and oil consumption can massively affect green asset markets and carbon emissions. Actually, the effective public health policies can maintain investor confidence in financial markets during public health emergencies, which is useful in stabilizing the market. Moreover, policymaker can promote the usage of clean energy by placing the environmental regulations, such as high air quality level, which may limit economic dependence on fossil fuels and stabilize energy futures markets.

The remainder of our paper is organized as follows. Section 2 provides a relevant literature review. In section 3, we introduce the sample data and variable measures with the relevant methodology. In section 4, we describe the empirical results for both the VAR model and GARCH model. Section 5 discusses the policy implications and conclusions of our paper.

2. Literature review

2.1 The impact of the pandemic on commodity market stability

The connection between pandemics and commodity market volatility has been widely studied by scholars. Farid et al. (2022) developed a new quantile-based connectedness approach to investigate the correlation of different markets before and during the pandemic outbreak in 2019, finding that the commodity market return connectedness significantly shifted due to pandemic shocks and that there was strong transmission of return shocks between energy, metals, and agricultural commodities during the pandemic. The epidemic also shows the most substantial time-varying jump information spillover pattern to China's chemical price. Guo et al. (2022) used wavelet coherence to confirm that both pandemic-positive cases and pandemic deaths significantly trigger volatility in natural resource commodity prices, although volatility is found at different periods and is observed only in the short run. Zhang and Wang (2022) extended the ARMA-GARCH model to explore the impact of the pandemic on both the long-term and short-term volatilities of four major commodity futures and concluded that an increase in the speed of the pandemic will increase the short-term instantaneous volatilities of copper and gold futures but decrease the instantaneous volatilities of soybean and oil. Using the TVP-VAR-based connectedness index approach, Lin and Su (2021) discovered that there was a significant increase in overall connectedness in energy markets after the pandemic outbreak in 2019 but that this change only lasted for roughly two months before returning to the previous level.

2.2 Commodity market stability and sustainable development

In fact, commodity market stability has a considerable impact on sustainable development, especially for natural resources and green assets. Primary commodity market stability, such as oil market stability, could have a massive impact on the sustainable development of natural resources (Huang et al., 2023). Dutta et al. (2020) uncover the close relation between green assets and the volatility of the oil market, where green assets tend to be vulnerable to the volatility of the oil market. This finding implies that the stability and performance of green assets are closely linked to the overall stability of the oil market. Kassouri et al. (2022) discovered that there is a close connection between oil prices and carbon emissions, and such a connection stems largely from an oil price shock. Similarly, Okwanya et al. (2023) provide empirical evidence for oil price shocks and carbon emissions in Africa, which implies the potential effect of oil market stability on carbon emissions and sustainable development. Li et al. (2023) also revealed that sustainable markets, including the green bond market and carbon futures market, are susceptible to oil price shocks. They indicate that oil price shocks can decrease the potential to negatively impact the long-term efficiency of sustainable markets, suggesting that these markets are highly vulnerable to fluctuations in oil market stability.

More recently, oil market stability, in terms of oil price shocks, has been identified as the prevailing influencing element of green financial markets. Umar et al. (2024) scrutinize the spillover effects between oil price shocks and green bonds. Their empirical results reveal that oil price shocks are the main contributors to shocks in the US and European green bond markets. These results are consistent with those of other studies, such as those of Azhgaliyeva et al. (2022) and Mokni et al. (2022), suggesting a dominant role of oil market stability in green finance and sustainable development.

Beyond the green financial markets, the nexus of sustainable development with the commodity market has also been witnessed in the existing literature. Peng and Liang (2023) attest the pivotal effect of oil market fluctuations on sustainable development. Wang et al. (2024) discovered that green technology innovation can be favored toward the sustainable development, as it can lessen the shocks from oil prices to the economy and thus be helpful in the sustainable development of the future economy.

In fact, public health policy and sustainable development are intrinsically connected against the backdrop for the whole society well-beings pursuit. In order to achieve sustainable development, it is essential that public health policies can be formulated and implemented holistically from both economic and social perspectives (Pereira and Marques, 2022). Nevertheless, the outbreak of the pandemic in 2019 has imposed an unimaginable challenge on the achievement of Sustainable Development Goals both economically and socially (Wang and Huang, 2021). As a consequence, our study aligns with the literature by analyzing the effect of public health policy as a stabilizer of the commodity market, which can, in turn, generate an achievable path toward sustainable development, especially when energy market fluctuations become moderate.

3. Data and methodology

3.1 Data and variable estimations

We collected sample data for eight commodity futures markets in the U.S. and China, namely, the carbon futures market, the copper futures market, the gold futures market, and the oil futures market. We also collected data on newly increased cases of the pandemic for both China and the United States. All sample data were collected on a daily basis from the WIND database. The sample covers the period from 1 January 2018 to 1 October 2022. As China gradually changed its public health policy beginning in November 2022, our sample covers the period until October 2022.

In our variable description, the superscript ‘car’ represents carbon futures, ‘cop’ represents copper futures, ‘gold’ represents gold futures, and ‘oil’ represents oil futures. We denote the commodity markets with ‘c’ as Chinese commodity markets and denote the commodity markets with ‘u’ as United States commodity markets. We further use ‘nchina’ to represent the percentage of newly increased pandemic cases in China, and we use ‘nusa’ to represent the percentage of newly increased pandemic cases in the U.S. For the empirical analysis, we use the futures prices (P^i_t) to produce the main variable we intend to investigate, which is the commodity return. The commodity return can be defined as $r_t^i = lnP_t^i - lnP_{t-1}^i$. σ^i_t represents the conditional volatility of commodity market i from the GARCH model at time t. w^i_t represents the percentage increase in new pandemic cases in country i from time t.

