INDERSCIENCE PUBLISHERS
Linking academia, business and industry through research

International Journal of Sustainable Society

ISSN online: 1756-2546 - ISSN print: 1756-2538
https://www.inderscience.com/ijssoc

Investment uncertainty due to COVID-19 on energy-efficient investing in India

Peeyush Bangur, Ruchi Bangur

DOI: 10.1504/IJSSOC.2023.10057168

Article History:

Received:	04 January 2022
Last revised:	08 March 2022
Accepted:	11 August 2022
Published online:	26 June 2023

Investment uncertainty due to COVID-19 on energy-efficient investing in India

Peeyush Bangur* and Ruchi Bangur

Women's Institute for Studies in
Development Oriented Management (WISDOM),
Banasthali Vidyapith,
Banasthali, Rajasthan, India
Email: peeyushsmbangur@rediffmail.com
Email: ruchipbangur@rediffmail.com
*Corresponding author

Abstract: This study examined the volatility implications of energy-efficient investing in India due to COVID-19. We have been used the symmetric GARCH (p, q) model on the S&P BSE GREENEX Index returns to assess the certainty of investment related to energy-efficient practices in India. The result shows increased volatility and a large degree of persistence on the energy-efficient investing in India. Further, the COVID-19 pandemic has increased the volatility of the S&P BSE GREENEX Index by 130.155%. To the best of the author's knowledge, this is the first article where the volatility of energy-efficient investing in India has been measured.

Keywords: energy-efficient practices; investment certainty; COVID-19; GARCH (p, q) model; India.

JEL codes: C22, B26.

Reference to this paper should be made as follows: Bangur, P. and Bangur, R. (2023) 'Investment uncertainty due to COVID-19 on energy-efficient investing in India', *Int. J. Sustainable Society*, Vol. 15, No. 2, pp.193–204.

Biographical notes: Peeyush Bangur is an Associate Professor at the Women's Institute for Studies in Development Oriented Management (WISDOM), Banasthali Vidyapith in Banasthali, Rajasthan, India. He has completed his PhD from the Devi Ahilya Vishwavidyalaya, Indore, India, in Financial Derivatives. He has over 11 years of teaching and research experience. Currently, his area of research is financial derivatives, portfolio management, and investment management.

Ruchi Bangur is an Assistant Professor at the Women's Institute for Studies in Development Oriented Management (WISDOM), Banasthali Vidyapith in Banasthali, Rajasthan, India. She has completed his PhD from the Devi Ahilya Vishwavidyalaya, Indore, India, in Portfolio Management. In addition, she has over five years of teaching and research experience.

1 Introduction

The COVID-19 is a disease of the respiratory system spread by a novel virus affecting humans worldwide (Bhuiyan et al., 2021; Sinha et al., 2020). Any human tragedy related to health affects the economies worldwide (Corbet et al., 2021), and the economies face a recession due to inequalities in the business market (Vorobeva and Dana, 2021). Further, the worldwide financial markets have tumbled due to the outbreak of this virus (Rizvi et al., 2020). As a result, the price has been impacted, and systematic risk (Baker et al., 2020) and volatility (Zaremba et al., 2020; Li et al., 2021; Bouri et al., 2021) have emerged in the capital markets. The increased volatility of COVID-19 has also increased the investment uncertainty (Jawadi et al., 2021; Engelhardt et al., 2021) and economic policy uncertainty (Zhang et al., 2020; Iyke, 2020) in the world economies.

Climate change has been an emerging risk in the global economy for the last three decades (Fang et al., 2019), and the increased emission of greenhouse gases is one of the main reasons for the threat of climate change (Bernardini et al., 2021). After the Kyoto protocol of the 1990s, problems related to climate change have been included in the sustainability concept (de Dios-Alija et al., 2021). Further, to keep global warming 1.5°C by 2050, the climate policies of any country need energy-efficient investments (Yamahaki et al., 2020; Naik and Bagodi, 2021), and to achieve this goal, there is a need to align the financial system for sustainable investing (IPCCC, 2018). India has the S&P BSE-GREENEX Index for energy-efficient investing, providing information to investors about energy-efficient stocks. The performance of companies listed in this index is assessed on the energy efficiency based on publicly disclosed energy and financial data. It was the second thematic index launched by BSE, and it was launched in February 2012.

