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Research Article

Swings in Crude Oil Valuations: Analyzing Their Bearing on China's Stock Market Returns amid the COVID-19 Pandemic Upheaval

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The advent of the COVID-19 pandemic has markedly affected energy valuations and financial markets. As such, this article aims to scrutinize the dynamic interplay between stock market returns and crude oil prices, with a particular focus on China, factoring in the second-moment effect of volatility spillover. Employing an EGARCH process to model the leverage impact on returns' volatility, the analysis utilizes daily data spanning from January 30, 2020, to August 30, 2022, and incorporates causality-in-mean and variance assessments. Empirical findings indicate that the QDII-LOF benchmark, representing oil prices, exerts a substantial influence on stock market returns. Nevertheless, the complete sample reveals no discernible spillover effects attributable to oil price fluctuations. These insights imply that the Chinese government's actions should carefully weigh the ramifications of spillovers. Concurrently, investors are advised to attentively monitor the crude oil market when making portfolio allocation decisions.

1. Introduction

The exploration of the effects of crude oil price fluctuations on China's stock market returns during the COVID-19 pandemic is of paramount importance, as it provides valuable insights into the intricate dynamics between energy and financial markets in one of the world's largest economies. This line of inquiry is particularly crucial given China's status as a significant energy consumer and its role in shaping global oil demand patterns. Furthermore, understanding the interdependencies between crude oil prices and China's stock market returns during the pandemic enables policymakers, investors, and other stakeholders to make informed decisions in the face of unprecedented economic challenges and market volatility. The COVID-19 crisis, with its far-reaching consequences on energy demand, supply chains, and macroeconomic stability, has amplified the need for a comprehensive investigation of the oil-stock market nexus in the Chinese context. By delving into this critical research area, scholars contribute to a richer understanding of the complex interplay between energy and financial markets, ultimately facilitating the development of robust and adaptive strategies to navigate the evolving economic landscape. Amid the COVID-19 pandemic outbreak, China has experienced profound ramifications across numerous sectors, encompassing energy prices and stock markets. Energy, as the cornerstone of China's economic growth and financial market efficacy, plays a pivotal role in corporate production. Wang and Wu [1] noted that stock market stability could be jeopardized when uncertainty spawned significant energy price volatility. Chiarella et al. [2] elucidated that such volatility could impact firms' outputs and profits by altering production costs and subsequently causing stock price fluctuations. Conversely, energy prices could influence stock prices through mechanisms like speculative demand and investor expectation effects.

Traditionally, China has focused on stock market-associated financial risks. The innately elevated risk of the stock market renders it vulnerable to the destabilizing forces of both internal and external elements, including substantial price shifts. Concurrently, stock market volatility can permeate other markets, ultimately culminating in the accumulation or triggering of systemic financial perils. Consequently, during the COVID-19 pandemic, it is crucial to rigorously examine the volatility spillover nexus between China's energy and stock markets, elucidating the risk transmission mechanisms between them. This insight will aid governmental bodies in enhancing energy and stock market price stability measures while mitigating financial hazards.

This study aims to scrutinize the influence of crude oil price fluctuations on China's stock market returns amidst the COVID-19 pandemic, drawing from the comprehensive research context outlined earlier. Utilizing the exponential generalized auto-regressive conditional heteroskedasticity (EGARCH) model alongside causality-in-mean and variance tests for our empirical analysis, we employed daily data spanning from January 30, 2020, to August 30, 2022. The results, underpinned by the QDII-LOF benchmark, indicate a significant correlation between oil prices and China's stock market returns. However, when examining the entire sample, we observed no substantial spillover ramifications from oil prices. This research not only offers valuable insights for the Chinese government and investors regarding the pandemic's impact on energy prices and stock market performance but also enriches the existing academic discourse on the subject.

Moreover, this study presents two notable contributions to the existing Chinese literature on the subject. Firstly, by employing the exponential generalized auto-regressive conditional heteroscedasticity, causality-in-mean, and variance approaches, this work delves into the issue from a distinct analytical perspective, thus augmenting the current body of knowledge. This differs from previous Chinese research (Zhu et al. [3]; Li et al. [4]; Luo and Qin [5]; Fang and You [6]; Ding et al. [7]), which primarily utilized vector auto-regression, Granger causality, structural vector auto-regression, and other methodologies. Secondly, considering China's status as the world's largest energy importer and the COVID-19 pandemic's origin, selecting China as the sample for examining this issue offers a more representative and insightful approach. This not only complements existing literature (Bashir [8]; Katsampoxakis et al. [9]; Managi et al. [10]; Refai et al. [11]; Jareño et al. [12]) but also broadens the scope of the ongoing discourse on this subject.