3.2 VAR model

The Vector Autoregression (VAR) model, which is a prevailing multivariate model used to analyze the impact of different variables in recent financial studies (Zhang and Lin, 2019; Gong et al., 2021; Chen et al., 2022; Inoue and Kilian, 2022), is the main method used in this study. The basic VAR (p) model takes the following form (for $\mathbf{X_t}$ is the vector of endogenous variables concerned):

$$\boldsymbol{X_t} = \boldsymbol{\theta_0} + \sum_{j=1}^{p} \boldsymbol{\theta_j}\, \mathbf{X_{t-j}} + \boldsymbol{\varepsilon_t}, \tag{1}$$

where $\boldsymbol{\theta_0}$ is a K × 1 vector of constants, $\boldsymbol{\theta_j}$ for j = 1, . . ., p, is a K × K matrix of model coefficients, and $\boldsymbol{\varepsilon_t}$ is a K × 1 vector of IID (Independent and Identically Distributed) Gaussian residuals terms for the VAR model.

3.3 GARCH model

We further use the Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model to understand the conditional volatility of these commodity markets.

The standard GARCH (1, 1) model consists of the following parts. The mean equation of the GARCH model can be defined as follows (see equation (2)):

$$r_t^i = \mu_t^i + \varepsilon_{i,t}, \tag{2}$$

where μ_t^i is the conditional mean and $\varepsilon_{i,t}$ is the residual term.

Then, based on the residual term, the GARCH (1, 1) model can be defined as (see equation (3)):

$$\sigma_{i,t}^2 = \alpha_0^i + \alpha_1^i \varepsilon_{i,t-1}^2 + \alpha_2^i \sigma_{i,t-1}^2. \tag{3}$$

where $\sigma_{i,t}$ is the conditional volatility and $\varepsilon_{i,t}$ is the residual term.

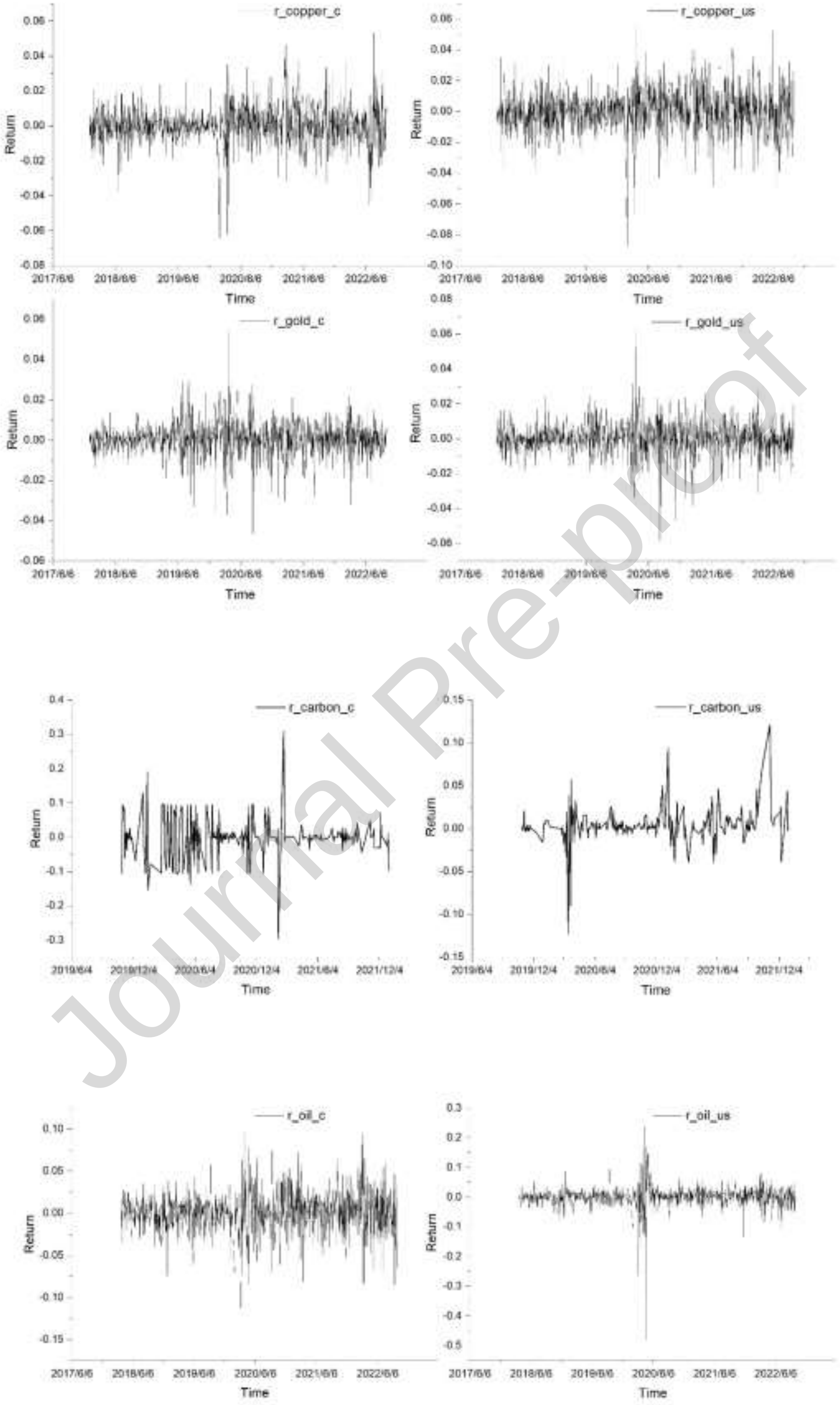

Fig. 1. Plot of eight commodity futures returns starting for our sample period (from 1 January

2018 to 1 October 2022).

4. Empirical results

This section presents the empirical results of the comparison of two-country commodity market volatility behavior against the increase in the number of pandemic cases.

Table 1. Descriptive statistics of the price differences of eight futures markets.