The main aim of this study is to analyze the investment certainty, volatility persistence, and change in volatility (by quantifying it) during the COVID-19 pandemic on energy-efficient investing in India. For energy-efficient investing, the Bombay stock exchange of India has S&P BSE GREENEX Index for the investment community, which aligns their investments with the energy-efficient theme. Fama (1970) discussed the efficient market hypothesis (EMH) phenomenon. As per the EMH, the market reacts to any available information present in the market, and the share price 'fully reflects' all information associated with it. Hence the S&P BSE GREENEX Index has been chosen as a sample because this index reflects the actual condition of energy-efficient investing in India. To the best of the author's knowledge, this is the first article where the volatility of energy-efficient investing in India has been measured. The structure of the paper is as follows: The related literature reviews have been surveyed in Section 2. Section 3 describes the data and methodology. Section 4 discusses the results, Section 5 reports the robustness of results, and Section 6 concludes the research.

2 Review of literature

The study of Siu and Wong (2004) examined the impact of the first deadly infectious disease (SARS) of the twenty-first century on the Hong Kong economy. They reported that the negative economic impacts due to infectious disease. However, the authors also suggested that fear and panic had been reduced after the control of the outbreak. Further, Wang et al. (2013) examined the impact of different infectious diseases (Enterovirus 71,

Dengue Fever, SARS and H1N1) outbreaks during the last 15 years on the stock of biotechnology companies of Taiwan. Their result evidenced the significant abnormal stock returns in the biotechnology companies. The study of Apergis and Apergis (2020) examined the impact of COVID-19 on the Chinese stock market return volatility. They found new evidence on the Chinese stock return and volatility that COVID-19 has negatively impacted the stock returns and positively impacted return volatility. Similarly, Liu (2021) focused on the impact of COVID-19 on China's economy and the policy response of China. The author found that China focused on corporate supporting programs rather than household supporting programs. Susilawati et al. (2020) evaluated the impact of the COVID-19 pandemic on the different sectors of the economy of Indonesia. They found that the household sector has been affected the most among transportation, household, tourism, trade, and health. In line with this, Mazur et al. (2021) explored the performance of the US stock exchange sectoral indices during the crash activated by the COVID-19. They found mixed evidence that natural gas, food, healthcare, and software stocks performed positively while petroleum, real estate, entertainment, and hospitality sectors performed negatively. Further, Liu et al. (2020) examined the impact of coronavirus outbreak on more than twenty stock indices from Europe USA, and Asia. They found that Asian stock indices have delivered more negative abnormal returns than other stock indices. Similarly, Ashraf (2020) assessed the response of the 64 stock markets to the COVID-19 pandemic. The result shows that the stock markets have responded negatively as the COVID-19 confirmed cases increases. Also, the author found that the market has responded to the COVID-19 outbreak very quickly. The study of He et al. (2020) assessed the impact of COVID-19 on the stock market performance of eight different countries. Their result suggests the presence of negative but short-term impact on the stock markets of the eight affected countries due to COIVD-19. Further, Harjoto et al. (2021) examined the impact of COVID-19 on the different stock exchanges and found that emerging markets have experienced more negative shocks due to COVID-19 than the US market. Conversely, Yiu and Tsang (2021) examined the impact of COVID-19 on ASEAN5 (Indonesia, Malaysia, the Philippines, Thailand and Vietnam) stock exchanges. They found that COVID-19 has been impacted the stock return. However, due to stringent policy responses, the severity of the pandemic has been reduced drastically. The study of Zaremba et al. (2020) assessed volatility implications and the stringent policy responses for the COVID-19. They found that the non-pharmaceutical interventions have increased the volatility in the equity market. Also, they have demonstrated that information campaigns and public event cancellations were the two main reasons for the increase in volatility. Similarly, Umar et al. (2021) examined the impact of COVID-19 on the gig economy. Volatility clustering results evidenced that the volatility has been increased in the gig economy with the news of COVID-19. Furthermore, the study of Acikgoz and Gunay (2020) discussed the economic consequences of different historical events, including COVID-19. They found that COVID-19 may adversely affect the economies of the world; also, this pandemic may severely affect the financial markets, employees, customers, and supply chains. The same impact of COVID-19 has been observed by the Asante-Poku and van Huellen (2021) on the commodity exporters of Ghana.

Broadstock et al. (2021) examined the ESG performance in China during the COVID-19. They found that the high ESG portfolios have been performed better than the low ESG portfolio in China, and ESG has reduced the risk during the COVID-19 crisis.