This article unfolds in a meticulously structured manner, with each section serving a distinct purpose. Section 2 delves into a comprehensive review of relevant literature, setting the foundation for the analysis. Section 3 outlines the robust econometric methodology employed, ensuring the accuracy and reliability of the study's results. Section 4 presents the findings and engages in an insightful discussion, enhancing readers' understanding of the topic. Finally, Section 5 concludes the article by offering thought-provoking conclusions and valuable policy implications, paving the way for future research and policy development in this domain.

2. Literature Review

The objective of this section is to meticulously synthesize and examine prior investigations concerning the repercussions of crude oil shocks on stock market volatility, thereby establishing a robust, credible, and impartial theoretical basis for the present study. A unified agreement has yet to emerge within the diverse and extensive literature regarding the precise impact of crude oil shocks on stock market volatility.

The COVID-19 pandemic has generated a wealth of academic literature probing the influence of crude oil price shocks on stock market returns as researchers strive to unravel the intricate interconnections between energy and financial markets during this unprecedented global occurrence (Sharif et al. [13]; Alaoui Mdaghri et al. [14]; Abuzayed et al. [15]; Ren et al. [16]; Salisu et al. [17]; Ren et al. [18]). Foundational studies have explored the myriad pathways through which variations in the price of crude oil affect stock market returns, emphasizing factors such as cost, demand, and expectations as pivotal drivers of this nexus (Phoong et al. [19]; Wang et al. [20]; Duan et al. [21]; Managi et al. [10]; Naeem et al. [22]). The COVID-19 crisis has intensified these interactions, with the convergence of collapsing energy demand, disrupted supply chains, and pervasive economic downturns engendering unparalleled market dynamics (Martins and Cró [23]; G. Tuna and V. E. Tuna [24]; Liu et al. [25]).

Innovative methodologies have been harnessed to untangle the complex linkages between crude oil prices and stock market returns amid the pandemic. For instance, Bani-Khalaf and Taspinar [26], and Lúcio and Caiado [27] have detected negative correlations between crude oil price shocks and stock market returns, positing that the drastic decline in energy demand and the subsequent oil glut have exerted downward pressure on both markets. In contrast, Benlagha and El Omari [28], and Nham [29] have observed positive associations, arguing that the resurgence in oil prices following the initial collapse has invigorated stock market performance. These investigations have employed cutting-edge econometric techniques, such as vector error correction models (Wang et al. [30]; Ren et al. [31]; Fareed et al. [32]), dynamic conditional correlation models (DCC) (Zhou et al. [33]), and wavelet coherence analysis (Tiwari et al. [34]), to shed light on the multifaceted relationships between crude oil prices and stock market returns during the pandemic.

Throughout the COVID-19 pandemic, the interplay between crude oil price shocks and stock market returns has garnered significant scholarly interest. Pioneering studies by Zhang et al. [35] laid the groundwork by identifying an intensified interdependence between oil prices, stock markets, and exchange rates through dynamic conditional correlation and wavelet coherence models. This foundation spurred a plethora of subsequent inquiries. For example, Dutta et al. [36], Hung and Vo [37], and Salisu et al. [38] adopted wavelet analysis to scrutinize the oil-stock market relationship, while Salisu and Obiora [39], and Mezghani and Abbes [40] deployed network-based approaches to examine the spillover effects between the two variables. Furthermore, scholars such as Rowland et al. [41], Ding et al. [42], and Umar et al. [43] have utilized cross-sectional, copula, and Bayesian vector autoregression models, respectively, to showcase the negative correlation between oil prices and stock market performance during the pandemic.

As the body of literature on this topic continued to grow, researchers began incorporating more advanced methodologies and data samples. For example, Kilic et al. [44] and Apostolakis et al. [45] implemented time-varying parameter and mixed data sampling models, providing further evidence of the oil-stock market nexus. Additionally, Topcu et al. [46], Chien et al. [47], and Li et al. [48] employed Granger causality tests, panel vector autoregression, and structural vector autoregression approaches, respectively, to explore the impact of oil price shocks on stock market returns across different countries. Meanwhile, Mzoughi et al. [49], Liu et al. [50], and Abuzayed and Al-Fayoumi [51] utilized quantile regression, machine learning, and asymmetric nonlinear models to capture the heterogeneous responses of stock markets to oil price fluctuations. Cumulatively, this vast and diverse literature, which also includes notable contributions by Dogan and Inglesi-Lotz [52], Goodell and Goutte [53], and Liao et al. [54], emphasizes the critical role of oil price shocks in influencing stock market returns during the COVID-19 pandemic.