	Mean	Max	Min	Std. Dev.	Obs.
r^{carc}_t	0	0.31	-0.30	0.06	265
r^{caru}_t	0.003	0.12	-0.12	0.019	265
r^{copc}_t	0	0.05	-0.06	0.011	1130
r^{copu}_t	0	0.05	-0.09	0.014	1130
r^{goldc}_t	0	0.05	-0.05	0.009	1130
r^{goldu}_t	0	0.06	-0.06	0.01	1130
r^{oilc}_t	0	0.13	-0.17	0.034	1130
r^{oilu}_t	0.001	0.37	-0.48	0.065	1130

Note: This table presents the mean and standard deviation (SD) with maximum and minimum values for price differences of eight futures markets from both China and the United States. Our sample runs from 1 January 2018 to 1 October 2022 (the carbon futures sample is from 1 October 2019 to 1 January 2022).

Table 1 presents the statistical properties of the price differences of eight futures markets. The means of the price differences of all futures markets are zero except for those of the U.S. crude oil futures market and U.S. carbon trading market, whose means are positive. In addition, the crude oil futures markets in China and the United States have the largest standard deviations, which also indicates that among the different commodity futures markets studied, the global crude oil market has experienced the most violent fluctuations. Overall, Chinese futures markets have smaller standard deviations than the United States, which implies less variability in Chinese futures markets.

Table 2 shows the unit root test results of the price difference series of eight futures markets. In this paper, the ADF method is applied to verify the unit root. The results indicate that the series of all variables reject the unit root hypothesis at the 1% significance level, which means that all the variables are stationary and can be applied to empirical research.

Table 3-1 and Table 3-2 present the correlations between commodity market volatilities and the pandemic effect represented by the new case growth speed. For both the metal commodity sector and the energy commodity sector, the connection between commodity market volatilities and the pandemic effect is mostly positive, indicating that the exacerbation of the pandemic could magnify volatility in commodity markets.

Table 2

Unit root test of the price difference series of eight futures markets.

Series	Prob.	Z(t)
r^{carc}_t	0.00	-17.79
r^{caru}_t	0.00	-15.81
r^{copc}_t	0.00	-35.44
r^{copu}_t	0.00	-34.21
r^{goldc}_t	0.00	-33.04
r^{goldu}_t	0.00	-32.45
r^{oilc}_t	0.00	-13.71
r^{oilu}_t	0.00	-17.22

Note: The table presents the individual unit root test results for each futures market, and all eight futures returns are stationary series based on the unit root test. Our sample runs from 1 January 2018 to 1 October 2022 (the carbon futures sample is from 1 October 2019 to 1 January 2022).

Table 3-1

Pearson correlation coefficients of the variables in the copper and gold markets.

Correlation	w^u_t	w^c_t	σ^{copc}_t	σ^{goldc}_t	σ^{copu}_t	σ^{goldu}_t
w^u_t	1.00					
w^c_t	0.01	1.00				
σ^{copc}_t	0.10	0.06	1.00			
σ^{goldc}_t	0.02	-0.03	0.30	1.00		
σ^{copu}_t	0.07	0.06	0.57	0.25	1.00	
σ^{goldu}_t	0.04	-0.04	0.43	0.84	0.33	1.00

Note: The table presents the correlations between metal commodity market volatilities and the pandemic effect represented by the new case growth speed. Our sample runs from 1 January 2018 to 1 October 2022.

Table 3-2

Pearson correlation coefficients of the variables in the oil and carbon trading markets.

Correlation	w^u_t	w^c_t	σ^{oilu}_t	σ^{caru}_t	σ^{oilc}_t	σ^{carc}_t
w^u_t	1.00					
w^c_t	-0.03	1.00				
σ^{oilu}_t	0.14	-0.02	1.00			
σ^{caru}_t	0.13	-0.04	0.22	1.00		
σ^{oilc}_t	0.28	0.05	0.62	0.29	1.00	
σ^{carc}_t	-0.01	0.05	0.35	0.08	0.30	1.00

Note: The table presents the correlations between energy commodity market volatilities and the pandemic effect represented by the new case growth speed. Our sample runs from 1 January 2018 to 1 October 2022 (the carbon futures sample is from 1 October 2019 to 1 January 2022).

4.1 VAR model analysis

For this subsection, we compare the impact of the pandemic on commodity market volatilities for both China and the United States. We establish two VAR models for the empirical analysis. One VAR model includes four metal commodity market volatilities, with the percentage of pandemic-positive cases increasing from China to the United States (see Table 4-1). The other model includes four energy commodity market volatilities, with the percentage of pandemic-positive cases increasing in China and the United States (see Table 4-2). We further adopt impulse response functions to obtain our empirical results based on the two VAR models.

Table 4-1

The results of the VAR model for the copper and gold markets under pandemic conditions (our sample data are from 1 January 2018 to 1 October 2022).

	(1) σ^{copc}_{t}	(2) σ^{goldc}_{t}	(3) σ^{copu}_{t}	(4) σ^{goldu}_{t}
W^{u}_{t-1}	0.07^{**}	0.004	0.13^{***}	0.027^{*}
	(2.10)	(0.35)	(2.73)	(1.68)
W^{u}_{t-2}	-0.05	0.001	-0.027	0.019
	(-1.46)	(0.072)	(-0.55)	(1.18)
W^{c}_{t-1}	0.01	-0.015	-0.14^{**}	-0.042^{*}
	(0.15)	(-0.85)	(-2.08)	(-1.85)
W^{c}_{t-2}	-0.004	-0.002	0.025	-0.021
	(-0.077)	(-0.089)	(0.37)	(-0.91)
σ^{copc}_{t-1}	0.84^{***}	0.001	0.028	0.022
	(26.69)	(0.09)	(0.65)	(1.48)
σ^{copc}_{t-2}	0.044	-0.004	0.022	-0.009
	(1.47)	(-0.34)	(0.54)	(-0.65)
σ^{goldc}_{t-1}	0.025	0.94^{***}	0.21^{**}	0.047
	(0.34)	(35.82)	(2.03)	(1.38)
σ^{goldc}_{t-2}	-0.02	0.032	-0.22^{**}	-0.008
	(-0.28)	(1.24)	(-2.21)	(-0.22)
σ^{copu}_{t-1}	0.23^{***}	-0.006	0.69^{***}	0.012
	(10.06)	(-0.67)	(21.61)	(1.11)
σ^{copu}_{t-2}	-0.11^{***}	0.002	-0.056^{*}	-0.002
	(-4.60)	(0.25)	(-1.74)	(-0.19)
σ^{goldu}_{t-1}	0.072	0.49^{***}	0.16^{*}	0.92^{***}
	(1.096)	(20.95)	(1.69)	(29.9)
σ^{goldu}_{t-2}	-0.071	-0.47^{***}	-0.09	0.004