On the other hand, using new Morningstar's ESG risk indicators, Ferriani and Natoli (2021) found that during the COVID-19, investors have been preferred low-ESG-risk funds. Furthermore, the study of Albuquerque et al. (2020) analyzed the causal link between ESG based firm's performance and value. Their result shows that stocks having higher ESG ratings generated higher returns and less volatility. Also, they found that these firms have higher operating profit margins during the first quarter of 2020. Similarly, Pisani and Russo (2021) examined the performance of ESG based thirty funds in terms of return volatility. Their result shows that funds with a higher ESG rating perform better than other funds during the pandemic. Conversely, Folger-Laronde et al. (2020) examined the impact of the COVID-19 on responsible investments. Their result shows that even high scores in sustainability performance do not safeguard the financial losses during the crisis. Further, Engelhardt et al. (2021) investigated the relationship between ESG ratings and European firms' return performance during the COVID-19. Their result shows mixed evidence that high-rated ESG firms show higher abnormal returns and lower stock volatility. Finally, in the case of India, Singh et al. (2021) examined the volatility implications of the COVID-19 on the S&P ESG 100 Index. Their result shows that COVID-19 has not impacted the return and volatility of the abovementioned index.

3 Dataset and methodology

The closing price of the S&P BSE GREENEX Index has been collected from the BSE India website. The collected data is based on the daily closing price. The data period span from 1 January 2015 to 28 October 2021. India's first case of COVID-19 was detected on 27 January 2020; hence, it has been taken as the cut-off date for the study. The data has been calculated in logarithmic form, using the following formula:

$$GNX_{r,t} = Log\left(\frac{M_t}{M_{t-1}}\right) * 100$$

$GNX_{r,t}$ is the S&P BSE GREENEX time series log return, M_t is the closing price at time t, and M_{t-1} is the closing price at time $t - 1$. We have been calculated the average return, risk measure (standard deviation), skewness, kurtosis, and Jarque-Bera test (Jarque and Bera, 1987) statistics of the data. These measures help to understand the symmetric nature of data. Further, the stationarity of the time series has been checked through the augmented Dickey-Fuller test (Dickey and Fuller, 1979). For this purpose, the null hypothesis has been tested that unit root is present in time series (time series is not stationary). Further, the heteroscedasticity in the return residual (ARCH effect) has been tested by ARCH-LM (Lagrange multiplier) test statistics. Here the null hypothesis was that the coefficients are not statistically significantly different from zero. Lastly, after confirming the ARCH effect in residuals, the GARCH (p, q) model has been introduced.

- *Modelling with GARCH (1, 1):* The volatility process is concerned with the evolution of conditional variance of the return over time (Tsay, 2005). The AR (autoregressive) type models capture the shocks generated from return residuals. These shocks are known as volatility persistence. ARCH model (Engle, 1982) discussed that the recent shocks influence the error term variance of today. Hence today's error term variance is affected by the error term of the previous day. The

ARCH coefficient has been treated as a 'recent news' parameter in this study. The bigger the coefficient, the higher the recent news impacts the index price and vice versa. Further, the GARCH model of Bollerslev (1986) proposed that conditional variance at time *t* depends on the squared error term and the conditional variance of the previous periods. The model was introduced in GARCH (*p*, *q*) form, where *p* is lagged term of the squared error term, and *q* is conditional variance. In this study, the GARCH coefficient has been treated as an 'old news' parameter available in the market, impacting the volatility persistence after the arrival of information. The bigger the GARCH coefficient, the higher the old news impacts the index price through volatility persistence and vice versa. We have pre-tested three GARCH (*p*, *q*) models on the data. These three models are the EGARCH model, GJR GARCH model, and GARCH (1, 1) model. The GARCH (1, 1) model was found most suitable for the analysis. In the present study, the GARCH (1, 1) model has been applied for a conditional variance on an i^{th} day. A model with errors follows the GARCH (1, 1) process is as follows:

- *Mean equation:*

$$GNX_{r,t} = \alpha_0 + \varepsilon_t \quad \varepsilon_t \setminus Y_{t-1} \sim D\left(0, \sigma_t^2\right)$$

- *Variance equation:*

$$\sigma_t^2 = \omega_0 + \omega_1 \varepsilon_{t-1}^2 + \omega_2 \sigma_{t-1}^2 + \omega_3 Dummy$$

where *D* is conditional normal density with mean zero and variance (σ_t^2), and Y_{t-i} is available information up to time $t - 1$. $GNX_{r,t}$ is the daily logarithmic return of the S&P BSE GREENEX Index. ω_1 is the ARCH effect coefficient, ω_2 is the GARCH effect coefficient, and ω_3 is the dummy variable coefficient. The dummy variable takes the value zero (0) before the first case of COVID-19 in India and one (1) after the reporting of the first case. Sign on the dummy variable is crucial to determining whether volatility has increased or decreased. The positive sign indicates the increase in volatility and vice versa. Further, samples have been divided into two subsamples. The pre-COVID 19 periods is before the cut-off date, while the COVID-19 period is after the cut-off date. In the end, the model has been estimated without a dummy variable in both subsamples. This methodology helps to compare the nature of volatility among both periods, and also it helps in quantifying the volatility. Change in conditional variance has been calculated by the formula $\omega_0/(1 - \omega_1 - \omega_2)$, applied by Butterworth (2000) and later on used by Bangur (2019).