In essence, the prevailing literature suggests notable correlations between oil prices and stock market performance, as evidenced in numerous industrialized countries. This study aims to explore the presence of such relationships within the Chinese context. Specifically, the objective of this paper is to evaluate the influence of oil price shocks on China's stock market returns, spanning the period from January 30, 2020, to August 30, 2022. Employing the EGARCH model and causality tests in mean and variance for empirical analysis, our results substantiate the notion that oil prices, as represented by the QDII-LOF benchmark, have a significant impact on stock market returns. Contrarily, when examining the entire sample, we observe no discernible spillover effects attributable to oil price fluctuations. In conclusion, these novel findings may enrich the existing body of knowledge and offer fresh insights into the complex interplay between oil prices and stock market dynamics in the Chinese market.

3. Econometric Methodology

In this study, we employ the exponential generalized autoregressive conditional heteroskedasticity (EGARCH) model, a powerful approach pioneered by Nelson [55], to conduct rigorous empirical analyses. The EGARCH model is adept at capturing the leverage effect present in return volatility series, thereby providing a robust framework for examining the relationship between crude oil and stock market returns. To ensure the validity of our analysis, we first establish the stationarity of the identified stock market return series and crude oil return series, denoted by stock_t, respectively. Subsequently, we apply the EGARCH model to these two variables, as articulated in equations (1) and (3), thereby offering a comprehensive and incisive assessment of the intricate interplay between the two series.

For the stock market returns,

$$\text{stock}_t = \mu_{\text{stock},t} + \delta_t, \tag{1}$$

where $[\delta_t \mid \delta_{t-1}, \delta_{t-2}, \delta_{t-3}, \cdots, \text{stock}_{t-1}, \text{stock}_{t-2}, \text{stock}_{t-3}, \cdots] \in (0, h_{\text{stock},t})$; $\mu_{\text{stock},t}$ denotes the mean of stock_t; δ_t denotes the residuals.

$$h_{\text{stock},t} = \omega + \beta \log\left(h_{\text{stock},t-1} + \alpha \left| \frac{\delta_{t-1}}{\sqrt{h_{\text{stock},t}}} \right| + \gamma \frac{\delta_{t-1}}{\sqrt{h_{\text{stock},t-1}}} \right). \tag{2}$$

For the crude oil market returns,

$$\text{oil}_t = \mu_{\text{oil},t} + \varepsilon_t, \tag{3}$$

where $[\varepsilon_t \mid \varepsilon_{t-1}, \varepsilon_{t-2}, \varepsilon_{t-3}, \cdots, \text{oil}_{t-1}, \text{oil}_{t-2}, \text{oil}_{t-3}, \cdots] \in (0, h_{\text{oil},t})$; $\mu_{\text{oil},t}$ denotes the mean of stock_t; ε_t denotes the residuals.

$$h_{\text{oil},t} = \omega + \beta \log) h_{\text{oil},t-1} + \alpha \left| \frac{\varepsilon_{t-1}}{\sqrt{h_{\text{oil},t}}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sqrt{h_{\text{oil},t-1}}}. \tag{4}$$

Then, following He [56], it is assumed that A_t corresponds to the information set $A_t = (\text{stock}_t;\ b \geq 0)$. Similarly, it is assumed that B_t corresponds to the information set $B_t = (\text{oil}_t;\ \text{stock}_t;\ b \geq 0)$. As a result, oil_t is regarded as the cause of stock_t in variance unless the following equation holds:

$$E\left\{ \left(\text{stock}_t - \mu_{s,t+1}\right)^2 \middle| A_t \neq \left(\text{stock}_{t+1} - \mu_{s,t+1}\right)^2 \middle| B_t \right], \tag{5}$$

where the causality-in-variance concept was developed by Cheung and Ng [57], and it serves as the foundation for equation (5). Calculating both the squared standardized residuals, δ_t in equation (1) and ε_t in equation (2), is required when using the causality-in-variance technique:

$$\begin{aligned} \mu_t &= \frac{\left(\text{stock}_t - \mu_{\text{stock},t}\right)^2}{h_{\text{stock},t}} = \delta_t^2, \\ \nu_t &= \frac{\left(\text{oil}_t - \mu_{\text{oil},t}\right)^2}{h_{\text{oil},t}} = \varepsilon_t^2. \end{aligned} \tag{6}$$

In accordance with Hong [58], the following test statistics can be used in order to investigate any potential causal association over a specified lag (w):

$$Q = \frac{T \sum_{t=1}^{T-1} k^2 w^{-1} \widetilde{\rho_{\mu\nu}^2}(l) - C_{1T}(k)}{\sqrt{2D_{1T}(k)}}, \tag{7}$$

where $\widetilde{\rho_{\mu\nu}^2}(b)$ denotes the sample cross-correlation on the period of lag (b). It is calculated as follows:

$$\widetilde{\rho_{\mu\nu}^{2}}(b) = \left[\widetilde{C_{\mu\mu}}(0)\widetilde{C_{\nu\nu}}(0)\right]^{-(1/2)}\widetilde{C_{\mu\nu}}(b). \tag{8}$$