	(-1.07)	(-19.95)	(-1.02)	(0.14)
Constant	-0.63**	0.11	4.13***	0.11
	(-2.51)	(1.28)	(11.93)	(0.90)
N	1129	1129	1129	1129

Note: This table presents the empirical results of the VAR model for the copper and gold markets under pandemic conditions. For the empirical results, t values are in parentheses, and ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 4-1 presents the VAR model regression results for constructing the metal natural resource commodity markets model for both China and the United States.

Based on the VAR model, we further use impulse response functions to compare the different responses of commodity market volatilities to country-specific pandemic situations, as shown in Figures 2-1. The left side of Figure 2-1 shows two subfigures for Chinese commodity market responses to the pandemic situation in China under the relatively strict control of the pandemic policy. The right side of Figure 2-1 shows two subfigures for US commodity market responses to the pandemic situation in the US under the relative open policy. Compared with the response of US commodity market volatilities, the response of Chinese commodity market volatilities tends to be moderate. The shock of the increase rate of the pandemic positive case shifts the Chinese metal market volatilities only near the zero horizon. For copper and gold market volatilities, the copper market is more sensitive to the increase rate of the pandemic-positive case than is the gold market.

The strength of the increase in copper market volatility toward the pandemic positive case increase rate is twofold. The worldwide spread of the pandemic triggered an economic recession, resulting in a decline in industrial demand for copper (Ahmed and Sarkodie, 2021). Furthermore, the pandemic has created massive disruptions in the copper supply chain (Ryter et al. 2021). The moderate response of the Chinese copper market might be attributed to the rapid recovery of the domestic supply and demand of copper under strict public health policy (He and Small, 2021). On the other hand, gold has been considered a safe haven for hedging against pandemic-induced economic recessions (Salisu et al., 2021); thus, the gold market does not respond as strongly as the copper market.

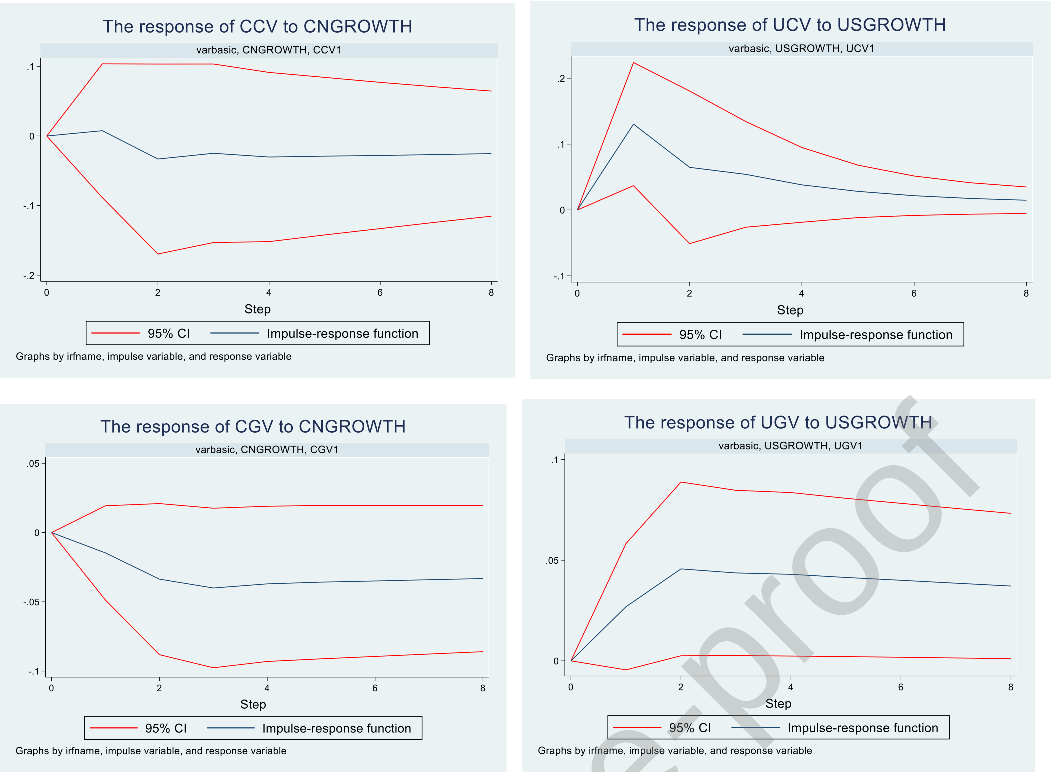

Fig. 2-1 The response of gold and copper price volatilities to the increase in the pandemic period for China and the US using impulse response functions. The left side presents the response of the Chinese commodity market volatilities to the increase rate of the pandemic positive case for both the copper and gold markets. The right side shows the response of US commodity market volatilities to a positive increase in the number of pandemics for both the copper and gold markets. Our sample runs from 1 January 2018 to 1 October 2022, and we take the 95% confidence intervals as the red lines.