4 Results

The descriptive statistics for the S&P BSE GREENEX Index time series has given in Table 1. The result shows that each time series has generated positive mean returns, indicating that the price of the index has increased over the period. Further, after the detection of the first case, the return has increased, which is an indication of higher trading in the index. The risk related to price has been measured through standard deviation. It shows that risk related to price has increased during the COVID-19 period. Furthermore, each time series have shown negative skewness, indicating higher

heterogeneity in the price. The statistically significant Jarque-Bera test statistics and kurtosis value (higher than three) show that all return series have fat tail distribution. Lastly, during COVID-19, the higher kurtosis value indicates that investment uncertainty has increased. The residual plot of the S&P BSE GREENEX (whole period) has shown in Figure 1. The time series shows volatility clustering due to changing variance. In volatility clustering, the period of high (low) volatility is followed by the period of high (low) volatility for a prolonged period of time. The augmented Dickey-Fuller test results have been reported in Table 2. The result shows that each S&P BSE GREENEX time series has been found stationary in its logarithmic form. Further, the ARCH effect has been tested by the ARCH-LM (Lagrange multiplier) test, and the results are shown in Table 3. The ARCH-LM test has been applied on each time series with coefficient separately. Statically significant coefficients indicate the presence of a sufficient ARCH effect in each time series.

Figure 1 Return residual plot (see online version for colours)

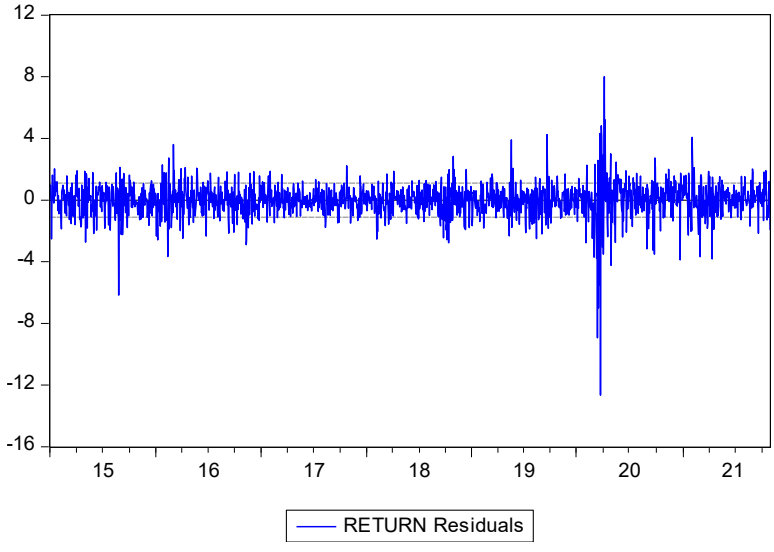

Table 1 S&P BSE GREENEX: descriptive statistic

Index	*Full period (1,690 days)*	*Pre-COVID-19 (1,252 days)*	*During COVID-19 (438 days)*
Mean	0.042177	0.020428	0.104346
Standard deviation	1.106203	0.901775	1.548018
Skewness	–1.292333	–0.277436	–1.746742
Kurtosis	19.49386	5.584295	18.09721
Jarque-Bera	19,627 (0.000*)	364.4606 (0.00*)	4,382.378 (0.000*)

Note: *statically significant at 1% level.

The presence of the ARCH effect allowed us to introduce the GARCH type model in the analysis. The result of the whole period with the GARCH (1, 1) along with the dummy variable has been reported in Table 4. All coefficients of the model have been found

statically significant at a one percent level of significance, indicating the presence of the GARCH process in the S&P BSE GREENEX Index. Further, the higher GARCH coefficient suggests the presence of long memory in the S&P BSE GREENEX Index. The addition of ARCH and GARCH coefficients is approaching unity, indicating that volatility shocks remain for a long time in the time series. In addition, the dummy variable coefficient was found statically significant and different from zero, indicating the change in the volatility. The positive sign of the dummy variable coefficient confirms that the volatility of the S&P BSE GREENEX Index has increased after the first case reported in India.

Table 2 Stationarity in time series – result of augmented Dickey-Fuller test

	ADF test statistic (probability)		
	Full period	*Pre-COVID-19*	*During COVID-19*
No intercept	–41.61629 (0.0000*)	–34.10840 (0.0000*)	–21.96349 (0.0000*)
With intercept	–41.4662 (0.0000*)	–34.11139 (0.0000*)	–22.04664 (0.0000*)
With intercept and trend	–41.49355 (0.0000*)	–34.09779 (0.0000*)	–22.11019 (0.0000*)

Note: *statically significant at 1% level.