The following are the results that the function of sample cross-covariance yields:

$$\widetilde{C_{\mu\nu}}(b) = \begin{cases} \frac{1}{T}\sum_{t=b+1}^{T}\widetilde{\mu_t}\widetilde{\nu_{t-b}}, b \geq 0, \\ \frac{1}{T}\sum_{t=-b+1}^{T}\widetilde{\mu_{t+b}}\widetilde{\nu_t}, b < 0, \end{cases} \tag{9}$$

where $\widetilde{C_{\mu\mu}}(0) = 1/T\sum_{t=1}^{T}\widetilde{\mu_t^2}$; $\widetilde{C_{\nu\nu}}(0) = 1/T\sum_{t=1}^{T}\widetilde{\delta_t^2}$.

In equation (7), $k(l/W)$ denotes a weight function, and the Barlett kernel is used for this purpose.

$$k\left(\frac{l}{W}\right) = 1 - \left|\frac{l}{W} + 1\right|, \text{with } \frac{k}{(W+1)} \leq 1. \tag{10}$$

Otherwise,

$$\frac{k}{W} = 0. \tag{11}$$

Therefore,

$$\begin{aligned} C_{1T}(k) &= \sum_{l-1}^{T-1}\left(1 - \frac{|l|}{S}\right)k^2\left(\frac{l}{W}\right), \\ D_{1T}(k) &= \sum_{l-1}^{T-1}\left(1 - \frac{|l|}{T}\right)\left[1 - (|l| + 1)k^4\left(\frac{l}{W}\right)\right. \end{aligned} \tag{12}$$

Drawing upon the work of Hong [58], the Q-statistic, an essential component of the one-sided test, adheres to an asymptotic normal distribution. Consequently, employing the critical values corresponding to the right tail of the normal distribution is deemed appropriate. Our analysis proceeds with the calculation of the Q-statistic for equation (7), followed by a comparison of the derived Q-statistic value with the upper-tail critical value of the normal distribution at a suitable significance level. The null hypothesis of no causality is rejected if the estimated Q-statistic value surpasses the critical threshold. Notably, numerous studies have delved into the time-varying relationship between crude oil markets and stock market returns. For instance, Lu et al. [59] employ a causality-in-mean and variance test based on the time-varying principle, utilizing rolling subsamples to capture the evolving dynamics between these markets. The test statistic is defined as follows:

$$Q_{t\nu} = \frac{S\sum_{l=1}^{S-1}k^2(l/W)\widetilde{\rho_{\mu\nu}^{2}}(l,S) - C_{1S}(k)}{\sqrt{2D_{1s}(k)}}, \tag{13}$$

where $k(l/W)$ denotes the weight function, namely, the Barlett kernel.

$$\begin{aligned} C_{1S}(k) &= \sum_{l=1}^{S-1}\left(1 - \frac{|l|}{S}\right)k^2\left(\frac{l}{W}\right), \\ D_{1S}(k) &= \sum_{l=1}^{S-1}\left(1 - \frac{|l|}{S}\right)\left[1 - \frac{(|l| + 1)}{S}\right]k^4\left(\frac{l}{W}\right). \end{aligned} \tag{14}$$

$Q_{t\nu}$ statistics belongs to the one-sided test. The critical values of the upper-tailed normal distribution are utilized. A rolling sample (S) is used to calculate the time-varying Hong test. According to Lu et al. [59], when the rolling sample size is too small, the test will provide biased findings. In contrast, when the rolling sample is too large, detecting changes in Granger causality would take a considerable amount of time. Regarding an adequate rolling window, Lu et al. [59] provide the following method for determining the optimal rolling sample (S):

$$S = \frac{2\left(z_{1-\alpha/2} + z_{1-\beta}\right)^2}{\left[\mu_0 - \mu_1/\sigma\right]^2}, \tag{15}$$

where z_{1-s} denotes the critical value of the significant level of N (0, 1); α denotes the type I error probability; β denotes Type II error probability; $\mu_0 - \mu_1/\sigma$ denotes the standardized difference between both mean values. In a manner analogous to equation (7), the Q-statistic will be computed. Then, at an appropriate level, the derived Q-statistic value is compared to the normal distribution's upper-tail critical value. The null hypothesis of no causality will be rejected if the estimated Q-statistic value exceeds the critical value.