Table 4-2

The results of the VAR model for the oil and carbon futures markets with pandemic effects (our sample data are from 1 January 2018 to 1 October 2022).

	(1) σ^{oilu}_t	(2) σ^{oilc}_t	(3) σ^{caru}_t	(4) σ^{carc}_t
w^u_{t-1}	2.37	4.41^{*}	-1.98	1.85
	(0.40)	(1.68)	(-0.75)	(0.15)
w^u_{t-2}	5.80	2.29	18.55^{***}	-12.98
	(1.01)	(0.91)	(7.37)	(-1.07)
w^u_{t-3}	12.98^{**}	2.03	-3.54	-1.62
	(2.09)	(0.74)	(-1.29)	(-0.12)
w^c_{t-1}	-0.07	0.86	-0.09	-1.19
	(-0.05)	(1.26)	(-0.13)	(-0.36)
w^c_{t-2}	0.63	-0.20	-0.71	-3.96
	(0.41)	(-0.29)	(-1.03)	(-1.21)
w^c_{t-3}	3.11^{**}	0.67	1.22^{*}	0.23
	(2.05)	(1.00)	(1.82)	(0.07)
σ^{oilu}_{t-1}	0.97^{***}	0.11^{***}	0.011	0.16

	(15.47)	(4.01)	(0.40)	(1.22)
σ^{oilu}_{t-2}	-0.18**	-0.07*	-0.05	0.11
	(-2.01)	(-1.84)	(-1.31)	(0.60)
σ^{oilu}_{t-3}	0.12*	0.002	0.022	-0.14
	(1.78)	(0.06)	(0.79)	(-1.00)
σ^{oilc}_{t-1}	-0.006	0.62***	0.04	-0.07
	(-0.04)	(8.91)	(0.59)	(-0.20)
σ^{oilc}_{t-2}	-0.10	0.017	0.07	-0.09
	(-0.52)	(0.20)	(0.81)	(-0.22)
σ^{oilc}_{t-3}	-0.03	-0.03	0.03	0.02
	(-0.18)	(-0.44)	(0.45)	(0.05)
σ^{caru}_{t-1}	0.03	0.045	0.85***	0.45
	(0.23)	(0.73)	(13.87)	(1.52)
σ^{caru}_{t-2}	-0.24	-0.099	-0.03	-0.80**
	(-1.37)	(-1.31)	(-0.40)	(-2.19)
σ^{caru}_{t-3}	0.22*	0.05	-0.004	0.43
	(1.77)	(0.94)	(-0.07)	(1.63)
σ^{carc}_{t-1}	0.06*	0.025**	0.009	0.84***
	(1.96)	(1.96)	(0.74)	(13.74)
σ^{carc}_{t-2}	-0.07*	-0.017	0.005	-0.25***
	(-1.85)	(-1.02)	(0.33)	(-3.21)
σ^{carc}_{t-3}	0.07**	0.012	-0.012	0.13**
	(2.50)	(0.97)	(-0.96)	(2.08)
Constant	3.02	9.61***	-2.15	15.22*
	(0.79)	(5.69)	(-1.27)	(1.87)
N	263	263	263	263

Note: This table presents the empirical results of the VAR model for the oil and carbon futures markets with pandemic effects. For the empirical results, t values are in parentheses, and ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 4-2 presents the VAR model regression results for constructing the energy natural resource commodity markets model for both China and the United States.

We also use impulse response functions to compare the different responses of commodity market volatilities to country-specific pandemic situations, as shown in Figures 2-2. The left side of Figure 2-2 shows two subfigures for Chinese commodity market responses to the pandemic situation in China under a relatively strict public health policy. The right side of Figure 2-2 shows two subfigures for US commodity market responses to the pandemic situation in the US under the relative open policy. Similarly, the response of Chinese commodity market volatilities is more temperate. The increase in the rate of increase in the number of pandemic-positive cases drove Chinese energy market volatilities within a small spectrum. Since the carbon market can sustainably plan carbon emissions (Zafar et al., 2019), carbon market volatility also plays a key role in future sustainable development. Thus, the strict public health policy of pandemics that can soften carbon market volatility could have a favorable effect on the formulation of a stable sustainable carbon emissions plan.

For carbon and oil market volatilities, the oil market is more sensitive to the increase rate of the pandemic-positive case than is the carbon market. Consequently, we further analyze the impact of oil market volatility on oil consumption and production, which are highly correlated with oil policy-making, such as the OPEC oil production policy (Brown and Huntington, 2017), in the next subsection.