Table 3 ARCH-LM test for heteroskedasticity before GARCH

	Test statistics (probability)		
	Whole period	*Pre-COVID period*	*COVID period*
F-statistics	20.34919	3.011272	3.817795
Probability (F-statistics)	0.000*	0.0829***	0.0514***
Probability (chi square)	0.000*	0.0828***	0.0512***

Notes: *statically significant at 1% level; ***statically significant at 10% level.

Table 4 GARCH (1, 1) with COVID-19 dummy (full period)

Mean equation: $GNX_{r,t} = \alpha_0 + \varepsilon_t$			
Variance equation: $\sigma_t^2 = \omega_0 + \omega_1 \varepsilon_{t-1}^2 + \omega_2 \sigma_{t-1}^2 + \omega_3$ *dummy*			
Variable	*Coefficient*	*Std. error*	*Prob.*
Mean equation			
α_0	0.058210	0.022294	0.0090*
Variance equation			
ω_0	0.048098	0.011292	0.0000*
ω_1 ARCH coefficient	0.102258	0.012595	0.0000*
ω_2 GARCH coefficient	0.844484	0.022512	0.0000*
ω_3 dummy variable coefficient	0.037767	0.011424	0.0009*

Note: *statically significant at 1% level.

Further, to understand the GARCH process and quantify the volatility, the model has been applied on both subsamples separately without a dummy variable. In Tables 5 and 6, all coefficients, including ARCH and GARCH coefficients, have been found statically significant, showing no change in the GARCH process after the first case reporting.

Furthermore, the addition of ARCH and GARCH coefficient has approached unity in both subsamples, indicating high volatility persistence in both periods. The ARCH coefficient has been treated as a parameter of 'recent news' in the study. From the ARCH coefficient, it can be inferred that recent news has a higher impact on today's index price. The increased ARCH coefficient during the COVID-19 period indicates that the recent news is impacting the price of S&P BSE GREENEX more quickly during the COVID-19 period than the pre-COVID-19 period. The GARCH coefficient has been treated as a parameter of 'old news' in the study. From the GARCH coefficient, it can be inferred that old news has a higher impact on today's index price. The decreased GARCH coefficient during the COVID-19 period indicates that the old news impact is reduced on the price of S&P BSE GREENEX during the COVID-19 period than the pre-COVID-19 period. In the end, the result of an increase in the unconditional variance by 130.155% fortifies the finding of an increase in volatility, which is reported in Table 7.

Table 5 GARCH model pre-COVID-19 (excluding dummy)

Mean equation: $GNX_{r,t} = \alpha_0 + \varepsilon_t$			
Variance equation: $\sigma_t^2 = \omega_0 + \omega_1\varepsilon_{t-1}^2 + \omega_2\sigma_{t-1}^2$			
Variable	*Coefficient*	*Std. error*	*Prob.*
Mean equation			
α_0	0.042032	0.024238	0.0829***
Variance equation			
ω_0	0.038862	0.013051	0.0029*
ω_1 ARCH coefficient	0.075038	0.015321	0.0000*
ω_2 GARCH coefficient	0.878209	0.026854	0.0000*

Notes: *statically significant at 1% level; ***statically significant at 10% level.

Table 6 GARCH model during COVID-19 (excluding dummy)

Mean equation: $GNX_{r,t} = \alpha_0 + \varepsilon_t$			
Variance equation: $\sigma_t^2 = \omega_0 + \omega_1\varepsilon_{t-1}^2 + \omega_2\sigma_{t-1}^2$			
Variable	*Coefficient*	*Std. error*	*Prob.*
Mean equation			
α_0	0.118050	0.061759	0.0559***
Variance equation			
ω_0	0.100036	0.030711	0.0011*
ω_1 ARCH coefficient	0.137675	0.026835	0.0000*
ω_2 GARCH coefficient	0.810035	0.040121	0.0000*

Notes: *statically significant at 1% level of significance; ***statically significant at 10% level.

Table 7 Percentage change in the unconditional variance of the GREENEX Index

Pre-COVID period volatility	*COVID period volatility*	*Increase (+) or decrease (–)*
0.831219	1.9131	+130.155%

5 Result robustness

For the robustness of the results, post GARCH model, the ARCH-LM test of heteroskedasticity has been applied again to check the presence/absence of the ARCH effect in the residuals. The result shows that the coefficient of the equation has not been found statically significant up to ten percent level of significance, meaning that the variance equation is perfectly applied on S&P BSE GREENEX returns, and no additional ARCH in residuals is left. The result has reported in Table 8.