4. Findings and Discussions

China emerged as the epicenter of the COVID-19 pandemic, reporting its first cases on January 23, 2020. To scrutinize the intricate relationship between oil prices and stock returns in this unprecedented context, we employ daily time series data from China spanning January 30, 2020, to August 30, 2022. By using a consistent trading day across all samples, we ensure a more accurate comparison of the number of trading days. The CSI 300 index serves as a representative proxy for China's stock market, while the DJ Global Oil & Gas (W1ENE) index embodies the global oil market. Furthermore, the QDII-LOF (162411) index reflects China's oil market. These indices were sourced from the reputable website investing.com. To facilitate model estimation, the return series is calculated by taking the first difference of the logarithm of the daily closing price series, thereby providing a solid foundation for our in-depth analysis.

4.1. Basic Description. Table 1 presents the outcomes of the essential descriptive statistical analyses conducted on each variable under investigation. This comprehensive examination of the data ensures a rigorous and insightful understanding of the underlying trends and patterns, thereby providing a solid foundation for subsequent analysis and interpretation.

Table 1 reveals several noteworthy observations about the return series under investigation. Firstly, the daily mean of the CSI return series is positive, while the W1ENE and QDII-LOF return series exhibit negative daily means throughout the study period. Among these, the CSI return boasts the highest mean, with the QDII-LOF return surpassing the W1ENE return in terms of the mean value. The W1ENE return's mean emerges as the lowest in the sample. Meanwhile, the CSI return series displays the highest volatility, as indicated by the standard deviation.

Intriguingly, all return series exhibit negative skewness and positive kurtosis, signifying the presence of leptokurtic distributions. Furthermore, the Jarque–Bera normality test confirms that none of the return series follow normal distributions at a 1% significance level. The Ljung–Box Q statistics indicate autocorrelation in both the return and squared return series. To assess the stationarity of all returns, three distinct unit root tests—augmented Dickey–Fuller, Phillips–Perron, and Kwiatkowski–Phillips–Schmidt–Shin—were employed. The results conclusively demonstrate that all return series are stationary at the 1% significance level, fulfilling a critical prerequisite for subsequent EGARCH model estimation.

Table 1: Results of basic descriptive statistics.

Variable & statistics	CSI	W1ENE	QDII-LOF
Mean	0.0004	−0.0014	−0.0012
Standard error	0.0076	0.018	0.014
Skewness	−1.114	−1.218	−0.098
Kurtosis	7.440	8.736	5.143
Jarque–Bera	122.335 (0.000)	192.562 (0.000)	22.959 (0.000)
Observation	119	119	119
ARCH (8)	17.392 (0.026)	19.472 (0.013)	17.612 (0.024)
Q (36)	24.867 (0.919)	50.155 (0.059)	40.574 (0.276)
Qs (36)	11.340 (1.000)	49.413 (0.067)	52.794 (0.035)
ADF	−11.889 (0.000)	−11.298 (0.000)	−11.299 (0.000)
PP	−11.764 (0.000)	−11.358 (0.000)	−8.647 (0.000)
KPSS	0.051***	0.089***	0.088***

Note: () stands for the p value; ARCH (8) stands for the LM conditional variance test; *** stands for the 1% significant level; Q (36) and Qs (36) represent the Ljung–Box serial correlation test, respectively.

4.2. (E)GARCH Model Estimation. Table 1's insights enable us to ascertain the presence of ARCH effects in all return series, suggesting that the GARCH specification is aptly suited for each series. Consequently, the EGARCH model is employed for further empirical analyses. Model diagnostics indicate that the EGARCH (1, 1) represents an ideal fit for capturing the volatility inherent in each return series comprehensively. Additionally, the mean equation substantiates that the optimal lag length for autoregressive parameters, as determined by the Akaike information criterion, is one. The estimated outcomes are conveniently displayed in Table 2 for further examination and interpretation.

Table 2: Results of (E)GARCH model estimation.

Coefficient & variable	CSI	W1ENE	QDII-LOF
ω	−1.392 (0.094)	−1.112 (0.013)	−6.613 (0.012)
α	0.532 (0.004)	0.371 (0.046)	0.943 (0.000)
β	0.902 (0.000)	0.904 (0.000)	0.333 (0.025)
γ	−0.126 (0.018)	−0.235 (0.012)	−0.117 (0.048)
N	1.098 (0.000)	1.022 (0.000)	1.065 (0.000)
$\ln(L)$	−231.370	−247.927	−230.594
Q(36)	26.473 (0.651)	32.963 (0.324)	32.722 (0.335)
Qs(36)	28.046 (0.826)	22.773 (0.958)	21.025 (0.978)

Note: ( ) stands for the p value; Q(36) and Qs(36) stand for the Ljung–Box serial correlation test, respectively.