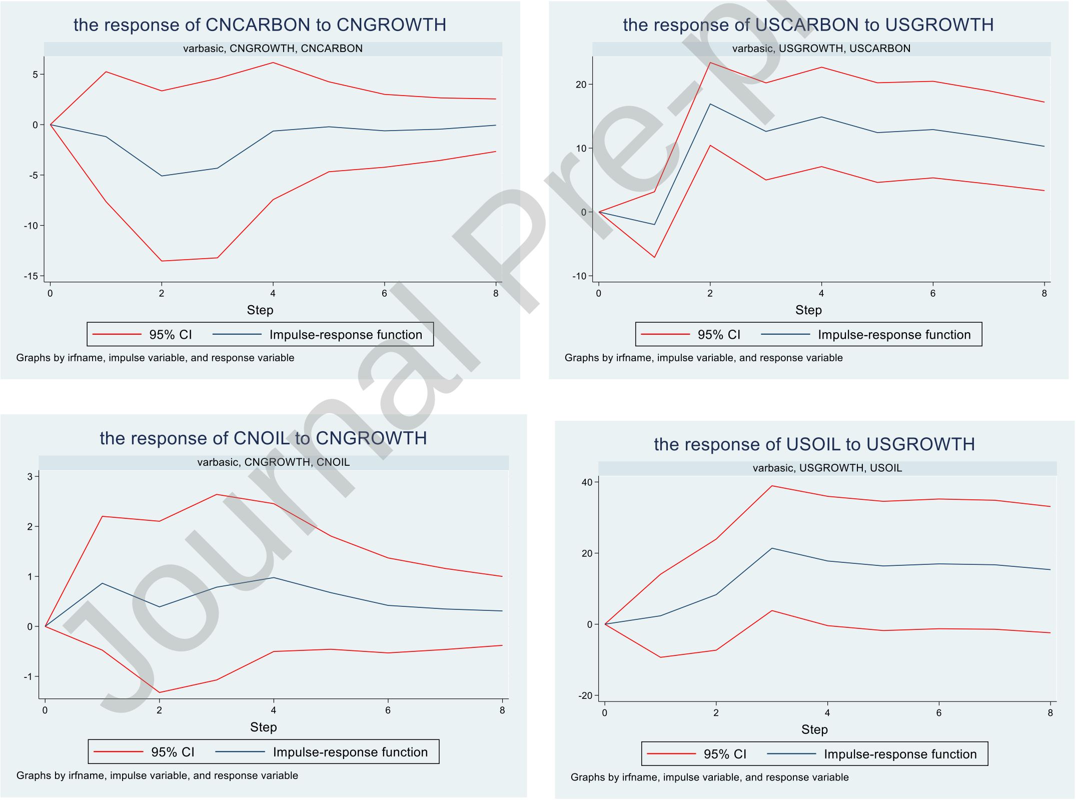

Fig. 2-2 The response of gold and copper price volatilities to the increase in the pandemic period for China and the US using impulse response functions. The left side presents the response of the Chinese commodity market volatilities to the increase rate of the pandemic positive case for both the copper and gold markets. The right side shows the response of US commodity market volatilities to a positive increase in the number of pandemics for both the copper and gold markets. Our sample runs from 1 January 2018 to 1 October 2022 (carbon data only run from 1 October 2019 to 1 January 2022), and we take the 95% confidence intervals as red lines.

4.2 Oil consumption and oil market stability

Natural resource consumption has been profoundly affected by natural resource commodity market volatility, which serves as the key measure of oil market stability. For instance, oil consumption is strongly dependent on oil market volatility since oil inventories are sharply increasing (Gao et al., 2022). On this basis, this section attempts to scrutinize the impact of natural resource commodity market volatility on natural resource consumption. We take oil consumption as an example.

In particular, Figure 3 presents the conditional variance of the oil returns of both the Chinese and U.S. markets over the sample period. It is clear that the peak of the oil market volatility synchronized in both China and the U.S., especially for the peak in 2020. The first peak of oil market volatility occurred in approximately March 2020, and the second peak occurred at the end of April 2020, when the oil price decreased to a negative value.

According to Figure 4 and Figure 5, these two peaks of oil market volatility have led to a decrease in both oil production and oil consumption since the oil market volatility peak arrived earlier than the plummeting of oil production and consumption, which can be envisioned as warning signals from the oil market. As a result, it is arguable that oil market volatility plays a crucial role in affecting oil production and consumption.

As a result, volatility in the oil market has fruitful policy implications since a pandemic shock can influence oil market volatility, and oil market volatility can further influence oil policy making. Thus, commodity market volatility serves as the transmission channel of the pandemic crisis to sustainable natural resource development.

In fact, Gao et al. (2022) demonstrate the effects of oil market volatility on oil sector fundamentals, suggesting that oil consumption can be significantly affected. On the other hand, the aggregate oil extraction rate is also heavily impacted. Firms respond to high oil volatility by enriching their oil inventories as a buffering cushion, which reduces the total amount of oil that can be put into the production process resulting from this precautionary savings effect. Therefore, commodity market volatility can influence oil consumption by reducing both the precautionary savings effect and the oil extraction rate. As a consequence, sustainable natural resource development is highly relevant to oil market volatility. Unstable oil prices could lead to disproportionate use, resulting in volatile demand cycles that hinder sustainable oil consumption. If the oil price remains stable without rigorous fluctuations, oil companies will be less inclined to over-extract in short periods to maintain the precautionary savings of the oil, while sustainable plans for long-term oil extraction become workable.

Therefore, public health emergencies and corresponding public health policies have uncovered the vulnerabilities of global supply chains, such as the oil industry. To reduce future disruptions from public health policies, there might be a revolution in the current oil supply chain network. A shift in the oil supply can create a long-term effect of public health policies since countries have begun to notice the importance of the oil supply, especially during lockdown periods. Therefore, it could be remarkable that the average level of oil production in the US after the pandemic (i.e., from 2020 to 2022) was generally lower than that before the pandemic (i.e., from 2017 to 2019) (see Fig. 5). The oil exporting and oil supply networks were disrupted by the pandemic, and in the long run, a new oil supply network will be established.