Table 8 ARCH-LM test for heteroskedasticity after GARCH

	Test statistic (probability)		
	Whole period	*Pre-COVID period*	*COVID period*
F-statistics	0.696928	0.142336	0.458713
Probability (F-statistics)	0.4039	0.7060	0.4986
Probability (chi square)	0.4036	0.7058	0.4975

6 Conclusions

Using the S&P BSE GREENEX Index sample study has been investigated the impact of COVID-19 on the volatility of investment related to the energy-efficient practices in India. The study has presented some important aspects related to investment related to the energy-efficient practices in India. First, the results of a positive average return of the time series show that the market price of the S&P BSE GREENEX Index is increasing during the sample period. Second, comparatively, risk related to market price has increased during the COVID-19. Third, the higher value of kurtosis during the COVID-19 indicates that investment certainty has been decreased in the investment related to the energy-efficient practices in India after the first case reporting. Fourth, the result of estimation of the GARCH (1, 1) model suggests the presence of a large degree of volatility persistence in the S&P BSE GREENEX Index. Further, the results indicate an increase in volatility during the COVID-19 period. The result of GARCH (1, 1) model estimation on both subsamples shows that there is no change in the GARCH process during both periods. Both subsamples show volatility persistency, but during the COVID-19 period, the higher ARCH coefficient suggests that recent news is impacting more rapidly than the pre-COVID-19 period. Conversely, a smaller GARCH coefficient during the COVID-19 shows that the impact of old news on the market price has been reduced than the pre-COVID-19 period. After reporting of the first case of COVID-19 showed an increase in unconditional variance by 130.155%. Due to COVID-19, investors' confidence has tumbled on investment related to the energy-efficient practices in India.

This study analyses the volatility implications of the COVID-19 outbreak on investment related to energy-efficient practices in India. The outcomes may be helpful to investors, corporate executives, financial market regulators, academicians, and government officials. It explains the return volatility of energy-efficient related practices in India. In addition, this study may assist in making more informed decisions in future consequences and maintaining market confidence despite any other disease. Further,

volatility implications may serve as a roadmap for initiating the first policy action in the event of similar incidents in the future.

References

Acikgoz, O. and Gunay, A. (2020) 'The early impact of the COVID-19 pandemic on the global and Turkish economy', *Turkish Journal of Medical Sciences*, Vol. 50, No. SI-1, pp.520–526 [online] https://doi.org/10.3906/sag-2004-6.

Albuquerque, R., Koskinen, Y., Yang, S. and Zhang, C. (2020) 'Resiliency of environmental and social stocks: an analysis of the exogenous COVID-19 market crash', *The Review of Corporate Finance Studies*, Vol. 9, No. 3, pp.593–621 [online] https://doi.org/10.1093/rcfs/cfaa011.

Apergis, N. and Apergis, E. (2020) 'The role of COVID-19 for Chinese stock returns: evidence from a GARCHX model', *Asia-Pacific Journal of Accounting & Economics* [online] https://doi.org/10.1080/16081625.2020.1816185.

Asante-Poku, N.A. and van Huellen, S. (2021) 'Commodity exporter's vulnerabilities in times of COVID-19: the case of Ghana', *Canadian Journal of Development Studies/Revue Canadienne d'Études du Développement*, Vol. 42, Nos. 1–2, pp.122–144 [online] https://doi.org/10.1080/02255189.2020.1857225.

Ashraf, B.N. (2020) 'Stock markets' reaction to COVID-19: cases or fatalities?', *Research in International Business and Finance* [online] https://doi.org/10.1016/j.ribaf.2020.101249.

Baker, S.R., Bloom, N., Davis, S.J. and Terry, S.J. (2020) *COVID-Induced Economic Uncertainty*, National Bureau of Economic Research, No. w26983, DOI: 10.3386/w26983.

Bangur, P. (2019) 'Investment certainty and demonetization: evidence from India', *The Journal of Private Equity*, Vol. 22, No. 4, pp.60–69 [online] https://doi.org/10.3905/jpe.2019.1.086.

Bernardini, E., Di Giampaolo, J., Faiella, I. and Poli, R. (2021) 'The impact of carbon risk on stock returns: evidence from the European electric utilities', *Journal of Sustainable Finance & Investment*, Vol. 11, No. 1, pp.1–26 [online] https://doi.org/10.1080/20430795.2019.1569445.

Bhuiyan, M.A.M., Mahmud, S., Romyull, M. and Tasnim, N. (2021) 'Volatility estimation for COVID-19 daily rates using Kalman filtering technique', *Results in Physics* [online] https://doi.org/10.1016/j.rinp.2021.104291.

Bollerslev, T. (1986) 'Generalized autoregressive conditional heteroskedasticity', *Journal of Econometrics*, Vol. 31, No. 3, pp.307–327.