Table 2 provides a comprehensive summary of the GARCH model outcomes, illustrating that both α and β successfully pass the significance test at a 5% level. The value of α serves as a measure of the persistence of shocks, while β quantifies the endurance of volatility clustering. The γ value captures the negative leverage impact on conditional volatility, with all estimation coefficients deemed significant at the 5% level. These findings imply that negative news has a considerably more pronounced effect on volatility than positive news in both the oil markets (as assessed by W1ENE and QDII-LOF) and the stock market. The policy implications of these results are manifold. First and foremost, the prominence of negative news in driving market volatility underscores the importance of effective communication and transparency from policymakers and market participants. Accurate and timely information dissemination can mitigate the potential for negative news to trigger panic and exacerbate market fluctuations.

Regarding the generalized error distribution, the parameter ν shapes the distribution's form, with higher values corresponding to lighter tails and lower values to heavier tails. Table 2 reveals that the predicted stock return shape parameter is less than 2, suggesting a distribution characterized by fat tails. This finding indicates that extreme events and significant market movements occur more frequently than anticipated under normal distribution assumptions. Policymakers should, therefore, remain vigilant for such tail risks and implement appropriate measures to strengthen the resilience of financial markets against unexpected shocks.

Additionally, the Ljung–Box serial correlation test results point to an absence of autocorrelation between the variance and mean series. This observation implies that past returns and volatilities may not necessarily provide reliable predictions for future market behavior. Policymakers should be cautious about relying solely on historical data for forecasting and decision-making and instead adopt a more holistic approach incorporating various economic indicators, market sentiment, and global trends to assess market risks and devise effective policy responses. In summary, the GARCH model outcomes presented in Table 2 offer valuable insights into the drivers of volatility in oil and stock markets. Policymakers should consider these findings in formulating strategies to promote transparency, mitigate tail risks, and enhance market resilience in the face of uncertainties and potential shocks.

4.3. Causality-in-Mean and Variance. This subsection conducts the causality-in-mean test utilizing the standardized residuals derived from the EGARCH model, with the results meticulously presented in Table 3.

Table 3 reveals a conspicuous absence of a causal connection between QDII-LOF and W1ENE; however, it distinctly identifies a causality between QDII-LOF and CSI across all lag periods. This observation highlights the impact of QDII-LOF oil price fluctuations on China's stock markets. Given China's significant consumption of QDII-LOF-type oil, the existence of such a causal relationship is reasonably anticipated. Consequently, understanding this relationship bears crucial policy implications. To assess the volatility spillover effects between the oil market and the stock market, the causality-in-variance test employs squared standardized residuals. These detailed results, presented in Table 4, offer valuable insights for policymakers. As China's economy continues to depend on oil imports, the interdependence between oil prices and stock market performance necessitates vigilant monitoring and proactive policy responses to safeguard the stability of financial markets and the broader economy. Policymakers should be cognizant of the potential risks associated with oil price volatility and consider formulating strategies to minimize its impact on stock market returns. This might involve diversifying the energy portfolio to reduce reliance on oil imports, increasing investment in renewable energy sources, and encouraging industries to adopt energy-efficient technologies. Additionally, promoting financial market resilience by enhancing risk management capabilities and strengthening regulatory oversight could mitigate the adverse effects of oil price fluctuations on stock market performance. In summary, the observed causal relationship between QDII-LOF oil prices and China's stock markets, as evidenced by Table 3, underscores the importance of comprehensive policy interventions to manage the ramifications of oil price volatility. By heeding the results of the causality-in-variance test displayed in Table 4, policymakers can better navigate the intricate dynamics between the oil market and the stock market, ultimately fostering greater economic stability and growth.

Table 3: Results of the causality-in-mean test.

Causality direction	Lag1	Lag2	Lag3	Lag4
CSI ⟶ W1ENE	0.012	0.267	0.097	0.064
W1ENE ⟶ CSI	0.245	0.146	0.598	0.194
CSI ⟶ QDII-LOF	1.297	1.149	0.175	2.260
QDII-LOF ⟶ CSI	5.242**	8.838***	4.799**	8.160***

Note: ⟶ stands for the causality direction; ** stands for 5% significant level; *** stands for 1% significant level.

Table 4: Results of causality-in-variance test.

Causality direction	Lag1	Lag2	Lag3	Lag4
CSI ⟶ W1ENE	0.172	2.717	1.352	0.104
W1ENE ⟶ CSI	0.226	0.248	0.0569	0.194
CSI ⟶ QDII-LOF	0.883	0.409	0.830	1.117
QDII-LOF ⟶ CSI	1.512	1.108	0.118	0.067

Note: ⟶ stands for the causality direction.