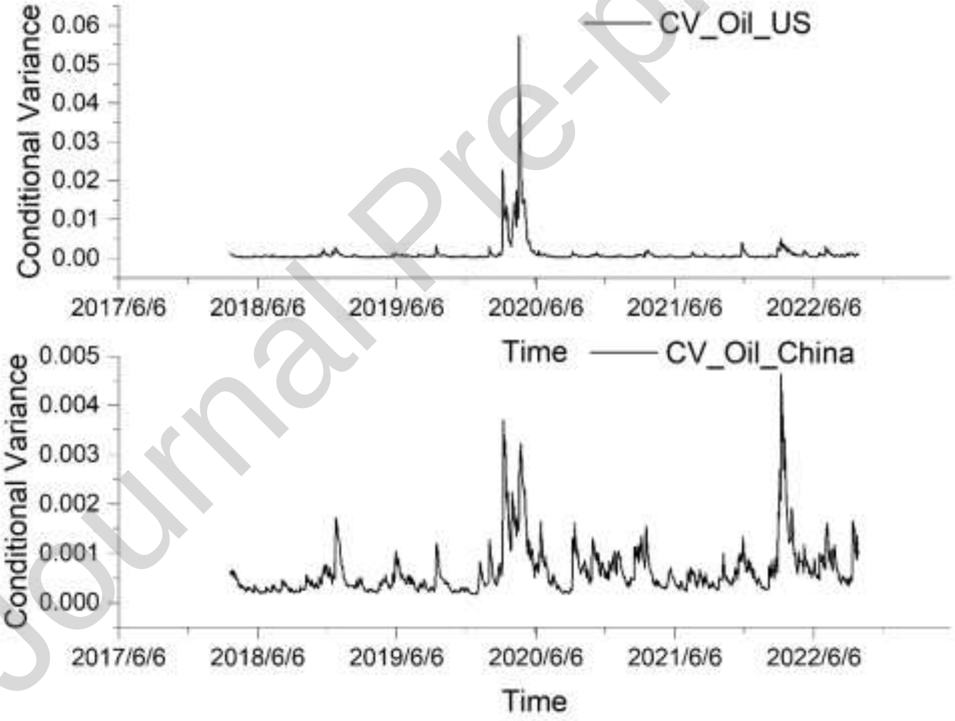

Fig. 3. The conditional variance of the oil returns of both the Chinese and U.S. markets over the sample period (our sample data are from 1 January 2018 to 1 October 2022).

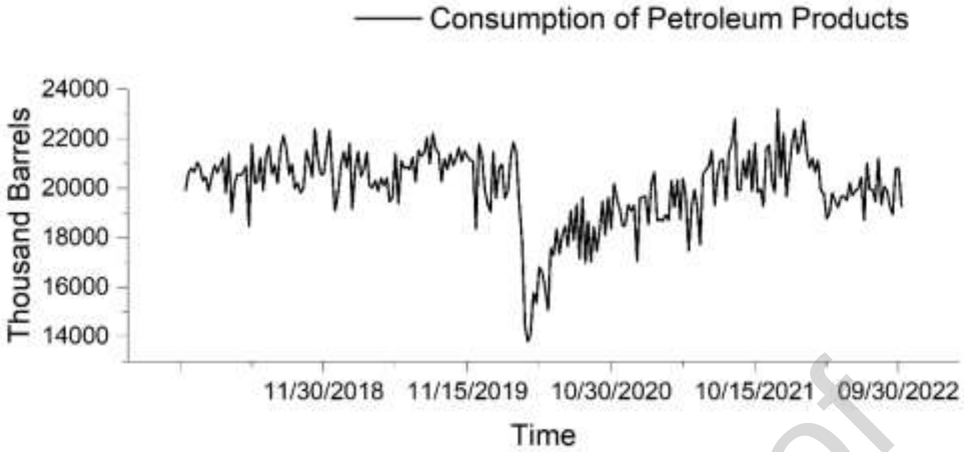

Fig. 4. The crude oil consumption amount of the U.S. over the sample period (our sample data are from 1 January 2018 to 1 October 2022).

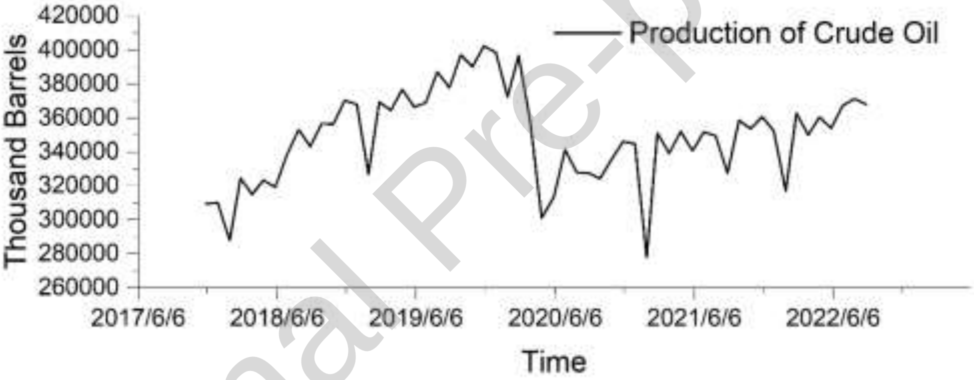

Fig. 5. The crude oil production amount of the U.S. over the sample period (our sample data are from 1 January 2018 to 1 October 2022).

5. Conclusion and policy implications

To conclude, our paper investigates two natural resource sectors' responses to the increasing rate of the pandemic, namely, the metal natural resource markets and the energy natural resource markets. Compared with the response of US commodity market volatilities, the response of Chinese commodity market volatilities tends to be moderate. The increase rate of the shock caused by the pandemic shifted the Chinese metal market volatilities within a small range.

Regarding the metal natural resource markets, the copper market is more sensitive to the increase in the number of positive cases of the pandemic than is the gold market in both China and the US. As pandemic-related public health policies are quite different in China and the US, the impact of pandemics on commodity market volatility can reflect natural resource demand under different public health policies in these two countries (Zhang et al., 2022). In particular, the demand and supply of copper were substantially disrupted during the pandemic (Ahmed and Sarkodie, 2021; Ryter et al. 2021). The moderate response of the Chinese copper market might be attributed to the rapid recovery of the domestic supply and demand of copper under strict public health policy (He and Small, 2021). Therefore, we demonstrate that strict public health policies can help to stabilize the domestic demand and supply of natural resources, which can lessen the impact of pandemics on commodity market stability.

We also unveil that sustainable natural resource development is highly relevant to oil market volatility by showing the effect of oil market volatility. Firms respond to high oil volatility by enriching their oil inventories as a buffering cushion, which reduces the total amount of oil that can be put into the production process resulting from this precautionary savings effect. Therefore, commodity market volatility can influence oil consumption by reducing both the precautionary savings effect and the oil extraction rate. The volatility of the oil market has a heavy impact on oil consumption and extraction, which affects the sustainable use of oil resources. When the oil market is stable, oil companies can more confidently invest in infrastructure that allows safer and more efficient oil extraction practices. Furthermore, the effect of carbon market volatility in our VAR model provides valuable insights into the impact of commodity market volatility on sustainable development. By employing carbon futures data, we highlight how commodity market stability, particularly in sustainable markets, can influence the progress and effectiveness of sustainable development initiatives.