Bouri, E., Naeem, M.A., Nor, S.M., Mbarki, I. and Saeed, T. (2021) 'Government responses to COVID-19 and industry stock returns', *Economic Research-Ekonomska Istraživanja* [online] https://doi.org/10.1080/1331677X.2021.1929374.

Broadstock, D.C., Chan, K., Cheng, L.T. and Wang, X. (2021) 'The role of ESG performance during times of financial crisis: evidence from COVID-19 in China', *Finance Research Letters* [online] https://doi.org/10.1016/j.frl.2020.101716.

Butterworth, D. (2000) 'The impact of futures trading on underlying stock index volatility: the case of the FTSE mid 250 contract', *Applied Economics Letters*, Vol. 7, No. 7, pp.439–442.

Corbet, S., Hou, Y.G., Hu, Y., Larkin, C., Lucey, B. and Oxley, L. (2021) 'Cryptocurrency liquidity and volatility interrelationships during the COVID-19 pandemic', *Finance Research Letters* [online] https://doi.org/10.1016/j.frl.2021.102137.

de Dios-Alija, T., del Río Caballero, M., Gil-Alana, L.A. and Martin-Valmayor, M. (2021) 'Stock market indices and sustainability: a comparison between them', *Journal of Sustainable Finance & Investment* [online] https://doi.org/10.1080/20430795.2021.1896988.

Dickey, D.A. and Fuller, W.A. (1979) 'Distribution of the estimators for autoregressive time series with a unit root', *Journal of American Statistical Association*, Vol. 74, No. 366, pp.427–431.

Engelhardt, N., Ekkenga, J. and Posch, P. (2021) 'ESG ratings and stock performance during the COVID-19 crisis', *Sustainability* [online] https://doi.org/10.3390/su13137133.

Engle, R.F. (1982) 'Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation', *Econometrica*, Vol. 50, No. 4, pp.987–1007.

Fama, E.F. (1970) 'Efficient capital markets: a review of theory and empirical work', *The Journal of Finance, Papers and Proceedings of the Twenty-Eighth Annual Meeting of the American Finance Association*, New York, NY, 28–30 December, Vol. 25, No. 2, pp.383–417.

Fang, M., Tan, K.S. and Wirjanto, T.S. (2019) 'Sustainable portfolio management under climate change', *Journal of Sustainable Finance & Investment*, Vol. 9, No. 1, pp.45–67 [online] https://doi.org/10.1080/20430795.2018.1522583.

Ferriani, F. and Natoli, F. (2021) 'ESG risks in times of COVID-19', *Applied Economics Letters*, Vol. 28, No. 18, pp.1537–1541 [online] https://doi.org/10.1080/13504851.2020.1830932.

Folger-Laronde, Z., Pashang, S., Feor, L. and ElAlfy, A. (2020) 'ESG ratings and financial performance of exchange-traded funds during the COVID-19 pandemic', *Journal of Sustainable Finance & Investment* [online] https://doi.org/10.1080/20430795.2020.1782814.

Harjoto, M.A., Rossi, F. and Paglia, J.K. (2021) 'COVID-19: stock market reactions to the shock and the stimulus', *Applied Economics Letters*, Vol. 28, No. 10, pp.795–801 [online] https://doi.org/10.1080/13504851.2020.1781767.

He, Q., Liu, J., Wang, S. and Yu, J. (2020) 'The impact of COVID-19 on stock markets', *Economic and Political Studies*, Vol. 8, No. 3, pp.275–288 [online] https://doi.org/10.1080/20954816.2020.1757570.

IPCCC (2018) *Global Warming of 1.5°C – An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, In The Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* [online] https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf (accessed 19 December 2021).

Iyke, B.N. (2020) 'Economic policy uncertainty in times of COVID-19 pandemic', *Asian Economics Letters* [online] https://doi.org/10.46557/001c.17665.

Jarque, C.M. and Bera, A.K. (1987) 'A test for normality of observations and regression residuals', *International Statistical Review/Revue Internationale de Statistique*, Vol. 55, No. 2, pp.163–172.

Jawadi, F., Idi Cheffou, A., Jawadi, N. and Ben Ameur, H. (2021) 'Conventional and Islamic stock market liquidity and volatility during COVID 19', *Applied Economics*, Vol. 53, No. 60, pp.6944–6963 [online] https://doi.org/10.1080/00036846.2021.1954595.

Li, W., Chien, F., Kamran, H.W., Aldeehani, T.M., Sadiq, M., Nguyen, V.C. and Hesary F.T. (2021) 'The nexus between COVID-19 fear and stock market volatility', *Economic Research-Ekonomska Istraživanja* [online] https://doi.org/10.1080/1331677X.2021.1914125.