As per the insights provided in Table 4, the volatility spillover effect between the stock market and the oil market remains indiscernible. This observation is attributed to the null hypothesis of no causality failing to pass the conventional significance test for all variables. The absence of clear volatility spillover effects between these markets has noteworthy policy implications. The lack of a discernible volatility spillover effect suggests that shocks in one market may not necessarily trigger immediate or significant repercussions in the other market. Consequently, policymakers should exercise caution in interpreting the relationship between the stock market and the oil market, as the implications may not be as straightforward as initially anticipated. This finding highlights the importance of adopting a multifaceted approach when formulating policies to manage market risks. Policymakers should consider both the direct and indirect channels through which oil price fluctuations may impact the stock market, and vice versa. In doing so, they can develop targeted interventions to address sector-specific vulnerabilities and bolster the resilience of the financial markets. Moreover, it is crucial for policymakers to monitor macroeconomic indicators and global economic trends, as these factors may influence the dynamics between the oil market and the stock market. This vigilance can facilitate the early identification of potential risks and enable timely policy responses to mitigate adverse effects on the economy. In conclusion, the inability to identify a clear volatility spillover effect between the stock market and the oil market, as indicated in Table 4, underlines the need for a nuanced understanding of the relationship between these markets.

4.4. Discussion. Annually, China experiences fluctuations in oil imports; however, since the advent of reform and opening-up policies, both oil consumption and imports have consistently grown. According to data from the China Energy Administration, China's oil consumption reached 737 million tons in 2020, with domestic production accounting for 195 million tons. Consequently, imported crude oil constituted a staggering 73% of China's total consumption. Given China's significant reliance on imported energy, particularly crude oil, several factors contribute to energy price fluctuations. Primarily, global energy price volatility, especially crude oil prices, must be considered. These prices are determined by supply and demand variables in the international market. Similar to other commodities, sophisticated auction markets and derivatives exist to manage risk and facilitate speculation. Therefore, supply and demand are not the sole contributors to oil price fluctuations. The heightened sensitivity of oil prices to demand and supply shifts, along with the growing utilization of oil as a financial asset, warrants further exploration. The increased demand and supply sensitivity may hinge on the potential for lower price elasticity, resulting in heightened oil price volatility. Escalating global uncertainties could contribute to declining price elasticity. Additionally, the expanding use of oil as a financial asset may precipitate oil price oscillations. The growing employment of oil for financial investments, hedging, and speculation could heighten oil prices' sensitivity to investor sentiment and financial market information flows. However, no definitive evidence has established a link between oil's role as a financial instrument and global oil price shifts, leaving the inquiry unresolved (Alquist and Kilian [60], Kaufmann and Ullman [61], and Liu et al. [62]). Notably, Van Robays [63] and Lin and Bai [64] posited that local oil price volatility could alter economic outlooks and, consequently, oil demand, generating a secondary feedback effect. Lastly, fluctuations in the value of the Chinese lira, which amplify the impact of global oil price shifts on the domestic economy, affect the cost of domestically produced petroleum products in China. Secondly, although our empirical investigation is limited to the relationship between global oil price shifts and China's stock market performance, we can postulate that China's retail energy prices have also experienced significant increases. This can be attributed, in part, to the dependence on energy product consumption taxes and the automotive sector's special consumption tax, both of which influence energy demand. These factors not only induce retail energy price volatility but also generate regulatory uncertainty and energy price instability.

Our study's findings reveal that global oil price volatility influences China's stock market returns, and in certain subperiods of the sample, these fluctuations have notable spillover effects on volatility. These results bear significant regulatory implications. It can be inferred that government actions, particularly frequent tax rate adjustments, contribute to retail energy price fluctuations both directly and indirectly through policy influence and uncertainty generation. This is attributable to China's substantial taxation on gasoline and the high special consumption tax imposed on the automobile industry and other products. In light of these findings, it is evident that the Chinese government levies a heavy tax on gasoline. If such governmental efforts exacerbate energy price volatility, they could negatively impact risk management strategies employed by consumers and businesses. Additionally, the Chinese government may alleviate some of the concerns by implementing policies that facilitate the adoption of more stable alternative energy sources. These measures could potentially contribute to pollution reduction in major urban areas. However, it is essential to recognize that alternative energy sources may entail high costs, necessitating substantial direct expenditures and investments in infrastructure. Furthermore, relying on strategic oil reserves serves as another viable approach to mitigating the impacts of significant global oil price fluctuations and guarding against potential supply disruptions. The Chinese government can also explore the potential of alternative renewable energy sources, such as solar, wind, and other forms of sustainable energy, to promote greater energy stability and resilience.