In fact, effective public health policies can retain investor confidence in financial markets during public health emergencies. When investors are confident, market panic can be frustrated, which could be helpful in stabilizing prices in commodity markets. Therefore, rapid and transparent public health policies during public health emergencies can serve as a stabilizer for commodity markets.

Concerning the interaction between carbon market volatility and other commodity market volatility, policymakers can better accommodate public health policies for pursuing sustainable development goals in a dynamic economic environment. The development of a carbon market can be adopted to promote the use of clean energy by trading carbon emission quotas. Policymakers can thereby work with the carbon market to reduce carbon emissions and increase air quality, which in turn reduces environmental and air pollution. Thus, public health policies and carbon markets can assist governments in achieving sustainable development goals. The wide application of clean energy can also restrain economic dependence on fossil fuels, which can further stabilize energy futures markets such as the oil futures market since the large demand for fossil fuels can be discouraged.

Based on our study, future research in this field could focus on the role of technology in managing and predicting commodity market volatility during market crises such as public health crises. Further studies can apply big data and machine learning techniques in forecasting or simulating financial market participant behavior and thus financial market stability under the conditions of sustainable development policy implementation. By employing such advanced techniques, scholars can dig a deep understanding of the effectiveness of sustainable development policy in stabilizing financial markets.

Funding Information

This paper is supported by the Philosophy and Social Science Planned Research Project of Zhejiang Province, "Study of Intelligentized Prediction and Management of Small and Medium-sized Enterprises' Credit Risk in Zhejiang Province” (grant number: 24NDJC240YBM); The Ningbo Natural Science Foundation Project, China (Project ID: 2023J194) and Financial Research Center, Ningbo University.

Conflict of Interest Disclosure

The authors report no conflicts of interest in this work. The sponsors had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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Funding Information

This paper is supported by The Humanities and Social Sciences Young Scholar Fund of China's Ministry of Education (grant number: 19YJC630158); The Natural Science Foundation of Zhejiang Province of China (grant number: LY22G020002); The Philosophy and Social

Science Planned Research Project of Zhejiang Province, "Study of Intelligentized Prediction and Management of Small and Medium-sized Enterprises' Credit Risk in Zhejiang Province" (grant number: 24NDJC240YBM), and Financial Research Center, Ningbo University.

Conflict of Interest Disclosure

The authors report no conflicts of interest in this work. The sponsors had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

CRediT Authorship contributions

Dr. Shusheng Ding: Investigation, Methodology, Writing – original draft

Mrs. Anqi Wang: Data curation, Resources, Software

Dr. Tianxiang Cui: Data curation, Formal analysis, Validation, Visualization

Dr. Anna Min Du: Conceptualization, Investigation, Resources, Supervision, Writing – review & editing

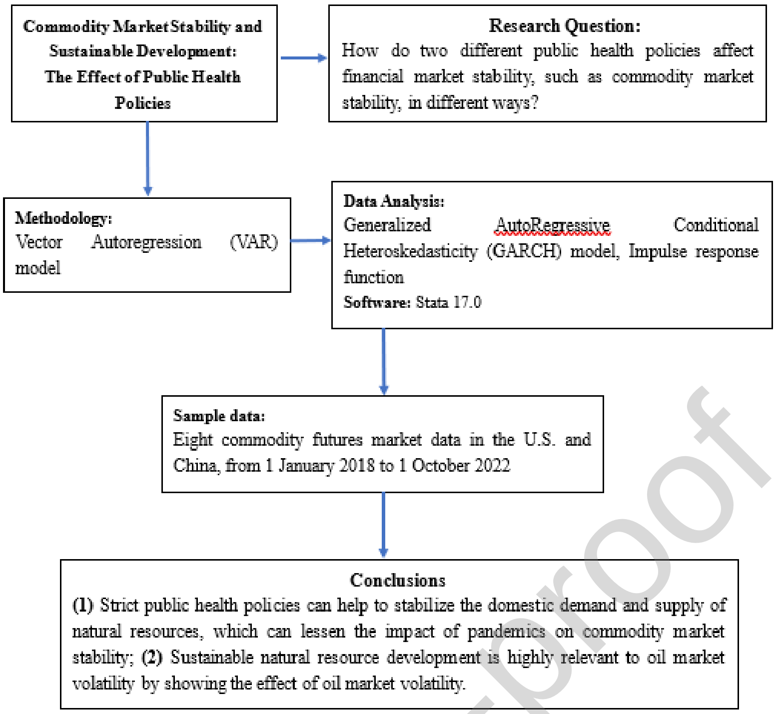
Prof Xinmiao Zhou: Funding acquisition, Validation, Writing – review & editing

Declaration of interests

☒ 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.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Graphical Abstract



Commodity Market Stability and Sustainable Development: The Effect of Public Health Policies

Research Question:
How do two different public health policies affect financial market stability, such as commodity market stability, in different ways?

Methodology:
Vector Autoregression (VAR) model

Data Analysis:
Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model, Impulse response function
Software: Stata 17.0

Sample data:
Eight commodity futures market data in the U.S. and China, from 1 January 2018 to 1 October 2022

Conclusions
(1) Strict public health policies can help to stabilize the domestic demand and supply of natural resources, which can lessen the impact of pandemics on commodity market stability; **(2)** Sustainable natural resource development is highly relevant to oil market volatility by showing the effect of oil market volatility.

Highlights

- Different public health policies affect impact of pandemics on commodity volatilities.
- Strict public health policy can be helpful in stabilizing commodity markets.
- Sustainable development is highly sensitive to commodity market volatility