Liu, H., Manzoor, A., Wang, C., Zhang, L. and Manzoor, Z. (2020) 'The COVID-19 outbreak and affected countries stock markets response', *International Journal of Environmental Research and Public Health* [online] https://doi.org/10.3390/ijerph17082800.

Liu, K. (2021) 'COVID-19 and the Chinese economy: impacts, policy responses and implications', *International Review of Applied Economics*, Vol. 35, No. 2, pp.308–330 [online] https://doi.org/10.1080/02692171.2021.1876641.

Mazur, M., Dang, M. and Vega, M. (2021) 'COVID-19 and the march 2020 stock market crash. Evidence from S&P1500', *Finance Research Letters* [online] https://doi.org/10.1016/j.frl.2020.101690.

Naik, S. and Bagodi, V. (2021) 'Energy conservation opportunities: evidences from three industrial clusters in India', *International Journal of Energy Sector Management* [online] https://doi.org/10.1108/IJESM-07-2020-0022.

Pisani, F. and Russo, G. (2021) 'Sustainable finance and COVID-19: the reaction of ESG funds to the 2020 crisis', *Sustainability*, Vol. 13, No. 23 [online] https://doi.org/10.3390/su132313253.

Rizvi, S.K.A., Mirza, N., Naqvi, B. and Rahat, B. (2020) 'COVID-19 and asset management in EU: a preliminary assessment of performance and investment styles', *Journal of Asset Management*, Vol. 21, No. 4, pp.281–291 [online] https://doi.org/10.1057/s41260-020-00172-3.

Singh, N.P., Makhija, P. and Chacko, E. (2021) 'Sustainable investment and the COVID-19 effect-volatility analysis of ESG index', *International Journal of Sustainable Economy*, Vol. 13, No. 4, pp.357–368, DOI: 10.1504/IJSE.2021.118620.

Sinha, D., Bagodi, V. and Dey, D. (2020) 'The supply chain disruption framework post COVID-19: a system dynamics model', *Foreign Trade Review*, Vol. 55, No. 4, pp.511–534 [online] https://doi.org/10.1177/0015732520947904.

Siu, A. and Wong, Y.R. (2004) 'Economic impact of SARS: the case of Hong Kong', *Asian Economic Papers*, Vol. 3, No. 1, pp.62–83 [online] https://doi.org/10.1162/1535351041747996.

Susilawati, S., Falefi, R. and Purwoko, A. (2020) 'Impact of COVID-19's pandemic on the economy of Indonesia', *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*, Vol. 3, No. 2, pp.1147–1156 [online] https://doi.org/10.33258/birci.v3i2.954.

Tsay, R.S. (2005) *Analysis of Financial Time Series*, Vol. 543, pp.97–122, John Wiley & Sons, New Jersey, USA.

Umar, M., Xu, Y. and Mirza, S.S. (2021) 'The impact of COVID-19 on gig economy', *Economic Research-Ekonomska Istraživanja*, Vol. 34, No. 1, pp.2284–2296 [online] https://doi.org/10.1080/1331677X.2020.1862688.

Vorobeva, E. and Dana, L.P. (2021) 'The COVID-19 pandemic and migrant entrepreneurship: responses to the market shock', *Migration Letters*, Vol. 18, No. 4, pp.477–485 [online] https://doi.org/10.33182/ml.v18i4.1400.

Wang, Y.H., Yang, F.J. and Chen, L.J. (2013) 'An investor's perspective on infectious diseases and their influence on market behavior', *Journal of Business Economics and Management*, Vol. 14, No. Sup. 1, pp.S112–S127 [online] https://doi.org/10.3846/16111699.2012.711360.

Yamahaki, C., Felsberg, A.V., Köberle, A.C., Gurgel, A.C. and Stewart-Richardson, J. (2020) 'Structural and specific barriers to the development of a green bond market in Brazil', *Journal of Sustainable Finance & Investment* [online] https://doi.org/10.1080/20430795.2020.1769985.

Yiu, M.S. and Tsang, A. (2021) 'Impact of COVID-19 on ASEAN5 stock markets', *Journal of the Asia Pacific Economy* [online] https://doi.org/10.1080/13547860.2021.1947550.

Zaremba, A., Kizys, R., Aharon, D.Y. and Demir, E. (2020) 'Infected markets: novel coronavirus, government interventions, and stock return volatility around the globe', *Finance Research Letters* [online] https://doi.org/10.1016/j.frl.2020.101597.

Zhang, D., Hu, M. and Ji, Q. (2020) 'Financial markets under the global pandemic of COVID-19', *Finance Research Letters* [online] https://doi.org/10.1016/j.frl.2020.101528.