The relationship between oil prices and stock market performance encompasses multiple dimensions. Steady oil prices contribute to the stabilization of production costs and consistent cash flow, bolstering profit and dividend forecasts. This, in turn, may result in higher retained earnings, increased investments, enhanced output, and employment, as well as elevated stock values and overall economic growth. Furthermore, consumers stand to reap additional benefits. Investors need to be cognizant of global oil price trends and the potential spillover effects in China when determining their portfolio allocation. When oil prices exert both first- and second-moment impacts, the returns from incorporating oil commodities into a portfolio are constrained in relation to both the oil price and traditional portfolio income. Concerning the latter, diversifying investment portfolios across various asset classes, including oil and other financial instruments, can offer valuable benefits for investors. These policy discussions are particularly relevant for countries akin to China in terms of dependence on energy imports and geographic or natural advantages. By addressing these considerations, investors and policymakers can better navigate the complexities arising from the interplay between oil prices and stock market performance, ultimately fostering a more resilient and prosperous economic landscape.

5. Conclusions

This research examines the dynamic relationship between stock market returns and oil price fluctuations in China during the COVID-19 pandemic, with particular attention to volatility spillovers. Utilizing causality-in-mean and variance tests on daily data from January 30, 2020, to August 30, 2022, the empirical analysis delves into this complex interaction. The results indicate that oil prices, as represented by the QDII-LOF benchmark, significantly influence stock market returns. However, when examining the entire sample, no discernible spillover effects stemming from oil prices are observed. These findings echo the conclusions of Cevik et al. [65], whose study on Turkey provided analogous results, thereby reinforcing the outcomes of this investigation.

Drawing from the empirical findings, several policy recommendations emerge. Firstly, policymakers and regulators should closely monitor the relationship between oil prices and stock market returns in order to proactively address potential risks and challenges arising from the dynamic interaction during periods of economic uncertainty. Secondly, encouraging investment in alternative and renewable energy sources could help mitigate the impact of oil price fluctuations on stock market returns, promoting economic stability and fostering sustainable growth. Thirdly, maintaining and promoting financial market stability should be a priority for policymakers, as this would help insulate stock markets from the adverse effects of global oil price movements during crises such as the COVID-19 pandemic. Fourthly, promoting greater awareness among investors about the relationship between oil prices and stock market returns could enable them to make more informed decisions when allocating their portfolios, potentially minimizing the impact of oil price fluctuations on their investments. Fifthly, policymakers should consider reviewing and adjusting fiscal policies related to oil taxation and consumption, as this could reduce the impact of oil price fluctuations on stock market returns and contribute to a more stable financial environment. Lastly, strengthening international cooperation among countries that are heavily reliant on oil imports could facilitate the sharing of best practices and the development of joint policy strategies to manage the economic consequences of oil price fluctuations and their spillover effects on stock markets.

This investigation presents two significant contributions to the existing Chinese scholarship on the topic. Firstly, by adopting the exponential generalized auto-regressive conditional heteroscedasticity, causality-in-mean, and variance methodologies, the study offers a unique analytical lens, thereby enriching the prevailing literature. This departs from prior Chinese studies that largely relied on vector autoregression, Granger causality, structural vector autoregression, and other techniques. Secondly, given China's position as the world's leading energy importer and the origin of the COVID-19 pandemic, using China as a case study provides a more illustrative and meaningful examination of the issue. This not only supplements existing literature but also expands the boundaries of the continuing dialogue surrounding this matter.

This study, while offering valuable insights, also presents certain limitations that can guide future research in promising directions. Firstly, the research exclusively examines the connection between energy price fluctuations and the performance of the Chinese stock market. Future scholars may build upon these findings to investigate similar relationships in other nations, particularly those that are net importers of oil and energy resources. Secondly, although escalating energy prices pose serious concerns for countries dependent on these resources, this paper solely focuses on the impact of such changes on stock market performance. Indeed, energy price volatility may have far-reaching consequences for various economies. Future research can delve deeper into these aspects. Thirdly, instead of concentrating solely on the COVID-19 pandemic, future researchers should consider exploring the broader implications of market volatility on the stability of energy supply, a critical factor for the growth of the global economy. Fourthly, future investigations could reevaluate these assertions employing advanced methodologies, such as machine learning and neural networks, potentially yielding more fascinating conclusions. Lastly, within the scope of this study, we utilize variable substitution as a means for conducting robustness tests. Scholars in the future are encouraged to explore more advanced and fitting methodologies for re-evaluating robustness tests, potentially yielding enhanced reliability in the outcomes.

Data Availability

The data presented in this study are available from the authors upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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